DESIGN AND CONSTRUCTION OF 1.5kVA HYBRIDE POWER MODULAR INVERTER TRAINER KIT

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A PROJECT REPORT SUBMITTED TO THE DEPATMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, FEDERAL UNIVERSITY OYE-EKITI, IKOLE CAMPUS IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) IN ELECTRICAL AND ELECTRONICS ENGINEERING

FEBRUARY, 2019

CERTIFICATION

This project work titled "DESIGN AND CONSTRUCTION OF 1.5kVA HYBRIDE POWER MODULAR INVERTER TRAINER KIT" by Oluwayomi Dare Joseph, meets the minimum requirements governing the award of Bachelor degree in Electrical/Electronic Engineering Department, Federal University Oye-Ekiti, Ekiti.

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DEDICATION

This project is dedicated to lovers of science and technology, most especially the power sector.

DECLARATION

I OLUWAYOMI DARE JOSEPH hereby declare that this work was carried out by me under the supervision of Engr. K.O. Olusuyi and is submitted to the department of Electrical Electronics Engineering.

Oluwayomi Dare J.
....
STUDENT'S NAME

5/03/2019
....
DATE

ACKNOWLEDGMENTS

Firstly, I would like to appreciate Almighty God for His unconditional love and provision in the course of my studies. I am also grateful to my supervisor, Engr. K.O. Olusuyi for his guidance during the period of the project. I would like to also thank my parents, family members, Mrs E. Ajayi's family, friends and colleagues for the support they accorded me in the course of my study. Thank you all and the grace of the Lord Jesus Christ be with you.

ABSRACT

The reliability of Power Company Electricity Service varies greatly due to many factors including the design of the power grid, protective features, power system maintenance practices and severe weather. This work is on the design and construction of a 1.5KVA Pulse Width Modulated (PWM), Metal Oxide Semiconductor Field Effect Transistor (MOSFET) based Inverter, which works on the principle of Pulse Width Modulation. The inverter uses the IC SG3524 and a pair of six IRFP260N MOSFETs to drive the load. The project is divided into four modules of which the design and construction details of the following two modules are covered in chapter three of this write up i.e. Transformer and Driver module. The focus is on designing an inexpensive, versatile, noiseless, no weather (environmental) pollution and efficient inverter that gives a 220V modified sine wave at the output. The project can as well be used to train students. Some problems were encountered during the construction of the project which are listed in chapter five of this write up such as burnt AC voltage meter, and the solution proffered.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

At the early stage, sun was the source of energy for generating power. Due to the inadequacy of the power generated through this source, there was a need to find other ways to improve the power supply when the generating station could not meet the demand of the people. As the technology advances, the hydroelectric generation was developed, gas firing generating station, and wired tubing methods of generating power supply were developed. In spite of all these developments, there was still failure in electrical power generation as a result of obsolete equipment at the generating stations. There was still need to find alternative for solving the problem [1]. As a result of this, some options like alternators, inverters and others were developed. The electrical inverter is a high power electronic oscillator. The inverter performs the opposite function of a rectifier formed in the late nineteenth century through the middle of the twentieth century; DC to AC power conversion was accomplished using rotary converters or motor-generator sets (M-G set). In the early twentieth century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits. The most widely used type of tube was the thyratron. Early A.C to D.C converters used an induction or synchronous AC motor directly connected to a generator (dynamo) so that the generators commutator reversed its connections at exactly the right 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 end only one field frame.

Electrical power exists in two main forms: Alternating Current (AC) and Direct Current (DC). The nature of alternating current is that, the voltage level can be step up or down by use of transformers while that of direct current is that it's possible to store in batteries. Most of the domestic electrical loads operate with an AC power supply of 220V, 50Hz frequency in Nigeria. It is normally available from plug point/power point in our houses. But in case of power cut-off due to fault or any other reason AC power can be obtained from stored DC power in Batteries. Hence as AC power can't be stored, it has to be converted from DC. The converter that converts DC to AC is known as an Inverter. The Inverter does not produce any power; the power is provided by the DC source. 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 (but in Nigeria, 220V, and 50Hz) with the use of appropriate transformers, switching, and control circuits. Solid-state inverters have no moving parts and are used in a wide range of applications, from small switching power supplies in computers, to large electric utility high voltage direct current applications that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries.

1.2 STATEMENT OF THE PROBLEM

In Nigeria, power outages have become more frequent owing to the lack of incentives to invest in aged national grid, transmission and distribution infrastructures, as well as the fact that energy from decentralized, "volatile" renewable sources is not well aligned to work on electricity grids. A practical example is seen in part of Ikole Ekiti, Asin area where there has been a black out since January, 2016 till now (February, 2019) [8].

More so, about two semesters ago, the department had to carry out experiment for students running on departmental generator (1kVA in capacity) because the generator installed in the faculty was faulty and small generator at the gate is not capable of carrying the entire school loads. These frequent power outages are inconvenient, expensive and difficult to mitigate without very expensive backup power systems. Some of the solutions to this problem is an auxiliary AC power generator and solar panels but the cost of fossil fuels continues to increase rapidly thus, it will not be cost effective in the future while solar power has some aesthetic, economic and technical drawbacks. A more effective and reliable alternative is battery power back-up system.

1.3 MOTIVATION

An inverter is used to provide uninterrupted 220V AC supply to the load connected to its output socket. It provides constant AC supply at its output socket, even when the AC mains supply is not available [3]. It is a combination of inverter circuit, charger circuit and a battery. The charger circuit keeps the battery charged when the mains supply is available and when the mains AC fails, the inverter circuit takes the DC power stored in the battery and converts it into 220V/50Hz AC supply, which can be used to power any common electronic equipment or computer systems.

Inverter unlike others is cost effective, easy to maintain. It poses no threat to the environment. The disturbance cause to the neighborhoods from the other power generator is eliminated as well.

1.4 SIGNIFICANCE OF THE STUDY

In this modern society, electricity has great control over the most daily activities for instance, in domestic and industrial utilization of electric power for operations. Electricity can be generated from public supply to consumers in different ways including the use of water, wind or steam energy to drive the turbine as well as more recently the use of gas. Generators, solar energy and nuclear energy are also source of electricity. In Nigeria, there is inconsistent supply of electricity by the power supplying company to the consumers, also high cost of fossil to run generators and the cost of its maintenance. Hence the use of additional electric power source for instance, semiconductor power devices such as the Bipolar Transistor, Thyristors and particularly MOSFET to generate electric power in conjunction with a DC battery in few kilowatts. An Inverter offers a better additional power source to Generators as well as UPS considering its long duration, cost effectiveness and maintainability.

This project would be of great benefit to all especially people in the rural areas. The beneficiaries include:

- Individuals of the community for residential use.
- Social groups for powering equipment such as lightings, cooling systems and sound systems.
- Religious groups such as churches and mosques.
- Governmental and non-governmental organizations such as academic institutions (lightings, powering equipment for Wi-Fi facility, virtual lectures such as power point lectures to enhance quality learning, and powering other equipment used in the academic environment); hospitals (to supply constant power such as to provide low temperature needed to keep vaccines effective and powering other equipment).
- Industries: To ensure that manufacturing process is not interrupted due to power failure.

1.5 PROJECT AIM AND OBJECTIVES

The aim of this project is to design and construct 1.5kVA hybrid powered modified sine wave trainer kit inverter capable of powering wide variety of electronics, household and laboratory equipments such as Computers, Oscilloscope, Signal generator, Mobile phones etc. The main objectives of this project can be summarized as follow

- To provide sustainable and reliable (i.e. cost effective and easy maintainability power source) power supply for EEE department
- To design a modular interconnected project that can be used to train student
- To design and implement a 1.5kVA modified sine wave inverter that converts 12V D.C to 220V A.C
- To design noiseless power source during operation because most of the power generators are noisy during its operation, this causes disturbances to the neighborhoods.
- Also to provide electric power without environmental threat, the smoke and the black oil from the generator pose threats to the environment as air and soil or water pollutant.

1.6 SCOPE OF THE PROJECT

One of the major measures of development in any organization or country is the availability of power supply. Electric power (a.c source in particular) is what no organization or country can do without. Inverter (a means of converting energy stored in a battery to a.c source) cut its uses across all fields, organization, and country and including households.

This study is limited to designing of 1.5KVA modified sine wave Inverter at a voltage of 220Vac, frequency of 50Hz. The circuitry involves PWM power control circuitry SG3524N, H-bridge driver stage which contains IRF260N MOSFET switches, 1.5KVA Soft iron core transformer (Transformer stage), and Auto transfer stage. The inverter requires a 12V DC battery as a source of DC energy and can also switch to the 220V AC mains for direct use by means of relay when there is power supply from the faculty utility.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

An inverter is a device that converts the DC sources to AC sources. The purpose of a DC/AC power inverter is typically to take DC power supplied by a battery, such as a 12 volt car battery, and transform it into a 240 volt AC power source operating at 50 Hz, emulating the power available at an ordinary household electrical outlet. Inverters are used in applications such as adjustable-speed AC motor drivers, uninterruptible power supplies (UPS) and AC appliances run from an automobile battery.

At the early stage, sun was the source of energy for generating power. Due to the inadequacy of the power generated through this source, there was a need to find other ways to improve the power supply when the generating station could not meet the demand of the people. As the technology advances, the hydroelectric generation was developed, gas firing generating station, and wired tubing methods of generating power supply were developed. In spite of all these developments, there was still failure in electrical power generation as a result of obsolete equipment at the generating stations. There was still need to find alternative for solving the problem. As a result of this, some options like alternators, inverters and others were developed. The electrical inverter is a high power electronic oscillator.

The inverter basically involves a signal generating stage with desired signal waveform and frequency of 50HZ (in Nigeria). The signal is inverted to form two alternate waveforms (pulses) usually employed in push pull fashion. Transistor or MOSFETs then drives current (i.e. D.C source) through the step-up transformer. The current is driven through the transformer alternately by the two stages of MOSFETs; emf is generated at the output of the step-up transformer. This inverted alternate pulses then allows to drive two sets of power devices either transistor in ladder network (depending on power aiming at) or power MOSFET.

