DESIGN AND CONSTRUTION OF 600VA UN-INTERRUPTED POWER SUPPLY (UPS)

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Dedication

This project work is heartily dedicated to my sisters, Gina Abah, Alice Abah and Lydia Abah. Not to be left out is my In-law in person of Mr. Israel Abah Finally my parents, Mr and Mrs. Abah and my creator, the God Almighty.

Declaration

I, Abah Alex Ochogwu, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna

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Acknowledgement

I hereby humbly acknowledge the divine assistance of the Almighty God in making this project a reality and a success.

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The acknowledgement will be incomplete, if I fail to mention the spiritual assistance, financial backbone and words of encouragement of my in-law, Mr Israel Abah.

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Abstract

Computer systems need to be shut down with series of commands so as not to crash the hard-drive, in the event of power failure the hard-drive can crash, so the need for an uninterrupted power supply unit can not be over emphasized. This UPS employs the use of battery, which is rechargeable, the battery charges when the power is on and disconnected when power goes off. This is achieved using a comparator which outputs a low (0), when the power goes off, then the relay cuts the battery from the charging point. Battery life is greatly affected by the way it is charged and drained. Hence, this UPS incorporates a charge controller to control how the battery is charged and drained.

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CHAPTER ONE

General Introduction

1.1 Introduction

The role of a good and reliable source of an electrical power cannot be over-emphasized, it is however, observed that this electrical power that is produced by Power Holding Company of Nigeria (formerly NEPA) is not reliable. This brought sharper focus the need for an alternative source which will serve as a backup to the unpredictable power outage. Even though there are many less expensive methods one can employ to provide some degree of protection for one's appliances from power problems, none of them can insulate one's equipment from power troubles except a good Uninterrupted Power Supply (UPS).

The modern state of technology would not have been attained without the existence of DC power supply, viz: the development and uses of uninterrupted power supply devices which convert the DC power supply to AC power supply. The fundamental purpose of a UPS is to provide an uninterrupted source of power for the equipment it protects, that is, electric device plugged into the wall has only two source of power. If there is a black-out, the electricity is cut off and the other source will switch on, in order to provide uninterrupted source of power for the equipment it protects. A UPS changes this equation by providing its equipment sources of power.

Equally, inconvenient and sometimes more costly is the damage to equipment caused by very high voltage such as those caused by lightning strikes. At worst, they can destroy banks of integrated circuits and basic components. It is now possible with new technology providing highly reliable back-up (UPS) power at a reasonable cost for almost any requirement.

1.2 Aims and Objectives

The main aim of this project is to design and construct an Uninterrupted Power Supply (UPS) incorporated with a charge controller. Towards achieving this aim. The following objectives are attributed to it:

- To prevent the interruption of power supply to the equipment it protects for example computer system.
- To design a very reliable and less expensive uninterrupted power supply device incorporated with a charge controller to prolong the life span of the battery.

1.3 Methodology

The method employed for the successful completion of this project was design and construction manually by soldering processes.

1.4 Scope of the work

Basically, this project is based on OFF-line system particularly the active (or hot) standby system, which involves the critical load that 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.

1.4 Sources of material

The materials (components) used for the completion of this project were being bought from a recommended shop according to the correct specifications and rating of the components.

The working principle of the UPS could also be illustrated in a flow chart as shown in fig 1.1.Once there is no power, the battery which is attached with a charger ,supplies the alternative power which is direct current (DC) to the load through an inverter and a step up transformer which convert the 12V to 220V if it's level is high, and shutdown if low.

But in the case whereby there is power, the alternating current (AC) will be supplied directly to the load.

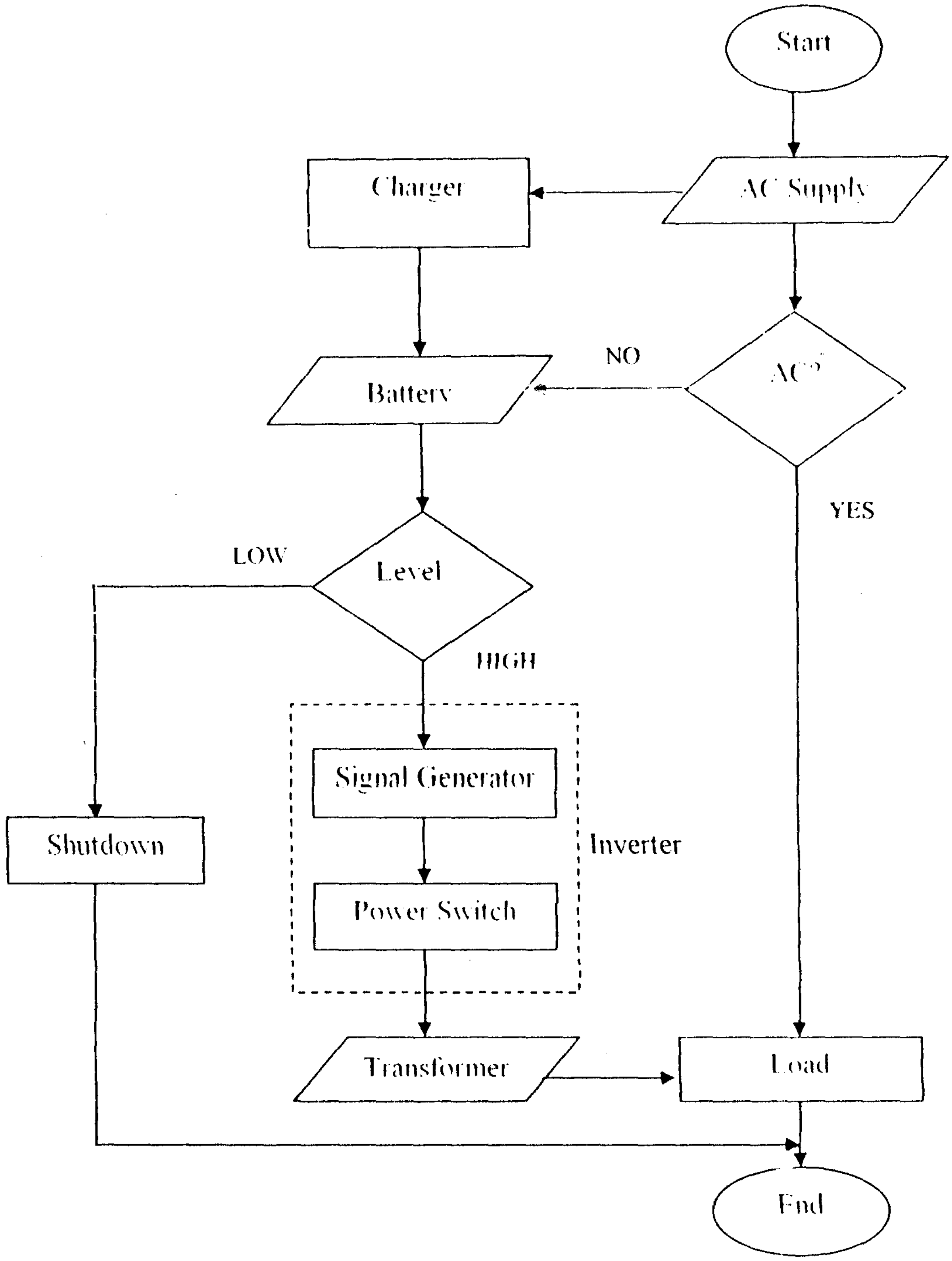


Fig. 1.1: Flowchart Diagram of Typical UPS

CHAPTER TWO

Literature Review/Theoretical Background

2.1 Literature Review

Historically, UPS units were very expensive and were most likely to be used on expensive computer systems and in areas where the power supply is interrupted frequently. However, UPS units are now more affordable, and have become an essential piece of equipment for data centers and business computers, but are also used for personal computers, entertainment systems and more.

