

**DESIGN AND CONSTRUCTION OF 100WATT
RECHARGEABLE LAMP**

BY

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(EE/08/1720)

**A PROJECT REPORT SUBMITTED TO THE
DEPARTMENT OF ELECTRICAL AND ELECTRONICS
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DEPARTMENT, SCHOOL OF ELECTRICAL AND
ELECTRONICS TECHNOLOGY**

NOVEMBER, 2012

DECLARATION

I hereby declare that this project report was written by me and it is a record of my own research work. It has not been presented before in any previous application for a bachelor's degree references made to published literature been duly acknowledged.

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CERTIFICATION

This project entitled “**DESIGN AND CONSTRUCTION OF 100WATT RECHARGEABLE LAMP**” by **IDOKO, ALFRED AYEGBA (EE/08/1720)** meets the regulations governing the award of the bachelor’s degree of the Modibbo Adama University of Technology, Yola and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This project work is dedicated to The Almighty God, my parents and Siblings for their endless prayers.

ACKNOWLEDGEMENTS

I have the privilege to express my gratitude to my project supervisor, Engr. A. Usman for his valuable time and energy spent in making numerous suggestions and painstaking corrections on this project this project work, right from the project design and construction stage to the successful completion of the project work.

Also, to the authority and management of Guaranty Trust Bank Yola, Adamawa state, most especially Mr. Henry Ajayi, Mr. Nakang Mikailu, Mr. Jenje Olanrewaju, Idris Elabor, Godwin Ogbu, Joseph George, Jackson Fizobe, Ilesanmi Emmanuel, Olaniyi Bolanriwa and all my colleagues for their understanding and moral support throughout my period of study, may God bless you abundantly.

Not forgetting to mention my course mates, friends and family especially my dearest friends; Ishaka Umar and Adewale Oseni for their moral support, my class rep. Mboli Julius, my brothers and sisters (Mrs. Rose, Miss. Joy, Grace, Cecilia, bro. Emmanuel, Godwin) for their prayers and unwavering support. And many other persons, whose names are too numerous to mention. Thank you all and God bless you abundantly.

ABSTRACT

The Design and Construction of 100Watt Rechargeable Lamp is presented in this report. The rechargeable lamp is an emergency lighting device which is normally powered by a battery that is recharged when there is power supply to it and discharges through a load which is 100watt lamp when power supply is cut off. The rechargeable lamp is renewed as its components consists of a 12V step down transformer with centre tap, the bi-phase rectifier, the filter, the automatic relays, the inverter, the step up transformer and load. We also have an oscillator section which actually converts the output dc voltage to ac voltage that is required in this project. The design and analysis of the lamp are explained in detail including the test carried out and the result obtained. Recommendations are also stated for improvements.

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ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

R	Resistor
C	Capacitor
D	Diode
R.M.S	Root Mean Square
SWT	Switch
UPS	Uninterrupted Power Supply
GND	Ground

SYMBOLS

μf	microfarad
Ω	Ohm

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

There are series of challenges concerning power supply especially in the third world countries. The developed countries have been able to ameliorate due to their technological advancement in their power sector.

In Nigeria, our power supply is epileptic and very unreliable and this has made the citizens of this country to look for alternatives especially when there is power outage at night. The most common alternative is the generator which is powered by either diesel or petrol, and this is not affordable to many Nigerians. From observations, it was noted that most individuals who could not afford generator set, use candles and kerosene lamps.

Observations have shown that the use of candles and kerosene lamps could be very dangerous because it can set a place ablaze. Also, the consistent use of candle or kerosene lamps for reading results in bad eyesight. Because light coming from the candle or kerosene lamp is not bright enough for reading.

Against the above background, this work considers the Design and Construction of a 100W Rechargeable Lamp that can be used in homes, offices and small business outfits.

1.2 PROBLEM STATEMENT

In Nigeria, the power supply is not reliable, especially in the local community and the common solution is the use of generator which is not quite affordable. As well, the use of generator requires an operator to start it and switch the supply source to generator which is time consuming and laborious. Many people use candle and kerosene lamp as alternatives which causes bad eyesight and fire incidence. Most people especially the rural communities are in serious need of affordable alternative electricity source that can provide adequate illumination in the night. This work has evolved a robust and low cost alternative source of illumination in the form of 100Watt rechargeable lamp.

1.3 OBJECTIVES

The key objective of this project is to come up with a robust, reliable and low cost 100watt rechargeable lantern. The designed lamp when fully charged can operate continuously for a very long period (about 6 hours) before running down.

1.4 SCOPE OF THE STUDY

Most rechargeable lamps available in the market are rated around 30W. The design specification for this work is 100W. This is responsible for the better comparative performance of the designed lamp.

1.5 SIGNIFICANCE

This project is very important as it can be used as an illumination source for students, shops and homes. The use of rechargeable unit like the one developed in this work mitigates the effect of frequent power outages experienced in schools, homes and

business outfits. This work is also an avenue of translating the theoretical lessons received in the class into practical reality thus enhancing the technical skills of the researcher.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, relevant background information required for the design and construction of 100 watts Rechargeable Lamp as given in the works of other authors are reviewed.

2.2 INTRODUCTION TO RECHARGEABLE LAMP

The main purpose of a Rechargeable Lamp is to provide regulated and stable power to load (lamps) regardless of power grid conditions. The need for a Rechargeable Lamp came as a solution towards providing light once there is utility power interruption. Many of these products are already available for sale in the local markets. Their drawback is lower power capacity. Almost all of them are rated below 30W.

2.3 HISTORY OF RECHARGEABLE LAMP

The history of Rechargeable Lamp dates back to the early 1920's. The first Rechargeable Lamp used mercury rectifiers and grid controlled mercury-arc tubes. However, these mercury-arc power supplies had limited commercialization due to some problems found in their low capacity. They were characterized by poor efficiency, high cost, questionable reliability and high maintenance [1].

During the late 1960's, these problems were surmounted when the semiconductor industry developed a variety of high performance switching devices. The discovery of

these switching devices became significant to power supplies and had a great impact on its industry. Their superior performance characteristics enabled them to break into markets that had been unattainable for mercury-arc. Nonetheless, it was only until 1970's that Rechargeable Lamp became widely used but with low capacity [2].

The proposed project work is aimed at solving the above problems since it is capable of supplying enough Alternating power (100watts) for a sufficient time and with the switching improvement, it can complement the normal power supply and turn the system into more or less an uninterrupted power supply [3].

2.4 OVERVIEW

All system designs have their unique ways of being realized. It is these variations based on project conceptions, configurations and types of materials used that make the differences within the products. This project work is therefore built around three main features, namely:

- The Charging Unit
- The Inverter Unit
- The Transformation Unit

2.4.1 The Charging Unit

All secondary batteries require Direct Current (DC) supply for charging. Basically, rechargeable lamp consists of a rechargeable battery or bank of batteries which require constant charging. It is the battery that serves as an alternative power source for

the lamp. The charging unit therefore is the unit that provides the charging current (DC) for the battery. There are various charging methods that can be employed and they are:

a) Constant Current Charging

In this method of charging the charge rate which is approximately normal is fairly constant throughout the charge. The battery voltage rises during the charging and to maintain current rates, some adjustments are made. Using the variable resistor, which is in series with the battery, regulates voltage. The time required to charge the battery depends on the extent of the battery's discharge.

b) Method Constant Potential Voltage Charging

This method of charging is used for traction batteries subject to regular routine of discharge and charge. Virtually constant applied voltage in the region is about 2.8V per cell with suitable ballast resistor [4].

c) Boost Charging

Charging batteries ordinarily necessitate higher rates where the ampere rates are one hour at twice the normal rate of half-hour. Abnormal increase in electrolytic temperature indicates that boosting have been carried out too far and should be discontinued. This method is not recommended as a regular practice [5].

d) Low Rate Charging

In this method of charging, the discharge requirements are at low constant rates and intermittent rates are at average with low values over a given period of time where charging rates are less than normal. 25% or more amperes hours then discharged must be put back into battery thereby making the length of time complete charge to be longer [7].

e) Trickle Charging

In this method of charging, any low rate charge in ampere is from 0.05-0% of battery capacity. This type of charging is sufficient to balance the internal loss of the battery and therefore, keeps the battery in the fully charged condition. Voltage required depends on temperature, age of battery, rate used and other factors [6].

f) Constant Voltage Technique

If constant voltage current is used, voltage is kept constant but this result in a very large charging current. In the starting, the back e.m.f of the cell is low and this results in the little current. As the back e.m.f increases, charging takes place. This method is used for charging lead-acid batteries. It uses a full wave pulsating DC with a centre tapped transformer, which provides full wave rectification. Commutation is usually automatic thereby causing a shutdown when full charge is reached. The battery voltage increases with the charge voltage across the resistor. The resistor can adjust the cut out voltage. While D_3 in Figure 2.3 from the four diodes employed for full wave rectification allows trickle charging and prevents discharge in the event of power failure [8].

g) Constant Current Technique

Using this float charging technique, the current is kept fairly constant. The current is controlled by the costal connected in the circuit used for batteries that do not show appreciable change in current level after charging for example nickel, cadmium battery. In other to manage the heat generated. The controlled current source is needed to deliver the correct current for the type of cell being charged. Parallel charging method is used so that different cells can be charged at the same time avoiding rotary switching technique [3].

