DESIGN AND CONSTRUCTION OF 12V, 20A, BATTERY CHARGER WITH AUTOMATIC CONTROL SWITCH

BY

ABDULAZEEZ NUHU

2003/15276EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

OCTOBER,2008

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG)

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

NIGER STATE.

OCTOBER, 2008

DECLARATION

I Abdulazeez Nuhu of Electrical and computer Engineering department declare that this project work was written by me, under the supervision of Professor.O. Usifo for the purpose of awarding a degree (B.Eng) Hon

.... ABDULAZEEZ NUHU

7/11/2008. .... DATE

CERTIFICATION

This is to certify that this project work is being written by Abdulazeez Nuhu, Reg No,2003/15276EE and it has not been submitted by anybody for any purpose.

It therefore meet the requirement governing the award of (B.Eng) degree Hon. In electrical and computer Engineering.

....30/10/08

Professor.O.Usifo
(SUPERVISOR)

DATE

....

Dr. Y.A. Adediran
(HEAD OF DEPARTMENT)

....

DATE

....

EXTERNAL SUPERVISOR

....

DATE

DEDICATION

This research project is dedicated to Almighty Allah for guiding and protecting me throughout all these turbulence years of studies. Praise and adoration be unto his name (Amin).

ACKNOWLEDGEMENT

Thanks be to Almighty Allah, the Omnipotent and the merciful for giving me sound health, strength and wisdom to bear things I cannot change. Guiding me throughout so many difficulties I had encountered during the course of this programme.

This work would not have been completed without the assistance and contribution of some people, I therefore express my profound gratitude to all who have directly or indirectly contributed towards the successful completion of this project work.

Special mention should be made to my project supervisor professor.O.Usifo who worked with me with all zeal and dexterity for sparing his time to go through the manuscripts. I equally express my sincere gratitude to my H.O.D Engr Dr Y.A.Adediran and the entire staff of electrical and computer Department for their moral support and encouragement.

My hearty thanks goes to my parents, Mallam Abdulazeez Abdulsalam Alkali and his wife Mrs Abdulazeez Asmau for their kindness and tireless effort to stand firmly behind through my pursuit of (B.Eng) in Electrical and computer Engineering.

I also acknowledge the effort made by my brother in person of messr. Abdulazeez Tijani Ihiezu, Abdulazeez Kabir, Abdulazeez Adobanyi and a host of others too numerous to mention for their support and contributions towards my success. I will also not forget to thank my mentor and my boss, Engr. Ibrahim Idris Adamu for his immensed contribution towards the successful completion of this programme (B.Eng).

Finally, my sincere appreciation goes to my friends, Mr Abdulazeez Zubair, Abdulrahaman suleimen, A.K salihu, Zacheaus, Salihu Jimoh, abdulKarim, sanusi, Akande, A.A Usman, Abdulrazaq, mark Ajoge, shamsudeen, Isah abubakar, Aliyu bello and others I cannot mention for their valuable contributions. Thank you, may Allah bless you all (Amin).

ABSTRACT

This work describes the design and construction of a battery charger (automatic) unit.

The unit is capable of charging any 12v battery at a maximum charging current of 20A and also supply loads at a constant 12v dc at 20A (maximum).

The methods, procedure and the realization of the system is contained in this thesis. The charger has been preset to charge any 12v DC battery to a maximum of 14.6v before switching off.

TABLE OF CONTENT

CHAPTER ONE

1.0 INTRODUCTION

In today's modern technology, electronic plays a major and important role in running our daily life. This is easily visible in most of our home appliances i.e video sets, televisions, cable satellite, decks and personnel computers e.t.c. which on one way or the other requires electrical power to operate or run them. This power is usually in direct current (D.C forms) which can easily be obtained by the conversion of A.C voltage to desired D.C voltage level by the use of appropriate rectifier circuits.

Electricity is expected to be provided reliably, constantly and free from problems. Unfortunately however, in a society like ours in which the supply from electricity board is traditionally irrational and inevitable. The cheapest and wideiy available D.C source is the battery (secondary cell).

It took appromimately 50 years from the time of volta's invention of the galvanic cell principle in 1800 for its application t the land/sculpture acid/lead dioxide system by siemen and sinsteden. Barely 10 years later, this was followed by plank's invention introducing the lead acid battery as an electrochemical storage.

For this contribution, plank's name was incorporated in the permanent lead acid battery terminology with reference to the so called plank's plate. These have their active materials layer of surface formally electronically from the lead substrate rather than applied to the substrate in a separate operation.

Plank's cell consist of lead sheet wound spirally in a cylindrical configuration and separated by rubber strips heavy liner or felt Pb/PO_2. The development progressed systematically till the present day. A significant development was achieved towards the ends of the nineeth century by faure. He utilized pasted plate structure consisting of an active materials mixed, applied to a variety of a lead current collector configuration. Increasing usage were found among the various types of separators starting with such "exotic" materials as flannels.

In the advent of a more technology era, with dynamic available for battery charging for the utilization of the advantage of rechargeablility in general and of the lead acid battery in particular [2].

By the year 1900 sufficient types of lead-acid battery have been developed. The world war II brought about new and improvement in the field, including new era materials for the construction of separators and battery case of well as the new method of manufacturing of all internal components of the battery. Also, additional type of grid alloy for various application, improved active, materials, composition, formulation and processing techniques e.t.c. Progress has been made lately in all these area thereby resulting in product being lighter in weight and more reliable.[3].

1.1 OBJECTIVE

The aim of this project work is to present a simple systematic method and approach for the design and construction of a battery charger which is capable of charging medium duty batteries of 12 volts within a comparatively short time.

The design is intended for both domestic and industrial application. Even commercial application is not left out.

However, a machine is said to be automatic when it is able to work with and without attention, hence the need for automation was included in the design to curtail cases and instances of over charging and undercharging which can jeopardize the life span of a battery system.

1.2 METHODOLOGY

The conventional use of standard symbols, block diagram and diagrams were adopted. The block diagram of a battery charger in this design consist of the transformation unit where there is a center-tapped transformer use to step-down the voltage from the mains a.c power supply of 230v at 50Hz. Followed by the rectification and filtration unit (circuit) and then regulation of the d.c output voltage from the rectifier and finally, before the output terminals, in the automatic charging unit which employs the aid of PWM IC and transistor to achieves this aim.

CHAPTER TWO

2.0 LITERATURE REVIEW

An automatic battery charger is an electrical device used in bringing a discharged battery to its optimum operating condition. It is concerned primarily with charging a battery by maintaining the supply voltage constant for the period of charge.

The battery charger commonly in use operate by passing a constant current and voltage over an indefinite period of time into the discharged battery. Thus, it is seen that emphasis in its design is placed only on the power supply needs; however, it is worthy to note that such, chargers are switched off and on manually.

The sort of battery charger described above posses some defects in its design it is at once seen that there is the danger of overcharging which can permanently destroy the life span of the battery, therefore there is the need for sort of control mechanism. Also there is the problem associated with the gases hydrogen and oxygen released during the charging process, these gases insulate portion of the battery plates from the electrolyte, thus reducing effective charging current raising the internal resist once of the battery. As a result the amount of time needed to charge the battery is increase considerably.

In this chapter, the various components of a battery charger are: Transformation system, rectification, automation control and the charging unit or circuit are being reviewed.[4].

2.1 TYPES OF BATTERY CHARGER

2.1.1 Car battery charger;

It contains a half wave rectifier with a protection from a short circuit and from reverse battery polarity. It also comprises of a switching element to terminate the high current charging process when battery gets fully charged.

2.1.2 Automobile battery charger:

The automobile battery charger contains a full wave rectification which is used to re-charge run-down lead-acid batteries in automobile without removing them from their original mountings and without any need for constant attention when the battery is fully charged. The switches from charging current to trickle charging and an indicator lamp lights up to provide visual indication of this condition.

2.1.3 Types of Batteries

There are two types of batteries;

a. Primary battery
b. Secondary battery.

The primary battery is the one that is not capable of being recharged when the active material has been used up. While the secondary battery can be restore to their original chemical state when the battery has been used up with the acid of a battery charger.

There are various types of secondary batteries that exist. Below are some list of some secondary batteries viz:

i. The lead-acid battery.
ii. The alkaline battery
iii. High temperature battery.

iii High temperature battery

It is a new group of source which requires operating temperature above the ambient temperature. They possess the advantage of high specific energy and power couple with low cost. They are particularly suitable for vehicle traction and load leveling purpose in the electric supply industry. We will briefly describe the following cell from which high temperature batteries are made.

1. LITHIUM/CHLORINE CELL

It has an emf of 3.5v, a theoretical specific energy of 2200wh/kg at 614°C and operating temperature of 650°C.

2. Lithium/sulphur cell

It has an emf of 2.25v, specific energy of 2625 wh/kg and an operating temperature of 365°C.

3 Lithium/ Aluminium

The emf of these cells is 1.3v and a specific theoretical energy of 450wh/kg [5]

2.2 DESCRIPTION OF MAJOR COMPONENTS.

Before embarking on the design procedure of this project, it is necessary to have knowledge of the theory of operation and the electrical characteristic features of the various components used in other to have an insight into how each section of the battery charger circuit is achieved which enable the circuit to charge 12V d.c batteries and at the same time act as 12V d.c source which produces 20A of current at the output for various load.

2.2.1 Transformer

A transformer is an electrical device that transforms electrical energy from one circuit to another purely by magnetic coupling. The principle of operation of a transformer is by electromagnetic induction using faraday's law of electromagnetism.

A transformer is not an energy conversion device. It neither converts A.c to d.c or d.c to A.c energy source. It cannot change the frequency of a signal.