In North America in particular, the electrical grid is under increasing strain particularly during heavy demand periods such as summer when air conditioning use is at its highest. In order to prevent blackouts, electrical utilities will sometimes use a process called load shedding, which involves cutting the power to large groups of customers for short periods of time. The single biggest event that brought attention to the need for UPS power backup units was the 2003 North America blackout in the north-eastern US and eastern Canada[1].

Older uninterruptible power supply designs that supply commercial quality AC power to equipment contain a motor-generators system with a large flywheel that keeps the generator rotating and producing electric power while an auxiliary motor is started at the moment of power interruption. Sometimes the flywheel itself is used to start the motor. These systems can typically cover a 30 second interruption until the auxiliary motor starts.

Fuel cell UPS have also been developed in recent years using hydrogen and a fuel cell as a power source potentially providing long runtimes in a small space. Internal UPS is a group of uninterruptible power supplies (UPS) designed also to be placed inside computer chasses. There are two types of Internal UPS. First type is miniaturized regular UPS that are made small enough to fit into a 5.25" CD-ROM slot bay of a regular computer chassis. The other type is re-engineered switching power supplies that utilize dual power sources of AC and/or DC as power inputs and have an AC-DC built-in switching management control units.

The first type often requires extra connection wires between the internal UPS and computer's power supply. Some internal UPS of this group output high voltage (110 V - 220 V) direct current (DC) and some output nine-step wave AC. Neither design is safe or energy efficient. As of 2006, there are only a couple of companies still selling this type of internal UPS in Asia and some part of Europe [1]

The second group of internal UPS replaces the regular switching power supplies. There are three main design mechanisms:

1. Optic-coupling that imitates AC during AC outages. This mechanism was first introduced by American Advanced Power of USA and Magnum Power of UK in 1997, as well as Apollo Power of Taiwan in 1998[1]. This design provides a low-cost solution but its efficiency is low and it has a very low overall wattage (<300 W) limit.
2. An analog-circuitry-controlled AC-DC switching mechanism. This design also provides a low-cost solution. However, because of the bulky component circuit board, little space is available for increasing wattage output. Plus, the final

products are very sensitive to factors such as local heat and causing frequent operational errors. Nevertheless, because of its low cost, it is still popular in China. Most Asian internal UPS manufacturers belong to this category.

3. A CPU controlled AC-DC switching mechanism. This design was first introduced by American Advanced Power Inc. of USA and Amsdeli of Canada [1].

Most of the UPS discussed above have a common battery problem which makes the battery to have short-life span because of the continuous charging of the battery without being controlled .

Having noted this limitation, a voltage comparator, was incorporated in my design to remedy this limitation by controlling the charging capacity of the battery, this indeed, acts as one of the major improvement on the design.

2.2 Theoretical background.

Uninterruptible Power Supply (UPS) is a device that provides battery backup when the electrical power fails or drops to an unacceptable voltage level. Small UPS systems provide power for a few minutes; enough to power down the computer in an orderly manner, while larger systems have enough battery for several hours. In mission critical datacenters, UPS systems are used for just a few minutes until electrical generators take over. UPS systems can be set up to alert file servers to shut down in an orderly manner when an outage has occurred, and the batteries are running out.

UPS is sometimes called an uninterruptible power source, is a device which maintains a continuous supply of electric power to connected equipment by supplying power from a separate source when utility power is not available. A UPS is inserted between the source of power (typically commercial utility power) and the load it is protecting. When a power failure or abnormality occurs, the UPS will effectively switch from utility power to its own power source almost instantaneously. While not limited to any particular type of equipment, a UPS is typically used to protect computers, telecommunication, equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss. UPS units come in sizes ranging from units which will backup a single computer without monitor (around 200 VA) to units which will power entire data centers or buildings (several megawatts). Larger UPS units typically work in conjunction with generators.

A UPS is not to be confused with a standby generator, which does not provide protection from a momentary power interruption, which may result in a momentary power interruption when it is switched into service, whether manually or automatically. However, such generators are typically placed before the UPS to provide cover for lengthy outages.

Common power problems that UPS units are used to correct are:

1. Power sag - Short term under-voltage
2. Power surge (spike) - Quick burst of over-voltage
3. Under-voltage (brownout) - Low line voltages for an extended period of time
4. Over-voltage - Increased voltages for an extended period of time
5. Line noise - distortions superimposed on the power waveform.
6. Frequency - variation of the power waveform.
7. Switching transient - under-voltage or over-voltage for up to a few nanoseconds.

8. Harmonic Distortion - multiples of power frequency superimposed on the power waveform.

UPS units are divided into categories based on which of the above problems their UPS units address. The general categories of modern UPS systems are *on-line*, *off-line* and *standby*. The traditional definition of an on-line UPS was one that continuously powered the load from a DC bus that was supplied by two sources: batteries and DC rectified from the incoming AC. In a standby UPS, the load is powered by the source until the power fails and then it quickly switches on an AC-to-DC converter and battery source. Since 2004, the majority of units sold below 1 kVA are standby UPS.

1 Standby (offline)

With this design, the UPS simply passes utility power through to the load until either a power failure, sag or spike occurs, at which point, the UPS switches the load onto battery power and disconnects the utility power until it returns to an acceptable level. In this design, the UPS unit only charges the battery when it is running on utility power. This design is the most cost effective and typically makes use of a square wave or modified square wave inverter. These units are typically found in units of 600VA and below and designed for home use. Ferro-resonant units operate in the same way as a standby UPS unit with the exception that a ferro-resonant transformer is used to filter the output. This transformer is designed to hold energy long enough to cover the time between switching from line power to Ferro-resonant battery power and effectively eliminates the transfer time. Because the transformer typically gives off a lot of heat, these units are typically large, bulky, and inefficient. While this used to be the dominant type of UPS, they are no longer used for common applications. Power factor correcting equipment found in newer computer systems interacts with the transformer, causing potentially damaging oscillations, and the transformer itself can create distortions which yield power less acceptable than poor quality line AC. These units are still used in some industrial settings, but have mostly disappeared from use with general computer equipment.

2 Line interactive

Line interactive UPS units are designed so that the inverter is always connected to the output of the UPS. When line power is present, the inverter operates in reverse to charge the battery. When utility power fails, the UPS reverses the power flow from the inverter and provides power to the load. This design provides better filtering than a standby unit because the inverter is always connected to the load.

Line interactive units typically will incorporate an automatic voltage regulator. AVR allows the UPS to effectively step-up or step-down the incoming line voltage without switching to battery power. This allows the UPS to correct most long term over-voltages or under-voltages without draining the batteries. Another advantage is that it reduces the number of transfers to battery which extends the lifetime of the batteries. Line-interactive UPS units are the most common design for units in the 0.5 kVA to 5 kVA range. They are typically used in small server environments.

