DESIGN AND CONSTRUCTION OF UNINTERRUPTIBLE POWER SUPPLY.

BY

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(93/3665)

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NIGERIA.

THIS PROJECT IS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING AS A PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF A DEGREE OF BACHELOR OF ENGINEERING.

DECLARATION

I hereby declare that this project work was done by me under the supervision of MR. PAUL ATTAH of the department of Electrical and Computer Engineering, Federal University of Technology, Minna, Niger State, during the academic session 98/99.

Dunmide
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Signature of Student

24/03/2000
……………………

Date

CERTIFICATION

This work was carried out by me OLAOSUN OLUMIDE DAVID of the department of Electrical and Computer Engineering, School of Engineering and Engineering Technology.

It has met the minimum standard requirement acceptable by both the department and faculty of Engineering and is hereby certified by:-

Mr. Paul Attah 24/03/2000

Project Supervisor .... Date & Signature

Dr. Y. Adediran ....

Head of Department .... Date & Signature

Dr. J.O. Oni 6/4

External Examiner .... Date & Signature

DEDICATION

I dedicate this project to the entire OLAOSUN's FAMILY, whose constant efforts made the completion of my programme a reality.

ACKNOWLEDGEMENT

I am most grateful to the Almighty God and His Son, Jesus Christ our Lord, for His divine protection and guidance over me throughout my stay on campus.

I also acknowledge the effort of my project supervisor in person of Mr. Paul Attah for his dedication, support, encouragement and understanding heart to see to the success of the work.

I am also indebted to my project group members particularly Adeoti Bamidele, R.E Watti, and Olayinka. K for their contribution, selfless sacrifice, constructive criticism during the course of the project. I really enjoy being in the same group with them.

Many thanks all goes to all both academic and non academic staffs of department of Electrical and Computer Engineering for their efforts and dedication to duties throughout my stay in the department.

I also appreciate the effort of my beloved uncle Mr. O.O. Odetunde of department of Land Survey for his fatherly advice, and kindness throughout my stay in the campus. May the Lord greatly reward you. Amen.

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Finally, my profound thanks go to my parents, Mr. and Mrs. L.P. Olaosun and the entire family for their love, care and support throughout my stay. Thank you all.

ABSTRACT

This project highlights the design and construction of an uninterruptible power supply. This is made possible by the use of high – current semiconductor MOSFET switches that convert DC low voltage power to AC line voltage power. An uninterruptible power supply unit thus ensures supply of A.C voltage to an equipment by changing over to an inverted back up DC voltage in the event of a mains failure or other irregularities in the mains supply.

During the process of the circuit design for the UPS, various factor, such as change over speed, commutation, output waveforms and power quality and efficiency were considered. A just switching relay and power MOSFET are amongst the various component employed. The pulses obtained from two 555 IC timers, connected in-phase to each other were used for gate firing although a more efficient technique is the sinusoidal pulse width modulation.

The UPS unit was designed to convert a 12V d.c, 30A max supply to feed a 500 watts 240V a.c load at 50Htz.

LIST OF FIGURE

NOMENCLATURE

V_A	- Voltage Ampere
V_{DD}	- Drain Voltage
V_{GS}	- Ground-Source Voltage
V	- Voltage
V_{max}	- Maximum Voltage
$V_{r.m.s}$	- root mean square Voltage
V_{cc}	- Common Collector Voltage
I_D	- Drain Current
IC	- Integrated Circuit
I_{max}	- Maximum Current
A	- Ampere
mA	- Millampere
A.C	- Alternate Current
R	- Resistance
D.C	- Direct Current
mS	- Millsecond
L	- Inductor
C	- Capacitor
GND	- Ground
D	- Diode
T	- Transformer
mW	- Millwatts
°C	- Celcius
T	- Time
ϕ	- Magnetic Field
F	- Frequency
MOSFET	- Metal Oxide Semiconductor Field Effect Transistor.

TABLE OF CONTENT

CHAPTER ONE

1.0 GENERAL INTRODUCTION

It is well known that power lines are subjected to malfunction (interruptions and disturbances) in a more or less pronounced manner depending on geographical area and time. The UPS is an equipment used to protect the operation of electronic equipment from incoming power failure. Thus, the equipment can continue to operate without the loss of data or information. In general power problems have existed all along but they are now more noticeable (and more of a problem due to the demand our technological society is placing on computers and related equipments. Power protection is the only way these equipments can be kept in operation.

In addition, natural phenomenum such as lightning, fire, etc. can cause failure of the supply. The cost to the industry of such utility failures, can run into large sum of money two good examples are as follows:-

(a) Air Traffic Control System:- radar and essential aircraft information are in constant display in the air traffic control system and mains failure could cause a breakout of radar data and lead to an unprecedented disaster.

(b) Computer Field/Industries:- an unpredicted power failure can wipe out the data or information contained in the memory banks, loss of information going and coming out of the computer when operating on real time. And of a truth re-programming cost can be quite expensive.

These are just examples, every interruption no matter how brief can cost someone in air industry and domestic considerable amount of money. Some forms of back-UPS equipment which can perform under the following conditions:-

(i) General power corresponding to the main supply with respect to frequency, phase and voltage level.

(ii) Continue to furnish power to the load during momentary dips, surges or interruptions of the main supply of a specified duration.

(iii) D... ...ating power from the main supply during the normal periods to reduce regulated output voltage with high frequency stability. Unaffected by variation in the main supply and during power failure for a specified period sufficient to allow orderly shut down of load equipment or activating standby generator system.

1.1 AIMS AND OBJECTIVES

The aims and objectives of this project was to construct UPS system with the following speculation values:-

- Power rating	500Watts
- Output power (VA)	500VA
- Output voltage	230V
- Output current	2.19A
- Main input range	220V
- Frequency range	50Hz
- Efficiency	96.8%
- Regulation	0.4%
- Changeover time	2ms
- Trickle charging current	10mA - 12mA
- Battery discharge time	20 minutes
- Battery recharge time	3 hr.20 minutes

1.2.0 TYPES OF UPS

UPS can fall under the following category depending on the way, it was deigned to operate. Each category having its own merits and demerits.

1.2.1.0 SINGLE TRACK UPS

In single track UPS, a supply path from the main supply to the load. Power is first rectified and applied to replenish the battery power that is simultaneously sent to the inverter.

1.2.1.1 MERIT OF SINGLE TRACK UPS

(i) No switching takes place when the power is off from the main A.C. Hence no system disruption.

(ii) Rate at which power is consumed is equal to the rate at which the battery is charged

1.2.1.2 DEMERIT OF SINGLE TRACK UPS

(i) Any fault in any subsection put the whole system out of use.

(ii) The bulkiness of the UPS.

(iii) The extra cost to get large transformer which may be quite expensive.

1.2.2.0 DUAL TRACK UPS

As the name implies, it contains a static by-pass switch and an alternative power path. The alternative power path comes up only when the inverter has a fault and fails to supply power to the load.

1.2.2.1 MERIT OF DUAL TRACK UPS

(i) It has the ability to supply power to the load even when the inverter is faulty and raw power present.

1:2.3.0 DOUBLE CONVERSION UPS

It has large charger and inverter. The charger converts the raw A.C. line to D.C. and sends it to the inverter. At the inverter it is reconverted to A.C. and supply to the load through a static by-pass switch.

1.2.3.1 MERIT OF DOUBLE CONVERSION UPS

(i) When there is a main failure, the static by-pass feeds the inverter and power is maintain undisturbed.

1.2.3.2 DEMERIT OF DOUBLE CONVERSION UPS

(i) Any fault with the inverter makes the entire system goes off.

(ii) The bulkiness of the whole system.

(iii) The static switch can get stuck and fail to change the voltage tap to the inverter.

1.2.4.0 FERRORESONANT UPS

The whole system is made up of small charger, battery, an inverter and a ferroresonant transformer. When the main power is available, the UPS passes it through ferroresonant transformer to the load.

1.2.4.1 MERITS OF FERRORESONANT UPS

(i) Ferroresonant transformer used make it possible for providing the level of power mains power supply.

(iii) Ferroresonant transformer also stores electrical energy (Flywheel effect) which aide in filling micro breaks of up to 20mS in duration.

1.2.5.0 ADVANCED TECHNOLOGY UPS

It makes use of microprocessor and reliable semiconductor device. The function of the microprocessor is to monitor the A.C line and generate a sinusoidal wave similar to that of the main when power is normal.

1.2.5.1 MERIT OF ADVANCED TECHNOLOGY UPS

(i) Microprocessor function very fast so that no outrage load is experienced by a critical load during switching from the main A.C. supply.

1.3.0 METHODOLOGY

Uninterruptive power supply can be classified into two types based on its methodology.

(i) ON-LINE

(ii) OFF-LINE

1.3.1.0 OFF-LINE METHODOLOGY

The off-line design which is used in this project described a system in which during the normal mains present operation, the inverter section of the UPS is off and the raw mains supply is routed directly to the output section.

Whenever there is a main power failure, the unit switch to the inverter mode and battery power. As the mains input power is on, the battery is charged by the battery charger circuit. The battery can maintain the units fully rated load for about twenty minutes. If the supply breaks exceeds the battery back-up time, the UPS will shut down once the battery voltage has fallen below the limit of specification which in this project is 6V d.c. However, the unit provides on the alarm to warn when this is about to happen to give adequate time to shut down the system. When the normal main input system is back, the "UPS" automatically start up with the aid of a relay switch and the battery start charging up immediately for further use.

system until there is a main power failure.

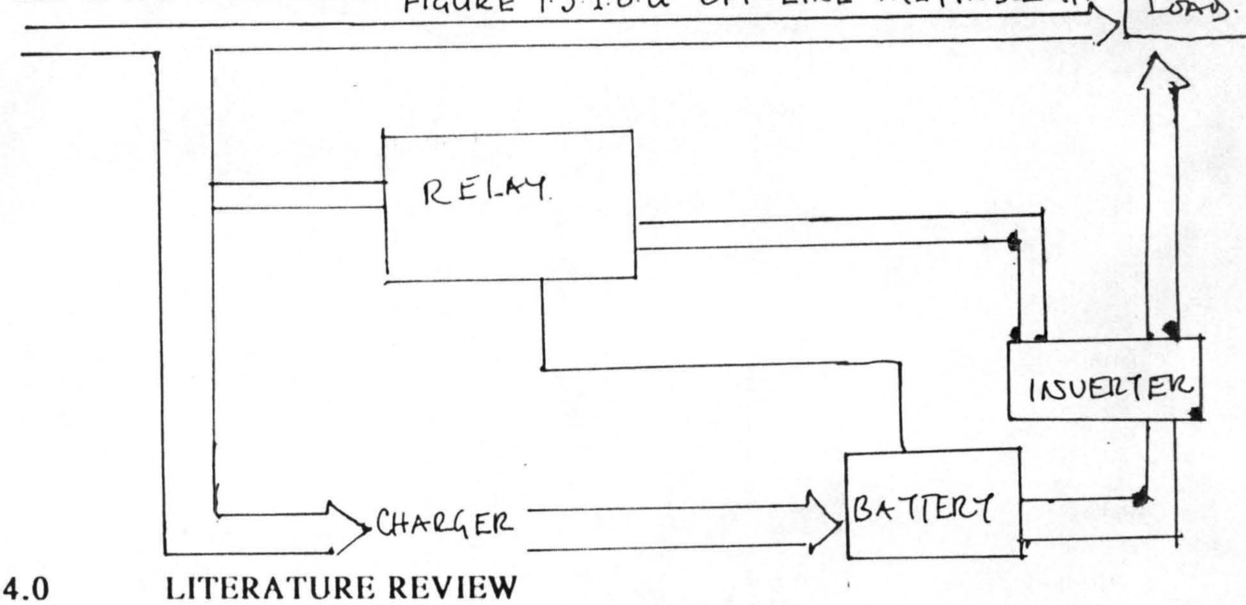
(b) The transformer, charger and other components are small, hence the whole system is portable.