It can rise (step-up) or lower (step-down) the voltage in a circuit with a corresponding decrease or increase in current. The physical basis of a transformer is mutual induction between two circuit linked by a common magnetic flux. In its simplest form, it consists of two inductive coils which are electrically separated but magnetically linked through a path of low reluctance.

For this project, a step down transformer rated at 15v (centre-tapped) was used.

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For this project, a step-down transformer rated at 15v (centered tapped) was used.

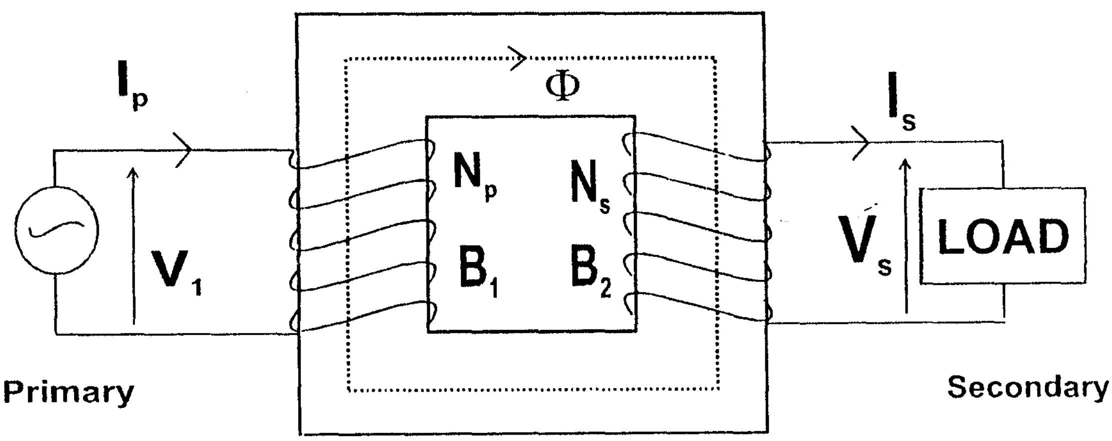
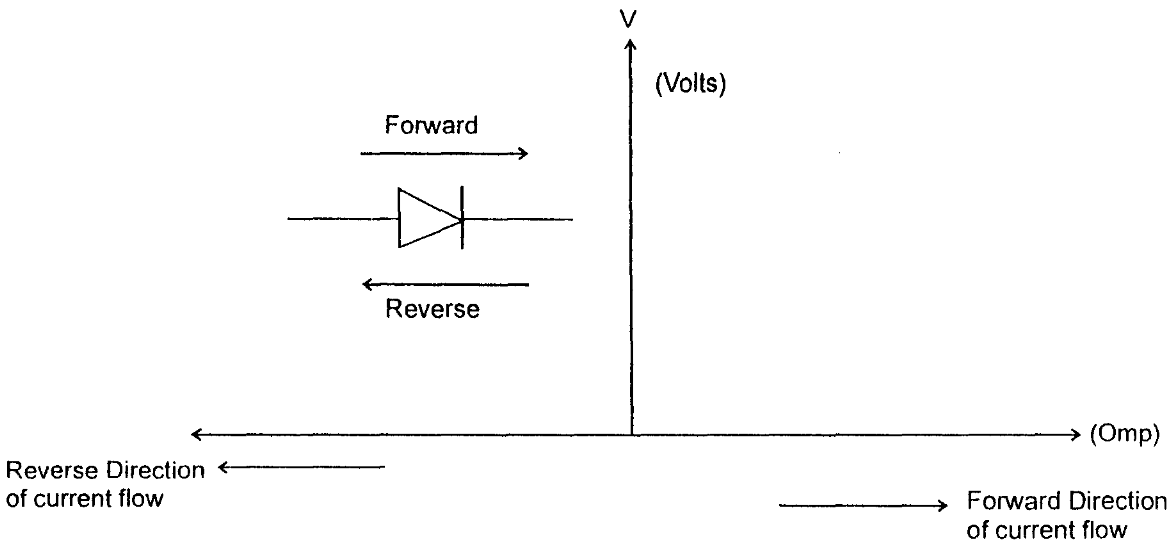


Fig 2.2.1 shown a circuit diagram of a transformer

2.2.2 Rectification Unit

Rectification is the conversion of an alternating current voltage to unidirectional voltage using rectifier or diode. Diode are used in rectification process because a diode will allow current to flow in any one direction.

When forward biased, the diode conducts current and block current flow when reversed biased. The direction of conduction is the direction in which the arrow points in the diode symbol.



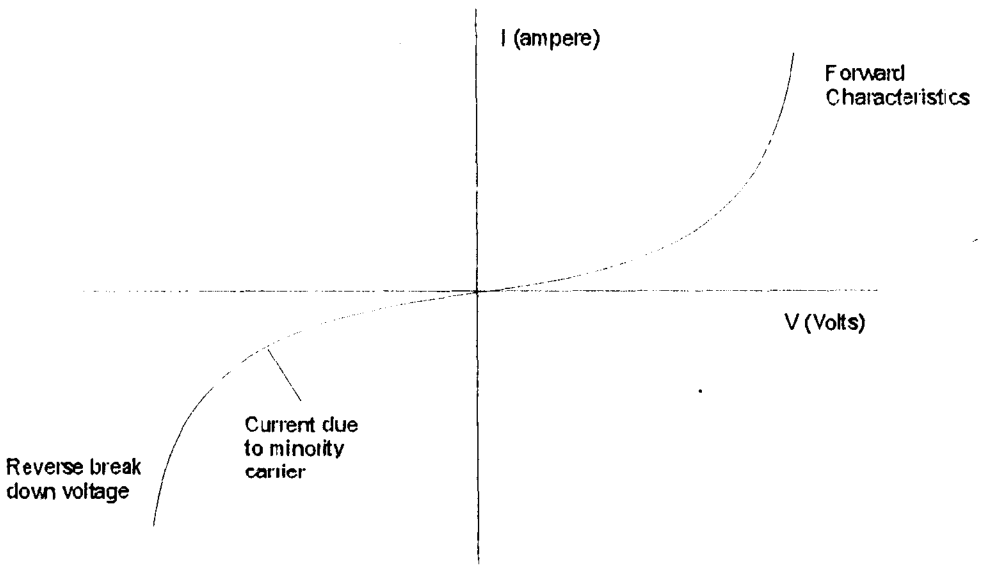


Fig 2.2.2 Full-Wave Bridge Rectifier

It is the most frequently used current for electronic d.c power supplies. It require four diode but the transformer used is not centre tapped and has a maximum voltage of V_{ms} (maximum value of transformer secondary voltage).

The full wave bridge rectifier is available in three distinct physical form,

i. four discrete diode

ii. One device inside a four terminal case.

iii. As part of an array of diode in an (I.C) integrated circuit.

The circuit using four discrete diode is shown in figure (a) During the positive half cycle, the secondary terminal N is negative as shown separately in figure (b) D_1 and D_3 are forward biased and diode D_2

And D_4 reversed biased. Current therefore passes from terminal M through Diode D_1 through the lead R_1 and return to terminal N through Diode D_3. This makes the output d.c voltage V_{out} positive.

During the negative half cycle, secondary terminal N becomes positive and M negative diode D_2 and D_4 are forward biased and D_1 and D_2 reversed biased current now flows from terminal M through diode D_4. Since the direction of the current in the output resistance is the same, the polarity of the output voltage is unchanged. Then both positive and negative half-cycle of the supply produces positive output peak and consequently point A of the bridge rectifier always act as an anode and point C a cathode. The output voltage across the load R_L as shown in Fig (a) has frequency twice that of supply. Note that in a short period of time between each half cycle, the supply voltage is less than turn on voltage of the diodes and all the diode are turned of.[6].

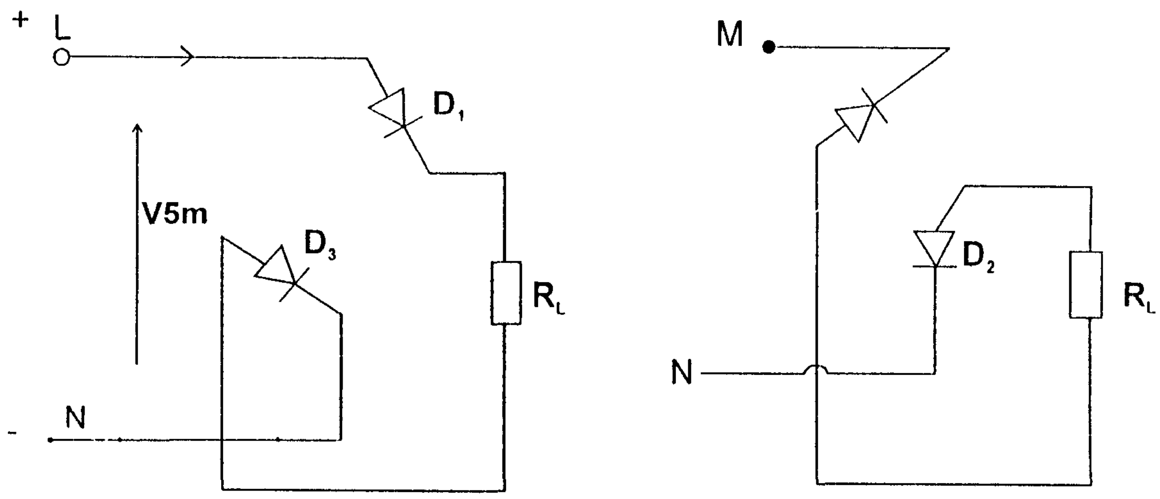


Fig 2.2.2 (a) conduction path for positive and negative half-cycle.