2.2 TYPES OF INVERTER

Inverter is broadly divided into three types but the first two types are mostly available in the market today. The three types are listed below, which are:

- Modified sine wave inverter
- Pure sine wave inverter
- Square wave inverter

2.2.1 MODIFIED SINE WAVE INVERTER

A modified sine wave is similar to a square wave but instead has a "stepping" look to it that relates more in shape to a sine wave. The waveform is easy to produce because it is just the product of switching between three values at set frequencies, thereby leaving out the more complicated circuitry needed for a pure sine wave hence provides a cheap and easy solution to powering devices that need AC power. However it does have some drawbacks as not all devices work properly on a modified sine wave, products such as computers and medical equipment are not resistant to the distortion of the signal and must be run off of a pure sine wave power source. Modified sine wave inverters approximate a sine wave and have low harmonics that do not cause problem with household equipment's. The main disadvantage of the modified sine wave inverter is that peak voltage varies with the battery voltage.

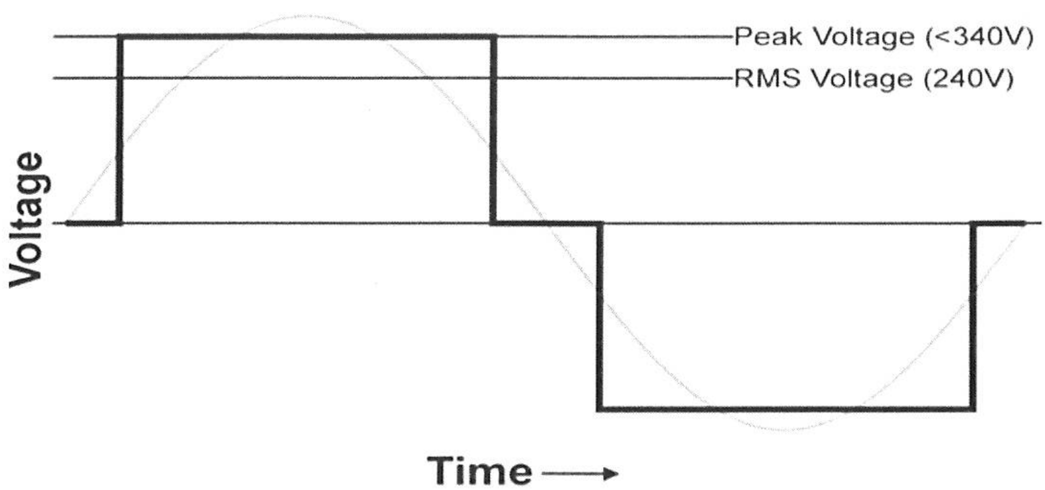

Fig.2.1: modified sine wave

2.2.2 PURE SINE WAVE INVERTER

Pure sine wave inverter represents the latest inverter technology. The waveform produced by these inverters is same as or better than the power delivered by the utility. Usually sine wave inverters are more expensive than the modified sine wave inverters due to their added circuitry.

There are two methods in which the low voltage DC power is inverted to AC power;

- The low voltage DC power is first boosted to high voltage power source using a DC-DC booster then converted to AC power using pulse width modulation.
- The low voltage DC power is first converted to AC power using pulse width modulation then boosted to high AC voltage using a boost transformer.

The second method is used in modern inverters extensively because of its ability to produce a constant output voltage compared to the first method that require additional circuit to boost the voltage.

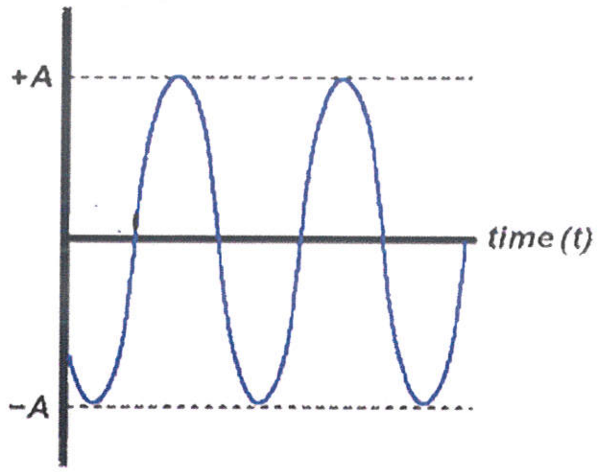

Fig.2.2: sine wave

2.2.3 SQUARE WAVE INVERTER

A square wave inverter is a type of electrical inverter that produces a square wave output; it consists of a DC source and power semiconductor switches that can carry a large current and withstand a high voltage rating. The switches are turned on and off in correct sequence, at a certain frequency. The square wave inverter is the simplest and the least expensive type of inverter, but it produces the lowest quality of power. The square wave will not be appropriate for some load because of large harmonics content which cause interference, it find its application in motors.

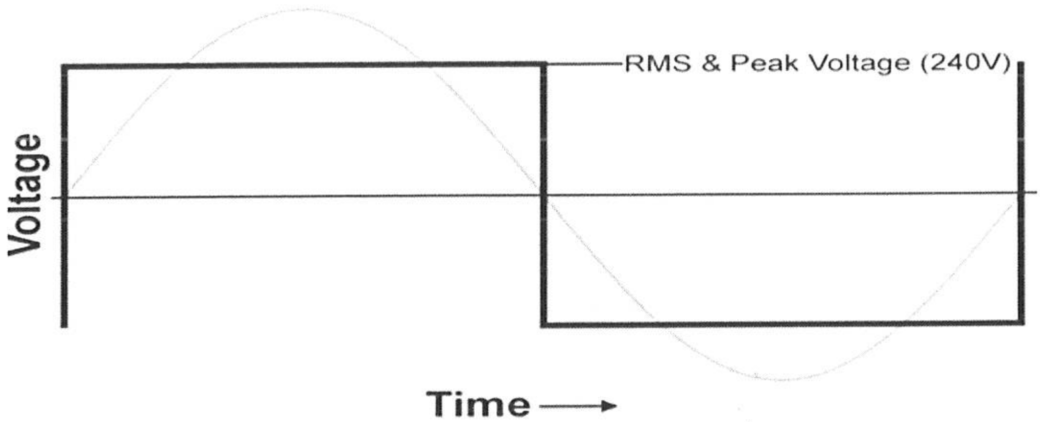

Fig.2.3: square wave

2.3 REVIEW OF THE RELATED WORKS

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

Purification, P. (2010)., worked on the power generated from the renewable sources, like solar energy, that produces a DC power which can be stored in batteries. This DC power was converted to AC power as most of the appliances used in our daily life are dependent on AC power. To overcome this obstacle, DC-AC Inverter took birth.

Fashina Olugbenga E. and et al. (2017)., worked on the production of photovoltaic system in which solar cell or module is used to power an inverter, which serves as a means of empowering our youth for nation's socio-economic development through alternative power generation. The system consists of solar modules, solar charge controller, 12V.d.c battery and an inverter (0.5 HP). Solar modules serve as source of charger through solar charge controller to the battery and inverter are used in converting the direct current into an alternating current for the domestic appliance. Self-charging inverter is more economical, noiseless, emission free, portable, rugged and uninterrupted alternate source of electricity which requires less maintenance and no fossil fuel. The estimated energy cost is comparable and competitive with the other inverters and renewable energy sources for both commercial power companies and technology suppliers. The 2KVA inverter with the alternator was able to power a table top refrigerator, Air-conditioning system, plasma TV, and ten 60watts bulbs for 7 hours continuously, before recharged. .

Sayat Moldakhmetov and et al (2016)., proposed one of the methods for multilevel power inverter implementation with capacity up to 30 kW. The method was based on a special topology for construction of multilevel inverter consisting of H-bridge and level switch. In accordance with the proposed topology H-bridge inverts voltage and a switch enables to get any number of voltage levels. In addition, the characteristic feature of this inverter is the use of converters as sources where multilevel voltage is generated. This allows reducing a number of accumulator batteries being used, decrease the dependence of the form of the inverter output voltage from the accumulators charging rate, as well as the dimensions of the whole unit. 17-level inverter was been developed following the proposed topology and methodology.

Neelashetty Kashappa1, Ramesh Reddy K (2012)., worked on the implementation of a new low cost five level inverter which converts the 9V DC to 9V AC. Complexity and cost of the system are reduced as compared to other configurations by using only five switches, eight diodes and two capacitors. In the proposed scheme, control circuit was designed using 89C51 microcontroller to produce sinusoidal pulse width modulation (SPWM). The developed system can be operated at very high modulation frequencies of up to 200kHz producing sustained output. This single-phase five level low cost inverter is developed and tested in power electronics laboratory. The waveforms are recorded and analyzed using Digital Storage Oscilloscope TDS2024B. The proposed scheme is very economic and less complex and the experimental results shows that it has low total harmonic distortion.

Olusegun O. Omitola and et al. (2014)., purposed on the design and construct of a 1000Watts (1KW), 220Volts Inverter at a frequency of 50Hz. The device was constructed with locally sourced components and materials of regulated standards. The basic principle of its operation is a simple conversion of 12V DC from a battery using integrated circuits and semiconductors at a frequency of 50Hz, to a 220V AC across the windings of a transformer. An additional power supply to the public power supply with the same power output is thus provided at an affordable price.

Ankit Kamani, Jaideep Satapara. (2018)., experimented on the simulation and generation of Modified Sine Wave from 12V Battery of 7Ah capacity. The whole circuit was divided into two parts i.e., Gate Driver Circuit and Inverter Circuit. The Gate Driver Circuit is obtained using two methods. First method deals with the use of IC 555 Timer and IC CD4017 which provides gate pulses to the Inverter Circuit. Second method deals with the use of Arduino UNO as a gate pulse generator which is provided to the Inverter Circuit. Using any of the two methods, output of 230V, 50Hz, 500W can be obtained from the secondary of the center tapped transformer.

