"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power System)"

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Date : 7 NOVEMBER 2008

# BATTERY CHARGER WITH ALARM APPLICATION

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Power System)

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**DEDICATIONS**

To all my family members and also to all my friends who helped me when doing this project

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Firstly, I want to take this opportunity to gave an acknowledgement and my deepest gratitude to my supervisor for my Engineering Project, Mr. Ruhaizad bin Ishak for his dedication that has helped me very much to gave me a knowledge, idea, advise and encouragement. Without him, this project will be over before it’s begun.

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# ABSTRACT

Unlike any other battery charger, this project is about the combination of battery charger circuit with alarm circuit. The main objective of this project is the alarm will send signal to the user. Thus, the user will know that the batteries are already fully charged. It consists of 3 segments, the power supply, charging circuit and alarm circuit. In this project, the charging process is focus more on AA batteries. The heart of the circuit located at LM324. It is the segment that controlling the charging process of the whole circuit. 2 pins are required. First pin (pin 12) is for Upper Limit Set, while the second pin (pin 9) is for lower limit set. This both pin sending the signal as a reference value. The upper limit send an information that the batteries is overcharged while the lower limit send the information about batteries deep discharge. Both of them are controlled by a potentiometer. When this is happen, the LM324 will send signal to the transistor. This transistor than operates thus energizes the relay coil. When the relay retracted, the charging process is halt and at the same time, operates the buzzer. The buzzer will continue to ring until the charger is turn off.

## ABSTRAK

Tidak seperti pengecas bateri yg lain, projek ini adalah kombinasi antara litar pengecas bateri dan litar amaran. Objektif utama projek ini adalah untuk menghasilkan bunyi amaran kepada pengguna. Sekaligus, menyedarkan pengguna bahawa batteri yg sedang dicas sudah dicas sepenuhnya. Terbahagi kepada 3 bahagian, Pembekal Kuasa, Litar Pengecas dan Litar penggera. Dalam projek ini, proses cas ditumpukan kepada bateri jenis AA NiCd. Lokasi utamanya terletak di bahagian LM324. Inilah bahagian yang mengawal proses cas seluruh litar. 2 kaki LM diperlukan. Kaki pertama (kaki 12), adalah untuk Had atas. Sementara kaki kedua (kaki 9), adalah untuk Had bawah. Kedua-dua pin ini menghantar isyarat sebagai isyarat rujukan. Had Atas mengahantar isyarat tentang lebihancas bateri, sementara had bawah menghantar isyarat lebihan nyahcas bateri. Kedua-duanya dikawal oleh Perintang Boleh Laras. Apabila ini berlaku, LM324 akan menghantar isyarat ke transistor. Transistor akan berfungsi sekaligus akan mengoperasikan gelungan relay. Apabila relay berfungsi, proses cas akan berhenti serta-merta. Dan, buzzer akan berbunyi sehingga suis ditutup.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Overview

Nowadays, battery charger has been widely used. With the advancement of the technology, most electrical appliances have now been adapted to use rechargeable batteries. This has been proved to be more economical and environmental friendly. The most obvious example is the 12V Car Batteries.

In this project, it's focused more to develop battery charger systems for small appliances, for examples, the AA batteries. The main contribution of this project is how the charger circuit can actually send enough current supply to the batteries so that the charger process can take place. Also, the aim of this project also to developed a new application for the current battery charger so that it can produce a better breed in the future.

## 1.2 Objectives

The objectives of the project:

i. To develop a battery charger equipped with alarm/buzzer that can give signal to user when the charging is completed
ii. To charge two AA NiCd, 1.2V from no charge state to it's fully operation state.
iii. To operates a buzzer when the voltage reach more than 3,0 V.

## 1.3 Scope of Project

There are two scope of the project, to develop a charger circuit and to develop a buzzer circuit/system. The charger circuit is to develop to charge a battery. The battery used in this project is an AA NiCd Battery, 700 mAh. The buzzer circuit function is to give signal to users. It is equipped to the circuit. The buzzer used is 5V buzzer.

## 1.4 Problem Statement

Among the main problem while develop the system are:

i. Firstly, the current charger circuit equipped with alarm circuit is a rare breed. It is very hard to find and also not widely used.

ii. Second, most of the current voltage tracing circuit was used to check a circuit for a low voltage. It is clearly not suitable for used in the system as it require circuit that can trace a high voltage (battery voltage during its full load)

## 1.5 Thesis Organization

Including this chapter, it consist of 5 chapters altogether. Chapter 1 is a brief introduction about the project. Chapter 2 is contained full description of the project, Chapter 3 is consisting of the project methodology, mostly about the project flow and how it’s organized. Chapter 4 is for presenting the expected result, while the conclusions are presented in Chapter 5.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Charging Circuit

### 2.1.1 Battery Charger

A battery charger is a device used to put energy into a secondary 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. For example, the current that should be applied to recharge a 12 V car battery will be very different from the current for a mobile phone battery

### 2.1.2 Types of Battery Charger

There are several types of battery charger which are namely simple, trickles, time-based, intelligent, fast, pulse, inductive and USB based. Each of this type is required in its own specifications.

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 on time or the charge on the battery. This simplicity means that a simple charger is inexpensive, but there is a tradeoff in quality. Typically, a simple charger takes longer to charge a battery to prevent severe over-charging. Even so, a battery left in a simple charger for too long will be weakened or destroyed due to over-charging. These chargers can supply either a constant voltage or a constant current to the battery.

A trickle charger is a kind of simple charger that charges the battery slowly, at the self-discharge rate. A trickle charger is the slowest kind of battery charger. A battery can be left in a trickle charger indefinitely. Leaving a battery in a trickle charger keeps the battery "topped up" but never over-charges. Trickle charging, also called float charging, means charging a battery at a similar rate as it is self-discharging, thus maintaining a full capacity battery. Most rechargeable batteries, particularly nickel-cadmium batteries or nickel metal hydride batteries, have a moderate rate of self-discharge, meaning they gradually lose their charge even if they are not used in a device. One must be careful, however, that if a battery regulator is not employed, the charge rate isn't greater than the level of self-discharge, or overcharging and possible damage or leakage may occur. For example, a 24 volt battery pack, comprising 12 2-volt flooded lead-acid cells, which has been deeply discharged, would normally be restored by a boost charge of approximately 2.4 volts per cell for a short time (perhaps around 72 hours). Once the collective cell voltage reaches a surface charge of 28.8 volts (2.4 volts x 12 cells), the charge rate would be switched to the sustained lower float-charging rate of typically 2.23 volts.

Eventually, with the Boost charge removed, the surface charge will diminish slightly and the battery-bank voltage will stabilise at a preset float voltage, in the case of the example above to approximately 27 volts (2.23 volts x 12). Charging rates for a trickle charge are very low. For example, if the normal capacity of a battery is C (ampere-hours), the battery may be designed to be discharged at a rate of C/8 or an 8-hour rate. The recharge rate may be at the C/8 rate or as fast as C/2 for some types of battery. A float or trickle charge might be as low as C/300 ( a 300-hour discharge rate) to overcome the self-discharge. Allowable trickle charging rates must conform to the battery manufacturer's recommendations. In low duty-cycle applications, where a relatively high current or power is required infrequently, charger costs can be minimized by applying trickle-charging principles. This can be an economy measure in cases where the charging method could be quite expensive if the full charging rate were employed, such as solar-cell installations. Full battery capacity can be achieved at a low charging current over a long period of time to provide a high-power load for a short period.

