

**DESIGN AND CONSTRUCTION OF A 2.5KVA
INVERTER SYSTEM**

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CERTIFICATION

This is to certify that the project titled “**Design and Construction of a 2.5KVA Inverter System**” was carried out by Aniaka, Samuel Chekwube of the department of Production Engineering, University of Benin, Edo State.

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DEDICATION

This project is dedicated to God almighty and to my lovely family.

ACKNOWLEDGEMENT

My appreciation goes to my supervisor, Prof. Joseph Achebo for his contributions and guidelines.

I also acknowledge the support and contribution of my team members who all made efforts to see that we succeed together.

Finally, I want to appreciate the Head of Department, all the staff and students of Industrial Engineering department.

ABSTRACT

The purpose of this research is to have an affordable and clean energy supply in our household. Inadequate power supply in Nigeria has been a major challenge bedeviling our institutions. Some areas connected to the distribution companies (DISCOs) have what is referred to as a regimented load shedding where power supply may range from 6.00 to 12.00 hrs within 24 hrs. Homes and offices have resolved to sourcing for alternative power supply such as generator plants, solar PVs, inverters, etc.

Thus, the 2.5KVA inverter system was proposed to serve as a backup once there is power outage from the DISCOs. An inverter system enables the conversion of direct current (DC) from batteries to alternating current (AC) needed to run the office appliances at a minimal cost and optimal efficiency. The project focuses on the design and construction of a pure sine wave 2.5KVA 50Hz inverter system to deliver 220V AC using 2 Nos 12V DC batteries (rated 200A) connected in series.

From the results obtained, the battery control shuts down when the battery voltage reaches 20V DC on inverter mode and also stops charging while full at 30V DC, and floats at 27V DC. The inverter was tested with an oscilloscope which produced a 50 Hz sine wave at the output.

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CHAPTER ONE

INTRODUCTION

Over the years, the power supply situation in Nigeria has been a far cry from the anticipated reality. Aside the fact that power is essential for the economic growth of the country, the generated capacity which hovers around 4,000MW is barely adequate for a population of over 180million people. As a means of having sustainable electricity supply, many homes and establishments in Nigeria are sourcing for alternative power supply – solar, diesel/petrol generators, inverters, etc which come at a high running cost.

The concept of inverter has been in existence since late 19th century. Inverter is simply a device which converts a DC supply from a collection of batteries into AC supply required for most electrical appliances. Inverter system is a clean energy source, but usually not cost efficient for maximum demand. Inverter system is an expensive technology and current research is ongoing to develop a lasting battery storage technology at a reduced cost.

In our homes, the inverter system provides an uninterruptible power supply in the event of power outages from the utility companies. The need for backup system became necessary because of sensitivity of some equipment in which prolong outage can have critical consequences. Example is some medical equipment, electrical panels in distribution substation, etc.

BRIEF HISTORY OF INVERTER

An inverter is an electrical/electromechanical device that converts direct current to alternating current. The inverter name stemmed from early mechanical AC to DC converters which were made to work in reverse, thus were “inverted” to convert DC to AC.

From the late 19th century, through the middle of the 20th century, DC to AC power conversion was accomplished using rotary converters or motor-generator sets (M-G sets). The first inverters used motor-generator sets but were inefficient, heavy and expensive.

In the early 20th century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits. The origin of electromechanical inverters explains the source of the term inverter, early AC to DC converters used an induction or synchronous AC motor directly connected to a generator (dynamo) so much that the generator's commutator reversed its connections at exactly the moments to produce DC. A later development is the synchronous converter in which the motor and generator windings are combined into one armature with slip rings at one end and a commutator at the other and only one field frame. The result with either is AC-in, DC-out. With an M-G set, the DC can be considered to be separately generated from the AC; with a synchronous converter, in a certain sense it can be considered to be "mechanically rectified AC". Giving the right auxiliary and control equipment, an M-G set or rotary converter can be run backwards converting DC to AC, hence an inverter is an inverter converter.

Other inverter applications are;

- Fuel cells
- Uninterruptible power supplies
- Induction heaters and electronic ballasts
- Wind turbines and microturbines
- Variable-frequency drives
- HVDC power transmission

STUDY PROBLEM

The erratic power supply has given need to seek for a cost friendly and reliable alternate source of energy. A 2.5KVA inverter system is being constructed to supply energy to an office in production engineering, University of Benin.

AIM AND OBJECTIVE OF THE STUDY

The aim of the research is to design and construct a pure sine wave 2.5KVA inverter system.

The objective of the study includes;

1. To design and construct an inverter system that can power appliances in a typical standard office
2. To produce an inverter from locally sourced materials
3. To provide a noiseless alternative source of power at a lower maintenance cost
4. To drastically reduce the costs associated with running generator set.

RELEVANCE OF PROJECT

In areas with low availability of power supply from the grid, the inverter will be of good use to people in the rural communities. Inverter system is relatively reliable to serve as a standby power supply.

LIMITATIONS OF THE PROJECT

The inverter batteries would still require to be charged via AC outlet before fully functioning. Also, the inverter system may not produce the desired result if overloaded.

The system can be further made to go off-grid by incorporating a solar panel and charge controller.

CHAPTER TWO

LITERATURE REVIEW

An inverter system converts direct current DC to alternating current AC. In a simple inverter circuit, DC power is connected to a transformer through the center tap of the primary winding. A switch is rapidly switched back and forth to allow current flow back to DC source following two alternate paths through one end of the primary winding and then the other. The alternation of the direction of current in the primary winding of the transformer produces alternate current AC in the secondary circuit. Early AC to DC converters combined a synchronous AC motor with a commutator so that the commutator reversed its connections to the AC line exactly twice per cycle. This results in AC-in, DC-out. Based on this, inverting the connections to a converter result in DC-in and AC-out. Hence an inverter is an inverted converter [1].

In more advanced inverter designs various techniques are used to improve the quality of the sine wave at the transformer input, rather than relying on the transformer to smoothen it. Capacitors and inductors can be used to filter the waveform at the primary of the transformer. Also, it is possible to produce a more sinusoidal wave by having split-rail direct current inputs at two voltages or positive inputs with a central ground. By connecting the transformer input terminals in sequence between the positive rail and ground, the positive rail and the negative rail, the ground rail and the negative rail, then both to the ground rail, a stepped sinusoid is generated at the transformer input and the current drain on the direct current supply is less choppy. These methods result in an output that is called a modified sine wave. Modified sine inverters may cause some loads, such as motors, to operate less efficiently [2].

More expensive power inverter uses pulse width modulation (PWM) with a high frequency carrier to more closely approximate a sine function. The quality of an

inverter is described by its pulse-rating. A 3 pulse is a very simple arrangement utilizing only 3 transistors, whereas a more complex 12-pulse system will give an almost sine wave. In remote areas where utility generated power is subject to significant external, distorting influences such as inductive loads or semiconductor-rectifier loads, a 12-pulse inverter may even offer a better output than the utility supplied power grid, and are thus often used in these areas. Simple inverters generate harmonics which affect the quality of power obtained using them [3].

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 drawing power from the batteries and supplying it to the building electrical system. For a business or home office, a reliable power source is invaluable for preventing lost data on computer systems. Most modern inverters also include over-voltage protection, protecting sensitive equipment from dangerous power surges as well [4].

Inverters, besides coming in a wide variety of power capacities, are distinguished primarily by the shape of the alternative current wave they produce. Three major waveforms are square wave, modified sine wave and true sine wave. Square wave inverters are largely obsolete, as the waveform shape is not well suited for running most appliances, and prices have come down considerably for the superior modified sine wave and true sine wave types.

CLASSIFICATION OF INVERTERS

Currently, there are two different types of inverters;

- Modified Square Wave (Modified Sine Wave)
- Pure Sine Wave (True Sine Wave)

These inverters differ in their outputs, providing varying levels of efficiency and distortion that can affect electronic devices in different ways.