Oluwakemi, F. O. (2016)., purposed on the design and construct of a 1600W (2kVA), 220V inverter at a frequency of 50Hz. The device was constructed with locally sourced materials of regulated standards. The basic principle of its operation is a simple conversion of 12V Direct Current (DC) from a battery using semiconductors at a frequency of 50Hz, to a 220V Alternating Current (AC) across the windings of a transformer. An additional power supply to the public power supply having the same power output was thus provided at an affordable price. The project was based on the design of 2kVA (1.6 kW) inverter system and incorporate the use of switching scheme automatic voltage regulator. The inverter was set to shut-down if the threshold voltage of 11.5V (Min.) is reached and more 13.5V (Max.) during the charging. The switch mode of a modified wave-switching scheme uses an Astable Multivibrator to switch on the semiconductor switches-Metal Oxide Semiconductor Field Effect Transistor (MOSFET).

Awelewa, S.A. (2016)., worked on single phase inverter system which serves as an alternative power supply. The conversion technique used was, first converted the low voltage DC power to AC power using pulse width modulation (PWM), then boosted to high AC voltage using a step up transformer for constant output voltage instead of boosting the low voltage DC power to high voltage power source using a DC- DC booster which can then be converted to AC power using pulse width modulation (PWM). It was a microcontroller-based single phase inverter system which produces a sine wave output approximate to the power supplied by the national grid which is stable and reliable.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This chapter describes the method adopted in the design and construction of the 1.5kVA inverter trainer kit. The scheme employed is the Pulse Width Modulation scheme. In this scheme, pulse width modulations are generated by the oscillator.

The block diagram is as shown in the figure below:

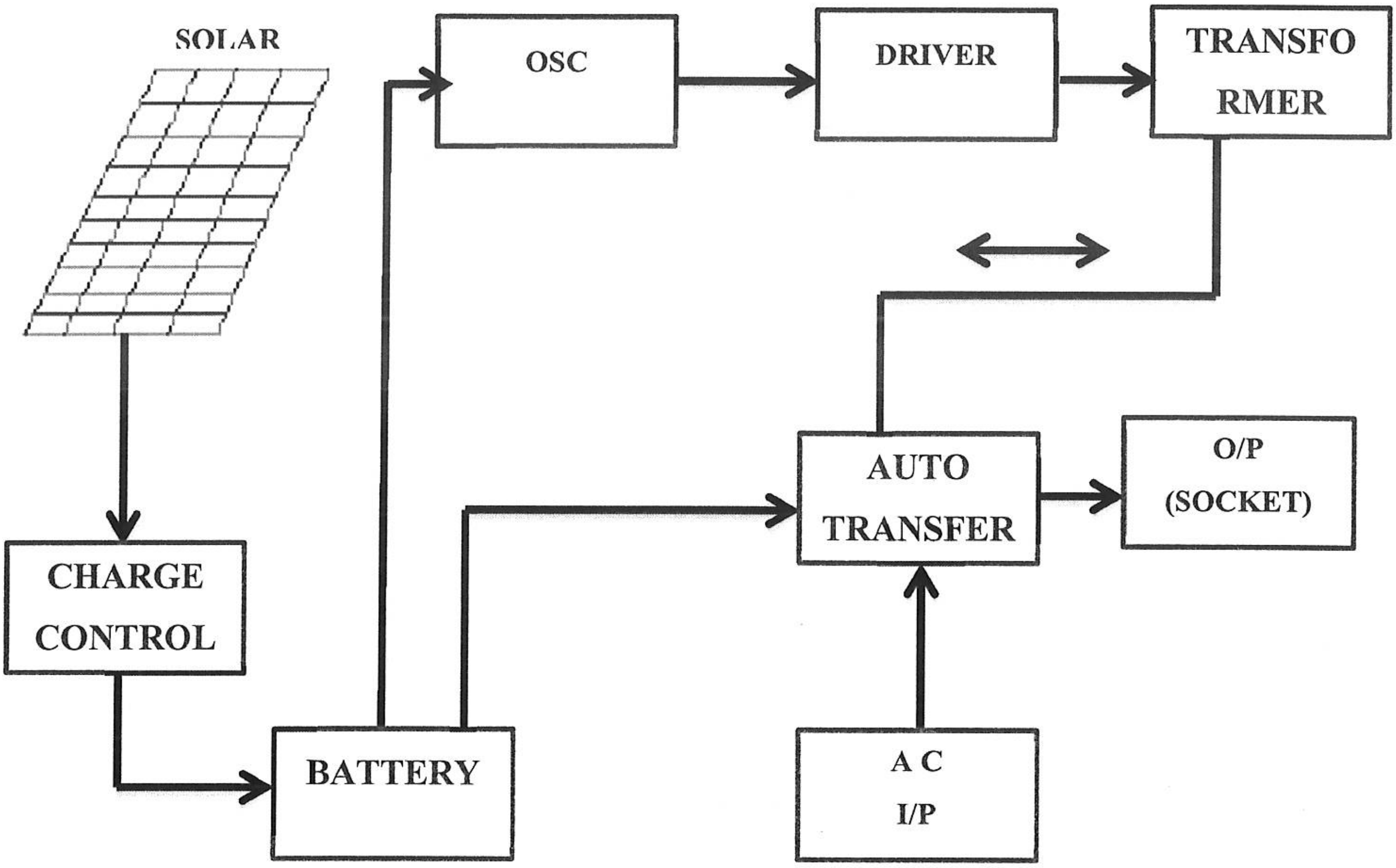

Fig.3.1: Inverter Block Diagram

3.2 TRANSFORMER DESIGN

A transformer is an electrical device that transforms energy from one form to another between two circuits through electromagnetic induction. In the transformer, electric energy is transferred from one circuit to another circuit. During this transfer, the current and the voltage can be changed, that is they can be increased or reduced [5]. In other word, a transformer may be used as a safe and efficient voltage converter to change the AC voltage at its input to a higher or lower voltage at its output (step-up or step-down transformer). There is no direct electrical connection between the primary and the secondary coil in a transformer [6]. A transformer consists of two windings of wire that are wound around a common core to provide tight electromagnetic coupling between the windings. The core material is often a laminated iron core. The coil that receives the electrical input energy is referred to as the primary winding; the output coil is the secondary winding. In the case of inverter, the transformer act as both step-up (inverter mode) and step-down (when the inverter is in charging mode).

3.3 TYPES OF TRANSFORMER

Transformer can be classified into two type base on construction

- Core type construction
- Shell type construction

3.3.1 CORE TYPE CONSTRUCTION

If the windings are wound around the core in such a way that they surround the core ring on its outer edges, then the construction is known as the closed core type construction of the transformer core. In this type, half of the winding is wrapped around each limb of the core, and is enclosed such that no magnetic flux losses can occur and the flux leakages can be minimized.

This type of arrangement proves quite useful for the flux circulation, such that each limb is covered by the windings and hence, the flux circulates through the complete core. But during this circulations, a bit of leakages also occur.

Single phase Three phase

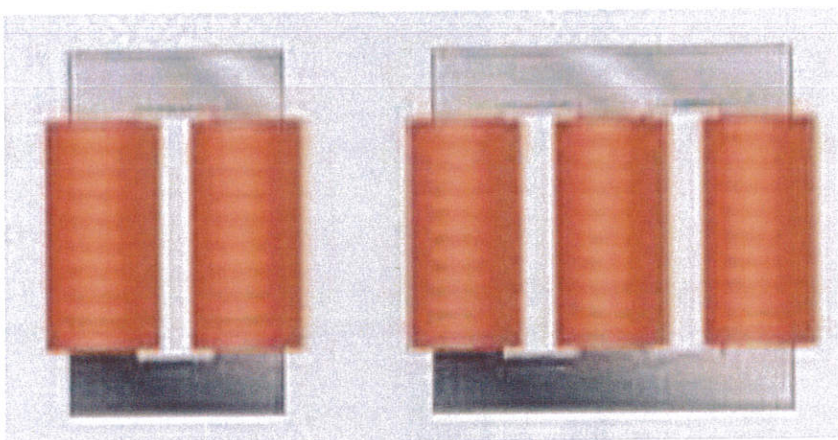

Fig.3.2: Core Transformer

3.3.2 SHELL TYPE CONSTRUCTION

In shell type construction of the core, the windings pass through the inside of the core ring such that the core forms a shell outside the windings. This arrangement also prevents the flux leakages since both the windings are wrapped around the same center limb.