The output of a timer charger is terminated after a pre-determined time. Timer chargers were the most common type for high-capacity Ni-Cd cells in the late 1990s for example (low-capacity consumer Ni-Cd cells were typically charged with a simple charger). Often a timer charger and set of batteries could be bought as a bundle and the charger time was set to suit those batteries. If batteries of lower capacity were charged then they would be overcharged, and if batteries of higher capacity were charged they would be only partly charged. With the trend for battery technology to increase capacity year on year, an old timer charger would only partly charge the newer batteries. Timer based chargers also had the drawback that charging batteries that were not fully discharged, even if those batteries were of the correct capacity for the particular timed charger, would result in over-charging.

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 the voltage, temperature and/or time indicates that the battery is fully charged. For Ni-Cd and NiMH batteries, the voltage across the battery increases slowly during the charging process, until the battery is fully charged. After that, the voltage *decreases*, which indicates to an intelligent charger that the battery is fully charged. Such chargers are often labeled as a ΔV, or "delta-V," charger, indicating that they monitor the voltage change. However, the magnitude of "delta-V" can become small or even nonexistant if (very) high capacity rechargable batteries are recharged. This can cause even an intelligent battey charger to not sense that the batteries are actually already fully charged, and continue charging. Overcharging of the batteries result. A typical intelligent charger fast-charges a battery up to about 85% of its maximum capacity in less than an hour, then switches to trickle charging, which takes several hours to top off the battery to its full capacity.

Fast chargers make use of control circuitry in the batteries being charged to rapidly charge the batteries without damaging the cells' elements. Most 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. Some fast chargers, such as those made by Energizer, can fast-charge any NiMH battery even if it does not have the control circuit.

Inductive battery chargers use electromagnetic induction to charge batteries. A charging station sends electromagnetic energy through inductive coupling to an electrical device, which stores the energy in the batteries. This is achieved without the need for metal contacts between the charger and the battery. It is commonly used in electric toothbrushes and other devices used in bathrooms. Because there are no open electrical contacts, there is no risk of electrocution.

Since the Universal Serial Bus specification provides for a five-volt power supply, it's possible to use a USB cable as a power source for recharging batteries. Products based on this approach include chargers designed to charge standard NiMH cells, and custom NiMH batteries with built-in USB plugs and circuitry which eliminate the need for a separate charger. Moixa Energy patented a design of batteries, branded USBCELL, that incorporate their own USB chargers internally, complete with their own plugs. In the currently available AA battery design, the positive end of the battery doubles as a flip-cap for the built-in USB plug.

### 2.1.3 Charge rate

The charge rate of battery charger is often denoted as *C* and signifies a charge or discharge rate equal to the capacity of a battery divided by 1 hour. For example *C* for a 1600 mAh battery would be 1600 mA (or 1.6 amps). 2*C* is twice this rate and 1/2*C* is half the rate.

### 2.1.4 Applications

The battery charger mainly is used widely in 3 categories, as a mobile phone charger, Battery charger for vehicles, and Battery electric vehicle.

Most mobile phone chargers are not really chargers, only adapters that provide a power source for the charging circuitry which is almost always contained within the mobile phone. Mobile phones can usually accept relatively wide range of voltages' as long as it is sufficiently above the phone battery's voltage. However, if the voltage is too high, it can damage the phone. Mostly, the voltage is 5 volts or slightly higher, but it can sometimes vary up to 12 volts when the power source is not loaded. Battery chargers for mobile phones and other devices are notable in that they come in a wide variety of DC connector-styles and voltages, most of which are not compatible with other manufactuers' phones or even different models of phones from a single manufacturer. Users of publicly accessible charging kiosks must be able to cross-reference connectors with device brands/models and individual charge parameters and thus ensure delivery of the correct charge for their mobile device. A database-driven system is one solution, and is being incorporated into some of the latest designs of charging kiosks.

The Ionhub charger can simultaneously charge several electronic devices: iPod Nano, Razr, Nintendo DS Lite, BlackBerry, portable DVD player, and electric shaver.

There are also human-powered chargers sold on the market, which typically consists of a dynamo powered by a hand crank and extension cords. There are also solar chargers.

China and other countries are making a national standard on mobile phone chargers using the USB standard.

## 2.2 Battery Definition

Battery or voltaic cell is a combination of one or more electrochemical Galvanic cells which store chemical energy that can be converted into electric potential energy, creating electricity. Since the invention of the first Voltaic pile in 1800 by Alessandro Volta, the battery has become a common power source for many household and industrial applications, and a multi-billion dollar industry. The name "battery" was coined by Benjamin Franklin for an arrangement of multiple Leyden jars (an early type of capacitor) after a battery of cannons. Common usage has evolved to include a single electrical cell in the definition [1]

### 2.2.1 AA Battery

AA Battery is a dry cell-type battery commonly used in portable electronic devices. The AA battery type was standardized by ANSI in 1947, and is designated E91 by DIN and AM3 by JIS. Internationally the IEC designated it as LR6 (alkaline), R6 (carbon-zinc), KR157/51 (nickel-cadium), HR6 (nickel-metal-hydride), and FR6 (lithium-iron-disulfide). Other names include MN1500 and HP7. In France it's known colloquially as Mignon. An AA battery is composed of a single electrochemical cell.

### 2.2.2 Rechargeable AA Battery

The capacity of rechargeable AA batteries varies with the technology used. Nickel-cadmium (NiCd or NiCad) AAs with a capacity of 650 to 800 mAh are commonly available, while 800 to 1100 mAh AA types are rarer and more expensive. Nickel-metal hydride (NiMH) AAs are also available in various capacities ranging from 1300 to 2900 mAh.

AA rechargeable batteries supply 1.2 Volts, and as such, there can be problems powering some devices. For instance, a device powered by 4 AA batteries uses 6 Volts, but when powered from rechargebles the voltage will be 4.8 V, which may not be in the normal operating range. Some devices include warnings not to be used with rechargeable batteries.

The older NiCd battery chemistry can supply a higher current than typical NiMHs, so NiCds are commonly used to power model cars or other relatively high-current-draw devices. New NiMH AAs designed for high current applications are beginning to become available. These use different construction and have lower capacity (1400–1600 mAh) than the highest capacity NiMH batteries. Newer forms, low self-discharge NiMH batteries, are sold pre-charged and ready for use.

Rechargeable AA-sized batteries based on Li-ion chemistry have also been introduced. These batteries do not supply voltage in the 1.2–1.5 V range and are thus not compatible with most AA-based devices.

### 2.2.3 How Batteries Work

A battery is a device that converts chemical energy directly to electrical energy. It consists of one or more voltaic cells. Each voltaic cell consists of two half cells connected in series by a conductive electrolyte. One half-cell is the negative electrode (the cathode) and the other is the positive electrode (the anode). In the redox reaction that powers the battery, reduction occurs in the cathode, while oxidation occurs in the anode. The electrodes do not touch each other but are electrically connected by the electrolyte, which can be either solid or liquid. In many cells, the materials are enclosed in a container, and a separator, which is porous to the electrolyte, which prevents the electrodes from coming into contact.

Each half cell has an electromotive force (or emf), determined by its ability to drive electric current from the interior to the exterior of the cell. The net emf of the battery is the difference between the emfs of its half-cells, as first recognized by Volta.

Thus, if the electrodes have emfs and , then the net emf is ; in other words, the net emf is difference between the reduction potentials of the half-reactions.

