DESIGN OF A 500W INVERTER

BY

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A PROJECT REPORT SUBMITED IN PARTIAL FULLFILLMENT

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SUPERVISORS

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DECLARATION

I Kyomuhendo Medius, declare that this is my original work and has never been submitted for any academic award.

Signature:…………………………………

KYOMUHENDO MEDIUS

Date:………………………………

APPROVAL

This project report has been carried out under my supervision and is ready for submission to Kabale University Faculty of Engineering with my approval.

Signature:………………………………..

Engr. Michael Nnamdi Irechukwu

Date:…………………………………….

DEDICATION

This project report is dedicated to my husband Mr. Namanya Aggrey who supported me financially towards the accomplishment of this report.

ACKNOWLEDGEMENT

I thank the Almighty God for my constant strength during the design and implementation of this project.

I honour my husband, parents and sisters for their financial support towards the accomplishment of this project.

In a nutshell, I extend my gratitude thanks to my friends who stood with me during the design and implementation of this project especially Jackline and Justus. May God„s favour always be upon them.

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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 software. The inverter circuit in this project work is based on the operation of the oscillator. 12V AC is stepped up to 240V 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

CHAPTER ONE

I.0 INTRODUCTION

The world demand for electrical energy is constantly increasing and conventional energy resources are diminishing and even threatened to be depleted. With the increasing popularity of alternative power sources, such as solar and wind, the need for static inverters to convert dc energy stored in batteries to conventional ac form has increased substantially.

The conversion of low voltage DC power will be completed in two steps. The first being conversion of low voltage DC power to a high voltage DC source, and the second step will be conversion of the high DC source to an AC waveform using pulse width modulation. [1]

A great deal of research has been done to improve the efficiency of inverters. As the market is now flooded with varieties of the inverter but they are very costly and some of those are very complicated to use and less efficient. In this project, the primary goal is to develop an efficient cost effective inverter that can convert DC power to AC, which will especially optimize the rural areas of Uganda. In this project, I have used only the essential switching and amplifying components to minimize the cost and losses. I have done simulation and hardware implementation and added snubber components for minimizing oddity of voltage and transformer heating. At last I attained splendid AC output which can be used for different types of AC lighting loads. These type of inverters are not expensive and is affordable especially by people in rural areas.

1.1 PROBLEM STATEMENT

In market there are a range of inverters from very expensive to very inexpensive with varying degrees of quality, efficiency and power output capability. My goal is to design a fairly inexpensive efficient 500 W inverter with a pure sine wave output.

1.2.0 Objectives

1.2.1 General objective

To design an efficient pure sine-wave more reliable inverter.

1.2.2 Specific objectives

To design the circuit.

To simulate the circuit

To test the circuit.

1.3 Significance of the study

The project shall be useful to the communities that use AC devices with DC sources for example renewable energy sources that have direct current output.

This project report will be used for further study in the related field.

This project will enable communities to use other sources of energy which generate DC.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter contains related information on the design of an inverter.

This project is a stepping stone to a cheaper and efficient pure sine wave inverter by Jim Doucet [2]Musa, A. and G.S.M. Galadanci in the design and simulation of a 50KVA power inverter based on converter and H-Bridge topology said that with increasing popularity of alternative power sources there is need to design an inverter.

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 [2]. 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 9DC 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 Ugandan homes with a 220 volt AC source. It should be noted that since 1954 there has 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.

An inverter is composed of a number of components which include resistors, capacitors, transistors, mosfets, diodes and transformer.

MOSFETS

A MOSFET is a Metal Oxide Semiconductor Field Effect Transistor; it is a three-terminal device: Source, Drain and Gate.

• Transistors are used for switching and amplification in circuits

A **semiconductor** (eg: Si) has an electrical conductivity value between a conductor and an insulator. Current conduction occurs through free movement of **electrons or holes**.

Doping introduces impurities into a pure semiconductor for the purpose of modulating its electrical properties.

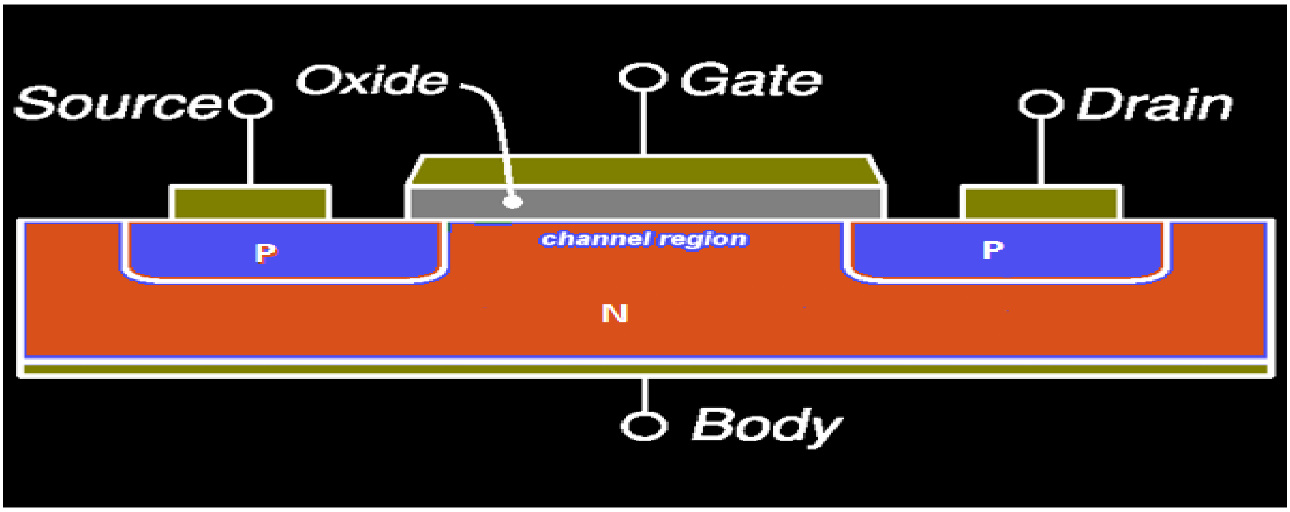


Figure 1: shows the different parts of MOSFET *. [2]*

How does enhancement MOSFET work without a channel?

This is where the gate voltage plays a significant part. Gate voltage serves to create the channel in enhancement mode, while in depletion mode it can be used to "deplete" the channel; As in destroy. Enhancement mode and depletion mode can be summarized as normally open and normally closed switches respectively. Creation of the channel by applying gate voltage. Threshold voltage: Gate voltage must be higher than Voltage terminal, only then is the conduction path created Channel is just the „path"; Additional potential difference is needed to instigate and sustain charge flow. This is provided by applying a potential difference voltage between drain and source terminals.

