DESIGN CONSTRUCTION AND TESTING OF A 600VA UNINTERRUPTIBLE POWER SUPPLY WITH A BACKUP SOLAR POWER CAPABILITY

BY

OGUNGBEMI OLUTOLA
REG NO 95/4563EE

A PROJECT REPORT SUBMITTED IN PATIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF ENGINEERING DEGREE (B.ENG) IN ELECTRICAL AND COMPUTER ENGINEERING.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING.SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

NIGER STATE

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DECLARATION

I Ogunbgbemi Olutola Temidayo, hereby solely declare that this project work "design construction and testing of a 600VA uninterruptible power supply with backup solar power capability" is a result of my personal effort. It has never been presented elsewhere either wholly or in parts for any degree or diploma. All information derived from published work used in this project has been dully acknowledged.

....

Signed Ogungbemi O T

....

Date

CERTIFICATION

This is to certify that Ogungbemi Olutola Temidayo in the Department of Electrical and Computer Engineering carried this project work and it has been found to be adequate in scope and content in partial fulfillment for the award of bachelor's degree in Electrical and Computer Engineering (B.Eng)

Mr. Kenneth Pinne
Project Supervisor

Date

Engr. (Dr) Y.A Adediran
Head of Department

16/1/07
Date

External Examiner

17/01/2001
Date

DEDICATION

ToGod who designed and constructed the heaven and earth in partial fulfillment of is Holy Spirit This project is dedicated toGod almighty and to my parents Engr and Mrs. T O Ogunbgbemi.

ACKNOWLEDGEMENT

I am grateful to God for granting me existence and good health through my staying in this university and from the time I was born to date

I am also grateful to my parents Eng and Mrs. T O Ogungbemi, for their unlimited financial support and encouragement with love and care right from the scratch of my academic life.

My special thanks also goes to my project supervisor Mr. Kenneth pinne for his thorough examination of my project work and guardians to the final stage.

My thanks also goes my elder sisters Mrs. Olubukola Olojo and Mrs. Oluwayemisi Adeleye for their financial support and encouragement throughout my stay in the university, not forgetting my younger brothers, Taiwo, Kehinder and dotun Ogungbemi.

My appreciation also goes to Mr. Tunde Olojo and Eng Bode Adeleye for there technical support during the taking off `of my project design

My appreciation will not be complete without expressing my thanks to my friends, Samuel Enujeke, Gbadegeshin Johnson, also not forgetting my half and next body Miss. Funmilayo daramola, who were a big encouragement during the preparation of my project. I love you all.

To you all I say big thank you and may god continue to bless you for the various assistance rendered

TABLE OF CONTENT

ABSTRACT

Due to the continues load shedding and irregularity in the electricity power supply system in Nigeria which is hazardous to various electronic equipments and most especially the computer systems in Nigeria today. It became very important to develop an uninterrupted power supply system, which is automatically operated and highly protective to our electronic equipments.

The component used in this design involved the use of analog push pull power amplifier Driven by a transistorized astable multiviberator automatic relay switching system. It Also allows for a controllable charging system and solar charging capability.
The output power is 600VA sinusoidal after passing it through a filter.

CHAPTER ONE

1.1 INTRODUCTION

Due to the constant and continuos load shedding of power and the breakdown of the power station in Nigeria today it became very important and essential that virtually all organiations using the computer system and electronic office equipments in general should acquire the use of UPS to meet up the standard of there services to the society and most especially to protect this expensive electronic equipment from the continuos power outage while the equipment are in use.

The hard disk of a computer system, which is one of the most expensive component develops bad sector due to this continues power outage and eventually crashes. This can lead to the loss of vital information that can even be more than the computer system itself.

The most suitable solution to this entire problem is the use of UPS to backup the source of power supply from the public mains.

The uninterruptible power supply unit is basically the transformation of a direct current to an alternating current with the automatic change of the source of power supply from the public mains to the battery and vice versa.

It is this ability to switch from public mains to battery automatically that differentiates a UPS from ordinary inverter system.

A UPS does not require warming up before transmission of power. It does not require consistence servicing and fueling like petrol engine generators. Finally it is a silent source of power supply and it does not give up smoke like exhaust of a petrol engine.

The major circuit in this UPS is the inverting circuit, which is made up of transistor. It also involved a controllable charging unit that protect and prevent the battery from over charging. A solar charging system is also incorporated in the design of the UPS as additional sources of charging unit most especially when the UPS is subjected to a remote environment.

The UPS incorporated with a solar charging unit can be used as source of power on satellite and generative repeaters power supply for Telecommunications.

