

A MOBILE SELF-POWERED BATTERY CHARGER

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ABSTRACT

The purpose of this project is to design and build a portable self-powered battery charger for the mobile phone which will overcome the demanding of battery power in a mobile phone especially during emergency. It will overcome the limitation of conventional mobile phone charger which required 240v a.c socket switch as source of electrical energy to charge mobile phone battery, which is only available at home or other premises. The portable self-powered battery charger use solar energy as an alternative way to obtain electrical energy to charge mobile phone battery. Thus, the charger can charge a mobile phone anywhere without having it to use a converter which has to be plugged to the 240V a.c socket switch. This project is fully hardware. A combination of step up DC to DC switching regulator circuit and high efficiency step up DC to DC controller has been used to accept a minimum of 0.7V output from solar cell and convert it to higher output voltage to charge a mobile phone battery.

ABSTRAK

Projek ini bertujuan untuk mereka bentuk dan membina sebuah pengecas bateri mudah alih berkuasa sendiri untuk telefon bimbit bagi mengatasi keperluan tenaga bateri di dalam sesebuah telefon bimbit terutamanya ketika masa kecemasan. Selain itu, ia akan mengatasi kebatasan pengecas telefon bimbit biasa yang memerlukan soket suis 240 a.u sebagai sumber tenaga elektrik untuk mengecas bateri telefon bimbit, yang hanya boleh didapati di rumah atau premis-premis lain. Pengecas bateri mudah alih berkuasa sendiri menggunakan tenaga suria sebagai jalan alternatif untuk menghasilkan tenaga elektrik untuk mengecas bateri telefon bimbit. Dengan itu, pengecas tersebut dapat mengecas di mana sahaja tanpa memerlukan ia untuk menggunakan pengubah yang disambungkan kepada soket suis 240V a.u. Projek ini adalah perkakasan sepenuhnya. Kombinasi litar pengatur pensuisan pengijak naik DC kepada DC dengan litar pengawal pengijak naik DC kepada DC kecekapan tinggi yg dapat menerima keluaran voltan serendah 0.7V dari panel suria dan mengubahnya kepada keluaran voltan yang lebih tinggi untuk mengecas bateri telefon bimbit.

CHAPTER I

INTRODUCTION

1.1 BACKGROUND

The primary power source for the majority of portable electronics today is the lithium-ion (Li-Ion) battery. Everything, from the iPod, mobile phones and digital cameras are now powered by standard single-cell Li-Ion batteries. Because of its high-energy density, it has become the power source of choice by portable electronic devices manufacturers. However, the limitation of the Li-Ion battery is that it needs to be recharged every time its energy runs out. The conventional charging device is a converter that is normally plugged directly into the a.c. supply which is only available at home or other premises.

Therefore “A Mobile Self-Powered Battery Charger” is a portable charging device that is designed to charge the mobile phone battery whenever it is needed, especially in an emergency situation. “A Mobile Self-Powered Battery Charger” operates by using available source surrounding our life to generate its own electricity and thus can be used to charge mobile phone batteries will be handy when the need arises. Therefore people can still move on with their daily activities while keeping their mobile phone powered.

1.2 PROBLEM STATEMENT

The problem statements regarding this project are:

- The usage of mobile phone is on the rise from time to time but it needs to be recharged whenever its battery power runs out.
- The conventional charging method in using the AC line voltage adapter (240V) and the source is only available at home or other premises.
- Method of charging Lithium-Ion batteries differs from other batteries such as Nickel Cadmium (NiCad)
- An alternate source needs to be identified to recharge Lithium-Ion battery.

1.3 PROJECT OBJECTIVES

Mobile phones are now a necessity to many people especially for those on the fast lane. Mobile phones need to be charged regularly and very often is done by the users at home before going to work or at the work place. In a situation when the user forgets to charge his mobile phone and has no access to any charging facility but critically in need to make a call, a portable self-powered battery charger will come handy. Therefore the objective of the project is to study and design a portable self-powered battery charger for the use of charging mobile phone battery.

1.4 SCOPE OF WORK

There are five main areas being identified that need to be worked out:

- Literature review to find out the various practical ways to generate electricity.
- Study the characteristic of charging Li-Ion batteries.
- Sourcing for suitable and practical circuits for the project.
- Develop a prototype to obtain the objectives of the project
- Conduct analysis and testing on the project
- Finally to conduct and verify the functionality of the end product.

1.5 PROJECT METHODOLOGY

In order to achieve the project objectives of the proposed project, the process listed below has to be considered. The entire point listed below is the process that has to be done from the beginning until the project is completed. The point listed below is the outline of the process, so if one of the processes cannot be fulfilled, the project may not be able to achieve its objectives as stated in the proposal.

