DESIGN AND CONSTRUCTION OF AN AUTO BATTERY CHARGER

BY

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DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING,

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE (B.ENG) IN THE DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

NOVEMBER, 2004

CERTIFICATION

The undersign satisfy this project has been carried out by OKE FUNSO EYITAYO and has been read and approved as meeting the requirement of the Department of Electrical and Computer Engineering of FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, for a project in partial fulfilment of the requirements for the award of the degree of Bachelor in Engineering.

Engr. Paul Obafemi Attah
Project Supervisor

6th Dec., 2004
Date

Engr. Musa D. Abdullahi
Head of Department

6/12/2004
Date

External Examiner

Date

DECLARATION

I hereby declare that this project work is a genuine one, which was wholly and solely, designed and constructed by me under the supervision of Engineer Paul Obafemi Attah. Information derived from published and unpublished work of other has been acknowledged in the text.

DEDICATION

This project is dedicated to the Almighty God for taking me this far in the journey of life.

Also to my entire family members, friends and loved ones, most especially my lovely sister MRS AYO OGUNTILOYE God will continually bless you.

ACKNOWLEDGEMENT

Things are best achieved in community. I am deeply indebted to those whose lives surrounded mine and have given substande to the idea in this project. It was through the supervision of Engr Paul Obafemi Attah that this project as come into being . without his unending support, objective criticism and advice I would not have been able to go this far knowing all that I know this day.

Also indebted to is my H.O.D in the person of Engr. Musa D. Abdullahi and the entire member of staff of the Electrical Department for their unquantifiable support morally and physically given to me, God Bless you all. I owe much to my sweet heart, my friends and colleagues Bunmi Micky Agbe He reigns, Lara, Nas, Tawa, Bukki, Timo Aji, Jabula, Yomy, Baba Tee, Prof. Baba imagine, Akeem, Rasheed, Bola, Seun, Gabjoe, Praises, Yinkus to mention a few, from my heart of hearts I say a big thank you for your been there when needed most. JAZZ AMBASSADORS, I say God Bless you all.

To Lado and Yomi I say a big thank you for the word of encouragement you are more than just friends I pray God will keep fire of love between us stronger.

To my entire family members, my dad S.S OKE, my mum L.E OKE you both are immeasurable, unquantifiable and indeed a pearl, may God give you long life to eat the fruit of your labour, my sisters and brother I say God be with you all.

I am most indebted to God Almighty, the one who was, who is and would forever be for sparing my life this far and taking my this long in the journey of life. I say I am grateful and pray that your favour, mercy and grace shall continually be with me as I continue this journey of life into another phase. I adore you Lord.

ABSTRACT

The project is about the design and construction of a car battery charger. The system is divided into four stages namely the power pack unit responsible for generating the d.c. voltage, the regulating unit responsible for steady supply irrespective of line and load regulation, the triggering unit for starting the charging process monitoring till full charge and switching off, and finally the output unit which is basically the shortest link between the battery and the charger.

TABLE OF CONTENT

CHAPTER ONE

1.0 INTRODUCTION

Basically, Engineering is all about invention and making life convenient for living. It has come a long way to improving the standard of living of mankind varying from provision of electricity, telecommunication, to mention but a few and at affordable rates.

Since the invention of TRANSISTOR in 1948, the size and power consumption of electronic equipment has drastically reduced. Many types of electronic equipment which had been operating on mains supply were re-designed to operate on batteries to provide portability and convenience.

As a result, today we have a large number of electrical electronic equipment operating on dry cells, and batteries, starting from toys to automobiles available in the market.

Development of rechargeable batteries brought life to the field of battery use in the society. These batteries could provide moderate amount of power for a short time at a steady voltage and could be recharged over again before becoming unserviceable and discarded. They come in various sizes that can directly replace the dry cells and where large amount current is required to lead acid battery remain the major work –house.

These lead acid battery are used in automobiles, mobile x-rays, they are also used as alternative source of electrical energy for application like emergency lights.

A way to replenish the lost energy in these cells (battery) during the time of operation, brought the quest for battery chargers for charging batteries from the smallest to the largest size.

A well designed charger must be able to charge fast, ensure a long life, and many cycles before the battery becomes unserviceable.

This is what has led to the design of this project, a 12volts car battery charger that would be able to charge the battery in good time and switch off at full charge to prevent the overcharging and so ensure the well being of the battery and at an affordable price for over gone to have at home.

The charger basically consists of four sections that depends one on the other for it to function properly and effectively.

The three parts/section are the power pack where the incoming a.c. supply is stepped down, converted to dc (rectification) and regulated to guide against fluctuation.