(c) Components are not over stress.

1.3.1.2 DISADVANTAGE OF OFF-LINE METHODOLOGY

(a) Allows a breakdown in mains A.C. supply whenever there is a power failure between an interval of 2mS and 10mS.

FIGURE 1.3.1.0.a OFF-LINE METHODOLOGY.



1.4.0 LITERATURE REVIEW

The foundation of modern electric power transmission was laid in 1882 when Thomas Edison's Pearl Street station a d.c. generator and radial live transmission system used primarily for lightning was built in New York. Thereafter, the development of a.c. transmission in U.S. began in 1885 when George Westinghouse bought the patent for a.c. system development by L. Gaulard and J.D. Gibbs of France.

As world population increase, demand and consumption for electric energy grow, The need for constant reliable power supply becomes necessary either in d.c. or a.c. supply. With increasing use of micro electronic in developing nations, there has been a high demand for miniature electronic components which was achieved through the development of integrated circuit in 1960.

Users need to protect sensitive equipment from disrupting effects of main failures and disturbance. As the sophistication of electronics increased, users have called for increasing uninterruptible power supply (UPS) system. With the breakthrough in silicon controlled

UPS provides a power source for an electronic device in the event of power breakdown, which is a temporary power supply source is installed to allow users of critical load to safely shut down their electronic system i.e. computer in event of power outrage. This event increases the reliability and availability of electrical energy.

In the history of this department, various groups have worked on this particular project producing up to 400VA UPS system. The main objective is to improve on the work done in terms of watts, efficiency, minimize cost of production, with less failure rate (trouble free). Longer timer of operation and lastly minimize the trickle charge current.

1.4.1 REQUIREMENT OF UPS

Based on the need for constant power supply when mains power is not available. The provided UPS must be able to meet the following standards:-

(i) It must be able to subdue interferences like glitches, surge/over voltage, RF noise, frequency variation, electrical storms and spikes.

(ii) The UPS must be able to produce continuous uninterruptible A.C. voltage such that the load does not defect a complete power failure or changes in the source of power supply.

1.4.2.0 THE UPS SUB-SECTION

The basic make-up of a UPS are divided into various sub-section, which are as follows:-

1.4.2.1 INVERTER

The inverter is responsible for converting D.C. power from battery to A.C. and sending it through a center-tap transformer that couple the swings together to give a square wave output.

1.4.2.2 CHARGING UNIT

Charger is responsible for the maintenance of approximate potential voltage across the battery. This is done with the aid of a.c. main supply.

1.4.2.3 FILTERING UNIT

This unit filters the output signal which is a square wave coming from the transformer to prevent damage to the inductive load.

will conduct without melting in this project is 2A which is known as the fuse current rating.

1.4.2.5 LOW BATTERY DETECTOR

The battery is switch-off when the battery voltage is lower than the reference voltage. An operational amplifier is used to compare the battery voltage with the reference voltage.

1.4.2.6 CHANGE OVER SWITCH

This unit acts as a by-pass switch by connecting the load to the inverter. This is made possible by means of a relay.

1.5.0 PROJECT OUTLINE

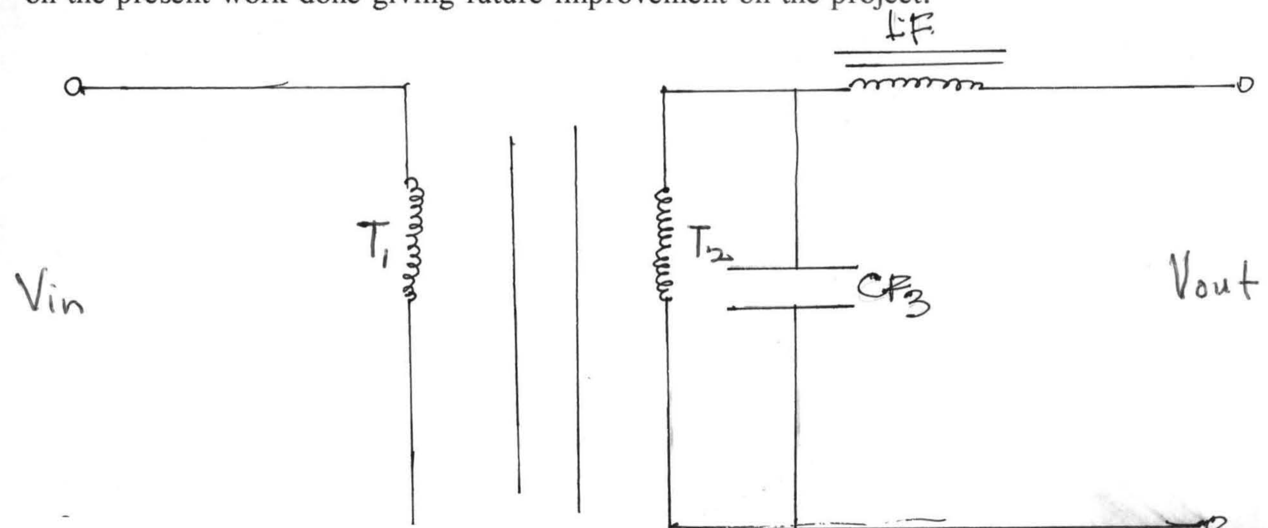
This thesis covers four chapters which include the following:-

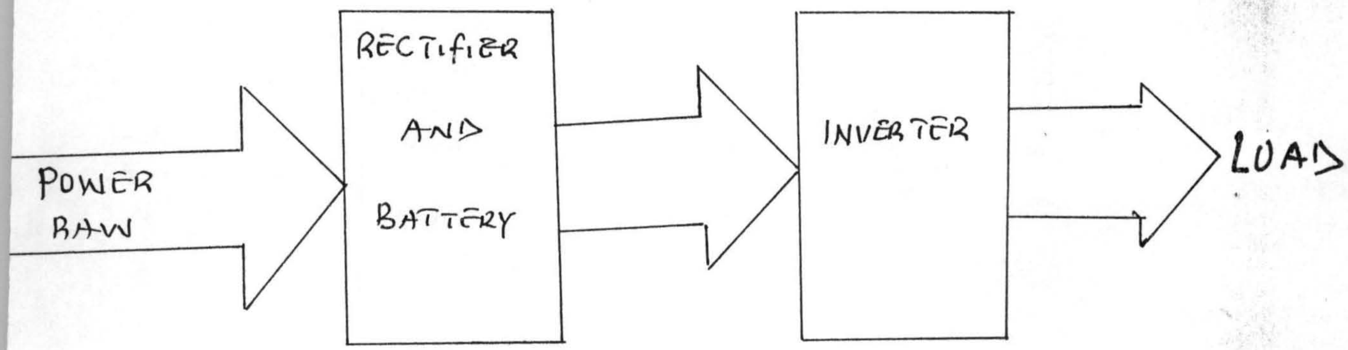
Chapter one includes aims and objectives, project outlines, literature review, methodology and general introduction about the project.

Chapter two which include the system design giving detail analysis of power supply. The general concept of power supply enumerated and the various types of power supply under A.C and D.C as related to the UPS i.e. A.C. Power supply, D.C. Power supply, inverter and battery charger. Lastly, discussion/analysis of components used in design and principle of operation.

Chapter three deals with the construction principle, tools and steps in system design, testing of the project work, trouble shooting technique, technical specification, performance parameter and discussion of results.

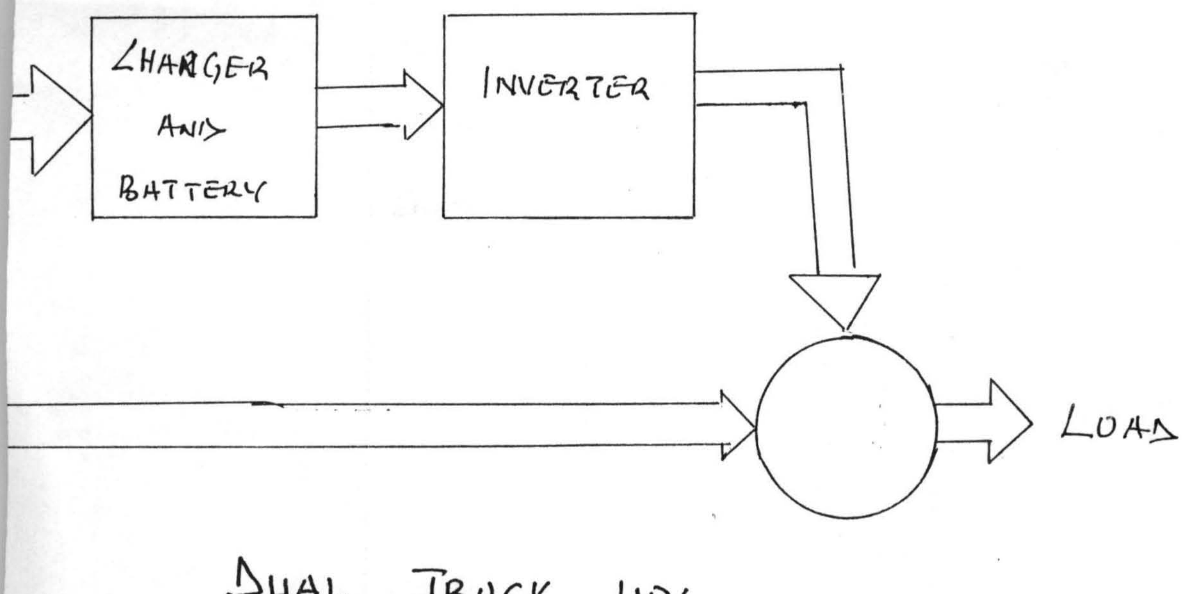
Chapter four entails conclusion of the project work, possible recommendation based on the present work done giving future improvement on the project.





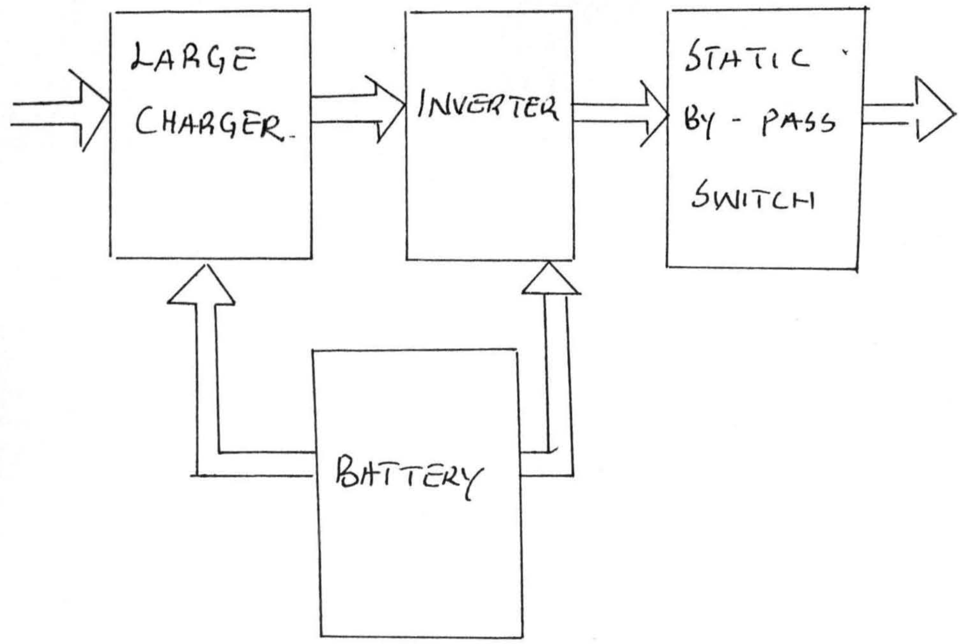
SINGLE TRACK. UPS

FIGURE 1.2.1.0.(a).



