DESIGN AND CONSTRUCTION OF A 500VA UNINTERRUPTED POWER SUPPLY

BY

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CERTIFICATION

This is to certify that this project work titled 500VA Un-interrupted Power Supply was carried out by MUSA .C. HASSAN Reg. No 98/7075EE under the supervision of Engr. Jonathan Kolo for the award of Bachelor of Engineering (B. Eng.) in Electrical and Computer Engineering Department of Federal University of Technology Minna.

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DECLARATION

I hereby declare that this project work is a genuine one which was wholly designed and constructed by me under the supervision of Engr. Jonathan Kolo. Information derived from published and unpublished work of others has been acknowledged in the text.

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MUSA .C. HASSAN

....
Date

DEDICATION

This project work is heartily dedicated to my Late beloved sister Mrs. Augustina Emmanuel Mbah who ascended to glory on 17th Nov. 2003. It's been said "time heals all wounds" may be it will but not today because it still feels and hurts like it was only yesterday. Thank you for your magnanimity upon my family. Peacefully remain in the boson of the lord till we meet to part no more and may your gentle soul rest in perfect peace (Amen).

ACKNOWLEDGEMENT

First and always, glory be to God the king eternal, the all – knowing, the only wise God, the essence of my existence who put the stars, the moon and the sun in place and upholds the universe by the power of his word. Thanks daddy, for the undeserved favour, strength, talent, health and for loving me first throughout my academic pursuit.

I am most grateful to my project supervisor, Engr. J. Kolo for his selfless support, caring and understanding despite his tight schedule. You are the greatest supervisor in the world. I am equally grateful to my Head of Department, Engr. M.D. Abdullahi for his advice and normal support and all the staff of Electrical/Computer Engineering Department both Academic and non – Academic.

Then, I wish to express my profound appreciation to my elder brother Vincent who each day exceeds my expectation of what a brother and father should be. Thanks for the best time of our life in unity. There are many virtuous and capable Men in the world, but you surpass them all. You have passed through thick and thin even the weathered storm to single handedly carter for my academics both financially and motivationally. Words are not enough to express my hearty appreciation. May your reward be like the stars in the sky.

My immense acknowledgement to my parent Mr. and Mrs. E. Emmanuel who inspired me with confidence to carry on and thought me that I truly can do anything I put my mind to.

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I am indebted to my lovely sisters Hussaina (Christy) and Gambo (Priscilla) for their immeasurable support, for there is no friend like sisters in calm or strong weather. In

all you do, remain united and blessing will overflow. May every new sunrise bring you closer to your dreams.

Special shouts and thanks to:- Mr. and Mrs. Nicolas Pulife, Mrs, Agnes Ozor, Mr. Marcel Ezechi. A special hello to my Nieces, Nephews, Cousins, little Nkasi (the rising star). Engr. Yakubu Ibrahim Oscar, Engr. Sabastine Onyekpe, my project partner Alex O. Oformata, Mr. Emmanuel I. Obakpe the Manager Ami-Tech Computer Ltd Minna. Chikwado Manu Chairman Mandone Electrical Enterprises Minna. Rev. father Bartholomew and members of ST John Vianey Catholic Church Gawu - Babangida.

So many have been there before, during and throughout my career, if I have neglected to mention you, please blame it on my head or constraint space and not my heart. Because there is no me without you and my world is nicer because I share it with all of you!

ABSTRACT

This project report examines the possibility of creating alternate source of energy utility by means of low cost power electronic interface, (D.C. – A.C. inverter) ups. From experience, it has been observed that as many as one thousand variations can occur in less than 48 hours on electric main supply, hence the design of the ups interface which is capable of producing the required AC output which is not affected by input fluctuations. The method applied is based on PWM inverter which has high frequency switching with pulse width modulation and output filtering to provide stable final output voltage. The circuit is made up of a transistor full bridge circuit which provide a series of rectangular pulses of varying width via an output transformer and filter. The output transformer and filter components are relatively small because of the high frequency switching. The output voltage is $220V_{AC}$ at a frequency of 50Hz and output power of 400watt which is suitable for domestic applications. Low cost, high reliability and safety are essential design issues since the inverter is for residential use. Low weight, small size, high efficiency dynamic regulation and ability to cope with non linear loads are the advantages PWM ups has over other ups design.

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CHAPTER ONE

GENERAL INTRODUCTION

1.0 INTRODUCTION

In recent and rapid advancement in power system, computer engineering and electronic communication, it is observed that the main supply i.e. National Electric Power Authority (NEPA) is not reliable. This brought into sharper focus the need for an alternative source which will serve as a back up to the unpredictable power outage. There are very few seasoned pc users who have not suffered data corruption as a result of disturbances on the mains supply or even worse, complete loss of programmes from the mains (NEPA) blackouts, since the use of small computer and micro - electronics gadgets in offices and homes are increasing on daily bases.

Equally, inconvenient and sometimes more costly is the damage to equipment caused by very high voltage surges such as those caused by lightning strikes. As a minimum they can activate over voltage trips on equipment power units, at worst they can destroy banks of integrated circuits and basic components. Traditionally, equipment used in critical applications has been provided with backup system to give varying degrees of immunity, typical examples are hospital operating theatres, air traffic control centres, large scale data processing installations, industrial process controls, crude oil pumping stations, Banks, and secured voice and data communication systems. It is now possible with new technology providing highly reliable backup power at a reasonable cost for almost any requirement.

Power line disturbances. It has been station that as many as 1000 variations occur in less than 48 hours on mains supplies. Normally, these are of a minor nature and do not interfere with the operation of equipment.

However, typical severe disturbances which occur on power lines are summarized as follows:-

1. Voltage spikes and transients:- These are caused by lightning strikes, nearby switching of highly inductive loads, automatic tap changing and power factor correction. The characteristics of these disturbances are high voltage peaks up to 2kv, and even occasionally to 10kv, with nanoseconds leading edge, and less than 100μs duration

2. Line voltage sags and surges:- These are normally caused by switching ON or OFF a high power equipment on the same distribution circuit. Amplitude may be ± 60% and duration upto 1 mains cycle.

3. Brown out:- An unplanned voltage reduction below the power company's specification, lasting several cycles. It causes lights to dim momentarily and TV pictures and computer CRT displays to shrink or even disappear. Local supply overloads and storms are the main causes.

4. Blackout:- Total loss of power caused by damage to power lines during storms, and sometimes from faulty cables and substation equipment.

1.1 SCOPE OF THE PROJECT WORK

Basically, this project is based on OFF-Line system particularly the active (or hot) standby system. The power rating of the project is limited to 500VA and operating at a $220V_{ac}$, 50±0.05Hz strictly used on electronics gadget for long life span of the unit.

1.2 AIMS AND OBJECTIVES

The main objective of this project is to design and construct an uninterrupted power supply (inverter/change) which has the sole aim of providing an alternative power supply to home and domestic appliances, especially, in case where priority is to be given to information storage. The purpose of the inverter (ups) is to safeguard the associated consumer equipment from potential hazardous line voltage fluctuations.

Another objectives is to provide a means of having a steady cost effective, reliable uninterrupted power supply device, and to have a clear understanding of the working principle of an inverter/charger.

1.3 UPS SYSTEM

UPS is a term applied to an apparatus which is designed to give a continuous stable AC supply irrespective of variations and interruptions in the local mains electricity supply. It is sometimes used for AC/DC power units which have integral battery back-up for one or more critical DC outputs. For ups's a number of different system configuration, are used, and a number of very different technologies, but from the users point of view they can be broadly separated into two categories;

(1) ON-Line

(2) OFF-Line (standby).

1.3.1 On Line Systems

Here, the load always takes it's power from the output of a Dc/Ac inverter which in turn is powered from the output of a mains driven rectifier/charger. When the electricity supply fails, the back up battery supplies power to the inverter. During normal operation the battery is float charged from the rectifier output.

The two main advantages of this system are:-

(1) No break in the supply to the critical load during changeover between mains and battery power.

(2) The load only ever sees pure power from the inverter output and is totally isolated from mains fluctuations and mains borne noise.