1.2 LITERATURE REVIEW

The world first inverter was introduced in 1983 by heart interface that had been a leader in inverter and charger technology.

In 1994 he introduced the use of MOSFET for the main power output of inverter circuit, which makes the design smaller than the use of BJT transistors.

In the early 90's the inverter circuit was then use to develop the UPS which is today the most useful and economical inverter circuit design for today's technology

1.3 PROJECT AIM AND OBJECTIVE

The main target of this project design is to achieve an output power of 600VA, which is at least more than the power required for a full multimedia computer system for example.

The design is also to achieve certain level of conservation of energy from solar energy and public mains to restore the potential energy of the battery after use.

CHAPTER TWO

2.1 SYSTEM DESIGN AND MODE OF OPERATION

This chapter shows the actual breakdown of the entire circuit into modules and the general mode of operation of the entire modules. It will also show the actual circuit of the modules, the mode of operation of each module, and how the modules are interconnected to form a complete system.

2.2 THE GENERAL MODE OF OPERATION OF THE ENTIRE CIRCUIT DESIGN

The uninterrupted power supply is of different design. The design here is a simple transistorized design. Analog astable multivibrator is used to generate the pulse signal at $50H_Z$.

The pulse signal is used to drive power BJT transistors connected in parallel and of push-pull configuration for the purpose of large power amplification to drive the step up center tap transformer.

The two relays RL1 and RL2 used in this design is powered by a different transformer directly connected to the public mains.

The design of the UPS is off line, such that when the public mains is OFF, the relay (RL1) will enable the multivibrator. At the same time (RL2) will disconnect the public mains from the output of the UPS during this process the battery had already taken over the source of power supply.

When the power from the mains is ON, the relay (RL1) will disconnect the battery from the astable multivibrator and (RL2) will connect the mains to the output continuity. The same step-up transformer for the inverter will be used as a step down when the public mains is connected to secondary winding. The output at the primary winding which is the input due to

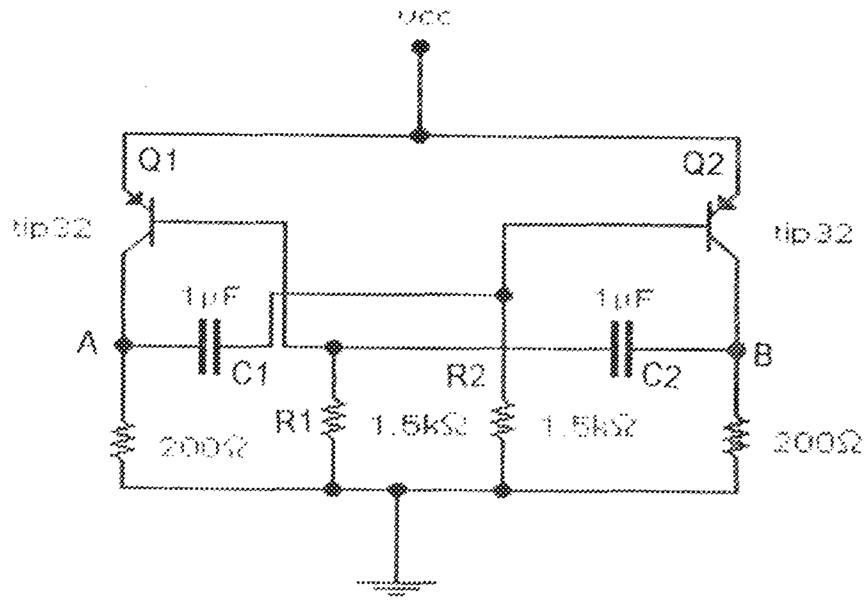

Fig 2.2…………Circuit diagram of astable multivibrator

2.4 MODE OF OPERATION

If Q1 is in saturation the voltage drop across RL1 is VCC, so capacitor C1 will start charging through the R2. This charging process will forward bias Q2 so setting it to cut OFF and the voltage at RL2 will be zero.

The voltage across R2 at the beginning of the process is VCC and it will continue to drop until the potential different is below (VCC-0.7V) which will eventually reversed bias Q2 and then drive Q2 to saturation.

When Q2 is saturated the potential at point B is VCC and capacitor C2 will start charging through R1. The potential head of R1 at the beginning of the charging of C2 is VCC, which will set Q1 OFF by forward biasing Q1. C1 will start discharging at that point.

The voltage across R2 will continue to drop until it is below (VCC-0.7V) as you can see in figure 2.2 above.