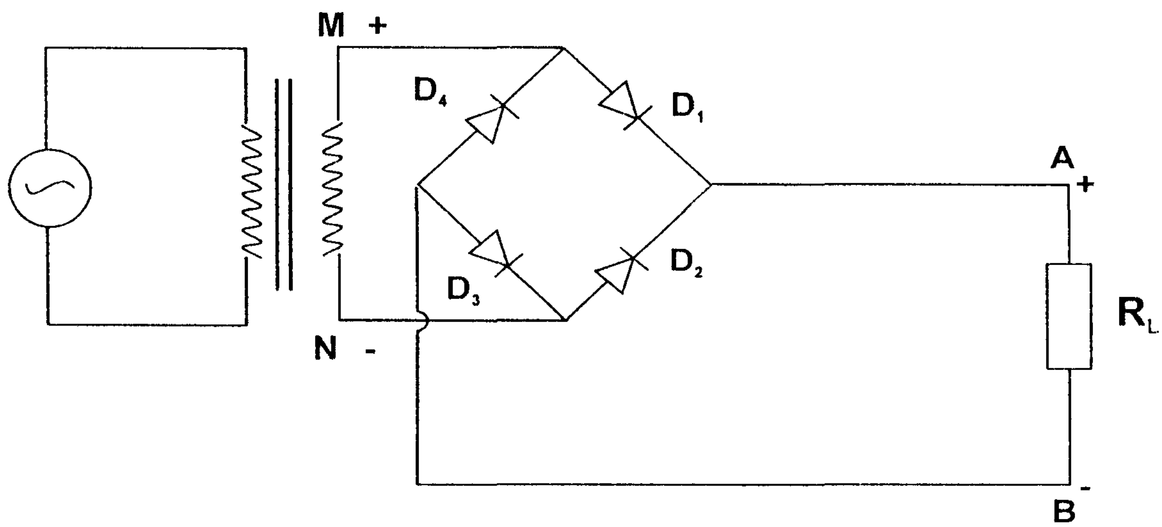


Fig 2.2.2 (b) Full wave Bridge Rectifier circuit.

2.2.3 FULL WAVE RECTIFICATION THEORY.

In full wave rectification at any instant the load current is given as $id = id_1 + id_2$.

Thus, in this circuit the current will repeat itself every circle of the supply voltage therefore, mean value of the load current.

$$I_{dc} = \frac{1}{\Pi}\int_0^{\Pi} \mathrm{Im}\, Sinwt\delta(wt)$$

$$I_{dc} = \frac{2\,\mathrm{Im}}{\Pi} - 0.639\,\mathrm{Im}(2xIdcHalf - wave)$$

The rms of the Load current is given by

$$Irms = \sqrt{1/\Pi \int_0^{\Pi} \text{Im}^2 Sin^2 wt \partial(wt)}$$

$$I_{rms} = \frac{1m}{\sqrt{2}} = 0.7071\,\text{Im}$$

Therefore,

$$10rms - 0.7071\,\text{Im}$$

Similarly, for the load voltage mean value of the voltage

$$V_{dc} = \frac{2Vm}{\Pi}$$

$$Therefore, V_{dc} = 0.639Vm$$

Rms Value of the load voltage Vrms = $\frac{Vm}{\sqrt{2}}$

V_{rms}= 0.7071Vm

2.3 FILTERATION

The main function of a filter circuit is to minimize the ripple content in the rectifier output. The output from the rectifier have a dc value and some a.c component called ripples.

This types of output is not useful for driving sophisticated electrons circuit/device that is, a relay designed specially for d.c may chatter if the ripple magnitude is pronounced. In order to smoothened the d.c output a filter circuit is required. A filter can be defined as a circuit that converts a pulsating d.c output from a rectifier into a steady d.c level.

These are various types of filtering circuit for d.c power supply.

1. shunt capacitor filter
2. Series inductor filter.
3. I.C filter
4. R-C filter.
5. R-L-C Filter.

In this design, I employed the shunt capacitor filter which consists of a capacitor connected across the rectifier and in parallel with the load to achieve filtering action.

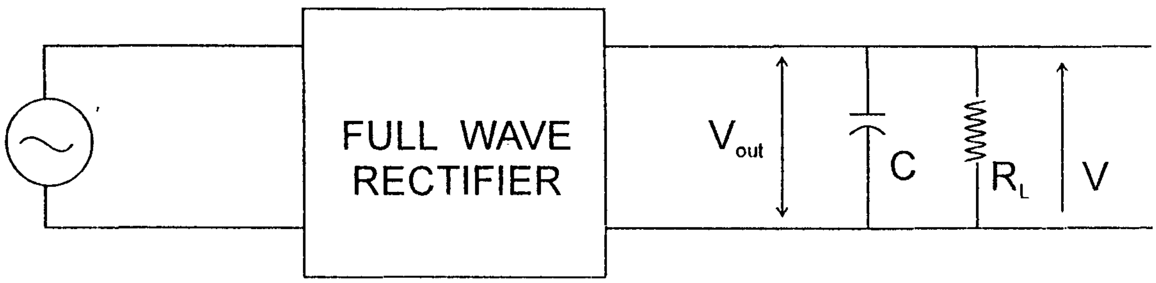


Fig 2.3 (a) Shunt capacitor Filter

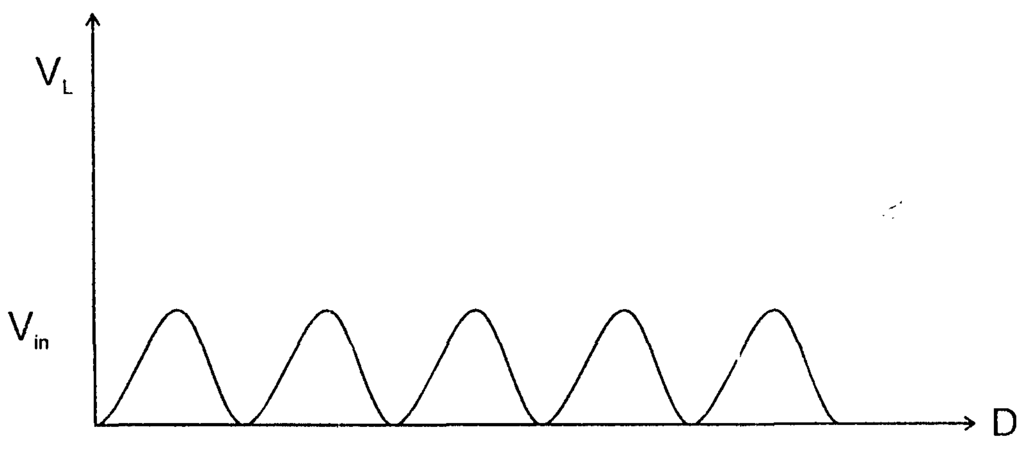


Fig 2.3 (b) rectifier output wave form without filter capacitor.

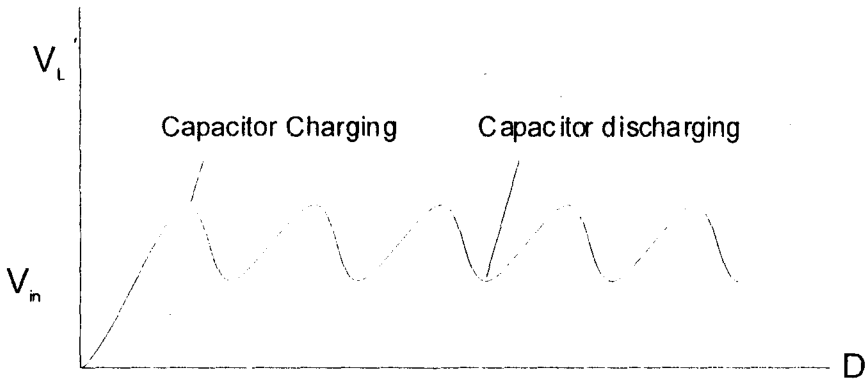


Fig 2.3(c) rectifier Output wave form with filter capacitor.

The shunt capacitor is as shown in Fig (a) this filter circuit depends for its operation on the property of a capacitor to charge up (i.e store energy). During conducting half cycle, the capacitor opposes any change in voltage, when connected across a pulsating d.c voltage it tends to smoothen out or filter out the ripple it should be noted that the capacitor stores energy when the voltage rises and return it to the circuit when the voltage falls. This charging and discharging process is represented during each ripple pulse period, thereby helping to maintain a fairly constant voltage.

It has been found that increasing the capacitor size.

i. Increase Vdc towards the limiting value Vm.

ii. Reduces the magnitude of the ripple voltage.

iii. Reduces the time of flow of current pulse through the diode.

iv. Increase the peak current in the diode.

2.4 RESISTOR

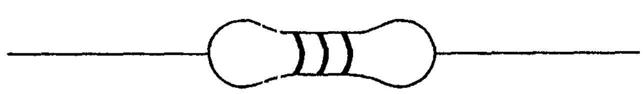


Fig 2.4 circuit symbol of a resistor

Resistors are passive components. They are mainly used to limit the flow of current in a circuit. Resistor are of various types, the most common of its is the carbon resistor which has colour codes for the identification of its value and the variable resistor which has a mechanical features that enables the variation of the resistor in ohm(Ω).

2.5 POWER TRANSISTOR

Power transitor which are used as switching elements in low to medium power application have controlled turn on and turn-off characteristics. The power transistor used in this project is known as bipolar junction transistor (BJT).

The characteristic and rating of each type should be examined to determine its suitability to a particular application.

The BJT was used as a power switch with its ON-time determined by the SG3524 pulse width modulator (PWM) integrated circuit. Its' gate drive from the collector of the transistor consist of a variable duty cycle rectangular pulses. The width of this pulse is controlled by the state of change of the battery.