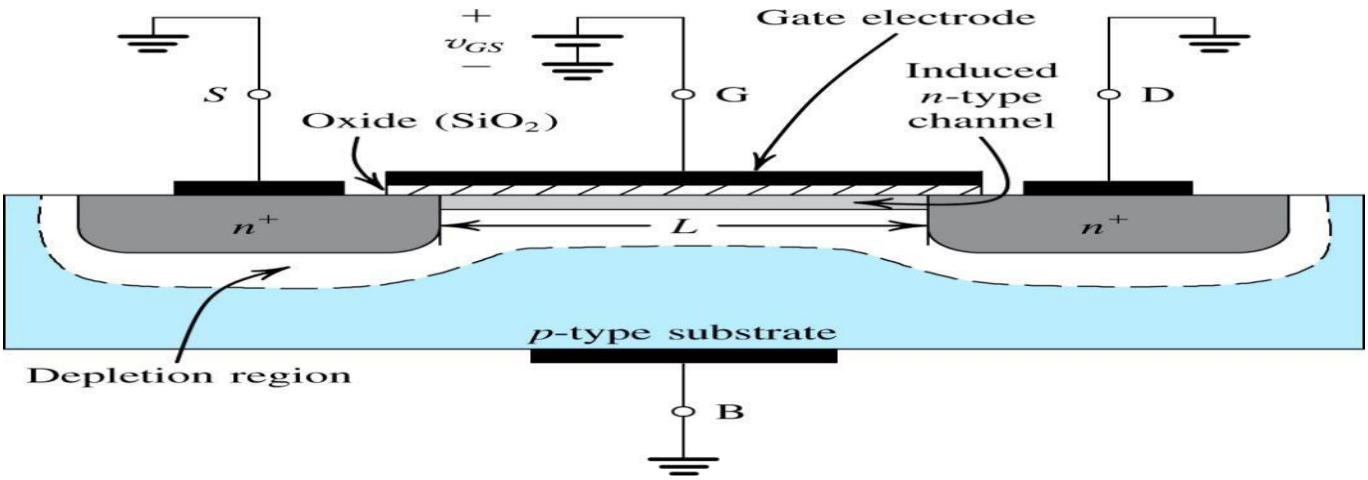


Figure 2:Shows the switching of the MOSFET [2]

I-V CHARACTERISTICS OF MOSFET

The plot is between the drain current and the drain-source voltage, for different values of gate voltage. The MOSFET operating regions include Cutoff mode, Triode/Linear mode and the Saturation mode.

RESISTOR

A resistance is the property of a substance, which opposes the flow of an electric current. It is measured in ohms. Each resistor has two main characteristics that is its resistance value in ohms and its power dissipating capacity in watts. Resistors are employed for many purposes such as electric heaters, telephone equipment, and electric and electronic circuit elements and in current limiting devices. As resistors are used in wide applications there values like power rating, R value, tolerance etc vary. Resistors of resistance value ranging from .1ohms to many mega ohms are manufactured. Acceptable tolerance levels range from +/- 20% to as low as +/-.001%. The power rating may be as low as 1/10 watts and can be in several hundred watts. These all vary in range and type of application a particular resistor is used.

Transformer: It is an inductively coupled circuit used for transmitting alternating current energy. It is also used for matching impedance between the generator and the load. It makes use of mutual inductance in which a current flowing in a coil produces a varying electromagnetic wound over the primary coil. Most transformers are used to step-up or step down voltage or current. The number of turns on the primary winding is usually different form that of Secondary. However, an isolation transformer provides secondary voltage and current that is same as that of primary voltage and current, because both winding have the same number of turns, (Expect for resistive losses). These transformers prevent the transfer of unwanted electrical noise from the primary to the secondary winding. The primary and secondary windings of conventional transformer for electronic application are wound on tubular bobbin (insulated spool that serves as a support for the coil) made of plastic and other insulated materials. The wound bobbins are then enclosed by iron or steel cores in the shape of figure start of “E” and “I” shaped laminated metal sheets, assembled through and round the wound bobbins. The laminations are then clamped down to form a rigid assembly; some transformers have plastic shrouds to insulate the windings from the core. Both primary and secondary windings can be wound on the same bobbin, but it is now common practice, to wind the primary and secondary windings separately on a split bobbin, to improve electrical isolation. The primary and secondary terminals may be connected to rigid pins on the bobbin that also functions as printed circuit board mounting pins.

TRANSFORMER DESIGN

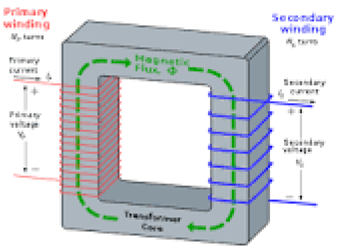


Figure 3: TRANSFORMER *[3]*

A transformer is a device that couples two AC circuits magnetically and provides electrical isolation between the circuits while allowing a transformation of voltage and current from one circuit to another i.e. it is mainly used for voltage and current transformation and hence we made use of current voltage transformers in this project.

The Generated E.M.F in a Wounded Transformer. In observing an ideal transformer with secondary opened and the primary connected to a sinusoidal alternating voltage V1, the potential different causes an alternating current to flow in the primary since primary coil is purely inductive and has no output but draw the magnetizing current I only. And this I will function as to magnetized the core in the secondary. It is small in value and lag voltage V1 by 90^0. It therefore produces an alternating flux that is proportional to the current inputs. This flux is linked by both primary and secondary windings .Thus; this leakage(s) produced a mutually induced e.m.f E_2 in secondary winding that anti-phase with V_1 and has magnitude proportional to rate of change of flux and the number of secondary turns. Let N_1=Number of turns in primary, N_2=number of turns in secondary. The transformation ratio, K= N_1/N_2 The equation for the voltage and current transformation of a transformer is given by K= V_2/V_1= I_1/I_2, F=Frequency of A.C input (Hz) Maximum flux in core (Webbers) =B*A Average rate of change of flux =maximum. Flux divided by 1/4F. (Wb/s or Volt.) Now rate of change of flux per turn means induced e .m .f in Volt Thus Average e.m.f /turn =4*F*max. Flux Since the flux is sinusoidal, r.m.s =form factor*Average e.m.f /turn But form factor = r.m.s value /Average value=1.11, Then r.m.s value of E.m.f =1.11*4F*max. Flux =4.44F*max. Flux , But max .flux =Bm*A r.m.s value of E.m .f in primary turn (Tp) =4.44F*Bm*A*Tp NOTE: Bm is assumed to be 15000Wb/m. F=50 Hz By introducing stacking factor (10-8) and Tp factor (0.9) then we have Number of turns per volt, NT.V-1= 7/A

CHOICE OF TRANSFORMER‟S COMPONENTS

The power Rating for the Inverter transformer (KVA) =1.0KA , E_2=12V Assuming the efficiency of transformer =85% Then Input rating =output /Efficiency=1000VA/0.85=1176VA Ip = PI / VP V_P = 260V Ip = 1176 / 260 = 4.5A Is = Po / Vs, Vs = 12V Ip = 1000 / 12 = 83.3A For practical design of inverter transformer Number of turns per volt for both primary and secondary winding is given by; NT.V-1= 7/A Where A is the area of transformer former in sq. inch Former area A is 2.3inch by 1.5inch = 3.45sq.inch NT.V-1= 7/3.45=2.03 NT.V-1 = 2 (approximate value). **Primary Winding** Charger tapping winding turns Np1= NT.V-1 * E_1 , E_1=220V Np1 = 2 * 220 = 440turns Inverter (out) tapping winding turns NS2= NT.V-1 * E_3 E_3=260V NS_2 = 2 * 260= 520turns Difference of Inverting and Charging turns = 520 – 440 = 80turns. For the primary windings, charging tapping is brought out after 440 turns and an addition 80 turns is made for the inverter out tapping.

Secondary Winding Secondary turns Ns= NT.V-1 * E_2 E_2 = 12V Ns= 2 *12= 24turns. (Bifilar winding) **SWG Estimation** Standard Gauge Weight, SGW, can be estimated as follow;

considering conduction current density J (with fixed value of 2.5A/mm2) and windings coil current. For Ip = 4.5A, the corresponding guage from tables is 24SWG and For Is = 83.3A, the corresponding guage from tables is 13SWG.

50 Hz FREQUENCY OSCILLATOR SECTION

The generation of 50 Hz frequency by the oscillator section is based on the application of a PWM controller IC SG3524. The IC has the following under listed features which makes it excellent for the application.