❖ Project Planning

- Define & understand the project title
- Prepare Gantt Chart for guidelines and progress of project
- Brainstorming for the project proposal

❖ Literature Review

- Background reading and reference
- Search for suitable and practical circuits
- Source for related and relevant ideas and projects

❖ Building the Hardware

- Components and parts identification/specifications/procurement
- Design circuit boards and assembling
- Test, analyze and diagnose circuits

❖ Finishing

- Testing of prototype in operation, application and result
- Presentation on outcome of project
- Preparation and presentation of technical report

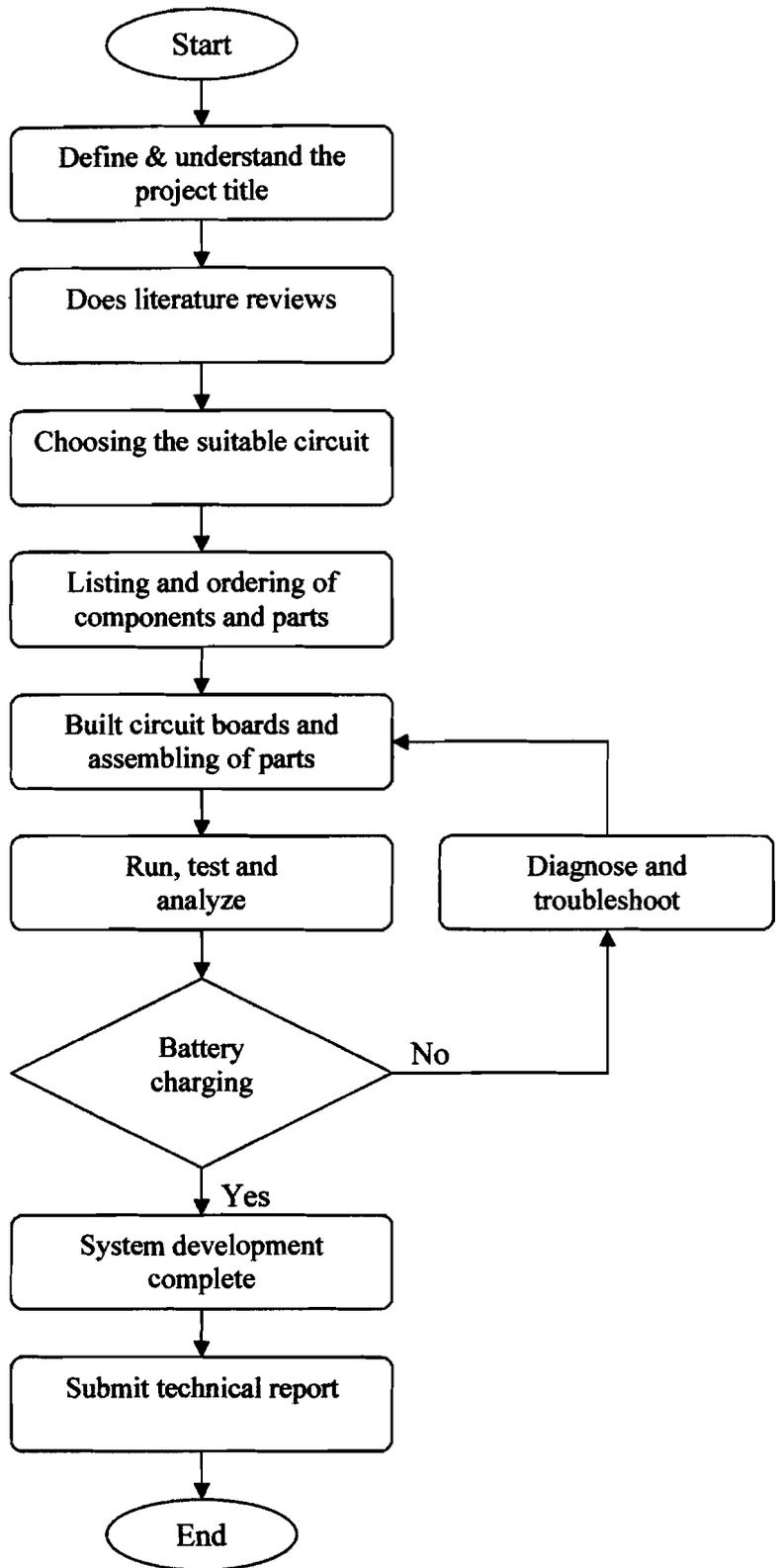


Figure 1.1: Process Flow Chart

1.6 REPORT STRUCTURE

Overall, this report is divided into seven chapters. Below is the summary of each chapter within this report:

➤ **CHAPTER I: INTRODUCTION**

This chapter will include the background of the project, objective of the project which needs to be achieved at the end of this project, problem statement of the project, all the necessary scope of work regarding the project and methodology of the project which is put in practice throughout this project.

➤ **CHAPTER II: LITERATURE REVIEW**

This chapter will explain the various sources of electrical energy and with their advantages and disadvantages.

➤ **CHAPTER III: LITHIUM ION BATTERY**

This chapter is about Lithium Ion battery which is widely used in portable devices. It focuses on the method of charging Lithium Ion battery and the Lithium battery pack characteristic.

➤ **CHAPTER IV: PHOTOVOLTAIC CELL**

This chapter briefly describes and explains on the Photovoltaic cell. It begins with the history of photovoltaic cell and its development to its anatomy and material, and finally the relationship between photovoltaic cell and light.

