DESIGN AND CONSTRUCTION OF A MULTI-SOURCE FRIENDLY MOBILE PHONE CHARGER (WITH DC RECHARGEABLE PEN - CELLS BACK-UP)

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DEDICATION

This work is dedicated to God Omnipotent, Omniscience and Omnipresent, the only true and excellent source of sound wisdom, He who never judges by the dictates of men and has not lost faith in the work of His hand; though tenderly patient yet pruning His work to make it the BEST for SERVICE to Him and humanity.

ATTESTATION

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

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ABSTRACT

This project work presents "the design and construction of a multi-source friendly mobile phone charger with DC rechargeable pen cells back-up. This charger charges the common mobile phone battery, 3.6v Li-ion, using readily available energy sources that could give 12v dc output. It also incorporates a quick and easily available source of energy via the battery back-up. The charging time from both AC mains supply and battery back-up were approximately 3 hours for an almost 'flat' battery. From the aforestated, a good throughput was gotten from the device thus meeting its design requirements.

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CHAPTER ONE

1.0 Introduction

The discovery of electricity has contributed immensely to the advancement of technology in today's world. With the fast pace of innovations both in Electronics and Telecommunications, the need for reliable supply of electrical energy becomes a necessity. This rising need for electrical energy led engineers into research to develop the means for storing this energy for use when required hence the development of "batteries and cells" came into being.

The term battery means an assembly of two or more cells that convert stored chemical energy directly to electrical energy. A cell, which is the basic unit of a battery, is a single unit of electrochemical device consisting of two electrodes (Positive and Negative) separated by an electrolyte.

There are two general types of electric cells, primary and secondary cells.

Primary Cells:- In primary cells, the stored chemical energy is converted to electrical energy and the process cannot be reversed and thus, these cells are characterized by a one time use. Batteries made up of this kind of cells are called PRIMARY BATTERIES. Examples here include Laclache and Mercury cells.

Secondary Cells:- Here inter-conversion of chemical and electrical energy can be achieved in repeated cycles. A battery made out of these cells is called storage or rechargeable batteries. Examples of these type of batteries include Lead acid cell, Nickel-cadmium cell and the types usually found in mobile phones; the Lithium-ion and Nickel-cadmium ion cell.

Batteries find application in the electrical (power), electronics, telecommunications, avionics and ICT industries. But for the purpose of this project its use is restricted to the telecommunication industry especially in its use mobile phones.

As batteries are being used, their stored electrical energy also decreases until a time when it can no longer effectively discharge energy. The battery (secondary) would need to be recharged in order to restore it back to its original working state. This is achieved with the aid of a battery charger. The output of the battery to be charged determines the kind of charger to be used.

Charging of cell-phone batteries become a big problem while travelling as power supply source is not generally accessible; thus, concept behind this project; to construct a multi-source friendly mobile phone charger having DC rechargeable pen cell back-up.

The charger consists of the following parts:

- Power circuit
- Control circuit and charging circuit
- Back-up module

A self-regulating battery charger eliminates the problem of damaged batteries due to over-charging, since it is able to regulate it charge.

The project makes room for, via a port, the powering of the charger from any source of energy be it wind, thermal or solar that can give a DC 12v output.

This project incorporates portability and cheap ready source of electrical energy and is geared, primarily, at assisting long distance travelers and call-centres in making available cheap and ready energy source needed to charge their phone batteries.

1.1 Aims and Objectives

The aim of this project is to design and construct a mobile phone charger for DC 3.6v batteries. The project is expected to meet the following basic requirements:

i. Charge a 3.6v battery (Li-ion) used in mobile phone

ii. Prevent overcharging which can damage the cells of the battery

iii. Provide visual indications of the state of charge of battery and that of the back-up

iv. Improvise an energy back-up pack using readily available DC pen-cell batteries.

1.2 Project Outline

Chapter one of this project contains the introduction to this project. A brief project literature review on previous work done related to this is represented in chapter two, also, the description of the circuit is given in order to give clear understanding of the devices employed. Chapter three presents the design and construction of the project. Chapter four and five give the test, result, discussion of result and conclusion/recommendations respectively.

CHAPTER TWO

2.0 Literature Review

Today batteries are common feature in our everyday lives. Most users of batteries take the development of batteries for granted, not realizing that the earliest ancestor to the modern battery was invented over two hundred years ago and has been a work in progress ever since. The explosion in the use of portable devices and electronic products such has mobile phones, computers, toys and audio devices has resulted in a rapidly increasing demand for both primary (non-rechargeable) and secondary (rechargeable) batteries. [1]

The first battery prototype was invented in the late 1700s by Italian physician Volta who used a stack of zinc and copper dicks separated by cardboard soaked in a saline or acid solution to generate low electric charge.

The onset of the first World War increased the demand for improved batteries that could be used to power equipment at the front lines. Great strides were made in battery performance between the two world wars, resulting in the development of silver zinc and Nickel zinc (a precursor to the rechargeable nickel cadmium) batteries.

The nickel cadmium battery was the first rechargeable battery introduced to the market in 1960. The first version of a Lithium metal rechargeable battery was introduced to the market in 1983. It was not commercialized as the popular lithium ion battery until 1991. Nickel metal hydride batteries appeared, about the same time in 1990. Lithium polymer became commercially available in 1999.

Table 2.1 presents the different types of primary consumer batteries in common use and the types of products in which they are typically used.

Table 2.1 Primary Consumer Battery Characteristics

Battery Type	Other names	Toxic substance under CEPA 1999	Uses	Status
Primary Dry Cell				
Zinc Carbon	"general purpose" battery Leclanche battery ZnC	None	-Low dranage uses i.e. flashlight, toys, radios, clocks, shavers, radio, calculators	- Limited use portable electronic devices - since 1993, no longer contain mercury -not used as much any more, being phased out
Zinc Chlorde	ZnCI	None	-low drainage uses i.e. flashlight, toys, radios, clocks, shavers, calculators, cassette players/recorders	- not used as much any more, being phased out
Alkaline	Zinc manganes dioxide $ZnMnO_2$ Zinc-alkaline	None	- general purpose battery available for low/medium or high drain requirements i.e. digital cameras, portable power tools, portable electronics, flashlights, toys, clocks, CB walkie-talkies, radio, portable televisions, video games, pagers, portable audio systems, MP3 players, shavers, toothbrushes, appliances	- represent majority of primary consumer battery sales - Since 1993, alkaline batteries manufactured in Canada, USA, Japan and Europe no longer contain mercury. - some of market share being replace by primary lithium and secondary NiMh batteries
Button Cell Batteries – silver oxide	$ZnAgO_2$ AgO	Contains small amounts of mercy	Used for high energy density and flat voltage i.e. hearing aids, watches, photographic equipment, calculators, photoelectric exposure meters, instruments, pagers	Not used as much due to mercury and silver
Button Cell Batteries – mercuric	ZnHgO HgO	Contains small amount of mercury	Used for high energy density and flat voltage i.e. hearing aids, watches, photographic equipment electronic measuring instruments, intruder alarms, pacemakers, sensors, detectors, radio transmitters	No longer available for sale in Canada since Jan 1996 due to mercy content

Table 2.2 presents the characteristic of secondary batteries and battery chemistry [2,3,4].