Complete PWM power control circuitry

Single ended or push – pull outputs

Line and load regulation of 0.2%

1% maximum temperature variation

Total supply current is less than 10mA [3]

2.2 CATEGORIES OF INVERTERS

Inverters are generally used in a host of applications that include variable speed drive, uninterruptible power supplies, flexible AC transmission systems (FACTS), high voltage DC transmission systems (HVDC), active filters among the others [6].

An inverter is a device which maintains a continuous supply of electric power to connected equipments or load by supplying power from a separate source, like battery, when utility power is not available. It is inserted between the source of power (typically commercially utility power) and the load is protecting. For alternative energy systems, inverters are the essential step between a battery's DC power and the AC power needed by standard household electrical systems. In a grid connected home, an inverter/charger connected to a battery bank can provide an uninterruptible source of backup power in the event of power failures, or can be used to sell extra alternative energy power back to the utility company. Batteries produce power in direct current

(DC) form, which can run at very low voltages but cannot be used to run most modern household appliances. Utility companies and generators produce sine wave alternating current (AC) power, which is used by most commonly available appliances today. Inverters take the DC power supplied by a storage battery bank and electronically convert it to AC power.

An inverter used for backup power in a grid connected home will use grid power to keep the batteries charged, and when grid power fails, it will switch to power from the batteries and supplying it to the building electrical system. For a business home or office, a reliable power source is invaluable for preventing lost data on computer systems. Most modern inverters also include overvoltage and under voltage protection, protecting sensitive equipment from dangerous power surges as well [3].

An inverter is a device that takes a direct current input and produces a sinusoidal alternating current output. An inverter needs to be designed to handle the requirements of an energy hungry household yet remain efficient during periods of low demand. The efficiency of inverter is highly is dependent on the switching device, topology and switching frequency of the inverter [11].

Alternating current (AC) power is used as a power source as well for transmission purposes because it can be generated and also converted from one voltage to another. Transmission of AC power over long distance is still used until now, however it results in relatively high transmission loses. The types of loses are transient stability problem and operational requirements such as dynamic damping of electrical system may also arise along the transmission line. Direct Current (DC) transmission is an alternative which overcomes most of this problem. Besides that, it is more economically feasible only when the transmission distance exceeds 500 to 600 km, underwater cables for the case in a small distance transmission. At the receiving end HVDC is converted back to HVAC or LVAC. The design of an inverter is referring to the requirement of point distribution and economical aspect [10].

An inverter with the use of many batteries is capable of generating power for hour‟s even days depending on the capacity of the battery and the load connected to it, and this power could be very crucial since in some office set-up, a failure of about one minute could cause losses that could run into millions. The ability of the inverter to change over automatically gives it an advantage over some UPS and they find applications in the following areas;

-The computer field: An unpredictable power failure can wipe out the information stored in the memory bank of the complete data base system.

- Air traffic system: Radar and essential aircraft information are on constant display in air traffic control system, and mains failure could cause a break out of radar and lead to unprecedented disaster.

-Other processes like boilers, flame detectors, etc.

- Domestic uses include items like TVS, CD players, Fans, Light points, boilers, etc.

Presently, inverters are extensively used in various applications. 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.

Voltage Reference: An internal series regulator provides a nominal 5V output which is used both to generate a reference voltage and is the regulated source for all the internal timing and control circuitry. This reference regulator may be used as a 5V source for other circuitry. It provides up to 50mA of current itself and can easily be expanded to higher current with an external PNP **Oscillator:** The oscillator in the SG3524 uses an external resistor (RT) to establish a constant charging current into an external capacitor (CT). While this uses more current than a series-connected RC, it provides a linear ramp voltage on the capacitor which is also used as a reference for the comparator. The charging current is equal to 3.6V ÷ RT and should be kept within the approximate range of 30µA to 2mA; i.e. 1.8k<RT<100k. The range of values for CT also has limits as the discharge time of CT determines the pulse-width of the oscillator output pulse. This pulse is used as a blanking pulse to both outputs to insure that there is no possibility of having both outputs on simultaneously during transition. [3]

THE OSCILLATOR SECTION

The schematic diagram of the oscillatory section is as shown in fig. 2. IC1 SG3524 is used to generate the 50 Hz frequency required to generate AC supply by the inverter. Battery supply is connected to the pin-15. Pin-8 of the IC1 is connected to negative terminal of the battery. Pin-6 and 7 of IC1 are oscillator section pins. The frequency produced depends on the value of the capacitor and resistor at these pins. The pin-6 timing resistor is a combination of a fixed resistor and a preset VR1 so that the value of the output frequency can be set. Signal generated by the oscillator section of IC1 coupled to the flip-flop section of IC1. This section converts the incoming signal into signal with opposite polarity. In a two signal with opposite polarity, when the first signal is positive, the second signal will be negative and vice versa. This process is repeated 50 times per second, i.e. an alternating signal with 50 Hz frequency is generated inside the flip-flop section of the IC1. The 50Hz frequency alternating signal is output at pin-11 and 14 of IC1. This alternating signal is called „MOS drive signal‟ having a value between 3.5V and 5.5V. The oscillator frequency is given by; F = 1.44/ (RC) For RT=140K CT=0.1μF F = 50Hz (approx.) [3]

Solar Energy

Solar energy systems convert the energy of the sun directly to electrical energy. Solar energy farms can generate a significant amount of electricity to feed the electrical systems.

Scaled-down solar systems can provide sufficient energy for residential and business utilization.

The solar cell is similar to a diode, and a practical model of the solar cell.

The milliohms level resistance___represents the collector traces and external wires, and the parallel kilohms level resistance is the internal resistance of the crystal.

The PV cell output current is derived as (1.1) [6]. The source current_is dependent on the solar irradiance. Since the thermal voltage and the reverse saturation current are dependent to the temperature, the PV output current is dependent on the temperature. Thus, the PV output current is actually a function of irradiance and environmental temperature. Based on the practical solar cell model, PV output current-voltage (I-V) and power-voltage (P-V) curves are plotted with different irradiances and temperatures.

Since the maximum power output of PV changes as the irradiation and environmental temperature varies, maximum power point tracking algorithm must be implemented in PV applications to obtain the maximum power from a PV string for the sake of conversion efficiency.

Many MPPT algorithms have been proposed and implemented. The most common and basic MPPT techniques are perturb and observe (P&O) algorithm, incremental conductance algorithm, and fractional open-circuit voltage algorithm.

There are many other maximum power point tracking techniques based on fuzzy logic and neural networks. However, the MPPT techniques are not the focus of this thesis. More related information can be found in.

BATTERIES

There a number of batteries which include Lithium ion batteries and Lead acid batteries. But for this project Lead acid batteries were used for power storage.

Lead acid Battery

The battery which uses sponge lead and lead peroxide for the conversion of the chemical energy into electrical power, such type of battery is called a lead acid battery. The lead acid battery is most commonly used in the power stations and substations because it has higher cell voltage and lower cost.

Construction of Lead Acid Battery

The various parts of the lead acid battery include Container, Plate and Active Material.

Container: The container of the lead acid battery is made of glass, lead lined wood, ebonite, the hard rubber of bitmus compound, ceramic materials or moulded plastics and are seated at the top to avoid the discharge of electrolyte. At the bottom of the container, there are four ribs, on two of them rest the positive plate and the others support the negative plates.

The prism serves as the support for the plates and the same time protect them from a short-circuit. The material should be resistant to sulphuric acid, should not deform or be porous, or contain impurities which damage the electrolyte.