➤ **CHAPTER V: PROJECT METHODOLOGY**

This chapter will explain about the approach taken in order to achieve the objectives of the project and a closer look on how the project is implemented. Each achievement and selection taken when the project is implemented will be explained in detail for each stage until the project is successful.

➤ **CHAPTER VI: RESULT AND ANALYSIS**

This chapter describes the final outcome of this project and the analysis that have been done to justify its function and to make sure it meets the objectives of project.

➤ **CHAPTER VII: CONCLUSION AND SUGGESTIONS**

This chapter will conclude the project and how it can be improved for further development.

CHAPTER II

LITERATURE REVIEW

2.1 SOURCE OF ELECTRICAL ENERGY

Batteries and electrical generators are two major sources of electrical energy. Batteries convert chemical energy into electrical energy while electrical generators rely on the principle of electromagnetic induction to convert mechanical energy into electrical energy. There are also other sources of electrical energy such as light sources and heat sources. Some sources produce direct-current energy whereas others produce alternating-current energy.

2.2 LIGHT SOURCE

Light is a form of energy that is easily converted to electrical energy. Light energy is currently becoming very popular with environmentalists and those who would like to purchase portable sources of energy for their own use. The device used to convert light energy into electrical energy is called a photovoltaic cell or a solar cell. Despite the term, solar cells can convert not only light from the sun but also light from artificial sources such as light bulbs.

Solar cells produce direct current electricity from the sun's rays which can be used to power equipment or to recharge a battery. Many pocket calculators incorporate a solar cell. When more power is required than a single cell can deliver, cells are generally grouped together to form "PV modules" or solar panels that may in turn be arranged in arrays.

A solar cell, shown in Figure 1, is usually made of two layer of material; N and P. The electrical characteristic of these materials are altered by the addition of other elements called impurities. When solar cell is exposed to light, the two materials interact, producing an excess of electrons on one layer. A negative charge is thus developed. The other layer then has a deficiency of electrons or a positive charge. This imbalance in the electrons causes a difference of potential (voltage) between the two layers. The difference in potential depends on the amount of light falling on the cell. The voltage is used to cause current to flow through a load connected to the cell. Thus, light acts as a source of electrical energy.

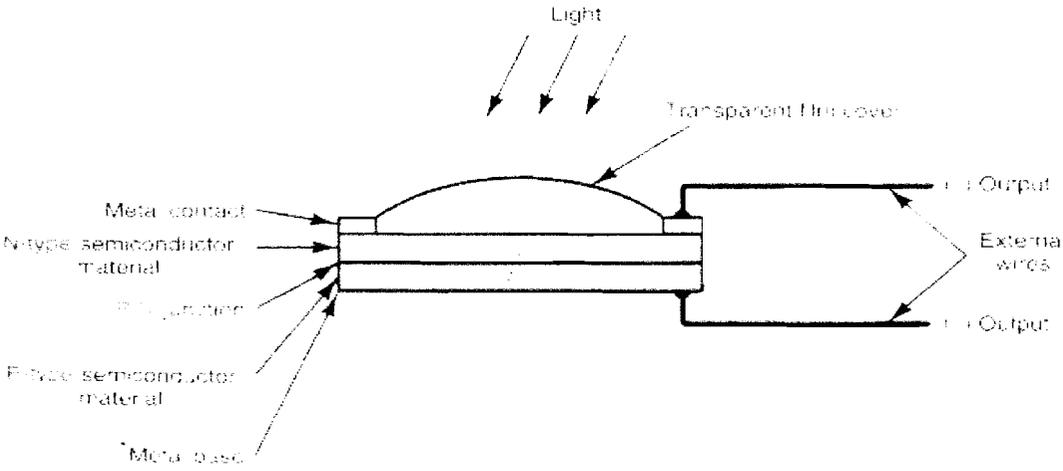


Figure 2.1: Solar Cell

2.3 HEAT SOURCE

Electrical energy is converted into heat energy when food is cooked and homes are heated. Similarly, heat can be converted into electrical energy. Thomas J. Seebeck, a German scientist, discovered that when the ends of two different types of metals are connected together and heated, a small dc voltage is created at the open ends. Converting heat into electrical energy by this method is known as the “Seebeck effect”.

2.3.1 Seebeck effect

“Seebeck effect” or “thermoelectric effect” is direct conversion from temperature differentials (heat) into electric energy or vice versa. This effect was first discovered, accidentally by the German-Estonian physicist Thomas Johann Seebeck in 1821 who found that a voltage existed between two ends of a dissimilar metal bar when a temperature difference ΔT existed in the bar. Today, it is the principle behind heat engines, heat pumps, thermocouples, thermal diodes and solid-state refrigerators in

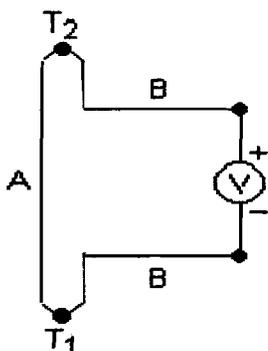


Figure 2.2: Seebeck effect circuit

The amount of dc voltage produced at the ends of the two pieces of metal will depend on the amount of heat being applied and the kind of metal being use. When metals are heated, their electrons tend to move away from the areas being heated, which

causes electrons to be more concentrated in a cool area than in a heated area. When two different types of metals are connected together and heated at their junction, electrons in both metals tend to move away from the heat. Because the two metals are different, there are more electrons at the cool end of one metal than at the other. This causes the metal with the most electrons to have negative (-) charge. Compared with the other metal, the one with the least electrons is positive (+). The different in charge between the two cooler ends of the metals developed a voltage. A small voltage, usually in mV is produced.