Another section is the charging unit where the rectified output is used to charge the battery and at full charge switches on a LED to indicate full charge and automatically switch off the charging process and allow for trickle charging. The last part is the charge indicator whose work is to let you know the state of the battery before and after charge so as to prevent overcharging of the battery and ensures long life of the cell.

This project if completed should be compact and relatively cheap for every car owner to have at home and do away with the stress of having to take your car battery to the charging workshop, instead you can conveniently charge it at home each time you discover the charge level is low and saves you some money at the same time.

1.1 LITERATURE REVIEW

To begin, we should cover a few facts about lead acid batteries in general. Traditional histories dated the invention of batteries to the early 1800. when experiments by Alessandro Volta (1798 – 1800) generated electrical current from chemical reactions between dissimilar metals. The original voltaic pile consisted of Zinc and Silver disks separated by a porous non conductive material saturated with seawater. When stacked in particular manner, a voltage could be measured across each silver and zinc disk.

However, others believe that the lead acid battery has been in existence since the days of Egyptian Pharaohs, but which ever way advances in construction and materials have come a long way over the years and the basic principles still apply.

Major step in the evolution of battery was the Daniel Cell, named after its inventor, the English Chemist John Fredric Daniel (1836). The cell invented was the first to include a depolarizer. This reduced the amount of hydrogen collected on the electrode and gave the battery life.

W.R. Grave (1840) an English Lawyer an another chemist develops a fuel cell which is of more interest to the space technologist of this century.

Gastoin Plante (1859) a French physicist invented the first practical storage battery using a lead sulphuric acid cell later played an important role in the use of electric motor.

Thomas Alva (1908) invented the Nickel – Iron alkaline storage battery. The first practical solar battery was invented by G.L Pearson, C.S. Fuller and D.M. Chapni (1954) all of bell laboratories

Lead acid cells of all types undergo a specific set of chemical reactions while charging and discharging. They are also formed from similar types of active materials, usually from lead plates submerged in a sulphuric acid solution made of sponge metallic lead. The porous nature of the lead plates allows the electrolyte to efficiently contact the maximum surface area and obtain the most charge carriers. The electrolyte solution provides the sulphate ions formed during the discharge chemical reaction process giving us the electron needed for current and as there happens lead sulphate is been released as by product.

As the battery continue to discharge, more lead sulphate is released and attached to the electrode plates raising the internal resistance of the battery which in turn lower its working terminal voltage and hence reduce the current in the battery.

To determine the state of charge (SOC) of a lead acid battery the voltmeter approach does not work, the terminal voltage will vary widely between batteries as a function of things like ambient temperature and the relative age of the battery. To test a lead acid battery's SOC, the best indicator/test equipment is the hydrometer, which actually measures the amount of sulphuric acid left in the electrolyte solution.

As more and more energy is drained from the battery the ratio of sulphuric acid to water decreases and the lead sulphate by product begin forming on the acid to water decreases and the lead sulphate by product begin forming on the electrode plates

1.2 AIM AND OBJECTIVE

The aim of this project work is to have a portable charges that is relatively cheap and affordable to everyone to have at home, and would be capable of safeguarding the life of the battery by preventing overloading.

CHAPTER TWO

2.1 DESIGN AND CONSTRUCTION

The design and construction of the project is divided into stages which is shown in the block diagram below and for simplicity purpose, individual stage would be briefly explained.

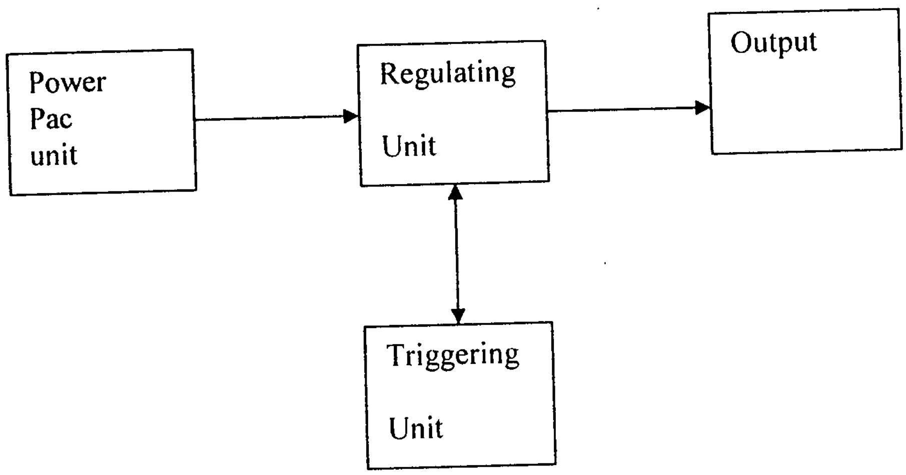

Fig 2.0: Simplified Block Diagram of a battery Charger

As it can be seen from the above block diagram the whole design is in four stages starting from the power pack where rectification and filtering had taken place, to regulating unit where steady supply is ensured to the triggering circuit whose responsibility is to switch on the charging system and also switch it off to prevent over – charging and finally to the output terminals which is connected to the battery to be charged. The output terminals is the shortest link between the charger and the charged (battery). The various stages are as explained below