Table 2.2 Secondary Consumer Battery Characteristic

Battery Type	Other names	Toxic substance under CEPA 1999	Uses	Status
Secondary Batteries				
Dry Cell				
Nickel Cadmium	NiCd Ni-Cad	Cadmium and nickel if found in oxidic, sulphidic or soluble inorganic nickel compounds	-used for low/medium drain requirement i.e lightweight portable power devices (cordless power tools, personal stereos, portable telephones, laptop computers, shavers, motorized toys, remote controls) portable radios and devices with a battery backup (answering machnes, clocks/radio) and standby power devices (alarms, emergency lighting)	-losing market share due to cadmium content and memory loss problem
Nickel-Metal Hydride	NiMH	Nickel if found in oxidic, sulphidic or soluble inorganic nickel compounds	-used for all discharge rates although commonly used in high drain devices i.e. digital cameras, portable power tools, flashlights, CB walkie-talkies, radios, portable televisions, video games, portable audio system, CD players, MP3 players, applicances shavers, toothbrushes, cell phones, camcorders, computer	-claiming greater market share, replacing NiCd and primary batteries
Lithium-Ion	Li-Ion	None	-used for high energy density i.e. cellular phones, laptops camcorders and other mobile computing devices	-provides more enegery than NiCd or NiMH batteries
Lithium Iion Polymer	Li-Polymer	None	-used for high energy density i.e. cellular phones, laptops camcorders and other mobile computing devices	-projected to grow in market demand
Wet Cell				
SSLA (Small sealed lead	SSLA	Lead	Small niche in electric mowers, electric wheel chairs electric bikes, some toys,	Use in portable market is low; man use is

acid)			camcorders, alarm systems, cordless./cellular pones	starter and drive application and UPS (uninterrupted power supply)
Lead-Acid		Lead	Automobile and other vehicle SLI (staring, lighting ignition) Power State	-estimated that 99.2% recycled in the United States in 20004 (Battery Council International, June 2005 - RIS 1994 report estimates over 90% recycled (RIS, 1994)

A concern regarding the need for mobile sources of power during hurricanes, icestorms, power blackouts and more recently, hand-held and operated electronic devices with a consequent need for charging of these mobile sources of power when they are drained has resulted in a rapidly increase demand for all types of batteries and portable power charging packs.

A battery charger is simply a device used to put energy into a cell or (rechargeable) battery by forcing an electric current through it. The charge current depends upon the technology and capacity of the battery being charged.

2.1 Types of Battery Chargers

2.1.1 Simple:- A simple charger works by connecting a constant DC power source to the battery being charged. The simple charger does not alter its output based in time or the charge on the battery. This simply means that a simple charger is inexpressive, but there is a trade off in quality.

2.1.2 Timer-Based: - The output of a timer is terminated after a pre-determined time. Timer chargers were the most common type for high-capacity Ni-cd in the late 1990s. Often a timer charger and a pack of batteries is bought as a bundle and charger time set to suit those batteries.

2.1.3 Intelligent: - Output current depends upon the battery's state. An intelligent charger may monitor the battery's voltage, temperature and/or time under charge to determine the optimum charge current at that instant. Charging is terminated when a combination of voltage, temperature and/or time indicates that the battery is fully charged.

2.1.4 Fast: - Chargers make use of control circuit in the batteries being charged to rapidly charge the batteries without damaging the cell's elements. Most of such chargers have a cooling fan to help keep the temperature of the cells under control. Most are also capable of acting as a standard overnight charger if used with standard NiMH cells that do not have the special control circuitry.

2.1.5 USB-Based:- Since the universal serial Bus specification provides for a 5 volt power supply, it's possible to use a USB cable as a power source for recharging batteries.

Some chargers use Pulse Technology in which a pulse is fed to the battery. This DC pulse has a strictly controlled rise time, shape, pulse with, frequency and amplitude. This technology is said to work with any size, voltage, capacity or chemistry of batteries, including automotive and value-regulated batteries. [5]

The concept involved in the pulse technology and intelligent charger where incorporated in the design and construction of this project.

Various design concepts of battery chargers abound, with most either commercialized already or patented [6]. Projects on battery chargers consulted included those from the Department's Archive [7,8,9]. Though brilliant feats as at when they were made, these projects were fraught with a number of limitations;

✓ Batteries used were the Bulky lead acid [7,8,9]

✓ There was the problem of gassing [8]

✓ Inability to charge the intended device and the battery backup simultaneously [7]

✓ Restriction of power source to only the mains supply [8,9]

✓ Inevitable spillage of liquids from the lead acid accumulator, portability and hence mobility were traded-off [7,8,9].

✓ High cost of solar panels and its rarity in the Nigerian market [7]

This project, though limited to charging of 3.6v Li-ion mobile phone batteries, seeks to eliminate the afore-stated limitations whilst achieving this with the use of chip and easy-to-source components from the market. The charge constructed consists of the following parts:

Power Supply Module:-

The unit employed in this project consists of a transformer, rectifier unit and filter. The transformer was used to step down the voltage to the value required and rectification (converting the AC voltage to DC pulsating signal) was gotten by applying the AC voltage across the 'Bridge rectifier'. Rectification was necessary as other modules of the project (Hardware) needed a DC voltage for operation [10,11,12,13,14].

The preceding rectified waveforms aren't good for much as they stand. They are DC only in the sense that they don't change polarity. But they still have a lot of 'ripple' (periodic variation in voltage about the steady value) that has to be 'smoothed' out in order to generate genuine DC. This is done by tacking on a low-pass filler. A large (electrolytic) capacitor C is used to produce a large and fairly steady DC voltage [13] for the correct operation of the device, a constant value DC voltage is needed, even though the input main voltage and/or the current taken from the power supply may vary. This was achieved by using an active feedback circuit (voltage regulator LM7809) to eliminate the remaining ripple.

Components used in this module are step-down transformer, diodes, capacitor and voltage regulator.

Charging Module:-

This module include the charging and control circuitry needed for the proper working of the device. Components used here include the 555 timer (which was configured to run in the monostable mode), zener diodes, capacitor, resistors, variable resistor, transistors and diodes. Design and connections are given in chapter 3.

Back-up Module:-

This module houses the pen cell batteries, the charging and discharging circuitry needed for the efficient operation of the Back-up pack. Components used here are 1.2v Nicad batteries (pen-cell) 10pcs., Transistor, LED, resistors, zener diode and IC (TIP 41C). Design and connections of this module are given in chapter 3.

CHAPTER THREE

Design and Implementation

3.1 Power Supply Unit

3.1.1 Transformer

From $\varphi_P = N_P AB$, $\phi_S = N_S AB$

Where

ϕ_P - Flux in primary winding

ϕ_S - Flux is secondary winding

N_p – No of turns of cost in primary winding

N_s – No. of turns of cost in secondary winding

A – Cross-sectional area

B – Flux density

The magnitude of E.M.F induced in secondary is

$$E_s = \frac{d\phi_s}{dt} = N_s A \frac{dB}{dt} \quad \text{...} \quad 3.2$$

The changing flux also induces a back e.m.f in the primary, whose magnitude is

$$E_p = d\frac{\phi_p}{dt} = N_p A \frac{dB}{dt} \quad \text{...} \quad 3.3$$

From the equation 3.2 and 3.3

$$\frac{E_p}{E_s} = \frac{N_p}{N_s} = n \quad \text{..} \quad 3.4$$

The transformer used was a step-down voltage transformer with rating of 240v/12v, 300mA.

Thus. $\frac{E_P}{E_S} = \frac{240}{12} = 20 = n$

Where n is the 'turns ratio'

3.1.2 Rectifier Unit

For bridge rectifiers.