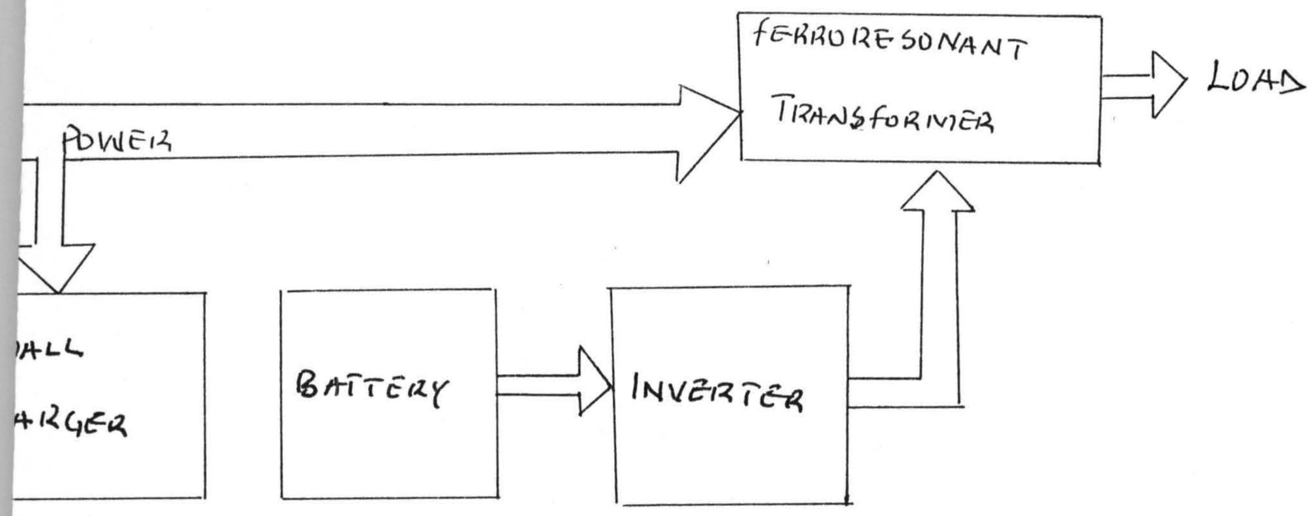
DUAL TRACK UPS

FIGURE 1.2.2.0.(a)



URE 1.2.3.0(a)

DOUBLE CONVERTION UPS.



RE 1.2.4.0(a)

FERRORESONANT UPS

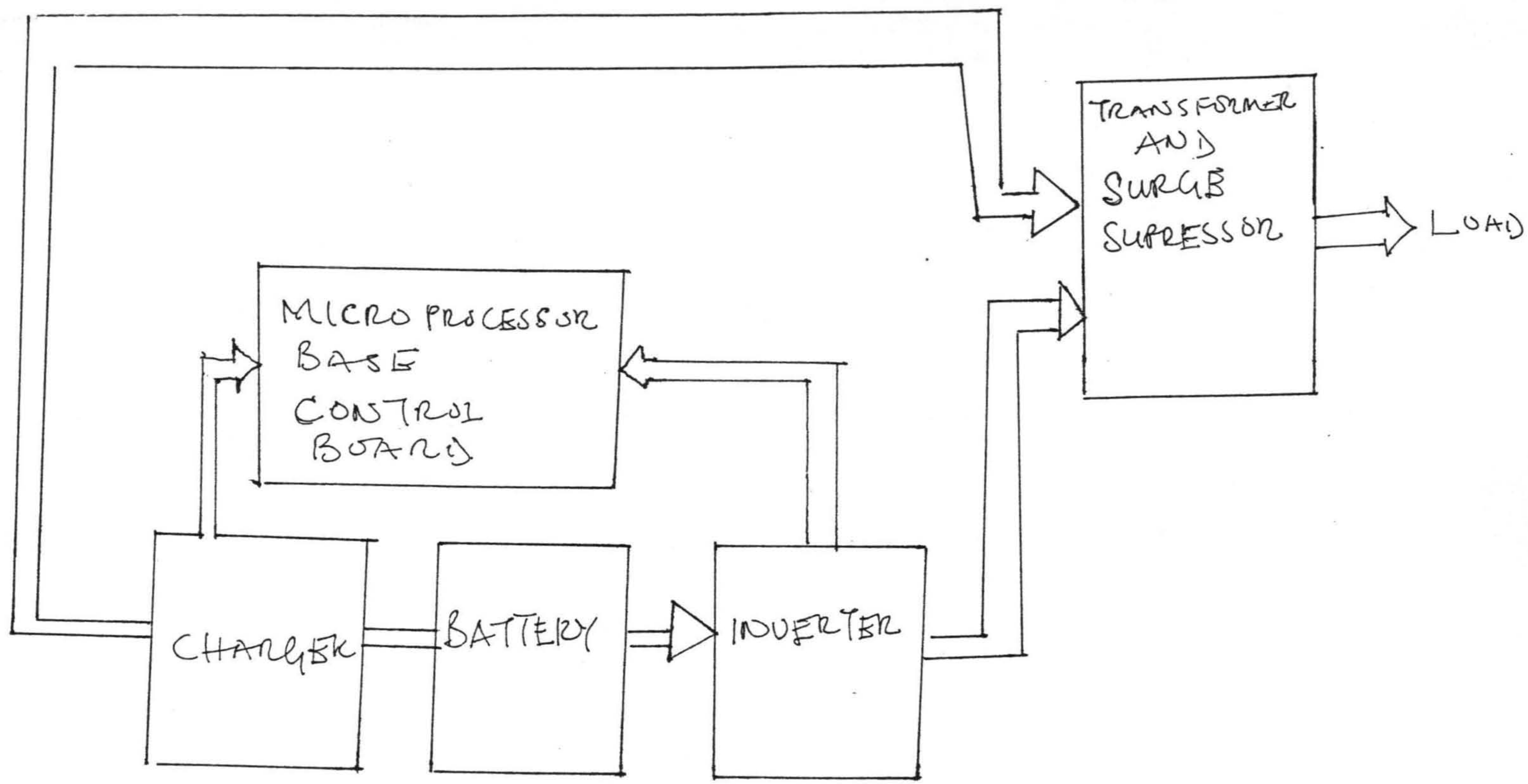


FIGURE 1.2.5.0.(a) ADVANCED TECHNOLOGY UPS.

CHAPTER TWO

2.0 SYSTEM DESIGN

The theory and design of UPS system was done effectively, which was carried out by breaking the whole UPS system into units. Each unit then made to perform specific and specialised tasks, which was carefully integrated together to satisfy the overall equipment of the UPS.

2.1.0 COMPONENT SELECTION

Various electronic devices are used for various sub-section with their uses and method of application stated below:-

2.1.1 TLC 555 TIMER

TLC 555 is a monolithic timing circuit fabricated using CMOS process. TLC 555 has ability to produce accurate timing delay due to its high input impedance. TLC 555 can function as monostable and astable multivibrator depending on the connection of resistor and capacitor.

The CMOS process allows the TLC 555 to operate at frequency of up to 2MHz. It also involve low power consumption over a wide range of supply voltage ranging from 2V to 18V.

The triggering voltage is one-third of the value of U_{DD}, which can be as well be altered. When trigger input fall below trigger level, the flip-flop is set and output goes high. Likewise when the trigger input is above the trigger level, the flip-flop is reset and output is low.

The threshold voltage is two-third of the value of U_{DD}. When the threshold input is above the threshold level together with the triggering value being high. The flip-flop is reset and the output is low.

Below are the absolute maximum rating

Supply Voltage U_{DD}	= 18V
Input Voltage Range	= -0.3V to 18V
Power Dissipation	= 600mW

2.1.2 VOLTAGE REGULATOR (78XX SERIES)

The main function of voltage regulator is to keep the terminal voltage of d.c. supply constant even when the a.c. input voltage to the transformer varies or when the load varies. (fluctuate).

In this project three terminal voltage regulator is available with several fixed output voltage making it useful for various application.

The voltage also allows it to be used in logic system instrumentation. This series allow a load current of approximate 1.5A provided there is heat sink.

Current limiting is considered because of peak output current. Safely mounted on heat sink because of internal power dissipation to prevent IC from overheating.

2.1.3 LM 324

LM 324 series consists of four independent high gam internal frequency compensated operational amplifiers which are designed specifically to operate from a single power supply over a wide range of voltage. LM 324 application are as follows transduer amplifier d.c. and all convectional OP AMP circuit. It is more easily implemented in single power supply.

2.1.4 BUZ II

BUZ II is an N-channel MOSFET design basically as a semiconductor controllable switch having voltage blocking and current carrying capacity both characteristic at turn-off point.

BUZ II having the following characteristics:-

- Drain-to-source breakdown voltage BU_{DSS} = 60V
- Gate-to source breakdown voltage BU_{GS} = 30V
- Maximum power dissipation P_D (watt) = 125W (max)
- Maximum continuous drain current I_D = 30A
- Gate-source threshold voltage V_{GS} (th) = 4V

BUZ II is also considered in this design because of the following factors:-

- high voltage device - inhibited breakdown characteristics
- high durability chances. - high speed

2.1.5 3 TERMINAL ADJUSTABLE POSITIVE REGULATOR (317T)

317T is an IC with an adjustable 3-terminal positive voltage regulator capable of giving excess current of 1.5A over a voltage range of between 1.20 to 37V output range. 317T requires only two external resistors to set the output voltage.

317T is applicable in various ways which are:-

as single adjustable switching regulator, programmable output regulator and as a precision current regulator.

2.2.0 CONTROL SIGNAL GENERATION (USING TLC 555 TIMER)

The switching signal for switching the driver circuit is generated using TLC 555 timer as an astable multivibrator.

The output signal is low at the time the capacitor C discharge from $2/3V_{cc}$ to $1/3V_{cc}$ which is given as

$$t_{low} = 0.695R_{BC}C \qquad (1)$$

The output signal is high at the capacitor C charges from $1/3V_{cc}$ to $2/3V_{cc}$. The time interval is given as

$$t_{high} = 0.695\ (R_A + R_B)\ C \qquad (2)$$

The period of oscillation given as T is equal summation of t_{high} and t_{low}.

$$T = t_{high} + t_{low} \qquad (3)$$

$$= 0.695\ (R_A + R_B)\ C + 0.695R_{BC}C$$

$$= 0.695\ (R_A + R_B + R_B)$$

$$T = 0.695C\ (2R_B + R_A) \qquad (4)$$

Free running frequency F is given as

$$F = \frac{1}{T} \qquad (5)$$

$$F = \frac{1}{0.695C\ (2R_B + R_A)} = \frac{1.4388}{(R_A + 2R_B)C} \qquad (6)$$

To obtain the required output frequency of 50Hz. Values of the two resistors R_A and R_B were chosen to be $10k\Omega$ and value of capacitor needed to be calculated using equation (6)

$$F \times (R_A + 2R_B)C = 1.4388$$

$$= \frac{1.4388}{50(30,000)} = \frac{1.4388}{1.5 \times 10^6}$$

$$C = 0.00000096F$$

$$C = 0.96\mu F$$

The driver circuit needs two anti phase signal for switching. The 555 timer output signal was then passed through a transistor configure as a NOT gate to phase invert the pulse signal by 180^0. Through this method two anti-phase signal is achieve in which other high and other low at different interval.