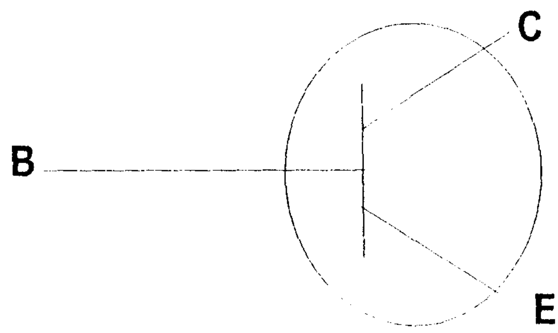


Fig 2.5 Shows a circuit symbol of a power transistor

2.6 OPERATIONAL AMPLIFIER.

It is a very high gain, high input resistance directly coupled negative feedback amplifier which can amplify signal having frequency ranging from 0HZ to a little beyond

1MHZ. they are made with different internal configuration in linear ICs. An operational amplifier is so named because it was originally designed to perform mathematical operation like summation, subtraction, multiplication, and differentiation and integration e.t.c in analogue computers. Present day usage is much wider in scope but the popular name operational amplifier continues.

Typical uses of operational amplifier are: scale changer, analogue computer operations, in instrumentation and control systems and a great variety of phase-shirt and oscillators circuits. The operational amplifier is available in different packages.

1. Standard dual-in-line package (DIL).
2. To 5 case and
3. The flat pack.

Although an operational amplifier is a complete amplifier, it is some designed that external components (resistors, capacitors etc) can be connected to its terminal to change its external characteristic. Hence, it is relatively easy to tailor this amplifier to fit a particular application an it is Infact, due to this versatility that operational amplifier base become so popular in industry. An operational amplifier IC may contain two dozen transistors, a dozen resistors and one or two capacitors. [7].

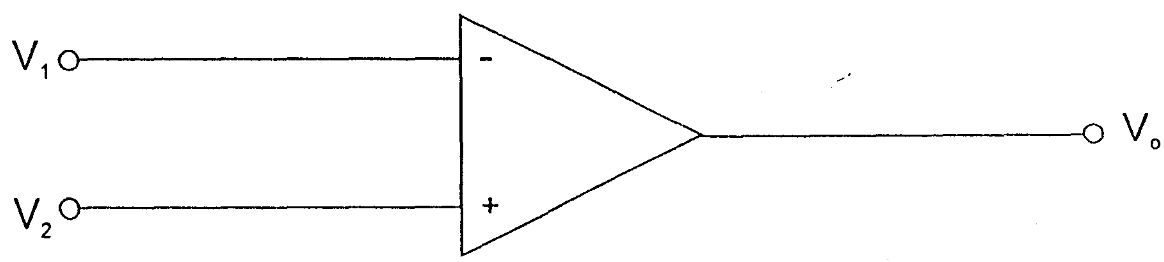


Fig 2.6 A circuit symbol of an operational amplifier with Negative input terminal and positive input terminals.

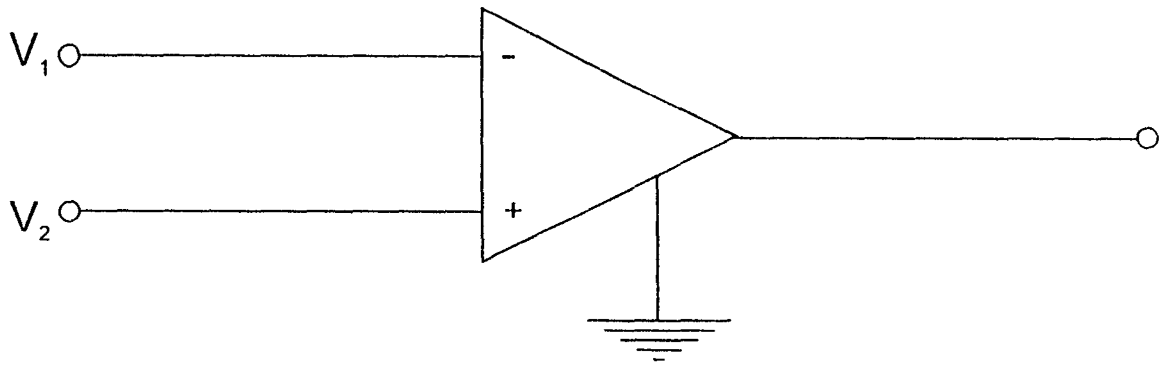


Fig 2.6 shows an operational amplifier symbol with earth.

2.7 CHARGING METHODS.

Charging has a profound effect in the secondary cell system, in this regard, several good methods have been employed as listed below;

The methods of charge can be put into four categories

i. Trickle charge.

ii. Constant current charge.

iii. Constant voltage charge.

iv. Floating charge system.

2.7.1 Trickle Charge.

A small current is passed through the battery for a very long period of time.

2.7.2 Constant Current Method

The charging current is kept constant by means of a variable resistance in series with the output of the charger. The current flowing through the variable resistance depends on its setting and on the potential difference between the terminals. The potential difference is the difference between the output voltage of the rectifier and the voltage required to charge the cells.

2.7.3 Constant Voltage Method

In this method, the charging voltage is maintained at a constant value slightly in excess of the e.m.f of the fully charged cell, but it result in every charging current in the beginning when their back e.m.f increase on charging. This charging current depends on the difference between the charging voltage and the total e.m.f of the battery and its internal resistance.

2.7.4 Floating System Method

In this method, (used in car-charging) system. The d.c generator recharge the battery when it falls below a certain voltage. The charging current is automatically cut-off when a certain voltage is reached, so that the battery does not feedback into the generator.[8]

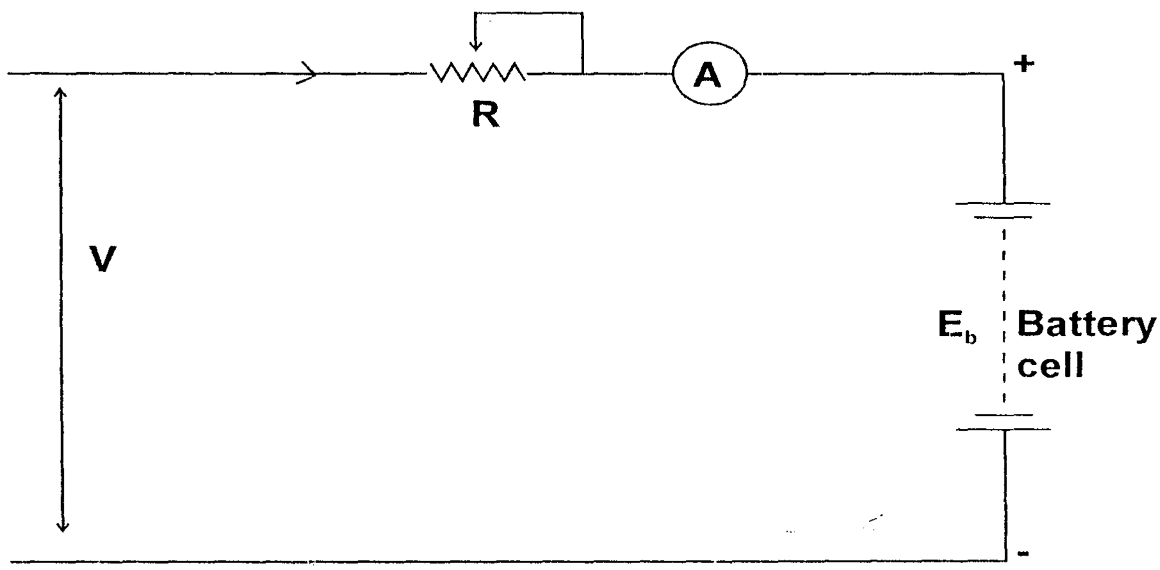
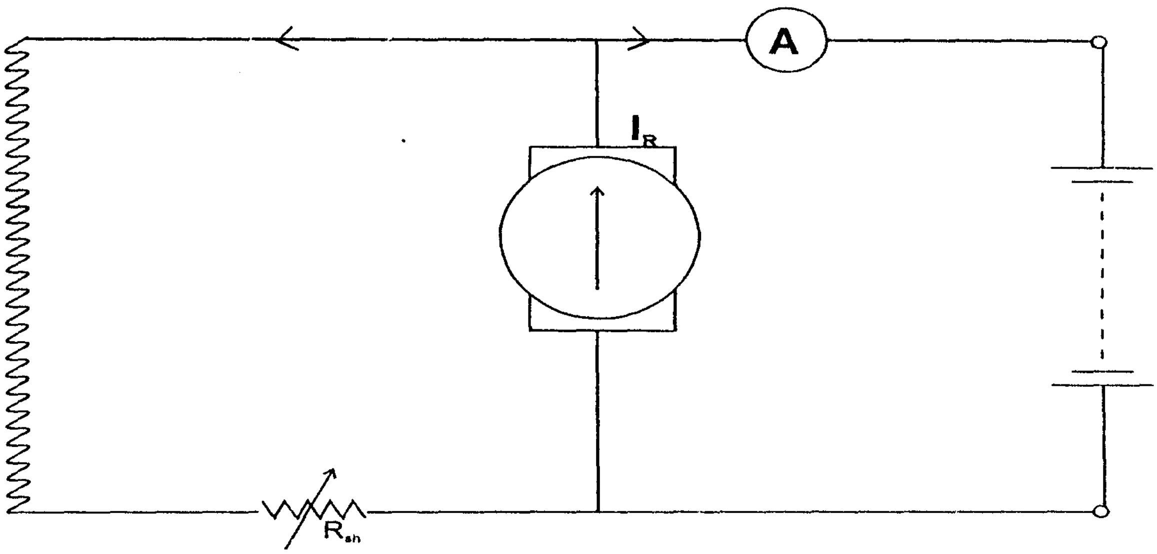


Fig 2.7 constant voltage method



2.8 INDICATION OF A FULLY CHARGED BATTERY

The indication of a fully charged cells are:

1. Gasing free
2. voltage
3. Specific gravity.
4. Colour of the plates

2.8.1 Gasing

When the battery is fully charged, it freely gives off hydrogen at cathode and oxygen at anode, the process being known as "gasing". Gasing at both plates indicates that the current is no longer doing any useful work and hence should be stopped. Moreover, when the cell is fully charged, the electrolyte assumes a milky appearance.