3 Online UPS

The online UPS is the most advanced and most costly UPS. The inverter is continuously providing clean power from the battery, and the computer equipment is never receiving power directly from the AC outlet. However, online units contain cooling fans, which do make noise and may require some location planning for the home user or small office.

CHAPTER THREE

Design and Implementation

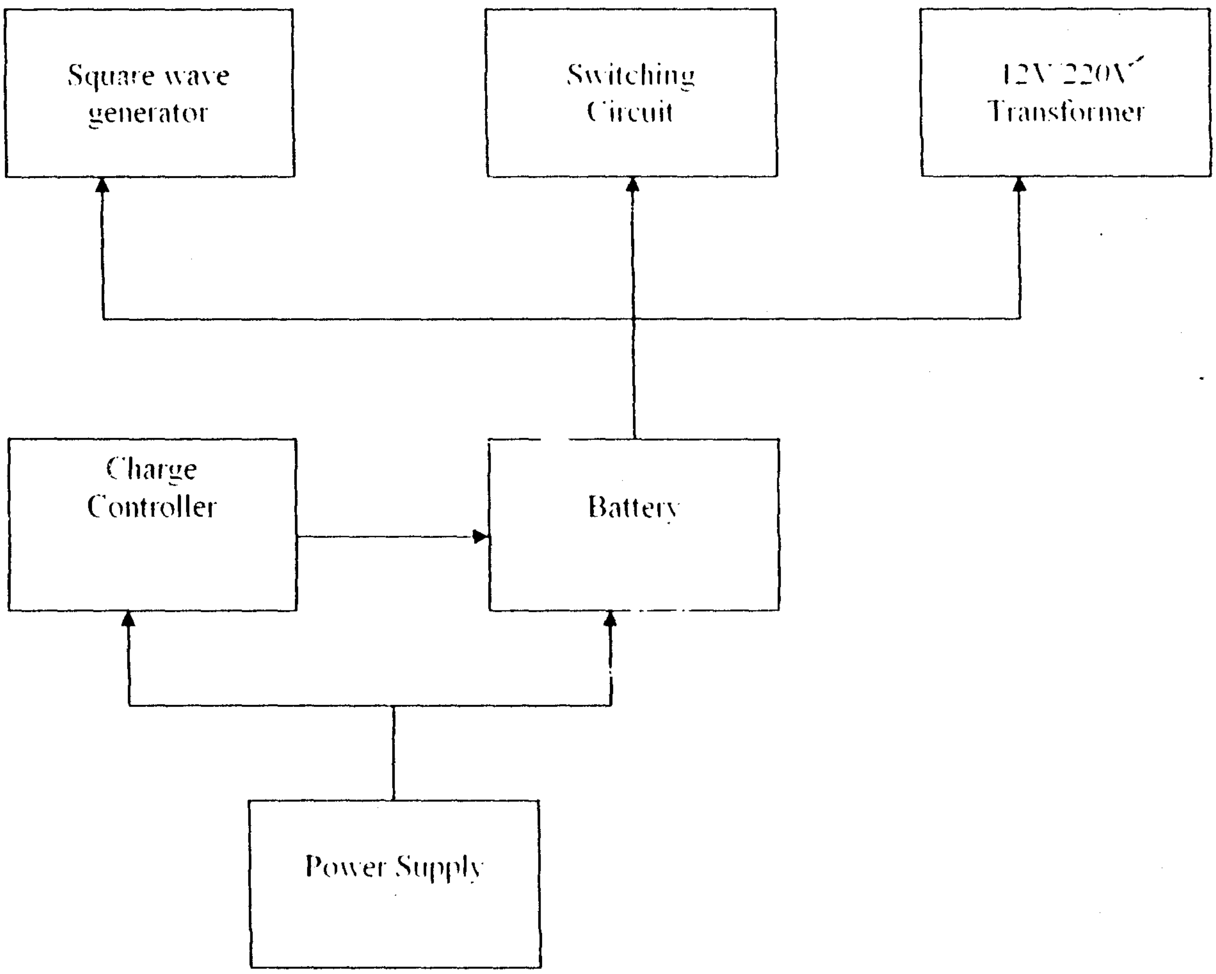


Fig. 3.1 Block Diagram of a Typical UPS System

The Units involved in the design of this project (UPS), as shown in Figure 3.1, are

1. Power Supply Unit
2. The Charge Controller Unit
3. The Battery Unit
4. Square Wave Generator Unit

5. Switching Circuit Unit

6. Transformer Unit

3.1 The power supply unit

Since the electronics circuit being designed requires dc voltage +12V and +16V with their common ground, the power supply unit converts the domestically supplied 220V or 240V ac voltage into the required dc voltages, which are expected to be constant, but when variations occur in the ac supply voltage, it also affects the output dc voltage.

It increases or reduces the mains voltage and then converts it from ac to steady dc so that it can be used in a range of electronic circuits [2]. To achieve the above, series of stages are involved in the power supply unit and they include:

(1) Transformation stage

(2) Rectification Stage

(3) Filtering Stage

(4) Regulation Stage

The block diagram of the power supply unit showing the various stages involved are shown below in fig, 3.2

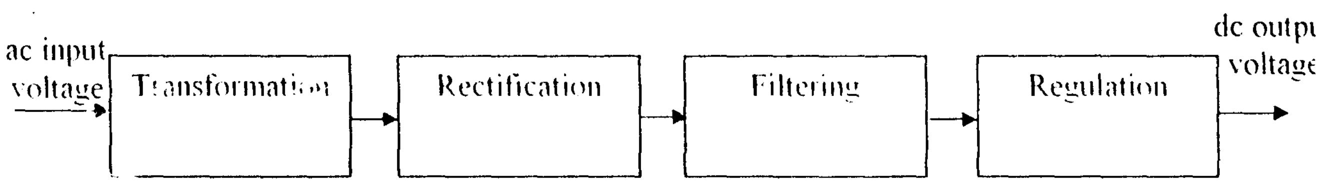


Fig. 3.2: Block Diagram of the Power Supply Unit

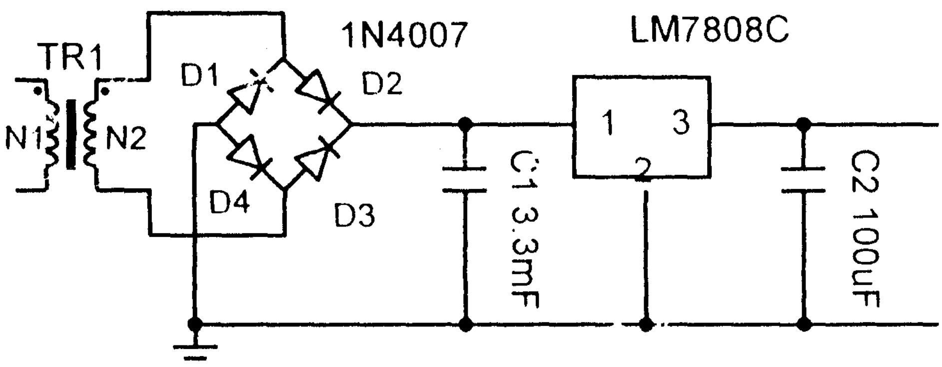


Fig 3.3 Circuit Diagram of the Power Supply Unit

3.1.1 Transformation stage

This stage involves transforming the domestic ac supply from level of 240V into a level of 15V. Therefore, a step-down transformer was required and of course used Actually, 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. It can raise or lower the voltage in a circuit but in a corresponding decrease or increase in circuit [3].