The electrical potential difference, or across the terminals of a battery is known as *terminal voltage* and is measured in volts. The terminal voltage of a battery that is neither charging nor discharging is called the open-circuit voltage and equals the emf of the battery. Because of internal resistance, the terminal voltage of a battery that is discharging is smaller in magnitude than the open-circuit voltage and the terminal voltage of a battery that is charging exceeds the open-circuit voltage. An ideal battery has negligible internal resistance, so it would maintain a constant terminal voltage of until exhausted, then dropping to zero. If such a battery maintained 1.5 volts and stored a charge of one Coulomb than it would perform 1.5 Joule of work. In practical batteries, the internal resistance will increase as it is discharged, and the open circuit voltage will also decrease as the cell is discharged. If the voltage and resistance are plotted against time the resulting graphs will typically not be a straight line, and the shape of the curve will vary with the chemistry and internal arrangement employed.

The voltage developed across a cell's terminals depends on the chemicals used in it and their respective concentrations. For example, alkaline and carbon-zinc cells both measure approximately 1.5 volts, due to the energy release of the associated chemical reactions. Because of the high electrochemical potential changes in the reactions of lithium compounds, lithium cells can provide as much as 3 volts or more.

### 2.2.4 Types of batteries

There are many kinds of electrochemical cells, including galvanic cells, electrolytic cells, fuel cells, flow cells and voltaic piles.[2] A battery's characteristics may vary due to many factors including internal chemistry, current drain and temperature.

However, there are two main types of batteries, each of which has its own advantages and disadvantages. [3]

- *Primary* batteries irreversibly (within limits of practicality) transform chemical energy to electrical energy. When the initial supply of reactants is exhausted, energy cannot be readily restored to the battery by electrical means.
- *Secondary* batteries can be recharged; that is, they can have their chemical reactions reversed by supplying electrical energy to the cell, restoring their original composition.

Historically, some types of primary batteries used, for example, for telegraph circuits, were restored to operation by replacing the components of the battery consumed by the chemical reaction. Secondary batteries are not indefinitely rechargeable due to dissipation of the active materials, loss of electrolyte and internal corrosion.

Primary batteries are ready to produce current as soon as they are assembled. Disposable batteries, also called *primary cells*, are intended to be used once and discarded. These are most commonly used in portable devices that have low current drain, are only used intermittently, or are used well away from an alternative power source, such as in alarm and communication circuits where other electric power is only intermittently available. Primary cells cannot be reliably recharged, since the chemical reactions are not easily reversible and active materials may not return to their original forms. Battery manufacturers recommend against attempting recharging primary cells.[32]

Common types of disposable batteries include zinc-carbon batteries and alkaline batteries. Generally, these have higher energy densities than rechargeable batteries, but disposable batteries do not fare well under high-drain applications with loads under 75 ohms (75 Ω).

Most types of secondary batteries must be charged before use; they are usually assembled with active materials in the discharged state. A very few types are manufactured in the charged state. For example, the lithium type batteries are manufactured fully charged. When discharged, rechargeable batteries or *secondary cells* can be recharged by applying electrical current, which reverses the chemical reactions that occur during its discharge. Devices to supply the appropriate current are called chargers or rechargers.

The oldest form of rechargeable battery is the lead-acid battery, a type of wet cell. Traditionally, this battery is notable in that it contains a liquid in an unsealed container, requiring that the battery be kept upright and the area be well ventilated to ensure safe dispersal of the hydrogen gas produced by these batteries during overcharging. The lead-acid battery is also very heavy for the amount of electrical energy it can supply. Despite this, its low manufacturing cost and its high surge current levels make its use common where a large capacity (over approximately 10Ah) is required or where the weight and ease of handling are not concerns. Modern sealed versions of this type of battery are available that can be discharged, but not necessarily charged, in any orientation.

A common form of the lead-acid battery is the modern car battery, which can generally deliver a peak current of 450 amperes. An improved type of liquid electrolyte battery is the sealed valve regulated lead acid (VRLA) battery, popular in the automotive industry as a replacement for the lead-acid wet cell. The VRLA battery uses an immobilized sulfuric acid electrolyte, reducing the chance of leakage and extending shelf life. VRLA batteries have the electrolyte immobilized, usually by one of two means:

- *Gel batteries* (or "gel cell") contain a semi-solid electrolyte to prevent spillage.
- *Absorbed Glass Mat* (AGM) batteries absorb the electrolyte in a special fiberglass matting

Other portable rechargeable batteries include several "dry cell" types, which are sealed units and are therefore useful in appliances such as mobile phones and laptop computers. Cells of this type (in order of increasing power density and cost) include nickel-cadmium (NiCd), nickel hydrogen, (NIH2) nickel metal hydride (NiMH) and lithium-ion (Li-ion) cells. By far, Li-ion has the highest share of the terrestrial dry cell rechargeable market. Meanwhile, NiMH has replaced NiCd in most applications due to its higher capacity, but NiCd remains in use in power tools, two-way radios, and medical equipment.

Recent developments include batteries with embedded functionality such as USBCELL, with a built-in charger and USB connector within the AA format, enabling the battery to be charged by plugging into a USB port without a charger, and low self-discharge (LSD) mix chemistries such as Hybrio, ReCyko, and Eneloop, where cells are precharged prior to shipping.

### 2.2.5 Battery Capacity and Discharging

The more electrolyte and electrode material there is in the cell, the greater the capacity of the cell. Thus a small cell has less capacity than a larger cell, given the same chemistry (e.g. alkaline cells), though they develop the same open-circuit voltage.

Because of the chemical reactions within the cells, the capacity of a battery depends on the discharge conditions such as the magnitude of the current, the duration of the current, the allowable terminal voltage of the battery, temperature and other factors. The available capacity of a battery depends upon the rate at which it is discharged. If a battery is discharged at a relatively high rate, the available capacity will be lower than expected.

The battery capacity that battery manufacturers print on a battery is the product of 20 hours multiplied by the maximum constant current that a new battery can supply for 20 hours at 68 F° (20 C°), down to a predetermined terminal voltage per cell. A battery rated at 100 A·h will deliver 5 A over a 20 hour period at room temperature. However, if it is instead discharged at 50 A, it will run out of charge before the 2 hours as theoretically expected.

The symbol for a battery in a circuit diagram.

For this reason, a battery capacity rating is always related to an expected discharge duration.

$$T = \frac{Q}{I} \text{ ......................................... (1)}$$

where

$Q$ is the battery capacity (typically given in mA·h).

$I$ is the current drawn from battery (mA).

$t$ is the amount of time (in hours) that a battery can sustain.

The relationship between current, discharge time, and capacity for a lead acid battery is expressed by Peukert's law. Theoretically, a battery should provide the same amount of energy regardless of the discharge rate, but in real batteries, internal energy losses cause the efficiency of a battery to vary at different discharge rates. When discharging at low rate, the battery's energy is delivered more efficiently than at higher discharge rates.

In general, the higher the ampere-hour rating, the longer the battery will last for a certain load. Installing batteries with different A·h ratings will not affect the operation of a device rated for a specific voltage unless the load limits of the battery are exceeded. Theoretically, a battery would operate at its A·h rating, but realistically, high-drain loads like digital cameras can result in lower actual energy, most notably for alkaline batteries. For example, a battery rated at 2000 mA·h may not sustain a current of 1 A for the full two hours.

### 2.2.6 Life of rechargeable batteries

Rechargeable batteries traditionally self-discharge more rapidly than disposable alkaline batteries; up to three percent a day (depending on temperature). However, modern lithium designs have reduced the self-discharge rate to a relatively low level (but still poorer than for primary batteries). Due to their poor shelf life, rechargeable batteries should not be stored and then relied upon to power flashlights or radios in an emergency. For this reason, it is a good idea to keep alkaline batteries on hand. NiCd Batteries are almost always discharged when purchased, and must be charged before first use.