2.8.2 Voltage:

The voltage ceases to rise when the cell becomes fully charged the value of the voltage of a fully charged cell is a variable quantity being affected by the rate of charging, the temperature and the specific gravity of the electrolyte during charging. The approximate value of emf is 2.1

2.8.3 Specific Gravity of the Electrolyte

A third indication of the state of charge of a battery is given by the specific gravity of the electrolyte. During charging, the density of the electrolyte decrease due to the production of water. Whereas it increases during charging due to the absorption of water. The value of density when the cell is fully charged is 1.21 and 1.18 when discharged up to 1.8v.

2.8.4 Colour

The colour of plates on full charged is deep chocolate brown for positive and grey for negative plate and the cell looks quite brisk and alive.

2.9 MAINTENANCE OF LEAD-ACID CELLS

The following important points should be kept in mind for keeping the battery in good condition:

1. The level of the electrolyte should always be 10 to 15mm above the top of the plates which must not be left exposed to air.
2. Evaporation of electrolyte should be made by adding distilled water occasionally.
3. It should mot be left in discharge condition for long.
4. Discharged should not be prolonged after minimum value of the voltage fir the particular discharged is reached.
5. Since acid does not vaporize none should be added.
6. Vent opening in the play should be kept open to prevent gasses from within building a high pressure.

7. The battery terminals and metal support should be cleaned down to bare metals and covered with Vaseline or petroleum jelly.
8. The acid and corrosion on the battery top should be washed off with a cloth moistured with baking sada or ammonia and water [9].

2.10 APPLICATION OF BATTERY CHARGER.

The battery chargers are used for keeping a constant voltage throughout its load range. They are used in industries where bank of batteries are kept in continuous voltage charging for use in control rooms to operate different types of dc equipment. They are also used to charge a battery to supply power where the electricity generating station fails.

A charger is used in area where batteries are used to supply low voltage for operating purpose in many different ways such as high tension switch gear, automatic telephone exchange and repeater broad casting station and also for wireless receiving sets.

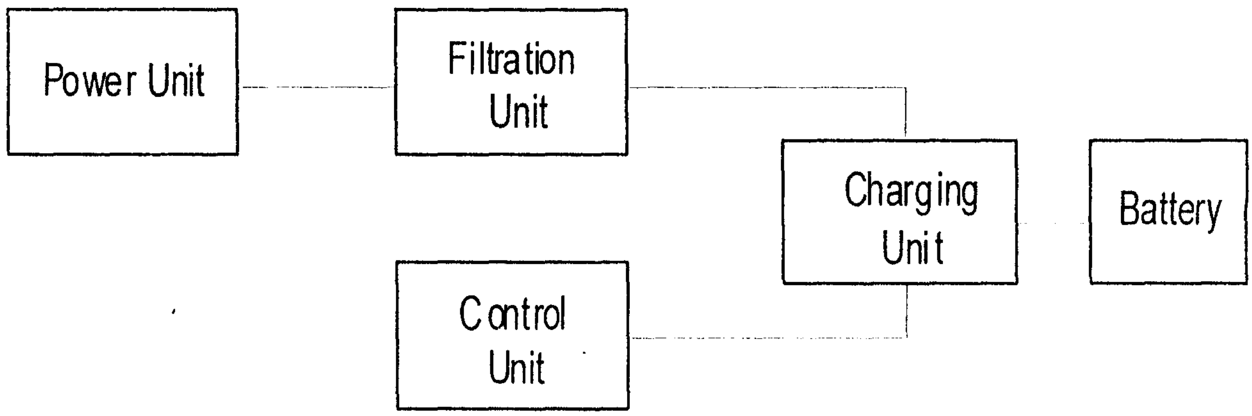
2.11 MAIN OPERATED BATTREY CHARGER.

A battery charger is an electrical device that is used for putting energy into a battery. The battery charger changes ac power sources into sources suitable for charger. However, dc generator and alternators are used as charging sources for secondary batteries.

In general, a main operated battery charger consist of the following elements;

1. A step-down transformer for reducing the high Ac main voltage to low Ac voltage.
2. A full wave rectifier t converts alternating current into direct current.

3. A charger – current limiting element for preventing the flow of excessive charger current into the battery under charge.
4. A capacitor to remove ripple voltages and also serves as filtering circuit. [10].



In the fig 2.11 shows the block diagram of the complete circuit of the charging circuit. The circuit consists of four different stages namely; the power unit, the filtration unit, charging and the control unit. The design of each stage will now be analyzed fully.

2.12 THE POWER UINT

The power unit consists of a transformer which steps down the alternating current from 220v A.C to 15V A.C. the AC is then rectified by a full wave bridge rectifier to a unidirectional current DC

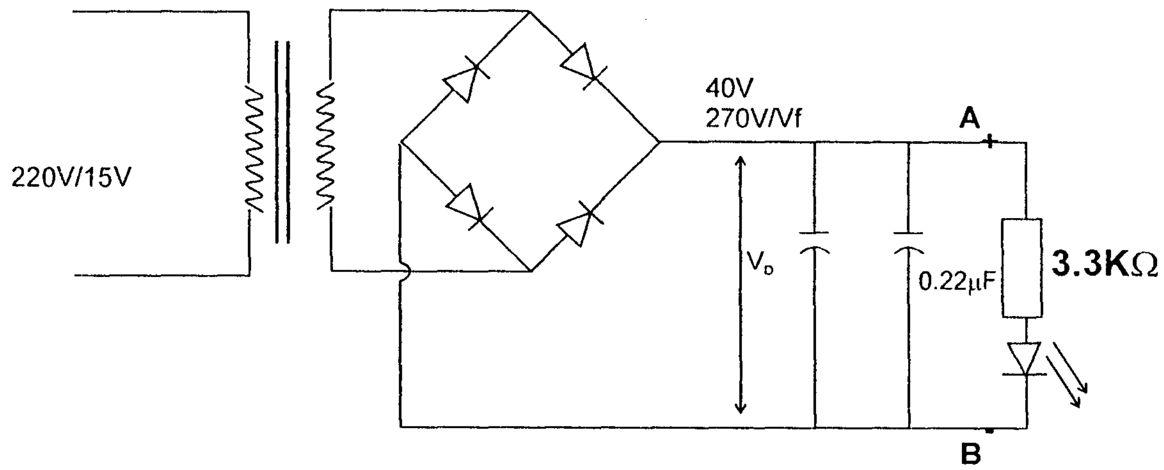


Fig 2.12 Shows the block diagram of the power unit.

2.13 THE FILTRATION UNIT

The filtration unit is the unit which contains the capacitory for removing the ripple voltages and extraneous noise in the rectifier output.

The output of a various rectifier circuit is pulsating. It has a d.c value and some a.c components called ripples. This type of output is not useful for driving sophisticated electron devices. It requires a steady d.c output that approaches the smoothness of a battery's output.

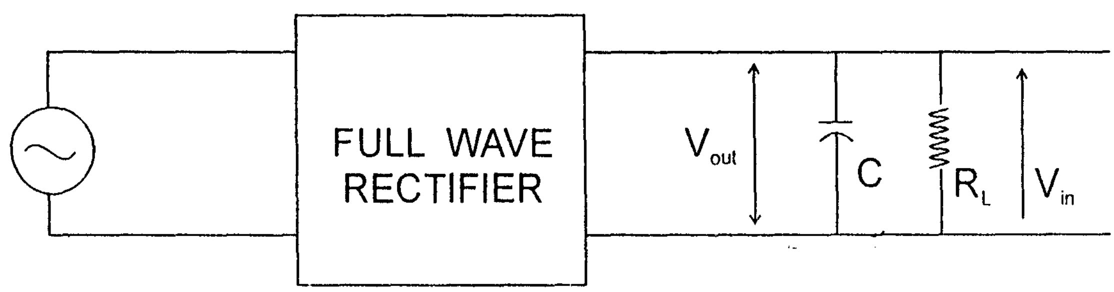


Fig 2.13 Shows the circuit diagram of filtration Unit.