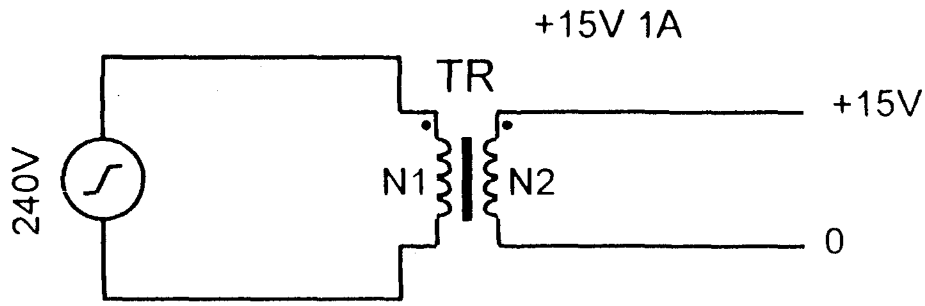


Fig. 3.4: Circuit Diagram of a Transformer

3.1.2 Rectification stage

Rectification is the process of converting alternating current (ac) to direct current (dc). It is used in power supply unit for producing low-power dc from the mains 240V supply [2]. The essence of this stage is to rectify the step down 15V ac voltage by converting it into a dc voltage of approximately the same value.

This rectification is achieved by using four diodes arranged as a bridge circuit. The circuit diagram of a full-wave bridge rectifier and its wave form are shown in fig. 3.5

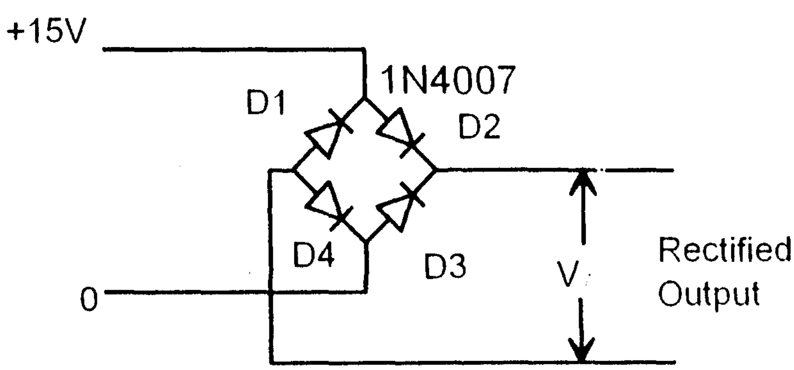


Fig. 3.5: Circuit Diagram of a Full-wave Bridge Rectifier

Calculations:

Let the rectified output be given by $V_l = \frac{2}{\pi} V_m$, where V_m is the peak value of the ac voltage and is related to the root mean square value of the ac voltage by $V_{rms} = \frac{V_m}{\sqrt{2}}$

Therefore, $V_L = \frac{2\sqrt{2}}{\pi} V_{rms}$ where $V_{rms} = 15V$

Therefore, $V_L = \frac{2\sqrt{2}}{\pi} \times 15 = 13.5V$

The full-wave bridge rectifier has been chosen because:

- It makes use of smaller transformer
- It has lower ripple factor compared to half wave rectifier
- The peak inverse voltage (PIV) rating of each diode is also less.

3.1.3 Filtering stage

The output of the previous stage (rectification) consists of two components:

- A dc component
- A number of ac components which form what is known as ripple (periodic variations in voltage about the steady value) that has to be smoothened out in order to generate genuine dc.

The vitality of the filtering stage is to eliminate the ripple or at least reduce it to such a value that its influence becomes negligible in the circuit. Various types of filters abound but the choice for this project work is a shunt capacitor filter.

Calculations

To calculate for the filtering capacitor, C_1

Recall, $I = \frac{Cdv}{dt}$

Where I = maximum current

C = filtering capacitor, C_1

dv = ripple voltage

dt = time interval between peak of ac voltage

But I = 1A (Transformer rating i.e. 1000mA)

dv = %ripple of the a.c. x V peak

Letting a ripple factor of 20% (since the ripple raise will not affect the battery in anyway)

dv = 20% x 15V

$$= \frac{20}{100} \times 15V$$

= 3.0V

$$dt = \frac{T}{2} = \frac{1}{2F}$$

$$\frac{1}{(2 \times 50Hz)}$$

dt = 0.01s

Therefore,

$$C_1 = I\frac{dt}{dv} = \frac{(1 \times 0.01)}{3.0}$$

= 3.33×10^{-3}F

= 3333×10^{-6}F

A preferred value of 3300µF was used

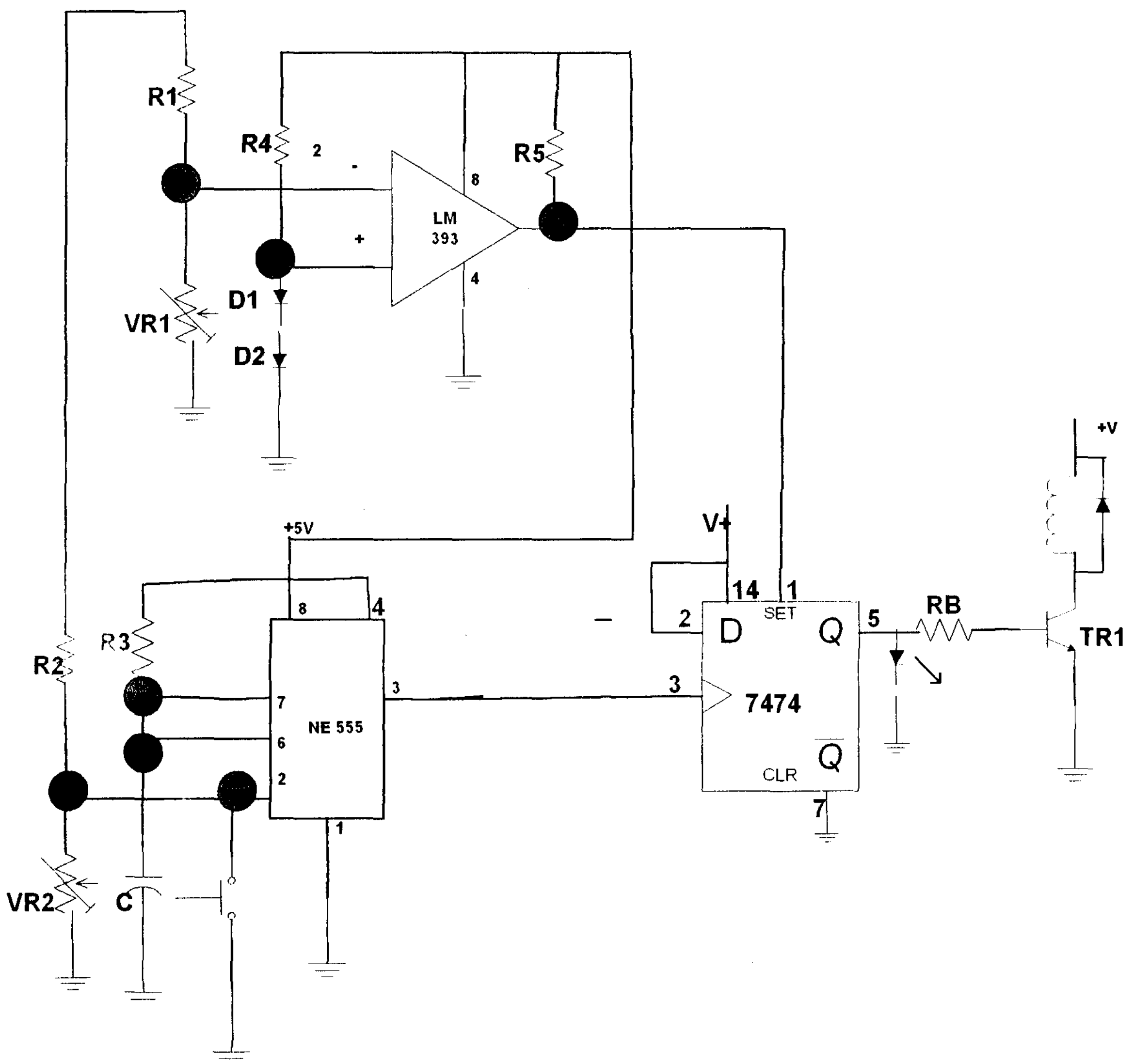
A compensating capacitor C_2 of $100\mu F$ was also used so that as the capacitor charges when power goes off, it won't take time to discharge