In either method of battery charging, there is power supply unit. Since our mains are Alternating Current (AC) and are converted to Direct Current (DC), the following stages are involved and they include the transformation stage, the rectification stage, the smoothing stage, the regulation stage and protection stage. The stages will be considered one after the other.

1) Transformation Stage

Transformation is the process of changing the amplitude of an AC input of a suitable value depending on the needed output voltage. This is achieved by using a transformer to either step up or step down the voltage.

A transformer is a device that converts AC from one voltage to another with little loss of power so that the power output is almost equal to the power input. The transformer is made up on the input coil called the primary and the output coil called the secondary. There is no electrical connection between the

two coils instead they are linked by alternating magnetic field created in the soft iron core of the transformer [7].

The ratio of the number of turns on each coil called the turn ratio. The step up transformer has more turns on its secondary than the primary thereby giving a high output voltage. The step down transformer on the other hand has a larger number of turns on its primary coil which is connected to high voltage thereby giving low output voltage.

The basic working principle of any transformer is that the primary winding is connected to the AC input and the coil to the secondary winding. The magnetic circuit coupling the winding is made of special low reluctance laminated steel. A layer of oxide makes the core of several thin sheets of steel all isolated from one another. The eddy current losses are reduced by setting up a magnetic flux ($\phi_{(1)}$) across the primary by the alternating input voltage.

This leak with the alternating flux in the secondary coil. Induce emf= Number of turns \times rate of change of flux, $E=N\phi_{(1)}dt$

$$E = \frac{Nd\theta_{(1)}}{dt}$$

$$\frac{d\theta_{(1)}}{dt} = \frac{e}{N}$$

Since the sum of flux links both coils

$$\frac{d\theta_{(1)}}{dt} = \frac{E_p}{N_p} = \frac{E_s}{N_s}$$

Cross multiplying gives us turns ratio

$$\text{Turns} = \frac{E_p}{dt} = \frac{N_p}{N_s}$$

Where $E_p = \text{primary voltage}$; $N_p = \text{primary turns}$;

$E_s = \text{secondary voltage}$; $N_s = \text{secondary turns}$

If $N_s > N_p$, then the transformer is a step up. However, if $N_s < N_p$, then it is a step down transformer.

There are three power losses and they are:

- The copper loss (I^2R) is the loss in the copper windings. The current flowing in them causes this.
- The hysteresis loss is small, energy lost each time AC primary current is reversed. Using low reluctance steel can reduce this.
- The eddy current loss is caused by back EMF and is reduced by using a laminated core [5].

2) **Rectification**

Almost every solid state device requires DC voltage to operate. Batteries are useful as phase type devices but since their operation is limited, it has to be recharged and this is achieved with an alternative power source, which is the 50Hz, 220 V_{rms} AC voltages by using a rectifier.

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important because it process full wave varying DC. A full wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes are cheaper. A single diode can be used as a rectifier but it only used the positive parts of the AC wave to produce half wave varying DC. This is also known as the single phase half wave rectifier [9].

3) **The Smoothing Stage**

The output voltage of the rectifier stage contains some ripples voltage (pulsating DC). Filter capacitor is connected across the rectifier to smoothen the pulsating DC. As the pulsating DC is applied across the capacitor, it charges to the peak applied voltage. Between peaks, the capacitor discharge through the load and the voltage gradually drops. The amount voltage drop before the capacitor begins to charge again is called ripple voltage. The DC voltage of the rectifier will therefore be smoothen to pure dc voltage supply to ensure that the connected dc battery charge properly.

Finally, the regulation and protection is achieved by relay and switch. The switch is used to connect the circuit to the power supply.

Once there is a DC voltage, relay RLA will be energized to close the Normally Open Contacts (NOC) which starts the charging of the battery (12 V DC). When there is power outage, the Normally Closed Contacts (NCC) of the relay connects the battery to the inverter circuit and at the same time energizing relay RLB to link up the output step-up transformer to the inverter section. This continues the supply of AC voltage needed to keep the bulb, B on until the battery goes down to de-energize relay RLB waiting for the recharging of the battery through the power rectifier [9].

A good relay system was applied in the project to cut off the charging battery from the inverter circuit while an output lamp is on, i.e. when there is power supply from the utility board. When there is power failure i.e. lamp is off, the relay returns to connect up the battery to the inverter for supplying an alternative power for the lamp in use, hence turning the lamp back on as shown in this project.

2.4.2 The Inverter Unit

Inverter is a circuit that converts direct current (DC) to Alternating Current (AC). It is the opposite of rectifier and the inverter circuit is basically an oscillator circuit. Chosen for this project was a non-sinusoidal oscillator, an astable multivibrator which will produce a square wave output well enough for transformation. With no external signal required, the oscillator oscillates when DC voltage from the battery is received by it as input, producing square wave signal from the Drain of both MOSFETs, not simultaneously but alternately. Usually the period of oscillation depends on the RC time constants of both MOSFETs. In this project, I chose an equal period of oscillation (50% duty cycle) for each MOSFET. This would mean that the resistor as well as the capacitor in either of the feedback of each MOSFET would be the same i.e. the same R and the same C [7]

2.4.3 The Transformation Unit

The transformation unit consists of two MOSFETs (IRFP150N); they take their input from the two oscillator outputs which would have being buffered across a buffer unit (IC 555 Timer). The essence of the buffering is to provide matching between the two stages. An advantage of this kind of buffering is that current is reduced thus yielding longer life of the rechargeable unit.

It is a known fact that there is a heavy signal loss between the stages of an amplifier due to impedance mismatch. This was totally eliminated through the use of an amplifier connected between the oscillator and the output MOSFETs. The result was for a better output at Q_1 and Q_2 for a strong transformation at T_2 .

Finally, T_2 is a step-up transformer, centre-tapped at the primary side which has few numbers of turns. It steps up the low output voltage of 12V to a high one of 220V for the 100W load [5]

CHAPTER THREE

DESIGN AND CONSTRUCTION PROCEDURE

3.0 INTRODUCTION

In this chapter, detailed design involving calculations and critical selection of various components are considered. Construction procedures are also considered.