Single phase Three phase

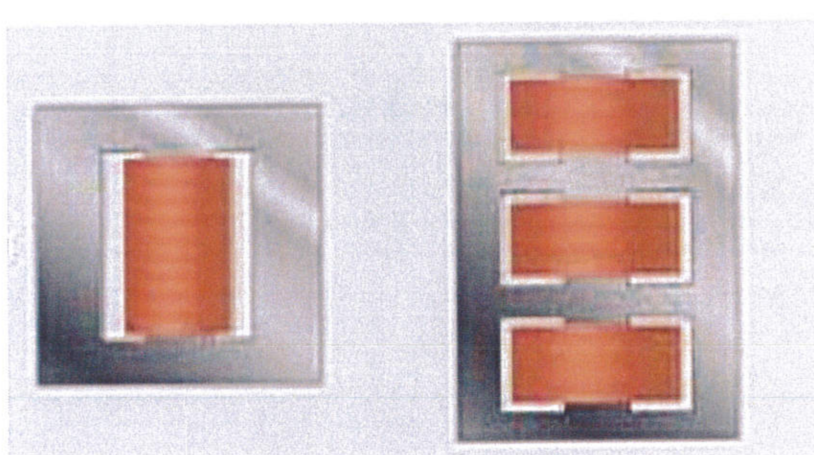

Fig.3.3: Shell Transformer

3.4 TRANSFORMER MAKING

Transformer is made up of laminations (E and I in this case), bobbin of required (4.4cm x 8.80cm) area, coil of required quage (primary quage is 2.360mm, secondary quage is 1.120mm)

3.4.1 TOOLS REQUIRED

I. Measuring tape
II. Pen knife
III. Paper tape

3.4.2 MATERIALS NEEDED

I. Bobbin of the required lamination core area
II. Lamination iron core stripes (E & I in this case)
III. Copper coil of the required gauge

3.4.3 TRANSFORMER CALCULATIONS

Inverter rating, P = 1500kVA

Bobbin area=core area (CA)

$CA = \sqrt{P}$ i

$CA = \sqrt{1500} = 38.73cm^2$

CA = core area

$CA = L \times B$ ii

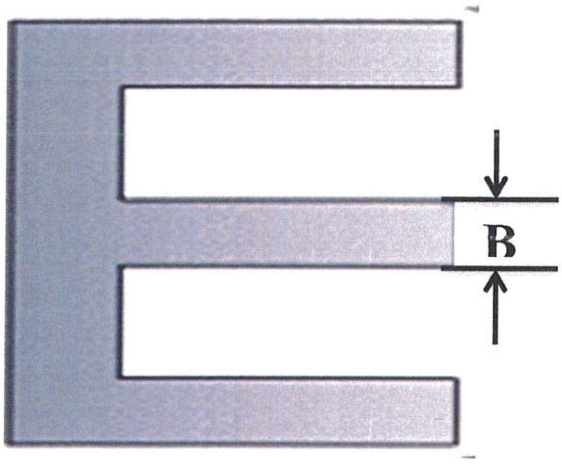

Fig.3.4a: Individual lamination

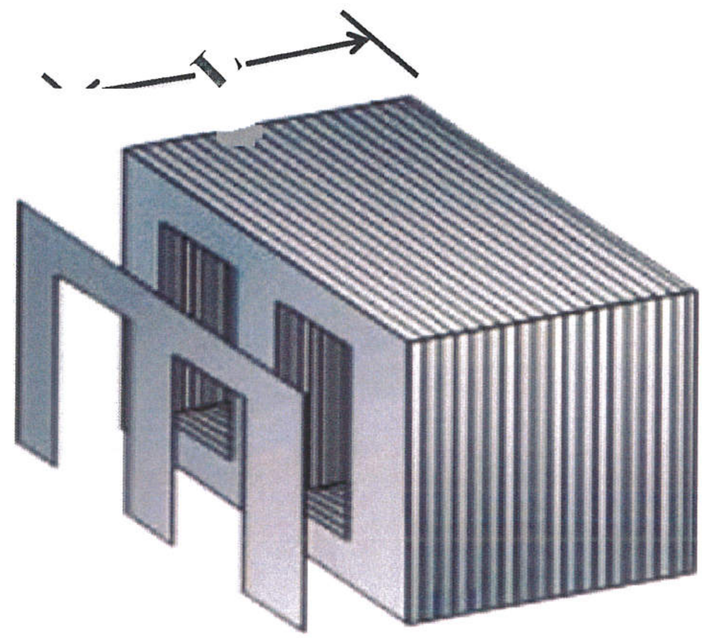

Fig.3.4b: Stacked lamination

B = breadth of lamination core

L = length of the lamination stacked together to give the required area

B = 4.4cm (measured value)

$$L = \frac{CA}{B} = \frac{38.73}{4.4} = \mathbf{8.80cm}$$

$$\text{Turn/volt} = \frac{\textbf{transformer constant}}{\textbf{CA}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{iii}$$

$$= \frac{\mathbf{42}}{\mathbf{38.73}} = \mathbf{1.08\ turn/volt}$$

$\boldsymbol{Turn = turn/volt\ X\ volt}$...iv

Primary voltage, $V_p = 12V$

Secondary voltage, $V_s = 220V$

Primary turns, $T_p = V_p$ x turn/volt = 12 x 1.08

T_p = 12.96 turns (approximately = 13 turns)

Secondary turns, $T_S = V_s$ x turn/volt = 220 x 1.08

T_S = 237.6 turns (approximately = 238 turns)

To calculate primary and secondary current

P=IV v

$$I = \frac{P}{V}$$

$I_p = P/V_p$ =1500/12 =125A

$I_s = P/V_s$ = 1500/220 = 6.8A

In a transformer, the relationship between voltage, current and number of turns in the coils is given by:

$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_1}{I_2}$..vi

- $V_1 = V_p$ is the input voltage to the primary
- $V_2 = V_s$ is the output voltage from the secondary
- $N_1 = T_p$ is the number of turns in the primary coil
- $N_2 = T_s$ is the number of turns in the secondary coil
- $I_1 = I_p$ is the current in the primary coil
- $I_2 = I_s$ is the current in the secondary coil

In an ideal transformer, there is no loss and the efficiency is 100%; but in reality, this is not easy to obtain. Figure below shows an Ideal transformer circuit.

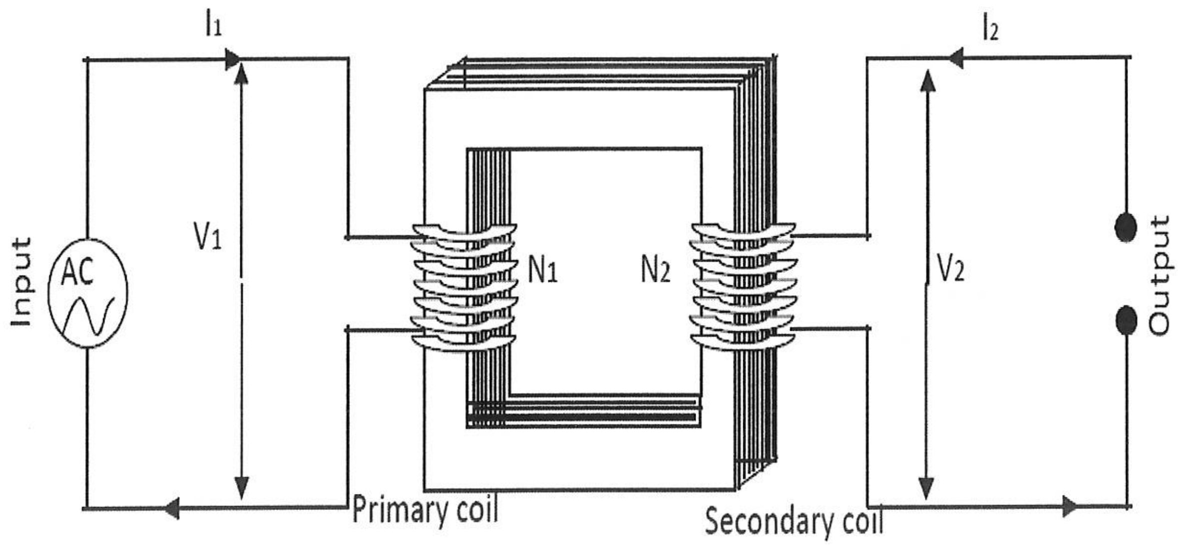

Fig.3.5: Ideal transformer circuit

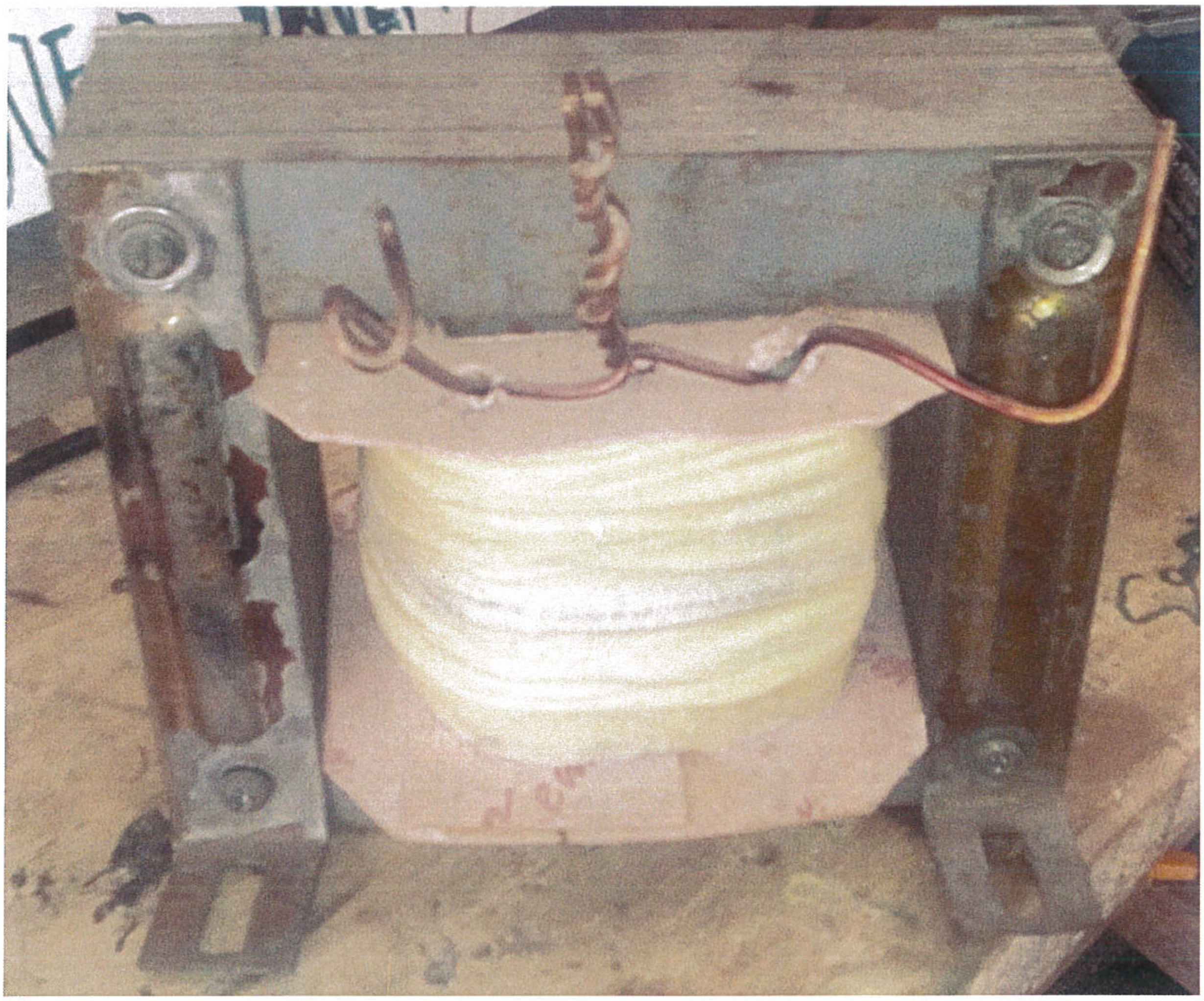

Fig. 3.6: center tap transformer image

Fig. 3.7: Bobbin of required area

3.5 DRIVER MODULE DESIGN

After stepping down the AC mains supply using a step-down transformer, the stepped-down AC supply is converted into DC by the rectifier circuit. The rectifier circuit is configured using N-channel MOSFET (IRFP260N)

Advanced drivers contain circuitry for powering high and low side devices as well as N and P-Channel MOSFETs. In this design, N-Channel MOSFETs are used due to their increased current handling capabilities than P-Channel.