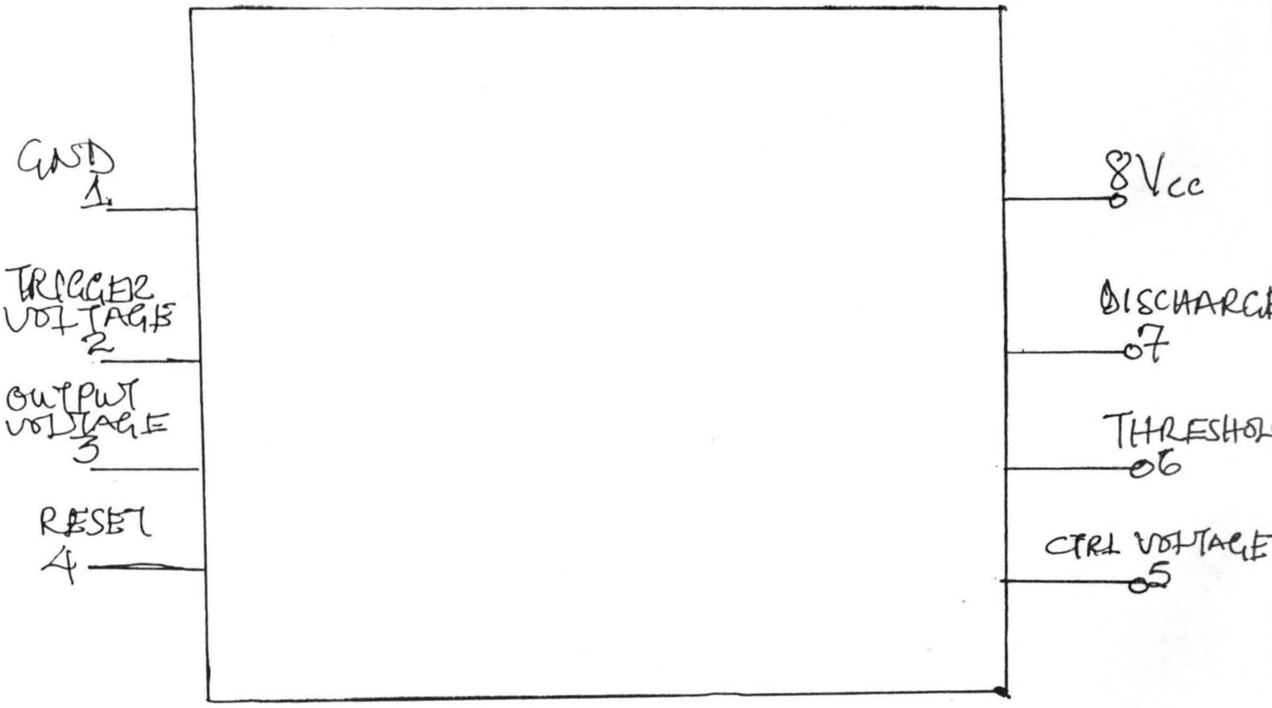


FIGURE 2.1.1(a) 555 TIMER POINT.

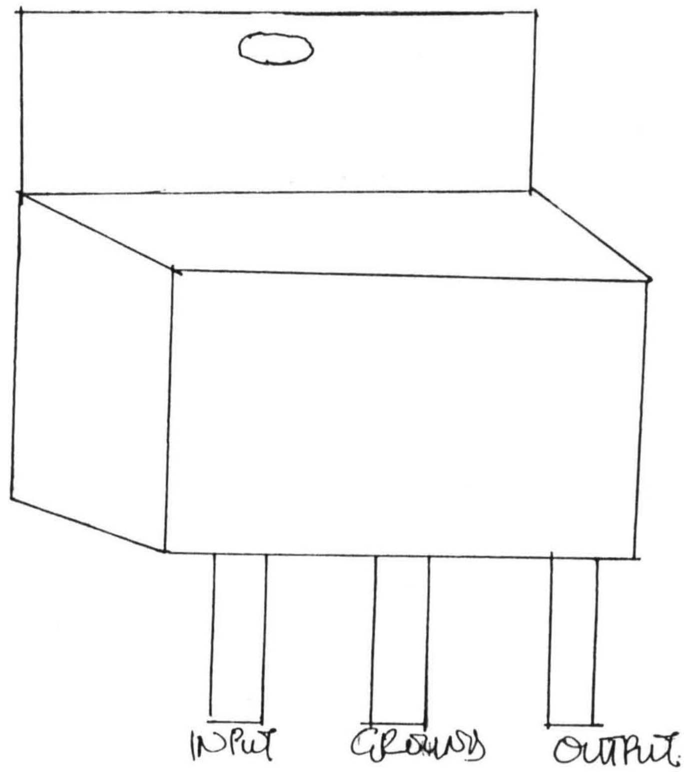


FIGURE 2.1.2.(a) 78XX PINOUT VOLTAGE REGULATOR

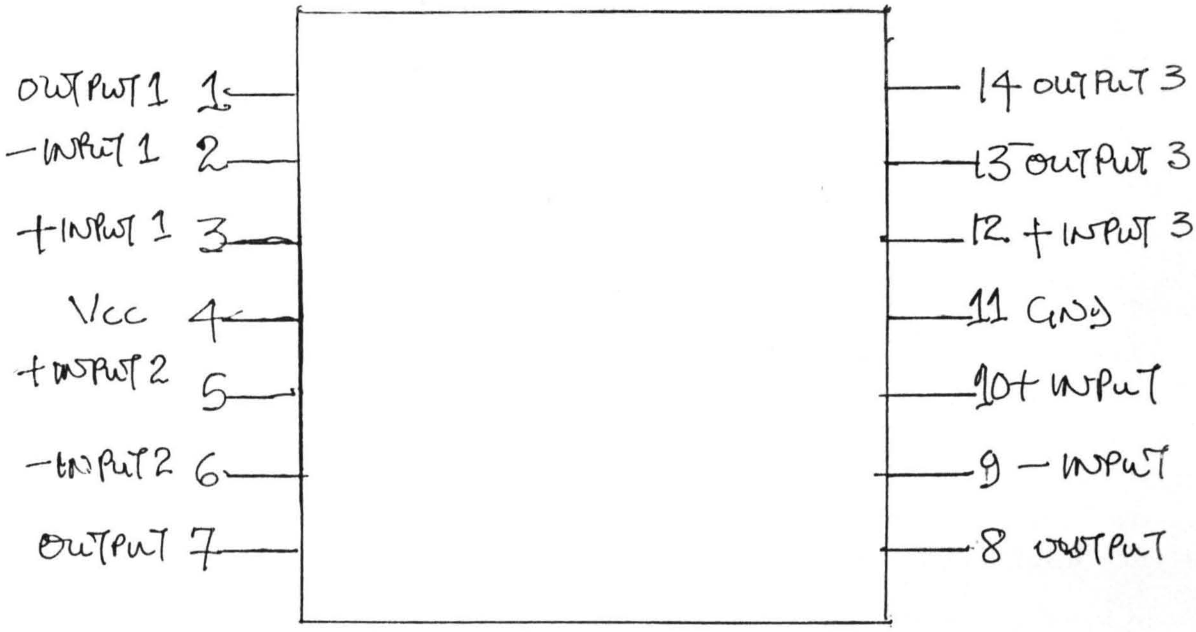


FIGURE 2.1.3(a) LM 324.

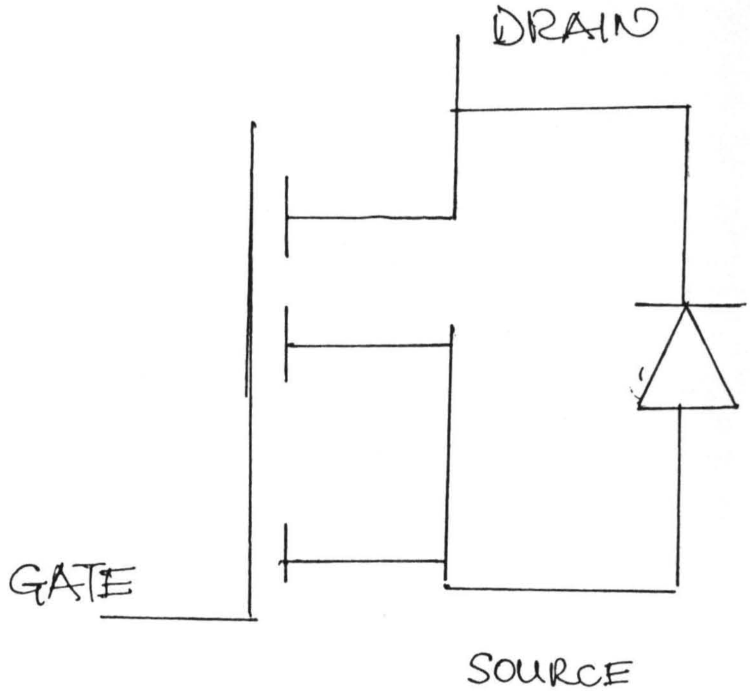
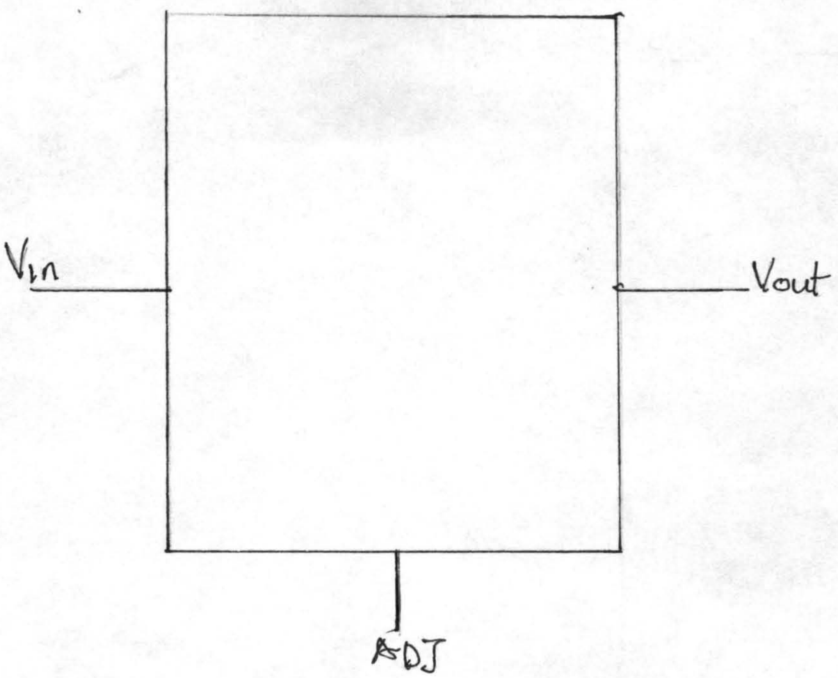
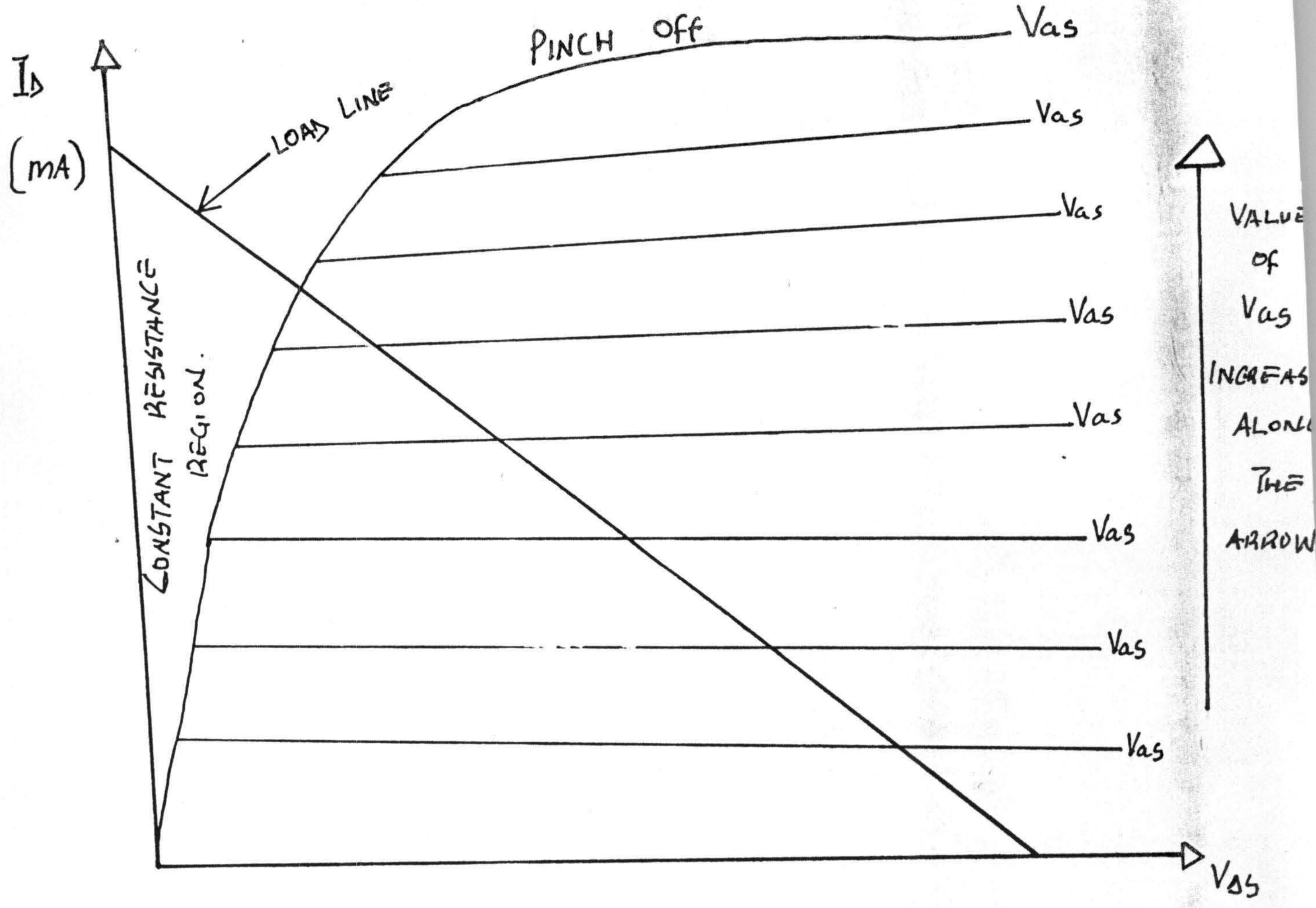