2.2 Power Pack

The power pack is just a unit in the system that is responsible for voltage conversions through the use of transformer, rectification, through the use of diodes and filtering through the use of capacitors.

Transformers could easily be defined as an electrical device that is responsible for the conversion of energy from one level to the other at the same frequencies (voltage transformer). There are other types of transformers for different purpose e.g. current transformer etc.

The voltage transformer could either be a step up or step down, depending on the turn ratio between its primary and secondary windings but for the purpose of this project, a step down domestic type is used since we are changing our energy level from a higher level to a lower level (220 – 18V), at the same frequency of 50Hz.

The rectifying unit, consists of four diodes connected together to form a bridge rectifier and its work is to convert ac voltage from the transformer into a pulsating dc voltage.

The reason behind choosing a bridge rectifier over the other types, is that, unlike in the other area, smaller transformer would be required for the same output because it utilizes the transformer output (secondary) continuously and no centre tap transformer is required.

The filter circuiting performs the operation of removing the fluctuations or pulsation (ripples), that might be present in the output voltage from the rectifier. Though there as not been any filter that had been able to remove completely ripples associated with rectifier output, but it can be reduced to the minima and that is what the filter used in this project work has been able to achieve.

A typical circuit diagram of a power supply as used for this project work is shown below in Figure 2.1.

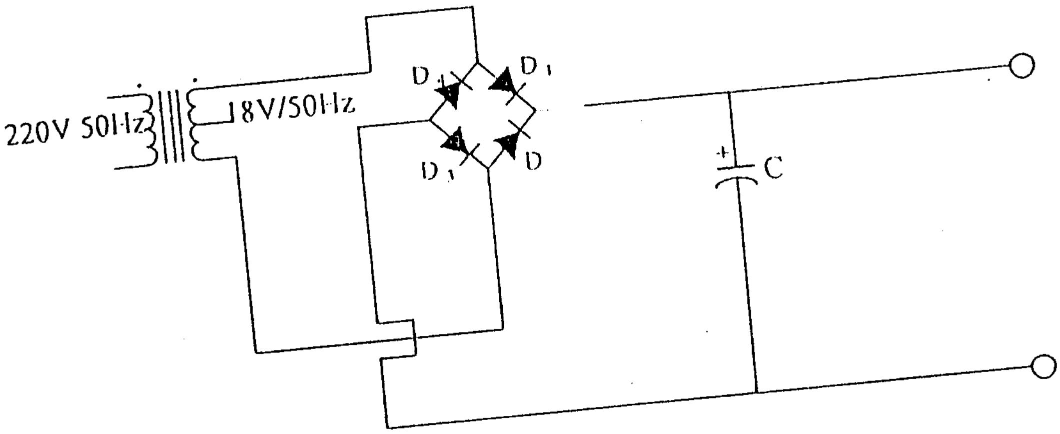

Fig 2.1: Typical Power Supply Circuit

2.2.1 MODE OF OPERATION

When power is supplied to the primary of the transformer from the mains (NEPA) due to mutual induction between the windings of the transformer (primary and secondary windings) on the same core, voltage is induced in the secondary and it is given as an output at the secondary winding. This output swings about a point, thereby having positive (+ve) and negative (-ve) half cycles.

During the first positive half cycle, terminal T of the transformer secondary is more positive and terminal U is negative, thereby enabling diodes D_1 and D_3 to be forward biased and D_2, D_3 are reversed hence current flows through points TABEFDCM. It is as shown in Fig 2.2.

During the first negative cycle, the secondary terminal U becomes more positive compared to T and so, diodes D_2 and D_4 are forward biased and diodes D_1, D_3, becomes reverse –biased. This time, current flows through points UCBEFDT Fig 2.3. It would be noticed, that in both cases of half cycles, the current flows through points E and F thereby maintain constant charging to the capacitor, that is, the capacitor is at maximum a.c.

voltage. This in turn maintains constant flow of current in the circuit through both cycles.