3.5.1 REQUIRED TOOLS AND COMPONENTS

- Drilling machine
- Soldering iron and lead
- PCB
- Heat sink
- IRFP260N (6)
- Resistors (1kΩ; 100Ω, each 6 in number)

3.5.2 NUMBER OF MOSFET CALCULATION

The number of MOSFET to be used can be calculated as follow

Number of MOSFET (NOM) $= \frac{\textbf{capacity of the inverter}}{\textbf{power dissipation of the MOSFET}}$

NOM$= \frac{1500}{300} = \mathbf{5}$

The inverter uses six (6) MOSFET, three on each channel.

The driver is mainly made up of IRFP260N MOSFET and resistor as show in the fig.3.8 below

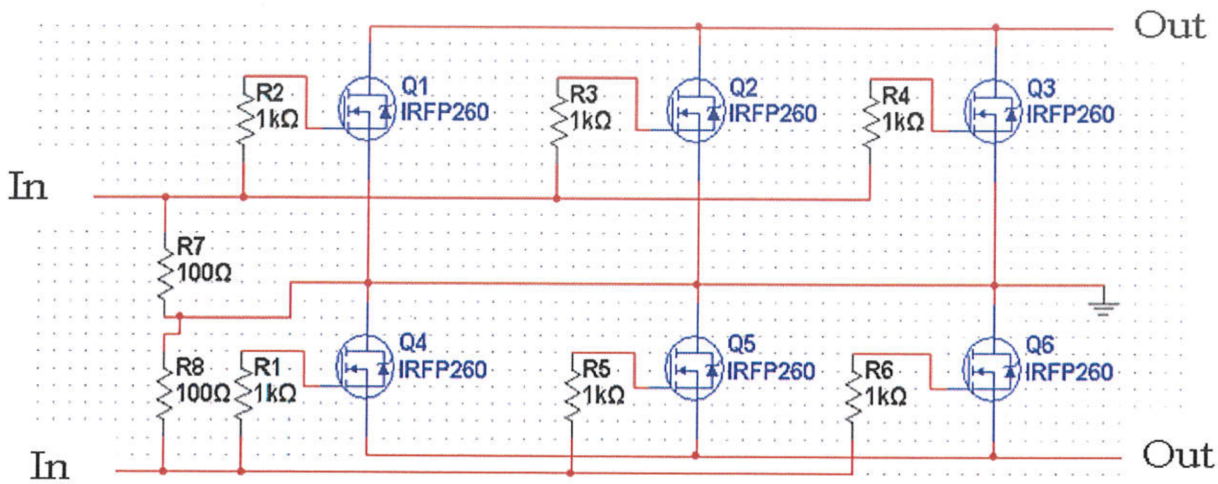

Fig.3.8 driver circuit

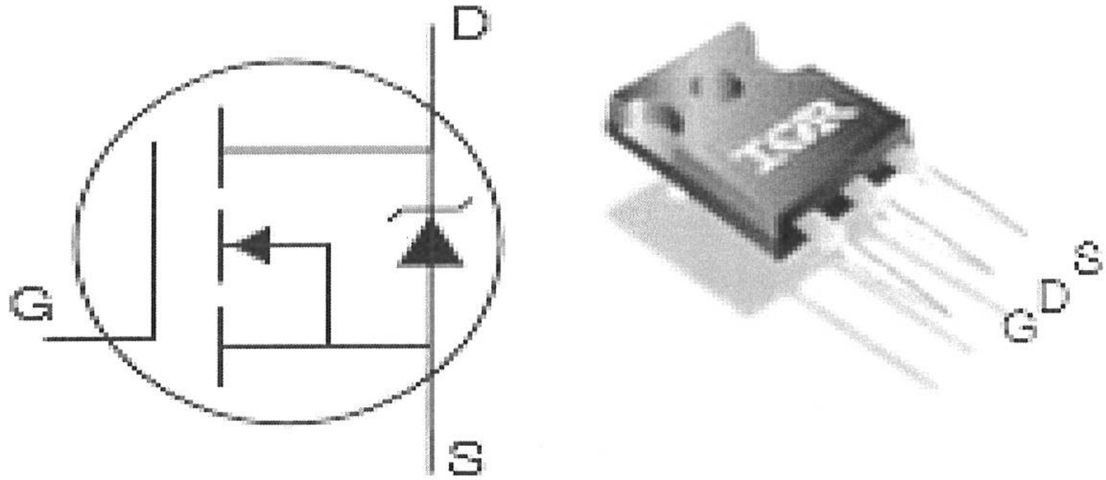

Fig.3.9: schematic diagram of IRFP260N

3.5.3 CHARACTERISTICS OF IRFP260N

- N-Channel type MOSFET
- Drain to Source breakdown Voltage: 200V
- Gate to Source Voltage: ± 20V
- Continuous Drain Current: 50A
- Power Dissipation: 300W

3.5.4 PRINCIPLE OF OPERATION

MOS drive signal from pin-11 and 14 of SG3524 IC are coupled to the source of IRFP260N through 1kΩ resistor. The signal is amplified to sufficient level and outputted at the drain of the MOSFET.

The 50Hz alternating MOS drive signal reaching the MOSFET channel separately results in the channels being alternatively ON and OFF.

Drains (D) of all the MOSFET on one channel are connected together and are connected to one end of the inverter transformer winding. The same is done to the second channel and the other end of the inverters winding. Positive terminal of the battery is connected to the center tapping of the transformer winding.

Source (S) terminal of each MOSFET is connected to the negative terminal of the battery. Because polarity of the 50Hz MOS drive signal at pin-11 and 14 are alternatively different, current flows through the first half and second half of the transformer's winding alternatively.

3.5.5 DRIVER STAGE CONSTRUCTION

After the PCB has been etched, the needed holes are drilled with the aid of PCB hand drilling machine and drilling bit of required diameter as shown in the figure bellow

Fig.3.10: drilling process

After the holes have been drilled, the components are mounted on the PCD and then soldered with the aid of soldering iron on soldering lead.

Heat sink: The heat sink is a passive heat exchanger on which IRFP260N transistors are mounted in order to transfer the heat generated by the MOSFET to a fluid medium (air) where it is dissipated away from the MOSFET and thereby allowing regulation of the MOSFET temperature at optimal levels.