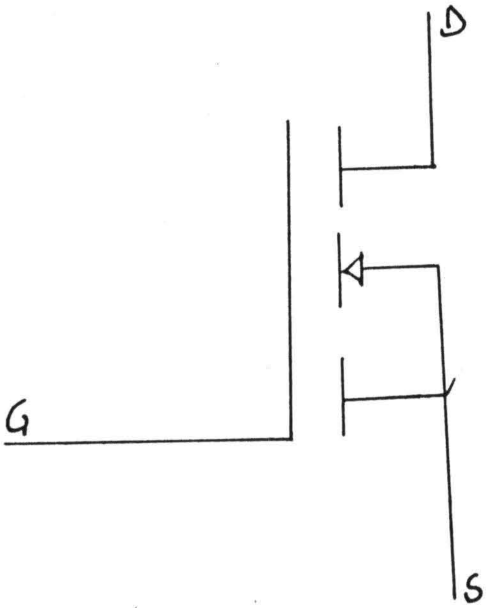
FIGURE 1.2.4(a) BUZ II PINOUT

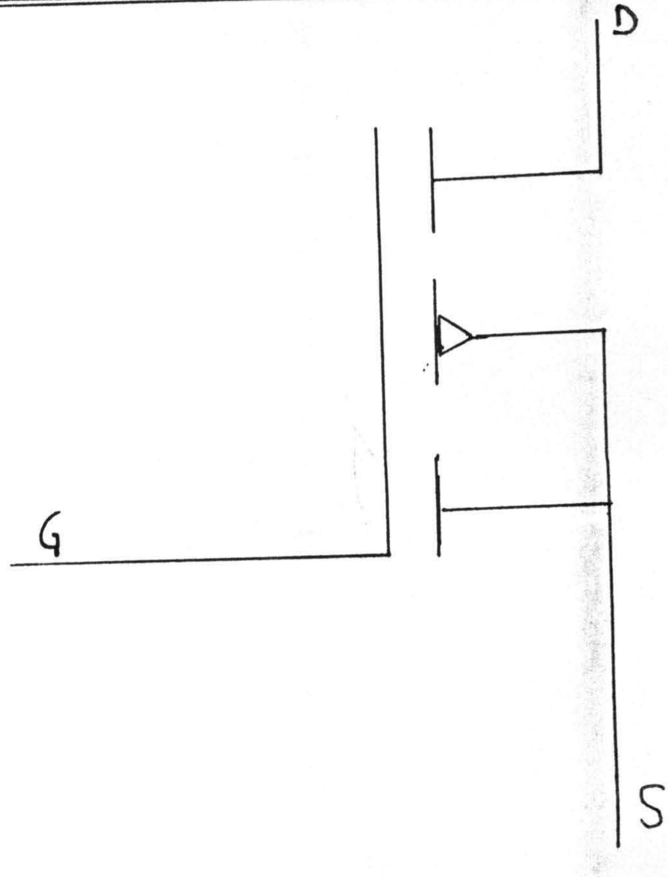


3 TERMINAL ADJUSTABLE POSITIVE REGULATOR
FIGURE 2.1.5.(a)



OUTPUT CURVE of MOSFET FIGURE 2.50(a)





2.3.0 TRANSFORMER

A transformer is a static piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. Transformer can also raise or lower voltage but with corresponding increase or decrease in current.

The basic principle of operation of a transformer is the Faraday's law of electromagnetic induction $e = M\ dI/dt$.

Transformer consists of two inductive coil (primary and secondary coil) which are electrically separated but magnetically linked through a path of low reluctance. It can be summarised that transformer in a device that:-

(i) Transfer electric power from one circuit to another

(ii) Does so without changing the frequency.

(iii) Accomplished this by electromagnetic induction.

(iv) Where the two electric circuit are in mutual inductive influence of each other.

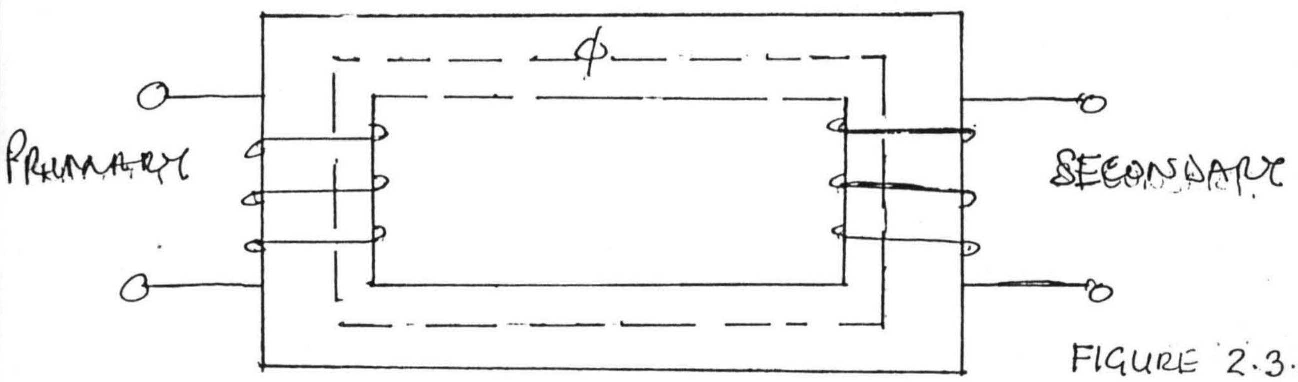


FIGURE 2.3.0(a)

2.3.1 TRANSFORMER DESIGN

A transformer converts an alternating voltage and current at a certain value in a coil to another value in another coil depending on the turns ratio.

In this project, 12V battery voltage used and the transformer designed to power 500VA. Peak to peak value at the primary coil is 24V.

$V_{r.m.s} = 0.707V_{max} = 0.707 \times 240 = 16.9680$

At secondary winding

$I_{(max)} = 500/240 = 2.08A$

Having $E_1 = 220V$, $E_2 = 16V$

Since $\frac{N_2}{N_1} = \frac{E_2}{E_1}$

$$N_1 = \frac{N_2E_1}{E_2} = \frac{1760 \times 16}{220} = 136 \text{ turns}$$

2.3.2.0 LOSSES IN TRANSFORMER

The following are the types of losses in transformer.

2.3.2.1 **(A) COPPER LOSS:-** is the loss due to ohmic resistance of the transformer winding. Total copper loss = $I_1^2R_1 + I_2^2R_2$. Since $I_1^2R_1 = I_2^2R_2$ i.e. Copper loss is proportional to square of the current.

2.3.2.2 **(B) CORE OR IRON LOSS:-** Power dissipated in magnetic circuit at constant supply voltage and frequency, its variation being 1 to 3% from no load to full load. It consists of two different parts:-

2.3.2.2.1 **(i) HYSTERESIS LOSS (W_h):-** is the energy loss as heat in the lamination is given as

$$W_h = \eta B^{1.6}_{max} fV \text{ (watt)}$$

2.3.2.2.2 **(ii) EDDY CURRENT LOSS (We):-** there is both power loss and voltage loss in the lamination because it acts as if they were loops of coils. When current flow in them. Eddy current loss is given as:-

$$W_e = PB^2_{max} f^2 t_2 \text{ (watt)}$$

2.3.3 EFFICIENCY OF THE TRANSFORMER

Transformer efficiency at particular load and power factor is given as output divided by the input.

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

Considering the loss in the transformer. Efficiency then becomes

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Output}}{\text{Output + Loss}} = \frac{\text{Output}}{\text{Output+Cu loss+Iron loss}}$$

$$\eta = \frac{\text{input - losses}}{\text{input}} = 1 - \frac{\text{loss}}{\text{input}}$$

In the case of this project K > 1 because it is a step up transformer.

2.3.4.3 EQUIVALENT RESISTANCE

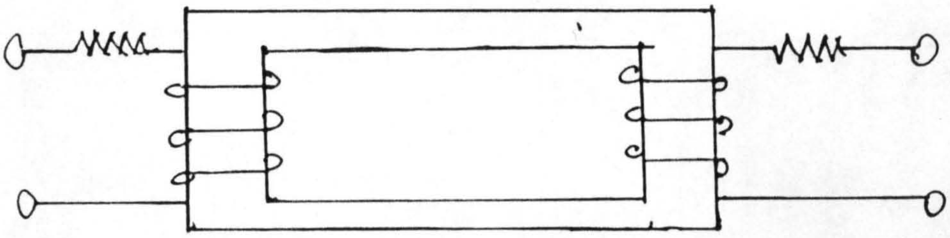


FIGURE 2.3.4.3(a)

Resistance R_2 in the secondary is equivalent to R_2/K^2 in primary.