3.1 BLOCK DIAGRAM OF 100 WATTS RECHARGEABLE LAMP

A 100 watts rechargeable lamp can be a fairly complicated circuit as can be seen from the diagram shown in Fig 3.1 below;

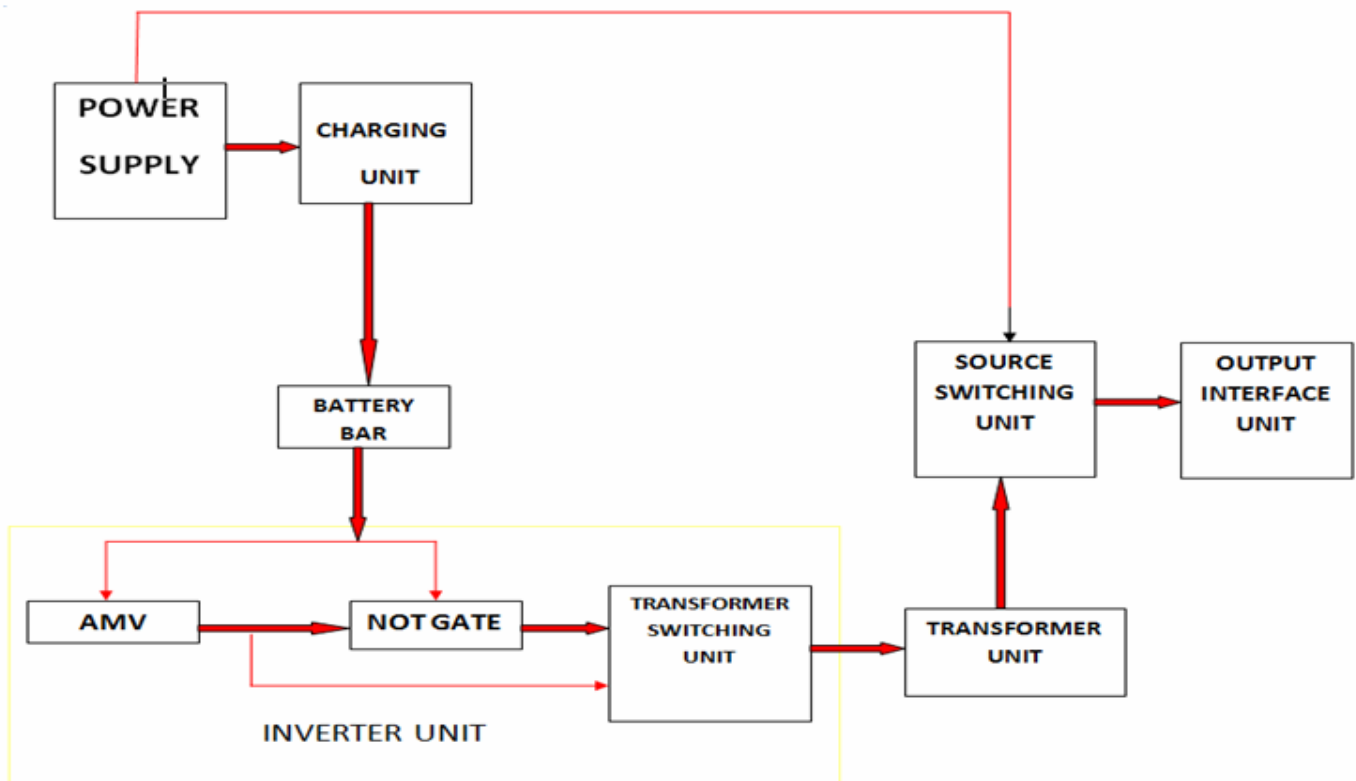


Fig. 3.1 Block Diagram 100watts rechargeable lamp

100Watts rechargeable lamp is made up of different units interconnected together these units are separately designed. The units are;

- A.C main supply unit
- Charging unit
- Battery backs unit
- Inverter unit
- Transformer unit
- Switching unit
- Output interfere unit

3.2 DESIGN

The design of each unit of the block diagram was considered in detail.

3.2.1 Design Specification

- (i). Maximum Input voltage $V_{in} (\max) = 240v$
- (ii). Minimum Input voltage $V_{in} (\min) = 220v$
- (iii). Line frequency (F_L) = $50H_z$
- (iv). Output voltage (V_o) = $220v$

- (v). Output current (I_o) = 8A
- (vi). Output power = 100 watt
- (vii). Maximum DC Voltage = 12v

3.2.2 AC Mains Power Supply

The AC main supply is the basic source of power supply for the project. The 220VAC power supply from the grid is feed to the 220v/12v step-down transformer. A suitable plug is used to connect the circuit with the wall socket outlet and a switch is used to break the connection as shown in Fig. 3.11.

3.2.3 Charging Unit

The basic principle of rechargeable lamp is that batteries is used as an alternative power supply in time of grid power outage. The battery require DC voltage for charging. The charging unit is the unit that supply the charging current that charges the batteries. The charging unit comprises;

- (i). Step-down transformer
- (ii). Rectification
- (iii). Filtering
- (a). Transformer:**

The transformer is a step down transformer with centre tap at the secondary terminal as shown in Fig. 3.2 below:

The rating of the transformer;

220V/12V 500 MA

Frequency of supply = 50Hz

Rating in VA = V_{rms} x current rating

$$= 12 \times 500 \times 10^{-3} = 6.0VA$$

$$V_{rms} = 12V$$

$$V_{rms} = 0.707V_{max} \dots \dots \dots 3.1$$

$$V_{max} = \frac{V_{rms}}{0.707}$$

$$= \frac{12}{0.707}$$

$$= 16.97 \cong 17V$$

(b). Rectification:

The system of rectification was the biphas rectification using two diode. The choice of IN4001 as the rectification diode was based on the fact that maximum normal forward current is 1A for IN4001 while the maximum current of the transformer is 500mA. Also the peak inverse voltage (PIV) rating of IN4001 is 50V. While the transformer can only present a peak inverse voltage as calculated below.

$$V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}} = 0.707 V_{\text{max}} \text{-----}(3.1)$$

$$V_{\text{DC}} = \frac{2 V_{\text{max}}}{\pi} = 0.636 V_{\text{max}} \text{-----}(3.2)$$

$$V_{\text{DC}} = 0.656 V_{\text{max}}$$

$$V_{\text{max}} = \frac{V_{\text{DC}}}{0.636}$$

$$= \frac{12V}{0.636}$$

$$= 18.87V$$

$$V_{\text{max}} \cong 19V$$

$$\text{But } V_{\text{rms}} = 0.707 V_{\text{max}}$$

$$V_{\text{rms}} = 0.707 \times 18.87$$

$$= 13.33V$$

$$\text{Peak inverse voltage (PIV)} = 2V_{\text{max}} \text{-----}(3.3)$$

$$\text{PIV} = 2 \times 18.87 = 37.74$$

$$\text{PIV} \cong 38V$$

A power diode with PIV 50V and above is appropriate for the design. IN4001 was chosen for D₁ and D₂ as its peak inverse voltage PIV is 50. Blocking diode D₄ is also IN4001 diode.

(c). Filtration:

Due to the fact that a pure DC 12V is expected from the charging unit, the filter capacitors are used to smoothen the pulsating DC output of the rectifiers. The value of the filter capacitor is calculated below;

$$V_r = \frac{I_L}{2FC} \text{-----} (3.4) [3]$$

Where:

I_L = Maximum current to be demanded

F = frequency of the input voltage

V_r = ripple voltage

V_{rms} = Voltage after rectification

$$V_{rms} = \frac{V_{max}}{\sqrt{2}}$$

$$V_{max} = V_{rms} \times \sqrt{2}$$

$$= 12 \times 1.414 = 16.97V$$

Frequency F = 50Hz

Assuming a ripple factor (r) of 7%

$$V_r = \text{ripple factor} \times V_{\text{max}} \text{-----} (3.5)$$

$$= 0.07 \times 16.97$$

$$V_r = 1.185\text{V}$$

From equation----- (3.4)

$$C = \frac{IL}{2V_r F}$$

$$IL = 0.022$$

$$C = \frac{IL}{2V_r F}$$

$$= \frac{0.022}{2 \times 100 \times 1.188}$$

$$= \frac{0.022}{237.6}$$

$$C = 9.4 \times 10^{-5} = 94\mu\text{F}$$

∴ The filter capacitor is required is 94μF which the value is gotten by using two capacitor in parallel (C₁ and C₂). The effective capacitance

$$C = C_1 + C_2 = 47\mu\text{F} + 47\mu\text{F} \text{ as shown in Fig.3.2 below.}$$

(d). **indicator:** LED is used to indicate battery charging as shown in the circuit diagram. The LED is connected in series with a resistor and the value will be calculated below:

$$V_{DC} = V_{R1} + V_{D3}$$

But $V_{D3} = 2V$ operating voltage

$I_{D3} = 10mA$ safe biased current

$$12 = 2 + V_{R1}$$

$$V_{R1} = I_{LED} \times R_1$$

$$R_1 = \frac{10V}{10mA}$$

$$\frac{10}{0.01} = 1K\Omega$$

Standard Value is $1K\Omega$

The normally close contact of the relay is connecting the battery supply to the circuit while the normal open contact charges the battery and cuts off its supply. The complete circuit of the charging unit is drawn below in fig.3.2;