Fig. 3.11a: soldering process

Fig. 3.11b: soldering process

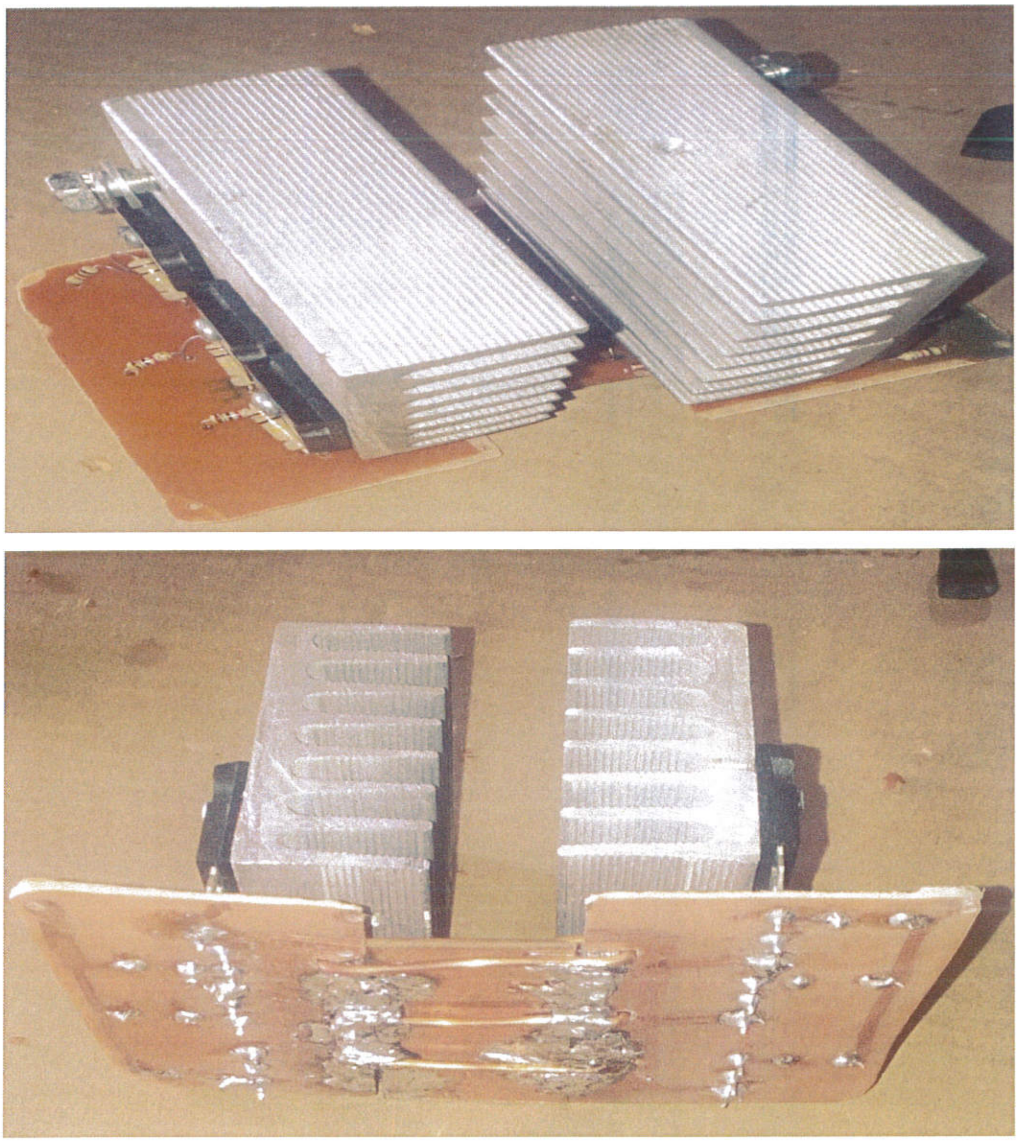

Fig.3.12: driver module

CHAPTER FOUR

TESTING, ANALYSIS OF RESULTS AND DISCUSSION

4.1 TESTING

After carrying out all the paper design and analysis, this project was implemented and tested to ensure its working ability, and was finally constructed to meet desired specifications. Stage by stage testing was done according to the block representation.

The process of testing and implementation involved the use of some test and measuring equipment which are listed below:

1) Digital Oscilloscope: The digital oscilloscope as shown in Fig. 4.1 below was used to visualize and analyze the output waveform

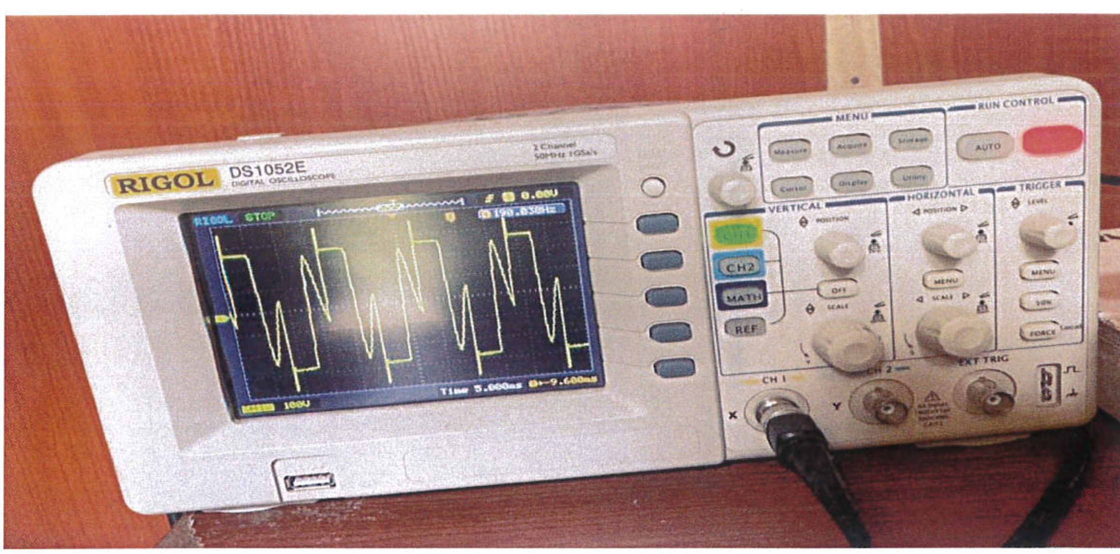

Fig. 4.1: oscilloscope

2) Digital Multimeter: The digital multimeter was used to measure the output voltage and current

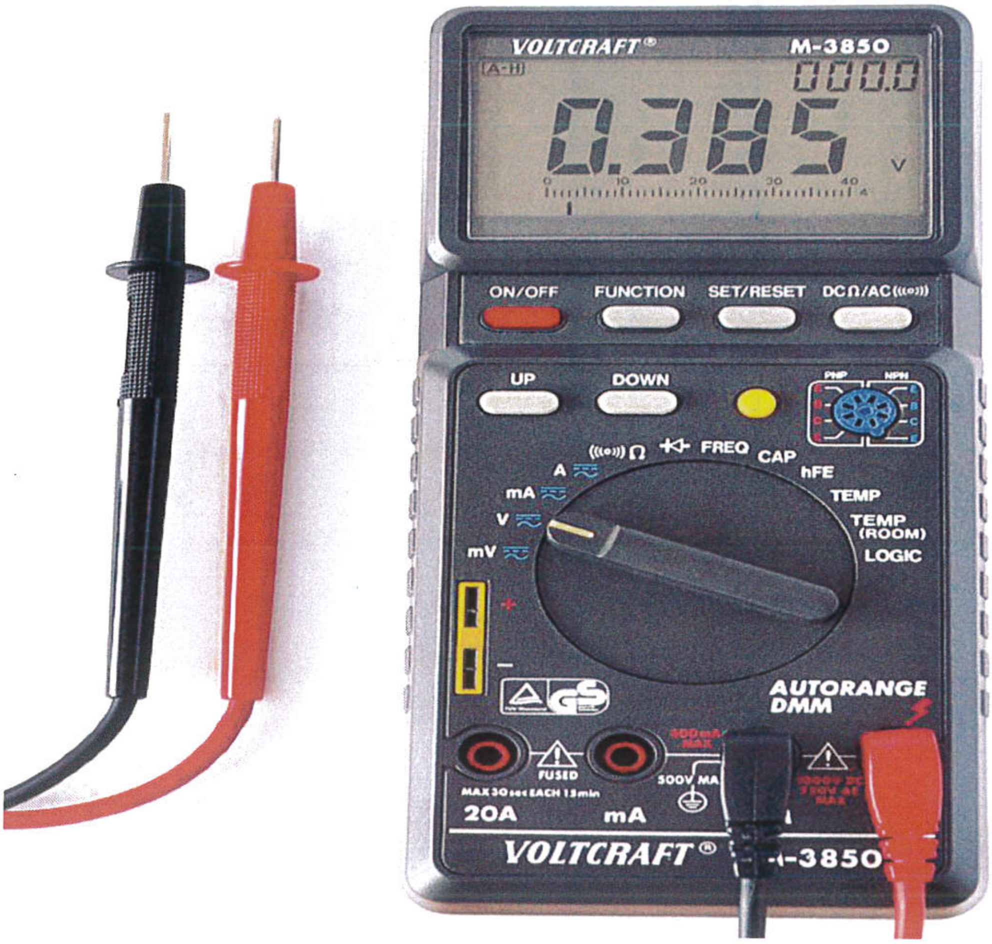

Fig.4.2: digital multimeter

3) Clamp meter: the clamp meter was used to measure the current of the battery

Fig. 4.3: clamp meter

4.1.1 RELIABILITY TEST

When tested with various loads such as resistive loads and inductive loads such as electric hand drilling machine, 200watts filament bulb, the inverter worked perfectly.

4.1.2 STABILITY ANALYSIS

This was done by examining the inverter system for a period of 21 minutes under no load condition and load condition.

Table. 4.1: stability test under no load

Time (minutes)	Voltage (Volts)
0	214
3	214
6	214
9	214
12	214
15	213
18	213
21	213

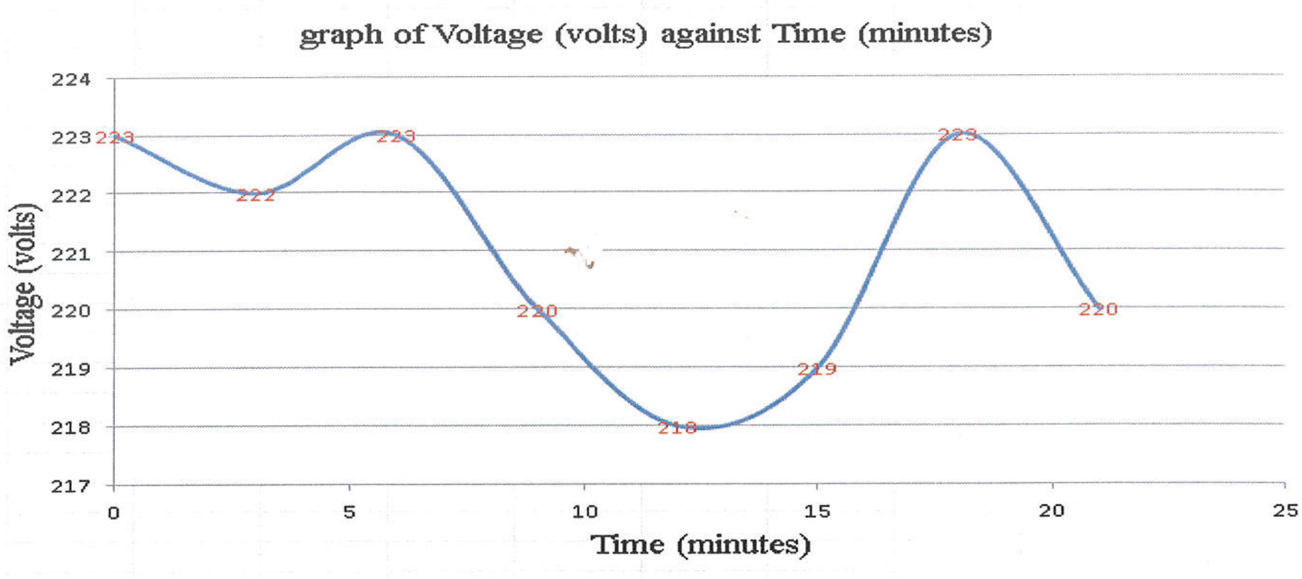

Fig. 4.4: stability test graph

From Figure 4.4 above, it was discovered that the output voltage is still within the range of the expected output voltage (±5%).