3.1.4 Regulation stage

The regulation of power supply is an index which shows how the output voltage changes with different load circuits [4]. A voltage source is considered to be well regulated if its output is constant under a variety of loads.

3.2 Charge Controller Unit

The charge controller unit is made up of a sensing circuit to automatically shut down the charger when the battery is charged and a dc voltage source which is the charging voltage.. The charge controller unit is shown in fig. 3.6



Where RB=8.4k, VR2=10K,R3=100KΩ,C=0.009μF,R1=R4=R5=1KΩ.

Fig. 3.6: Circuit Diagram of the Charge Controller Unit

The charging circuit is a constant voltage type. The charging voltage is derived from a constant regulated dc voltage while the control for the charge is composed of a combinational logic circuit.

The comparator compares the battery voltage with a fixed reference and when the battery is fully charged, the monostable on the other hand detects whether the battery is discharged and automatically initiates charging. We shall consider each of the charge controller units separately.

3.2.1 LM 393 Comparator

The function of the comparator is to compare two voltages and give an output which tells if they are equal or unequal. It is also used to sense when the battery is charged or not. The comparator stage is shown in fig. 3.7

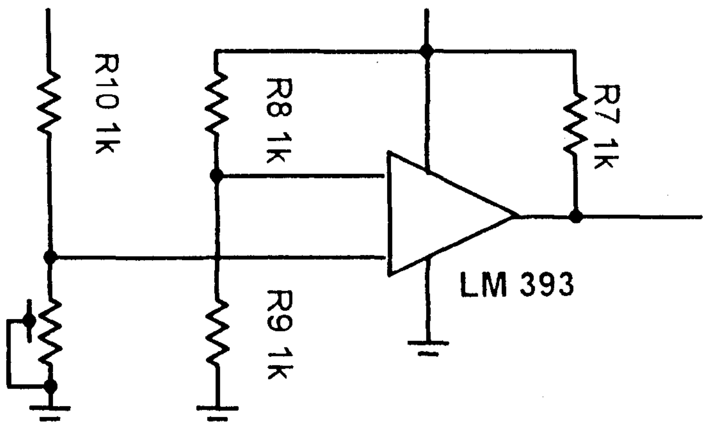


Fig. 3.7 Comparator Circuit

Calculations

Let reference voltage = 4.5V

Let $R_2 = 1k\Omega$

From Voltage Divider Theorem

$$4.5V = \frac{R_3}{R_3 + 1k} \times 9V$$

$4.5R_3 + 4.5k = 9R_3$

$9R_3 - 4.5R_3 = 4.5k$

$4.5R_3 = 4.5k$

$$R_1 = \frac{4.5k}{4.5} = 1k$$

let R_1 = 1k

Voltage divider Theorem

Let reference voltage be 5V

$$5V = \frac{VR_1}{VR_1 + 1k} \times 12V$$

$5K + 5V_{R1} = 12V_{R1}$

$7V_{R1} = 5k$

$$V_{R1} = \frac{5k}{7} \approx 714.3\,\Omega$$

∴ 1k is used as preferred value

3.2.2 7474 D Flip-flop

The D-type flip-flop is built around logic control. It is the flip-flop that tells the system when to start and stop charging the battery. These flip-flops are available as inexperience packaged ICs and are always used in that form [5]

The operation of the system is described in the Table 3.1

Table 3.1: Truth Table of D-Flip Flop

mode	D Input	CK	Q	$\bar{Q}$	R
Ste up	1	↑	1	0	1
Reset	0	X	0	1	1
Hold	X	X	0	1	0

X = Don't care

↑ = Rising edge

Q and $\overline{Q}$ = outputs

D= Data Input

The logic control circuit operates in its set and hold mode. When the monostable sends clock signal, the flip-flop shifts data from data input to the Q output to start charging. When the battery is charged, the comparator sends a low to the reset input to set the flip-flop to hold mode to stop the charging. The diagram of the flip-flop stage is shown in fig 3.8

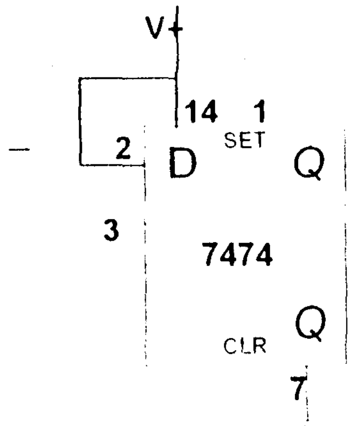


Fig 3.8 D flip-flop circuit diagram

3.2.3 Monostable design (IC LM555 Timer)

The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are powered for triggering or resetting if desired.

It was introduced in 1972. Since that time it has become one of the most widely used IC [4]. The monostable multivibrator is a form of relaxation oscillator that only has one stable state. When triggered, the multivibrator goes to its unstable state for T = 1.1RC and turns to its stable state. The trigger condition for the monostable is that the voltage at its trigger inputs should be $\leq \frac{1}{3} V_{cc}$.