$V_{dc} \approx 0.636(V_m - 2V_k)$ 3.5

Where V_k – forward voltage drop across diode 0.7v;

V_m –maximum/peak voltage gotten from the ware form plotted

For $V_{dc} = 12v$

$$V_m = \frac{Vdc}{0.636} + 2V_k$$

$$= \frac{12}{0.636} + 2(0.7)$$

$$V_m = 20.27v$$

A safety of 2.5 is allowed, therefore

20.27 x 25 = 50.67v

Diodes in 4001-7 have PIV rating of 50-100v and are thus suitable for use. Diode in 4007 was used.

DC voltage $V_{DC} = V_m - \frac{Idc}{4fc}$ 3.6

From above equation

$$C = \frac{Idc}{(V_m - V_{dc})4f}$$

Using I_{dc} = 300Ma, V_m = 20.27v, V_{dc} = 12v and f = 50Hz

$$C = \frac{300\times10^{-3}}{(20.27-12)}\times4\times50 \approx 1.8138\times10^{-4}F180F$$

Calculating for ripple voltage with 1804F

$$V_r(r.m.s) = \frac{Idc}{4\sqrt{3}fc} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.7$$

$$= \frac{300\times10^{-3}}{4\sqrt{3}\times50\times180\times10^{-6}} = 4.78v$$

This ripple voltage is large, thus to suppress the voltage to a minimum, a large electrolytic capacitor with 2200F, 25v rating was used

$$V_r(r.m.s) = \frac{Idc}{4\sqrt{3}fc} = \frac{300\times10^{-3}}{4\sqrt{3}\times50\times2200\times10^{-6}}$$

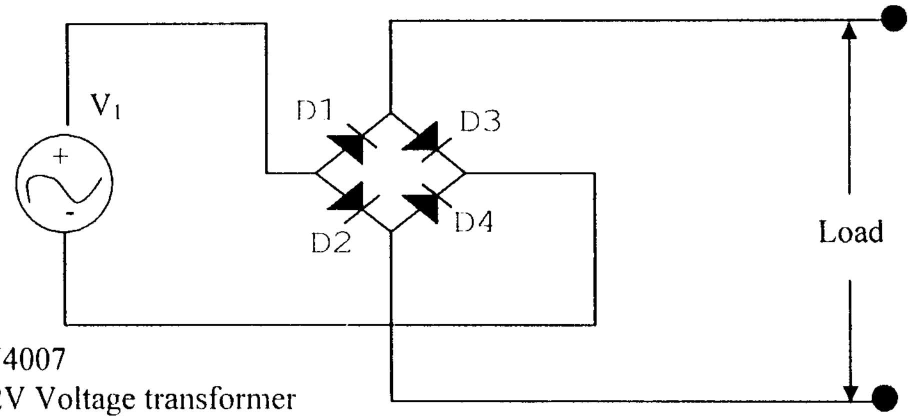
$$= 0.39v$$

By choosing capacitor that is sufficiently large, the ripple voltage could be reduce to any desired level, though, this approach has two disadvantages:

1. The required capacitor may be bulky and expensive
2. Even with the ripple reduced to negligible levels, there will still be a variation of output voltage due to other cause e.g the DC output voltage will be roughly proportional to the AC input voltage, giving rise to fluctuations caused by input line voltage variations.

The correct operation of many equipments demands that the direct power supply voltage is maintained at a constant value, within fairly fine limits, even though the input main voltage and/or the current taken from the power-supply may vary. The power-supply design approach used in this project is to use enough capacitance to reduce ripple to low levels and then use an active feedback circuit, voltage regulator LM7809, to the eliminate the remaining ripple. The function of the voltage regulator is to maintain a constant voltage of 9 volts across the load as the input voltage and/or the current vary within specified range.

A 240v/12v transformer was chosen since the output voltage, 12v, caters for the $\approx$ 2v drop across the transistors in the IC (LM7809).



-D4 = IN4007
= 240/12V Voltage transformer

Fig. 3.1 Full-wave Bridge Rectifier

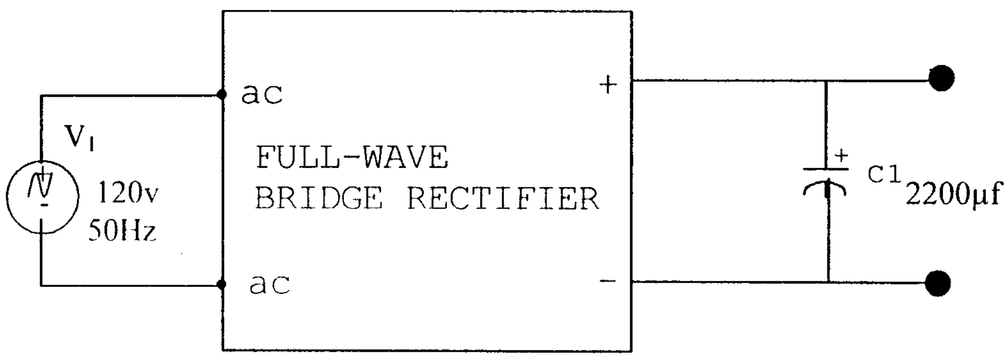


Fig 3.2 Schematic diagram of a full-wave rectifier

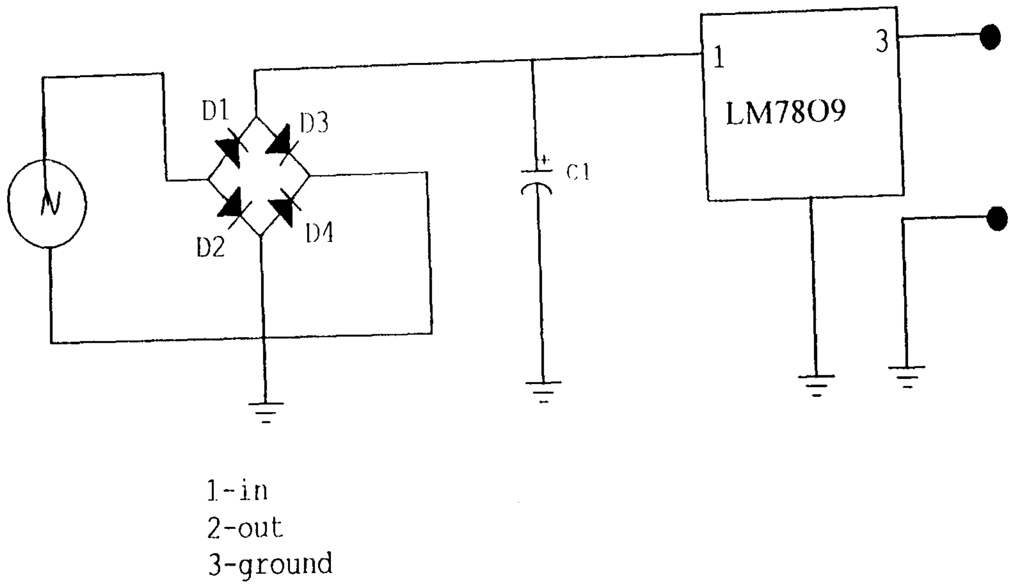


Fig: 3.3 Regulated D.C Power Supply

3.2 Charging Unit

3.2.1 555 Timer

The NE5555 (also LM555, CA555 and MC1455) is a widely used IC timer, a circuit that can run in either of two modes; monostable (one stable state) or astable (no stable state) and as such is referred to as a multivibrator.