THE INVERTING CIRCUIT

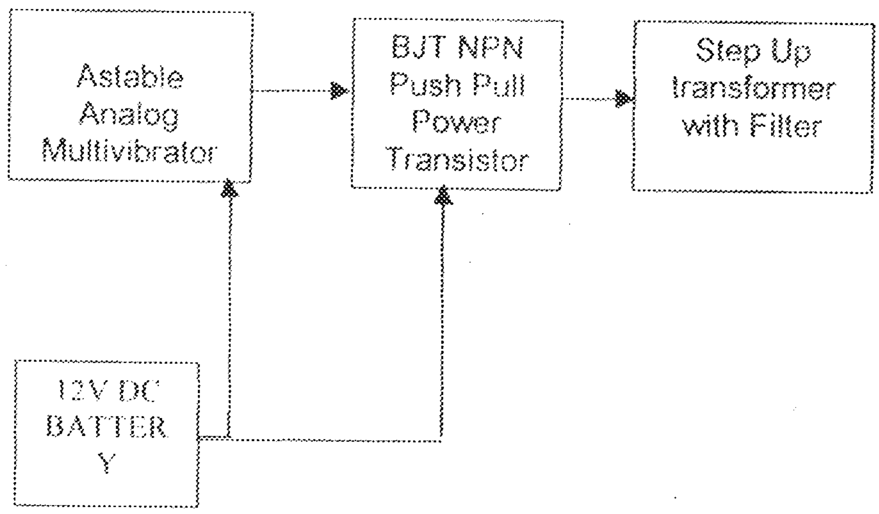

Fig2.3 ....Block diagram of the inverting circuit

The inverting circuit is the most important part of a UPS because it does the actual transformation from the DC to AC.

It involve an astable multiviberator generating the pulse signal that is been use to fire the BJT power transistors.

The 12VAC power output was then pass through a step-up transformer to 220VAC at the output.

The final 220VAC was pass through a filter for the pulse wave output power signal to be sharpened to it sinusoidal equivalent

Is = secondary winding current

Ip = primary winding current

Np = primary numbers of turns

Ns = secondary numbers of turns

B1 = 75 (current gain of Q1)

B2 = 100 (current gain of Q2)

The target power output of the UPS is 600VA at 220V considering an ideal transformer

$$Is = \frac{600}{220} = 2.73A$$

The turns ratio of the transformer. Np: Ns = 1:18

$$IpNp = IsNs$$

$$Ip = \frac{NsIs}{Np} = \frac{18}{1} \times 2.73 = 49A$$

$$Ic2 = 49A$$

$$Ib2 = \frac{Ic2}{B2} = \frac{49}{100} = 0.49A = 490mA$$

$$Ib = \frac{Ic1}{B1} = \frac{0.49}{75} = 0.0065A = 6.5mA$$

$$R1 = \frac{Vcc - 0.6}{Ib1} = \frac{12 - 0.6}{0.0065} = 1.75Kohm's$$

The value of the feed back capacitor that is required to generate output signal at 50HZ is

$$F = \frac{1}{069\ (R1C1 + R2C2)}$$

Since R1 = R2 and C1 = C2

$$F = \frac{1}{069\ (2 \times R1C1)}$$

F = 50HZ and R1 = 1.75Kohm's

C1 = ?

$$C1 = \frac{1}{50 \times 0.69\ (2 \times 1.75)}$$

= 8.28 microfarad

Because of the in availability of all the values of component in the market. The values calculated above can be replaced by the closest available values of the component that will, and then produce the required power output. The nearest preferred value of C1 = 10 microfarad and R1 =1.5Kohm's