On line ups's must be very highly reliable – there is no point introducing equipment between the AC supply and the critical load which is less reliable than the electricity supply. In the unlikely event that the rectifier inverter system fails, some ups systems have an automatic static by – pass switch to changeover to direct supply from the mains. To minimize transient effects on changeover the inverter waveform should be synchronized to the mains

1.3.2 Off-Line (Standby) System:-

In this case, critical load normally draws power directly from the mains electricity supply, and in the event of a mains failure, the output of a battery driven Dc/Ac inverter is automatically switched into supply power to the load. Mains failure would normally be defined as a drop in supply voltage to less than 85% of nominal value. Off line systems are normally less expensive than ON line ups because the inverter need not be designed thermally to run continuously at full rating. Also the rectifier is only required for battery charging, whereas in the ON line unit the rectifier has to be capable of supplying the inverter with full load power and float charge the battery at the same time. There are several different configurations of Off line systems, which are broadly categorized as, active (or hot) standby systems and cold system.

ACTIVE:- The inverter runs continuously and is synchronized with the mains. This gives fast smooth changeover from the mains to battery and allows continuous fault monitoring of the inverter during normal operation from the A.C. supply.

COLD:- In these systems the inverter is only switched on after the mains failure is detected, thus a short interruption of 1 or 2 seconds is likely. These systems can only be used for non critical applications where a short break in supply is not important, emergency lighting is a good example.

1.4 PRINCIPLE OF OPERATION

The basic principle of operation is based upon high frequency switching with pulse width modulation (PWM) and output filtering to provide stable final output voltage. PWM consists of a transistor from bridge circuit which provides a series of rectangular pulses of varying width via output transformer and filter. The output voltage is continuously compared with a constant amplitude, constant frequency reference sine wave generated by an internal stable oscillator. The error signal is used to control the width of the pulse train to maintain the output wave form. Because of the high frequency switching the output transformer and filter components are relatively small.

In normal operation when the mains is present, the load is powered by the mains via the change over circuitry/switch. The battery charger converts the AC supplied to DC which is compatible with the battery. The charger maintains the battery at constant voltage to ensure that the battery will have the capacity to support the load as often possible. This charging method, known as FLOAT charging, provide maximum battery service life.

On the other hand, a monitoring circuit is employed in order to detect the battery level. During utility failure, the battery provides inputs voltage to the inverter circuit. However, if the battery drains low the monitoring circuit shuts down the system automatically after a predefined period of time.

Advantages claimed for PWM ups systems are low weight, small size, high efficiency, good dynamic regulation and the ability to cope with non-linear loads. The disadvantage is that the circuitry is complex and component stresses are high because of high power switching.

Shown below is the block diagram and flowchart of a typical ups system.