MODIFIED SINE WAVE

A modified sine wave is quite similar to a square wave only that there is a “stepping” look to it which relates more in shape to a sine wave. Modified sine wave inverters are cheaper when compared with pure sine wave. However, some drawbacks for modified sine wave is that not all devices work properly on it. Some equipment with circuitry that functions well on smooth oscillation of a pure sine wave (e.g PC power supplies, scientific oscilloscopes) may not function efficiently as expected. In modified sine wave, the peak voltage varies with the battery voltage. This poses as a major disadvantage.

PURE SINE WAVE

A pure sine wave inverter converts a DC supply to an almost perfect true sine wave. Pure sine wave inverter represents the latest inverter technology. Usually sine wave inverters are more expensive than the modified sine wave inverters due to their added circuitry. The pure sine wave is necessary to convert power from a DC source to a useable universal AC supply to power most appliances [5].

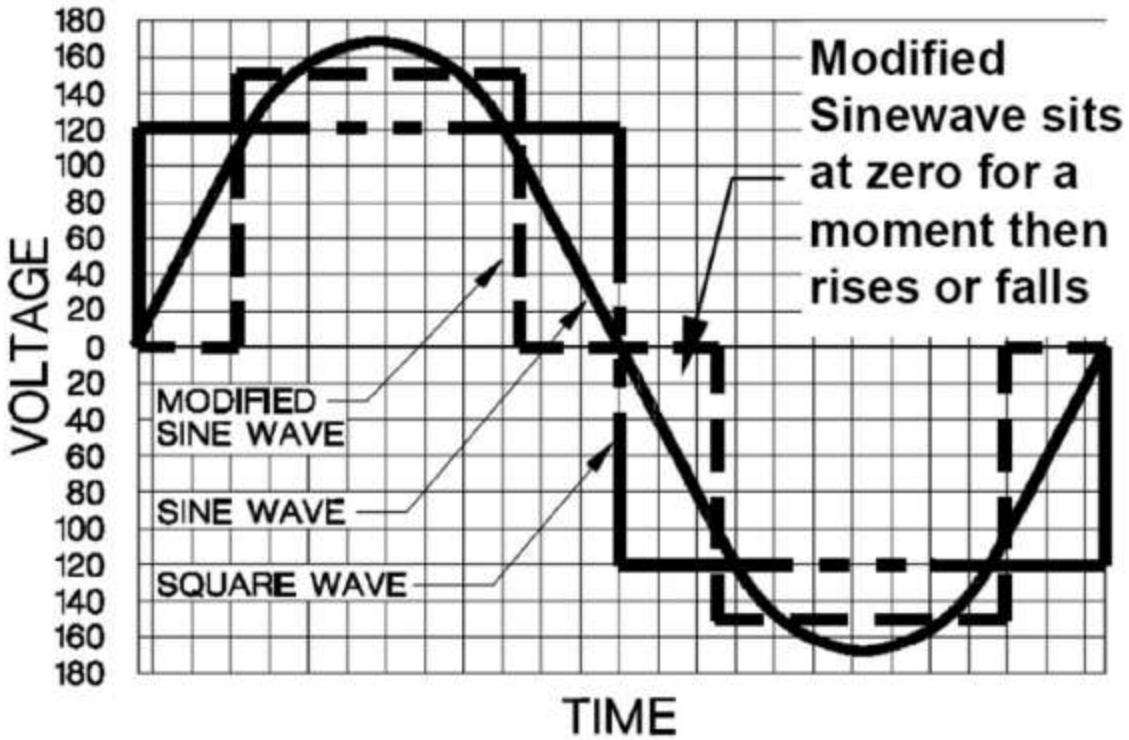


Figure 2.0.1: Square, Modified and Pure Sine Wave

COMPONENTS OF AN INVERTER SYSTEM

- Resistors
- Diodes
- Capacitors
- Transformer
- Transistors
- Voltage regulator
- Integrated circuit
- Octo coupler
- Relay
- Batteries

RESISTORS

Resistors are the most fundamental and popularly used of all the electronic components and they play a vital role within a circuit.

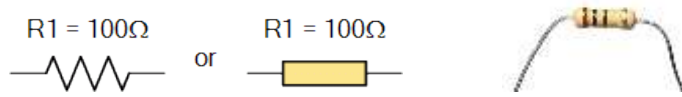


Figure 2.0.2: Symbol of a resistor

There are many different Types of Resistor available to choose from, from very small surface mount chip resistors up to large wire wound power resistors.

The main function of a resistor within an electrical or electronic circuit is to “resist” (hence the name **Resistor**), regulate or to set the flow of electrons (current) through them by using the type of conductive material from which they are composed. Resistors can also be connected together in various series and parallel combinations to form resistor networks which can act as voltage droppers, voltage dividers or current limiters within a circuit.

Resistors are what are called “Passive Devices”, that is they contain no source of power or amplification but only attenuate or reduce the voltage or current signal passing through them. This attenuation results in electrical energy being lost in the form of heat as the resistor resists the flow of electrons through it.

Most types of resistor are linear devices that produce a voltage drop across themselves when an electrical current flow through them because they obey Ohm’s Law, and different values of resistance produces different values of current or voltage. This can be very useful in Electronic circuits by controlling or reducing either the current flow or voltage produced across them we can produce a voltage-to-current and current-to-voltage converter.

In all Electrical and Electronic circuit diagrams and schematics, the most commonly used symbol for a fixed value resistor is that of a “zig-zag” type line with the value of its resistance given in Ohms, Ω . Resistors have fixed resistance values from less than one ohm, ($<1\Omega$) to well over tens of millions of ohms, ($>10M\Omega$) in value.

Fixed resistors have only one single value of resistance, for example 100Ω , but variable resistors (potentiometers) can provide an infinite number of resistance values between zero and their maximum value.

A resistor is a form of impedance in a circuit, which is the same way we have inductors and capacitors as other forms. They all impede or restrict current flows. However, for a resistor, it impedes current flow without changing the phase relationship.

DIODES

A diode is a two-terminal electrical device, that allows the transfer of current in only one direction. The diode is also known for their unidirectional current property, where the electric current is permitted to flow in one direction. Basically, a diode is used for rectifying waveforms, within radio detectors or within power supplies. They can also be used in various electrical and electronic circuits where ‘one-way’ result of the diode is required. Most of the diodes are made from semiconductors like Si (silicon), but sometimes, Ge (germanium) is also used. It is sometimes beneficial to summarize the different types of diodes are existing. Some of the types may overlap, but the various definitions may benefit to narrow the field down and offer an overview of the different diode types.

Different Types of Diodes

There are several types of diodes are available for use in electronics design, namely; a Backward diode, BARITT diode, Gunn Diode, Laser diode, Light emitting diodes,

Photodiode, PIN diode, PN Junction, Schottky diodes, Step recovery diode, Tunnel diode, Varactor diode and a Zener diode [6].

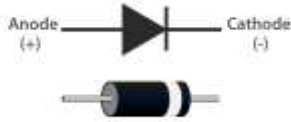


Figure 2.0.3: Symbol of electrical diode

CAPACITORS

Capacitors are simple passive device that can store an electrical charge on their plates when connected to a voltage source

The capacitor is a component which has the ability or “capacity” to store energy in the form of an electrical charge producing a potential difference (*Static Voltage*) across its plates, much like a small rechargeable battery.

There are many different kinds of capacitors available from very small capacitor beads used in resonance circuits to large power factor correction capacitors, but they all do the same thing, they store charge.

In its basic form, a capacitor consists of two or more parallel conductive (metal) plates which are not connected or touching each other, but are electrically separated either by air or by some form of a good insulating material such as waxed paper, mica, ceramic, plastic or some form of a liquid gel as used in electrolytic capacitors. The insulating layer between a capacitors plates is commonly called the **Dielectric**.



Fig 2.0.4: A Typical Capacitor

Due to this insulating layer, DC current cannot flow through the capacitor as it blocks it allowing instead a voltage to be present across the plates in the form of an electrical charge.

The conductive metal plates of a capacitor can be either square, circular or rectangular, or they can be of a cylindrical or spherical shape with the general shape, size and construction of a parallel plate capacitor depending on its application and voltage rating.

When used in a direct current or DC circuit, a capacitor charges up to its supply voltage but blocks the flow of current through it because the dielectric of a capacitor is non-conductive and basically an insulator. However, when a capacitor is connected to an alternating current or AC circuit, the flow of the current appears to pass straight through the capacitor with little or no resistance.