Although rechargeable batteries may be refreshed by charging, they still suffer degradation through usage. Low-capacity nickel metal hydride (NiMH) batteries (1700-2000 mA·h) can be charged for about 1000 cycles, whereas high capacity NiMH batteries (above 2500 mA·h) can be charged for about 500 cycles. Nickel cadmium (NiCd) batteries tend to be rated for 1,000 cycles before their internal resistance increases beyond usable values. Normally a fast charge, rather than a slow overnight charge, will result in a shorter battery lifespan. However, if the overnight charger is not "smart" (i.e. it cannot detect when the battery is fully charged), then overcharging is likely, which will damage the battery. Degradation usually occurs because electrolyte migrates away from the electrodes or because active material falls off the electrodes. NiCd batteries suffer the drawback that they should be fully discharged before recharge. Without full discharge, crystals may build up on the electrodes, thus decreasing the active surface area and increasing internal resistance. This decreases battery capacity and causes the dreaded "memory effect". These electrode crystals can also penetrate the electrolyte separator, thereby causing shorts. NiMH, although similar in chemistry, does not suffer from "memory effect" to quite this extent. When a battery reaches the end of its lifetime, it will not suddenly lose all of its capacity; rather, its capacity will gradually decrease.

Automotive lead-acid rechargeable batteries have a much harder life. Because of vibration, shock, heat, cold, and sulfation of their lead plates, few automotive batteries last beyond six years of regular use. Automotive starting batteries have many thin plates to provide as much current as possible in a reasonably small package. Typically they are only drained a small amount before recharge. Care should be taken to avoid deep discharging a starting battery, since each charge and discharge cycle causes active material to be shed from the plates. Hole formation in the plates leads to less surface area for the current-producing chemical reactions, resulting in less available current when under load. Leaving a lead-acid battery in a deeply discharged state for any significant length of time allows the lead sulfate to crystallize, making it difficult or impossible to remove during the charging process. This can result in a permanent reduction in the available plate surface, and therefore reduced current output and energy capacity.

"Deep-Cycle" lead-acid batteries such as those used in electric golf carts have much thicker plates to aid their longevity. The main benefit of the lead-acid battery is its low cost; the main drawbacks are its large size and weight for a given capacity and voltage. Lead-acid batteries should never be discharged to below 20% of their full capacity, because internal resistance will cause heat and damage when they are recharged. Deep-cycle lead-acid systems often use a low-charge warning light or a low-charge power cut-off switch to prevent the type of damage that will shorten the battery's life.

Special "reserve" batteries intended for long storage in emergency equipment or munitions keep the electrolyte of the battery separate from the plates until the battery is activated, allowing the cells to be filled with the electrolyte. Shelf times for such batteries can be years or decades. However, their construction is more expensive than more common forms.

## 2.3 Buzzer Circuit

### 2.3.1 General Definition

A buzzer or beeper is a signalling device, usually electronic, typically used in automobiles, household appliances such as a microwave oven, or game shows. It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise).

Often these units were anchored to a wall or ceiling and used the ceiling or wall as a sounding board. Another implementation with some AC-connected devices was to implement a circuit to make the AC current into a noise loud enough to drive a loudspeaker and hook this circuit up to a cheap 8-ohm speaker. Nowadays, it is more popular to use a ceramic-based piezoelectric sounder like a Sonalert which makes a high-pitched tone. Usually these were hooked up to "driver" circuits which varied the pitch of the sound or pulsed the sound on and off.

In game shows it is also known as a "lockout system," because when one person signals ("buzzes in"), all others are locked out from signalling. Several game shows have large buzzer buttons which are identified as "plungers". The word "buzzer" comes from the rasping noise that buzzers made when they were electromechanical devices, operated from stepped-down AC line voltage at 50 or 60 cycles. Other sounds commonly used to indicate that a button has been pressed are a ring or a beep.

## 2.4 Power Supply Circuit

### 2.4.1 General Definition

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This is the chapter that will present the overall methodology, flow of operation and principles or work of the battery charger. The main focuses of the project is during the interfacing of the buzzer circuit with the battery voltage value so that it can be operates when the battery is already fully-charged.

## 3.2 Methodology

As the project doesn't use any PIC, the circuit will operate bases on relay operation. There are several steps that need to be done first so that it can perform according to the specifications. Firstly, the 'decision maker' in the circuit is LM 324. Thus, we must interfacing with the input voltage. Secondly, interfacing with the output of LM 324 so that it could activate the buzzer and thirdly, interfacing with the relay so that the charging process is stopped after the buzzer operates.

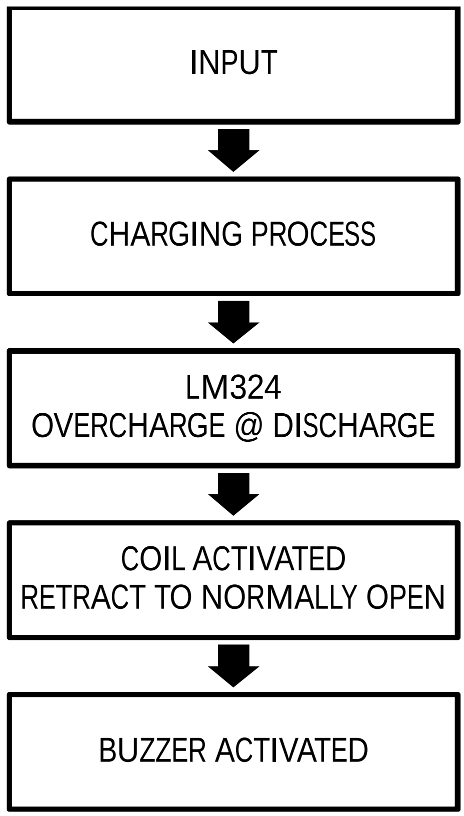


**Figure 1:** The Flow Chart for whole process

Figure 1 shows the whole process of the project. It is consist only one flow of working principles. Firstly, the circuit receives an input from the power supply. During this time, the charging process is started. In this project, the charging process is focus more on AA batteries. The heart of the circuit located at LM324. It is the segment that controlling the charging process of the whole circuit. 2 pins are required. First pin (pin 12) is for Upper Limit Set, while the second pin (pin 9) is for lower limit set. This both pin sending the signal as a reference value. The upper limit send an information that the batteries is overcharged while the lower limit send the information about batteries deep discharge. Both of them are controlled by a potentiometer.