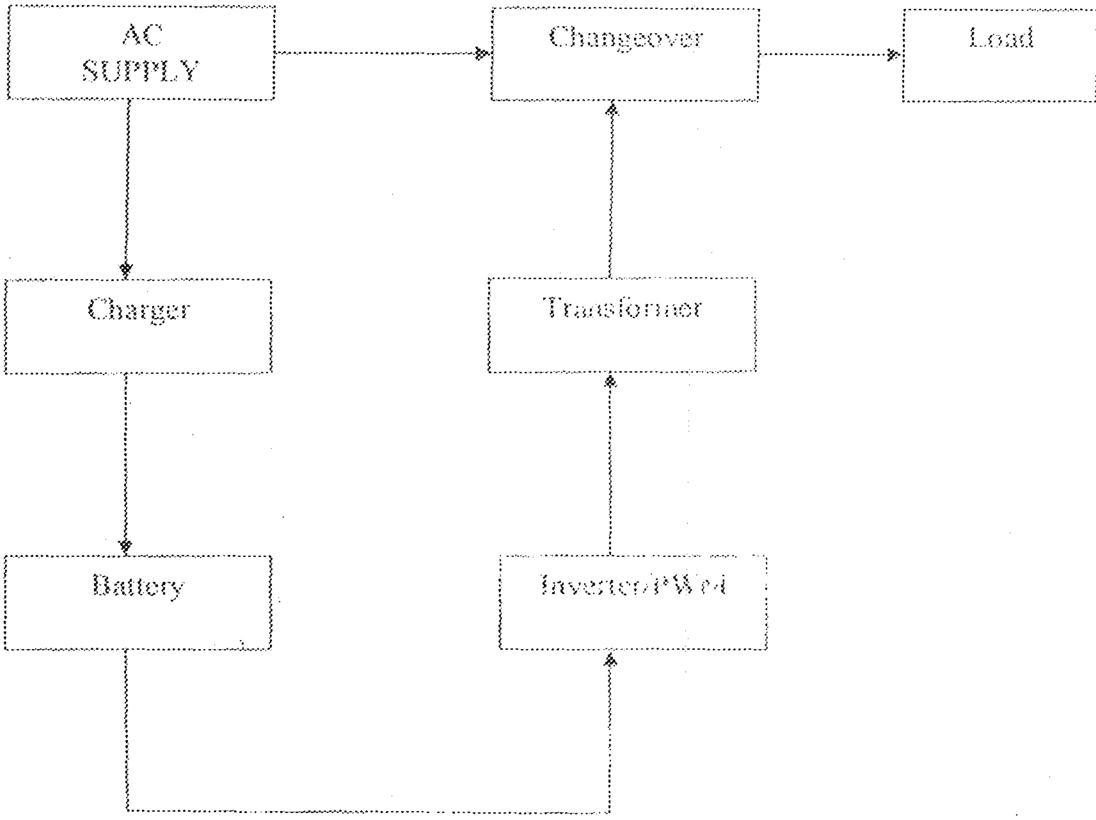


Fig. 1.1 Block diagram of an UPS

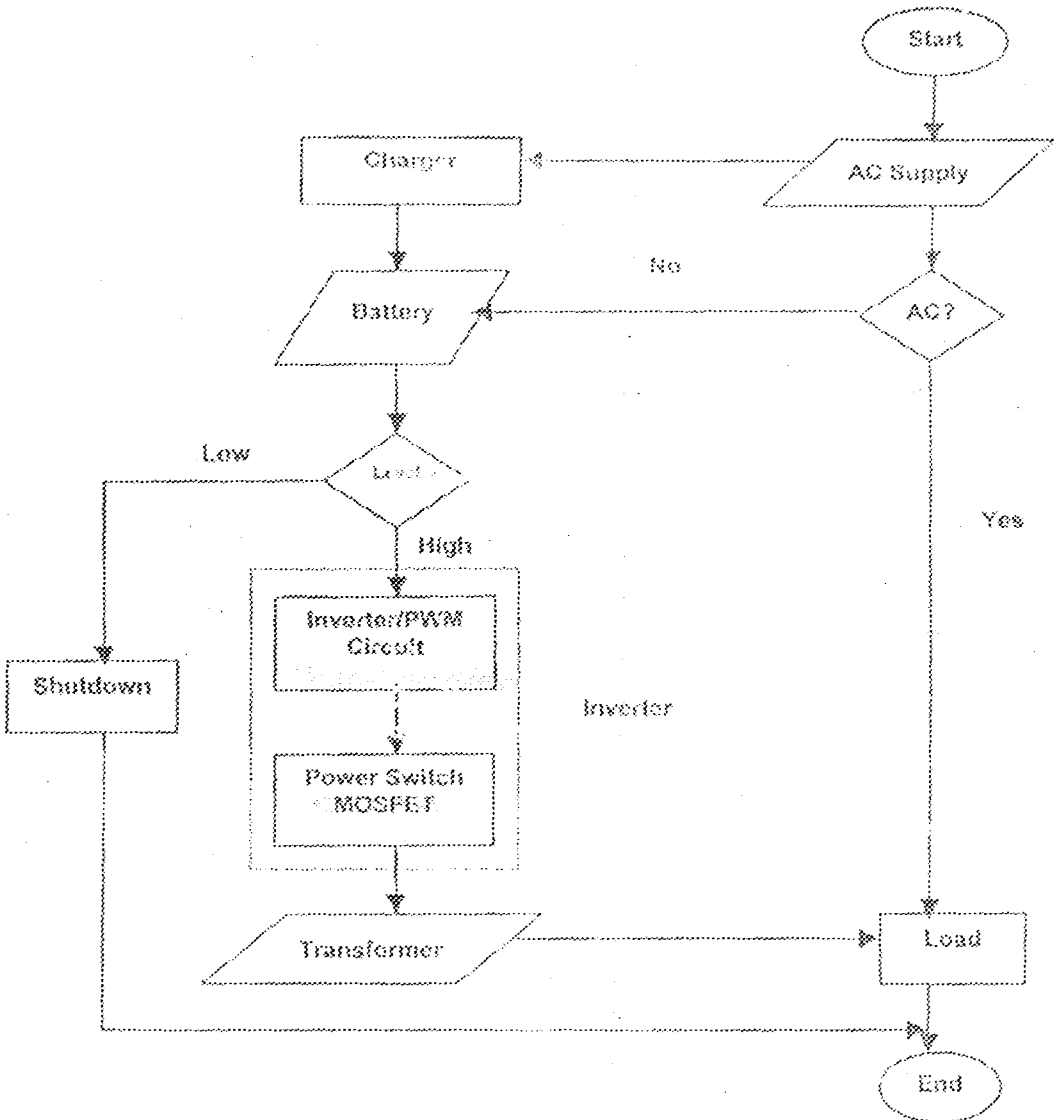


Fig 1.2 Flowchart diagram of typical UPS

1.5 LITERATURE REVIEW

The inverter (ups) systems are intended to improve the quality of a.c. power in order to provide uninterrupted operation of a.c. powered equipment. To accomplish this function, an uninterrupted power supply takes in normal quality alternating current power and provides three enhancements which are stipulated below:

- Power quality improvement
- A redundant (backup) power source
- A regulated supply voltage

Project report of inverter Design for 2002 future Energy challenge by Student teams as follow: Duy, BIU, Nancy Saldbana, Bassem Khoury, Steve pugh, Joy Mazumdar, and Manasi Soundalagekar from college of engineering and computer science, University of central Florida, Orlando. In their report dated 15th January 2002. For a design of a high power density, 10kw inverter circuit, is presented for conversion of energy from D.C. fuel cells to A.C power to be used mainly for domestic utility applications. The configuration is achieved using a high frequency D.C to D.C push-pull converter at input side followed by a full bridge PWM inverter and a low power filter at the output side. Due to the simplified power stage and the application of digital signal processing (DSP)-based sinusoidal pulse width modulation technique output voltage. Total Harmonic Distortion (THD) is reduced and a relatively smaller overall inverter size is achieved. The practical circuit operates from a 48V D.C fuel cell input, and output a regulated 120V AC with a frequency of 60Hz sinusoidal voltage having 3-wire configuration. A low power inverter has been redesigned tested and prototyped to deliver a 1.5KW load.

The inverter/charger is a system that ensures continuous supply of power (electrical) when there is an outage by conversion of DC which is drawn from a secondary cell. The inverter/charger consists of four sections, the inverter, the battery, the rectifier/charger and the electromechanical relay switch. The inverter receivers the D.C. power supply from the battery to the circuit and does the inversion from d.c. to a.c., the battery stored the d.c. power that is being used by the inverter, to convert the stored d.c. charges by the aid of the relay switch to A.C. to automatically alternate whenever needed.

1.6 PROJECT OUTLINE

The inverter (ups) unit designed in this project is made up of four sections.

This report opens with general introduction in chapter one. Chapter two and three deal with design and analysis (the major sub – units making up the system), and the construction, testing and discussions of results. Then chapter four finally discusses the recommendations and conclusion.

CHAPTER TWO

ANALYSIS AND DESIGN

2.1 THE TECHNOLOGY

A number of alternative technologies are in use to implement the inverter section which may be regarded as the heart of ups system. The essential circuit element in a static inverter was originally the SCR and these are still in frequently use in 10KVA plus systems. They have now been largely replaced in sub 10KVA systems by bipolar power transistors and more recently by MOSFET transistors, and very recently by GTO thyristors.

The simplest and least expensive ups provides a square wave output at mains frequency. However these are not suitable for many applications, especially where the load is highly reactive. They are usually unable to supply the high peak current pulses demanded by a switched mode power supply without very severe power derating.

Some improvement of performance can be obtained using inverters with stepped square waves. With sufficient steps, performance can approach that of pure sine wave inverters especially if output filtering is employed to get rid of the worst harmonics.

There are basically five types of inverter in use.

1. The voltage source inverter
2. the current source inverter.

The most commonly used is the voltage source inverter (VSI). It is further divided into:

(i) voltage source inverter with fixed DC link

(ii) voltage source inverter with variable D.C. link.

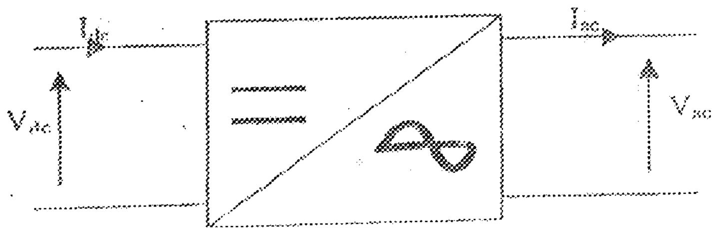


Fig. 2.1 General block diagram of an dc/ac inverter

Voltage source inverter (VSI) with fixed D.C – link.

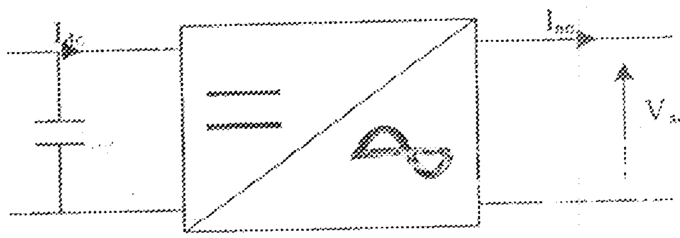


Fig. 2.2 Voltage source inverter (VSI) with fixed D.C. link

The VSI with fixed D.C. – link utilizes the PWM concept of switch. This is the actual type of inverter used for this project work.

The following are it`s characteristics

- The DC voltage is uncontrollable and held constant.
- The output voltage amplitude and frequency are varied simultaneously using PWM technique.
- Good harmonic and control, but at the expense of complex waveform generation.

Voltage source inverter (VSI) with variable D.C. link

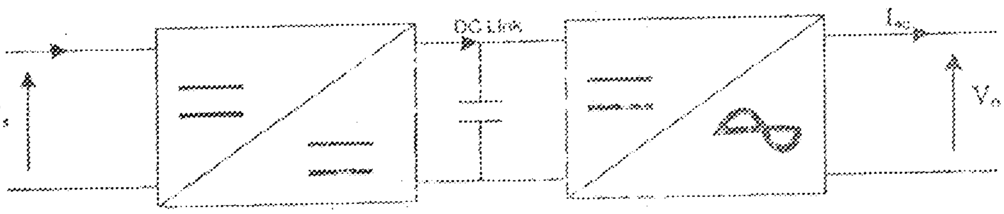


Fig. 2.3 Voltage source inverter VSI with variable D.C. link.

It has the following characteristics:

- the D.C. link is controllable and this varied by a DC to DC converter or controlled rectifier
- it generates square wave as output voltage
- the output voltage amplitude is varied as D.C. voltage
- frequency of the output voltage is varied by changing the frequency of the square wave pulses.

The advantages of this type of inverter are:

- simple waveform generation
- it has high degree of reliability

2.2 INVERTER DESIGN

The Inverter consists of three subunits: the modulated signal generator, Pre-amplification/amplification and the Transformer. Fig. 2.2 shows the block diagram.