There are two types of electrical charge, positive charge in the form of Protons and negative charge in the form of Electrons. When a DC voltage is placed across a capacitor, the positive (+ve) charge quickly accumulates on one plate while a corresponding and opposite negative (-ve) charge accumulates on the other plate. For every particle of +ve charge that arrives at one plate a charge of the same sign will depart from the -ve plate.

Then the plates remain charge neutral and a potential difference due to this charge is established between the two plates. Once the capacitor reaches its steady state condition an electrical current is unable to flow through the capacitor itself and around the circuit due to the insulating properties of the dielectric used to separate the plates.

The flow of electrons onto the plates is known as the capacitors **Charging Current** which continues to flow until the voltage across both plates (and hence the

capacitor) is equal to the applied voltage V_c . At this point the capacitor is said to be “fully charged” with electrons.

The strength or rate of this charging current is at its maximum value when the plates are fully discharged (initial condition) and slowly reduces in value to zero as the plates charge up to a potential difference across the capacitors plates equal to the source voltage.

The amount of potential difference present across the capacitor depends upon how much charge was deposited onto the plates by the work being done by the source voltage and also by how much capacitance the capacitor has and this is illustrated below.

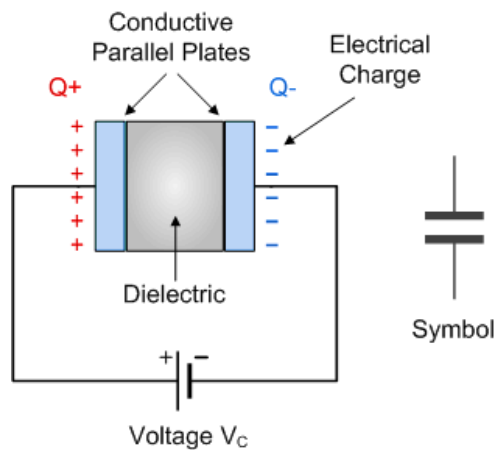


Fig 2.0.5: Capacitance of a capacitor

The parallel plate capacitor is the simplest form of capacitor. It can be constructed using two metal or metallized foil plates at a distance parallel to each other, with its capacitance value in Farads, being fixed by the surface area of the conductive plates and the distance of separation between them. Altering any two of these values alters the value of its capacitance and this forms the basis of operation of the variable capacitors.

Also, because capacitors store the energy of the electrons in the form of an electrical charge on the plates the larger the plates and/or smaller their separation the greater will be the charge that the capacitor holds for any given voltage across its plates. In other words, larger plates, smaller distance, more capacitance.

By applying a voltage to a capacitor and measuring the charge on the plates, the ratio of the charge Q to the voltage V will give the capacitance value of the capacitor and is therefore given as: $C = Q/V$ this equation can also be re-arranged to give the familiar formula for the quantity of charge on the plates as: $Q = C \times V$

Although we have said that the charge is stored on the plates of a capacitor, it is more exact to say that the energy within the charge is stored in an “electrostatic field” between the two plates. When an electric current flow into the capacitor, it charges up, so the electrostatic field becomes much stronger as it stores more energy between the plates.

Likewise, as the current flowing out of the capacitor, discharging it, the potential difference between the two plates decreases and the electrostatic field decreases as the energy moves out of the plates.

The property of a capacitor to store charge on its plates in the form of an electrostatic field is called the **Capacitance** of the capacitor. Not only that, but capacitance is also the property of a capacitor which resists the change of voltage across it [7].

TRANSFORMER

Transformers transfer electrical energy from one circuit to another without changing the frequency but with a change of voltage and current, they protect secondary circuits and people from electrical shocks because of energized conductors and earth grounding.

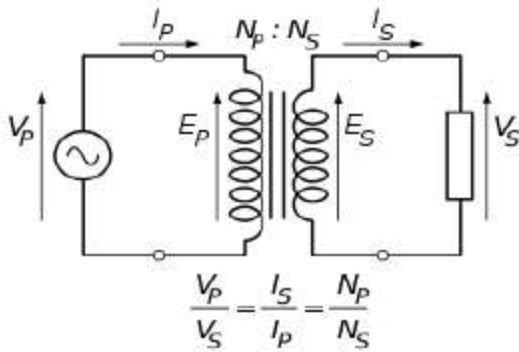


Fig 2.0.6: A Transformer

A transformer consists of an input connection, an output connection, windings or coils and the core. When the input voltage is applied to the primary winding, AC flows in the primary winding direction and a changing magnetic field is set up in the core. As this magnetic field cuts across the secondary winding, alternating voltage is produced in the secondary winding. The ratio between the output voltage and the input voltage is the same as the ratio of the number of turns between the two windings. There are different configurations for both single-phase and three-phase systems. The ratio between the number of actual turns of the wire in each coil determines the output voltage and hence the type of transformer. Mentioned below are the two types of transformers available in the industry.

- Step up transformer: This transformer's output voltage is greater than the input voltage, if the secondary winding has more turns of the wire than the primary winding, leading to the stepping up of the output voltage.
- *Step down transformer*: Here the secondary winding has fewer turns than the primary winding and the output voltage is lower.

The latest technology and quality control measures will ensure compliance and flawless operation. Some key features of a good transformer include:

- Air flows between coils, from layer to layer, and between the coils and the core so that heat escapes quickly and the temperature drops
- Being compact and lightweight
- Moisture-proof and mildew-proof
- Insulation Class F or H
- Lower noise

With no distinction with regard to shape or size, a transformer converts electrical power from one type to another. Some of the major types of transformers used in UPS systems and inverters are listed below.

- *Inverter transformers or electronic transformers:* These are commonly used for small power conversion or to get the desired voltage. The power transformers usually seen in substations are similar to this variety but are used for converting large amounts of power. It can be said that all inverter transformers are power transformers but not all power transformers are inverter transformers.
- *Inverter duty transformers:* These are mainly used in solar applications and operate at the fundamental frequency of an alternating system. They are designed for one or more output windings connected to the inverter's load. Owing to multiple outputs, multiple inverters paralleled to photovoltaic arrays are connected to these transformers and reduce the project cost without compromising on the transformer's functions. Generally, with the three-and five-windings construction to address the harmonics, they can also be customised to suit the voltage, power, low losses, sound level and operating

conditions, environmental impact and safety issues. Other features include galvanic isolation between the solar inverter and the feeding network.

- *Instrument transformers:* Also known as accurate ratio transformers, these are used along with standard low range measuring devices to measure high values of current or voltage. As the name suggests, they transform at an accurate ratio to allow an attached device to gauge the current or voltage without actually running full power through the instrument. While the ‘current type’ of an instrument transformer measures current in AC voltages, the ‘potential type’ measures voltage in AC.
- *Isolation transformers:* These types of transformers isolate the power source from the powered devices, thereby providing safety to appliances as well as their users. Being capable of reducing noise and power surges, they are ideal for appliances that require a high-quality power supply for efficient operation. The primary purpose of these transformers is to isolate the circuits as opposed to the more common transformer function of voltage conversion. UPS systems with such transformers are found to be more robust, flexible, and have better fault management. Hence, there is a growing demand for these transformers in UPS systems.

Bipolar Transistor

The Bipolar Junction Transistor is a semiconductor device which can be used for switching or amplification. In the diode tutorials we saw that simple diodes are made up from two pieces of semiconductor material to form a simple pn-junction and we also learnt about their properties and characteristics. If we now join together two individual signal diodes back-to-back, this will give us two PN-junctions connected together in series that share a common **P** or **N** terminal. The fusion of these two

diodes produces a three-layer, two junction, three terminal devices forming the basis of a **Bipolar Junction Transistor**, or **BJT** for short.