### 3.2.1 Development of Charger Circuit

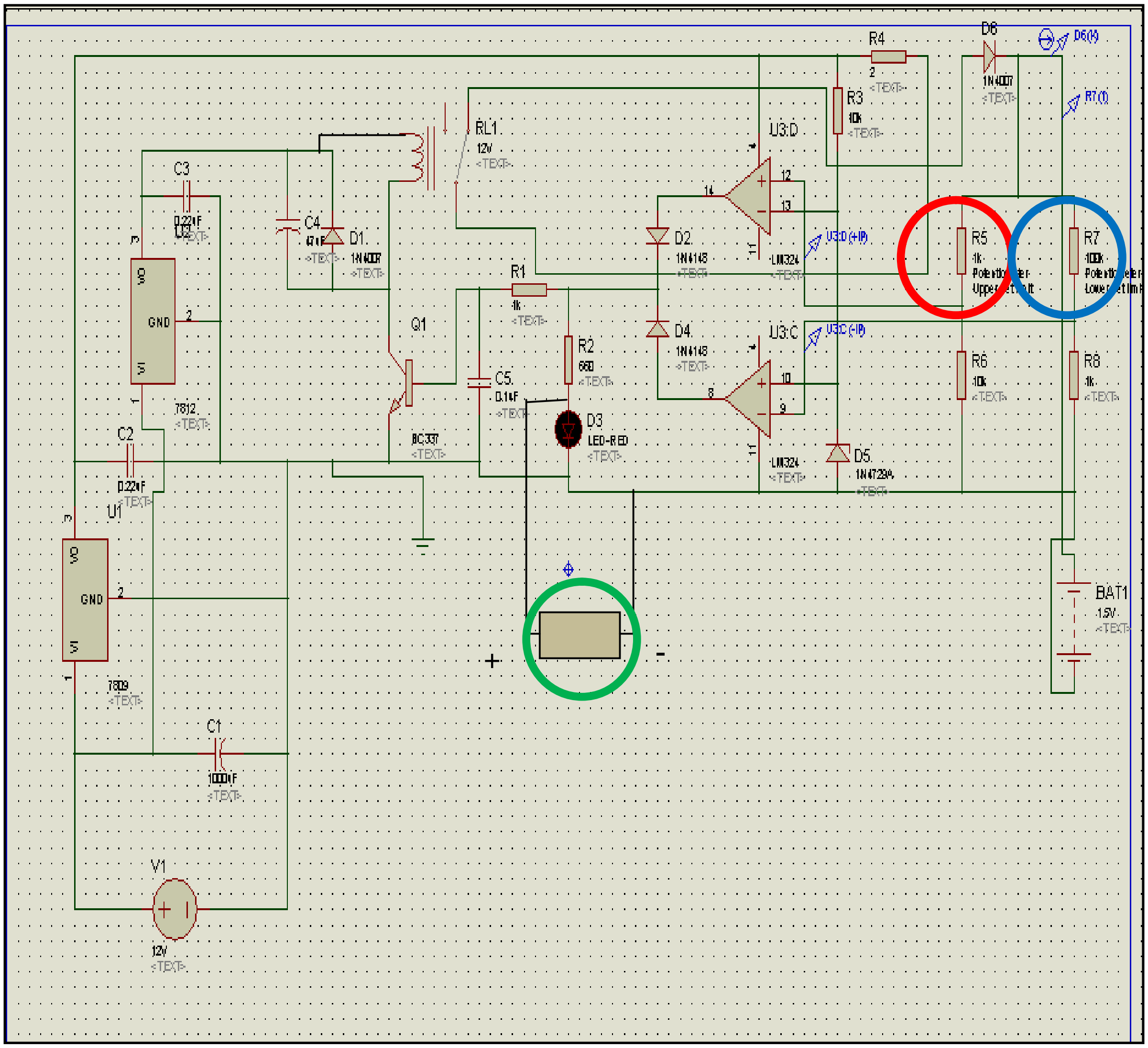


**Figure 2:** Charger circuit diagram

LEGEND:

Blue marker represents Lower Set Limit

Red Marker represents Upper Set Limit

Green Marker represents buzzer circuit

Figure 2 shows the circuit diagram of the charger. The diagram above is draw by using a proteus program. Other program like OrCAD PSpice can also be use. The basic Principle of operation is the battery charger used the LM 324 for activating the buzzer circuit. In the circuit, the buzzer circuit is connected in parallel with the red LED D3. It is a potentiometer that determined the voltage insert into the LM324 feet (No. 9 and 12). The potentiometer is representing by resistor R5 and R7. From Figure 2, the Red Marker represents the Upper Set Limit that determined the overload level of the battery. While the Blue Marker represents the Lower Set Limit of the Battery. The diagram of the circuit is shown in Figure 6 and Figure 7 at the end of this chapter.

The circuit power supply using from 240 V AC. It later feed into the regulator circuit. There are two regulators in the circuit, 9V and 12V. The regulator used is 7809 and 7812. Each of them has specific functions. The 7809 is used to supply 9V to the battery, while the 7812 is used to supply 12V to energize the relay. Be aware to put some heat sink for the regulator as it will become very hot during its operations. It is also a safety measures so that the circuit could operate longer.

**Figure 3:** Voltage Regulator

The function of the Blue Marker is to detect the lower set limit of the Battery. In the diagram, it is shown as a resistance. But, it is actually a 100kΩ potentiometer. The value of its resistance can be change so it can serve to set the lower limit of the battery. In this circuit, it is fixed at 100kΩ. During this stage, if the voltage across the battery is 0V, LM324 will activate the buzzer. Thus, if the Charger is idle or the charging process is disturb midway, buzzer will automatically operates. In Figure 7, the Lower Set limit is determined as the blue colored potentiometer.

The function of the red marker is to detect the upper limit of the battery. As its name imply, it is to detect a high voltage in the battery. It is also a 100kΩ potentiometer. The larger the value, the larger the voltage will be, for example the battery that being charge are two AA NiCd rechargeable battery. The voltage across the battery will be roughly 3V. Thus, the sets of the potentiometer must also have 3V of potential difference. When the cell potential difference rise above 3V, the voltage across the potentiometer will be rise as well, above 3.6 V, and the LM324 will activates and buzzer will operates.

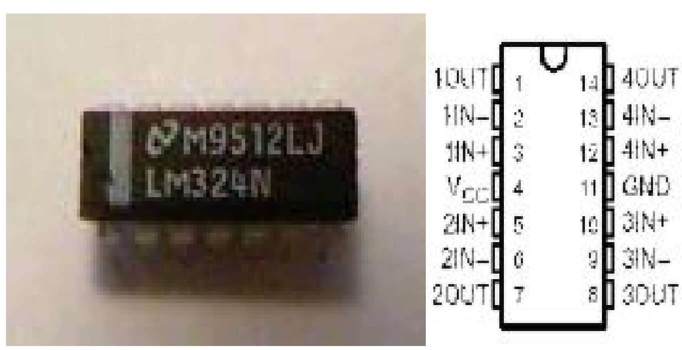


**Figure 4:** LM 324 and its circuit diagram

Hardware of the circuit can be seen in Figure 7. Be aware that the diagram is not exactly the same as the diagram as there are some features that do not included in the pictures of Figure 5. For example, switch is not included in the diagram. It is connected series into the battery. The switch is functions to switch off/on the charge process.

### 3.2.2 Development of Buzzer Circuit

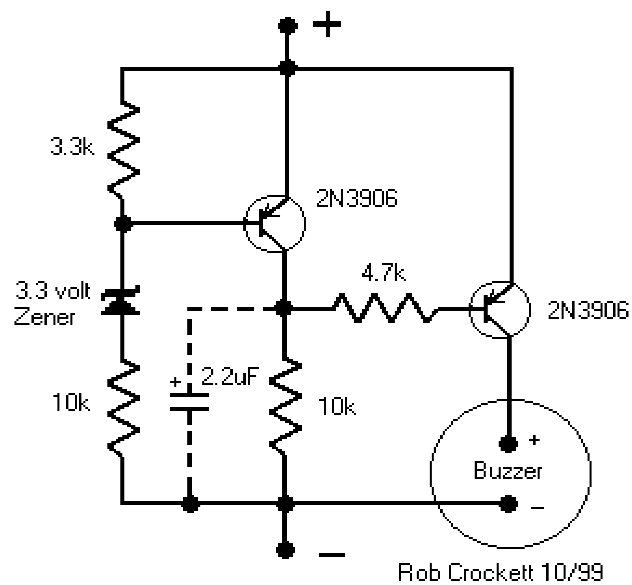


**Figure 5:** Buzzer circuit diagram

Figure 5 shows the diagram of the buzzer circuit. The reference voltage is the 3.3V zener diode. The circuit used the concept of voltage tracing device, thus it can trace a voltage in 3.3V interval. The buzzer will operate when the relay activates. In this project, the buzzer is connected parallel with the red diode. But, it is also can be connected series with the parallel, as the diode does not make either a difference in operation of the buzzer or safety measures. It only serves a signal to determined that the circuit is actually works.