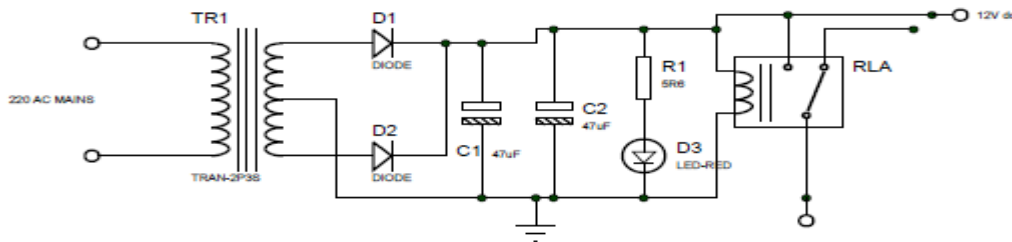
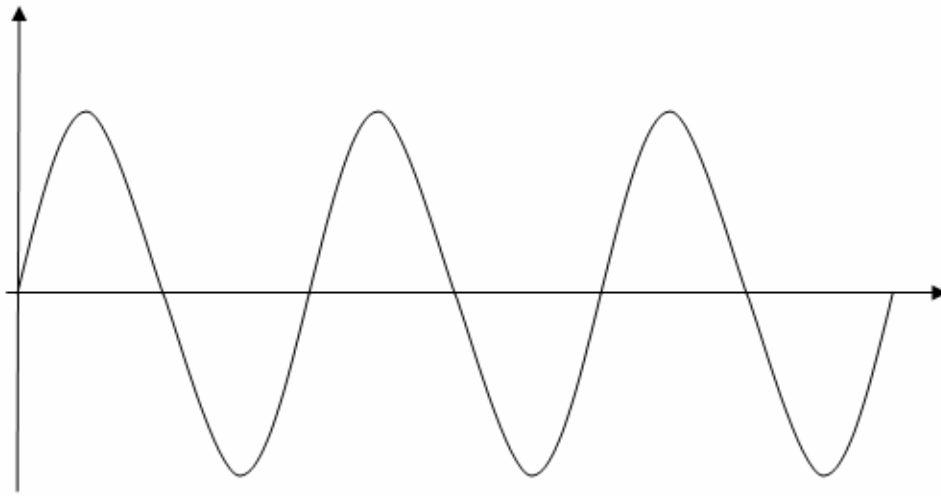
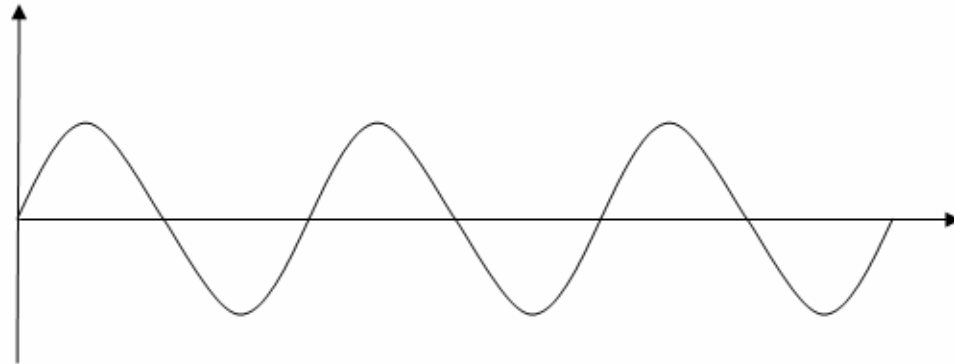


Fig. 3.2 Charging Unit

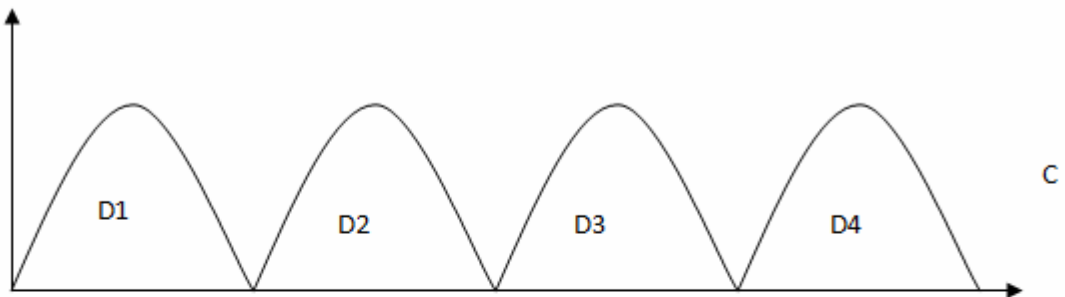
220V
MAINS
SUPPLY
INPUT TO
TRANSFORMER



12V AC
OUTPUT
OF STEP
DOWN
TRANSFORMER



OUTPUT
OF
RECTIFICATION



OUTPUT
OF
FILTERATION

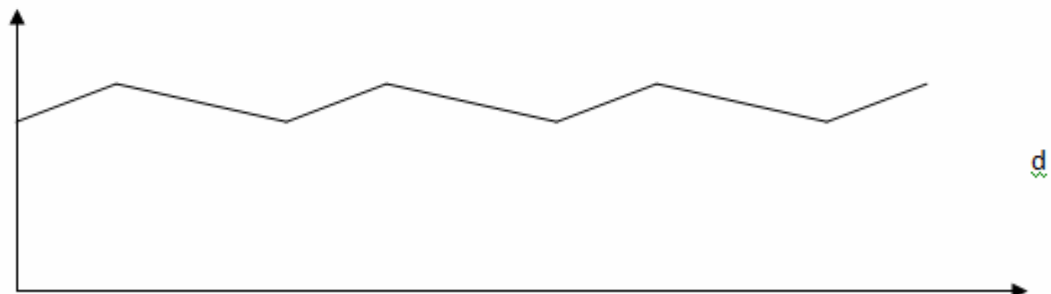


Fig. 3.3 Wave form of Transformer, rectification and filtration

3.2.4 Battery Unit

The back-up battery is position in the circuit where the charging unit and the inverter unit can be connected to it. It can be a single battery or more than one battery. When we have more than one battery, they are connected in parallel and it last longer depending on the number of batteries and the Ampere Hour rating (AH) of the batteries.

The battery used for this project is a rechargeable battery with the following rating:

LCL 12V 7.2P (Lead Acid Battery).

Voltage rating = $12V_{DC}$

Ampere Hour rating = 7.2Ah/20Hrs

Battery power = $P_B = AH$ (Ampere Hour)----- (3.5)

Power P , = $I V$ ----- (36) [6]

Where P = Load power

$$I = P/V$$

$$P_B = \frac{P.H}{V}$$

$$P_B = \frac{Pt}{V}$$

$$t = \frac{P_B V}{P}$$

Where, V= voltage

P = power demanded by load

T = time in hour

PB = battery amp.hour

$$t = \frac{7.2 \times 12}{100} = 0.86\text{hrs}$$

$$t = 0.86\text{hr} \times 60$$

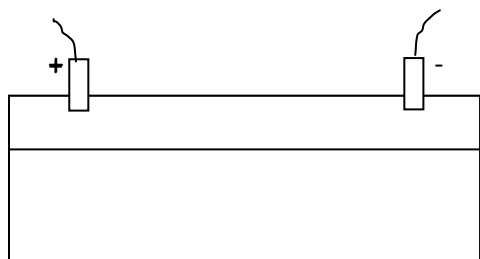
$$= 51.84 \text{ min}$$

Assuming losses in the circuit

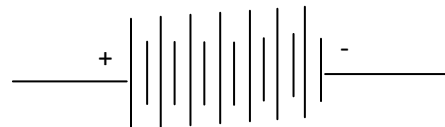
$$t \cong 50\text{min}$$

This time can be increase by using battery of higher AMP – Hour rating and using more than one battery.