A multivibrator is a two-state circuit that has zero, one or two staple output states. When the 555 timer is used in the monostable mode. it is stable in the low state until it receives a trigger which causes the output to temporarily change to the high state. The high state, however. is not stable because the output returns to the low state when the pulse ends. When operating in the monostable mode, the 555 timer is often referred to as a one-shot mutivibrayor because it produces only one output pulse for each input trigger. The duration of this output pulse can be precisely controlled with an external resistor and capacitor.

The 555 timer is an 8-pin IC. Pin 1 is connected to the positive supply voltage. The 555 timer will work with any supply voltage between +4.5v and +18v. The trigger goes into pin 2 and the output comes from pin 3. The other pins are connected to external components that determine the pulse width of the output.

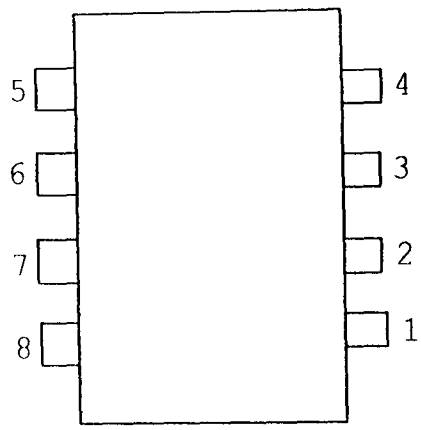


Fig: 3.4 555 timer IC showing pin configuration

The schematic diagram of a 555 timer is complicated because it has about two dozen components connected as diodes, current mirrors and transistors. Figure 3.5 shows a functional block diagram of 555 timer. The 555 timer contains a voltage divider, two comparators, an RS flip-flop and an npn transistor. Since the voltage divider has equal resistors, the top comparator has a trip point of:

$$UTP = \frac{2}{3}V_{cc} \qquad 3.8$$

The lower comparator has a trip point of:

$$LTP = \frac{1}{3}V_{cc} \qquad 3.9$$

Pin 6 is connected to the upper comparator. The voltage on pin 6 is called threshold. When the threshold voltage is greater than the UTP, the upper comparator has a high output.

Pin 2 is connected to the lower comparator. The voltage on pin is called trigger. This is the trigger voltage that is used for the monostable operation of the 555 timer. When the timer is inactive, the trigger voltage is high. When the trigger voltage falls to less than LPT, the lower comparator produces a high output.

Pin 4 may be used to reset the output voltage to zero. Pine 5 may be used to control the output frequency when the 555 timer is used in the astable mode.

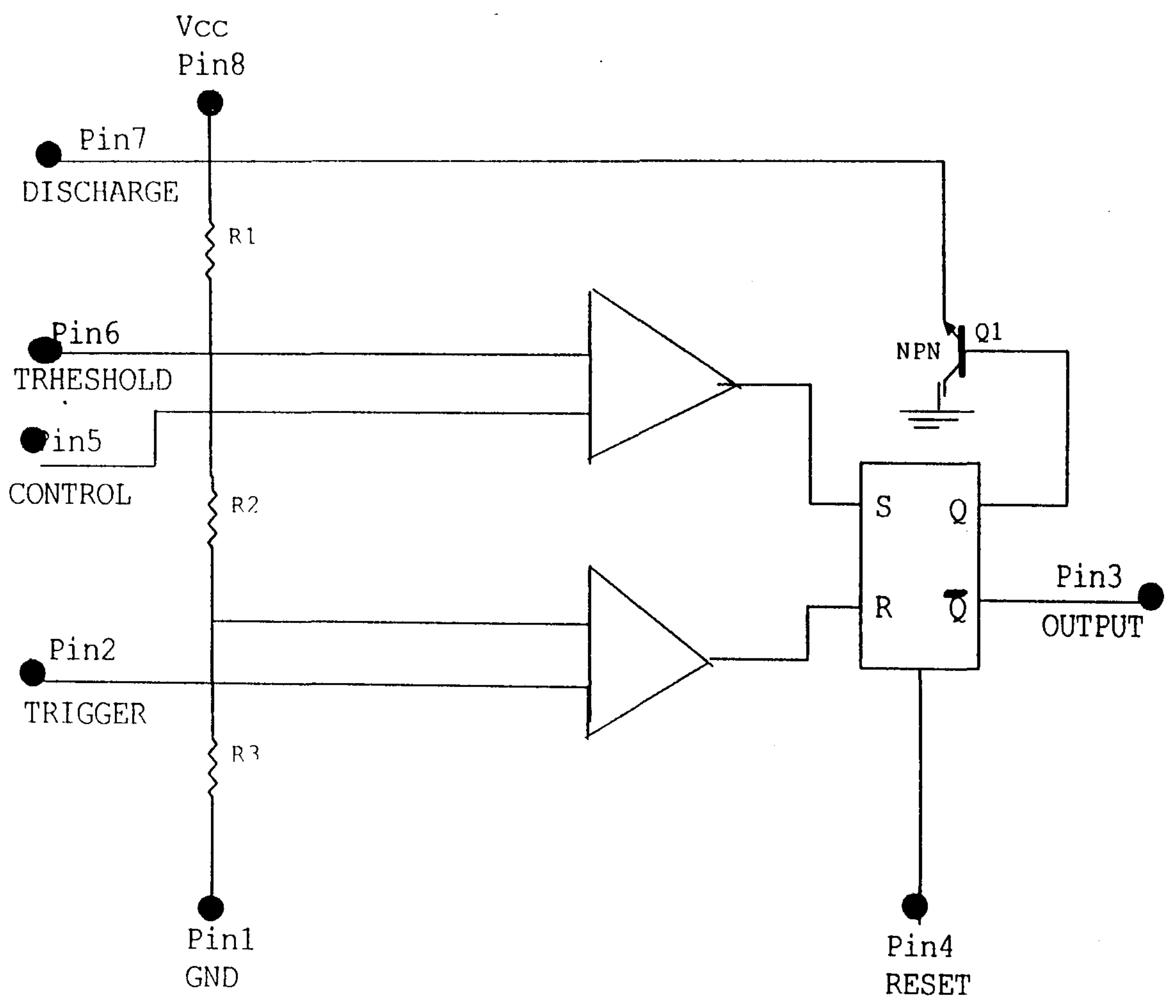


Fig:3.5 simplified functional block diagram of a 555 timer

Monostable Operation

Initially the ϕ output of the RS flip-flop is high. This saturates the transistor and clamps the capacitor voltage at ground. The circuit will remain in this state until a trigger arrives. Because of the voltage divider, the trip points are the same as previously stated:

$UTP = \frac{2}{3}V_{cc}$ and LTP $= \frac{1}{3}V_{cc}$

When the trigger input falls to slightly less than $\frac{1}{3}V_{cc}$, the lower comparator resets the flip-flop.

Since Q has changed to low, the transistor goes into cutoff, allowing the capacitor to charge. At this time, Q has changed to high. The capacitor now charges exponentially. When the capacitor voltage is slightly greater than $\frac{2}{3}V_{cc}$, the upper comparator sets the flip-flop. The high Q turns on the transistor, which discharges the capacitor almost instantly. At the same instant, Q returns to the low until another input trigger arrives.