4.2 LOAD ANALYSIS

The inverter was loaded up to 900W by a mixture of three 200W and three 100W tungsten filament bulbs and the inverter still worked perfectly.

Table 4.2: Load analysis

Load (watts)	Current (ampere)
100	0.31
200	0.49
300	0.78
400	0.93
500	1.19
600	1.42
700	1.55
800	1.75
900	1.94

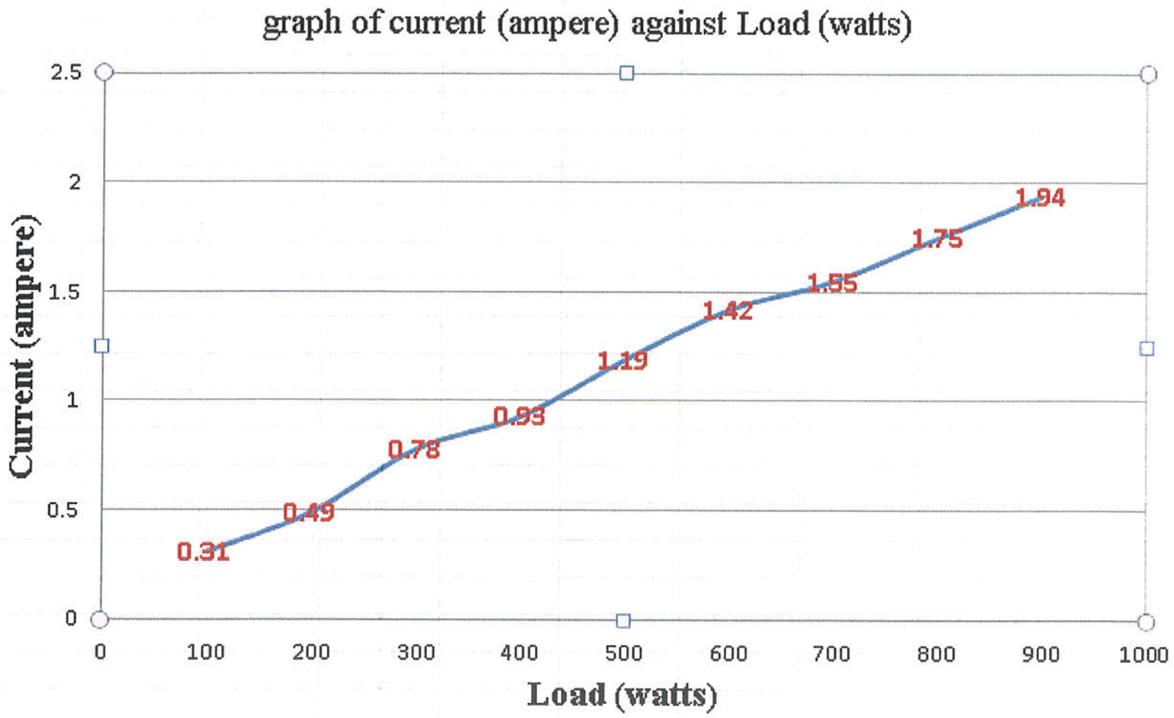

Fig. 4.5: Load analysis graph

From Figure 4.5 above, it is discovered that the current drawn for the inverter system is directly proportional to the load drawing the current which follows that it obeys the equation 1:

$P=IV$ .... (1)

When Voltage is constant, as P increases, I increase. Where P is the power, V is the Voltage and I is the Current

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In view of the inconsistent and unreliable public power supply and high cost of electric power generators coupled with the high cost of maintenance, the inverter is found to offer a better constant additional power supply for a sustainable duration. It is noiseless, harmless, and cost effective. It is also a means of power backup to a computer and other appliances because it automatically transfer (switches) to the battery when the AC mains is not available. Thus, reduce system breakdown, prevent hard disk damages and data loss. More so, the life span of the computers and other devices connected to either a standby or a continuous inverter is prolonged. The project which is the design and construction of 1.5kVA hybrid powered modular inverter trainer kit was designed based on some factors such as exposing of students to inverter modules, design economy, efficiency, compatibility and portability and also durability. The operation and performance of this project is solely depends on the user(s) who is prone to wrong handling, exposure to moisture. The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user should there be any system breakdown.

5.2 CONCLUSION

The purpose of supplying electricity is to meet the variable and instantaneous demand for electricity by wide and variety consumers at the most economic cost, and to satisfy consumers by a good standard reliability and quality typical in terms of voltage and frequency. It is obvious that the electrical energy supplied by the national grid to the consumers is inadequate and unreliable to overcome the challenges of the gigantic problems of power supply in the country. Hence, the need for new and alternative schemes in supplying power. The construction of this 1000Watts (1KVA), 220Volts inverter at a 50Hz frequency was a gradual process from gathering of materials to testing of components. It is to be noted that the efficiency of this project depends on the power rating of the battery connected to the input and on the total power of the load connected to its output terminals. Thus, the inverter could deliver constant power for a calculated number of hours.

5.3 PROBLEMS ENCOUNTERED

Following problems were encounter during the construction of the project

1. Transformer continuity test failed i.e. there was continuity between the coil and the laminations of the transformer.
2. Digital AC meter stop working during testing of the project
3. When the inverter was on charging mode, the cooling fan was making irrelevant sound.

5.4 SOLUTION TO THE PROBLEM ENCOUNTERED

1. The transformer laminations was readjusted and aligned
2. It was discovered that the capacitor of the Digital AC meter had been burnt. The meter was replaced with another one.
3. It was discovered that the cooling fan blade was scratching its body. The blade was properly aligned and part of its body was scrapped.

5.5 RECOMMENDATION

Although the objectives of this project have been achieved, the inverter cannot be used to power any device of higher power rating. In addition, when the inverter is operating on mains supply, any fluctuation of the AC input gets to the inverter output.

Therefore, for improvement on this project, further research can include; regulated output voltage, increasing the power rating of the inverter by increasing the number of the power switching devices and the current rating of the transformer.

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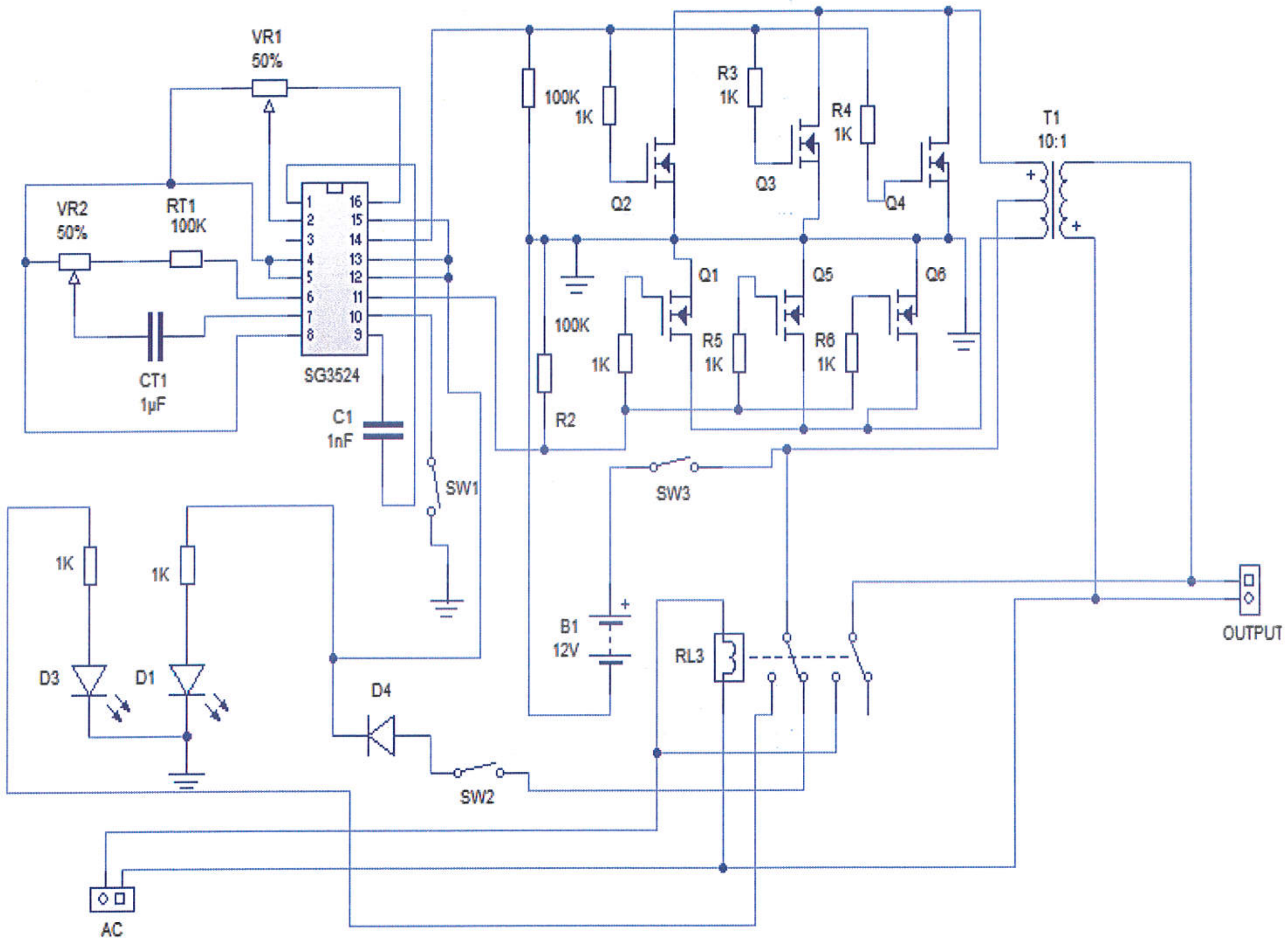
APPENDICES