$$F = \frac{1}{0.69\ (2 \times 1500 \times 10 \times 10^{-6})}$$

= 50Hz

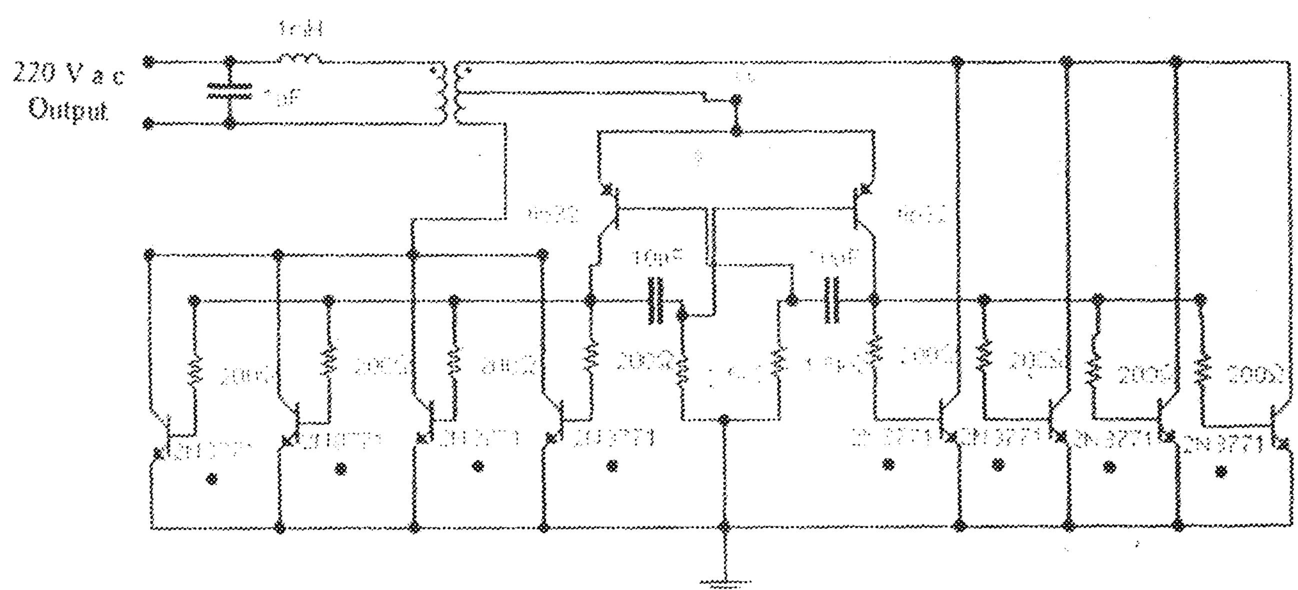

fig 2.5........The DC to AC inverter circuit of the uninterruptible power supply system.

2.7 THE INVERTER STEP UP TRANSFORMER

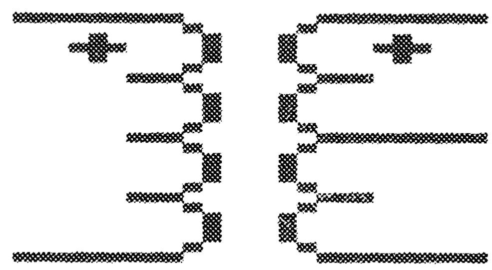

fig 2.6 The Inverting transformer

The inverter step up transformer is rated 1000VA in other to withstand the 600VA power transformation with minimum loses. The primary winding with respect of the secondary winding is in the ratio of 1 18.

The primary winding is a center-tapped configuration in other to enhance the push-pull function of the inverting power transistor.

2.8 THE SYNCHRONOUS RELAY SWITCHING SYSTEM

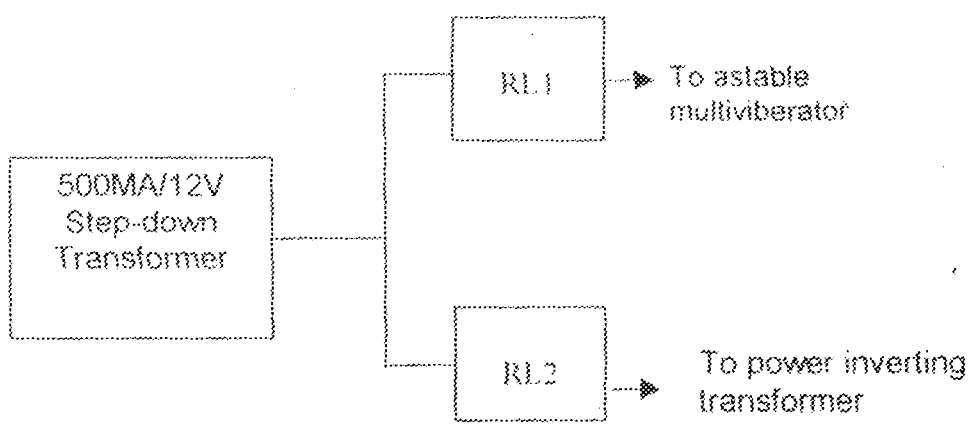

Fig 2.7 Block diagram of the UPS relay switching system

The synchronous switching system enable the same transformer used as a step up during the inverting mode to be used as a step down to charge the bettery.

A 500mA 12V transformer is permanently connected to the mains and the output is feed into a bridge rectifier before powering the two relays RL1 and RL2 for changing of state.

RL1 connects the battery normally to the astable multivibrator when there is no source from the public mains but disconnects when the mains is ON.

RL2 also is not connecting the mains to the output of the inverting power transformer but connects when the mains is ON.