The complementary output Q comes out of pin 3. The width of the rectangular pulse depends on how long it takes to charge the capacitor through resistance R, the longer the time constant, the longer it takes for the capacitor voltage to reach $\frac{2}{3}V_{cc}$. In one time constant, the capacitor can change to 63.2 percent of V_{cc}. since $\frac{2}{3}V_{cc}$ is equivalent to 66.7 percent of V_{cc}, it takes slightly more than one time constant for the capacitor voltage to reach $\frac{2}{3}V_{cc}$.

The pulse width:

$$W = 1.1RC \qquad 2.10$$

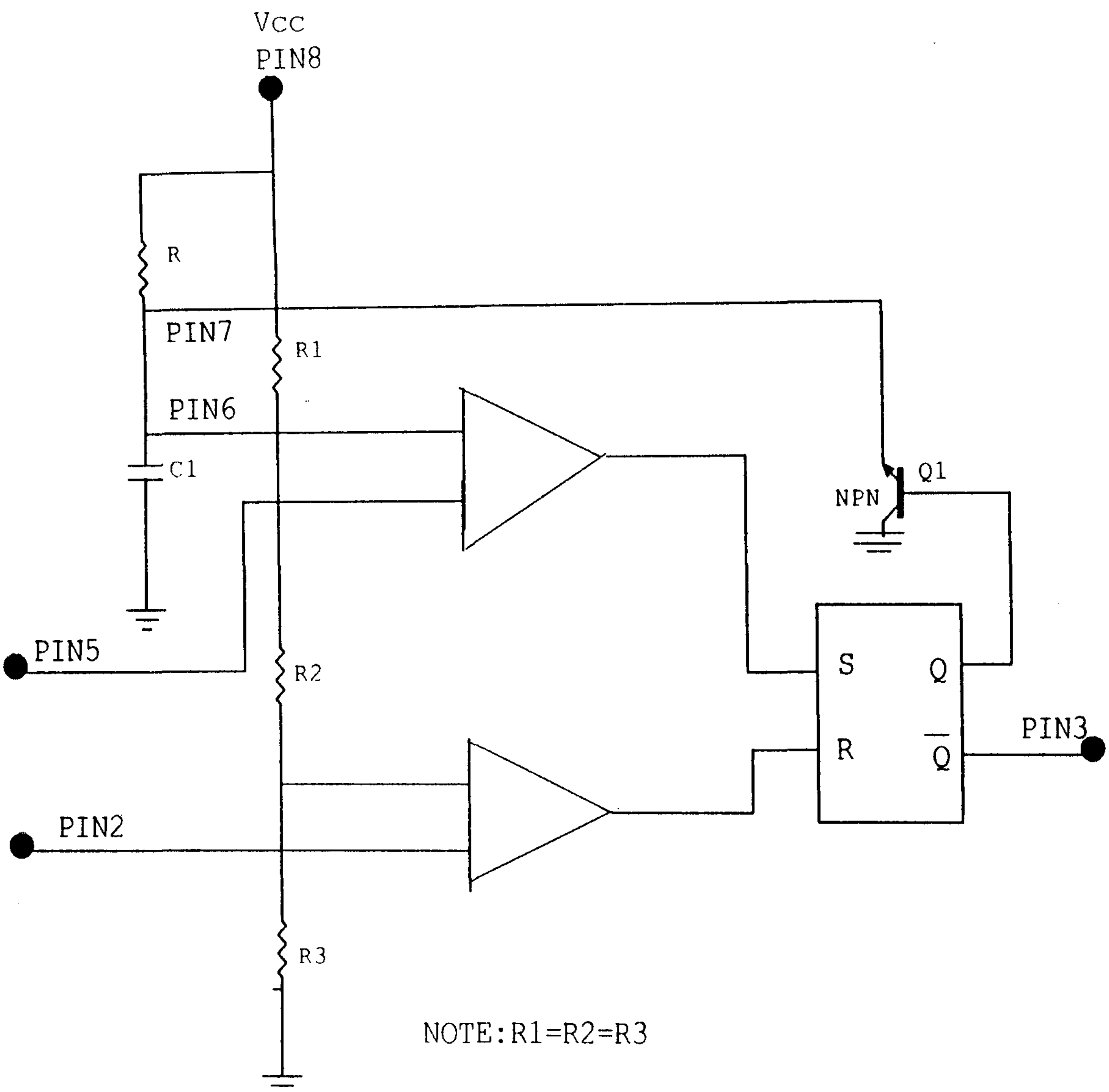


Fig: 3.5 Timer connected for monostable operation

Fig 3.7 shows the schematic diagram for the monostable 555 circuit as it usually appears. Only the pins and external components are shown. It is worth noting that pin 4 (reset) is connected to V_{cc}; this is to prevent pin 4 from having any effect on the circuit [14].

A further modification to this circuit for the purpose of this project was that pin 5 (control) was given a reference voltage, thus changing the UTP, which changes the width of the pulse.

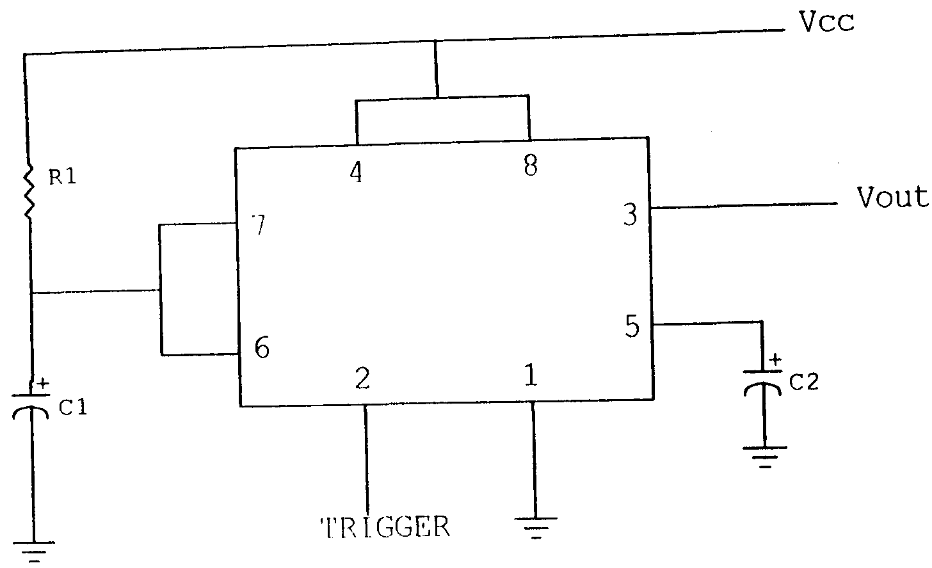


Fig: 3.7 Monostable timer circuit

3.2.2 Pulse-Width Modulation (PWM)

With the 555 timer connected in the monostable mode, the values of R,C, UTP and V_{cc} determine the width of the output pulse as follows:

$$W = RC \ln\left(1 - \frac{UTP}{V_{cc}}\right) \quad \text{.............................. 3.11}$$

Since pin 5 control the value of UTP, V_{mod}, the voltage with which it is referenced, is being added to the quiescent UTP. Therefore, the instantaneous UTP is given by:

$$UTP = \frac{2}{3}V_{cc} + V_{mod} \quad \text{...................................... 3.12}$$

Each trigger on pin 2 produces an output pulse. Since the period of the trigger is T, the output will be a series of rectangular pulses with a period of T. the reference