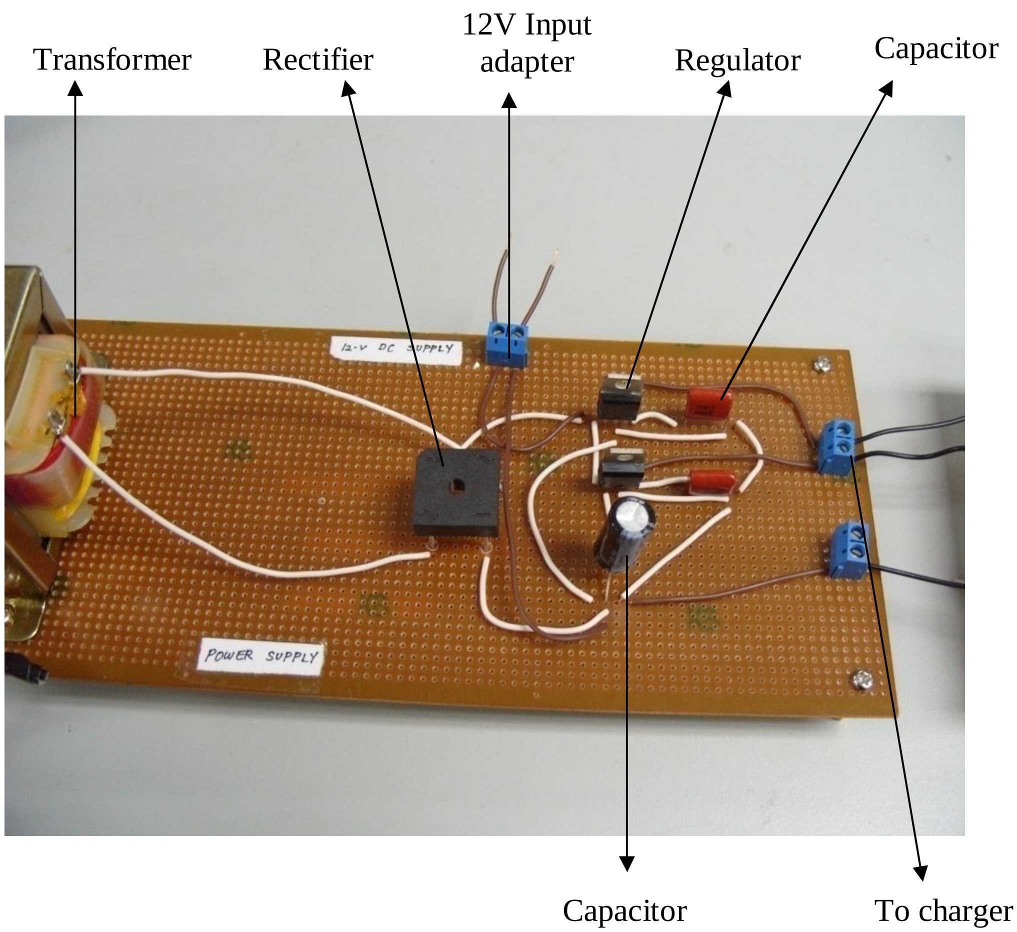


**Figure 6:** Power supply circuit

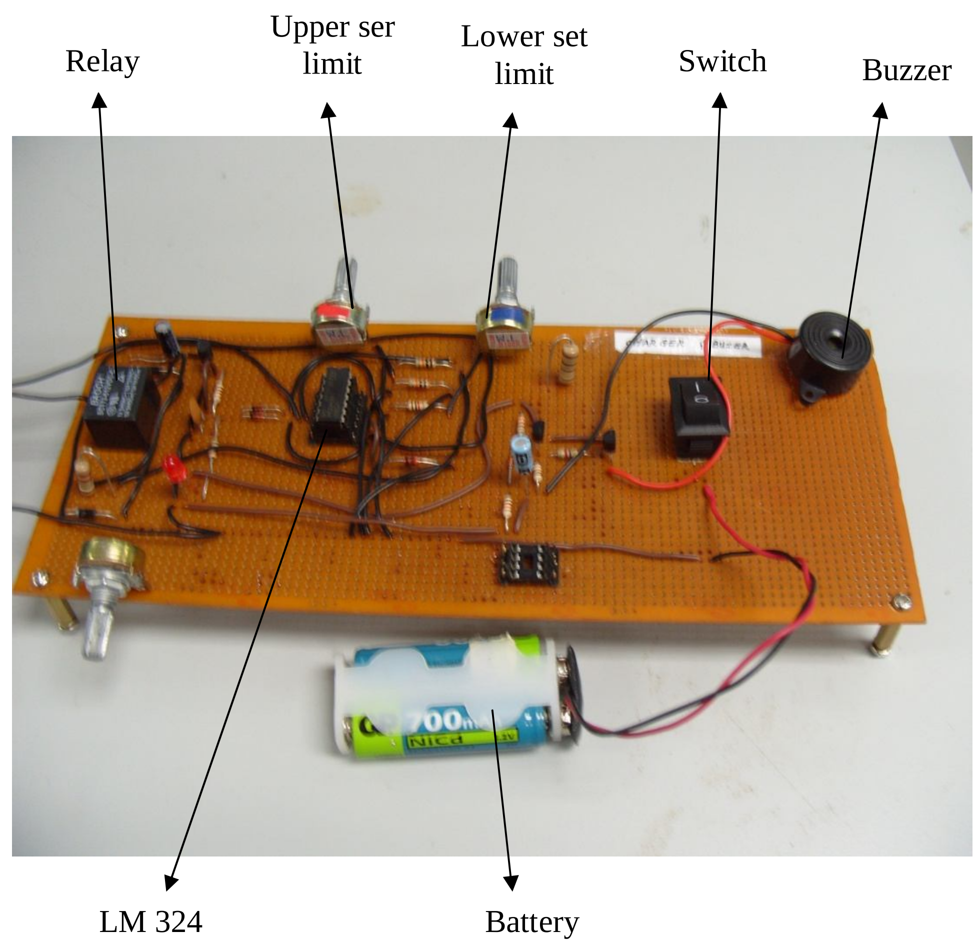


**Figure 7:** Charger circuit

# CHAPTER 4

# RESULT DISCUSSION

## 4.1 Introduction

This chapter emphasizes the result that has been gain after the project is successfully simulated. The result presentation can be divided into 2 parts, the expected data and result data. The expected data is based on theory and guide as a reference to see that the result is actually true. While the results is determined to prove the theory and to see the hardware can operates perfectly. The project problems and solution are also included in this chapter.

## 4.2 Expected Data

The profile of the data can be determined theorically by the Table 1:-

**Table 1:** The Cell type with its charge time

| CELL TYPE | CHARGE TIME |
|---|---|
| 700mAh NiCd | 1.5h |
| 1100mAh NiCd | 2.5h |
| 1600mAh NiMH | 3.5h |
| 2000mAh NiMH | 4.5h |
| 2500mAh NiMH | 5.5h |

From Table 1, there are differences between the NiCd and NiMH battery. Firstly, the differences are in the charging time of the battery. The charging time of the battery is largely affected by the current inside the battery, the higher the current, the longer its get to charge the battery. And it is must be known that the current value does not affect the current that being supply to the battery during the charging process. It is because, during charging process, the cell does not emit any battery current but it is received the current from the outside. The current that being supply to the battery in the table are around 0.9 A. So, theorically if the supply current is lower than that, the charging time is longer.