2.14 THE CHARGING UNIT

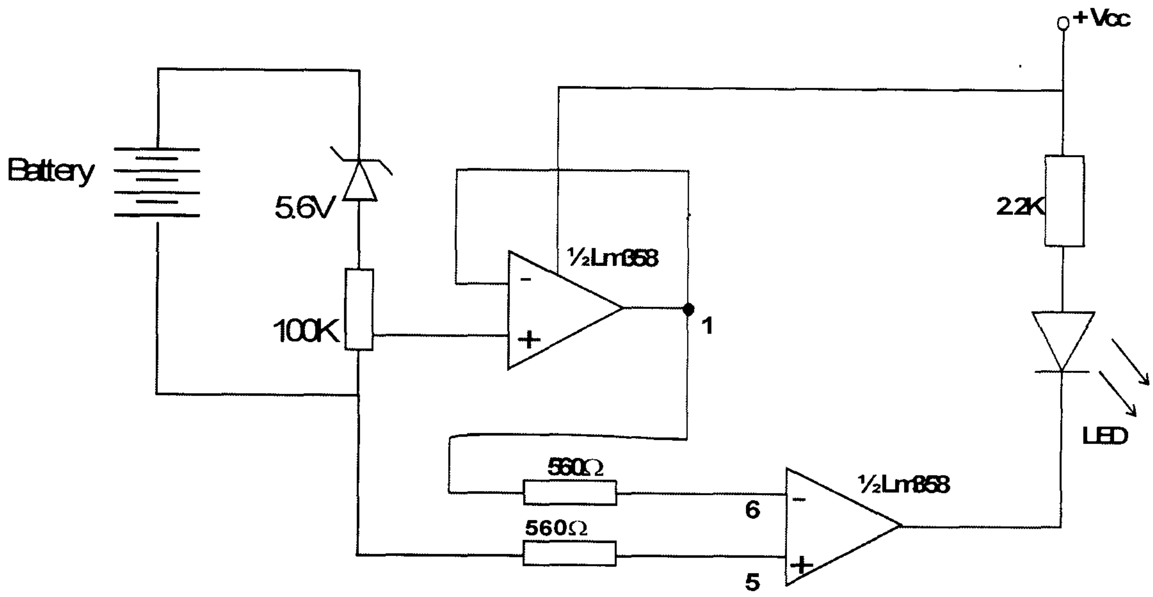


Fig 2.14 Circuit diagram of the charging Unit.

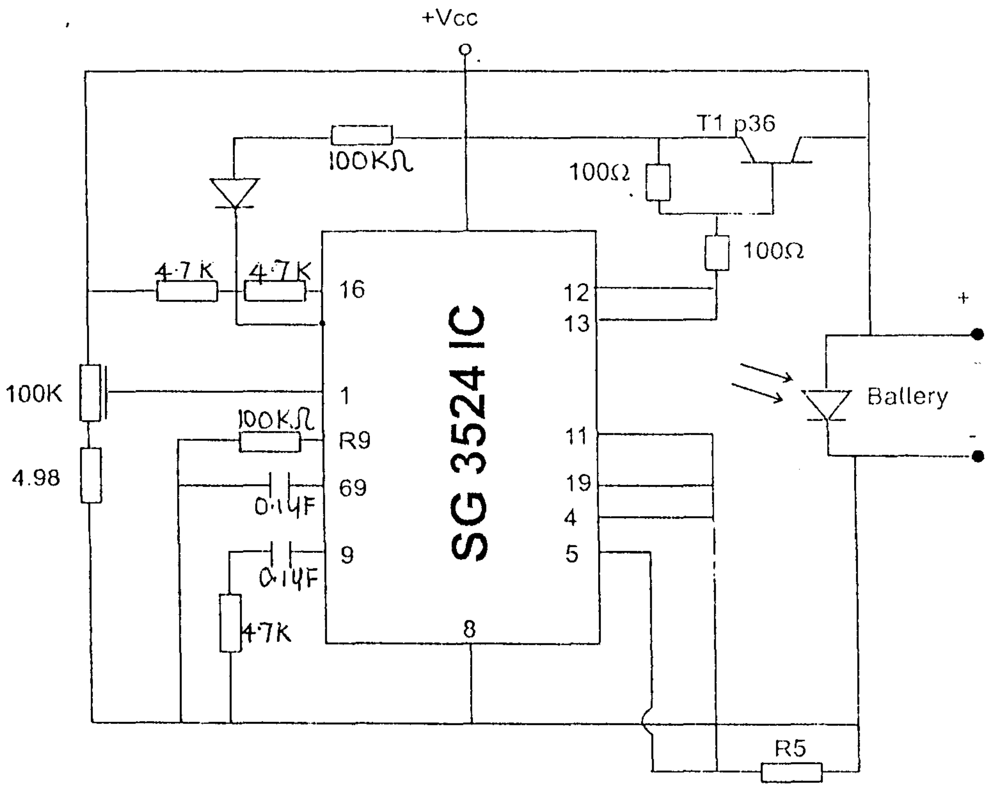
In the fig shows the block diagram of the charging unit of the charger circuit. An end of charge indicator was provided to monitor the voltage across the battery and provide visual indication of charging progression.

An LM 358 dual operational amplifier to detect end of charge. It was connected across the battery under charge to track and reflect the battery voltage status via a blue LED.

2.15 THE CONTROL UNIT

The Control units consist of the pulse width regulator IC.A 16-pins (PWM) regulated IC was employed to control the charging process. The device is an integrated circuit using feedback to establish any desired output voltage relative to a reference voltage of 2.5v.

The device was used to control a high power pnp transistor to whose output the battery under-charge was connected. Figure above shows the circuit diagram of the control unit.


+Vcc
T1 p36
100KΩ
100Ω
100Ω
4·7 K
4·7 K
16
SG 3524 IC
12
13
+
Ballery
-
100K
1
100K.Ω
R9
11
4.98
69
0·1μF
19
4
9
0·1μF
5
4·7K
8
R5

CHAPTER THREE

3.0 DESIGN AND CONSTRUCTION

3.1 CONSTRUCTION

The 12 volts battery charger system was designed around the following subsystem;

i. Power supply.

ii. Pulse width modulation voltage control IC.

iii. 25A PNP transistor switch.

iv. End of charge detector/indicator.

3.2 POWER SUPPLY

The power supply was designed around components specified by system requirements.

i. High power encapsulated rectifier.

ii. 40v, 2700μF capacitor.

iii. Power indicator.

The power supply was obtained from a 15v, 30A step down transformer and a full wave bridge rectifier diagrammed below;

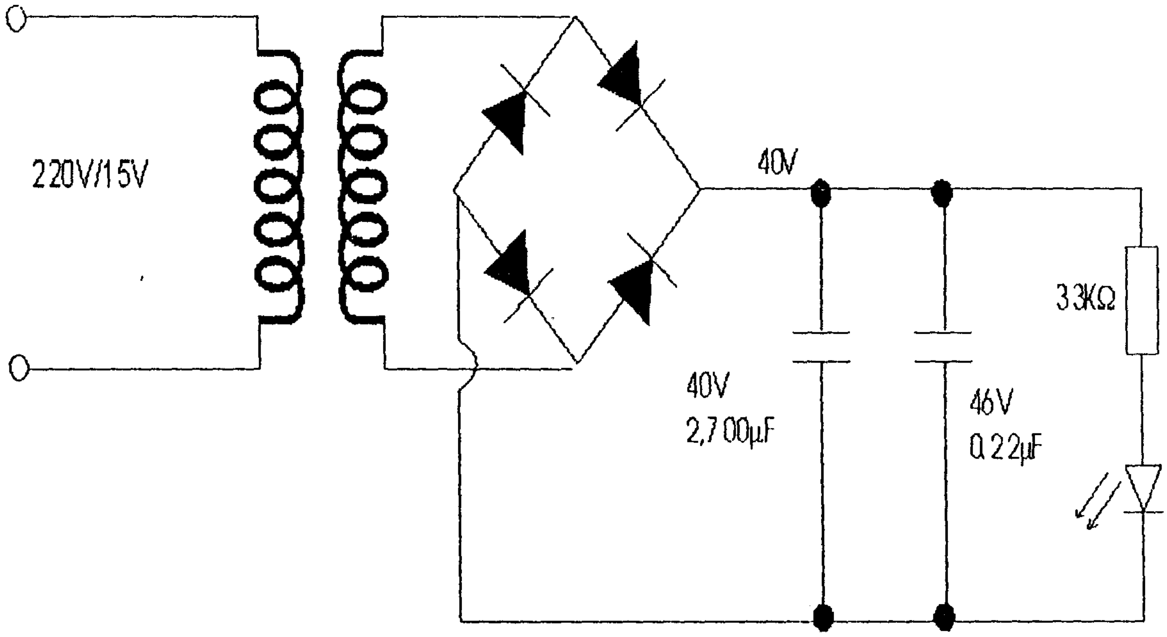


Fig 3.10 system power supply.

The 15v low value A.C voltage was concerted to a pulsating D.C by a four diode full wane bridge rectifier as illustrated above. The D.C voltage was stabilized by a 40v D.C 2,700µF capacitance, the value which was gotten form the design calculation shown below.

$V_{RMS} = 15V$

$V_{DC\ peak} = V_{RMS}\ 2\ - 1.4$

$= 15\ (1.44) - 1.4$

$= 19.6v$

The value of capacitance selected was deduced from the expression

$Q = CV = It$

Taking a differential of the voltage

$C = \frac{It}{V}$ $\quad$ I = maximum Load current

$t = ½\ F = ½ \times 50$

V = maximum Ac ripple voltage on the DC supply.

The power supply requirements for the SG 35324 control IC were not stringent as it could operate up to +40v D.C.

A maximum A.C ripple voltage of 4v or the 20v D.C supply was assumed at a load current of 20mA.

$$C = \frac{20A \times 1/(2x50)}{4} = 0.05F$$

$$= 50{,}000\mu F$$

This value was deemed necessarily high and a 2,700μF capacitance was choosen or therefore substituted

3.3 PULSE WIDTH REGULATOR IC

A 16 pins regulator was employed to control the charging process. The device is an integrated circuit using feedback to establish any output voltage relative to a reference voltage of 2.5V.

The device was used to control a high power pnp transistor to whose output the battery under charge (BUC) was connected. The device has the specifications related below;

±I% precision 5-volt refernce with thermal shutdown.

Output current to 200mA D.C.

60v output capability.

Wide common mode input range for error amplifier.