The battery is shown below in fig.3.4 a and b



a. Schematic diagram of 12v rechargeable battery



b. Circuit diagram 12v rechargeable battery

Fig. 3.4 rechargeable battery

3.2.5 The Inverter Unit

The inverter Unit is the unit that converts the $12V_{DC}$ voltage to ac voltage. The circuit diagram is drawn below in fig.3.5

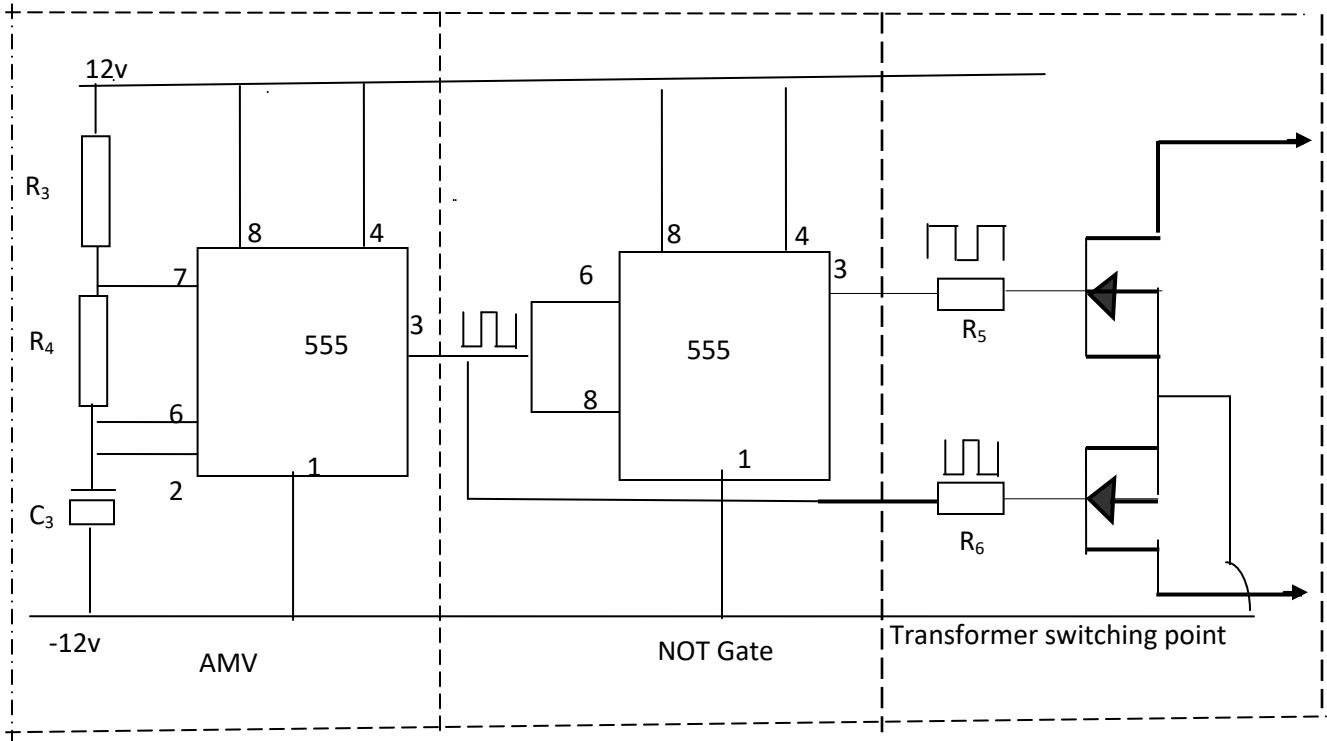


Fig. 3.5 Circuit diagram of the inverter unit

From fig.3.5 above, the inverter unit is the interconnection of the following circuit

(a) The Astable Multivibrator (AMV). The astable multi vibrator is a circuit that uses **555** time IC to generate rectangular wave signal without input signal as long as V_{DC} is applied. The circuit diagram is drawn below and the design of the Astable multivibrator is detailed below.

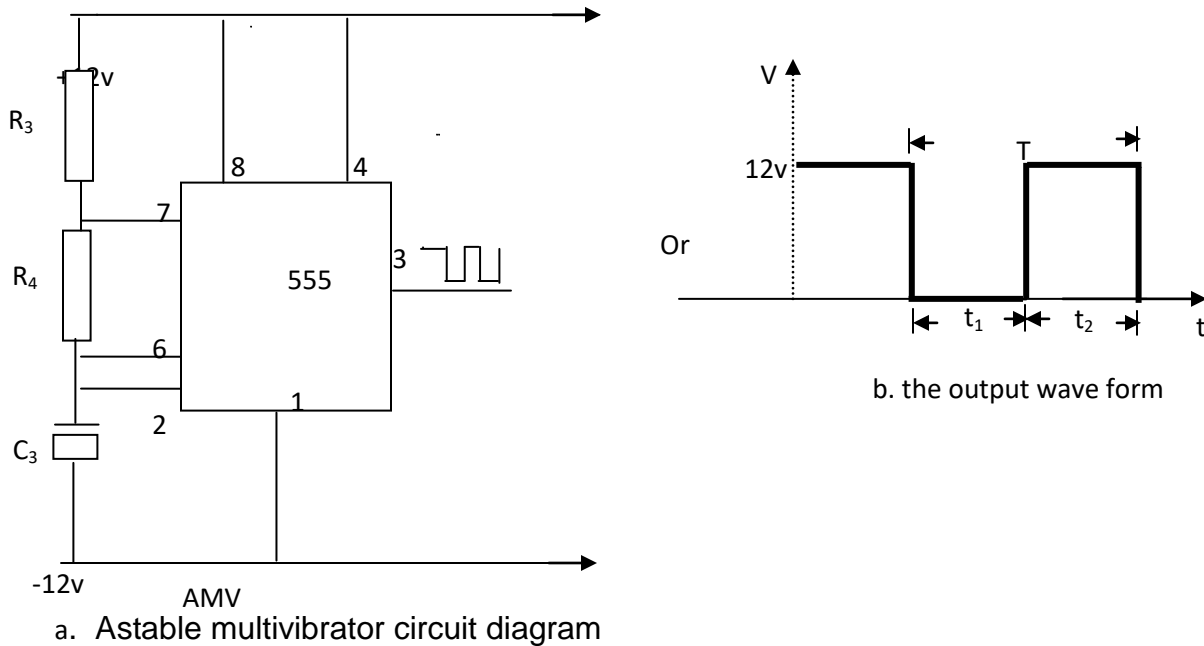


Fig 3.6 Circuit diagram of Astable multivibrator and the output wave form.

DESIGN:

As seen from the diagram, the output switches between two logic levels with the time interval (t_1 and t_2) at each level. These two time intervals are determined by the Resistor and Capacitor values.

The time interval t_1 is given by the equation,

$$t_1 = 0.7 R_4 C_3 \text{ ----- (3.7) [9]}$$

The interval,

$$t_2 = 0.7 (R_3 + R_4) C_3 \text{ ----- (3.8) [9]}$$

the time period of the output wave form

$$T = t_1 + t_2$$

Substituting the value of t_1 and t_2 from equation (3.7) and (3.8), the time period or

$$T = 0.7 R_4 C_3 + 0.7 (R_3 + R_4) C_3$$

$$T = 0.7 (R_3 + 2R_4) C_3$$

The frequency of the output wave form;

$$F = \frac{1}{T} = \frac{1}{0.7(R_3 + 2R_4)C_3} \text{(3.9)}$$

$$= \frac{1.44}{(R_3 + 2R_4)C_3}$$

$$\text{Duty cycle} = \frac{t_2}{T} \times 100\% \quad [8]$$

at 50% duty cycle (used in this project) $R_4 \gg R_3$

and R_3 must be greater than $1K\Omega$ [8]

let the value of $R_3 = 2.2k\Omega$

and the capacitor C_3 can be less available value so C_3 is chosen to be 1uf.

$$F = \frac{1.44}{(R_3 + 2R_4)C_3}$$

$$R_3 + 2 R_4 = \frac{1.44}{FC_3}$$

$$2 R_4 = \frac{1.44}{FC_3} - R_3$$

$$R_4 = \frac{1.44}{2FC_3} - \frac{R_3}{2}$$

$$F = 50 \text{ Hz}$$

$$R_3 = 2.2 \text{ K}\Omega = 2.2 \times 10^3$$

$$C_3 = 1 \mu\text{f} = 1 \times 10^{-6} = 10^{-6} \text{ f.}$$

$$R_4 = \frac{1.44}{2 \times 50 \times 10^{-6}} - \frac{2.2 \times 10^3}{2}$$

$$= 14\,400 - 1.1 \times 10^3$$

$$= 14\,400 - 1\,100 = 13\,300 \pm 5\%$$

Resistor R_4 chosen is 12 K Ω .