This operation takes place synchronously without delay or interference of operation within a fraction of a second, which makes the changes not noticeable to electronic equipment connected to it.

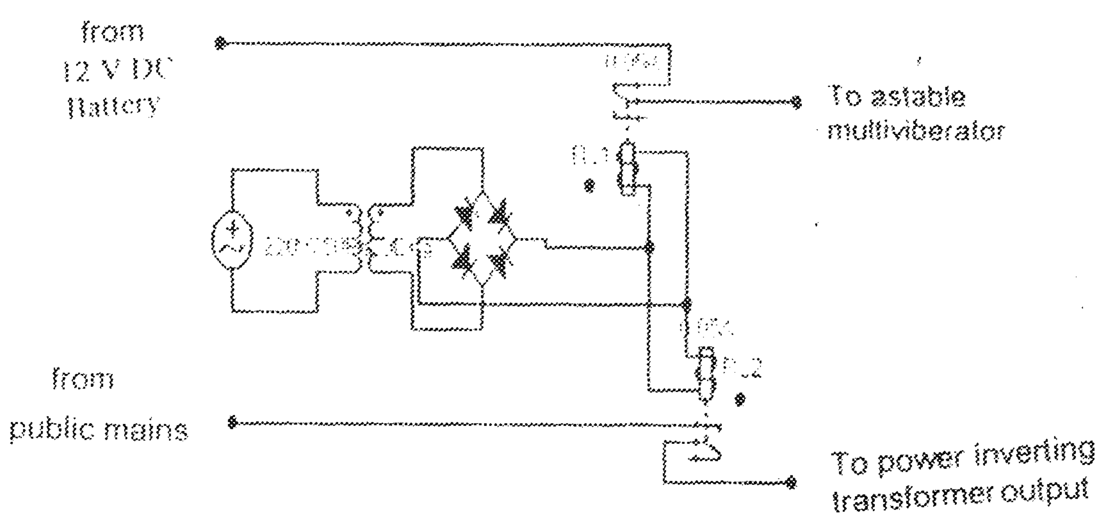

Fig. 2.8..........The internal circuitry of the UPS relay switching system.

2.9 THE CONTROLLABLE CHARGER SYSTEM

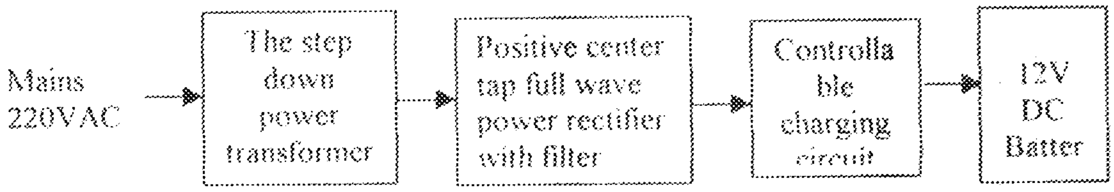

Fig. 2.9 Block diagram of the controllable charging system

One very interesting part of the controllable charging section of the UPS is that the same power transformer used for step-up in the ,inverting mode is used to power the charging unit when the public mains is ON.

The output is converted to DC after passing it through the rectifier circuit and a low pass filter and the output is 15VDC.

The DC output is then used to charge the battery by connecting it through the controllable charger circuit, whichis a special switching device that stop the charging current from flowing into the battery whenever the battery is fully charged.

The controllable charging system can be set to any charging voltage level within the range of DC supply from the transformer. The circuit protects the life span of the battery.

2.10 THE CONTROLLABLE CHARGER MODE OF OPERATION

The controllable charger is a very special control unit system for regulating the rate of charging a battery.

The sensitive component that is responsible to the ditection of battery voltage level is the zener diode, which is connected across a variable resistor VR1 which is specially used to select the maximum charging voltage of the battery before tripping OFF.

The VR1 is connected to the battery terminal through R1 acting as a current limiter to protect the zener diode from the large current from the battery.

The zener diode is connected in a reversed bias polarity such that when the voltage of the battery charging up to the required voltage that correspond to the zener diode through the potential divider. Then the diode will then break down allowing current to flow out of the base of Q1. Q1 will be saturated and the output collector current of Q1 will flow into the base of Q2 setting it OFF. The output Q2 will be grounded because current is not flowing and will set the power MOSFET connected in series with the 15V DC source to switch OFF the charging circuit. The moment the battery voltage level drops below the setting ON of the variable by R4 connected to Q2 in reverse bias, this biasing process drives Q2 to saturation and current flows through Q2 to fire the gate of the MOSFET will then close the circuit and the charging process will continues. The resistor R5 connecting the gate of the MOSFET to the negative terminal of the source discharges the gate when there is no enable input. The R3 is connected to the LED acting as a current limiter to the diode indicator as you can see in figure 2.10 below.