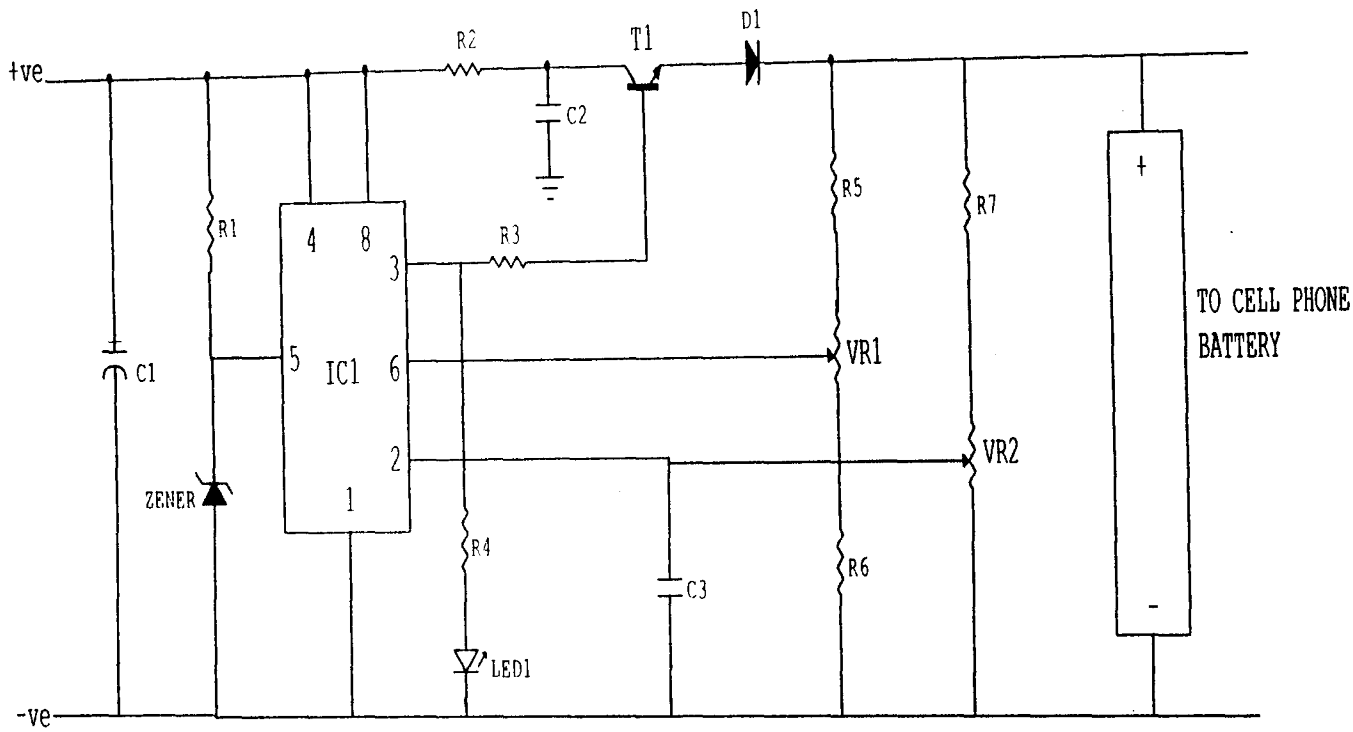


Fig: 3.8 Charging Circuit

voltage on pin 5 has no effect on the period T, since the period is determined by the frequency of the input triggers. but it does change the width of each output pulse. [15]

Component List

IC	-	555 Timer	R1	-	390Ω	VR1	-	20K Ω
C1	-	10µf	R2	-	100Ω	VR2	-	20K Ω
C2	-	10µ	R3	-	39Ω			
C3	-	1.0pf	R4	-	680Ω			
ZD1	-	3.6v	R5	-	27KΩ			
D1	-	IN4001	R6	-	47KΩ			
T1	-	BC324	R7	-	3.3KΩ			

3.2.3 Circuit Operation

Basically, the charger is a current-limited voltage source. Generally, cell phone battery packs require 3.6-6v DC and 180-200mA current for charging. Current of 100mA is sufficient for charging the cell phone battery at a slow rate. The circuit also monitors the voltage level of the battery. It automatically cuts off the charging process when its output terminal voltage increases above the predetermined voltage level.

Timer IC NE555 is used to charge and monitor the voltage level in the battery. Control voltage pin 5 is provided with a reference voltage of 3.6v by zener diode ZDI. Threshold pin 6 is supplied with a voltage set by VRI and trigger pin 2 is supplied with a voltage set by VR2.

When the discharged cell phone battery is connected to the circuit, the voltage given trigger pin 2 of the timer IC is below $^1/_3$ V_{cc} and hence the flip-flop in the IC is switched on to take output pin 3 high. When the battery is fully charged, the output terminal voltage increases the voltage at pin 2 above the trigger point threshold. This switches off the flip-flop and the output goes low to terminate the charging process. Threshold pin 6 is referenced at $^2/_3$ V_{cc} set by VR1. Transistor T1 is used to enhance the charging current. Value of R3 is critical in providing the required current for charging. With the given value of 10-ohm the charging current is around 180mA.

3.3 Back-Up Module

Nickel-cadmium batteries can save much time and money when they are used to replace other non-rechargeable dry batteries. They must however, be treated in a suitable manner or they could become useless within just a few weeks. Different batteries have different discharge properties and, thus, these has impact upon the type one chooses for experiment. In general. it is the terminal voltage. capacity and operating temperature range that will determine choice. Nickel-cadmium batteries only have 1.2volt output per cell, thus, ten cells would be needed to make up a 12volt battery pack. Typical capacity = 700mAH.

3.3.1 Charging Nicads

Nicad batteries should be charged at 0.1C rate where C is the total capacity of the battery for example. a 500mA/Hour battery will deliver 500maM current for one hour at 20 degrees centigrade. It should therefore be charged for 0.1 x 500 = 50mA. It should also be charge for 10 hours plus 40%= 14 hours. THIS ONLY APPLIES to a cell that has been fully discharged. NiCd batteries are best charged at a constant rate.

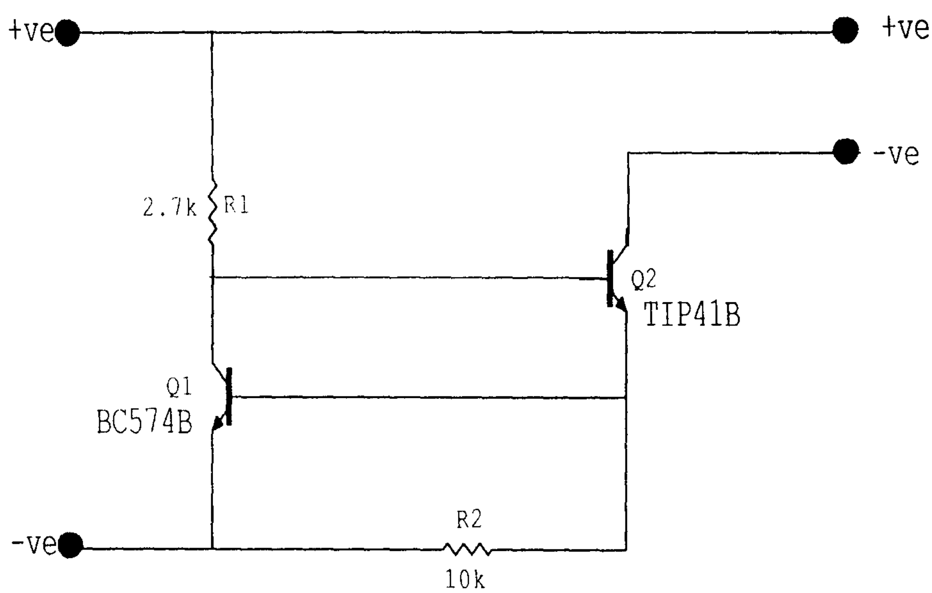


Fig:3.9 Charging Circuit for NiCd

R2 is used to set the current though the battery and is calculated as $R = \dfrac{0.7}{\text{Amperes}}$

For 70mA this becomes $\frac{0.7}{0.07}$ = 10 ohms. R1 will depend upon the transformer used, with 12v transformer and a POWER-ON LED in series with R1, then it is about 2.6k.