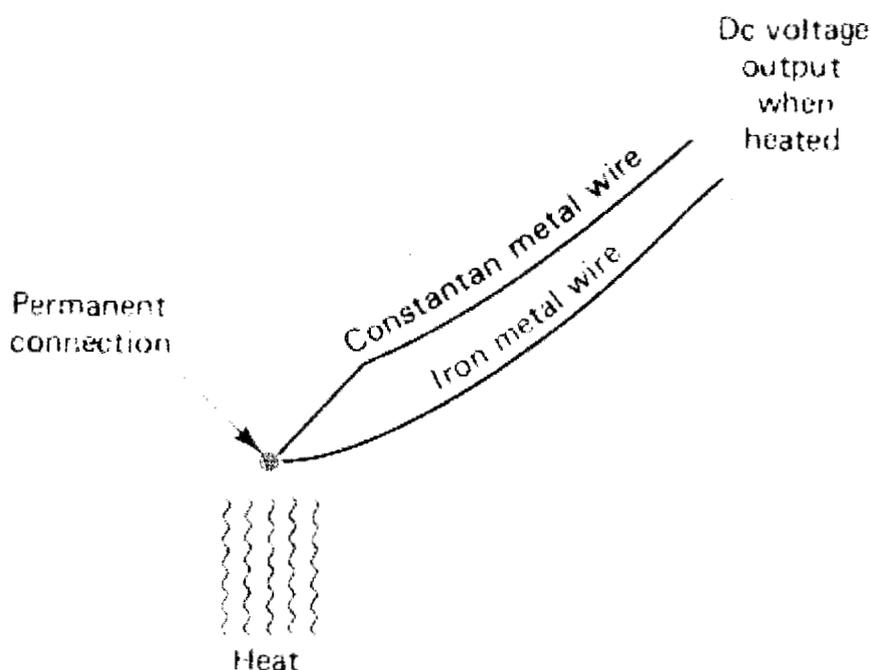


Figure 2.3: Operating Principle of Thermocouple

2.4 PRESSURE SOURCE

The change of mechanical pressure into electrical energy is called the “piezoelectric effect”. Certain crystal materials may be compressed as pressure is applied to the surfaces and a voltage is created between the top and bottom surfaces of the crystal. The amount of voltage is determined by the amount of pressure - the greater the pressure, the greater voltage; the less the pressure, the less the voltage will be for any piezoelectric crystal.

2.4.1 Piezoelectricity

Piezoelectricity means pressure electricity and is rightly named, since it is the creation of electricity by applying mechanical pressure (a force) to certain types of minerals. It was discovered by two French physicists named Pierre and Jacques Curie, who publicized their findings in 1880.

Several substances with a crystalline structure like quartz, tourmaline and Rochelle salts, are able to display this piezoelectric effect. When a potential difference that is voltage, from a power source is placed on these crystals, it will cause it to stretch and contract, causing vibrations. Vice versa, when a force is put on the surface of these crystals, which will cause it to vibrate and distort, a potential difference will be created.

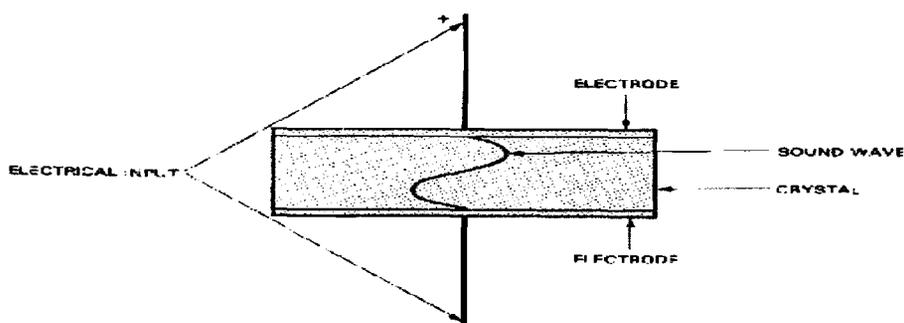


Figure 2.4: General layout of a piezoelectric cell

When these crystals are compressed, charged particles in its atoms move. The moment of charged particles causes potential difference. The voltage produced is directly proportional to the amount of pressure and vibrations that was applied to the crystal. In the reverse situation, the amount of distortion that the crystal undergoes is also proportional to the amount of voltage applied.