Plate: The plate of the lead acid cell is of diverse design and they all consist some form of a grid which is made up of lead and the active material. The grid is essential for conducting the electric current and for disturbing the current equally on the active material. If the current is not uniformly distributed, then the active material will loosen and fall out.

The plates of the battery are of two types. They are the formed plates or plante plates and pasted or faure or faure plates.

Plante"s plates are used largely for stationary batteries as these are heavier in weight and more costly than the pasted plates. But the plates are more durable and less liable to lose active material by rapid charging and discharging. The plantes plate has low capacity weight ratio.

Feature process is much suitable for manufacturing of negative plates rather than positive plates . The negative active material is quite tough, and it undergoes a comparatively low change from charging and discharging [4].

Active Material- The material in a cell which takes active participation in chemical reaction that is absorption or evolution of electrical energy during charging or discharging is called the active material of the cell. The active elements of the lead acid are

Lead peroxide ($Pb0_2$) – it forms the positive active material. The PbO_2 are dark chocolate broom in colour.

Sponge lead- It forms the negative active material. It is grey in colour.

Dilute Sulphuric Acid (H_2SO_4) – it is used as an electrolyte. It contains 31% of sulphuric acid.

The lead peroxide and sponge lead, which form the negative and positive active materials have the little mechanical strength and therefore can be used alone.

Separators – The separators are thin sheets of non-conducting material made up of chemically treated lead wood, porous rubbers, or mats of glass fibre and are placed between the positive and negative to insulate them from each other. Separators are grooved vertically on one side and are smooth on the other side.

Battery terminal- A battery has two terminals the positive and the negative. The positive terminal with a diameter of 17.5 mm at the top is slightly larger then the negative terminal which is 16mm in diameter.

Working Principle of lead Acid Battery

When the sulphuric acid dissolves, its molecules break up into positive hydrogen ions ($2H^+$) and sulphate ions (SO_4^-) and move freely. If the two electrode are immersed in solutions and connected to DC supply then the hydrogen ions being positively charged and move towards the electrodes and connected to the negative terminal of the supply. The SO_4^- ions being negatively charged moved towards the electrodes connected to the positive terminal of the supply main.

Different types of Lead Acid batteries

Flooded type- This is the conventional engine ignition type and has free movement in the cell section. People who are using this type can have accessibility for each cell and they can add water to the cells when the battery gets dried up.

Sealed Type- this kind of lead – acid battery is just a minor change to the flooded type of battery. Even though people hold no access to each cell in the battery, the internal design is almost similar to that flooded type one. The main variation in this type is that there exist enough amount of acid which withstands for the happening of smooth flow of chemical reactions throughout the battery life. [5]

VRLA Type – These are called Valve Regulated Lead Acid batteries which are also termed as sealed type of battery. The value controlling procedure permits for the safe evolution of O_2 and H_2 gases at the time of charging.

AGM Type- This is the Absorbed Glass Matte type of battery that permits the electrolyte to get stopped near to the plate‟s material. This kind of battery augments the performance of the discharge and charging processes. These are especially utilized in the power sports and engine initiation applications.

Gel Type- This is the wet kind of lead – acid battery where the electrolyte in this cell is with silica-related which makes stiffening of the material. The recharge voltage values of the cell are minimal when compared with other types and it has more sensitivity too.

Lead Acid Battery Applications

These are employed in emergency lighting to provide power for pumps.

Used in electric motors

Submarines

Nuclear submarines.

CHAPTER THREE:

3.0 Methodology

The construction of the pure sine wave 500w inverter will be complex when thought of as a whole but it will be broken up into smaller projects and divisions and it becomes a much easier to manage project. It will involve the analogue circuitry as well as discrete components. The first step will involve creating an accurate pulse width modulation using analogue circuitry.

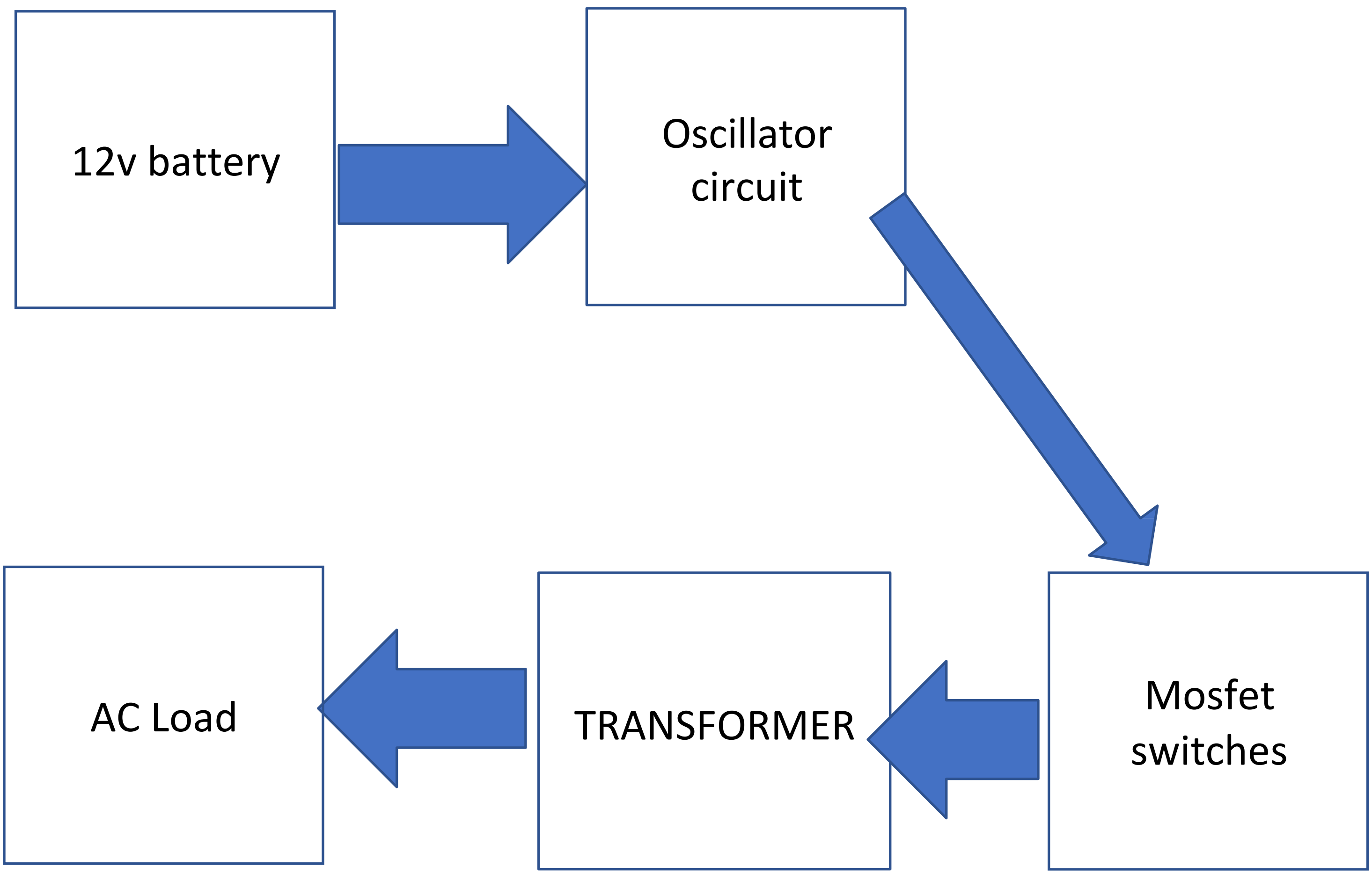
Objective	**Method**	**Deliverables**
General objective To design an efficient pure sine wave more Reliable inverter.	The process shall begin with gathering information, followed by system design, budget and Circuit building.	The collection of data shall help in knowing the different components to use. The system design shall enable me in knowing the how it will look. Circuit building shall enable us achieve the desired project.
To design the circuit	Computer aided designs shall be used to come with the design.	A fully well designed circuit shall be achieved.
To test the circuit.	Different tests shall be carried out.	The different tests shall enable me to have a proper functioning

		system.