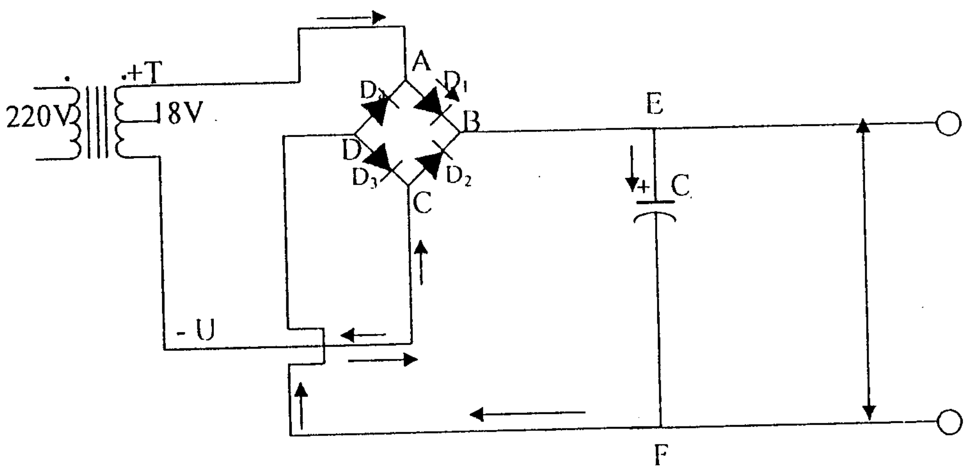

Fig 2.2: Curent path during positive half cycle

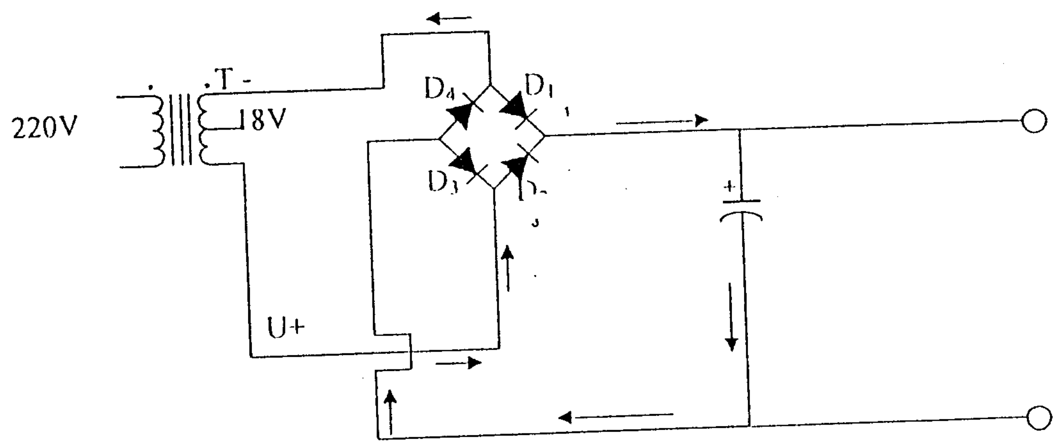

Fig 2.3: Current path during Negative half cycle

In fig 2.4 below the various waveforms from the cathode Ray Oscilloscope to shown as follows:

a. a.c. waveform

b. Positive half cycle waveform for diodes D_1 and D_3

c. Negative half cycle waveform for diodes D_2 and D_4

d. Waveform of the two combined

e. Waveform across the capacitor.