Double Pulse suppression

The electrical specification are,

Supply voltage; 40V

Collector supply voltage of 40V

Internal Power dissipation of 1 watt

The IC was connected to the PNP transistor switch as below:

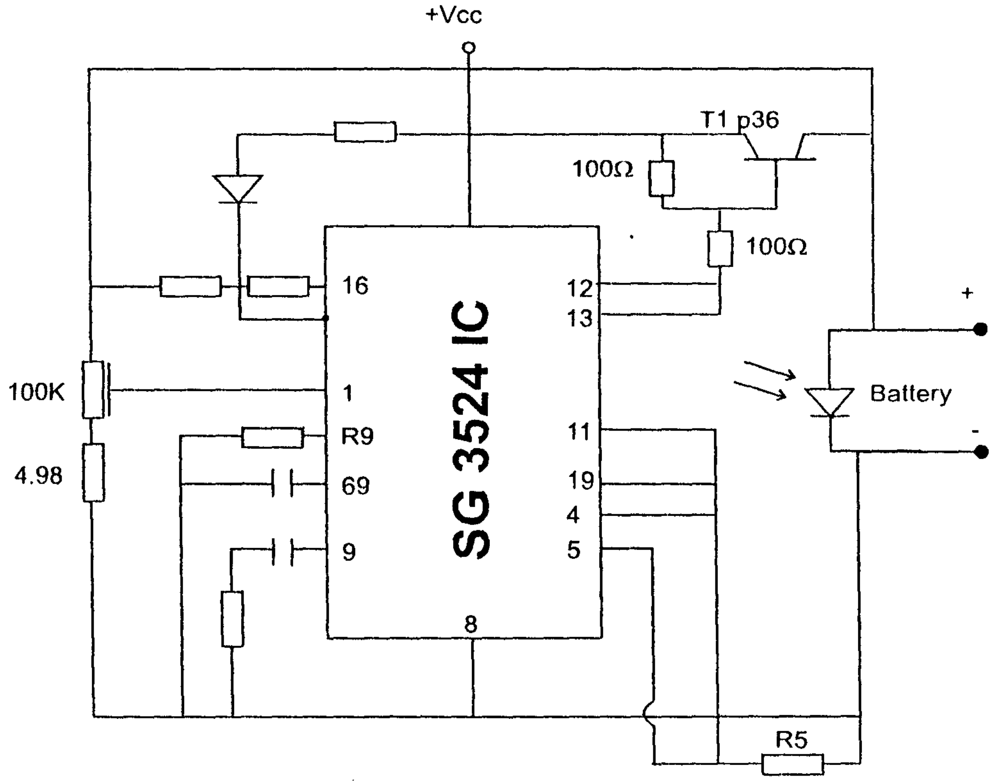


Fig 3.3 pulse width regulator IC

Power-on indication was provided by LED 1. LED 1 was protected against over current by a series resistance whose value was calculated:

$$R_S = \frac{V_{SS} - V_{LED}}{I_{LED}} \qquad V_{LED} \equiv 1.7V \quad I_{LED} \equiv 5MA \text{ or } 20MA$$

A 5MA, I_{LED} was selected as it was satisfactory enough on a peak D.C. supply voltage of 20V.

$$R_S = \frac{20 - 1.7}{0.005} = 3.6K\Omega$$

The nearest preferred value of 3.3KΩ was used. The frequency of the on-chip oscillator was set by timing the components connected to pins 6 and 7. The frequency was determined by the equation:

$$F = \frac{1}{1.3R_T C_T}$$

C_T was chosen as 0.001Mf capacitance.

R_T was made a variable of 100KΩ resistance to ease fine-turning.

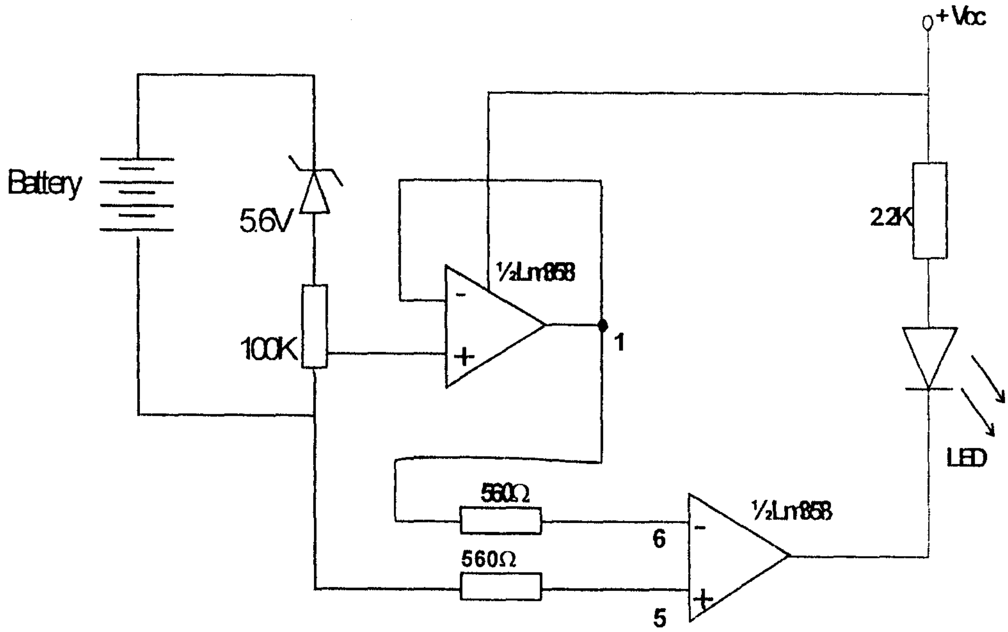
A switching frequency of about 10KHZ was designed for.

The PNP transistor driver was connected to pins 12 and 13. Feedback was from its collector (across the battery under charge) to pin 1of the inverting input of the error operational amplifier. During operation, the device regulates the duty cycle of the wave form at pins 12 and 13 to control the on-time and off-time of the PNP transistor.

If the feedback voltage rises above the fixed 2.5V reference voltage on pin 2 (non-inverting input of the of the error amplifier), the duty cycle at pin 12 and 13 increase and since Q1 is a PNP transistor device, its conduction time reduces, causing the voltage at its collector to reduce.

3.4 BATTERY END OF CHARGE INDICATOR

An end of charge indicator was provided to monitor the voltage across the battery and provide a visual indication of charging progression.



5V reference voltage (pin of 5h 3524).

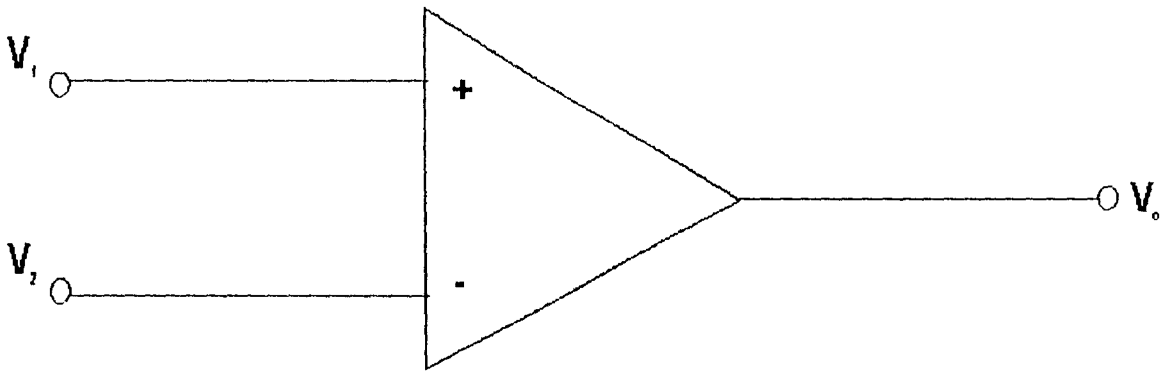
Fig 3.4 end of charge-indicator.

An Lm 358 dual operational amplifier was used as a comparator to detect end of charge. It was placed across the battery under charge to track and reflect the battery voltage status via a blue LED.

As it was made a voltage follower for the battery voltage, this reduces loading on the battery. Its input voltage was derived from a Zener-diode 100KΩ resistance combination shown in the figure 3.12

The voltage at pin 1 of A1 rises with the battery terminal voltage. This voltage was compared with a fixed 5V reference applied to pin 5 of A2. If the voltage on pin (– input) of A2 is lesser than the voltage on pin 5 (+ input), A2 switches high, turning LED 2 off. If however, the voltage rises above V terminal, A2 switches low, forward biasing the LED 2 which thus glows.

The comparator action is diagram below:



If $V_1 > V_2$; $V_0 =$ Low

If $V_1 < V_2$; $V_0 =$ High

fig. 3.4 (b) comparator illustration.

The LED 2 is initially off (at low battery terminal voltage). It slowly turns on, increasing in brightness as the battery voltage increases up. At full charge , it is switched fully on and thus glows brightest. A current limiting resistor was provided on to avoid over current charging.

A 100Ah battery was designed for a maximum charging current of 20A. Every charging at this maximum current reduces the life span of a battery and therefore not recommended.

The current through the battery was sensed by a low-value improvised resistance made up of a thick solder paste fabricated under board. The SG 3524 IC has a current limiting amplifier section with the expression:

$$I_{limit} = \frac{200M_V}{R_S}$$

200MV is an internal reference voltage, RS is the resistance of the sense resistor, I limit is the maximum current programmable for the load.

I_{limit} was set at 20A, thus $R_S = 0.2 \quad = \quad \frac{0.01\Omega}{20}$

With 20A through the sense resistor, the 200Mv connected across pins 4 and 5 of the device directly modulates the duty cycle of the output transistor to keep the load current at or below this maximum, preventing over current charging.