The second part of the circuitry will consist of an integrator circuit. [4]

Table 1: Table showing objective, method and deliverables

A BLOCK DIAGRAM FOR THE PROJECT



DC-AC Inverter Circuit

In this circuit, the only necessary adjustment will be in the choice of transformer rating and the MOSFETs to be used.

The Transformer Choice

Primary winding Ip = P/V = 500/12 = 41.667A

Secondary winding Is = P/V = 500/240 = 2.08A

Each half of the centre tapped transformer will therefore carry 2.08A. Hence, a transformer with the following parameters will be required:

Primary winding: 12V, 41.667A

Secondary winding: 240V, 2.08A

The MOSFET Driver Circuit

MOSFETs were chosen for use in this project due to its fast switching rate and ruggedness. The signal from the push-pull amplifier driver circuit was used to trigger the gate of MOSFET to enable it to start conducting at the rate at which the pulses switches. 12Ω resistors were connected between the output from the driver circuit and then gate of the MOSFET to prevent static electricity from getting into the gate. The power output needed is 500VA. By applying a power factor of 0.7 (due to loses). The output power = 0.7 x 500VA = 350watts. For power to be equal to 350 watts. According to Akande et al, (2007) [1];

I = –

I = — = 29.167A (Using a 12v battery)

This implies that the power element must have a current handling capability in excess of 29.167A.

IR510 MOSFETs with the following specifications were thus selected for use.

Table 2:showing current, voltage and power

I_D (MAX)	V_D(MAX)	P_D (MAX)
30A	40V	200 watts

Using the design parameters and formulas below according to Akande et al (2007) [1], Alade and Akande (2010) [2], with G = Power gain, P_{out} = the AC output power, P_{dc} = DC input power, η = the efficiency, V_{out} = output voltage, Vcc = supply voltage, I_{dc} = direct current, R_L = load and V = input voltage.

V= IR

I= –

I= — = 2.5W

P_{in} = 0.25 x 10 = 2.5 w

$Pout = V_{out} / 8R_L$

Pout = 340/ (8.0x10) = 4.25w

$G = P_{out} / P_{in}$

G = 4.25/ 2.7 = 1.7

Pdc = Vcc Icc

Pdc = 12.0 x 0.5 =6.0w

$$R = \frac{Pout}{Pdc} \times 100\%$$

$$R = \frac{4.25}{6.0} \times 100\% = 71\%$$

Capacitor charge and selection

The following equation gives the minimum charge which needs to be supplied by the capacitor.

$$Q_{bs} = 2Q_g + \frac{I_{gbs\,(max)}}{f} + QIS + \frac{I_{cbs\,(leaks)}}{f}$$

where Q_g = Gate charge of high side FET

Icbs (leak) = bootstrap capacitor leakage current

QIs = level shift change required per cycle

Igbs = quiescent current for the high side driver circuitry.

$C \{2 [2Q_g + I_{gbs\,(max)}) + QIS + I_{cbs\,(leaks)}\} / (V_{cc} – V_f - V_{IS}$

where V_f = forward voltage drop across the bootsrap diode side FET

V_{IS} = Voltage drop across the low side FET.

The elements of the equation above were determined from data sheets as;

Q_g = Gate charge of high side FET=110nC Icbs (leak) = bootstrap capacitor leakage current=250µA Q_{Is} = level shift charge required per cycle = 5nC I_{gbs} = quiescent current for the high side driver circuitry =230µA

$Q_{bs} = 26.4x10^{-3}$

By substitution

From C = Q/ V

$= 26.4 \times 10^{-3} / 12 \quad = 2.2\mu f$

3.1 SYSTEM SPECIFICATION

Inverter and switching devices specification are illustrated below

3.2 Inverter Specification

The Characteristics of the proposed inverter system is showed in table below.

Table 3:inverter specification

Input Voltage	12 Volt (DC)
Input Current	8.3 A(DC)
Maximum Output Power	500 Watt
Output Voltage	220 Volt (AC)
Output Current	2.27 A(AC)
Input Frequency	Nil
Output Frequency	50 Hz

3.4 Switching Specification

MOSFET Switches were used and it"s specified according to expected output of inverter. [4]

CHAPTER FOUR: PROJECT SCHEDULE

4.0 INTRODUCTION

I have used both software Simulation and hardware implementation of this inverter. Both are illustrated below.

4.1 Software Simulation Design

We used Proteus design suit for Simulation of total circuit

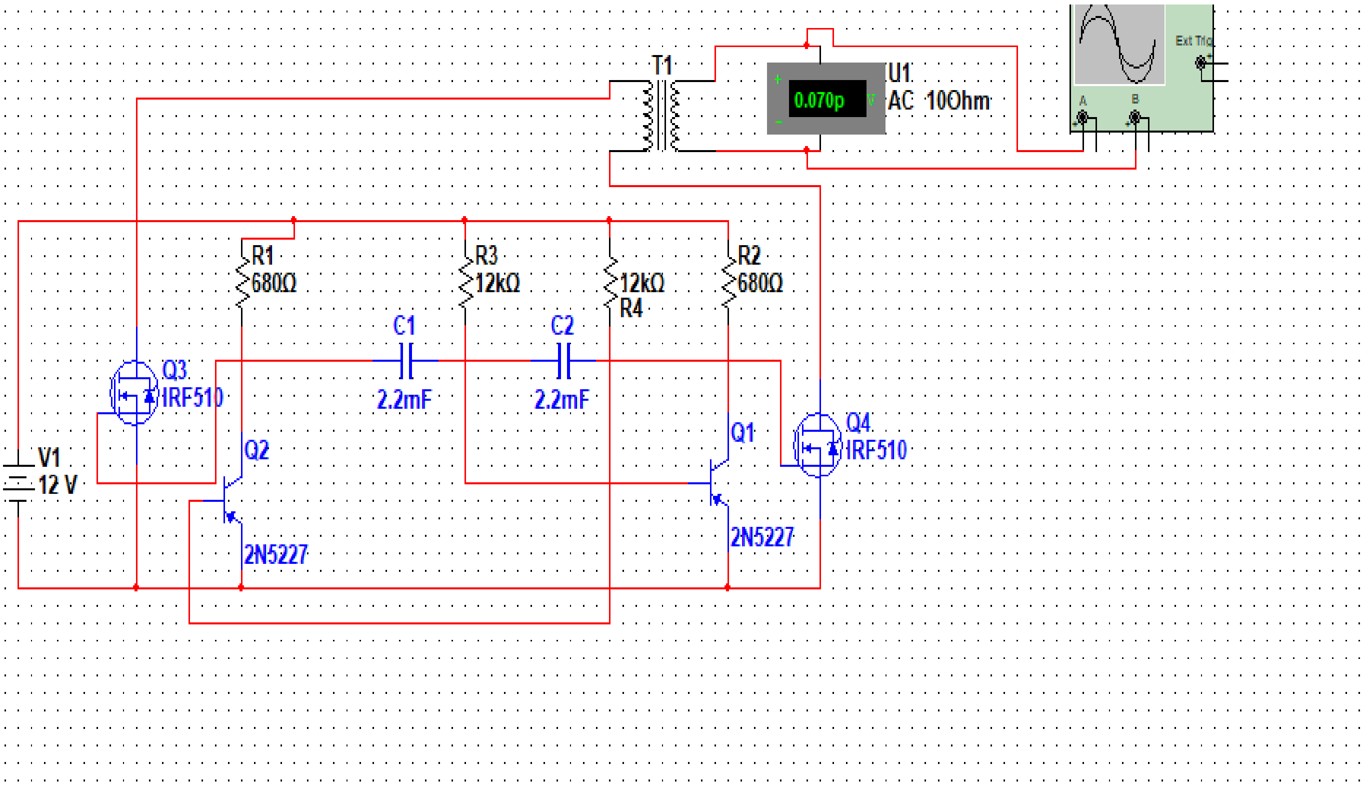


Figure 4: hardware design of proposed inverter circuit

SYSTEM OUTPUT

We have attained three parameters output

- ✓ Oscillator circuit.
- ✓ Push-Pull inverter output.