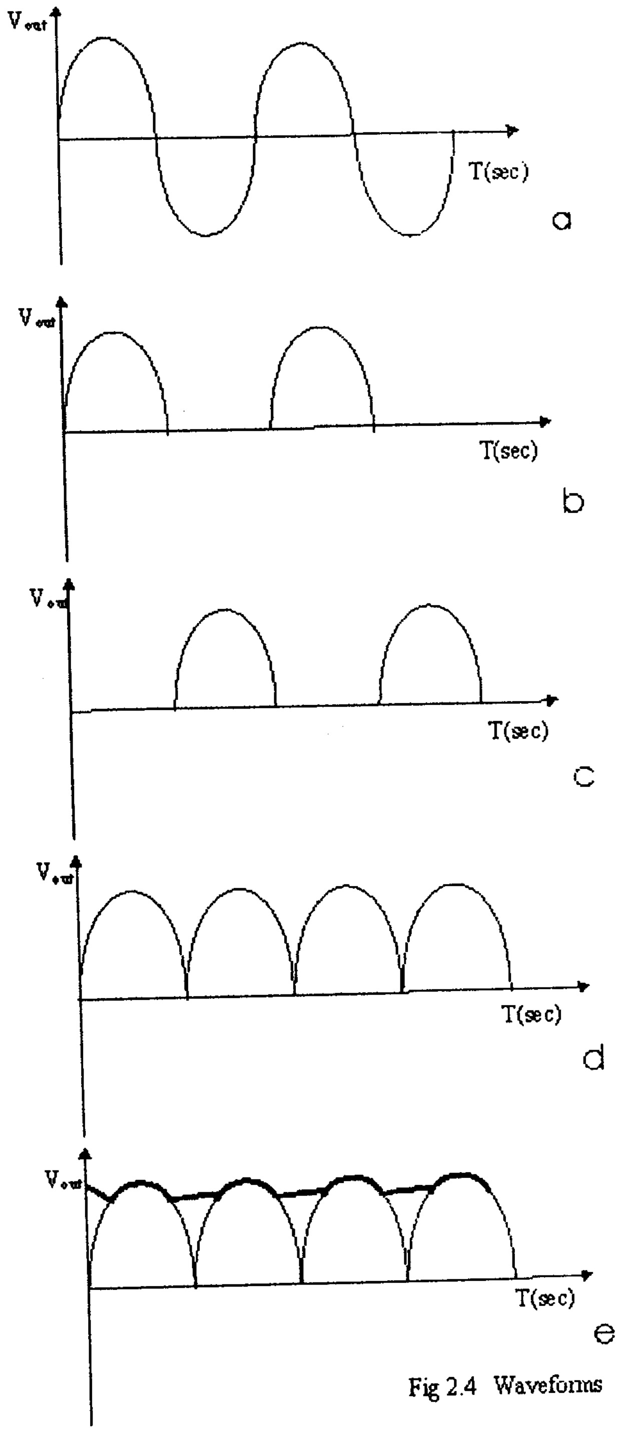

Fig 2.4 Waveforms

2.2.2 CALCULATION

Neglecting the losses in the coil, the rms value of the induced emf in the whole primary winding is equal to the product of the induced emf and number of primary turns (N), that is,

$E_1 = 4.44fN.B \times A$................................2.1

Similarly rms value of the induced emf in the secondary winding is equal to the product of the induced emf and number of secondary equal to the product of the induced emf and number of secondary turns (N_2), that is,

$E_2 = 4.94fN_2 B \times A$..2.2

Thus from these two equation it could be deduced that

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = k \quad \text{...2.3}$$

Where E_1 = emf induced in the primary winding

E_2 = emf induced in the secondary winding

f = frequency of operation

N_1 = Number of turns of coil in the primary

N_2 = Number of turns of coil in the secondary

B = Maximum flux density

k = voltage transformation ratio.

For this particular project $N_2 < N_1$, since 1 made use of a step down transformer whose transformation ratio is 12: 2: 1

Also, for an ideal transformer

Input power (VA) = Output power (VA)

Where

I_1 = current in primary winding

I_2 = current in secondary winding

V_1 = Voltage in primary winding

V_2 = Voltage in secondary

For the purpose of this project work, these are the parameter for the transformer used.

Primary voltage $V_1 = 220V$

Secondary voltage $V_2 = 18V$

Primary current = ?

Secondary current $I_2 = 1.2A$

From the equation 2.5

$$\frac{I_2}{I_1} = \frac{V_1}{V_2}$$

This gives

$$I_1 = \frac{I_2 V_2}{V_1}$$

$(1.2 \times 18) \div 220$

$= 0.0982A$

From the transformer, the output was connected to the bridge rectifier whose output 0.89times the r.m.s voltage at the input.

$V_{rectifiede} = 0.89V_{r.m.s}$ -----------2.6

2.3 Filters

In choosing a capacitor for the purpose of filleting,. Two things are put into consideration, namely.

1. Voltage rating
2. Capacitance value.

The purpose of filtering is to remove any pulsation ripples that might be present in the rectified voltage. The essence of this is to increase the usefulness of the rectified voltage by levelling out pulses and producing current at a more steady rate.

2.3.1 Voltage Rating

The reason for putting into consideration voltage ratings in the selection of capacitors is to avoid charging up the capacitor with a voltage higher than the manufacturers rated voltage, and if this happens, the capacitor could explode and could be very HAZARDOUS.