(a) Not Gate

The Notgate is basically the circuit that produces the inverse or compliment of the wave form at the input to give the complemented or inverted wave form at the output. The rectangular wave form generated by the AMV above is feed to the NotGate. The circuit diagram of the NOTGATE is shown below.

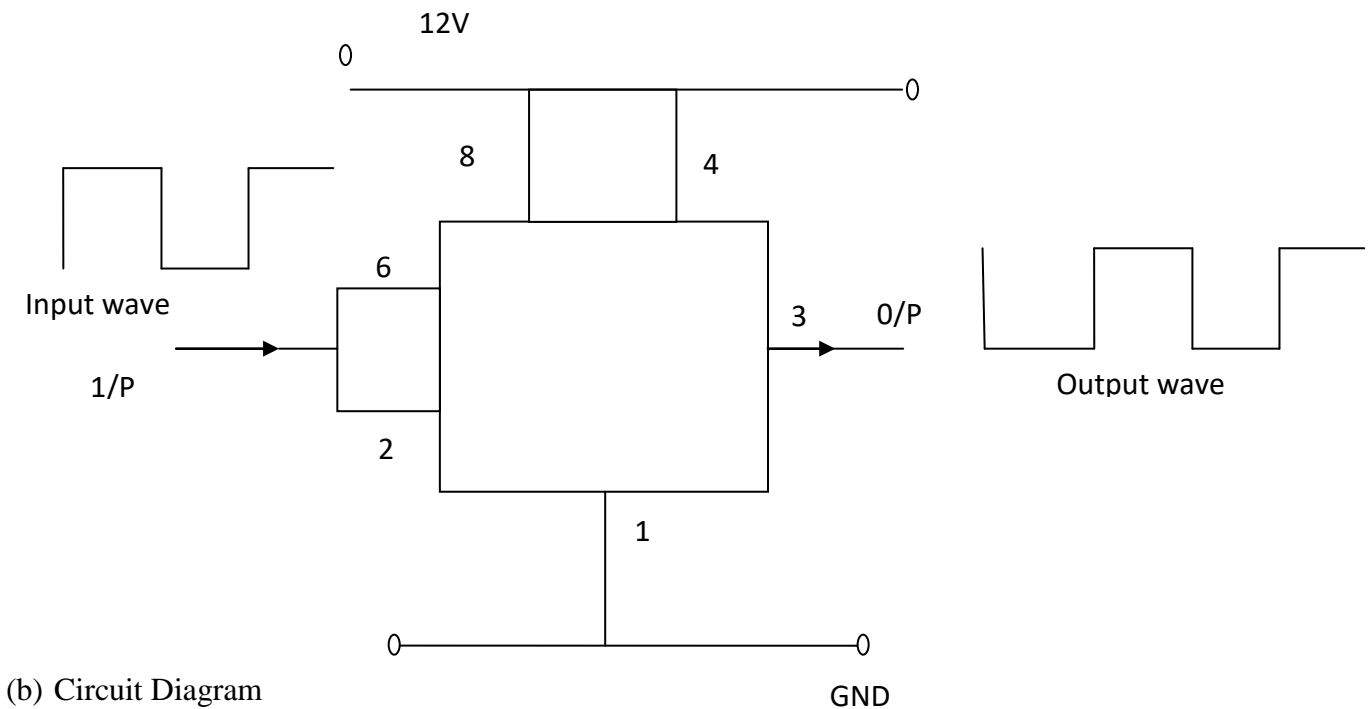
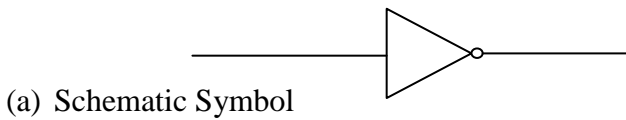


Fig. 3.7: Schematic symbol and circuit diagram of NOT Gate.

(c) The Transformer Switching Unit

This unit consist of two FET (RFP150N) connected in complementary form. They provide the alternating signal that switches the output transformer and also amplifies the signal from the Astabel Multivibrator and NOT Gate. The circuit diagram is drawn below:

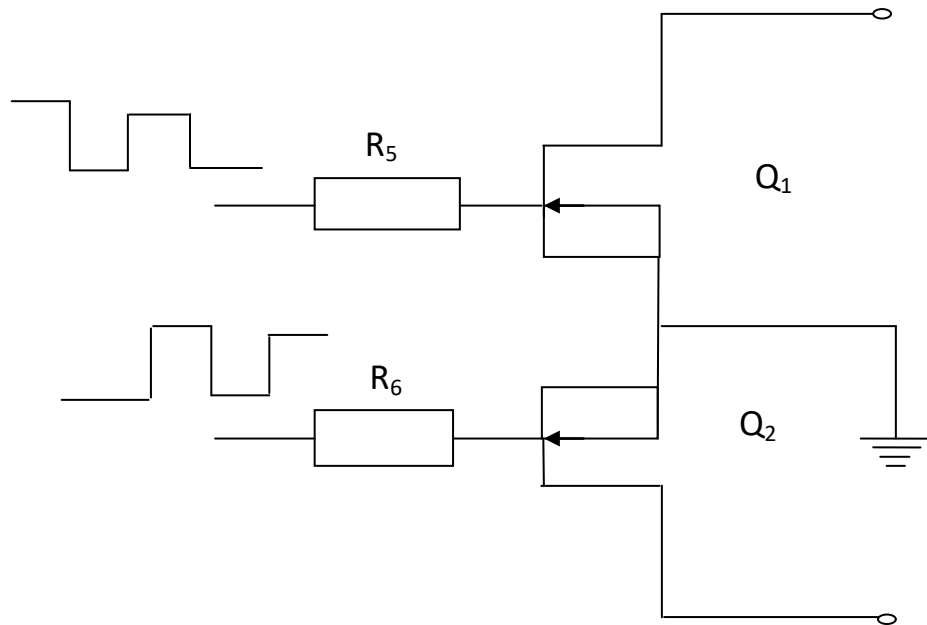


Fig 3.8 Circuit diagram of the transformers switching unit

Q_1 and Q_2 are the same MOSFET [RFP150N]

Resistors R_5 and R_6 are current limiters and does not have precise value.

It can be $1\text{ K}\Omega$, $2\text{ k}\Omega$ etc

But for this design:

$$R_5 = 2.2\text{ k}\Omega$$

$$R_6 = 2.2\text{ K}\Omega$$

3.2.6 Transformer Unit

At the output of the inverter unit, a suitable transformer is designed to step up the voltage to 220V ac. The output Transformer T₂ is a step up transformer 12V/220V with centre tap at the primary coil.