Transistors are three terminal active devices made from different semiconductor materials that can act as either an insulator or a conductor by the application of a small signal voltage. The transistor's ability to change between these two states enables it to have two basic functions: "switching" (digital electronics) or "amplification" (analogue electronics). Then bipolar transistors have the ability to operate within three different regions:

- Active Region – the transistor operates as an amplifier and $I_c = \beta \cdot I_b$
- Saturation – the transistor is "Fully-ON" operating as a switch and $I_c = I(\text{saturation})$
- Cut-off – the transistor is "Fully-OFF" operating as a switch and $I_c = 0$

The **Bipolar Transistor** basic construction consists of two PN-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are known and labelled as the Emitter (E), the Base (B) and the Collector (C) respectively. Bipolar Transistors are current regulating devices that control the amount of current flowing through them from the Emitter to the Collector terminals in proportion to the amount of biasing voltage applied to their base terminal, thus acting like a current-controlled switch. As a small current flowing into the base terminal controls a much larger collector current forming the basis of transistor action. The principle of operation of the two transistor types PNP and NPN, is exactly the same the only difference being in their biasing and the polarity of the power supply for each type.

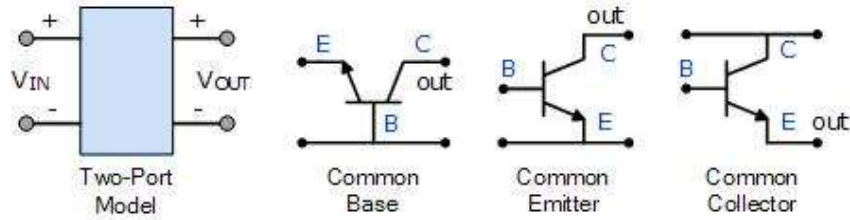


Fig 2.0.7: Bipolar Transistor Configurations

METAL OXIDE SEMI-CONDUCTOR FIELD EFFECT TRANSISTOR

The MOSFET is a class of FET transistors. The FET as the name implies conduction in a channel is controlled to the gate electrode. There are no forward-biased junctions, so the gate draws no current. The MOSFET is an important semiconductor device and is widely used in many circuit applications. In an inverter however, the MOSFETs are used as switching device at the inverter output section.

The various terminal of MOSFET are;

- a. Source: This is terminal which majority carrier enter the bar. Since carrier come from it, it is called the source.
- b. Drain: This is terminal through which majority carrier leave the bar i.e. they are drained out from this terminal. The drain to source voltage V_{DS} drives the drain current I_D .
- c. Gate: These are two internally connected heavily doped impurity regions, which form two P-N junctions. The gate - source voltage V_{GS} reverse biases the gates.
- d. Channel: This is the space between to gates through which majority carrier pass from source to drain when V_D is applied.

To understand the working principle of the MOSFET, we need to know about the different type of MOSFET.

DEPLETION-ENHANCEMENT MOSFET (DE-MOSFET)

The MOSFET is so called because it can operate in both depletion and enhancement mode by changing the polarity of V_{GS} . When negative gate to source voltage is applied, the N-channel DE-MOSFET operates in the depletion mode. However, with positive gate to source voltage applied, it operates in the enhancement mode. In other words, channel exists between the drain and source, hence I_D flows even when gate to source voltage $V_{GS} = 0$.

ENHANCEMENT ONLY MOSFET (E-MOSFET)

This MOSFET operates only in the enhancement mode and has no depletion mode. It works with large positive gate voltages only. It differs on construction from the DE-MOSFET because there exists no channel between the drain and source. Hence, it does not conduct when $V_{GS} = 0$. Hence, drain current I_D flows only when exceeds V_{DS} [8].

VOLTAGE REGULATORS

A voltage regulator has only three legs and appears to be a comparatively simple device, but it is actually a very complex integrated circuit. A regulator converts varying input voltage and produces a constant regulated output voltage. Voltage regulators are available in a variety of outputs, basically 5 volts, 9 volts and 12 volts. The last two digits in the name indicate the output voltage. The „LMxxx“ series of voltage regulator are designed for positive input. For applications requiring negative input, the “LM317” series is used.

14V TO 5V VOLTAGE REGULATOR

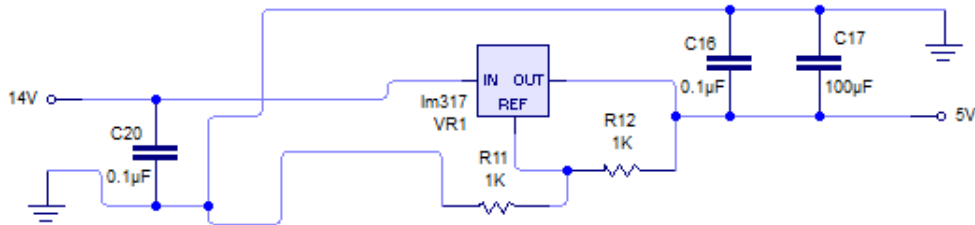


Fig 2.0.8: showing symbol for a voltage regulator

This part of the power rail is a voltage regulator circuit. and this is controlled by the IC LM317. r11 and r12 are the only external components needed to set the output voltage at the reference pin. The operating voltage of this IC is 4volt to 40volt and the current handling capacity is 1,5amp. c20 and c16 are dicoupling capacitors for spike rejection, while c17 is to smoothen the output voltage. The output voltage from this circuit shall be used to power the DSP IC micro controller, LCD display screen and the optocouplers. Voltage regulators are very robust. They can withstand over-current draw due to short circuits. In both cases, the regulator will shut down before damage occurs. The only way to destroy a regulator is to apply reverse voltage to its input. This reversal of polarity can destroy the regulator almost instantly. To avoid this possibility, diode protection of the power supply is used.

Generally, the input voltage should be limited to 2 to 3 volts above the output voltage. The LM317 series can handle up to 30 volts input, but the power different between the input voltage/current ratio and output voltage/current ratio appears as heat. If the input voltage is unnecessarily high, the regulator will get very hot. Unless sufficient heat sinking is provided, the regulator will shut down. The LM317regulator is used for this project.

INTEGRATED CIRCUIT (IC)

An integrated circuit as the name implies is a complete electronic circuit in which both active and passive components are fabricated on extremely single chip of silicon. Active components are those components which have the ability to produce gain e.g. transistors, while passive components are those components which do not have the ability to produce gain e.g. resistors, capacitor and inductors.

Therefore, the integrated circuit is a discrete circuit which is built by connecting several components together. The integrated circuit is preferred in electrical/electronic circuits because it does the work of the entire components that are composed on it, and is handier and less bulky than using the components in it. In this project, the IC used is UC3843 IC.

FUNCTION OF UC3843 IC

This integrated circuit contains all the control circuitry for a regulating power supply inverter. Included in the 8-pin dual-in-line package is the voltage reference, error amplifier, oscillator, pulse width modulator, pulse steering flip-flop, dual alternating output switches and current limiting and shut down circuitry. This IC is a very common IC in MOSFET based inverter device [9].