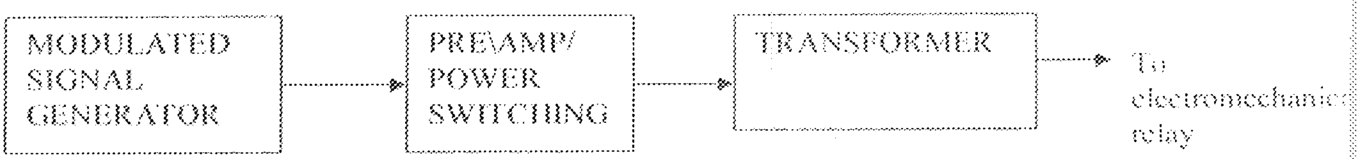


Fig. 2.2

2.2.1 MODULATED SIGNAL GENERATOR

The modulated signal generator comprises of 555 Timer and 4027 CMOS dual JK Flip-Flop. The 555Timer is configured to operate in an astable mode for the generation of a non-sinusoidal wave of duty cycle greater than 50%.

Internal structure of 555 Timer and its Mode of Operation in Astable Mode

A 555Timer configured to operate as an astable multivibrator, which is a free running non-sinusoidal oscillator is shown in fig. 2.3a while the internal structure with the external component is shown in fig. 2.3b. The external components, R_1, R_2 and C_1 form the timing network that set the frequency of oscillation. The 0.01µf capacitor C_2 connected to control (CONT.) input is strictly for decoupling and has no effect on the operation.

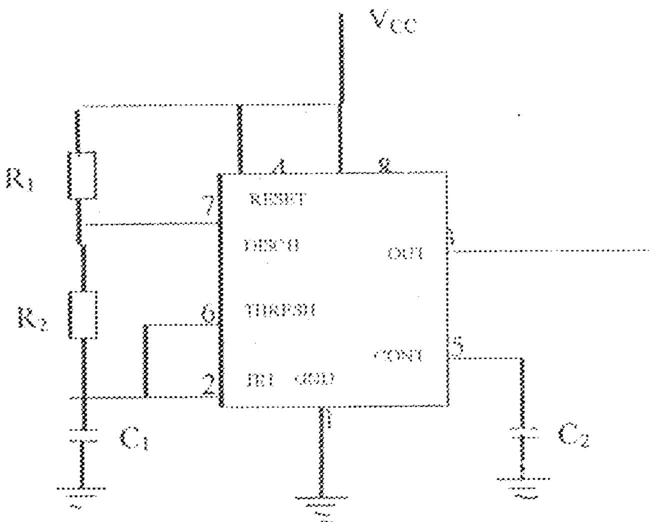


Fig 2.3a

Initially, when the power is turned ON, the capacitor C_1 is uncharged and thus the trigger voltage (pin 2) is at 0v. This causes the output of comparator B to be HIGH and the output of comparator A to be LOW forcing the output of the latch and thus the base of

Q_1 LOW and keeping the transistor OFF. Now C_1 begins charging through R_1 and R_2. When the capacitor voltage reaches $\frac{1}{3}V_{CC}$, comparator B switches to its low output state and when the capacitor voltage reaches $\frac{2}{3}V_{CC}$, comparator A switches to its high output state. This RESETS the latch, causing the base of Q_1 to go high and turns ON the transistor. This sequence creates a discharge path for the capacitor through R_2 and the transistor. The capacitor now begins to discharge, causing comparator A to go LOW. At the point where the capacitor discharges down to $\frac{1}{3}V_{CC}$, comparator B switches HIGH, the SETS the latch, which makes the base of Q_1 LOW and turn OFF the transistor. Another charging cycle begins and the entire process repeats. The result is a rectangular wave output whose duty cycle depends on the value of R_1 and R_2.

The time that the output is HIGH (t_H) is how long it takes C_1 to charge from $\frac{1}{3}V_{CC}$ to $\frac{2}{3}V_{CC}$. It is expressed as

$$t_H = 0.7(R_1 + R_2)C_1$$

The period "T" of the output wave is the sum of t_H and t_L.

$$T = t_H + t_L$$

$$= 0.7(R_1 + R_2)C_1 + 0.7R_2C_1$$

$$= 0.7(R_1 + 2R_2)C_1$$

$$\text{Frequency of oscillation } f = 1/T = \frac{1}{0.7(R_1 + 2R_2)C_1}$$

$$= 1.44/(R_1 + 2R_2)$$

In this project, the value of R_1, R_2 and C_1 are such that the frequency of oscillation is 200Hz

Let $R_1 = 18K$

$R_2 = 27K$

$C_1 = 100nF$

$$F = \frac{1.44}{(R_1 + 2R_2)C_1}$$

$$= \frac{1.44}{(18+54)\times10^3\times100\times10^{-9}}$$

$= 200Hz$

The duty cycle of the signal generated by the 555 Timer is always greater than 50%

Function of 4027 Dual JK Flip Flop

In this circuit, the J-K flip flop serves two purposes, viz

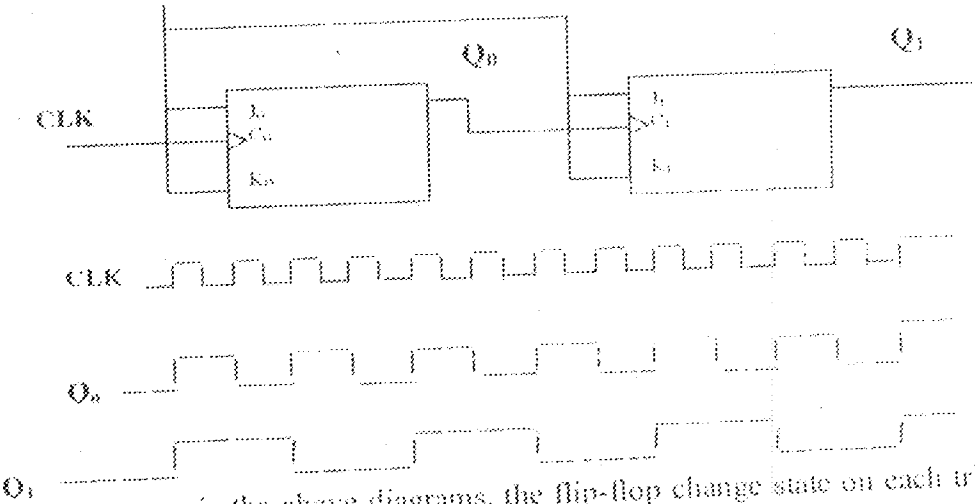
(i) Pulse width modulation.

(ii) Frequency division

The 4027IC is a J-K flip-flop that outputs a square wave of duty cycle 50 percent independent of the duty cycle of the input waveform. As in this design, the duty cycle of the waveform generated by 555 Timer IC is greater than 50 %. When this waveform is supplied to the 4027IC, it will then output a waveform with duty cycle 50 percent.

Another application of the J-K flip-flop that is utilized in this project is its ability of dividing (reducing) frequency. This IC (4027) is a dual (master-slave) flip-flop. Each of the flip-flop divides the frequency of its input by two. This with two of them cascade, the frequency of the input waveform will be divided by four.

The diagram of arrangement of the two flip-flops and the corresponding wave waveform is shown in fig 2.4a and 2.4b respectively.



As we can see in the above diagrams, the flip-flop change state on each triggering clock edge (positive edge-triggered in this case). Also from the waveform, the output frequency of the first flip-flop is half the frequency of the original clock Pulse. When the output of the first flip-flop is connected to the clock input of the second flip-flop, this then outputs a waveform of half the frequency of its input, thereby dividing the original clock frequency by four. The functional diagram and tables of the 4027 IC JK flip-flop are as shown in fig 2.5a and tables 2.Ia and table 2.1b respectively.