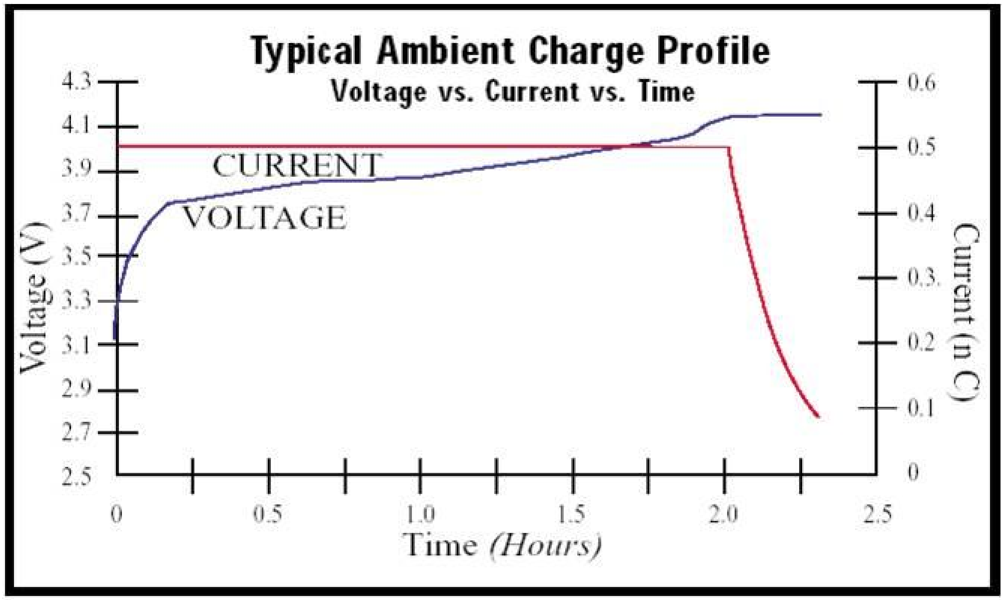


**Figure 8:** Charging profile until the cell is overload

Figure 8 above shows the typical ambient charge profile. This process occurs when the battery is being charged. The voltage inside the battery will slowly increase until it will reach a certain point where it is not increase anymore. The battery is already overcharged and the current will drop means that the charge is stopped.

## 4.3 Result data

This segment emphasizes the result part:-

**Table 2**: Data receive from charging process

| TIME | BATTERY VOLTAGE |
|---|---|
| 9.00 PM | 1.23 V |
| 9.30 PM | 2.82 V |
| 10.00 PM | 2.99 V |
| 10.30 PM | 3.05 V |

Table 2 shows the charge time a voltage of the battery, during the process, the battery that being used is NiCd 700mA. According to the theory, it takes about 1 hour and 30 minutes for it to fully charge. And the result shows almost accurate according to the theory. It has proved the theory. The battery started at 1.23V at 9 PM, there are 2 AA cells. And in its full discharge, a single cell value about 0.7V. The voltage increase until I is almost full load at 3.05V. One single battery in its operated condition is about 1.2V ~1.4 V. Thus, after it is already full load, the buzzer operates.

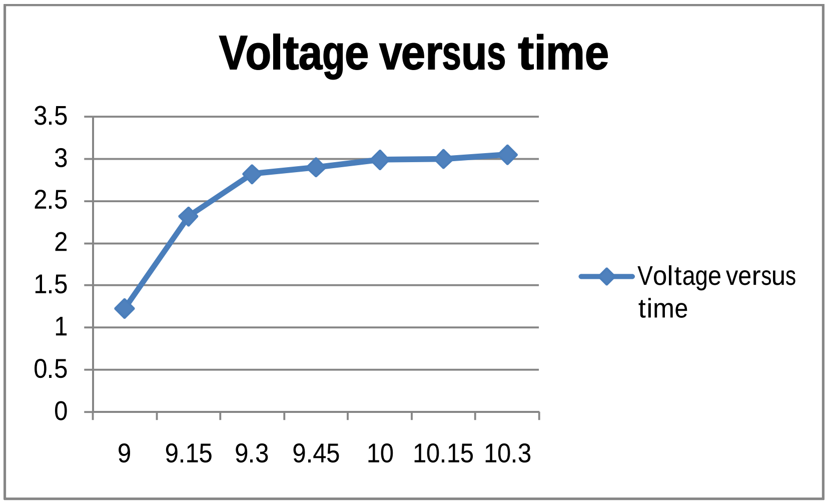


**Figure 9:** Voltage vs time graph

Figure 9 shows the voltage vs time graph. It is almost the same as in theory graph in Figure 8. During this experiment is done, there are two cell AA NiCd. During discharge state, the potential difference in the battery is only around 0.7V. With two cells, the values double to almost 1.4V. In the beginning, the voltage increases fast. But, it is later get slower. The rate will eventually stopped increases. The battery is in full charge during its potential difference value at 1.5V.

## 4.4 Project problems and Solutions

The project also suffers from some problems along the way. The project problems are presented here along with the way to overcome it. Most of the problems occur was a minor problem that can be overcome easily.

It is very irony to hear what functions of the charger if it's cannot charge the battery. But this is the fact that occurs during the first phase of the project. After it's complete for the first time, the charger is not working. The problems arise because of the relay is energize right after the switch is on. And because of that, the diode operates. During this time, the buzzer circuit still not implemented to the circuit. The problem is cause by wiring error. The wire that leads to the battery is not connected makes the currents is not connected and makes the voltage around it 0V. To the first problem is solve by rewiring the error part.

After the circuit can finally charge, the buzzer is installed to the circuit. The circuit is not an original design but rather a developed design where some of the features have been changes. The circuit is connected to 4 white LED where it is parallel to the battery connection wire. This is where the buzzer circuit is connected for the first time, when the circuit charge, the potential difference around the battery, even though it still not finished. The buzzer original circuit is design as Low voltage detector. In this case, it has been developed to detect a fully load battery detector. It has been proved that the buzzer can't be put parallel with the battery. Thus, the solution for the second problem is solve by connecting it in series with the relay and it will operates when the relay is activates.

The third problems arise after the second problem solved. After some reconstruction of the circuit, the charging circuit becomes to slow, its takes about 1 hour to just rise the cell potential difference to just 0.1V. The voltage is not 0V and the circuit is still working perfectly due to the fact the buzzer not operates, thus make the searching for the error is completely hard. The problem is caused by a short circuit. There is one connection from the battery that connected straight to the ground, makes the charger completely inoperable. The problem is solved after the wire is cut.

# CHAPTER 5

# CONCLUSIONS AND RECOMMENDATION

## 5.1 Conclusions

The design and development of the circuit has been implemented on charging process. All the system including the charger and buzzer circuit is working perfectly. From the project it can be conclude that the buzzer can operates when the battery already fully charged. It can be operates by implement in to circuit that can send signal of overcharge voltage, In this case, the potentiometer and LM324. The battery used is 2 AA NiCd with operable voltage of 1.2 V respectively. Thus, the buzzer operates after the potential difference reach above 3V.