DC TO DC switchmode power supply.... 12v to 14v

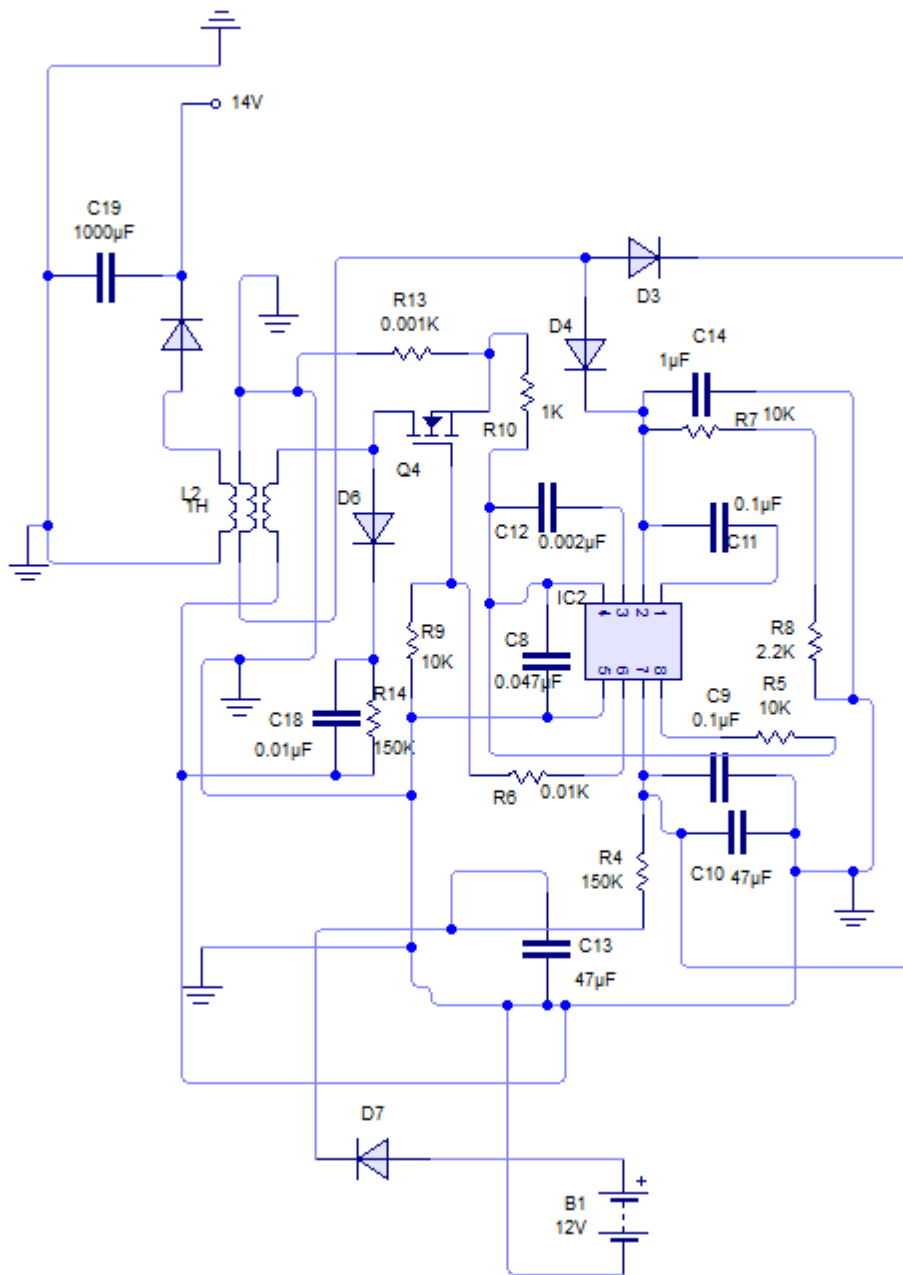


Fig 2.0.9: showing pin configuration of UC3843

we shall be converting from 12v to 14 volt as result of the high voltage needed to switch the high side mosfet which is the positive side.

we used the ic uc3843 for the controlle of this section. it generatse the 50khz frequency needed to switch the ferrite transformer and also stabilises the output voltage.

1, pin1 is the inverting feed-back used to stabilise the output voltage of the ferrite transformer

2, pin2 is the non-inverting feed-back used to stabilise the output voltage of the ferrite transformer

3, pin3 is for over surge and ramp start

4, pin4 is where the frequency is set

5, pin5 is ground connection

6, pin6 is the out driver

7, pin7 is the vcc supply input

8, pin8 is the reference output

typically, ground is connected to pin5 while 9 to 30 volt is connected to pin7 vcc through resistor r4 from the battery positive.

d7 is the protection diode to the circuit, it prevents wrong polarity damages

the frequency is set by c8 and r5 with the formular $f=1.8/rc$.

c13 is to smoothen the input from battery by low pass filter formed by d7 and c13

c10 is to smoothen the input to pin7

c11, c12, and c18 are decoupling capacitor for noise rejection to the following inputs

q4 is the mosfet that switches the transformer, the drain is connected to coil, source is connected to ground while the gate is connected to pin6 through r6

r9 is used to ground the mosfet gate to prevent it from floating signals which can damage the mosfet.

l2 is the ferrite off-line transformer, it has three separate coil in it. the first coil by the left is the coil that exite the transformer at 40khz for a period of 500us. when this happens, the mosfet switch is turned off for another 500us and the magnetic flux will generate voltage at the other two coils. the centre coil is connected to pin7 through d3 to boost switching current, while the third coil is the main output coil, it is fed back to the non-inverting input pin2 for a stable output.

lastly, a fast switching diode is connected to the output and c19 to smoothen the output through the low pass formed.

LM317

The LM317 device is an adjustable three terminal positive voltage regulator capable supply more that 15A over an output voltage range of 1.25v to 37v, it requires only two external resistors to set the output voltage. The device features a typical line regulation of 0.01% and typical load regulation of 0.1%. The terminal 1 is to the ground, terminal 2 and 3 are input and output respectively.

OCTOCOUPLER

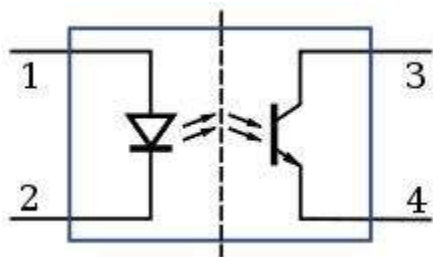


Fig 2.1.0: Schematic diagram of an opto-isolator showing source of light (LED) on the left, dielectric barrier in the center, and sensor (phototransistor) on the right.

An **opto-isolator** (also called an **optocoupler**, **photocoupler**, or **optical isolator**) is an electronic component that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal. Commercially available optoisolators withstand input-to-output voltages up to 10 kV and voltage transients with speeds up to 25 kV/ μ s.

OPERATION

A common type of opto-isolator consists of an LED and a phototransistor in the same opaque package. Other types of source-sensor combinations include LED-photodiode, LED-LASCR, and lampphotoresistor pairs. Usually opto-isolators transfer digital (on-off) signals, but some techniques allow them to be used with analog signals. An opto-isolator contains a source (emitter) of light, almost always a near infrared light-emitting diode (LED), that converts electrical input signal into light, a closed optical channel (also called dielectrical channel), and a photosensor, which detects incoming light and either generates electric energy directly, or modulates electric current flowing from an external power supply.

The sensor can be a photoresistor, a photodiode, a phototransistor, a silicon-controlled rectifier (SCR) or a triac. Since LEDs can sense light in addition to emitting it, construction of symmetrical, bidirectional opto-isolators is possible. An optocoupled solid-state relay contains a photodiode opto-isolator which drives a power switch, usually a complementary pair of MOSFETs. A slotted optical switch contains a source of light and a sensor, but its optical channel is open, allowing modulation of light by external objects obstructing the path of light or reflecting light into the sensor [10].

RELAY

An electromagnetic relay is basically a switch operated by a magnetic force. This magnetic force is generated by flow of current through a coil in the relay. Current

flowing through the coil of the relay creates a magnetic field which attracts a level and changes the switch contacts. The coil current can be on or off, so relays have two switch positions and must have double throw (changeover) switch contacts.

A relay basically consists of four parts:

- a. An electromagnetic made of a coil and a magnetic circuit
- b. A movable armature
- c. A set of contacts
- d. A frame to mount all these components.

A relay contains a coil which surrounds a core. The assembly of the core and coil is mounted on a metal frame. An armature attached to a return spring is located on top of this core/coil assembly. The return spring keeps the armature downward. Hence due to the downward pull of the armature, it touches a terminal known as the top contacts. When current flows through the relay coil, the coil is energized and when the force of attraction of electromagnet generated in the coil is sufficient to overcome the opposition of the tension of the return spring, the armature and the contact arm is pulled downwards, hence the contact arm touches another terminal known as bottom contact. Hence, the circuit being driven by the relay becomes complete and current starts to flow from the pole to the bottom contact and into the circuit. When the relay circuit is de-energized by switching off the switch and cutting supply to the relay, the electromagnet will lose its magnetism. The return spring will pull the armature once again back to the top contact position; hence, the circuit is open.

BATTERY

The battery serves the dc source on which the inverter depends for its power to supply when the mains supply fails. Proper working of inverter depends on the condition and capability of the battery being used. There are many types of battery

that an inverter can be run with but the most durable is the Nickel cadmium which last up to ten years. This battery can provide very consistent performance and is mainly used in nuclear science applications. The battery used with inverter is determined by its voltage rating and capacity, defined in an ampere-hour [AH].