Here the Oscillator generated pulse signal for triggering transistor switches. Comparator circuit was used to make this pulse more strong for switching the MOSFET switches accurately.

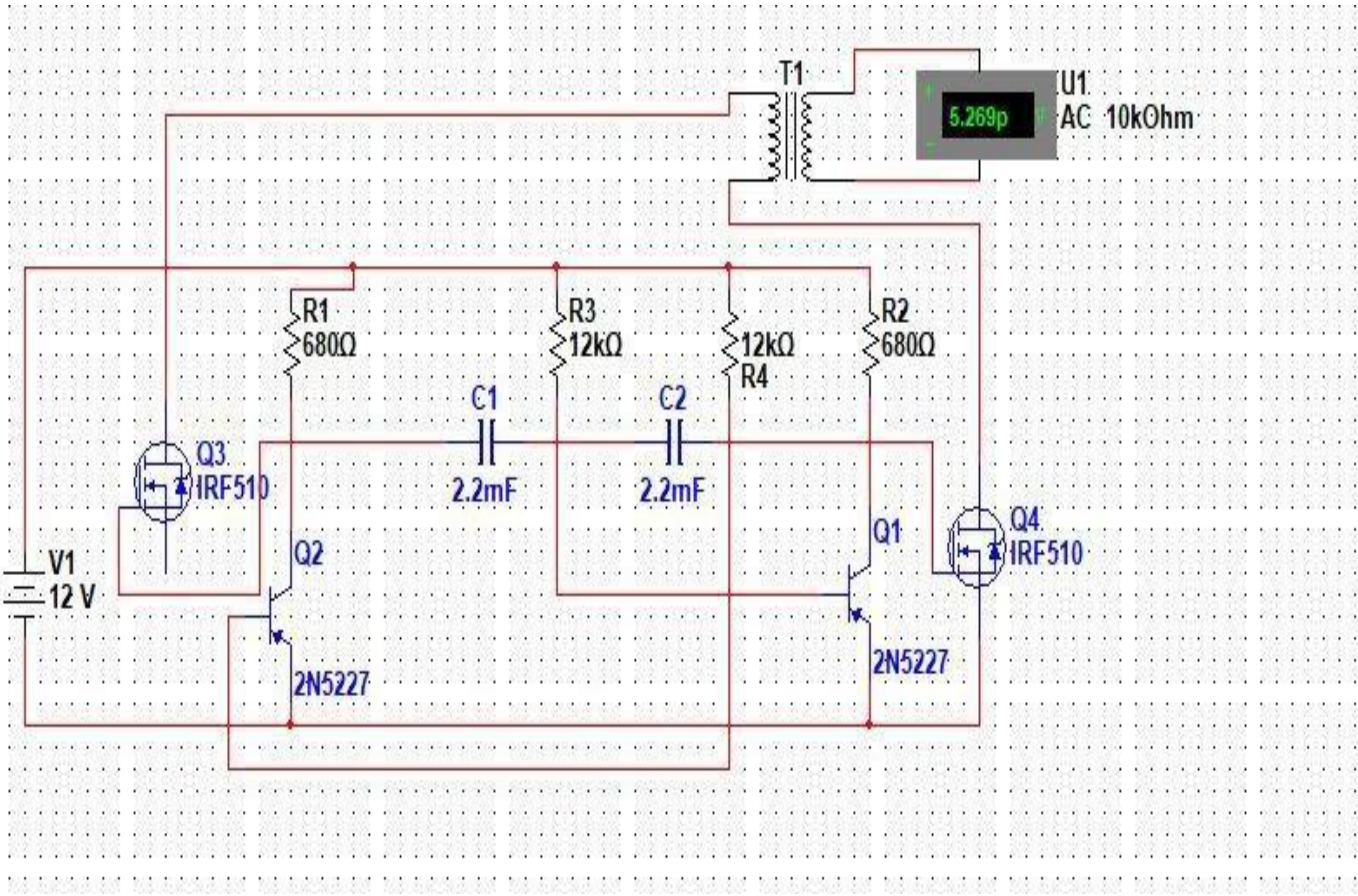


Figure 5: simulated circuit

CHAPTER FIVE:

5.0 INTRODUCTION

Circuit Diagram

This is the circuit diagram of the proposed inverter and snubber circuit are added with transformer and MOSFET switches.