Whether the stress applied on the crystal is a compression or an expansion will effect the direction of electron flow. If a compression produces a current flow in one direction, an expansion of the crystal will cause the current to reverse direction. Likewise, when a current is applied to the crystal in one direction, and then the positive and negative terminals are switched, it will also cause the opposite kind of physical distortion as when the electron flow was the other way

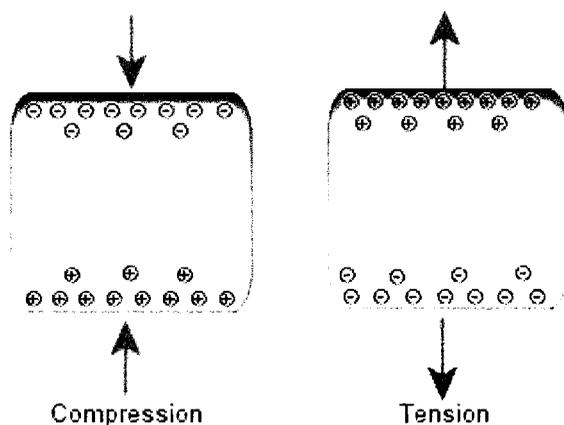


Figure 2.5: Charge in piezoelectric material

One application is in the conversion of sound waves into electrical energy, such as in a crystal microphone. Sound waves strike the surface of the diaphragm in a microphone, which is connected to a crystal's surface. When the diaphragm vibrates, it also causes vibrations in the crystal, which produces varying amounts of voltage according to differences in vibrations. In this way, sound is converted to electrical signals. This signal can then be amplified and converted back into sound waves through speakers, or recorded.

An old record player works on a similar principle. The needle in the phonograph is connected to a crystal in the pickup cartridge. As the needle moves through the grooves in records, it produces pressure and vibrations on the crystal and an electric potential is produced. Different movements of the needle in the groove will cause different vibrations, and variations in the frequency and amount of voltage produced. This continuously varying signal is amplified and changed back into sound waves, and reproduced through speakers.

One important use of the piezoelectric effect is in controlling frequency in radio transmitters using a quartz oscillator. The crystals are cut in a way so that only signals at a certain frequency can go through them. An oscillator is a device that produces electric signals at a chosen frequency.

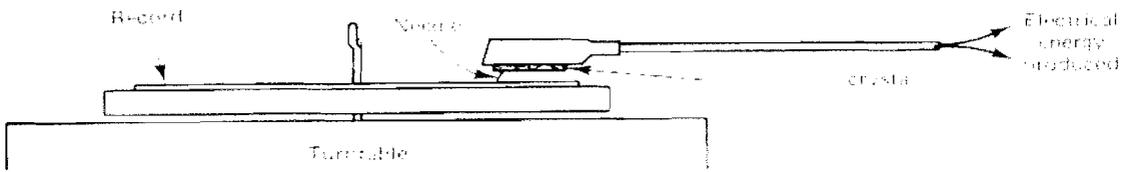


Figure 2.6: Piezoelectric of a phonograph cartridge used for vinyl recording sound systems

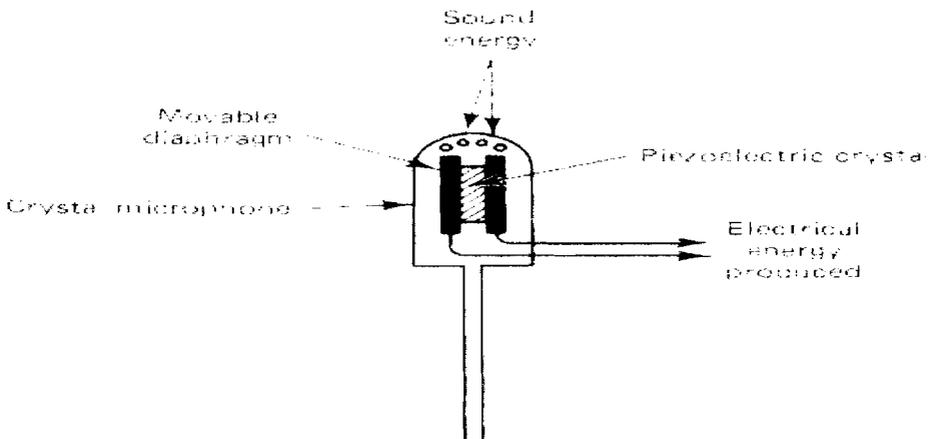


Figure 2.7: Piezoelectric principle of a microphone

2.5 ELECTROMAGNET INDUCTION

Electromagnetic induction is the production of voltage across a conductor situated in a changing magnetic field or a conductor moving through a stationary magnetic field. The phenomenon of electromagnetic induction was first noticed and investigated by the English Scientist Michael Faraday in 1831. Faraday found that the induced electromotive force through a circuit is equal to the rate of change of magnetic flux through it.

Figure 2.8 shows the principle of electromagnetic induction. When a conductor passes through a magnetic field, it cuts across the flux lines and as the conductor cuts across the flux lines, the magnetic field developed a force on the electrons of the conductor. The direction of the electron movement determines the polarity of the induced voltage. Electrical current is produced only when there is motion or in other word when the magnetic field is changing. When the conductor is brought to a stop while crossing lines force, electrical current stops.