In choosing this it is always better to measure the output from the rectifier with a voltmeter on NO LOAD because at this point in time the maximum voltage is always across the terminals (rectifier). Whenever on load there is always a drop in the voltage value. In the selection of a capacitor for a circuit, the given is in 2.7

Voltage rating of a capacitor = $\sqrt{2}\ V_{r.m.s}$ 2.7

For the purpose of this project work, the selected capacitor is 35V, and the reason been that, From the equation above, (2.7)

$V_c = \sqrt{2} \cdot V_{r.m.s}$

$V_{r.m.s} = 21.5$

$V_c = \sqrt{2} \times 21.5$

$V_c = 30.1$

From this calculation the voltage value to be chosen is approximately 30V but in the various voltage ratings of a capacitor, the closest to this value is 25 and 35V and that was why 35V capacitor was chosen because 25V is lower in value

2.3.2 Capacitance Value

Basically, the property of a capacitor is to oppose changes in voltage. It is therefore necessary to note that a bigger capacitance would tend to reduce the ripple magnitude, increase V_{dc} towards the limiting value of V_{ip}, thereby resulting in a better d.c. supply for the circuit.

2.4 REGULATING UNIT

The output voltage at the terminals of the filter capacitor in an unloaded rectifier circuit is always 1.414times the r.m.s value. In an ideal case, this voltage should remain steady as load is applied but in practice, the voltage starts falling with increase in load.

This effect of drop in voltage while load increase is put under check through the use of a fall wave rectifier (bridge rectifier) and a large value capacitor for filtering.

For high regulation, an electronic regulator is used, which apart from guiding against drop in voltage and current as load increases also protects against sudden rise and fall with variations in the a.c. line input voltage. Regulators maintain a steady output voltage in spite of line voltage and load variations.

Since a high current of about 2A would be needed on the starting charge current in this project work an LM 350 regulator was chosen.

The LM 350 is an adjustable three terminal positive voltage regulator capable of supplying in excess of 3.0A over an output range of 1.2V to 33V. This regulator was chosen because of its wide range of use and for the following reasons.

- Guaranteed 3.0A output current
- Output Adjustable Voltage between 1.2V and 33V
- Load Regulation Typically 0.1%
- Internal Thermal overload protection

2.4.1 OPERATION

In operation, the LM 350 develops a nominal 1.25V reference voltage V_{REF} between the output and adjustment terminal. The references voltage is impressed across program resistor R_1 (fig 2.5) and since the voltage is a constant, a constant current I, then flows through the output set resistor R_2 giving an output voltage of

$$V_o = 1.25\left(1 + \frac{R_2}{R_1}\right) + I_{adj} R_2 \quad \text{.............................2.8}$$

I_{adj} is always less than 100μA.

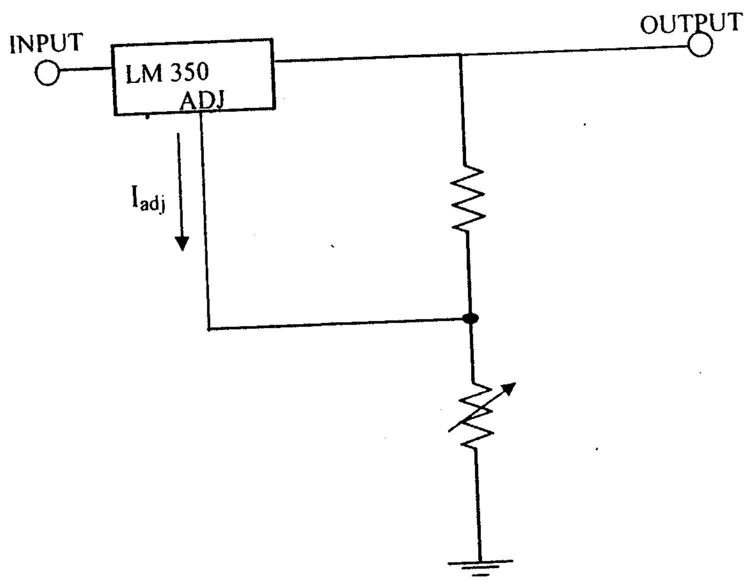

Fig 2.5: Typical LM 350 Regulator

From the equation 2.8, the output voltage V_o is obtained as follows

$R_2 = 3000\Omega$

$R_1 = 245\Omega$

$I_{adj} = 100\mu A$

$V_{REF} = 1.25V$

$$V_0 = 1.25\left(1 + \frac{R_2}{R_1}\right) + I_{adj}R_2$$

$$V_0 = 1.25\left(1 + \frac{3000}{245}\right) + 100\mu A \times 3000$$

$V_0 = 1.25\ (1 + 12.25) + 0.3$

$V_0 = 1.25\ (13.25) + 0.3$

$V_0 = 16.8625V$, $V_0 = 17V$

2.5 LOAD REGULATION

The load regulation of a power supply could be defined as the response of the supply system to various changes in the load system. That is, it ability is maintain a steady supply irrespective of what the load demand is. The reason for choosing the LM350 as the regulator for this work is its ability of providing extremely good land regulations.