Fig. 2. ***Simulated*** *Circuit Diagram of the inverter using multism*

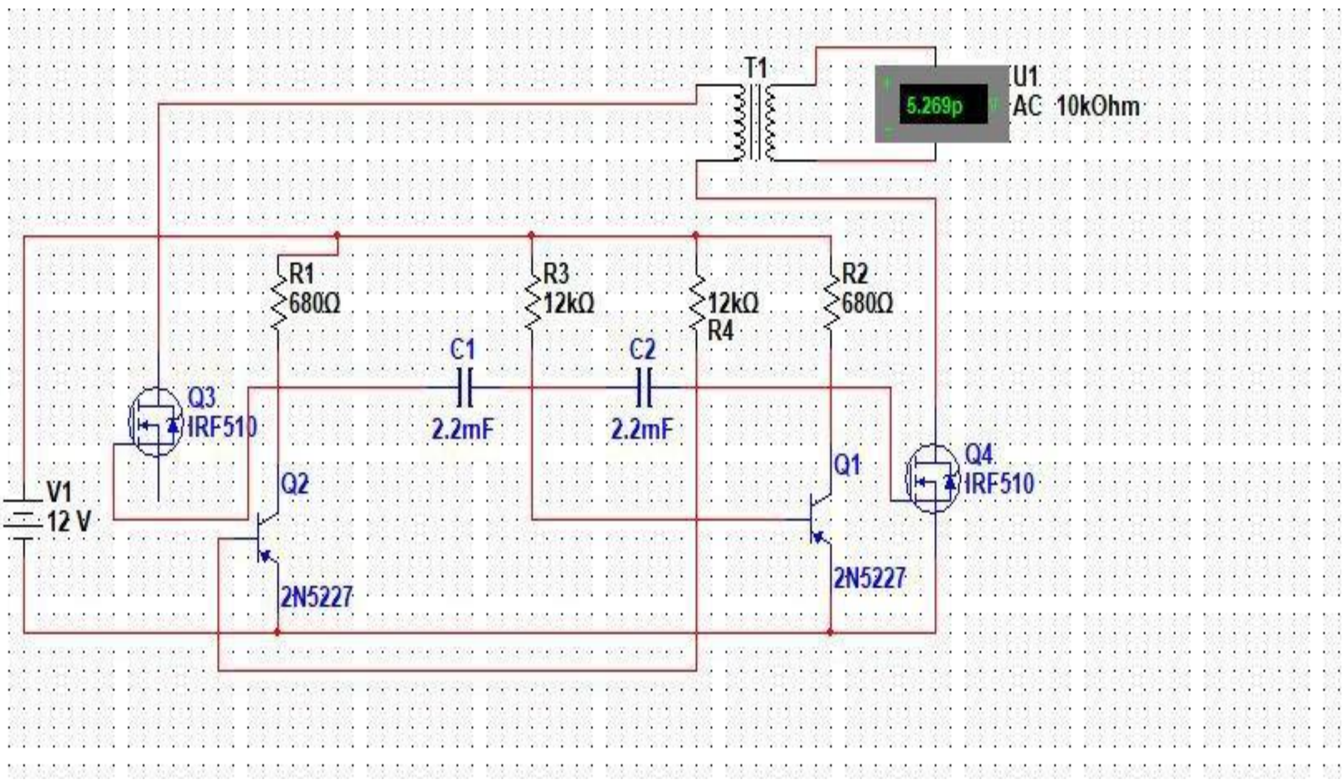


Figure 6: Simulated circuit Diagram of the inverter using multism

5.1 Hardware Design

The hardware for this project can be divided into seven main phases

12 volt DC battery.

Switching Transistor.

7805 for drive the circuit

220 Volt/12 Volt Centre-tapped transformers for implementing Push-Pull Inverter

Table 4: showing the system output

Frequency(f)	50 Hz
Time Period (T)	0.02 Sec
Gate Current (Ig)	0.0183A
Drain Current(Id)	8.34 A

5.2 SYSTEM OUTPUT

We have attained three parameters output

i. Oscillator circuit.

ii. Comparator output

iii. Push-Pull inverter output.

Here the Oscillator generated pulse signal for triggering transistor switches (Figure 5 and Figure 6). Comparator circuit was used to make this pulse more strong for switching the MOSFET switches accurately (Figure 7 and Figure 8).

5.3 Inverter Pure AC Signal

For Oscilloscope X axis= Time period and Y axis=Voltage

Here in X-axis,

Time period =24 unit

Tiny 1 Unit=0.83 ms

Time period =24*0.83ms=19.2ms

Frequency, $f = 1/T$=1/19.2ms≈50 HZ

Here in Y-axis,

Peak Voltage, V=2.25 Unit

Large 1 Unit=100 Volt

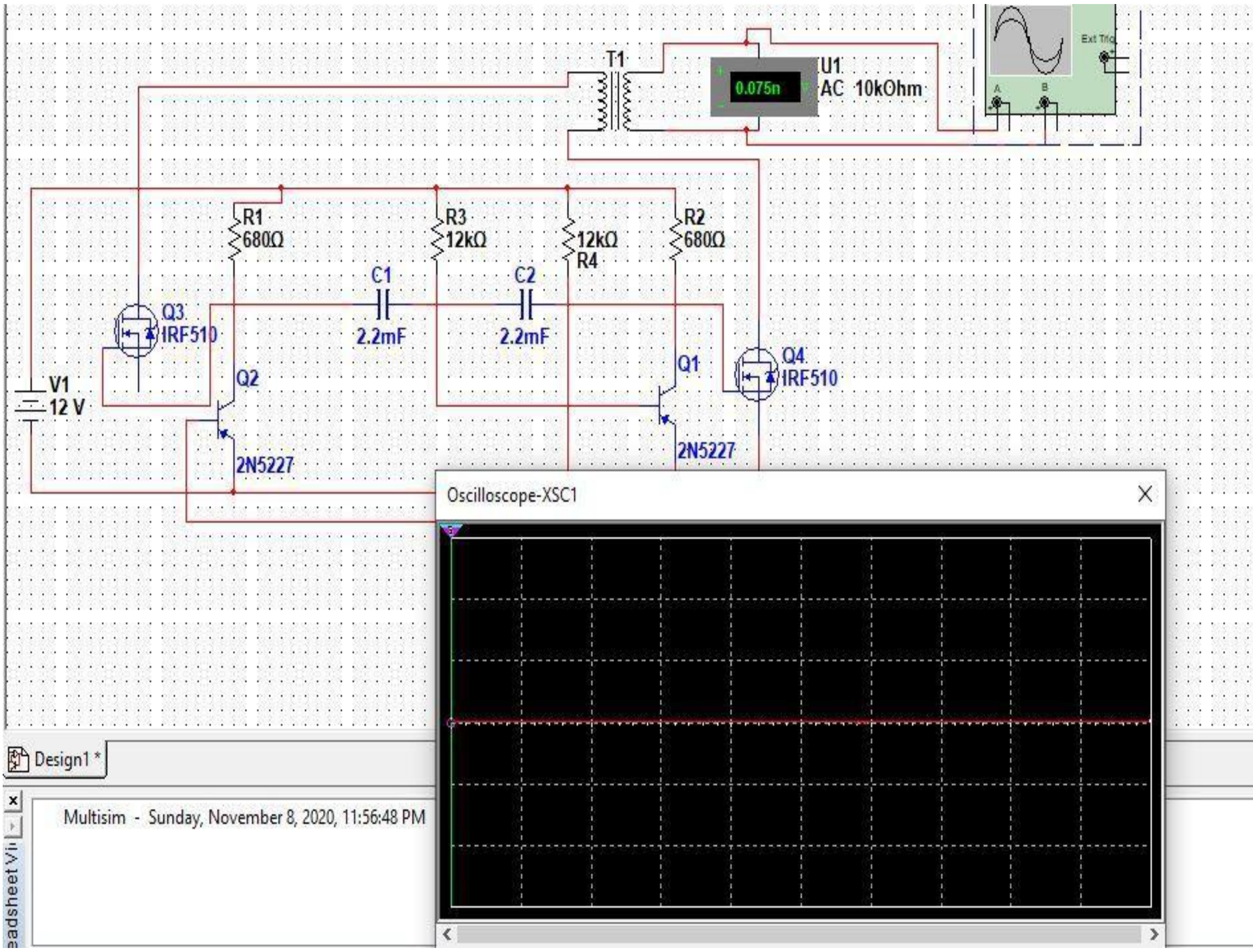


Figure 7: Simulated system

EFFICIENCY

The efficiency of the system was calculated from the input and output power of the inverter for various AC lighting load. For testing purpose we were using 12 V DC Battery as an input source.

COST EFFECTIVENESS

One of the key characteristics of this project is cost effectiveness. Usually the price of available components since it doesn‟t involve micro controllers is low. Uganda being one of the developing countries with the largest population under a living of less than a dollar it can be resourceful to them.

LIMITATION

The system is affected by the draining of batteries at a faster rate and therefore for it to achieve a maximum efficiency it should be placed or incorporated on a system with a stable energy harvesting such as solar tracking panels that ensure continuous flow of energy.

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. I believe to the best of my knowledge that this design has exposed 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 500W inverter system.