$R^2/K^2 = R_2^1$ = equivalent secondary resistance as referred to primary copper loss in secondary $I_2^2R_2$.

R_2^1 is the equivalent resistance in primary which would have caused the same loss as R_2 in secondary

$I_1^2R_2^1 = I_2^2R_2$

$$R_2^1 = \left(\frac{I_2}{I_1}\right)^2 R_2$$

$$ALSO \quad \left(\frac{I_2}{I_1}\right) = \frac{1}{k}$$

$$R_2^1 = \frac{1}{k^2} R_2$$

Also for secondary equivalent resistance.

$$R_2 + R_1^1 = R_2 + K_2R_1$$

2.3.4.4 TRANSFORMER WITH LEAKAGE REACTANCE AND IMPENDANCE

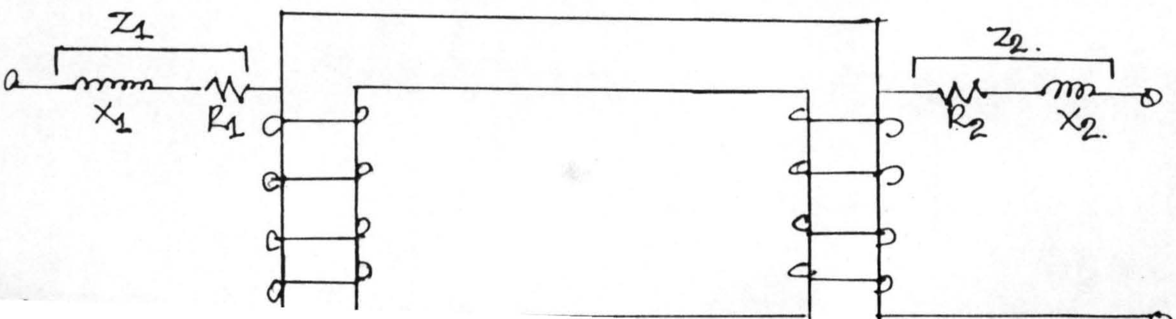
For primary leakage reactance equals

$V_1 = E_1 + I_1(R_1 + jX_1) = E_1 + I_1Z$

For secondary leakage reactance here I_2R_2 and I_2X_2.

Drops in secondary which combine with V_2 to give E_2.

$E_2 = V_2 + I_2(R_2 + jX_2) = V_2 + I_2Z_2$.



Primary Impendance equals

$$Z_1 = \sqrt{(R_1^2 + X_1^2)}$$

Secondary Impendance equals

$$Z_2 = \sqrt{(R_2^2 + X_2^2)}$$

2.4.0 OPERATIONAL AMPLIFIER

Operational amplifier has a very high-gain ,high input resistance directly coupled negative - feedback amplifier which can amplify signals having frequency ranging from 0Hz to a little beyond 1MHz. Made with different internal configuration in linear IC. The OP-AMP is available in three different package which are standard dual-in-line package (DIL), To -5 case and flat pack.

OP-AMPS are complete amplifier design that external component can be connected to its terminals to change its external characteristics. The figure shows a typical OP-Amps symbols

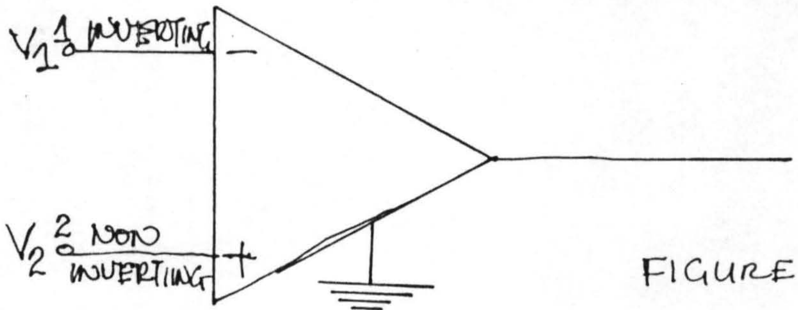


FIGURE 2.4.0.(a)

Having a minimum of five terminals which are:-

(i) Inverting input terminal

(ii) Non-Inverting input terminal

(iii) Output terminal

(iv) Positive bias supply terminal

(v) Negative bias supply terminal.

An ideal OP-Amp also have the following parameter

(i) Input resistance R_i is equal to infinite (∞)

(ii) Output resistance R_o is equal to zero (0)

(iii) Bandwidth (Bw) is equal to infinite (∞)

(iv) Open-loop gain (Av) is equal to negative infinite value of ($-\infty$)

OP-AMP application are as follows:-

(iii) Comparator

(iv) Adder or Summer

(v) Subtractor

(vi) As Unity Follower

(vii) As a scale or linear of constant gain amplifier both inverting and non-inverting

For the scope of this project, Linear amplifier is discussed which include inverting and non-inverting OP-AMP.

2.4.1 INVERTING AMPLIFIER (NEGATIVE SCALER)

From the diagram non-inverting terminal has been grounded whereas R_1 connect the input signal V_1 to the inverting input.

A feedback resistor R_f has been connected from the output to the inverting input.

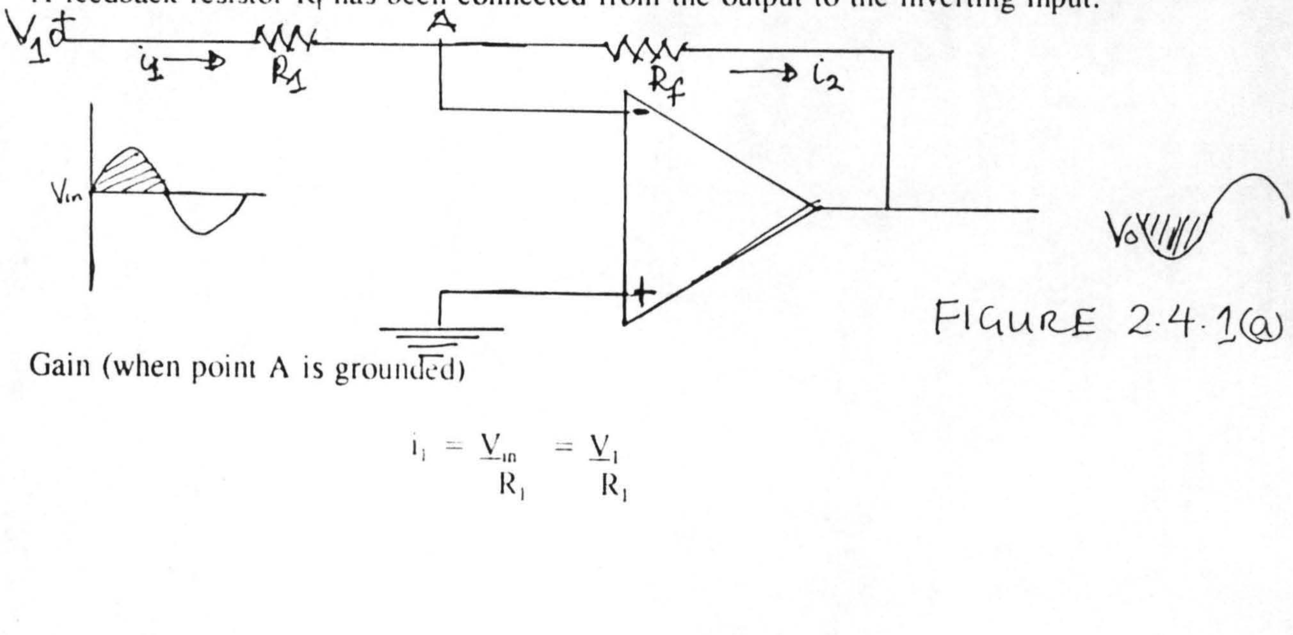


FIGURE 2.4.1(a)

Gain (when point A is grounded)

$$i_1 = \frac{V_{in}}{R_1} = \frac{V_1}{R_1}$$

$$i_2 = -\frac{V_0}{R_f}$$

Using KCL from point A

$$I_1 + (-I_2) = 0$$

$$\frac{V_1}{R_1} + \frac{V_0}{R_f} = 0$$

$$\frac{V_1}{R_1} = -\frac{V_0}{R_f}$$

$$Hence\ \frac{V_0}{V_1} = -\frac{R_f}{R_1}$$

$$= -\frac{R_f}{R_1} = -K$$

Since Av is a negative value, inverting amplifier is taken as a negative scalar.

2.4.2 NON-INVERTING AMPLIFIER

This circuit is when there is need for an output which is equal to the input multiplied by a positive constant. The input voltage V_2 is applied to the non-inverting terminal, in non-inverting amplifier. The figure below shown non-inverting AMP.

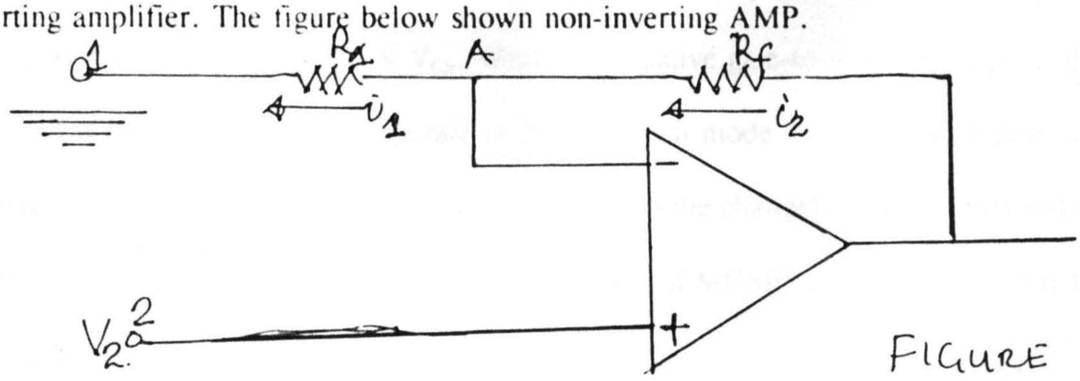


FIGURE 2.4.2(a)

Gain

Voltage across R_i is the input voltage V_2. Also, V_o is applied across the series combination of R_i and R_f

$$V_{in} = V_2 = IR_i$$

$$V_o = i(R_i + R_f)$$

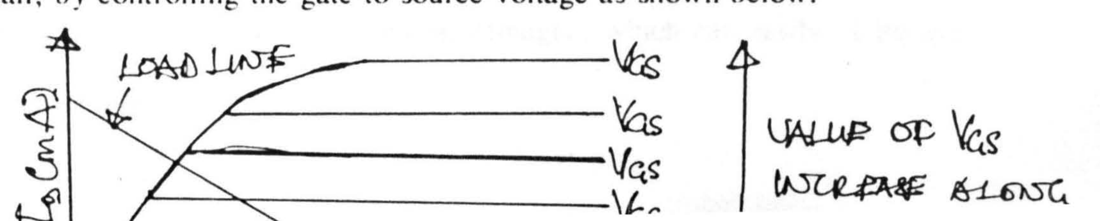
$$Av = \frac{V_o}{V_{in}} = \frac{I(R_i + R_f)}{iR_1}$$

$$= \frac{R_i + R_f}{R_1}$$

$$= 1 + \frac{R_f}{R_1}$$

2.5 MOSFET AS A SWITCH

MOSFET can be used as switch, since the conduction in the drain-to-source path is controlled by the gate-to-source voltage. i.e. which describe an n-channel enhancement mode device. The current in the drain-to-source path can be switch between two values, one large and one quite small, by controlling the gate-to-source voltage as shown below.



sheet, making sure of proper insulation between the transistor and the iron sheet to avoid conduction.