$$\text{Load Regulation } (\%V_0) = \frac{V_{0\,(minloan)} - V_{0\,(more\ load)}}{V_{o(min\ load)}} \times 100$$

And for this project work the load regulation was calculated as shown below

$V_{0(min\ load)} = 16.24V$

$V_{0(max\ load)} = 15.95V$

$$\text{Load Regulation } (\%V_0) = \frac{V_{0\,(minloan)} - V_{0\,(more\ load)}}{V_{o(min\ load)}} \times 100$$

$$= \frac{16.24 - 15.95}{16.24} = \frac{0.29}{16.24} \times 100$$

$$= 1.7857$$

TRIGGERING CIRCUIT

The triggering circuit is the part of the project that is response for start of the charging process and also responsible for the switching off of the circuit when battery is fully charged to prevent overcharging which in turn reduces the life span of the battery.

The triggering circuit consists of a switch to start the charging process, an operational amplifier, transistor and a LED to indicate full charge. At the push of the switch button, the output of the charge goes to about 17.54 delivering about 2A at the start of the charges and on the battery approaches full charge, the charging current reduces and the voltage is reduced then the transistor Q_1 is set ON and the LED lights as a visual indication of full charge at this point the charge with the aid of this triggering circuit switches to a lower float voltage preventing overcharging and also starts a trickle charging to help maintain the charge on the battery to avoid discharging while left alone.

CHAPTER THREE

3.0 CONSTRUCTION

In the construction of the project work, certain things were put into use such as breadboard/project board, which is usually a white rectangular kind of board with some ting holes that conduction vertically and horizontally.

The essence of the breadboard is to assemble whatever the design is and carry out any that possible and ascertain the practicability of the project with necessary adjustment made necessary before it is transferred to a Vero – board where soldering finally occurs.

Among other things that were used was the soldering iron for the purpose of soldering, lead suckers for sucking molten lead during de –soldering. Also used was a Vero board, onto which the individual components were mounted and soldered. It is a permanent place where components are placed. It has both components and soldering parts.

Other things used during the process of construction are pliers, side catter, cable stripper etc.

3.1 TESTING AND OBSERVATION

At the end of the whole construction of the project work, it was connected to the mains power and switched on. At switches ON two LEDS were ON, one was indicating power on to the circuit and the other was for the charging process. At the switch ON of the charge button the charge process went off indicating start of the charging.

At switch ON of the whole circuit before the start of the charging process the voltage (output) from the charger was measured and recorded while the terminals were connected to the battery terminals, the voltage was measured and when the charging switch was ON, the charging voltage was also recorded, along with the current. At intervals of time the corresponding voltage and current were monitored until full charge

In a simple statement, the test carried out on the work proved good and when a battery was charged with the charger. It charged it up making the purpose of the work a success.

3.2 PREVENTIVE MEASURE

Preventive is an act of safeguarding the circuit against mishaps such as overloading, fluctuations and surge and long use.

Against surge and overloading fuse were provided to protect the input to the transformer and the output of the rectifier. Fuse is regarded as the weakest point of an electronic circuit and the best friend of an Engineer.

Against fluctuation, the regulator acts as an agent to ensure steady supply at all time irrespective of the input and the LM 350 used as a good line regulator that can meet up with the task.

Towards long use and charging process, it is advice able to, from time to time open up the gadget and dust away all dust able and check for any partial contact that might have occurred on the soldered components due to heating process and ageing. In case of any partial contact, normal soldering should be carried out on such terminal or leg.

3.3 RESULTS

The following results were obtained at the end of the construction.

Output voltage from rectifier – 21.5 V

Input voltage from regulator – 21.5 V

Output voltage of charger on no load – 16.24 V

Output voltage of charger on load – 15.95 V

Load Regulation – 1.7857 V

3.4 DISCUSSION OF RESULTS

Comparing the expected result (theoretical) with the results obtained at the end of the work, there were some little differences which was too much anyway. I believe this differences might be due to the tolerance values of the various components used which might not make the exact values and secondly some components were not found and so I had to make up with something very close to its value. The joy of it al was that it worked perfectly and effectively.

Another thing noticed was that at the start of the charging process more current was demanded and the voltage across the terminals of the battery was about 12V which is the battery voltage , but as the charging progresses the demanded current gradually reduces and the terminal voltage also increases in value until a level si attained in which the current was constant at about 320mA which is the pint of **TRICKLE CHARGE.**

CHAPTER FOUR

4.0 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

From the whole work, though there were difficulties along the way it could be concluded that the aim of the project was achieved, that is, a portable and inexpensive charger was constructed and the charger would charge a battery up within seven and eight hours of charging which in fairly OK, and at full charge indicates with the glow of a LED.