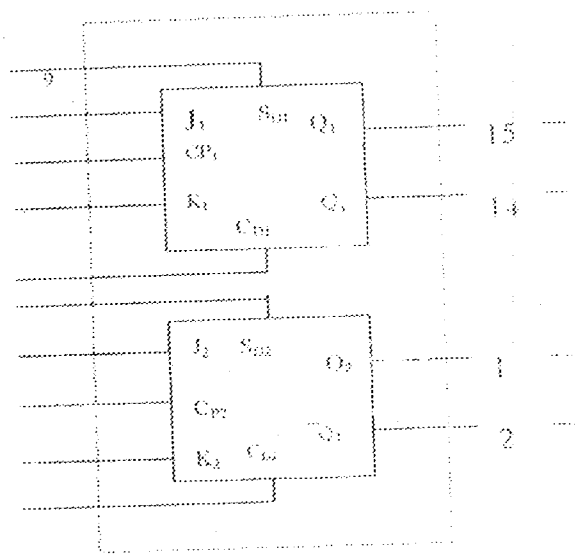


Fig. 2.5a

Table 2.1a

INPUTS					OUTPUTS	
S_D	C_D	C_P	J	K	Q	$\bar{Q}$
H	X	X	X	X	H	L
L	X	X	X	X	L	H
H	X	X	X	X	H	H

Table 2.1.b

INPUTS					OUTPUTS	
S_D	C_D	C_P	J	K	Q_{n+1}	$\bar{Q}_{n+1}$
L	L	↑	L	L	No Change	
L	L	↑	H	L	H	L
L	L	↑	L	H	L	H
L	L	↑	H	H	$\bar{Q}_n$	Q_n

Pinning

JK Synchronous Input

CP Clock Input (L to H edge triggered)

S_D Asynchronous set-direct Input (active High)

C_D Asynchronous clear-direct Input (active High)

Q True output

$\bar{Q}$ Complementary output

2.2.2 BUFFER (PRE-AMPLIFICATION) AND POWER SWITHING

To design the buffer and power switching circuit, it is more convenient to design from the power switching back to the buffer.

For a particular transistor to be used as a power-switching device, it has to posses some qualities that will make it suitable for the switching work. It must at least posses the following qualities:

1. It must be able to withstand certain amount of voltage
2. It must be able to carry a certain amount of current.
3. It must have a high switching speed.

Before choosing a transistor, we need to know the voltage and current that the transistor is supposed to carry.

Considering the output of the inverter in design with the output power and voltage of 500W and 240V respectively, we can determine the current and voltage that the transistor should be able to withstand as follows:

Power 'P' = 500W

Voltage 'V' = 240V

Output Current I_2 = P/V = 500/240 = 2.08A

Now, assuming that the efficiency of the transformer is 90%, then the input power to the transformer is given as:

$P_{in} = 500 \times 100/90$

$= 555.56W$

Then $I_{in} = I_1 = P_{in}/V_{in}$

$= 555.56/12$

$= 46.296 = \underline{46.3A}$

On the primary side of the transformer, there are five transistors connected in parallel, therefore the current (collector current) that is to be carried by each of the transistor is given by

$I_C = I_1/5 = 46.3/5 = 9.26A$

Also each transistor must be able to withstand a collector voltage of twice the peak battery voltage

$V_C = 2\sqrt{2} \times 12 = 33.94V$

Now, the transistor to be used must be capable of carrying a collector current greater than 9.26A and collector voltage greater than 33.94V. Hence the transistor 2N3055, which has a maximum collector current of 15A and maximum collector to emitter voltage (V_{CE}) of 60V is suitable for the inverter power switching. Therefore 2N3055 transistor is chosen.

For a transistor to "ON" the relationship

$I_B > I_C/\beta$ must be satisfied.

From ECG book, h_{FE} (which is β) for the transistor is equal to 40

$I_C = 9.26A$

$\therefore I_B > I_C/\beta$

$> 9.26/40$

>0.23

now let I_B 0.24A

but $I_{B1} = I_{B2} = I_{B3} = I_{B4} = I_{B5}$

$\therefore I_C' = I_{B1} = 5 \times 0.24$

$= 1.2A$

The parallel connection of the five power transistors are as shown below

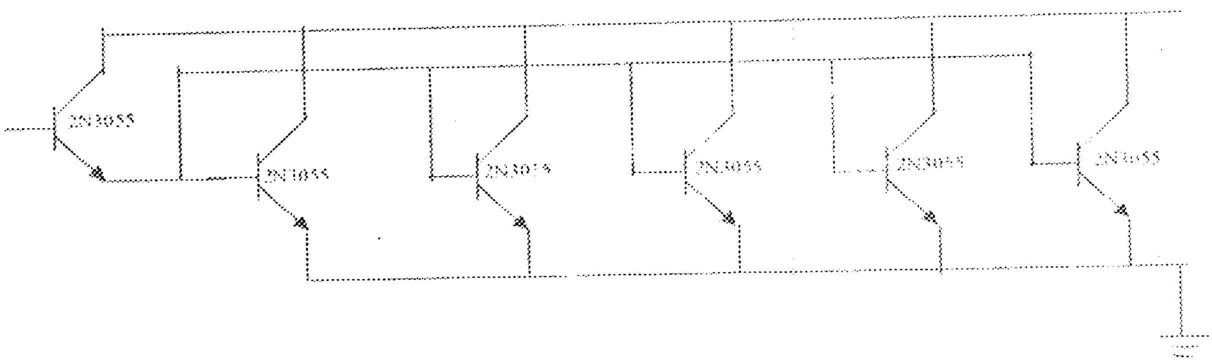


Fig. 2.6

For a push-pull inverter, it is made of two switches arranged adjacent to each other. These two switches do not switch "ON" at the same time rather they alternate. The other side of the switch is the same as the one above

Buffer (Pre-Amplifier)

The buffer circuit used in this project is the darlington transistor which is made up of two dissimilar transistors hooked together. For a darlington transistor, the combination tends to act like a rather slow transistor because Q_1 cannot turn off Q_2 quickly. This problem is taken care of by including a resistor from base to emitter of Q_2. Also a resistor is connected between the collector of Q_1 and of Q_2 to prevent leakage current throughQ_1 from biasing Q_2 into conduction.

The resultant diagram of the buffer circuit used in this project is as shown below.

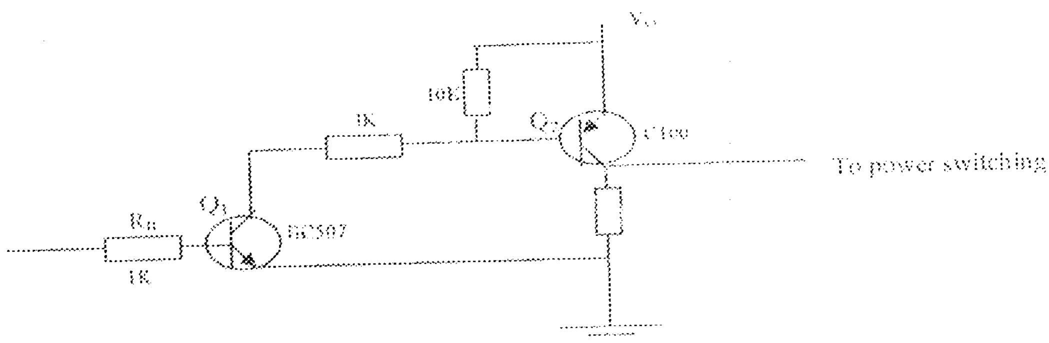


Fig 2.6

2.2.3 TRANSFORMER DESIGN

The inverter design type used in this project is the push-pull configuration. This configuration requires two input signals to the switching transistor at 180° out of phase, which is applied, to the two halves of a center-tapped transformer.

It is assumed that the output from the transformer flows continuously. With this assumption, when the 180° out of phase signal flows, switch T_1 closes and T_2 opens, current flows in the upper half of the primary winding and induces current in the secondary coil. In the second half cycle, T_2 closes and T_1 opens, current flows in the lower half of the primary winding coil and induces current in the secondary coil.