## 5.2 Future Recommendations

For future recommendation, it is advisable other features to be added or improve especially the buzzer signal. We can actually give it a more interesting signal like producing sound “fully charged”. From today technology, we can actually use a IC to developed programmed sound and it can be emitted by suitable program. Other than that, as it is an alarm application, we also can used it to other applications. For example, alarm clock with battery charger application. Or it can also be connected to the LCD screen to detect the potential difference value

**5.3 Costing and Commercializing**

The cost of this project is very economic and has a huge potential to be commercialize. The current battery charger in the market was almost up to RM100 without any other additional features. Even with some additional features, charger equipped with alarm is still a rare breed. This newly developed circuit was only costing half of the price, only about RM50 equipped with buzzer signal. Also, when it is mass produce, the cost is expected to be reduced.

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# APPENDIX



National Semiconductor

August 2000

## LM124/LM224/LM324/LM2902 Low Power Quad Operational Amplifiers

### General Description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

### Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage
- The unity gain cross frequency is temperature compensated
- The input bias current is also temperature compensated

### Advantages

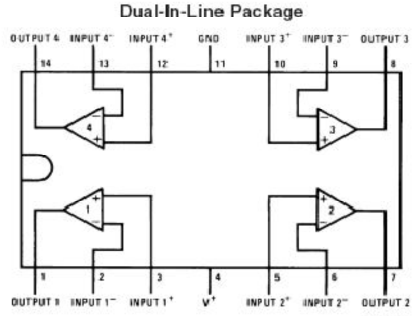
- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and $V_{OUT}$ also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

### Features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range:
  Single supply 3V to 32V
  or dual supplies ±1.5V to ±16V
- Very low supply current drain (700 µA)—essentially independent of supply voltage
- Low input biasing current 45 nA (temperature compensated)
- Low input offset voltage 2 mV and offset current: 5 nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0V to $V^+ - 1.5V$

### Connection Diagrams

Dual-In-Line Package




Top View

**Order Number LM124J, LM124AJ, LM124J/883** (Note 2), **LM124AJ/883** (Note 1), **LM224J, LM224AJ, LM324J, LM324M, LM324MX, LM324AM, LM324AMX, LM2902M, LM2902MX, LM324N, LM324AN, LM324MT, LM324MTX or LM2902N LM124AJRQML and LM124AJRQMLV**(Note 3)
**See NS Package Number J14A, M14A or N14A**

tyco Electronics — General Purpose Relays — SCHRACK

# Miniature Relay PT

- 2 pole 12 A, 3 pole 10 A or 4 pole 6 A, 2, 3 or 4 CO contacts
- DC- or AC-coil
- Switching performance up to 3000 VA
- Relay height 29 mm
- Mechanical and electrical indicator
- Manual test tab, optionally lockable.
- White marking tabs
- RoHS compliant (Directive 2002/95/EC)

**Applications**

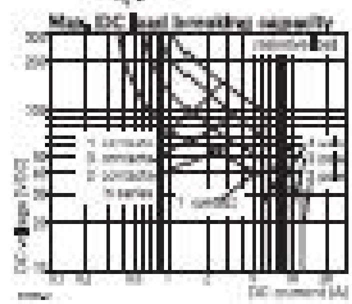
Universal use in control and automation

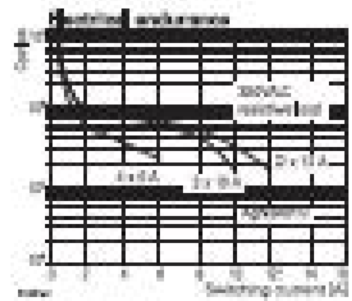
**Approvals**

REG.-Nr. [illegible], [illegible], [illegible]

Technical data of approved types on request.

| Contact data | PT2 | PT3 | PT5 |
|---|---|---|---|
| Contact configuration | 2 CO | 3 CO | 4 CO |
| Contact set | | single contact | |
| Type of interruption | | micro disconnection | |
| Rated current | 12 A | 10 A | 6 A |
| Rated voltage / max. switching voltage AC | 240/400 VAC | 240/400 VAC | 240/400 VAC |
| Maximum breaking capacity AC | 3000 VA | 2500 VA | 1500 VA |
| Limiting making capacity max. 20 ms | [illegible] | [illegible] | [illegible] |
| Contact material | | AgNi90/10, AgNi90/10 gold plated | |
| Minimum contact load | | [illegible] | |
| Mechanical endurance DC coil | | $20x10^6$ cycles | |
| AC coil | | $20x10^6$ cycles | |
| Rated frequency of operation with / without load | | [illegible] | |





**Contact ratings**

| Type | Load | Cycles |
|---|---|---|
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KOBITONE™ AUDIO COMPANY

## Piezoelectric Buzzer

(Built-In Drive)

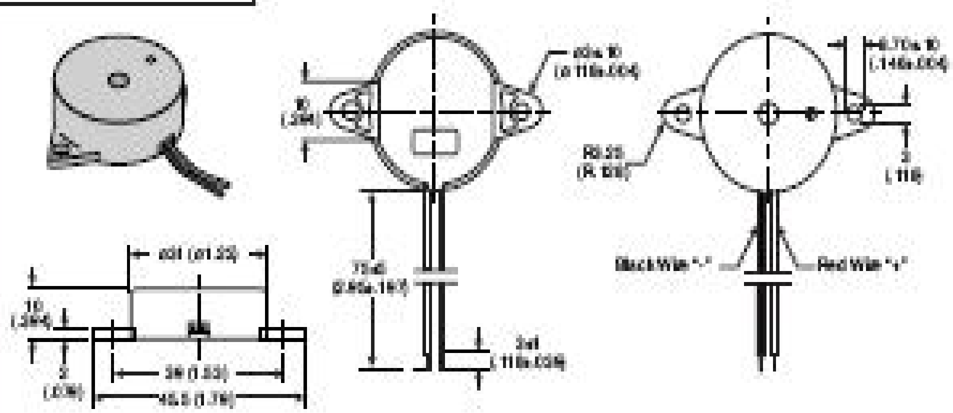
Date: 3/6/06

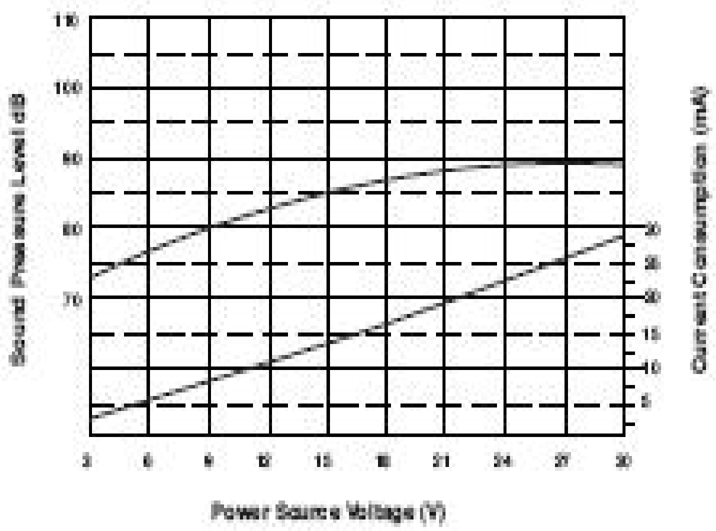
Dimensions: mm (in.)

**Part Number:**

254-PB511

Piezoelectric Buzzer (Built-In Drive)




KT-400142

**Electrical Specifications:**

- Sound Pressure Level: 80dB min./30cm./5VDC
- Oscillating Frequency: 2.5 ± 0.5KHz
- Current Consumption: 8mA max./5VDC
- Operating Voltage: 3 to 30VDC

**Mechanical Specifications:**

- Operating Temperature: -30°C to +70°C
- Storage Temperature: -40°C to +85°C

**Materials:**

- Tone: Continuous
- Case: PBT
- Lead Wire: UL1095 28AWG
- Weight: 7 grams