The diagram of the transformer is shown below:

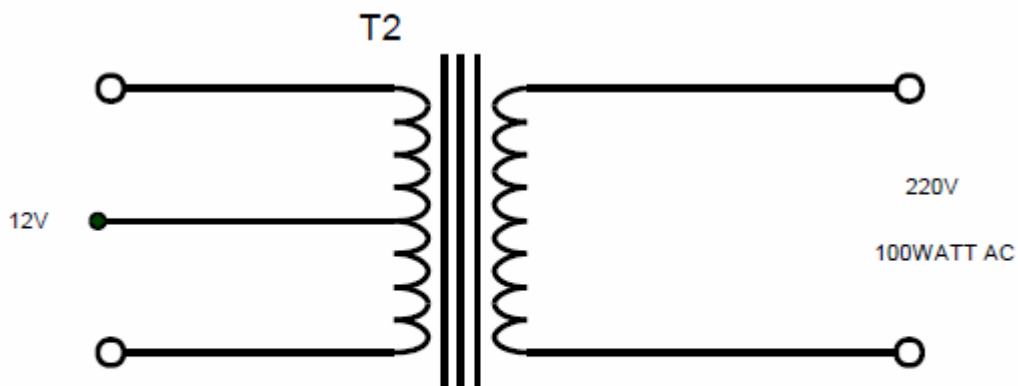


FIG. 3.9 TRANSFORMER UNIT

Coil Analysis:

Output power demanded $P = 100$ Watt.

$$P = IV \text{ -----} 3.10$$

At the primary, voltage $V = 12V$

$$I = P/V$$

$$= \frac{100}{12} \approx 8A$$

According to standard wire gauge (SWG) [8]

2.5mm² handles = 16A of maximum current

So primary coil gauge = 2.5mm²

Secondary coil

P = 1W

$$I = P/V = \frac{100}{220}$$

$$I = 0.45A$$

Gauge = 1mm²

Number of Turns N₂ and N₁

Where N₂ – is secondary turn

N₁ – is primary turn

$$\frac{N_2}{N_1} = \frac{V_2}{V_1} \text{ -----3.11 [8]}$$

Secondary voltage V₂ = 220V

Primary voltage V₁ = 12V

Primary coil has 28 turns

$$N_1 = 28$$

$$N_2 = ?$$

$$N_2 = \frac{N_1 V_2}{V_1} = \frac{28 \times 220}{12}$$

$$= 18.33 \times 28$$

$$N_2 = \underline{513} \text{ turns}$$

A suitable magnetic core with proper lamination was used to construct the transformer.

3.2.7 Switching Unit

The switching unit is an electromagnetic relay that is used to switch load supply to AC mains power supply and the battery power supply.

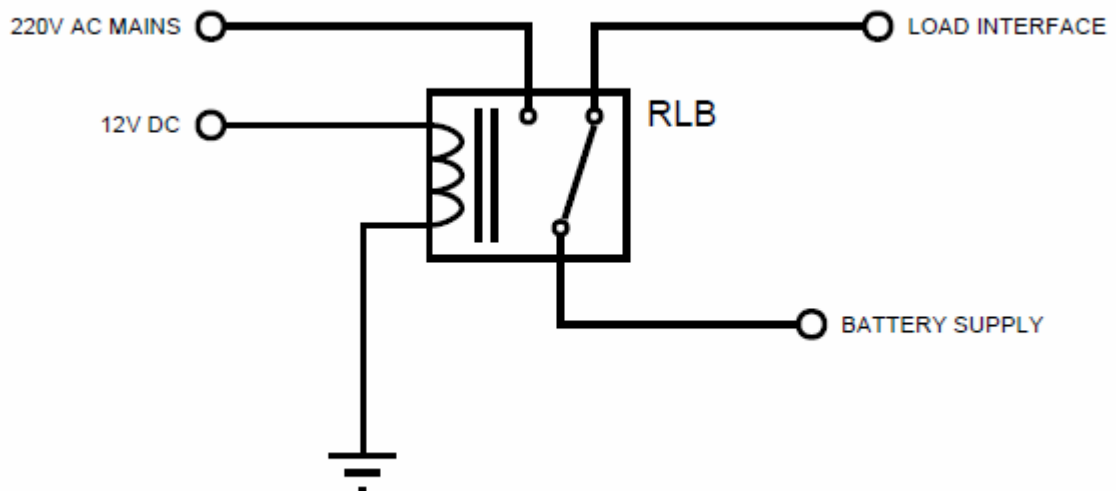


FIG. 3.10 SWITCHING UNIT

The relay normally close contact is connected to the battery supply and the AC main is connected to the normally open the load is on the common. As shown in Fig.3.10 above.

The rating of the relay

Voltage = 12V

Load power = 100 watt

$$\text{Load current} = \frac{\text{Power}}{\text{Voltage}}$$

$$I_L = \frac{100}{12} = \underline{\underline{8.33A}}$$

3.2.8 Output Interface Unit

The output interface unit is the unit that provide interface for connection of standard load. It is basically a 13A socket outlet in this project.

The output of the circuit is connected to the interface and a switch is used to break the

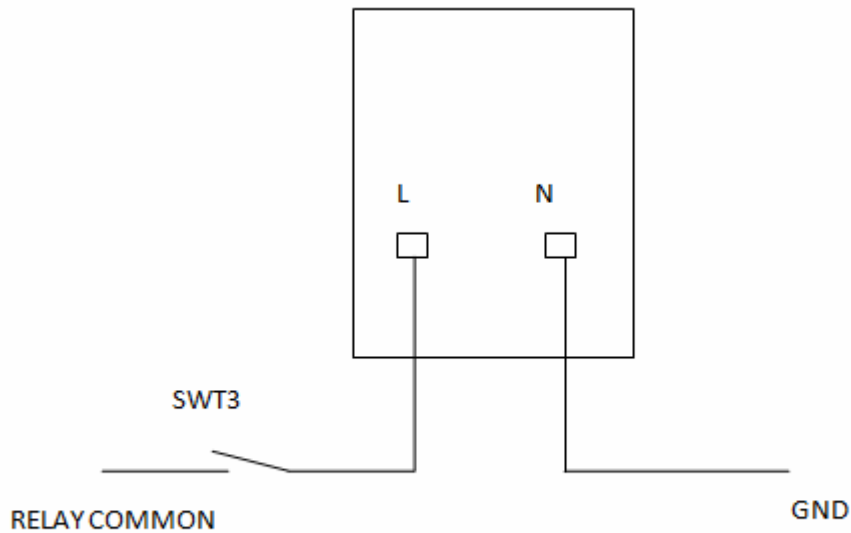


FIG. 3.11 OUTPUT INTERFACE UNIT

3.3 PRINCIPLES OF OPERATIONS OF 100WATT RECHARGEABLE LAMPS

A 100Watt Rechargeable Lamp can be a fairly complicated circuit as can be seen from the block diagram shown in fig. 3.1. It consists of the A.C mains supply unit. Charging unit. Battery unit. Inverter unit, transformer unit, switching unit and the output interface. This unit are connected together to form the system respectively

Fig. 3.12 is the general circuit diagram of the 100w rechargeable lamp. It is the direct coupling of each unit. Switch one (swt1) connects the AC mains 220V 50Hz power supply from the grid to the circuit. When the switch is close, the normally open terminal of relay (RLB) is energized and the transformer F_1 primary coil is feed with 220V AC which gives 12VAC at the secondary. The rectifier full wave bi-phase rectifies the 12 VAC to give a pulsating D.C 12V which is then filtered by the parallel capacitors (C_1 and C_2). The LED D_3 light up to indicates battery charging and power supply from grid. The 12V DC to energise relay (RLA) thereby charges the battery which is connected to the normally open contact. At the same time, the energized relay (RLB) close the normally open contacts (NO) onto the output interface thereby, switching the load to the AC mains power supply from the grid. When there is power outage from the grid, relay RLB will be de-energized and close the output interface to the battery supply while relay RLA will; also be de-energized and close the better to normally close contact (NC). Diode D_4 is a blocking diode that prevents the battery from discharging through RLB relay. When

switch 2 (swt₂) is closed, the charged battery discharges through the inverter circuit and LED D₄ light up to indicate battery supply in the circuit.

The 12V DC triggers the Astable multivibrator (AMV) and it oscillates to generate rectangular wave form pulse of equal duration which is feed to the NotGate and the MOSFET (Q₂). The NotGate invert the wave form and gives the inverted output which is fed to MOSFET (Q₁). This triggers the transformer switching unit respectively and the transformer steps the 12 VAC output of the inverter to 220VAC at the output. The step up 220VAC is fed to the load interface unit at the normally close contact of relay RLB.

Finally, when there is AC mains power supply, with switch 1 closed, the battery charges and the load is switched to the AC mains supply. At the time of power outage, with switch (swt₂) closed the battery discharge 12VDC and it is inverted and step up to 220VAC supply. And the load will be switch to the battery supply instantly. As soon as AC mains power supply is restored, the process is repeated and the battery charges while the load is switched to AC mains supply. Switch 3 (swt₃) is used to isolate the load from the load interface and the heat sink derates the MOSFETs.

PLATE 3.2: 100W RECHARGEABLE LAMP



3.4.0 Construction

The complete system shown in fig 3.11 was first connected on the bread board to ensure that it works properly. The assembly is then transferred to the veroboard. The arrangement was then troubleshooted and final soldering of the components was done. The arrangement of the component on the electronic board is shown in plate 3.1.