To achieve the trigger condition the voltage at the trigger is not discharged, the drop at the trigger input is just $\frac{1}{3} V_{cc}$ [4]. The monostable stage once triggered, clocks the flip-flop and puts it in the set mode to allow for charging. The circuit diagram of the monostable is shown in fig. 3.9

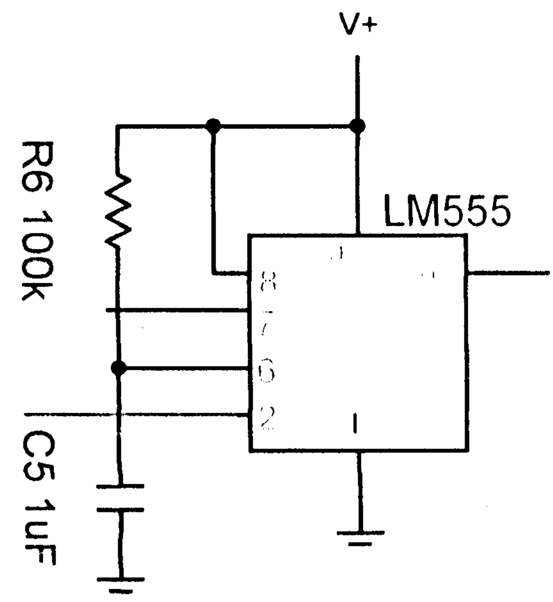


Fig. 3.9: Circuit Diagram of a LM555 Timer

Calculations

The supply V_{CC} is known to be the battery voltage 12V. therefore, the trigger input voltage, V_t = 1/3 (12) = 4V

sBut in the monostable state, it is required that the timer times for a certain period of time when switched and set to the required time.

For a good operation of the system (UPS) the timer delay for the UPS to switch to battery when the power goes off has to be very small. For a time-delay of 1 second to be used the capacitor value has to be determined.

But the time during which the output stays in the astable state is T = 1.1RC

where T = time-delay

R = Resistance of the timer

C = Capacitor of the timer

Let R = 100k

For a time of one second,

$$C = \frac{T}{1.1R} = \frac{1}{1.1 \times 100}$$

$$\approx 0.009 \mu F$$

3.2.4 The relay

The relay is an electromagnetic device or a solid device operated by varying the input, which in turn is used to control other devices connected to its output [6]. It consists of a coil and a magnetic switch. The relay used in this design are three. one is connected to the NPN transistor which is responsible for the tripping "ON" and "OFF" of the transistor whenever the battery is fully charged or drained.

The other 2 are for switching to battery (circuit closed) when there is no power and open when there is power. It makes use of the 9V supplied by the regulator to operate. It is categorized into two modes:

- Normally open and
- Normally closed

. The diagram is shown in fig. 3.10

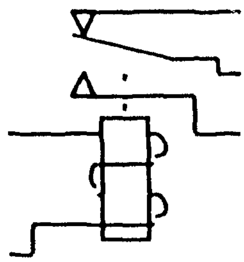


Fig 3.10 Relay diagram

3.2.5 Transistor

Transistors are active components used basically as amplifiers and switches.

In this mode of bias, the circuit is designed such that current flows without any signal present.

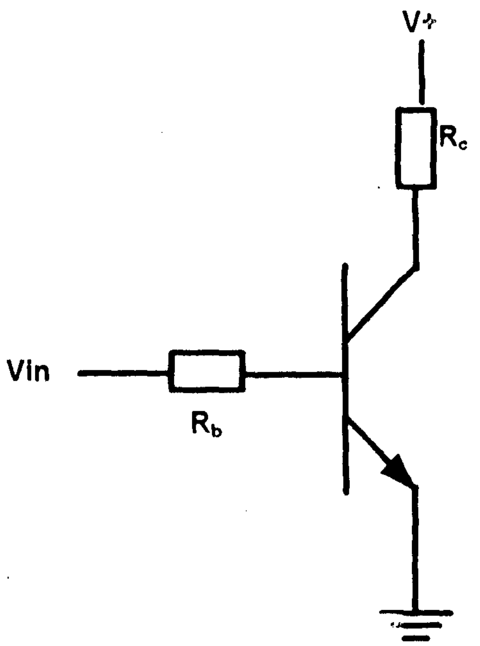


Fig. 3.11: NPN Transistor as a Switch

For the transistor configuration, since the transistor is biased

$V_{CE} = 0$, when the transistor is ON [7]

This implies that,

$V' = I_C R_C + V_{CC}$

$V_{in} = I_B R_B + V_{BE}$

$$\frac{I_c}{I_b} = hfe$$

$$R_b = \frac{V_{in} - V_{BE}}{I_b} \text{ ---------------------------- (1)}$$

where I_C = collector circuit

I_b = base current

V_{in} = Input voltage

V' = Supply voltage

V_{CC} = Collector-emitter voltage

hfe = current gain

In this design, FET is not used as switching transistor because they have relatively smaller gain-bandwidth product and have greater susceptibility to damage while handling [8].

Calcuiations

At saturation, the transistor is ON

$V_{CC} = 0$

At cut-off, the transistor is OFF

$V_{CE} = V_{CC}$

Using R_C to be $= 300\Omega$

hfe = 400 (multimeter reading)

$V_{CC} = I_C R_C + V_{CE}$

$I_R R_C = V_{CC} - V_{CE}$

$$I_C = \frac{V_{CC} - V_{CE}}{R_C} \text{ ----------------------------- (2)}$$

At saturation, $V_{CC} = 0$

$$I_b = \frac{I_C}{hfe} = \frac{0.04}{400} = 0.0001A$$

$$hfe = \frac{I_C}{I_B} = \frac{0.04}{0.0001} = 400$$

$V_{BE} = 0.6V$

$$\therefore \ R_B = \frac{V_{in} - V_{BE}}{I_B}$$

But $V_{in} = 9V$

$$R_B = \frac{9 - 0.6}{0.0001} = \frac{8.4}{0.0001} = 8.4k\Omega$$

3.3 The battery unit

The battery being the sole energy source is a critical aspect of the design, hence a very reliable battery charger is required to enable proper charging and discharging cycles.

The battery used in this design is sealed lead-acid battery. It was bought from a computer spare parts shop. The voltage rating of the battery is 12V. The electrolyte is an aqueous solution of sulphuric acid. The overall electrochemical processes taking place in a lead-acid cell can be summarized as

Lead + Lead dioxide + sulphuric acid   lead suphate + water [8]

OR

$Pb + PbO_2 + 2H_2SO_4 \quad 2PbSO_4 + 2H_2O$

3.4 Square wave generator unit

It is the heart of digital UPS design. The UPS needs to generate a.c. voltage at a frequency of 50Hz. Hence, there has to be some kind of oscillator circuit for this to be achieved. The oscillator stage used here is a pulse width modulator IC. The pulse width modulator has an internal RC oscillator, which could be made to oscillate to frequencies in excess of 1MHz depending on external components. The circuit of the oscillator is shown in fig. 3.12.