PRICE LIST

Table 5: Price list

Equipment	**Quantity**	**Total Amount**
Transformer	**1**	65,000=
DC Battery	**1**	120,000=
MOSFET	**3**	6,000=
LM7805	**1**	6000=
Variable Resistor	**1**	20000=
Resistor	**7**	7000=
Capacitor	**6**	6000=
Casing	**1**	50,000=
Total		280,000=

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APPENDIX

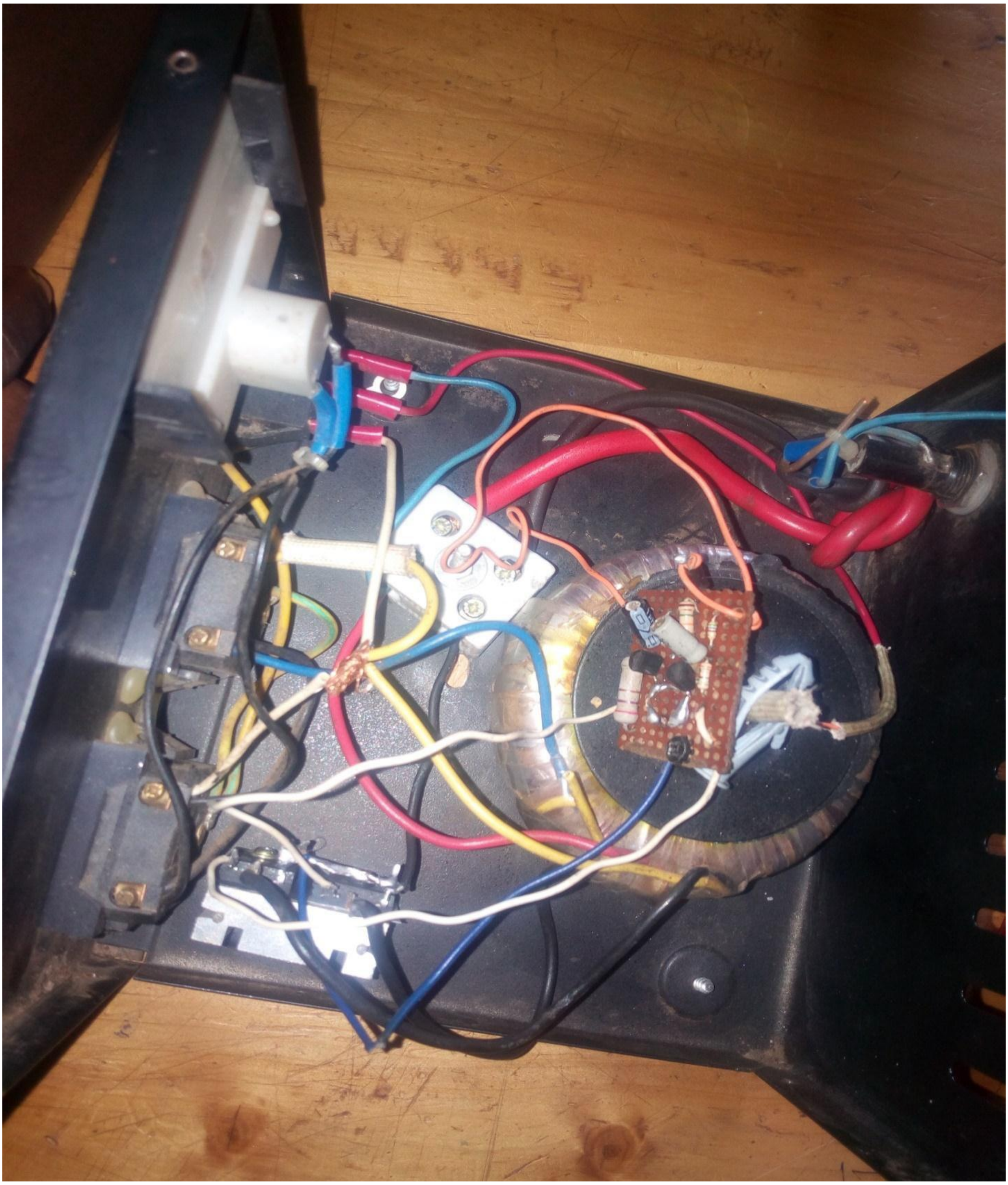

Figure showing the internal components of the inverter. It shows the transformer the oscillator circuit and other accessories.

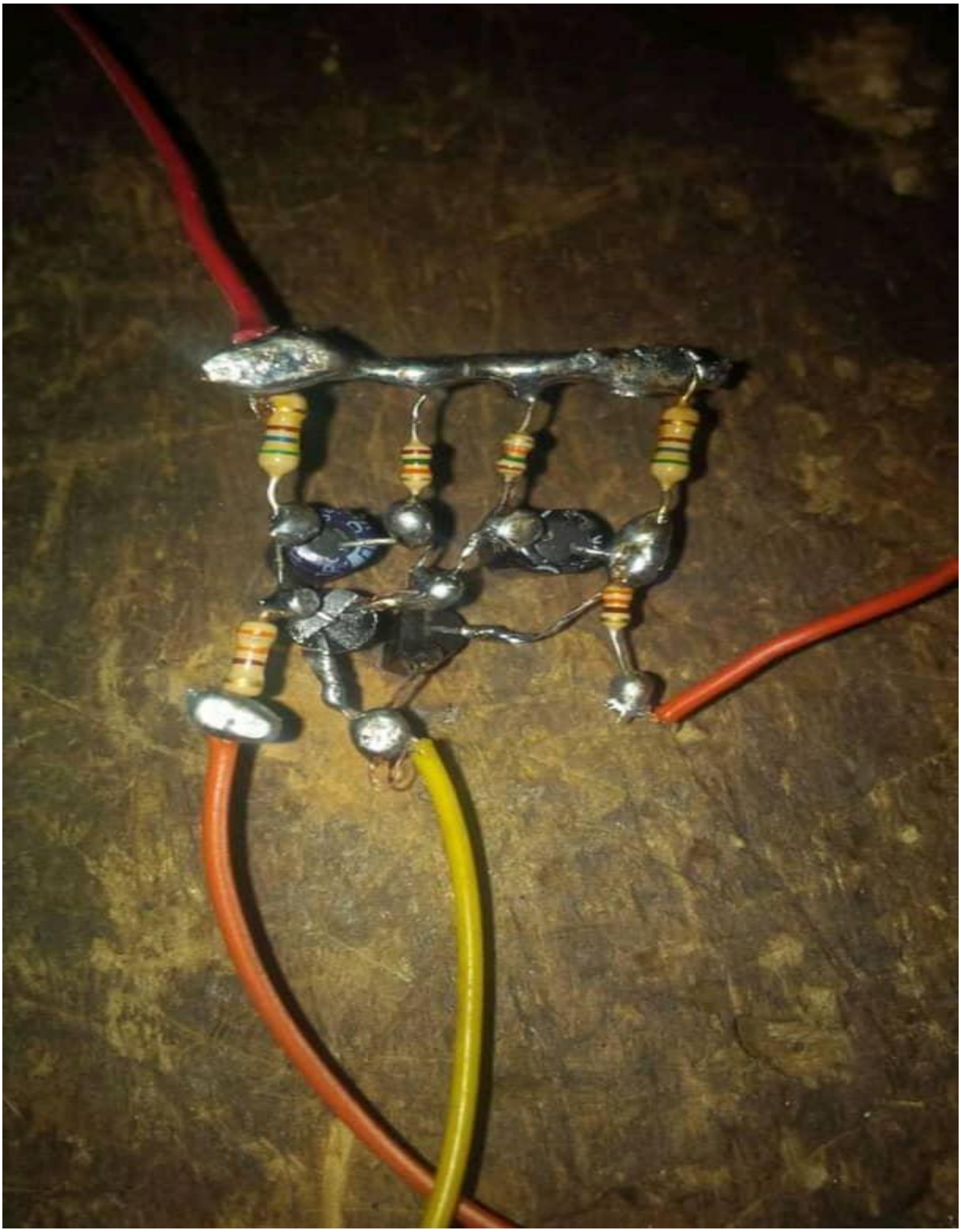

Figure shows the Oscillator circuit