CHAPTER THREE

DESIGN OF 2.5 KVA INVERTER

Introduction

This chapter explains the design and calculation of the various stages of the 2.4KVA inverter, using assumed values and manufactured data sheet to obtain the components values needed for the design of the circuit. The design is divided into several units, each of the units is design separately and then combined to form the whole inverter design [11].

Design Specifications

This circuit design incorporates several major circuits, but these circuits have a collective specification, which are:

1. Power Rating = 2.4KVA
2. Frequency = 50HZ
3. Number of phase = Single
4. Battery input voltage =24V DC
5. Mains supply voltage =220V AC
6. Inverter output voltage = 220V AC

Specifications of the Selected Transformer

In transformer design, the transformer is design in accordance to the specification given or required of the transformer to be used in this design.

1. Power rating = 2.4KVA
2. Frequency = 50HZ
3. No. of phase = Single
4. Design type = Shell type
5. Primary voltage = 36V AC

6. Secondary voltage = 220V AC

7. Cooling medium = Natural air

Transfer Design

3.3.1 Core Design

Voltage per Turn (E_t)

$$E_t = K \sqrt{S} \text{ (KVA)} \quad 3.1$$

Where S = Output KVA

Choosing $K = 1.0$ for shell type single phase

Required output $S = 2.4$ KVA $E = 1.0/2.4$

$$E_t = 1.58 \text{ V/turn}$$

Net Core Area

Knowing that the EMF equation of a transformer for an induced voltage per unit turn of the transformer winding is

$$E_t = 4.44 f B_m A_i \text{ volt} \quad 3.2$$

B_m = the magnetic flux density

A_i = cross sectional area (C.S.A) core limb

For a 50HZ, power transformer the magnetic density ranges from (1,1-1,4) web/m², since ferrite cores are known for their higher resistivity, giving rise to, higher frequency materials hence low eddy current loss.

So for the design let, $B_m = 1.4$ web/m²

$$\begin{aligned} \text{Thus, } A &= E / 4.44 f B_m \text{ from equation (3.2)} \\ A_1 &= 1.58 / 4.44 \times 50 \times 10^6 \\ &= 5083.65 \text{ mm}^2 \end{aligned}$$

Magnetic Flux (ϕ_m)

$$\phi_m = B_m A_i \quad 3.3$$

$$\phi_m = 1.4 \times 5083 \times 10^{-6}$$

$$= 7.117 \times 10^{-3} \text{ web}$$

Window Space Factor (K_w)

$$K_w = 0.1 + 0.07 \log_{10} \left[\frac{KVA}{0.1} \right] - 0.2 \log_{10} KV \quad 3.4$$

$$= 0.1 + 0.07 \log_{10} (2.5/0.1) - 0.2 \log_{10} (22 \times 10^{-3})$$

$$= 0.3294$$

Core Window Area (A)

For a single phase transformer, the power equation is

$$S = 2.22 F B_m A_i A_w K_w J \times 10^{-3} \text{ (KVA)} \quad 3.5$$

Where, J = current density of winding.

The current density depends on the power loss distribution per unit area of the coil surface in contact with the cooling medium. The range of the radiator is (2.0-3.2) A/mm².

$$\text{Let } J = 3.0 \text{ A/mm}^2$$

$$A = S / (2.22 F B_m A_i K_w J \times 10^{-3}) \text{ from equation (3.5)} \quad 3.6$$

For current density $J = 3.0 \text{ A/mm}^2$

$$A_w = 2.5 / (2.22 \times 50 \times 1.4 \times (5083.65 \times 10^{-6}) \times 0.3294 \times 3 \times 10^{-3})$$

$$= 320.35 \text{ mm}^2$$

Window Area = Window Length x Window Height

$$A_w = L \times H$$

Where $L = 3W$ = Window length

$$H = W$$

$$A = (3w) \times (W)$$

$$A = 3W^2$$

$$W = \sqrt{A_w / 3}$$

$$= \sqrt{(3202.35/3)}$$

$$W = 32.67\text{mm} = 33\text{mm}$$

Then, L is defined as:

$$L = 3W$$

$$\therefore L = 3 \times 33 = 99\text{mm}$$

To get the center limb, we must know that the cross sectional area A is related to gross cross sectional area, A_g .

$$A_i K_s \times A_g \tag{3.7}$$

K_s = Slack factor ($K_s = 0.9$)

$$A_g A_i / K_s$$

$$= 5083.65/09$$

$$= 5648.5\text{mm}^2$$

A_g = Stack height x width of central limb

For a shell type transformer the centre limb width is twice the outer limb width.

Where the out limb width (W) is 103mm, as calculated above.

Centre limb width (W_c) = 2 x Outer limb width

$$W_c = 2 \times 33 = 66\text{mm}.$$

Stack height 86mm.

With the information gotten so far, the fig. 3.1 below shows the dimensions of a single lamination core design.

Thus the transformer chosen for the design is shown below:

No. of stacked lamination, $n = \text{stack height/lamination thickness}$ 3.8

For thickness of 0.5mm,

$$n = 86/0.5 = 54$$

$n = 172$ laminations.

Number of Turns

Recall that $V = V/N$ (volt per turn) 3.9

The primary Turns $N_1 = V_1/V_t = 36/1.58$

$$= 22.8 = 23 \text{ turns.}$$

The secondary Turns $N_2 = V_2/V_t = 220/1.58$

$$= 139 \text{ turns.}$$

Since the winding of the transformer to be used in the design is a centre tapped primary side, then the total number of turns in the primary side will be

$$N_1 = 2 \times 23 \text{ turns}$$

$$N_1 = 46 \text{ turns}$$

Winding Design

To calculate for the winding the current carried by the various winding must be defined first.

Primary winding current, $I_p = \text{KVA rating Primary (input) voltage}$ 3.10

$$I_p = 2500/36 = 69.44 \text{ A}$$

Secondary current, $I_s = \text{KVA rating Secondary (output) voltage}$ 3.11

$$I_s = 2500/220 = 11.36 \text{ A}$$

Conductor Size

To get the winding size, we must define the current density of the copper conductor used for the winding of this transformer.

Let the Current density, $J = 3\text{A/mm}^2$

$$\text{Cross sectional area of conductor } A = \frac{I}{J} \quad 3.12$$

For a primary winding current of 69.44A

$$A = 69.44/3 = 23.15\text{mm}^2$$

$$\text{Recall, } A = \frac{\pi d^2}{4} \quad 3.13$$

$$d_1 = \sqrt{\frac{4 \times A}{\pi}}$$

$$d_1 = \sqrt{\frac{4 \times 23.15}{3.142}} \\ = 5.43\text{mm}$$

For the secondary windings current of 11.36A

$$A = 11.36/3 = 3.79\text{mm}^2$$

$$d_2 = \sqrt{\frac{4 \times 3.79}{3.142}} = 2.19\text{mm}$$

Total Number of Turns (NT).

$$N_T = \text{maximum voltage/voltage per turn} \quad 3.14$$

- Primary turns = 46 turns
- Secondary turns = 139 turns

Total = 185 turns

Winding Height

The height occupied by the winding coils is appropriately defined by

$$H_w = (L) - 5\% (L) \quad 3.15 \\ = 95\% (L)$$

Where L = window length

$$= 0.95L = 0.95 \times 99$$

$$= 94.05\text{mm}$$

Turns Per Layer

$$\text{Turns per layer} = \text{Winding Height/Diameter of conductor} \quad 3.16$$

For the primary side:

$$\text{Turns per layer} = 94.05/5.43$$

$$= 17.3217 \text{ turns per layer}$$

For the secondary side:

$$\text{Turn per layer} = 94.05/219$$

$$= 45.95 = 43 \text{ turns per layer}$$

Number of Layers

$$\text{Total number of layers} = \text{No, of turns/turns per layer} \quad 3.17$$