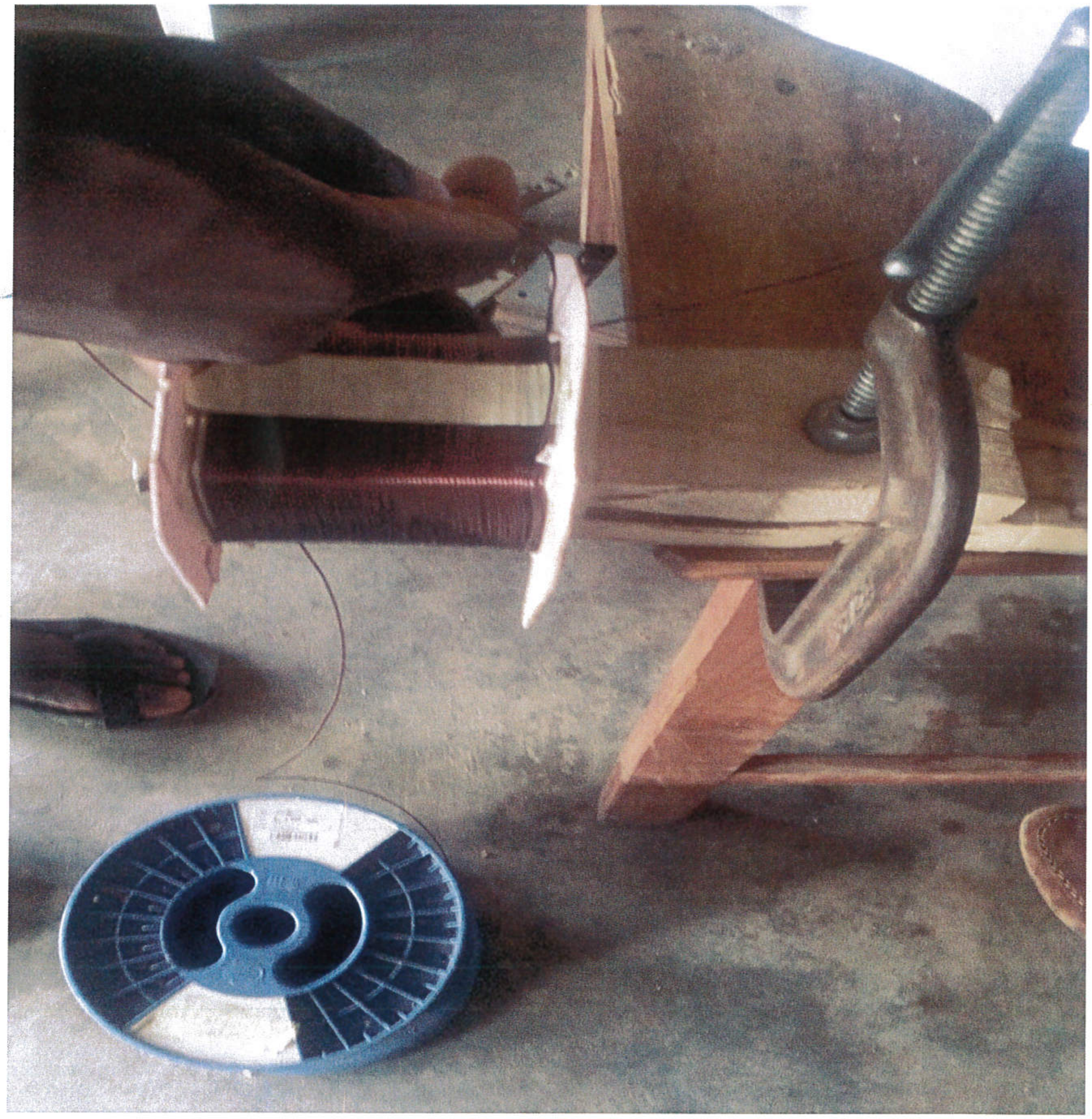
Appendix I

CIRCUIT DIAGRAM OF THE PROECT



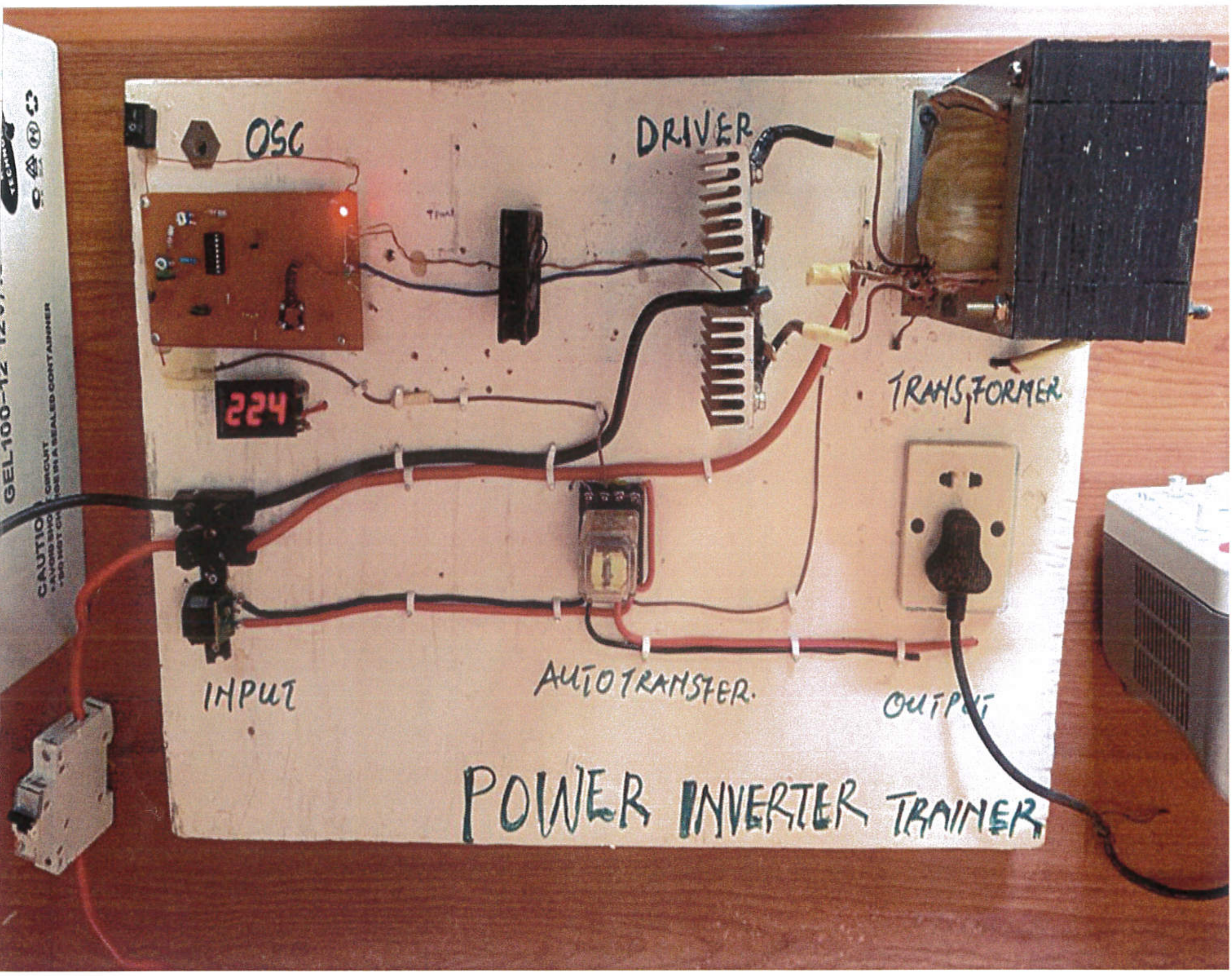
Appendix II

IMAGE OF TRANSFORMER WINDING



Appendix IV

IMAGE OF THE PROJECT UNDER TESTING



Appendix III

BILL OF ENGINEERING MATERIAL AND EVALUATION

S/N	COMPONENT	COMPONENT DESCRIPTION	QUANTITY	UNIT AMOUNT (₦)	TOTAL AMOUNT (₦)
1	RESISTOR (OHMS)	1K	6	10.00	60.00
		100K	3	10.00	30.00
		50K (VARIABLE)	2	10.00	20.00
2	CAPACITOR(F)	1u	1	10.00	10.00
		1n	1	10.00	10.00
3	IC	SG3524	1	250.00	250.00
4	SOCKET	IC SOCKET	1	50.00	50.00
5	MOSFET	IRFP260N	6	500	3000
6	DIODE	LED	2	20.00	40.00
		IN4001	2	20.00	40.00
7	SWITCH	SPST	1	50.00	50.00
8	FAN		1	250.00	250.00
9	AC RELAY	DPCO	1	2500.0	2500.0
10	METER	DIGITAL AC METER	1	1500.0	1500.0
11	CABLE CLIP		16	5.00	80.00
12	CABLE LUG		2	20.00	40.00
13	TRANSFORMER	CENTER TAP	1	20,000	20,000
14	BOARD	PCB	1	250.00	250.00
15	CHARGE CONTROLLER		1	12,000	12,000
16	OUTLET	TWIN SOCKET	1	250.00	250.00

17	SOLAR PANEL	150 WATTS	1	3,5000	3,5000
18	CONNECTOR	TWO WAYS	1	30.00	30.00
19	BATTERY	12V, 100AH	1	35,000	35,000
20	CABLE	$6mm^2$	20yards	250	5000
	Miscellaneous				10,000
	GRAND TOTAL				**125,460**