The diagram for this arrangement is as shown in fig. 2.7 below

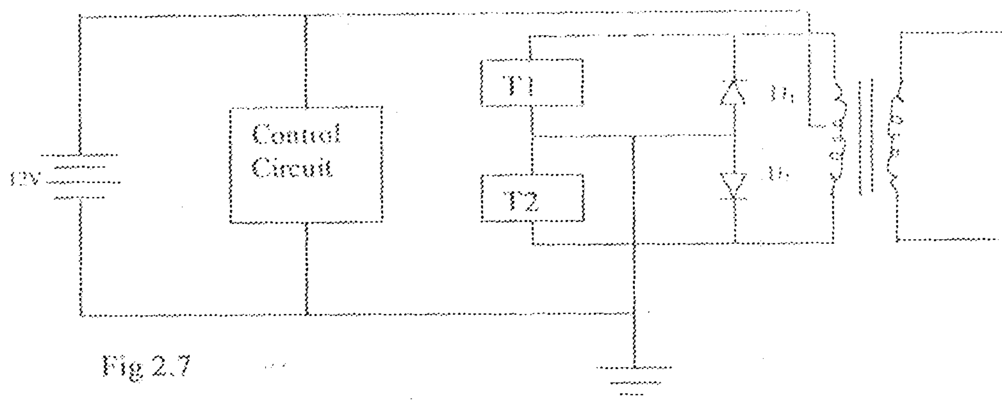


Fig 2.7

The reason for employing push-pull configuration is to minimize power loses. When a switching occurs at the primary of the transformer, the voltage shifts from one half of the primary winding to the other half. This therefore requires good magnetic coupling between the two half winding of the primary in order to reduce energy losses associated with leakage inductances of the primary winding. This issue was well taken care of in the design of the transformer. The diodes D_1 and D_2 across the switch in the push-pull configuration serves to return inductive energy back to the supply bus.

Therefore, regardless of the value of output current from the transformer, the output voltage is given by

$$V_o = \frac{M_s V_{dc}}{n}$$

Where:

n = the tansformer turns ratio.

M_s = modulation factor or power of the input signal, which is one for a square wave inverter (M_s = 1)

V_{dc} = 12V, battery.

For this inverter,

Power = 500W

Primary Voltage, V_p = 12V

Secondary Voltage, V_s = 240V

J = 200cm/A (j = operating current density), j ≤ 200cm/A from the manufacturer's data for wire size material.

K = 4.0 (for push-pull configuration)

Frequency = 50Hz

Primary current, $I_p = P/V_p = 500/12 = 41.67A$

Secondary Current $I_s = P/V_s = 500/240 = 2.08A$

Wire size for primary = $I_p \times J = 41.67 \times 200 = 8334cm$

From the wire specification chart, the gauge is AWG 10

Wire size for secondary = $I_s \times J = 2.08 \times 200 = 416cm$

From the wire specification chart, the wire gauge is AWG23.

Selection of core size:

$$\text{Core sile, } A_eA_c = \frac{(0.68 P_o J) \times 10^3}{freq. \times B_{max}}$$

Where: A_cA_e = core effective area in cm^4

B_{max} = Maximum flux density (given as 12000G at 240Vac)

Therefore:

$$A_cA_e = \frac{0.68 \times 500 \times 200 \times 10^3}{50 \times 12000} = 113.33cm^4$$

From the manufacturer's data sheet, a transformer core size is selected with A_c =16cm^2.

A_e = 10cm^2.

Number of turns in primary

Assuming 4turns per volt, the primary winding Np which takes 12V, will have:

$N_p = 12 \times 4 = 48$turns.

Since the primary is a centre-tapped, there will be a total of (2×48) 96turns in the primary with the centre-tapped at the middle of the coil.

To find the number of turns of the secondary.

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

where: N_p = number of turns of the primary winding = 48

N_s = number of turns of the secondary winding = ?

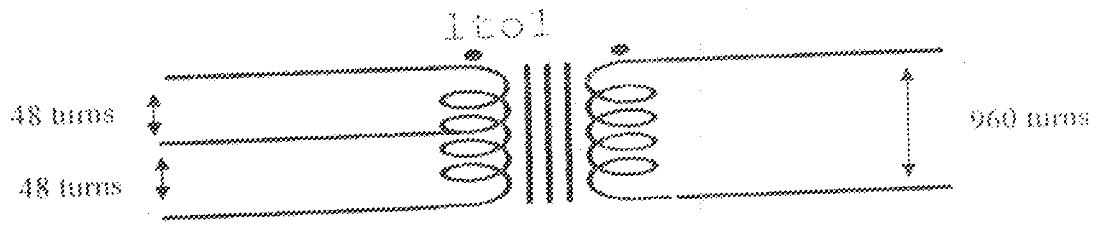
V_p = voltage at the primary = 12V

V_s = voltage at the secondary = 240

$\therefore N_sV_p = N_pV_s$

$$N_s = \frac{N_pV_s}{V_p} = \frac{48 \times 240}{12} = 960$$

$\therefore N_s$ = 960turns.

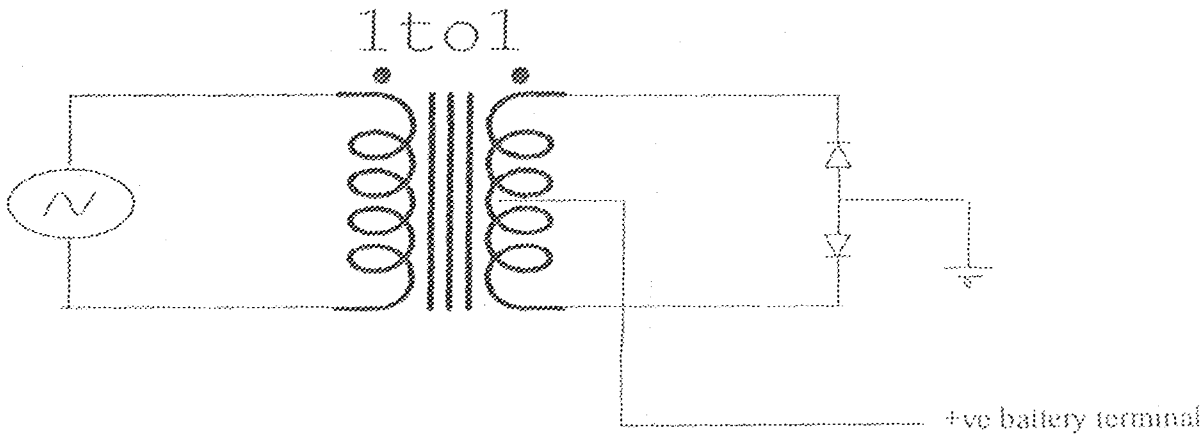


2.3 THE CHARGER.

To make the battery operative, it must be charged, i.e. an electric current must be passed through the battery. When a d.c current supplied by external power source flows through the battery, a chemical process takes place inside it as a result of which, the lead sulphate on the plate connected to the positive terminal of the power source changes to spongy lead gradually as the acid leaves the plate and returning to the electrolytes, thus increasing its density.

2.3.1 THE CHARGER CIRCUIT.

The charger circuit is a rectified power source, which supplies a dc voltage to the battery for charging. This consists of a step-down transformer and rectifier diodes. The circuit diagram is as shown below.



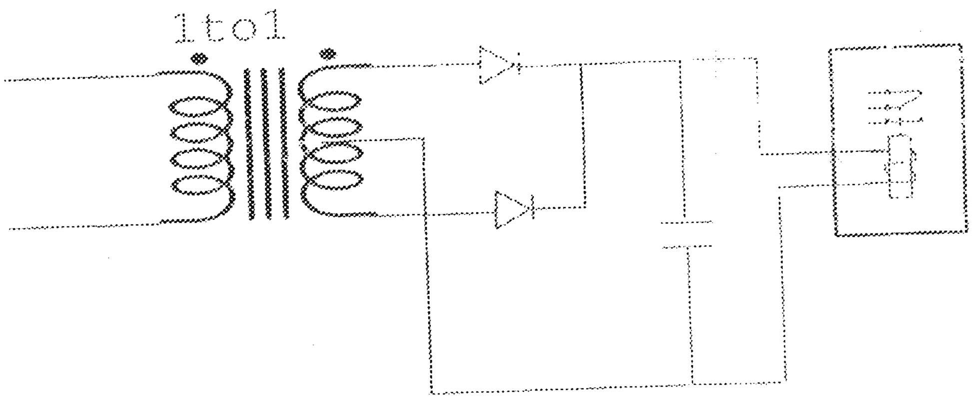
2.3.2. MODE OF CHARGING.