4.2 RECOMMENDATION

The charge level indicator part of the project work, could not be completed due to some problems encountered in the progress of the work.

Therefore, I would recommend that whoever takes up this project for improvement/advancement should work out modalities of making this part of the project, work so that the whole idea behind this project could be achieved.

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APPENDIX

Components Used	Quantity Used
Diodes	
IN 4001 –	4
IN 4148 –	1
LED –	4
Zener Diodes – 9.8V, 11V, 12V	1
Resistors	
47Ω -	3
39Ω -	1
3kΩ -	1
15Ω -	1
230Ω -	1
0.33Ω -	1
500Ω -	1
Capacitors	
35V 1000µF	1
1000pF –	1
0.1µF –	1
1µF -	1

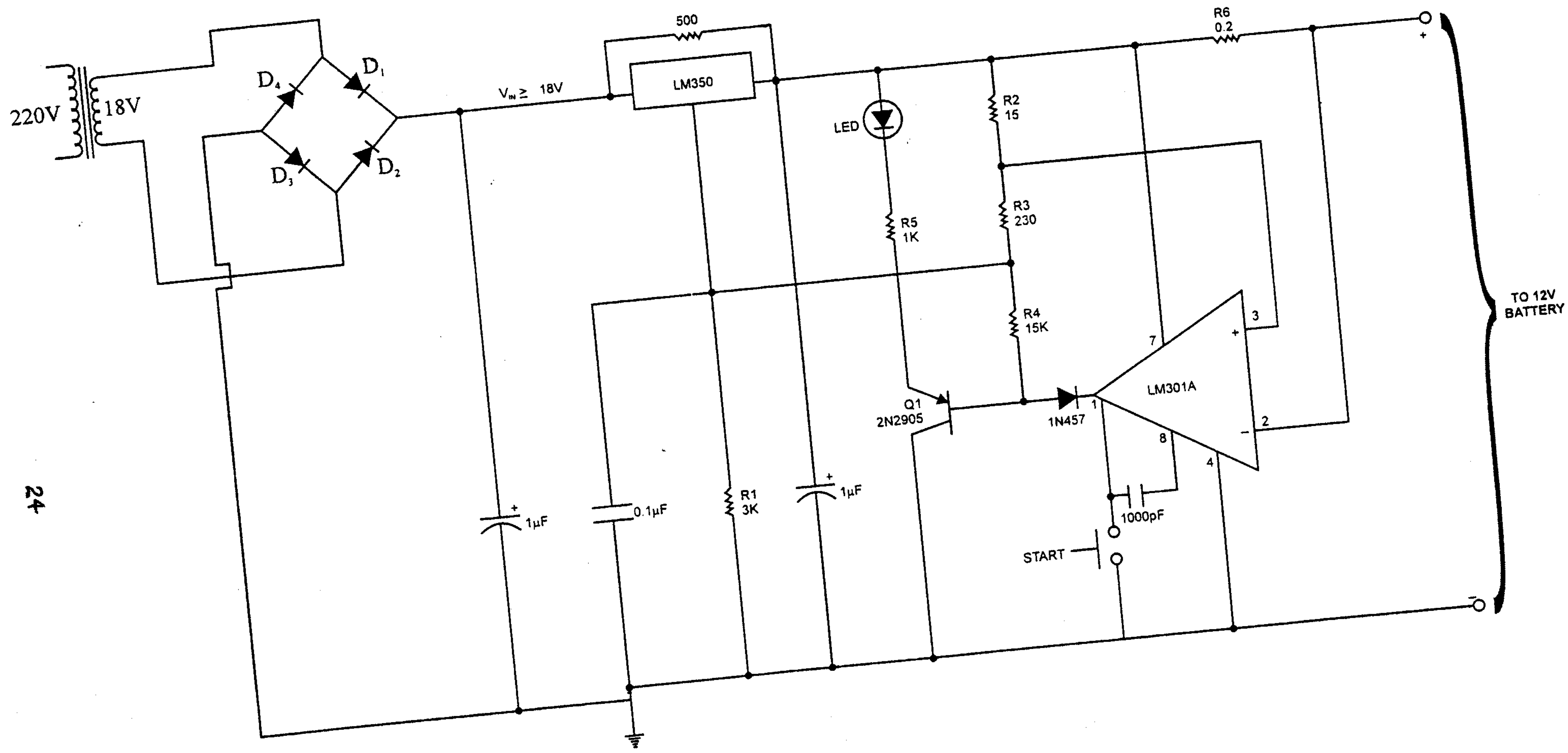

FIG. CIRCUIT DIAGRAM OF A BATTERY CHARGER

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