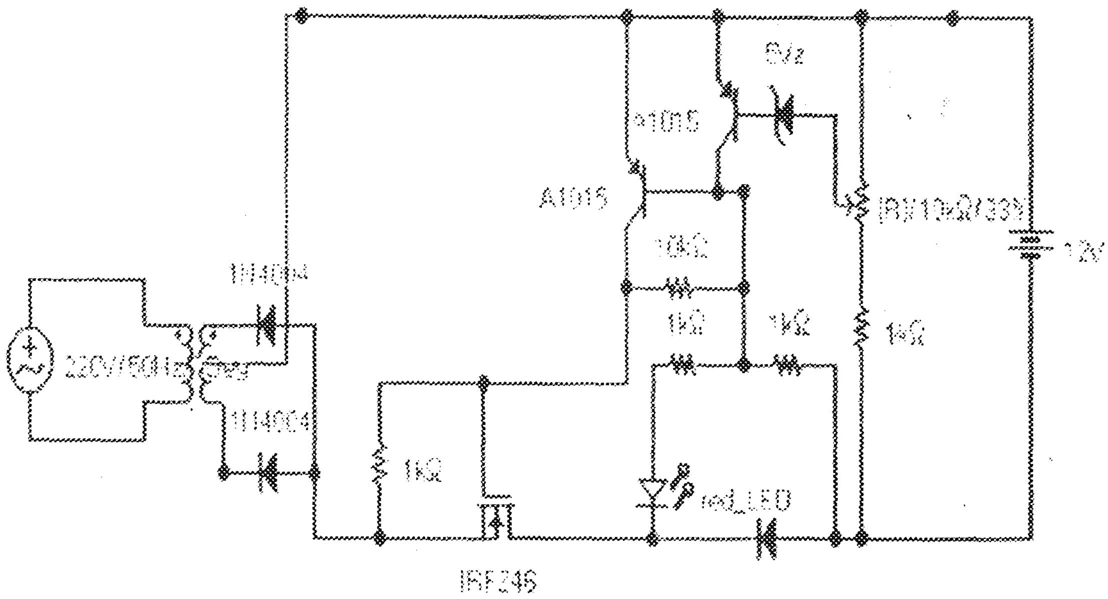

Fig. 2.10 The controllable charger circuit diagram

2.11 THE DETERMINATION OF THE CHARGING CURRENT

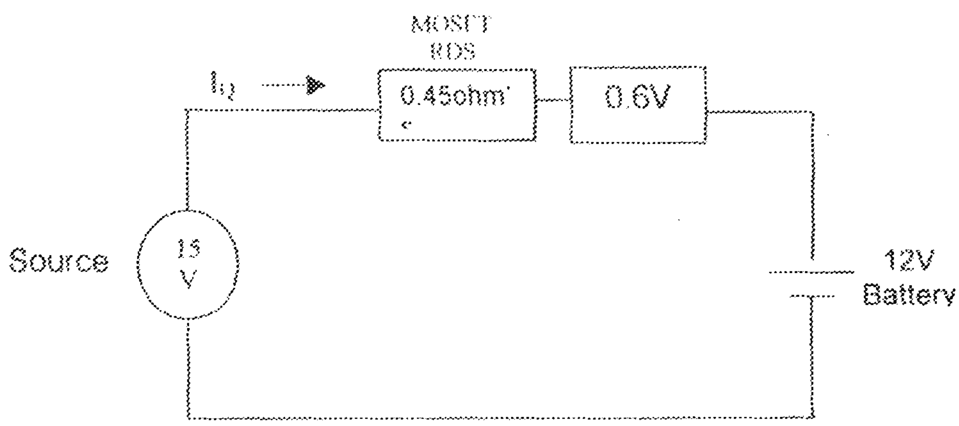

Fig. 2.11 The charging circuit

The minimum charging current is achieved when the battery is at 12V just before the controllable charger trips OFF.

$$Iqmin = \frac{15V - (12 + 0.6)\,v}{0.45}$$

$$= \underline{5.33A\ min}$$

But when the battery runs down about 10V

$$IQ = \frac{15V-(10+0.6)V}{0.45}$$

$$= 9.78A$$

The large value of the charging current enables the battery to charge fast while the controllable charger automatically switch the circuit OFF when the battery normal voltage level is acquired.