Electromagnetic induction is the key phenomenon behind the operation of electrical generators, induction motors and transformers. For examples, hydroelectric generators use the force of moving water to create large amounts of electromagnetically induced current. Similarly, steam generators use the force provided by steam to rotate turbines that provide changing magnetic flux to produce induced current. The steam that is produced by the combustion of fossil fuels like gas or coal, or by controlled nuclear reactions in nuclear power plants.

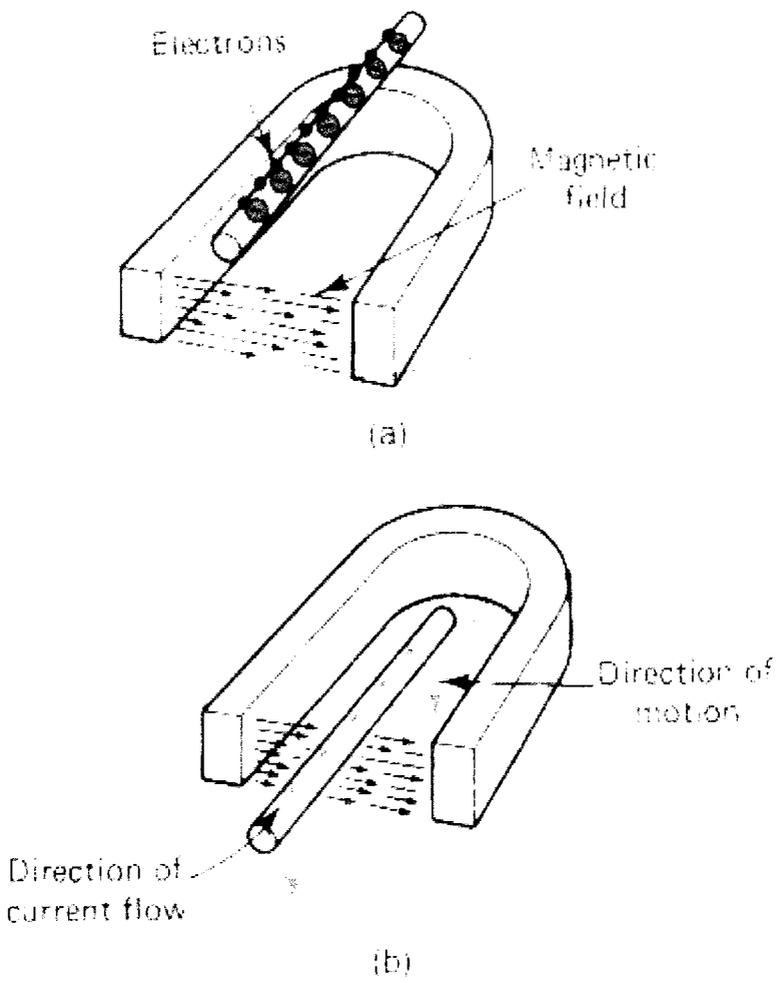


Figure 2.8: Principle of electromagnetic induction: (a) conductor placed inside a magnetic field; (b) conductor moved downward through the magnetic field

2.6 ENERGY COMPARISON

The used of alternative energy to generate electricity has its own advantages and disadvantages. Table 1.1 shows the comparison of the alternative energy that have been discussed and with their pros and cons.

Table 2.1: Energy Comparison

Energy	Type of current produced	Element	Description
Light	DC	Photovoltaic Cell	<ul style="list-style-type: none"> • Light is a renewable source of energy which is easily accessible • A solar cell can produce a high voltage but low current. To get enough energy for larger applications, a large number of photovoltaic cells are needed. • Solar cells/panels can be very expensive. However Solar cells require very little maintenance since they have no moving parts that will need to be fixed and they last a long time. • Solar power cannot be created at night.
Heat	DC	Thermocouple	<ul style="list-style-type: none"> • Required heat which not suitable for electronic device as it would increase its temperature and damage the device. • Generate low voltage. Many stages of thermocouple would be required to produce high voltage making it impractical.

Pressure	DC	Quartz	<ul style="list-style-type: none">• Required mechanical pressure• Can generate potential differences of thousands of volts.• Suitable for sensors and actuators applications.
Electromagnet Induction	AC/DC	Generator	<ul style="list-style-type: none">• Required mechanical energy to crank up the generator.• The generator is difficult to construct.• Can produced high voltage (depend on how fast the cranking operation)

CHAPTER III

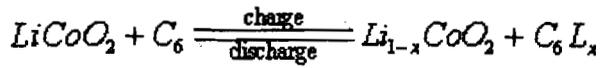
LITHIUM ION BATTERY

3.1 OVERVIEW

The Li-Ion battery was commercially introduced in the early 1990s and slowly gained popularity during that decade as the default standard for mobile phones. The high energy density is the main attraction of the Li-Ion battery technology because it allows a smaller battery size with the equivalent capacity of alternative technologies such as nickel-metal-hydride or nickel-cadmium. Also, it allows for a smaller, lighter battery, making the overall portable product lighter. This is especially important in mobile phones where a majority of the weight is still in the battery pack.