For the primary side:

$$\text{No. of Layers} = 46/17$$

$$= 2.713 \text{ layer for primary}$$

For the secondary side:

$$\text{No. of layer} = 139/43$$

$$= 3.23 \text{ 3 layer of secondary}$$

Mean Length of Turn (MLT)

$$\text{MLT} = 2(\text{width of central limb } [W_c] \text{ stack height} + \text{window width } (W_w)) \quad 3.18$$

$$3.18$$

$$= 2(66 + 86 + 33)$$

$$\text{MLT} = 370\text{mm}$$

Total Winding Length (T_L)

$$T_L = \text{MLT} \times \text{Total NO. of Turns} \quad 3.19$$

For primary side, TPL 370 x 46 = 17020mm

For secondary side, Ts L = 370 x 139 = 51430mm

Total length of conductor used is

$$T_L = 17020 + 51430 = 68450\text{mm}$$

Total Mass of Copper Conductor Used

The mass of copper used can be defined if the volume of copper is known. This relationship between mass and volume is mathematically defined as:

$$\text{Mass of copper} = \text{Density of copper} \times \text{volume of copper} \quad 3.20$$

The density of Copper is taken to be, 9 x 10³kg/cm³

To get the volume of copper

$$\text{Volume of copper} = T_L \times \text{Cross sectional Area} \quad 3.21$$

Volume of Primary winding (V_p)

$$\begin{aligned} V_p &= 17020\text{mm} \times 23.15\text{mm}^2 \\ &= 1702.0\text{cm} \times (23.15 \times 10^{-2})\text{cm}^2 \\ &= 394.013\text{cm}^3 \end{aligned}$$

Volume of Secondary winding (V_s)

$$\begin{aligned} V_s &= 51430\text{mm} \times 319\text{mm}^2 \\ &= 5143.0\text{cm} \times (3.7 \times 10^2) \text{cm}^2 \\ &= 194.92 \text{cm}^3 \end{aligned}$$

Total volume of copper conductor (V_T)

$$V_T = 394.013 + 194.92 = 588.93 \text{cm}^3$$

Therefore,

$$\text{Mass of copper} = (9 \times 10) \times 588.93$$

$$\text{Mass of copper} = 5.3\text{kg}$$

Choice of Pulse Width Modulator

The pulse width modulator stage is designed using a dedicated PWMIC, SG3524. This versatile PWM controller can be used in a variety of isolated and non-isolated switching power supplies such as inverters.

From the data sheet that propelled the usage of this device; the oscillating frequency is programmed by R1, R2 and C1 using the formula below:

$$F = \frac{1.15}{2R_T C_T} \quad 3.22$$

The frequency of Oscillation (F), of the output power of the inverter is 50HZ.

Choosing CT $0.2\mu\text{F}$

$$R_T = \frac{1.15}{2FC}$$
$$= \frac{1.15}{2 \times 50 \times 0.2 \times 10^{-6}} = 57500 \Omega = 57.5\text{K} \Omega$$

- Battery voltage is 24V dc.
- A fixed value of $56\text{K} \Omega$ and a variable resistor, which is adjusted to $20\text{K} \Omega$, was used in the design.
- Vin for the PWMIC is taken from the battery source.
- The chip is powered with 12 volts through a 7812 voltage regulator.
- Pin 16 is connected to an internal 5V regulator and it was used to set the voltage reference of 2.5V for the pulse-width control through voltage divider resistors to pin 1. From voltage divider theory, both resistors value are equal and recommended value for R1 and R2 resistor according to datasheet is $5\text{k}\Omega$ but $4.7\text{k}\Omega$ was used as the closest available standard value C1 was connected for stability and its chosen value is $47\mu\text{F}$.
- Pin 1 was used as the feedback control input from the Opto-coupler stage.

- C_2 and R_3 was used for compensation to cancel a pole at frequency, $f = 200\text{h}$, as recommended by the datasheet for stability and their values can be determined, from the expression.

$$F = 1/(RC)$$

Choosing $C_2 = 100\text{nF}$,

$$R = (FC)^{-1} = (200 \times 100 \times 10^{-9})^{-1}$$

$$R_3 = 50,000 \Omega = 50\text{K} \Omega$$

A value of $47\text{K} \Omega$ was used as the available standard.

Resistors R_4 and R_5 form a voltage divider to aid manual pulse-width variation through compensation pin. To achieve this, R_4 is fixed while R_5 was made variable for pulse-width adjustment.

According to voltage divider theory,

$$V_o = V_m [R_5/(R_4+R_5)]$$

$$V_m = 5\text{V and thus;}$$

Choosing $R_4 = 4.7\text{k} \Omega$

$$R_5 = R_4 [V_o/(V_{in} - V_o)] = 4700 [3.4/(5-3.4)]$$

$$R_5 = 10\text{K} \Omega$$

Diode D_2 was connected to prevent R_4 and R_5 from affecting the compensation by R_3, C_2 .

Choice of MOSFET Driver

The MOSFET stage conducts the necessary load current through the step up transformer.

- The MOSFET used in the design is the IRF 150 N – Channel.
- Fixed resistors of $10\text{K} \Omega$ were connected between the gate and source to aid fast switching by discharging any residual static charge at the gate.

IRFISON Data

Drain to source breakdown voltage $B_{V_{DS}}$	=	100V
Gate to source voltage (cut-off)	=	4V
Gate to source breakdown voltage	=	$\pm 20V$
Drain current (continuous)	=	41A
Drain to source resistance r_{DS}	=	0.055 Ω
Power Dissipation	PD =	230W

- A total of 10 MOSFET were used for the design of the MUSI'LE driver. S MOSFET function for each half of the full period.

Change Over Switch

An automatic changeover switch was designed for this project.

- A 220Volts operating relay was connected to serve as the mains voltage detector and switchover. When mains power is interrupted this activate relay switch contact to change c:er the supply from mains to inverter mode supply.
- The action reverse when mains power is restored, hence providing automatic changeover action.

Opto-Coupler Feedback

The Opto-coupler is used in the feedback loop to control the pulse width, thereby effecting voltage regulation.

- The opto-coupler used in the design is the 4N35. The chip is as shown in figure 3.3. below

- The LED has a forward current of 5mA and the phototransistor has a maximum current of 200mA.
- A bridge rectifier provides dc input to tie LED of the opto-coupler.

For a conducting current of 1mA, the limiting resistor would be:

$$R = \frac{V_s - V_f}{I_F} \quad 3.24$$

For $V_s = 220V$, $V_F = 2V$, $I_F = 1mA$

$$= \frac{220-2}{1 \times 10^{-3}} = 218000\Omega$$

$$= 220k \Omega$$

- For the pulse with control, the pin 2 is used for the reference voltage.
- Using a voltage divider of equal resistance, the V_{I1} for pin 2 is set to 2.5V when the supply is taken from pin 16 V_{ref} .
- Choosing R_1 and R_2 to be 10KQ, this implies then that for a collector current of 1mA in the photo transistor, the resistance R_E needed will be;

$$R_E = \frac{V_{refe}}{I_c} = \frac{2.5}{1 \times 10^{-3}} = 2500 \Omega$$

Thus a variable resistor of 5KQ was used and adjusted accordingly. The feedback control is shown in fig.34 below. The diode used has a PIV of 400V.

Discussion of Result

The complete circuit diagram of the 2.5KVA inverter is shown in figure 3.5. The operation of the circuit will be explained using the circuit diagram as a reference. The inverter basically consists of two stages namely the inverting stage and the changing stage.

The two 12V deep cycle batteries are connected in series making a battery of 24V. This 24V is fed to the input of the inverter circuit.

When the switch SW is closed, current flows to the input of the inverter circuit through pin 15. PWMIC is the pulse width modulator IC, the function is to generate the alternate pulses needed to drive resistors R6 and R7 are for compensation while R8 and C₁ determine the frequency of oscillation (5 OHZ in our case). R9 and R10 set the reference voltage of 2.4v for the pulse width modulation control through pin 6. This resistance is constantly compared with the voltage at pin 1 from the opto-coupler to determine the trend of the pulse-width variation but it works reverse relation as to balance the change in output voltage such that output voltage tend to increase, the pulse-width reduces and to keep the output voltage constant within a tolerance range the out from the ten (10) MOSFETs is fed to the center tapped of the transformer T1. The function of transformer T1 is to step up the voltage from the MOSFETs from 36Vac to 220Vac. The output of the transformer is fed through relay RL2 to the output terminal of inverter. A load connected to the output terminal of the inverter will applied appropriately with power.