2.12 THE BATTERY VOLTAGE LEVEL INDICATOR

This circuit will enable you to monitor the voltage level of the battery when the UPS is ON line. It also enables you to adjust the controllable charger circuit setting such that you don't over charge the battery.

The circuit involves three light emitting diode indicators each connected in series with a revered bias polarity zener diodes of voltage ratings. 10V, 11V and 12V respectively 100ohm's resistor was connected in series with each of the zener diode acting as current limiter.

The zener diode breaks down when ever the battery voltage is just above the zener diode rating, allowing current to flow to enable the light emitting diode to come ON.

This is a special simple circuit design, which is an alternative to multimeter to monitor the behaviour of the battery as you can see in figure 2.12 below.

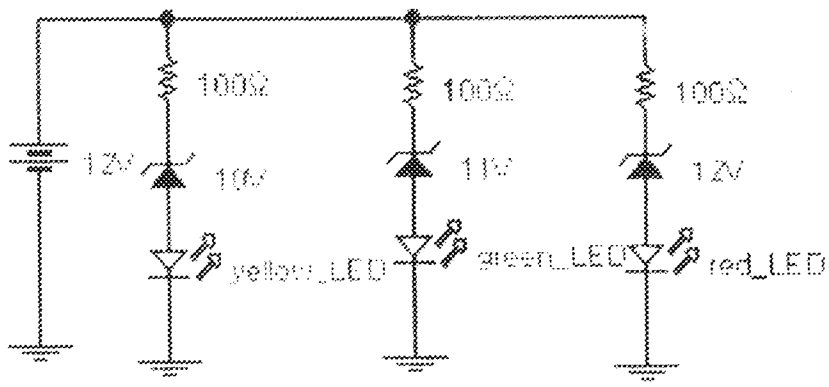

Fig2.12 The circuit diagram of the battery voltage level indicator

3.3 MODIFICATION

The power transistor mounted on heat sink was latter doubled by the addition of two power transistors connected in parallel along with the one already in the circuit. The power output improved and losses due to heat also minimized.

A controllable charge circuit was also introduced to the circuit to control the battery rate of charging.

The heating up and forming of the battery electrolyte stopped and the battery started charging at the normal voltage level. The heating up of the LED voltage level indicator also stopped after the introduction of the current limiting resistors.

3.4 FINAL CONSTRUCTION

The entire circuit was later transferred to a large Vero board after the modific a tions. The final component connection was first sketched on paper to view the appearance of the component on Vero board for compatibility and simplicity in other not make mistakes during the transfer of the circuit on Vero board.

Step by step soldering was done following the sketch on paper and special care was taken to prevent shot circuit and wrong polarity of the various soldered on the Vero board.

The soldered circuit on Vero board was later tested with a multimeter to ensure that there was no shut circuit and all the conductor current was properly terminated. Finally the soldered circuit board was later transferred to the wooding box (casing) along with the battery and transformer. The wooding was perforated at the top to aid ventilation for the heat dissipated by the power transistors on heat sink to escape.