3.2 WORKING PRINCIPLE

Lithium battery uses lithium cobalt oxide as positive electrode - cathode - and a high crystallized special carbon as negative electrode - anode. Also an organic solvent specialized to be used with the specific carbon works like electrolytic fluid. The chemical reaction that takes place inside the battery is as follows, during charge and discharge operation:



The main principle behind the chemical reaction is where lithium in positive electrode material is ionized during charge and moves from layer to layer in the negative electrode. During discharge Li ions move to the positive electrode where embodies the original compound.

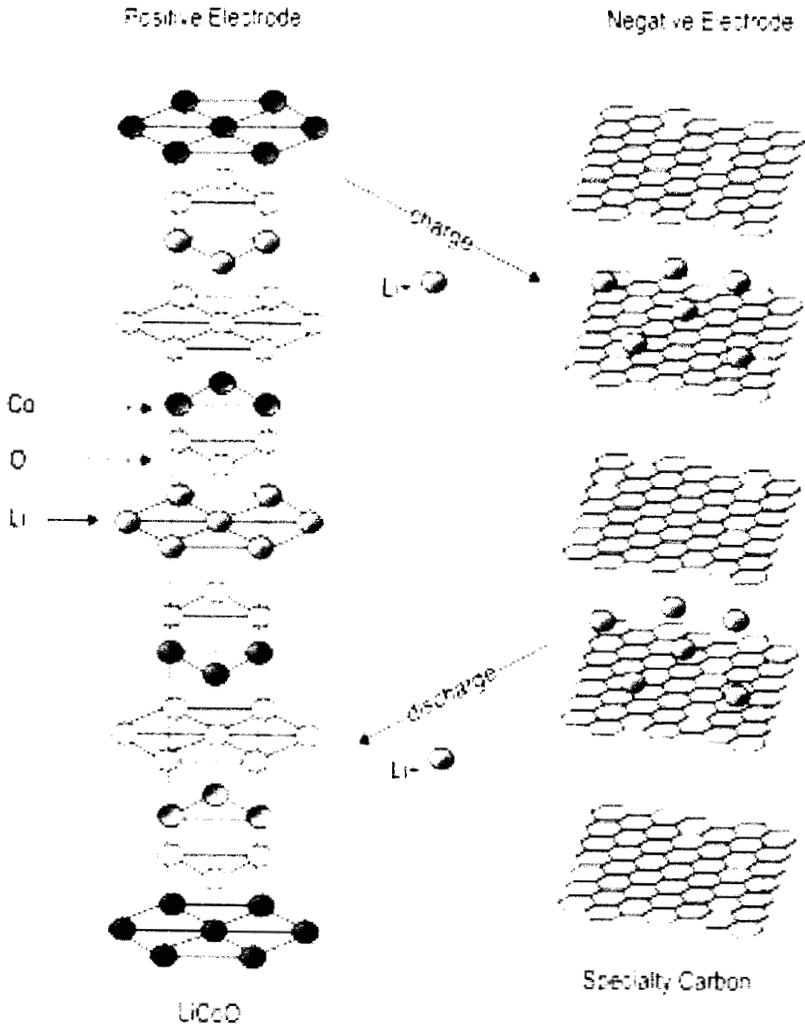


Figure 3.1: Chemical Structure of Lithium Ion Battery

3.3 GENERAL FEATURES

- High energy density that reaches 400 Wh/L (volumetric energy density) or 160Wh/Kg (mass energy density).
- High voltage. Nominal voltage of 3.6V or even 3.7V on newer Li-Ion batteries.
- No memory effect. Can be charged any time, but they are not as durable as NiMH and NiCd batteries.
- High charge currents (0.5-1A) that lead to small charging times (around 2-4 hours).
- Flat discharge voltage allowing the device to stable power throughout the discharge period.
- High cycle life 400 – 500 cycles to 80% of initial capacity.
- Low pollution and high safety – does not contain metal likes cadium, lead or mecury.
- Typical charging Voltage $4.2 \pm 0.05V$.
- Charging method: constant current - constant voltage (CV-CC).
- Typical operation voltage 2.8V to 4.2V
- Recommended temperature range 0-40°C

3.4 STRUCTURE

Li-Ion cell has a tree layer structure. A positive electrode plate made with Lithium Cobalt oxide – cathode, a negative electrode plate made with specialty carbon - anode and a separator layer.

Inside the battery also exists an electrolyte which is a lithium salt in an organic solvent. Li-Ion is also equipped with a variety of safety measures and protective electronics and/or fuses to prevent reverse polarity, over voltage and over heating and also have a pressure release valve and a safety vent to prevent battery from burst.