Opto-coupler, bridge rectifier RFI, R1 and R5 make up the feedback work. Resistor R1 function is for appropriate adjustment of the error value for effective control. The source of the feedback voltage is taken as the output of the auxiliary winding. When

the output voltage cases, the auxiliary winding (Aux) output voltage increases and this increase in output from R_1 . This change is detected by PWM rough pin 1 and the consequence is that the pulse-width of the pulses generated is gradually reduced in proportion to the change. This is such that the output voltage that was initially high would begin to drop to nominal value and vice – versa.

When power is restored by the mains, relay RL1 is used to prevent the power supplied by the mains fro directly going in to the inverter while it is in operation. At the same time, this power from the mains is supplied to step down transformer T2. The function of transformer T2 is to step down the voltage from 220Vac to 12Vac. This voltage is rectified by the RF2 circuit. This rectified 12Vdc is supplied to pin 10 of the PWMIC to shut down the inversion operation. After the shutdown process, relay RL2 is energized hence power from the mains moves in to transformer Ti. Transformer Ti now acts as a step-down transformer step down the voltage from 220V to 36V. This 36Vac is rectified by the ten (10) to 36Vdc which is then supplied to charge our batteries

The supervisory circuit consists of the low battery detector and also the battery full detector. The comparator is used to detect the low battery charge of 30V by comparing a sampled d.c charge voltage from the batteries with a reference voltage set by zener diode D5. When the low battery limit is reached (which is at 30v), the comparator our goes positive and D3 comes on to indicate low battery charge. When the battery is full, (which is at 39V), the second comparator output goes positive and diodeD2 comes onto indicate the full battery charge. At the same instant in time, relay RLI is de-energized to prevent power supply from the mains from flowing into the inverter circuit.

CHAPTER FOUR

CONSTRUCTION TESTING AND RESULTS ON CONSTRUCTION

The construction of this circuit involves the bringing together of different electrical and electronic components. Some of these components are sourced from the local electrical and electronic stores either in the form of discrete component or as an integrated component. The construction of the object was done in segments, which was later brought to form a complete circuit diagram of an inverter.

The following tools and instruments were used in the construction work:

1. Digital multi-meter
2. Soldering iron and lead
3. Long nose pliers
4. Copper stripping knife
5. Lead sucker
6. Wire cutter/stripper
7. Bread board
8. Vero-board.

Bread board is used first in the circuit design so as to ensure that the circuit will work well when tested before transferring to Vero-board for permanent soldering. If the design did not work well in the bread board, necessary corrections and adjustment must be done before transferring the component to the Vero-board for permanent soldering.

The component layout was planned first before the components were laid out on the breadboard and Vero-board respectively.

Integrated circuit (IC) socket stand was used for the SG3524 and the components were neatly soldered and the copper strips along the Vero board were neatly scrapped off at points where it is not needed to avoid short-circuits.

After complete soldering has been down, continuity test was carried out to check for any likely shorts.

Each of the steps was carefully soldered on the Vero-board with leads.

The voltmeter and the LEDs were connected out from the circuit.

Looping of the power cord to the transformer and also connecting tires from the transformer stage to the MOSFETs and to the relay and internally to the battery terminals via the relay was carefully and neatly one. The MOSFETs were screwed down to heat sinks for effective heat dissipation.

Circuit Description

The inverter is comprised of four major parts which is accurately connected together to achieve its function.

The first stage is the oscillator circuit stage, this dose the conversion of the dc current to an AC current. The oscillator generates complementary pulses on pin 11 and pin 14 which drives the power MOSFETs. Each of the pins is connected to the ground through $10K\Omega$ resistor so that charges in the MOSFETs gate can sink when the pulse is zero. This action causes current to flow through each half of the primary winding of the transformer (the second stage) at alternate half and alternate current is produced at the secondary winding. The MOSFET driver circuit (the third stage) helps to amplify the signal from pulse generator to level required viewer transformer.

The output from the transformer is configured to ways (the fourth stage) which help in switching the supply from the public power and the inverter.

The LED which are connected to the battery terminals are used for monitoring the level of the battery when charging or using.

Construction of Casing

The complete unit was housed in a metallic casing with the battery terminals for positive and negative, power switch, handle, and output voltmeter, were neatly connected and placed in their allotted space and pots.

The casing was earthed and the components were also carefully laid out inside it.

BILL OF QUANTITIES

Table 4.1 below shows the components or item used in the design and construction of the project, the quantity, and the amount spent.

Table 4.1: Bill of Quantities

ITEMS	QUANTITY	UNIT RATE (#)	TOTAL AMOUNT (#)
PWM IC (SG3524N)	1	200	200
MOSFET (IRF2 SON)	10	500	5,000
Deep cycle battery	2	100,000	200,000
LEDs	4	10	40
Resistor	30	10	300
Big Capacitor	1	600	600
Small capacitor	10	30	300

Diode	10	15	150
Power switch	1	80	80
LM324	2	160	200
Fuse	5	20	100
12V Relay	4	200	800
Rack	1	20,000	20,000
Soldering lead	1	1,500	1,500
Power cord	1	1,000	1,000
Casing	1	2,500	2,500
4103	1	200	200
Jumper wire	1	500	500
Vera board	2	100	200
Heat sink	1	500	500
Power plug	1	140	140
Bridge rectifier	2	200	400
12V/240V Tnx	1	500	500
2.5KVA Transformer	1	25,000	25,000
Voltmeter	1	100	100
Bread board	1	200	200
Comparators	2	50	100
IC Socket	3	30	90
Screw	-	100	100
Tape	1	150	150
Soldering iron	2	600	1,200
Miscellaneous	-	-	20,000
TOTAL			282,150

Tests

Tests were done to confirm that all the components used were in good condition before use. Open circuit and closed-circuit test were also carried out on the transformer.

No Load Test

A 24V sealed rechargeable battery was connected to the inverter circuit. The positive terminal of the battery was connected to the center tapped transformer while the negative terminal was connected to the overall ground of the inverter circuit. When the inverter was; switched, a low humming noise from the transformer was observed which shows that the output was too high. A screw driver was used to adjust the pulse width output by turning the variable resistor in the control circuit. The exact value of the output voltage was determined by inserting the terminals of a digital multimeter into the socket. In this process, the output voltage was reduced to 220V.

Table 4.2: No load test

Types of test	Designed value			Measured values			Efficiency (%)
	V (V)	I (A)	P(KVA)	V (V)	I (A)	P(KVA)	
No load test	220	11.36	2.5	220	11.02	2.43	97.20

4.4.2 Load Test

This test was done to ensure that the inverter is working as expected. The test would help to ascertain its behaviour under load condition with respect to the output voltage stability. This was achieved by connecting a 2KW load.

Table 4.3: Load test

Types of test	Designed value			Measured values			Efficiency (%)
	V (V)	I (A)	P(KVA)	V (V)	I (A)	P(KVA)	

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

Conclusion

A 2.5KVA from a 36V D.C battery supply has been designed and constructed according to the aim and objective stated in this project.

The D.C to A.C inverter delivers a square wave output voltage because it converts the direct current (dc) into an alternating current (ac), through the use of a Pulse Width Modulating [PWM] IC, with the use of MOSFET transistor to switch the title value of current from the PWM IC to respective amp (A) that is required. This gives very height conversion efficiency, but the alternating pulse output wave form has relatively high harmonics. Some appliances does not operate in such wave form, for this reason inverter manufactures do make a small number of inverter models that are design to deliver a square wave output. Generally, this inverter uses more complex circuit because it is difficult to produce a pure sine wave while still converting the energy into A.C efficiently. As a result of that pure sine wave inverter tend to be significantly more expensive even when they have the same output power rating.

Recommendation

Though, pure sinusoidal output is not possible to achieve as long as driving waveform is not sinusoid, but improvement should be made the output voltage waveform in other to lower the harmonics content the final output.

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