The amount by which the temperature rises depend on the rate at which thermal energy can be transferred to the surrounding. The construction of the iron sheet is based on the assumption of thermal resistance θ. It is then possible to define temperature of the device in terms of θ and the average power dissipated in the device as:

$$T_D = P_D\theta_D + T_A.$$

where T_D is the temperature of the device in degree celcius.

T_A is the ambient temperature in degree celcius.

θ_D is the thermal resistance in degree celcius/watt.

P_D is the average power dissipated by the devices.

2.8.0 BATTERY CHARGES UNIT

A device which converts chemical energy contained in its active materials directly into electrical energy by means of oxidation-reduction of electrochemical reaction is called a BATTERY.

Hence the battery charger arrangement is included in this project since when a battery is used for sometime it gets discharge then need to be recharged. This is achieved by having a reference voltage at which below the value. The alarm goes up for the battery to be recharged.

2.8.1 CALCULATION ON BATTERY CHARGER DESIGN

The Ampere hour rating of the battery = 7AH

Battery voltage = 12V

Discharge time = 0.3hr.

$$\text{Charge average} = \frac{1.15 \times \text{Battery capacity}}{\text{Desired recharge time}}$$

NOTE:- The desired recharge time is normally made to be 10 times the discharge time.

$$\text{Charger amperage} = \frac{1.15 \times 12V}{0.3hr} = \frac{13.8}{0.3}$$

The charge is designed with rating = 46 Vhr

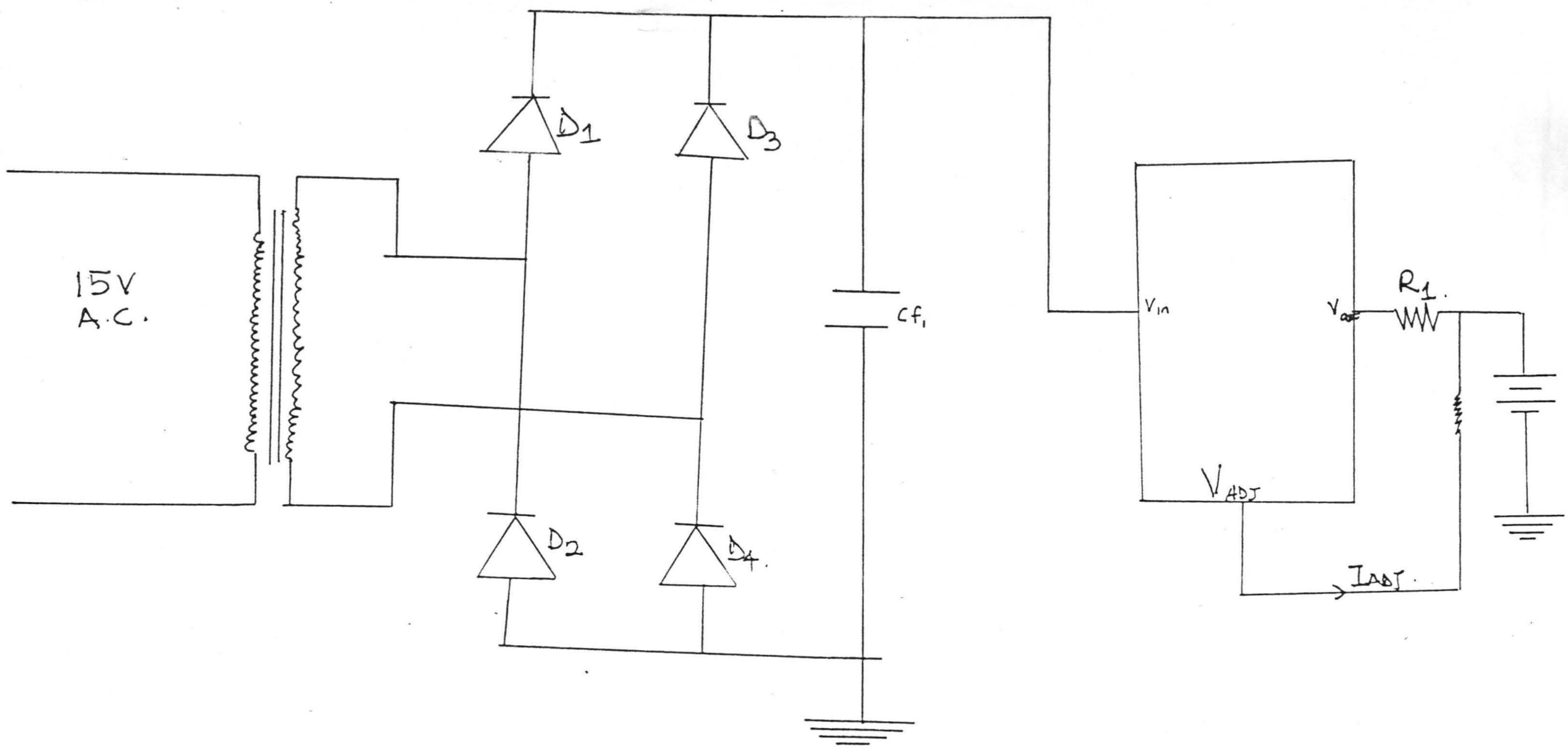


FIGURE 2.8.0(a) BATTERY CHARGER.

2.8.2 BATTERY MODE OF OPERATION

The lead acid battery is being used in this project which is the most widely used and economical secondary battery used for the UPS application.

When the line voltage is ON, the battery is trickle charge to offset the slight self discharge by the battery. This requires a constant trickle charge voltage be applied across the battery and the battery continuously draws a small amount of current, hence the battery is fully charge by this method.

When there is a line outrage, the battery supplies the load. The battery voltage should not be allowed to fall below the final discharge voltage level to avoid damage on the battery. The capacity of the battery is expressed in ampere hour.

2.8.3.0 POWER SUPPLY TO THE INVERTER FROM D.C. BATTERY.

The inverter circuit gets its supply from the D.C. supply of the Lead-Acid battery. A battery consists of a cells and each cell of the battery consists of the following:-

2.8.3.1 PLATES

These consist of a lattice type of grid of cast antimonial lead alloy which is covered with active material. The positive and negative plate grid are often of the same design and also conducts electric current.

2.8.3.2 SEPARATORS

These are thin sheets of a porous material placed between the positive and negative plates for preventing contact between them and thus avoiding material being short circuiting.

2.8.3.3 ELECTROLYTE

It is dilute sulphuric acid which fills the cell compartment to immerse the plate completely.

2.8.3.4 CONTAINER

It consists of the plate, separators and electrolytes. It is made up of celluloid material.

(i) Lead Peroxide:- Combination of lead and oxygen (O_2) and the chemical combination is (PbO_2). It forms the positive active material.

(ii) Sponge Lead:- It is pure lead in soft sponge or porous condition. Its chemical combination is H_2SO_4. Positive and negative plates are immersed in this solution known as electrolyte.

2.8.4.0 CHEMICAL CHANGES

The changes that usually occur are classified into charging and discharging.

2.8.4.1 CHARGING

When the cell is recharged, then H_2 ions move to the cathode and SO_4 ion goes to anode and the following charges take place.

$PbSO_4(aq) + H_2(aq) \rightarrow Pb + H_2SO_4(aq)$ - Cathode.

$PbSO_4(aq) + SO_4(aq) + 2H_2O(aq) \rightarrow PbO_2(aq) + 2H_2SO_4(aq)$ -Anode

During charging the following action take place:-

(i) There is rise in voltage

(ii) Energy is absorbed by the cell

(iii) Specific gravity of H_2SO_4 is increased due to consumption of water.

2.8.4.2 DISCHARGING

At discharging, current is sent through the external load, then H_2SO_4 is dissociated into positive H_2 and negative SO_4 ions. Current within the cell is from Cathode to Anode, while H_2 ions moves to anode and SO_4 ion move to the cathode.

It will be noted that the following occur during discharge:

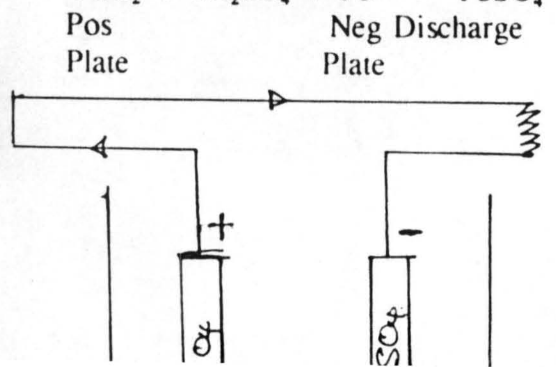
(i) Voltage of the cell decrease.

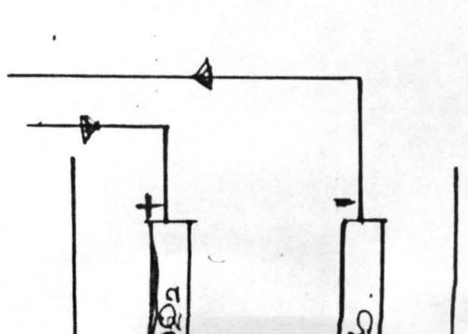
(ii) Cell gives out energy.

(iii) Specific gravity of the acid decrease because of formation of water.

Hence, a single charging and discharging of the cell can be represented by a single reversible equation and diagram below:-

$$\underset{\text{Pos Plate}}{PbO_2} + 2H_2SO_4 + \underset{\text{Neg Plate}}{Pb} \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} PbSO_4 + 2H_2O + PbSO_4$$





2.8.5 MAINTENANCE OF THE BATTERY

The following precaution act must be followed to enable the battery last longer

(i) The battery terminal should be kept free from corrosion by applying grease on them.

(ii) Automatic control unit should be provided to prevent battery from over-charged or over-discharged as these make plate shed easily.

(iii) The battery should be recharged when the voltage and the specific gravity falls.

(iv) Removing the electrolyte and the dry cells when the battery is not in use.

(v) Regular checking on the level of the battery specific gravity of the electrolyte so that it would not fall below 12V.

CHAPTER THREE

3.0 CONSTRUCTION

The construction stage precedes only the testing stage in this project. This is the mounting and soldering of the components into the vero-board. Also involve hooking-up, trimming, and joining of connecting leads, re-modelling and layout of components mounting devices such as the heat sink etc. Since the circuit incorporates are sub-circuit. There is need to ensure compatibility when coupling, for instance the output.

Power MOSFET needs to be mounted on heat sink and isolated from the rest of the circuit because of its thermal emission from which might impair the operation of other components.

Effort was made for easy identification in terms of troubleshooting. The following are considered before assembling the system:-

3.1.0 EASY IDENTIFICATION OF SUB-CIRCUIT

The circuit is laid in such a way that identification can be easily done without the aid of schematic diagram. This was achieved by coupling the sections separately on the same vero-board.

3.1.1 PROVISION FOR REPLACEMENT OF PARTS

Bearing in mind, the inevitable failure of the system, provision are made for identification, removal and replacement of burnt out components. Components are neatly soldered and each unit is mounted so as not to obstruct the identification of nearby units, i.e. removal of failed components should not cause the unnecessary desoldering of adjacent components.

3.1.2 ISOLATION OF HEAT RADIATING COMPONENTS

Components which emit heat as a result of power being drawn from them i.e. power transistor are mounted on the heat sink to allow for easy dissipation of heat generated within due to the thermal nature of these components.

3.1.3 COMPATIBILITY IN ASSEMBLING

A sense of compatibility is exhibited in putting together of this project, making sure it meets up with any standard assigned to locally fabricated UPS system. The vero board is

3.1.4 MAINTAINABILITY OF THE UPS SYSTEM

Maintainability is the probability that a unit or the system will be restored to operational efficiency within a given period of time. When the maintenance action is performed in accordance with prescribed procedure, using components part which are easily source from local market.