The mode of charging used is the constant voltage method; a constant voltage is applied to the battery terminals. Initially a heavy current will flow through the battery when charging an already discharged battery and gradually the current reduces as the battery is being completely charged.

2.4 CHANGE – OVER RELAY SWITCH.

The reliability of an inverter be it standby or online, is its ability to continue to supply power uninterruptedly when there is power outage from the mains. On this note, an electromechanical automatic relay switch is employed which performs the function of switching from mains supply to the inverter and vice versa. The switching operation is expected to be done substantially in less than 50 microseconds, without much transient noise during the switching.

The electromechanical relay switch is energized with a 12v dc. The 12v dc is received from the output voltage of a full wave rectifier. The circuit diagram is as shown below:



Three pieces of single pole/double throw (SPDT) cascaded in parallel are used for the switching process.

CHAPTER THREE

CONSTRUCTION AND TESTING

3.1 INTRODUCTION

The construction and testing of the equipment inverter/ charger as analyzed and designed in the previous chapter is dealt with in this chapter. This work is done step-wise. Each of the main building blocks is constructed and tested one after the other.

3.2 CONSTRUCTION

The circuit was first simulated with the computer with the use of circuit maker before construction on breadboard. The circuit was then after tested satisfactory transferred to vero board where it is left as the working circuit. The working circuit of the inverter/ charger is as shown in page…

3.2.1 MODULATED SIGNAL GENERATOR

The modulated signal generator was made up of two ICs, the 555 Timer and 4027 dual J-K flip flop. The 555 Timer was configured to operate in an astable mode to generate a square wave. The output of the timer is then connected to the input of the 4027 dual J-K flip-flop.

The ICs were both first connected and arranged on the breadboard with their associated resistors and capacitors. The unit was then powered with 12V battery through 7805 regulator. This unit was then after powering, tested for its frequency with use of digital multimeter. After the test, it was then dismantled and soldered onto the vero board.

3.2.2 PRE- AMPLIFICATION/ AMPLIFICATION

The pre- amplification (also known as buffer) circuit was constructed using BC 547 and BC 558 which were arranged as a Darlington transistor for high current gain. Power transistor 2N3055 was used as the power amplifier. They were properly arranged on the breadboard and the signal generator was connected to it and the output was tested. After tested satisfactory, the preamplifier circuit was soldered to the Vero board while the power amplifier was mounted on a heat sink.

3.2.3 VOLTAGE TRANSFORMATION UNIT

With reference to the transformer design, the transformer was connected to the circuit after the design and the performance was noted. When it was tested satisfactory, it was then permanently screwed to the casing and the terminal properly connected where they are supposed to be connected.

3.3 IMPLEMENTATION

The implementation of this project was done on the bread board. The power supply was first derived from a bench power supply in the laboratory to confirm the workability of the circuit before the power supply stage was soldered to the Vero board. Stage by stage testing was carried out according to the block representation on the breadboard before soldering of the circuit commenced on the Vero board. The oscillator, the driver, the charger and the changeover stages were bread boarded respectively.

3.4 CONSTRUCTION TOOLS USED AND SOLDERING PROCESS

Some of the construction tools used during the construction work are as outlined below

1. Bread board and insulated copper wire; these were used to mount and connect components in building a proto type model for testing design modification.
2. Vero board; this was where the working circuit was finally mounted and soldered permanently.
3. Soldering iron and lead; a 40W soldering iron and lead were used in soldering the entire component on board.
4. Side cutter; this was used in cutting wire to appropriate length and for the cutting the legs of components to prevent short circuit.
5. Suction tube; this was used to suck de-soldered lead away from unwanted area.
6. Digital multimeter; this device was used to for continuity during construction

3.5 SOLDERING PROCESS

Each time a component is to be soldered, its leg is first cleaned with the use of razor blade. It is then inserted into the hole on the vero board and heart is applied through the soldering iron to one side of the leg of the [illegible] heat is enough to melt component the melted lead is then allowed to dry.

3.5.1 PRECAUTION

In the construction work certain precautions were taken which made it possible that the work is successful. Some of the precaution are as stated below

1. Care was taken to ensure that the heat supplied to the soldered components during soldering was not too much for the component to withstand as too much heat could damage the component.
2. An IC socked was soldered on the vero board with the IC inserted into it after soldered rather then soldering the component directory onto the board. This habit ensures that the IC pins are not damages during soldering.
3. It was ensured that no power was supplied to a circuit while no reading is being taken in order to reduce power consumption.
4. Proper care was taken to ensure that the correct polarity of polarized component such as electrolytic capacitor were soldered together.
5. All components were properly soldered, to the vero board to avoid shorting of component legs, shorting and opening of circuit
6. Heart sink was used to the mount the power transistor in order to absorb heat dissipated otherwise the transistor will burn.

3.6 TESTING OF COMPONENT

Each of the constituting units of the device being constructed was simulated one after the other before being tested on project board and then finally soldered to the vero board. In testing the output of the charger, I made sure that the voltage was 12. 5V, which is the ***charger voltage, with reference to the variation of the ac applied input voltage.*** Using a digital multimeter, when a load of 1KΩ was connected to the output of the charger, the output current was measure as 1500A approximately

Likewise, it was tested and made sure that the output frequency of the signal generator was 200Hz and also observed that the flip-flop divided the frequency by four giving 50Hz

The results obtained during testing are given below

- Used charger voltage-12. 5V
- Used ac input voltage = 220V
- Charger current=1500ma at RL= 1KΩ
- Output frequency of signal generator= 200Hz
- Output frequency of flip flop =50Hz
- Output inverter voltage=220V

3.7 DISCUTSSIONOF RESULT

The voltage of the inverter before transformer step-up was approximately 13V ac, which is due to the battery being fully charged. However, the output of the inverter was greater than 200V but less than 220V.

A bulb of 60w (as load) was connected to the output of the inverter to indicate the result and it was bright. Nevertheless, the more the load was added the more the voltage drops. If the battery is fully charged it will give a longer duration. However the higher the capacity of the battery, the longer the duration of the load.

3.8 PROJECT CASING

The entire circuit was housed in a wooden casing. A wooden casing was preferred to others (such as plastic and metal) for reason of ability to with stand heat, lightness and conductivity the cable and other outlet slit were made at the side to allow air flow-ventilation.

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The design and construction of inverter/charger has been presented in the previous chapters. The device is designed to be used as a dc inverter as well as battery charger. It is also designed to be used as a back up power supply to an equipment in which case it is known as uninterrupted power supply. The device consists of four basic units:

1. The rectifier and charger unit, which converts the incoming ac mains into dc, which is, used to charger the battery.
2. The battery unit, which is used to store energy in readiness for power failure. Invariably, the battery is used to power the inverter circuit. The larger the battery capacity, the more the equipment can stay on battery power before shutting down.
3. The Inverter unit, which converts the dc power of the battery into an ac power for the load. The inverter is switched on and draws power from the battery when the ac mains fail.
4. A static relay switch unit, which is responsible for switching the output from ac mains to inverter and vice-versa.

4.2 RECOMENDATION

Since the field of electronics remains ever dynamic, it is always very possible, with no limitation to modify the design and construction of any electronics devices for better performances. In view of the above statement, some recommendations are herby made:

i. Incorporation of an automatic voltage regulator (AVR) system in the project design which automatically adjust the mains input to correct under-voltage (and some times over-voltage) without having to draw on the precious battery reserves.

ii. In the project design, an integral microprocessor could as well be incorporated which, constantly monitors the quality of the mains supply, ensuring virtually instantaneous correction in the event of any power deterioration.

iii. A surge protector could as well be incorporated in the project design to trim the ac mains in the event of very high over-voltage of short duration.

iv. It is highly recommended in this project that the relay switch need to be replaced with the one that is faster than the one incorporated in this project.

v. For effective capacity of the battery, the electrolyte in the battery needs to be replaced at least once in six months.