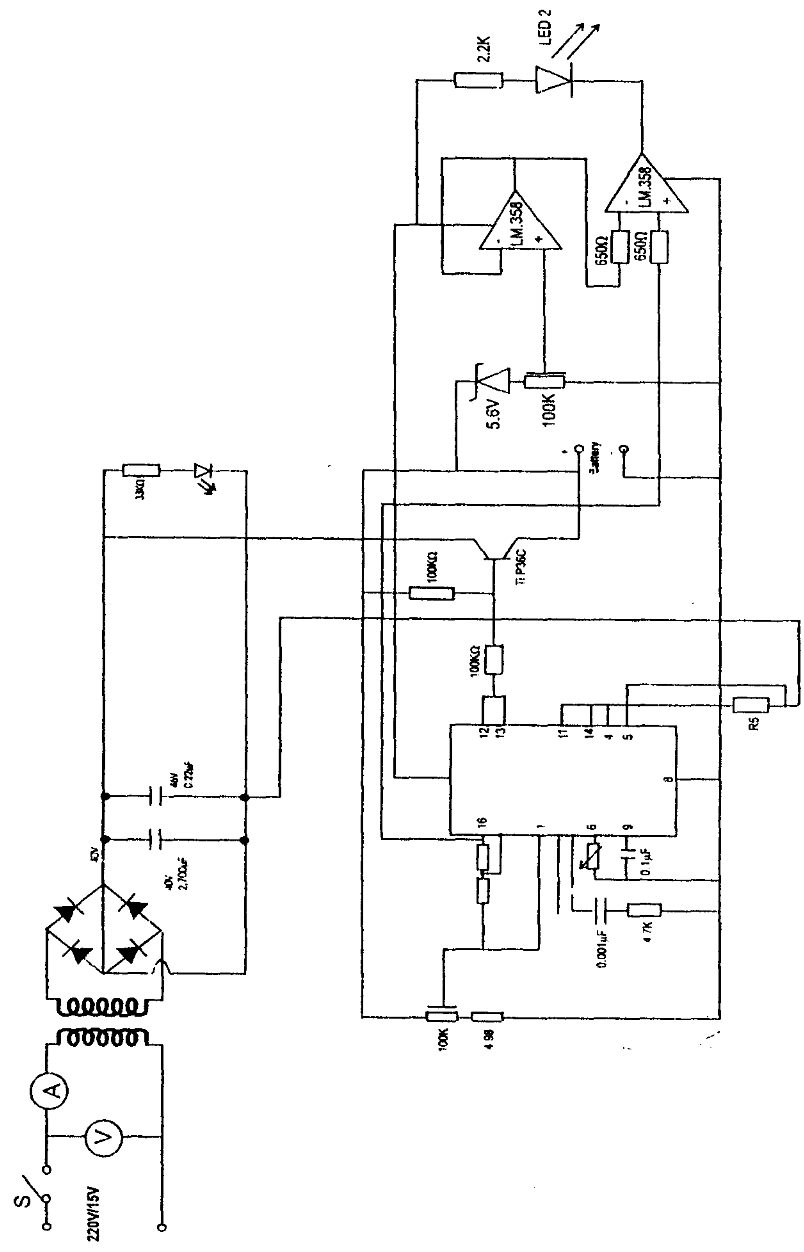


Fig. 3.16 THE CIRCUIT DIAGRAM OF THE BATTERY CHARGER

Fig. 3.16 THE CIRCUIT DIAGRAM OF THE BATTERY CHARGER.

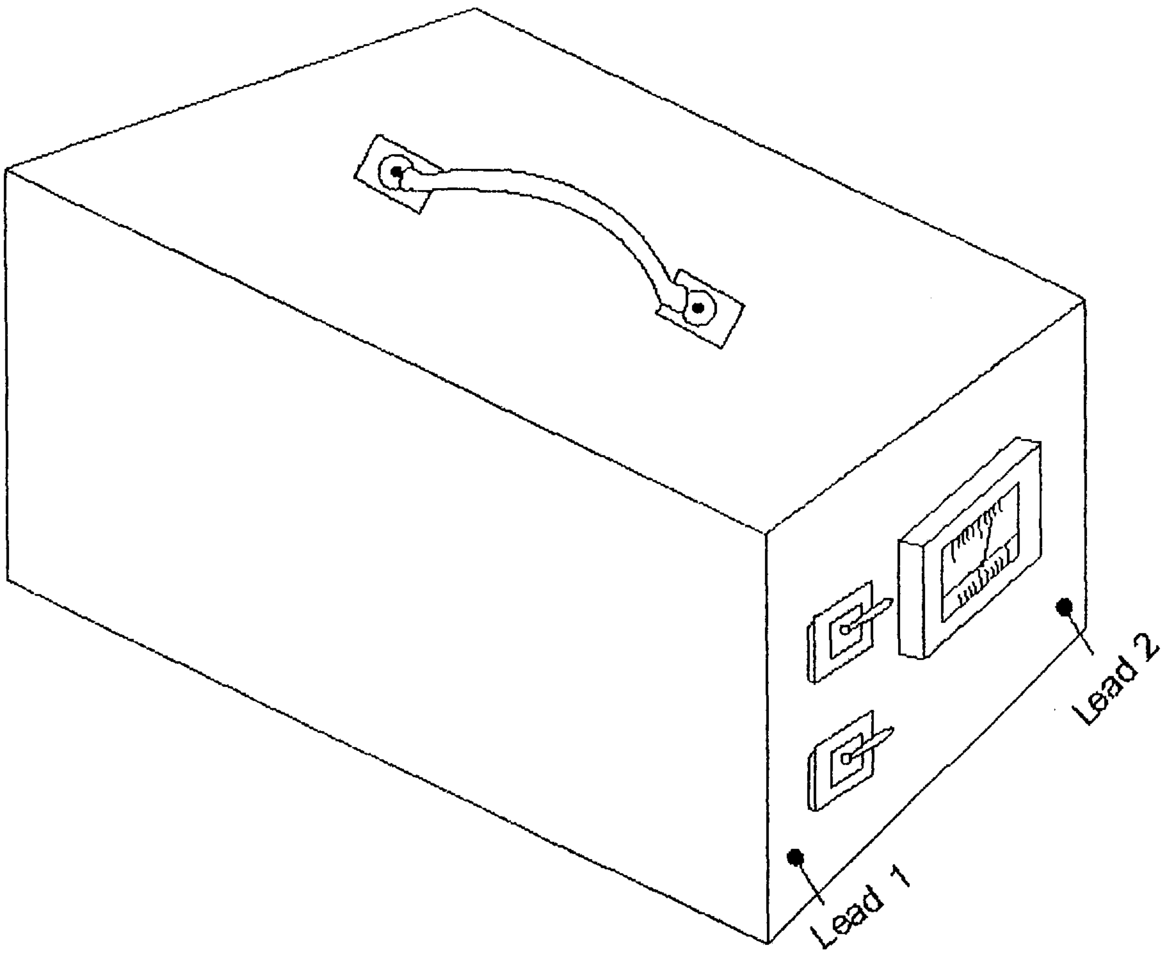


Fig. 3.17 AN ISOMATRIC VIEW OF THE COMPLETED AUTOMATIC BATTERY CHARGER.

CHAPTER FOUR

4.0 TEST, RESULT AND DISCUSSION OF RESULTS

4.1 CIRCUIT TESTING

After all the necessary connections and soldering was made, the circuit was checked over to ensure that there was no short or open circuit fault anywhere in the circuit.

When switching on the circuit or system, the output of the external power unit was tasted with the aid of a voltmeter, the reading of which remains at 12V for varying input voltages (between 12 -15V). Similarly, the output of the charging was also measured with the voltmeter. The value was 19.5V D.C

The overall system performance test was carried out by connecting a lead acid battery (with initial terminal voltage of 9.2V D.C) to the external power and charging unit respectively. An end of charge indicator was connected across the terminal to provide visual indication of charging process. The blue LED was initially off (at low battery terminal voltage). It slowly turns on increasing in brightness as the battery voltage increases up. At full charge it is switched fully on and thus glows brightest.

4.2 TESTS ON 12V CHARGING

On testing the input voltage to the transformer was found to be $V_{In} = 220V$

The output voltage from the transformer was found to be $V_{out} = 19.6V$

While the output dc voltage from the rectifier was found to be Vdc = 19.6v.When the battery was connected to the charger, the d.c current or charging current was found to be

$I_{d.c} = 20A$

When the battery voltage has risen to 14.6V, the charger switches off automatically which indicates that the performance of the charger is in line to the designed requirements. Throughout the period of charging, the temperature of the various components that made up the circuit was found to be within acceptable range.

4.3 RESULT:

After the charging unit was switched off automatically, the terminal voltage of the battery was measured and found to be 14.6V d.c

4.4 DISCUSSION OF RESULTS:

From the test and results obtained, it was found out that high charging current was initially drawn by the battery during the commencement of charging. This was as a result of constant voltage method used.

At the end of the charging period, the temperature of the cells increased slightly, and the cells also shows other indication of a fully charged battery which includes: the given off of hydrogen gas freely: the rise in terminal voltage up to (14.6V) and the change in the colour of the plate to deep chocolate brown for the positive plate and slate grey for the negative plate.

CHAPTER FIVE

N AND RECOMMENDATION.

CON LUSION.

The paramount importance of partial knowledge and skill for the technological advancements can not be over emphasized neither should it be under estimated in any way and in all ramification. No doubt this project work has exposed me to the practical aspect of engineering and technology alongside its theories.

The automatic battery charger has been designed, constructed and tested and form the response of the unit, it can be conclusively said that the aim of the project has been accomplished.

5.2 RECOMMENDATION

As discussed earlier, the charging current of this design was peak at 20A, while the charging voltage is 14.6V. The system could be improved on to be able to charge any voltages and current up to 300A by suitable component selection (i.e transformer, op-amp, SCR, zener diode and capacitor).

It is also recommended that the power supply unit (external) be improved on to be adjustable (variable), so that it will accommodate wide range of outputs.

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