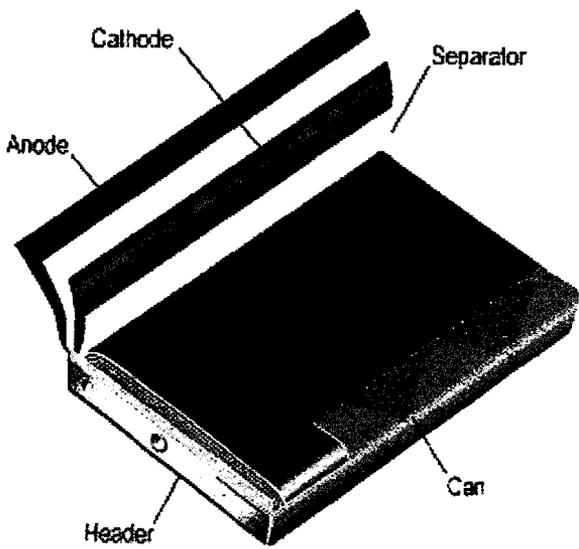


Figure 3.2: Prismatic Cell Structure

3.5 CHARGING CHARACTERISTIC

Charging method is constant current - constant voltage (CV-CC). This means charging with constant current until the 4.2V are reached by the cell (or 4.2V x the number of cells connected in series) and continuing with constant voltage until the current drops to zero. The charge time depends on the charge level of the battery and varies from 2-4 hours for full charge. Also Li-Ion cannot fast charge as this will increase their temperature above limits. Charging time increases at lower temperatures.

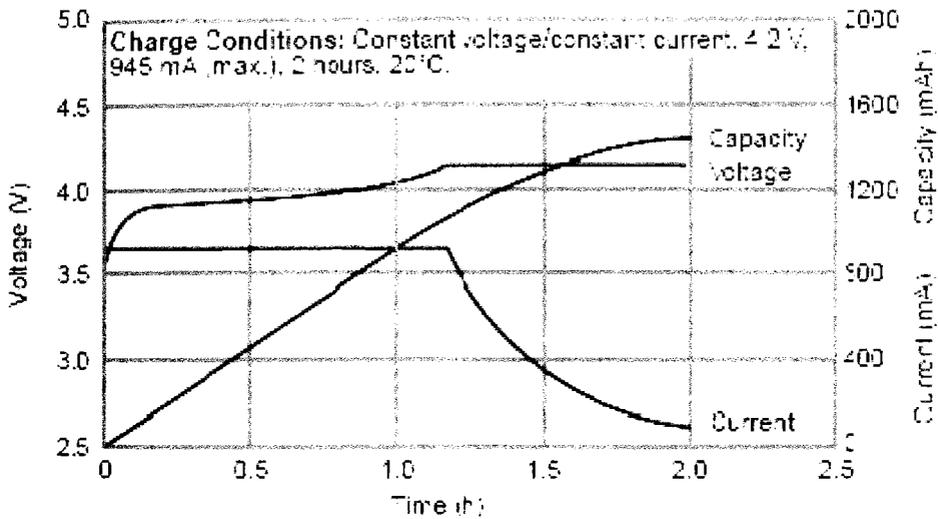


Figure 3.3: Typical charging characteristic

Charge current is recommended to be set at 0.7CmA where C is battery capacity. If voltage is below 2.9V per cell it's recommended to charge at 0.1CmA. Charging environment must have a temperature between 0-40°C. Maximum discharge current must not exceed 1.0CmA and discharge voltage must not go below 3.0V.

3.6 CAPACITY

At a typical 100% charge level at 25°C, Li-ion batteries irreversibly lose approximately 20% capacity per year from the time they are manufactured, even when unused. (6% at 0°C, 20% at 25°C, 35% at 40°C). When stored at 40% charge level, these figures are reduced to 2%, 4%, 15% at 0°C, 25°C and 40°C respectively. Every deep discharge cycle decreases their capacity also.

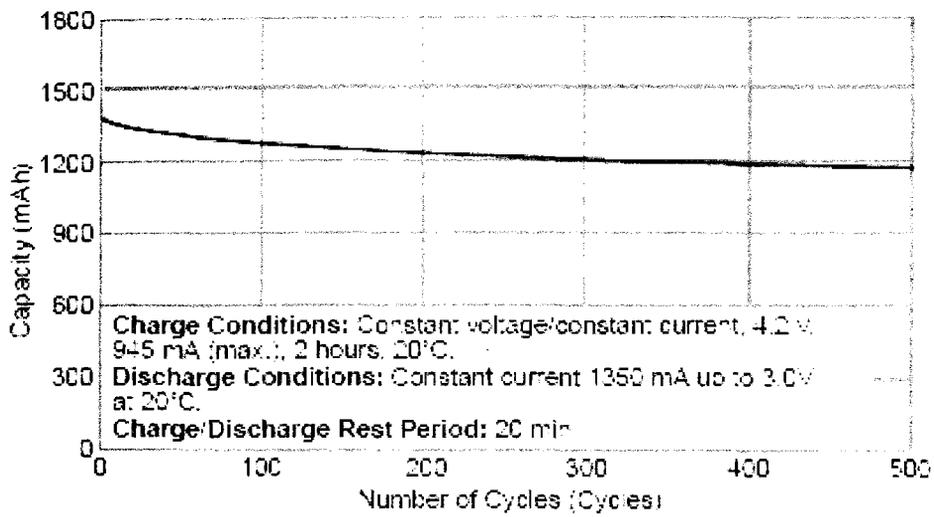


Figure 3.4: Typical capacity characteristic over charge cycles

100 cycles leave the battery with about 75% to 85% of the original capacity. When used in notebook computers or cellular phones, this rate of deterioration means that after three to five years the battery will have capacities too low to be still usable.