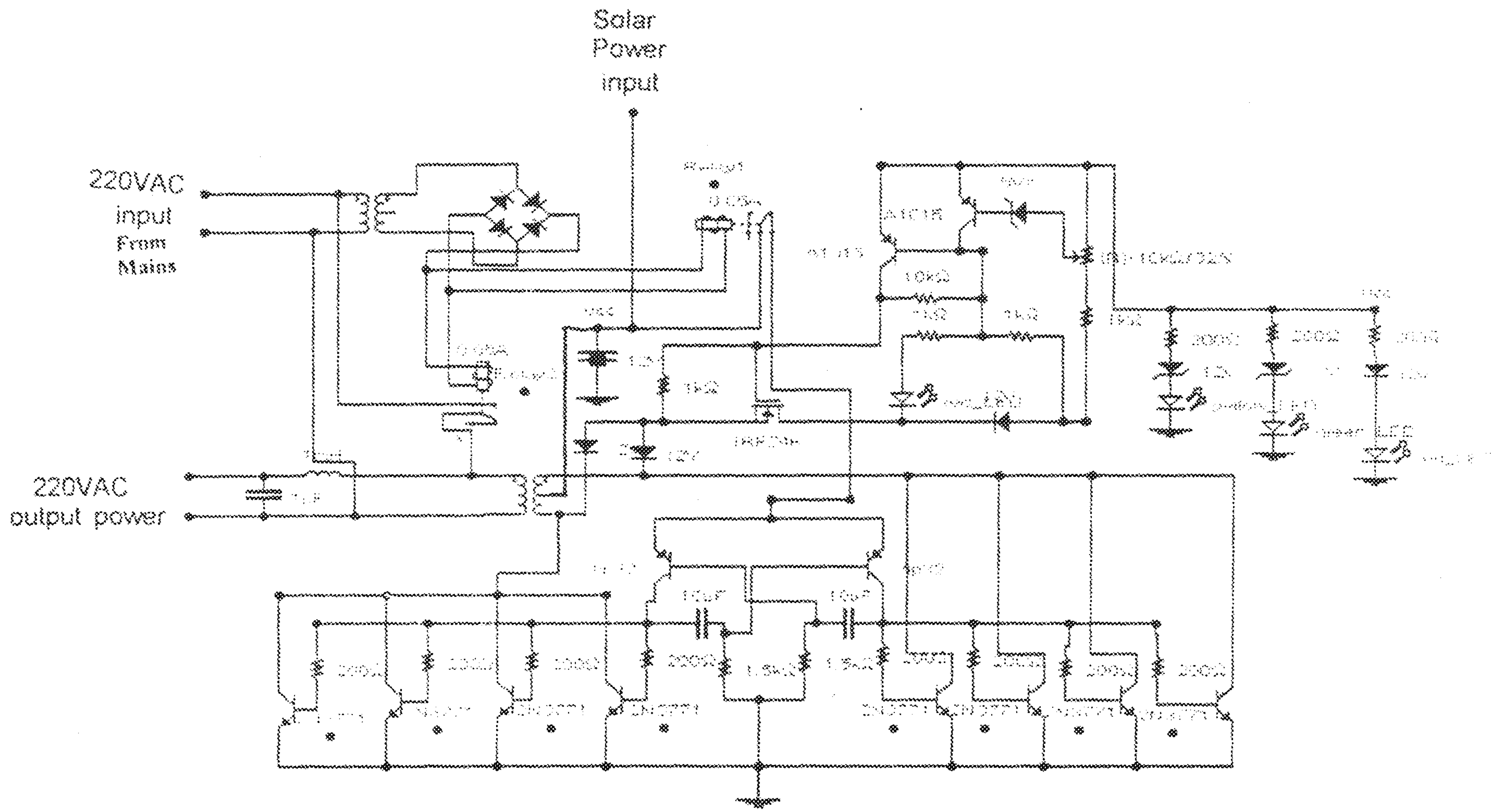

Fig3.1 The entire UPS internal circuit diagram

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1 CONCLUSIONS

The design and construction of this UPS incorporated with a solar charging unit is the cheapest and the most economical to protection and maintenance of our computer system and office equipment.

The cost of production is about ₦5000, which is far cheaper than APC 650AV, which is currently sold in the market at the rate of ₦15, 000 to ₦20, 000 or an equivalent power-rating generator, which is sold at the rate of ₦ 30,000 or more.

This design can successfully power a computer system for about 20 to 30 minute which is quit enough time to quickly "roundup" and save all previous programs on the computer and to shut down properly without lose of data on the sensitive storage devices.

4.2 RECOMMENDATION

For future improvement the UPS should be produced with large battery voltage source to reduced the turn ratio of the step up transformer because the lower the turn ratio the higher the efficiency and the lower the input current and cupper loss in the transformer. Another means of conservation of energy in the UPS design is the incorporation of automatic power regulator (APR). This is a way of controlling the number of power transistor in the inverting circuit that will be activated with respect to the magnitude of the load connected at the output.

Table 4.1 **LIST OF COMPONENTS AND PRICES**

COMPONENT	QTY	PRICES ₦	COST ₦
Wooding case	1	200	200
2N3771 Power transistor (NPN)	8	100	800
Tip 32 Power transistor (PNP)	2	35	70
1.5k ohm's resistor	2	5	10
10 Microfarad capacitor	2	10	20
IRFz 46 power MOSFET	1	120	120
Heat sink	2	50	100
A1015 transistor	2	15	30
5V zener diode	1	10	10
LED	4	10	40
200 ohm's resistor	8	5	40
1k ohm's resistor	4	5	20
10k ohm's resistor	1	5	5
12v relay	2	50	100
1 Microfarad 300V capacitor	1	50	50
1KVA power transformer	1	1000	1000
12V\500mA transformer	1	100	100
1N4001Power diode	5	10	50
1N4004 Power diode	2	20	40
2200 Microfarad\50V capacitor	1	50	50
5A bridge rectifier	1	40	40
10K ohm's variable resistor	1	20	20
100 ohm's resistor	3	5	15
Zener 10V\11V\12V	3	10	30
6V battery	2	800	1600
Plug and socket	2	50	100
Battery clips	2	10	20
TOTAL		TOTAL	4680

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