The construction of the output transformer. The winding of the transformer were wound round the iron core comprising of “E and I” shape. The two windings were all inside the “E and I” formation of the iron core. The primary side of the transformer was centre-tapped for the positives voltage connection. Long bolts and nuts were used in holding together the “E” and “I” shape formation.

Other components were selected and checked and tested differently before their assemblage on a breadboard. The assembly was in stages according to the units. A success in each unit gave way to the subsequent one until all the stages result were gotten. Heat sink was used to derate the MOSFETs.

Finally, the coupling of all stages were carefully done and tested quickly and carefully.

There was nothing at the output since a digital meter was at this stage used as a measuring instrument. A re-check was done, this time an open-circuit was spotted and corrected. The device was powered again. The voltage scale of the meter read 230V ac.

this good result opened the chapter for the final part of the project – soldering and packaging.

Both were carefully done, especially the soldering which was carried out on a vero board with a good soldering iron. After the final assembly inside a cased box of quality plastic another test was done.

3.4.1 CASING

This is the final finishing of the project work. The packaging was done using perspex plastic case. The assessment of the casing is shown below;

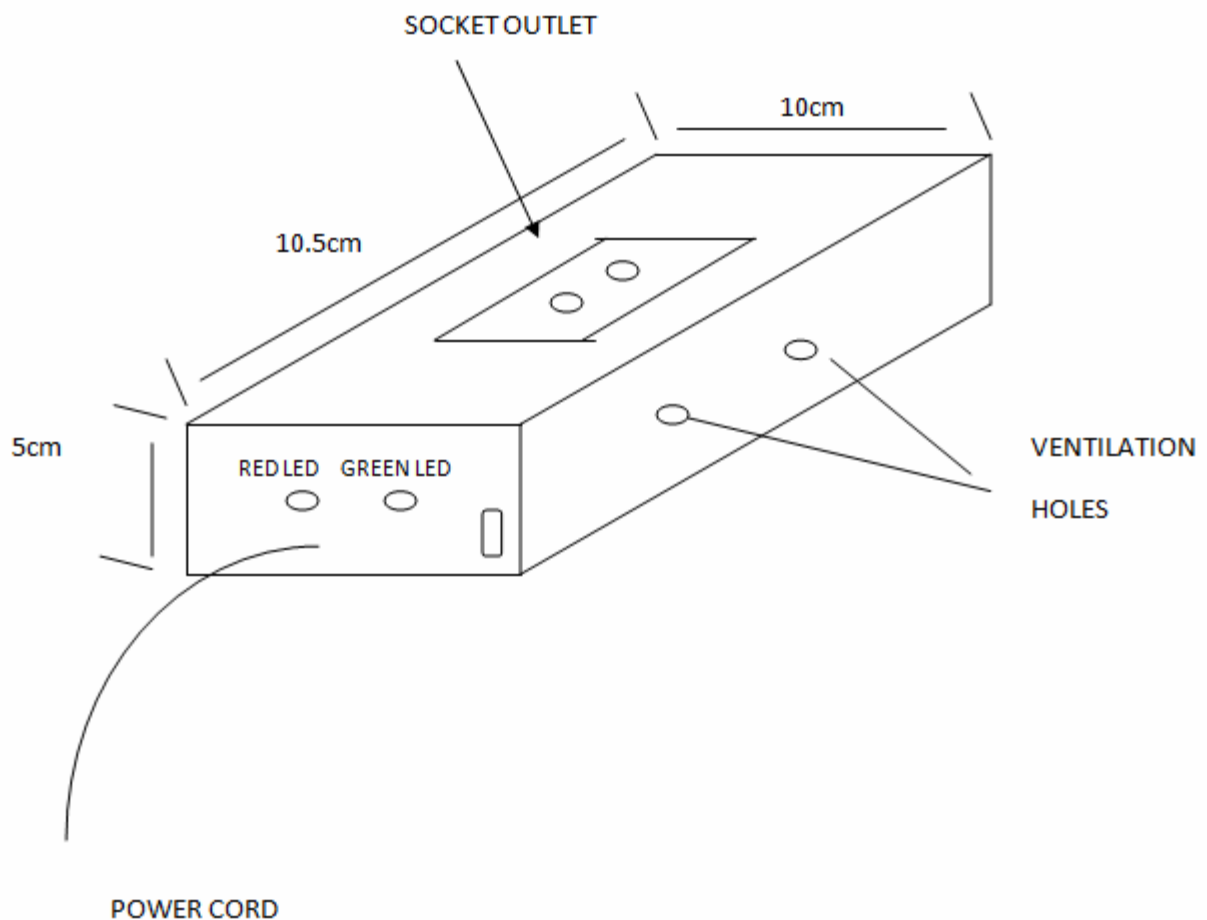


Fig. 4.1 Package Dimension of the system

CHAPTER FOUR

PERFORMANCE AND COST EVALUATION

4.1 TESTING

After the final soldering, the circuit was then troubleshooted and some tests carried out to determine the functionality of the device before powering the circuit. With the aid of a multimeter resistance test was carried out to ensure that there was no open or short circuit in the vero board connection. In the same line, voltermeter was also used to check voltage levels at different points after powering the designed circuit. A Digital multimeter was used to measure the frequency of the pulse.

Finally, a 100W, 220V bulb rating was connected to the output of the transformer unit, the plug was connected to AC mains power supply (of 220v) from the national grid as an input of 220V. The device energized or rather switched ON and in that process the bulb came ON. It was left for 45minutes, when the input source from PHCN was withdrawn. The bulb was still ON which confirms that the power source was no longer from the national grid but from the battery which gave an output that powered 100 watts bulb used in the project

Table 4.1 Test Result

S/N0.	QUANTITIES	Obtained Results
1	Output voltage	220v
2	Output power capacity	100watt
3	Frequency	50.1Hz
4	Time	45mins.

4.2 COST EVALUATION

Table 4.2 Cost Estimation

S/N0.	ITEM	QTY	PRICE (NAIRA)
1.	220/12V 500mA transformer	1	500
2.	IN4001 diodes	3	30
3.	LED	2	20
4.	Resistor 1K Ω	2	40
5.	Resistor 2.2K Ω	3	90
6.	Resistor 12 K Ω	1	20
7.	Capacitor 47 μ f (electrolytic)	2	100
8.	Capacitor 1 μ f (electrolytic)	1	50
9.	12V relay (ElectroMagnetic)	2	300
10.	555 Timer IC	2	200
11.	RFPI50N MOSFETs	2	400
12.	Transformer core ETD ferrite	1	500
13.	Switch	2	60
14.	Socket outlet (13A)	1	500
15.	Plug wire	1	50
16.	Heat sink	2	100
17.	Coper wire 2.5mm ²	1 yard	200
18.	Coper wire 1.mm ²	1yard	200
19.	Plastic casing	1	1400
20.	12V rechargeable lead acid battery	1	2500
21.	Soldering lead	1	50
22.	Miscellaneous		100
	Total		7,510

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The never ending drive towards smaller, highly efficient and high capacity electronic power supply necessitated the design and construction of 100Watt Rechargeable Lamp incorporated with a fast switching capability that switches the supply source thereby acting as an Uninterrupted Power Supply (UPS). The system consist bank of batteries which charges and store charges when there is utility power supply while it discharges at the time of utility power outage to provide 100Watt 220V AC power supply capable of powering standard appliance. And also at the instant of power outage, it automatically switches the load unit to the battery supply.

5.2 CONCLUSION

The Design and Construction of a 100Watt Rechargeable Lamp has been achieved in this project through the use of low cost components which are readily available in the market. The idea was to evolve a robust and cost effective rechargeable lantern.

5.3 RECOMMENDATION

In the course of this research works, several factors and challenges have been encountered which should be taken into careful consideration when modifying the design for enhanced performance.

These include;

- Adequate protection against voltage surge and spikes should be incorporated in the design to avoid frequent damage of sensitive components like MOSFETS AND 555Timer ICs.
- The battery could be replaced higher rated battery to increase the duration of un-energized operation.
- The output transformer could be wound with a coil of higher rating to improve the load carrying capacity beyond 100watt.

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