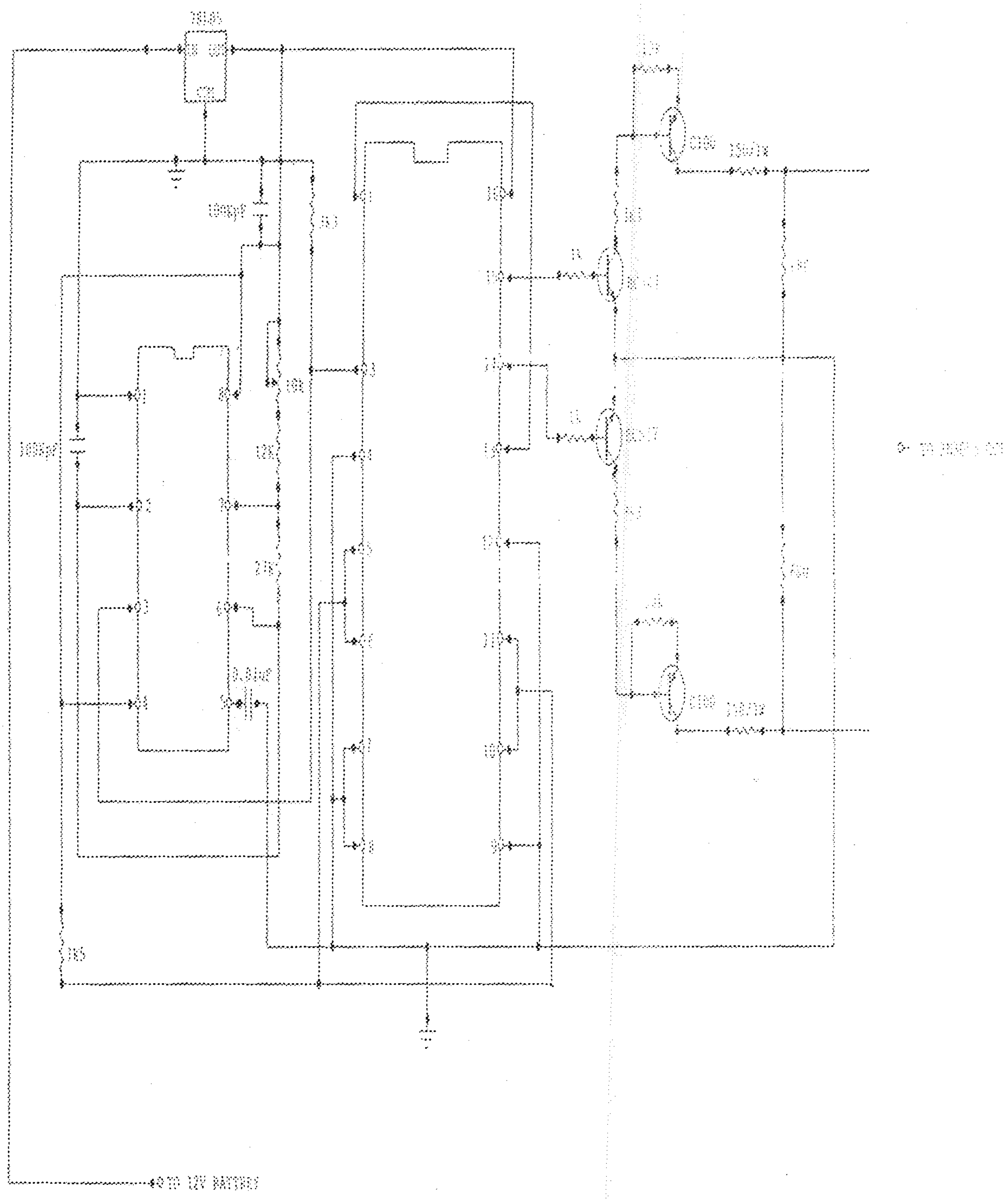
vi. The use of GTO thyristor or power switching MOSFET will provide better performance of the UPS.

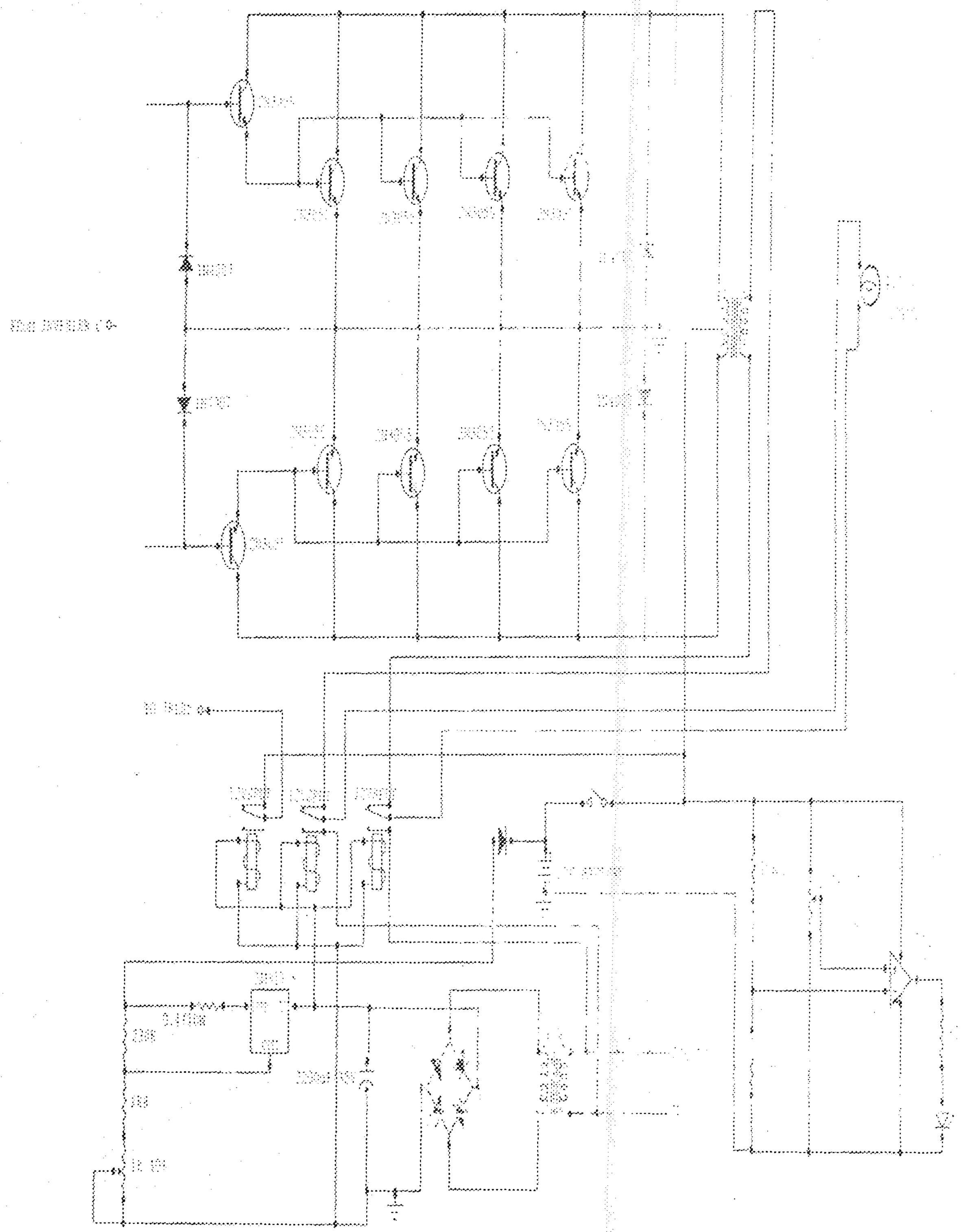
4.3 EDUCATIONAL BENEFITS

Overall, the project provided a good learning experiences, and exploits to the two students involved in terms of providing:

- Technical multi-disciplinary design opportunity.
- Opportunity for project planning and management
- Knowledge in manufacturing techniques
- Learning means of effective resource utilization
- Team work and the importance of project co-operation

- Good technical and commercial communication skills.
- Realizing the acute power crisis we may face in the future and think of alternative.
- Models for superior design project work.


TO 12V BATTERY



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