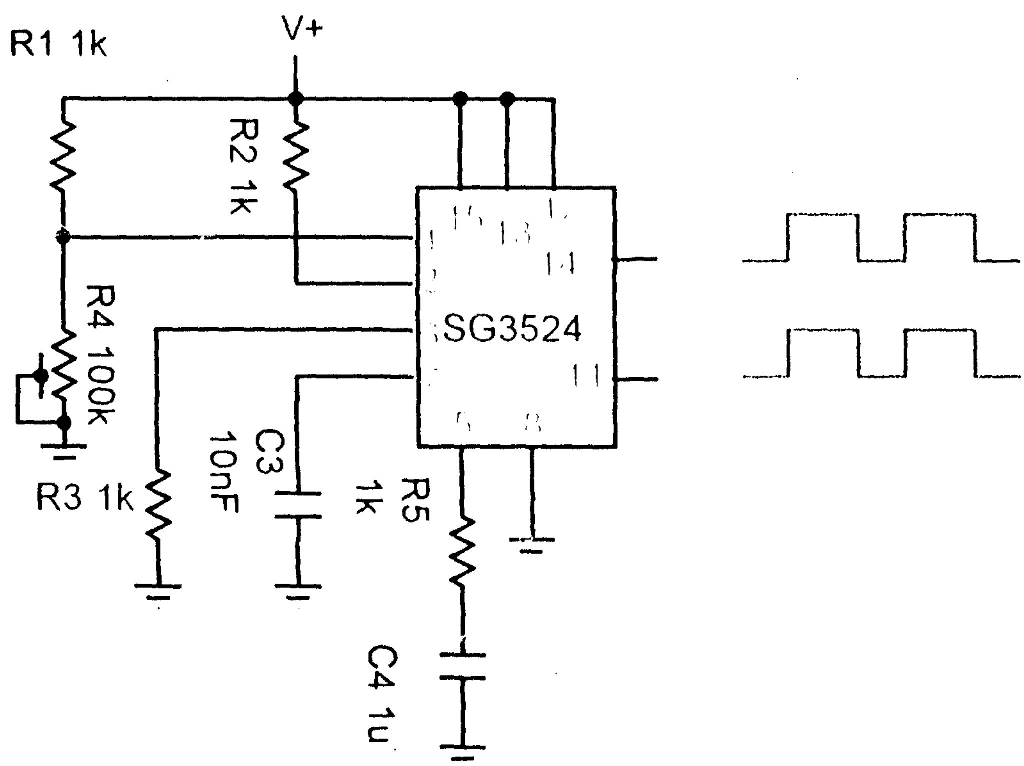


Fig. 3.12: Pulse width oscillator

The oscillator outputs a frequency that is 180^0 out of phase from each other between pin 11 and 12. The output of the oscillator stage now goes to the switching stage, which feeds the transistors. The frequency of the oscillator is given by:

$F = \frac{1}{RC}$ (where R and C are the frequency determining components).

For F = 50Hz using capacitor of capacitance $0.1\mu F$, the value of resistor R can be calculated thus:

$$R = \frac{1}{FC}$$

$$R = \frac{1}{(50 \times 0.1 \times 10^{-6})}$$

$= 200\mathrm{k}\Omega$

The remaining resistors are those that bias the internal amplifier in the pulse width oscillator.

5 Switching circuit unit.

This uses MOSFETs to produce the AC voltage by alternating the current at the input terminals of the transformer. The square wave signals are used as the gating signals for switching the driver transistors "ON" and "OFF" alternatively. Since the signals are 180^0 of phase, the push pull arrangement will only have one of the switches T_1 and T_2 in each half cycle of the output signal. Due to the high input impedance of MOSFET, its driver amplifier must be configured as a voltage buffer amplifier Fig. 3.13 shows the driver stage.

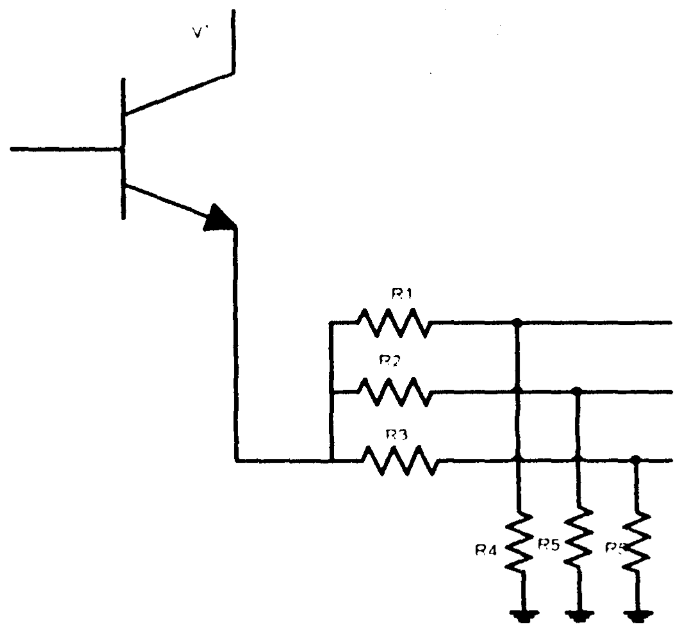


Fig. 3.13: Driver Stage

Resistors R_1 to R_6 are potential dividers used to isolate the various gate voltages.

. The choice of MOSFET solution depends on maximum circuit and power dissipation. For this project, IRF540 was used. The IRF540 has the following specifications:

Table 3.2: IRF540 Specifications

I_D (max)	V_{DS} (max)	P_D (max)
39A	60V	150 watts

where I_D = Drain Current

V_{DS} = Drain Source Voltage

P_D = Power dissipated

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

3.6 Transformer design

Power = 600W

Primary Voltage, V_P = 12V

Secondary Voltage, V_S = 220V

J = 200cm/A (J – operating current density), J< 200cm/A from the manufacturer data sheet for wire size material.

K = 4.0 (for push-pull configuration)

Frequency, F = 50Hz

Primary current, $I_p = \frac{P}{V_p} = \frac{600}{12} = 50.0A$

Secondary current, $I_S = \frac{P}{Vs} = \frac{600}{220} = 2.7A$

Wire size for primary = I x J = 50 x 200 = 8334cm

Wire size for secondary = I x J = 2.5 x 200 = 500cm

Selection of Core size

Core size, $A_eA_C = \frac{(0.68P_0J)10^3}{freq. \times B_{max}}$

where A_eA_C – core effective area in cm^4

B_{max} – maximum flux density (given as 12000G at 240V)

Therefore,

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

From the manufacturer data sheet, a transformer core size of 160cm^4 is selected with A_c = 16cm^2, Ac = 10cm^2

Number of turns in primary

$$N_p = \frac{V_p \times 10^8}{K \times f \times B_{max} \times A_c} = \frac{12 \times 10^8}{50 \times 1200 \times 16 \times 4}$$

Np = 31.25 turns

Np is rounded up to 32 turns, but since the primary is centre tap, therefore the total number of turns in the primary is thus 64 turns with the centre tap taken at the 32 winding.

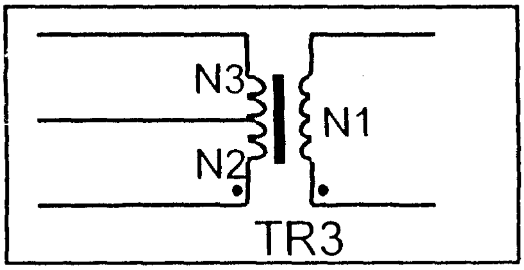
Number of turns in secondary

$$N_s = \frac{V_s \times 10^8}{K \times f \times B_{max} \times A_c} = \frac{220 \times 10^8}{4 \times 50 \times 12000 \times 16}$$

Ns = 572.9 turns = 573 turns

The number of turns in the secondary is 573 turns.