3.2.0 TOOLS USED IN CONSTRUCTION

The following tools or equipment are used in the construction of the system.

(i) Soldering iron

(ii) Soldering lead

(iii) Sucker

(iv) Vero board

(v) Bread board

(vi) Insulated copper wire

(vii) Long nose plier

(viii) Cutter and razor blade

(ix) Screw driver

(x) Digital multimeter.

3.3.0 STEPS IN SYSTEM DESIGN

The following steps were taken in carrying out the construction.

(i) The circuit was first tested on a bread board with few adjustment and modification of component valve.

(ii) The whole circuit layout was then transferred into the vero board, also unnecessary distance between components are avoided to reduce the length of wires.

(iii) IC sockets were then soldered unto the vero board in places allocated to them in the layout.

(iv) Discrete component like capacitor, resistor were soldered directly on the vero board.

(v) The MOSFET was then carefully mounted on the heat sink, ensuring proper insulation between the MOSFET and the heat sink.

(vii) A digital multimeter was then used to check the contact and continuity where necessary.

(viii) With the IC's plugged into their sockets, the circuit was then tested.

3.4.0 TESTING

Due to the design of the UPS system. It is pertinent to note certain changes in the output that may occur as a result of changes in some of the characteristics of components as used in the circuit. The following should be tested when troubleshooting:-

(a) Lead acid accumulator

(b) MOSFET transistor

(c) Voltage regulator

(d) Diodes, resistors etc.

These may cause such defect as follows:-

(i) Frequency drift as a result of heat conversion to the circuit from the external sources.

(ii) Reduction in output voltage as a result of fall in input voltage that is battery potential.

Also the following precaution should be observed:-

(i) Refer servicing to qualified personnel with schematic diagram.

(ii) Always ensure that the equipment is used for the purpose designed for.

(iii) Ensure that the potential difference of the battery is within its rated voltage.

(iv) Avoid exposing the equipment to direct sunlight or heat source.

3.5.0 DISCUSSION OF RESULTS

The goal of this project was to design and construct a UPS of output power of 500VA at an output voltage of 240V

Although the result obtained shows some slight difference from the expected value. The output voltage was 230V, output current is 2.19A. Hence the output power being equal to

Output power = Output voltage x Output current (VA)

$$P = V \times I \ (VA)$$

$$= 230 \times 2.19 \ (VA)$$

$$= 503.70A$$

was 20 minutes.

Though, the obtained result values are quite different from the expected result. Factors responsible to slight difference are as follows:-

(i) There are voltage drop across the passive components which invariably affect the output power.

(ii) Non-availability of exact component value, hence components with close values were used which finally affect the output power.

(iii) The winding of transformer and energy loss by the transformer also affect the output power.

3.5.1 TECHNICAL SPECIFICATION

The table below shows the expected technical result and the result obtained.

TECHNICAL SPECIFICATION	EXPECTED RESULT	RESULT OBTAINED
POWER RATING	500W	503.7W
OUTPUT VOLTAGE RANGE	230V	215V
MAINS INPUT RANGE	220V	235V-240V
EFFICIENCY	100%	96.8%
REGULATION	0.4%	0.43%
CHANGEOVER TIME	2mS	3mS
BATTERY DISCHARGE TIME	20minutes	16minutes
BATTERY RECHARGE TIME	3hr.18minutes	3hrs.
TRICKLE CHARGING TIME	10mS-12mS	11mS
FREQUENCY RANGE	50Hz	50Hz

3.6 FAULT TREE ANALYSIS OF THE PROJECT.

It is an analytical method of accessing the system to detect or discover fault by deduction. It also indicate those parts of the system which are important with respect to the failure of the system. By testing using fault tree method, personnel is able to concentrate on a particular system failure mode.

Fault tree analysis is a top-down approach design in which faults are attempt to be

The two major logic relationship use in fault tree analysis are the AND and OR gate. An AND gate is used when all the input events must occur for the output events to occur. Likewise the OR gate is used when an input event occurring alone causes the output event to occur (i.e. failure of the system).

AND GATE:-

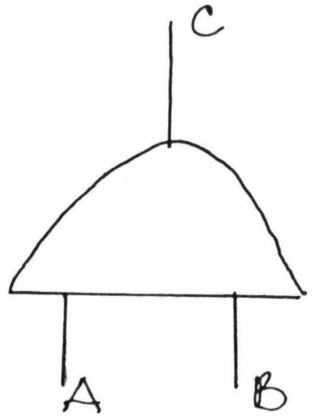


FIGURE 3.6(a)

OR GATE:-

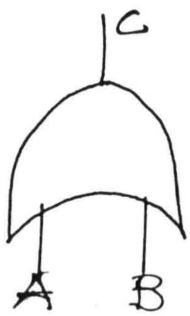


FIGURE 3.6.(b).

CHAPTER FOUR

4.0 CONCLUSION

This project has been subjected to a series of tests during and after construction. The basic objective of this project was achieved by inverting 12V d.c. to 230V. Its main function is that it supplies the load with a voltage where amplitude, frequency, and harmonic contents are within the required tolerance.

The result was achieved within the battery limit without any interruption, even in the event of more or less prolonged failure. It could be concluded that this project provides compliance with rules concerning mains supply and other factors.

4.1 COST ANALYSIS

One of the important aspect in every engineering project management is the aspect of cost analysis. A project can never be accepted as good for implementation if it is not cost effective as dictated by market forces.

Direct material cost will be considered since this particular project is a prototype model. The figure below shows the components, quality, unit price and cost.

NO	ITEMS	QUANTITY	UNIT PRICE (N)	COST (N)
1.	Switch	1	40	40
2.	Plug	1	50	50
3.	Cooling fan	1	50	50
4.	Casing	1	550	550
5.	Plug	1	50	50
6.	Vero board	1	70	70
7.	Transformer 15V	1	150	150
8.	Transformer step up	1	3000	3000
9.	Heat sink	1	80	80
10.	Connecting wire	1	100	100
11.	Power MOSFET	4	200	800
12.	Voltage regulated	1	60	60
13.	Unregulated voltage regulator	1	60	60
14.	Rectifier	1	40	40
15.	Inductor	1	40	40
16.	Capacity	4	5	20
17.	Resistor	13	5	65
18.	Power resistor	1	10	10
19.	Bolt & nut	6	6	60
20.	UPS battery 12V,7AH	1	3000	3000
21.	Lead	1	50	50
22.	Soldering iron	1	150	150
23.	Transistor	1	40	40
24.	555 timer	3	40	120
	TOTAL			N8,655

4.2 LIMITATION AND PROBLEMS

The major limitation of this project are enumerated below.

(i) Non availability of exact component value because of this approximate output value of most subsection had to be accepted.

4.3 RECOMMENDATION AND IMPROVEMENT

Though the experiments have been successfully carried out, some steps may be taken into consideration to make it more useful and effective. Moreover, for future working improvement on this particular project, the following suggested are given:-

(1) An oscillator could be used to give 50Hz sinusoidal wave so as to reduce the harmonic distortion which is produced by the square wave.

(2) Instead of using an accumulator (which is a chemical source of energy) an adaptation of this system using solar cell could be used.

(3) Equipment of over temperature alarm could also be incorporated whenever further improvement is done on this particular project.

(4) It is recommended that the electrical department makes available some of the basic components for the project in order to create a harmonized working condition for the students and also to relieve students of financial stress.

(5) Change over time can be improved by making use of sophisticated microprocessor.

(6) Raw power can be improved upon if it is stabilized before passing it over to the load.

4.4 COMMENTS

This project was completed from development stage to fabrication in the space of ten months. The first four months was used for research, finding of appropriate circuit diagram and developing a suitable design, while the remaining months were used to assemble the UPS.

At local level, if mass production is encouraged, this project is still considered to be cost effective.

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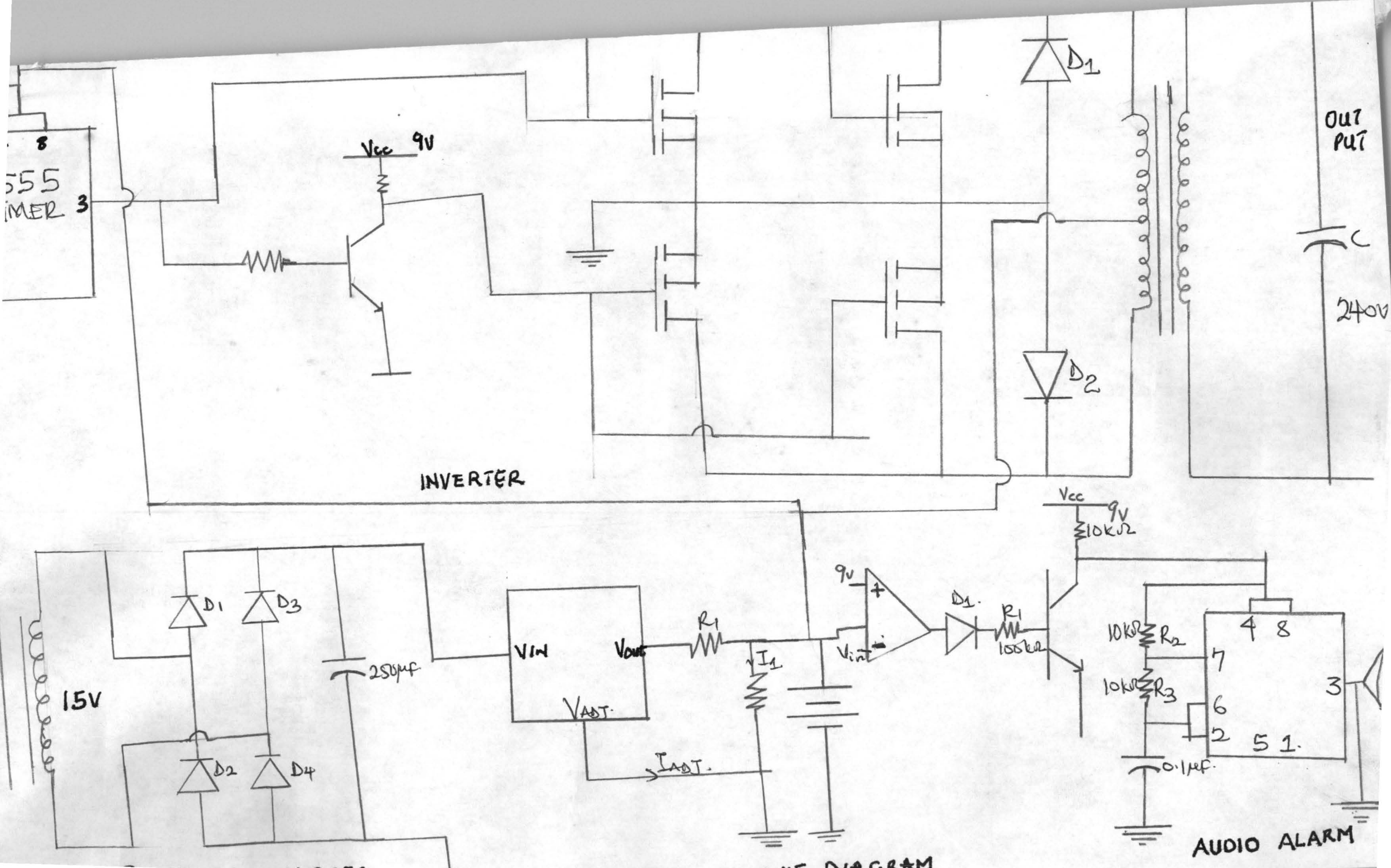

CIRCUIT DIAGRAM