3.3.2 Discharging NiCad

Before a cell is charged it should always be discharged. Each cell should be discharged to about 1.00v – 1.05v. Since terminal voltage of the cell is reasonably constant then it could be discharged with a simple resistor or batter still a simple discharger could be made for it.

For a 12v battery pack, the 250 ohm resistor is the load resistor and in this case is designed to draw about 45mA from the battery. When the battery voltage falls to IV per cell (10 cells-10v) then the zener diode will not all sufficient voltage to turn ON the Darlington pair. In practice, the LED will slowly begin to dim a little before it goes out completely. A slow discharge is far better than a fast discharge. Measuring this discharge time is also an indication of the true capacity of the battery

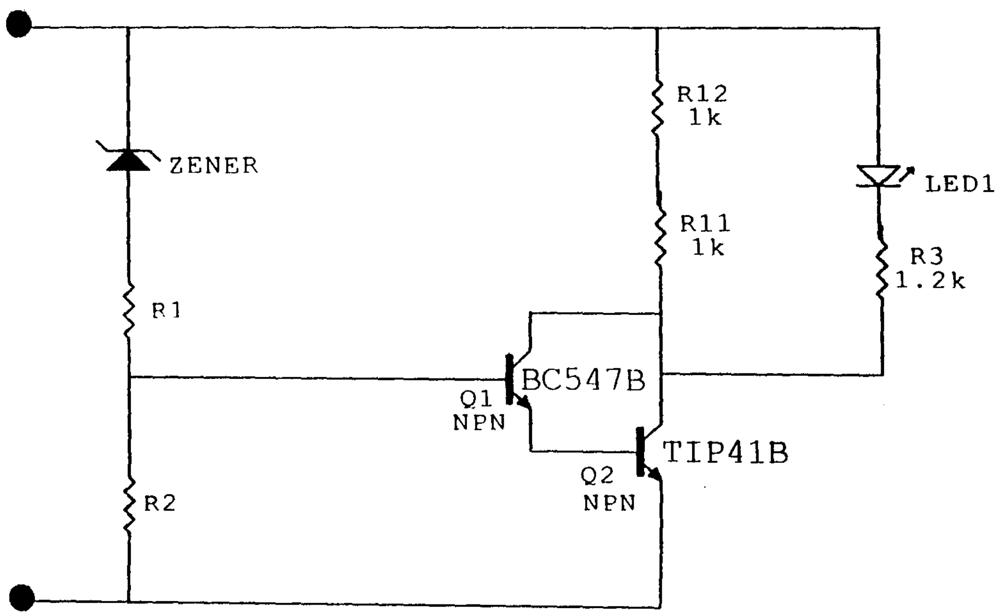


Fig: 3.10 Discharge Circuit for NiCd

Nicad will also discharge themselves with time. In general, a normal Nicad battery will discharge itself at about 2% per day. It is therefore, always advisable to recharge again before use. A self discharged battery may be allowed to drop to zero volts per cell without damage.

3.3.3 Memory Effect

This is a situation where a NiCad battery has been repeatedly 'topped-up' after a partial discharge. What happens is that the battery can only be used for the part of the capacity that has been exercised. Often the cause of memory effect is gross overcharging; fully discharging to 1.0v per cell before charging again will prevent it from happening.

3.4 Alternative Energy Source Interface

This provides the plug-in by other energy sources given 12v dc to the charging units of the project.

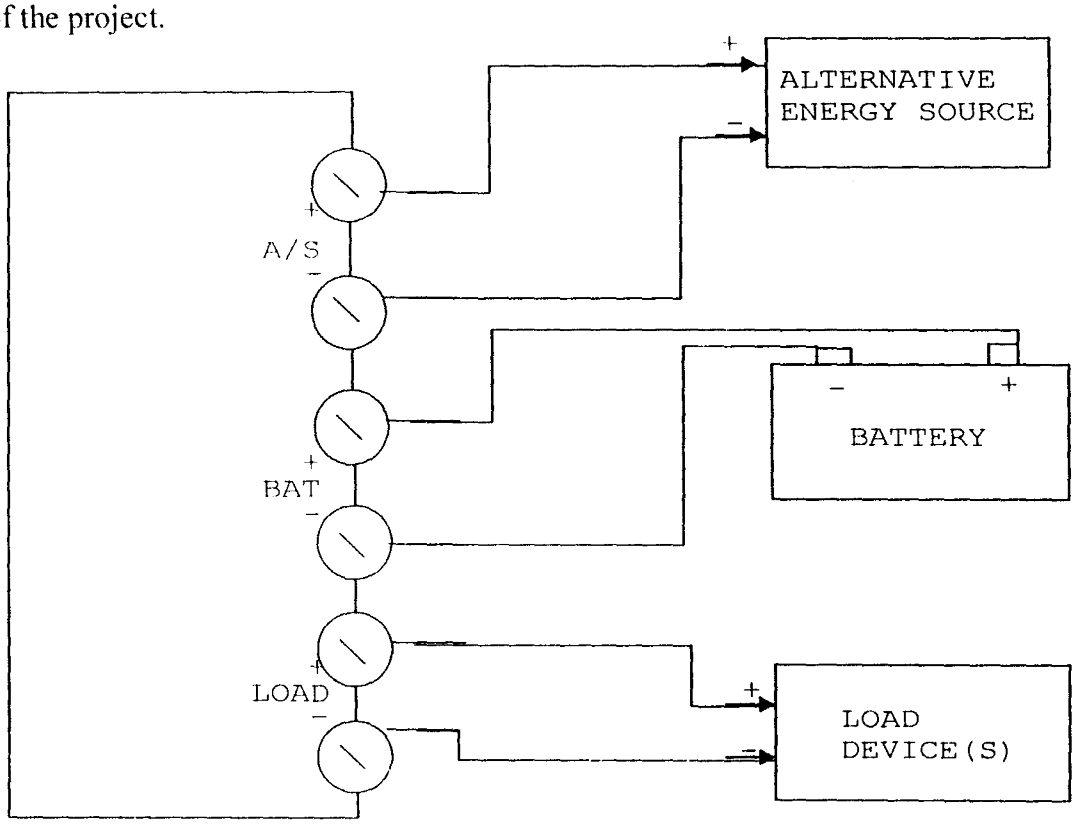


Fig 3.11 block diagram of the charging device

The circuits as given in figure 3.3, 3.8, 3.9, 3.10 and 3.11 were constructed on a Vero board with all necessary precautions, when soldering, adhered to, the constructed work was then enclosed in a box but with an outer board as an interface to aid effective operation of the device. In all, aesthetics and portability were given paramount consideration in enclosing the project.