The schematic diagram of the transformer is shown in fig. 3.14



N =573Turns

N2=32 Turns

N3=32 Turns

Fig. 3.14: Schematic Diagram of the Transformer

CHAPTER FOUR

Tests, Results and Discussion

4.1 Tests

Each of the constituting units of the device being constructed was simulated one after the other before being tested on project board (bread-board) and then finally soldered to the main Vero-board.

The 12V sealed-lead acid battery bought was tested with the help of a digital multimeter and the rated voltage was confirmed.

The UPS was tested and made sure that the output frequency of the signal signal generator was 50 Hz.

Finally the UPS was tested with a complete system in the absence of power supply (electricity)

4.2 Results

The results obtained during testing are;

1. Used battery voltage=12V.
2. Used ac input voltage=between 19V and 240V.
3. Output frequency of the signal generator=50Hz.
4. Output voltage of inverter ≅ 2i9.

4.3 Discussion

The design of this project was made to have an output power of 600VA, that's to carry a load of 600W maximum with a voltage output of 220V.

With the load of 350W on the UPS, the discharging time of the battery was timed to be one hour, and with a computer system it was used for about 20 minutes before it was shut down.

Nevertheless, the more the load was added, the more the voltage drops. If the battery is fully charged, with a lesser load, it will give a longer duration.

The output power calculated after construction with the output voltage of 219V and output current (A) of 2.5A was 547.5VA. It was seen that the output power falls when compared to the target (expected value) and this of course could be attributed to some inconsistencies in the winding of the transformer.

CHAPTER FIVE

Conclusions

The target of this project which is "design and construction of a 600VA capacity UPS" was achieved as demonstrated by the results obtained from the test carried out as explained in chapter three.

My aim which was to control the charging of the battery with the help of a comparator, being the major problem many UPS are facing today was achieved.Perhap, it is the improvement I made on this UPS compared to the previous UPS.

A number of difficulties were encountered at the initial stage of the design and construction, this was because very little was known about the project, but constant research into books, internet and suggestions from senior friends, I was able to get through.

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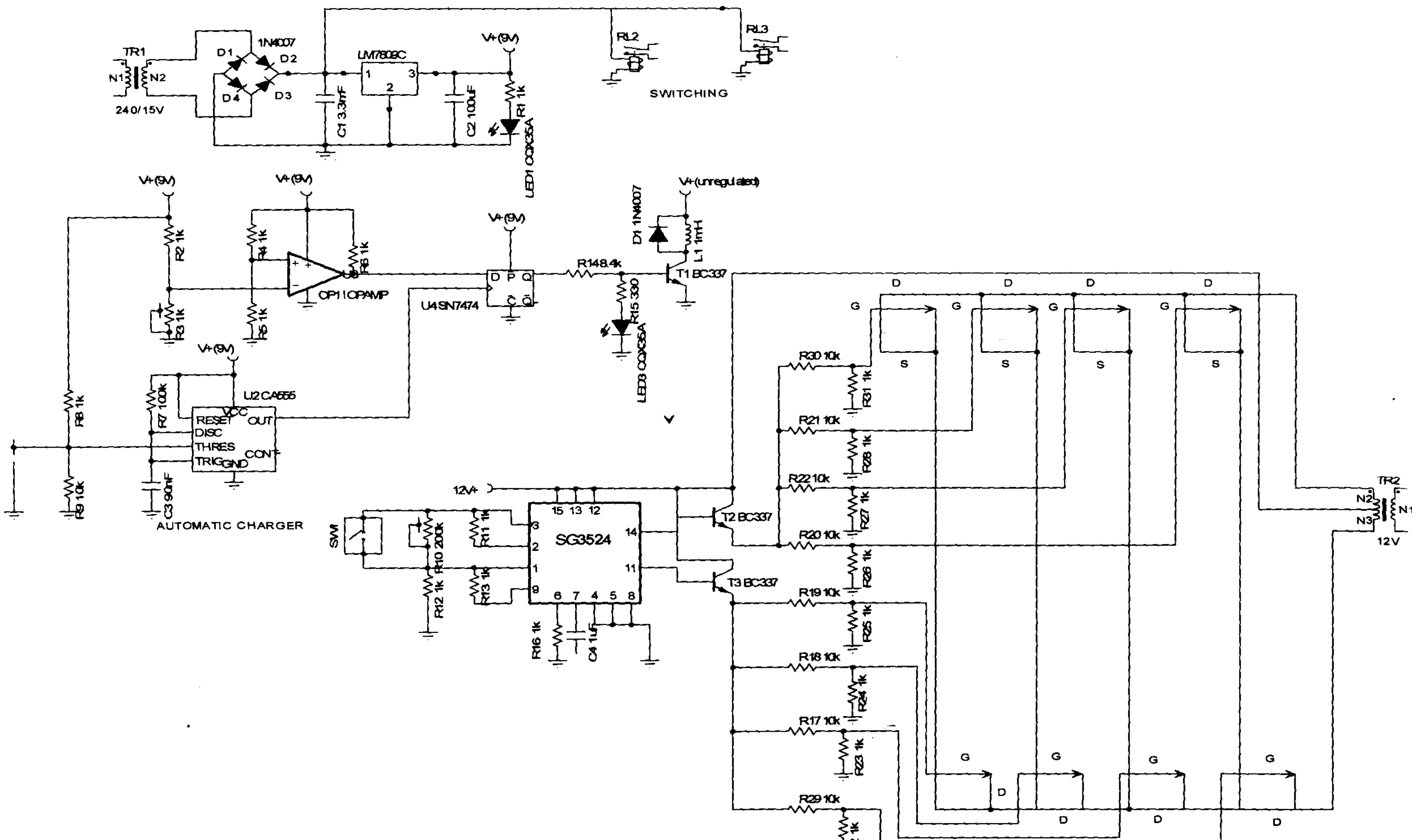
Appendices

BILL OF ENGINEERING MATERIALS AND EVALUATION (BEME)

S/N	ITEM	QUANTITY	UNIT PRICE (N)	COST (N)
1	Transformer 15V, 1000mA	1	300	300
2	Inverter Transformer	1	2,000	2000
3	555 Timer (IC)	1	20	20
4	7474 D-flip-flop	1	23	23
5	LM 393 Comparator	1	20	20
6	IN4007	4	20	80
7	7809 Regulator	1	15	15
8	Capacitor 3300μF	1	10	10
9	Capacitor 100μF	1	10	10
10	Relay switch	3	35	105
11	12V battery	1	2,500	2,500
12	Resistors 1K	22	10	220
13	Resistors 330 Ω	2	5	10
14	Resistor, 47K	1	10	10
15	Resistors 10K	8	10	80
16	Resistor 10K	1	10	10
17	Capacitor 1μF	2	10	20
18	Capacitor 100μF	1	10	10
19	Capacitor 3300μF	1	10	10
20	LED Indicator	2	15	30
21	IRF 540	8	100	800
22	BC 337 Transistor	3	15	45
23	Oscillator SG 3524	1	50	50
24	Resistor 4.7K	1	5	5
25	Casing	1	500	500
26	Vero-board	1	80	80
	TOTAL			5,965

U1LM7808C



CIRCUIT DIAGRAM OF THE UNINTERRUPTIBLE POWER SUPPLY