CHAPTER FOUR

A digital multimeter, set to the required range, was used for the measurement of required values.

i. Rectified DC input (without LM7809)

Current = $\approx 228mA$

Voltage = 12v

ii. Rectified DC to charging module

Current = $\approx 210mA$

Voltage = 9v

iii. Output current from charging module for battery pack = 70mA

iv. Charging current = 198mA

v. Voltage across charging terminal = 8.35v

vi. Output voltage from battery pack when fully charged = 12v

output current from battery pack when fully charged = 700mAH

4.1 Supported Mobile Phone Battery

Specification:

Product : c 113a

Voltage rating : 3.6v

Current rating :

Manufacturer : Motorola

Charging times will vary depending on the following conditions;

1. Capacity of mobile phone battery

2. Level of mobile phone battery

Changing time can be calculated as follows:

$$\text{Time} = \frac{\text{Battery capacity}}{\text{Measured output charging current}}$$

Source	Output	Measured Output Voltage/Current	Capacity of Cell Phone Battery	Actual Charging Time
AC Mains	12v 300mA	9v	700	3 hrs
Battery pack	12v 700mA	9v	700	3 hrs

CHAPTER FIVE

5.0 Conclusion

The device "Friendly Mobile Phone Charger having DC rechargeable pen-cell back-up" was constructed and found to meet its design requirements.

A charging time of approximately 3 hours for an 'almost flat' battery was obtained, thus, offering a better output when compared to other common chargers.

During the design and implementation of this project, aesthetics, portability, durability, redundancy (introduced via the various energy sources) and protection schemes were factors considered, thus making the project work not only presentable for an award of a first degree but also marketable if so desired by the department.

5.1 Recommendations

This project, though noble, still has areas that could improve it;

1. Programmable ICs could be incorporated in the work so that it could be more compact and efficient.

2. The charging time for the back-up pack (14 hours for this project work) could be improved upon.

3. A means should be improvised to charge the mobile phone battery without removing it from the cell phone.

The following recommendation should further strengthen and better the department

1. The syllabus should be so designed as to balance theory and practical. (at least the basis of practical and research work).

2. Better and more teaching aids. (computer, programmer, programmable ICs) should be acquired for computer programming and networking courses.

3. The department library project should be update and sustained.

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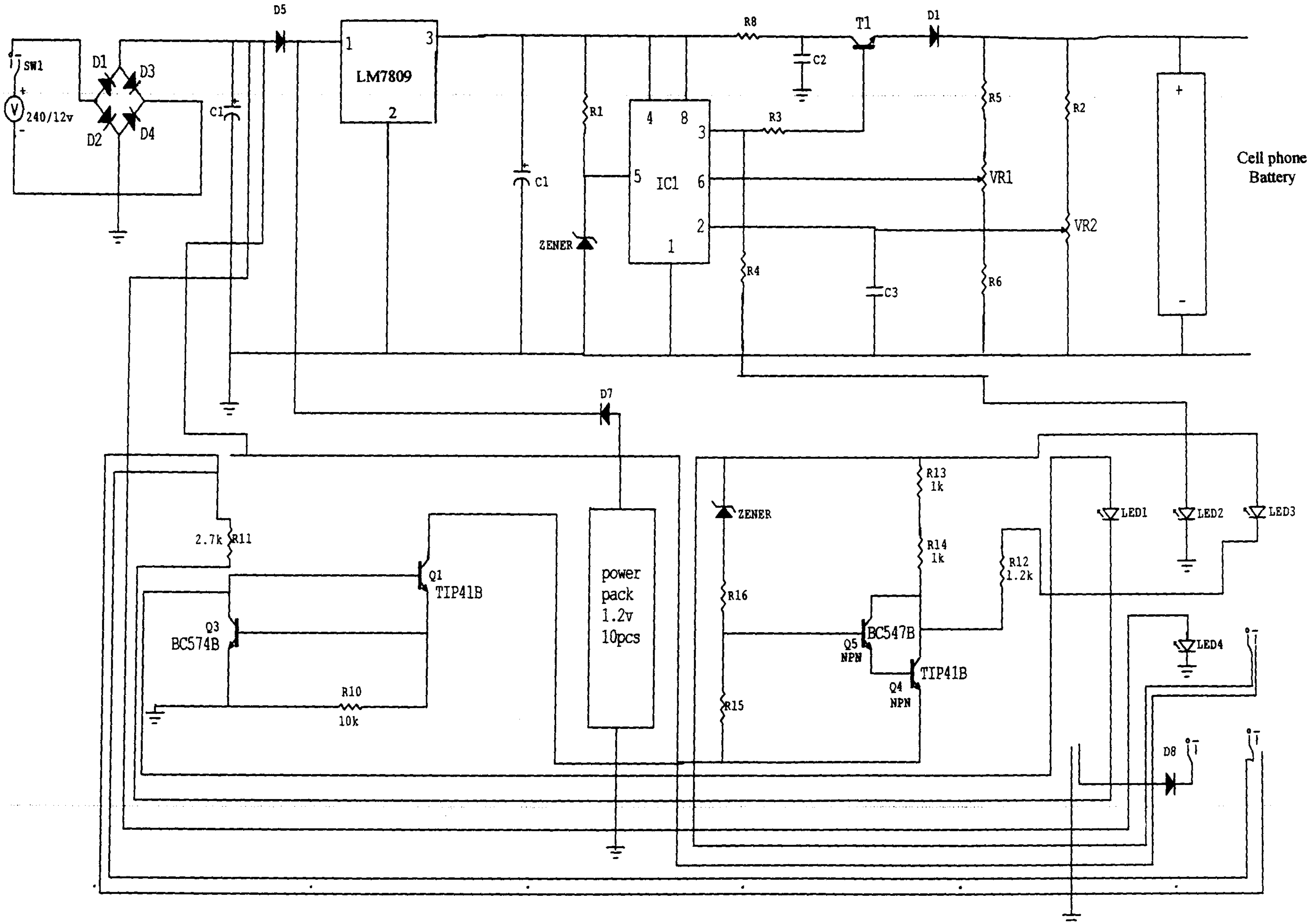
Appendix A


SW1
240/12v
D1
D3
D2
D4
D5
C1
LM7809
1
3
2
C1
R1
ZENER
R8
C2
T1
D1
4
8
3
5
IC1
6
2
1
R3
R5
R2
VR1
VR2
R4
C3
R6
Cell phone Battery
D7
2.7k
R11
Q1
TIP41B
Q3
BC574B
R10
10k
power pack 1.2v 10pcs
ZENER
R16
R15
R13 1k
R14 1k
R12 1.2k
Q5
NPN
BC547B
Q4
NPN
TIP41B
LED1
LED2
LED3
LED4
D8

Appendix B

Component list

V1	240/12v Transformer
SW1	Power Switch
SW2	Discharge Switch
SW3	P/charge Switch
SW4	Ext Energy Switch
IC1	LM 7809
IC2	NE 555
D1-d7	IN 4007
C1	2200 μf , 25v
C2	100 μf , 12v
C3	10pf
C4	1pf
R1	390 Ω
R2	100 Ω
R3	10 Ω
R4	680 Ω
R5	27K Ω
R6	47K Ω
R7	3.3K Ω
R8	2.7K Ω
R9	10 Ω

R10	2.2KΩ
R11	47KΩ
R12	240Ω
R13	10Ω
R14	1.2KΩ
VR1	20K
VR2	20K
ZD1	3.6V
ZD2	8.3V
Q1	BC 547
Q2	TIP 41
Q3	BC 547
Q4	TIP 41
P1	port for interfacing Ext. Energy source
T1	BD 681