CHAPTER 1

INTRODUCTION

1.1 Background of studies

Electronics devices such as cell phone, digital camera and MP3 use battery as the energy supplier to power up. Battery charger is an essential component to the devices. These batteries need to be charged up so that it can continuously supply power to the device. Usually, battery chargers rely on the power supply from the grid. The main supply of electricity is from Tenaga Nasional Berhad (TNB). The supply voltages that come out from the plug are 240 VAC. In order to charge the devices battery, charger must do two things. First, step down the voltage to the rated voltage value required by the battery. Second, convert the AC voltage to DC voltage by using rectifier. Some additional circuit require in the charger to prevent from damaging the battery.

The aim of this project is to design a battery charger that gets the energy from the sun instead of electrical power from the house electrical port. This charger is universal in nature, as it should be to charge difference electronic devices. This charger is design to help portable electronics devices user to surpass the charger barrier. With this charger, user can easily charge up their mobile phone or other electronics device at anywhere.

The charger's function is to charge up difference types of devices. Difference types of devices will have their own voltage and current value to charge up their battery. The charger must have some additional circuit in it so that the charger can regulate the output from the charger to supply the energy to the difference types of electronics devices.

1.2 Problem statement

Electronic devices such as mobile phone have become necessity. The drawback is that the mobility is reduced due to the need to charge the devices occasionally. Then the charging session can only be done at the electric wall supply. This will give the problem to the traveler as in their travel period, they could not charge up their electronics devices.

Battery capacity for mobile phone will reduces fast when the connectivity to the network is low. This is because more energy is used to search the network connection. This problem can happen when user goes to travel in jungle for example. Their electronics devices battery will go out faster. Then the user cannot charge up their devices because does not have the supply power.

1.3 Objective

The objectives of this project are:

- To carry out a study on the different charging requirement of electronic devices.
- To do feasibility study on the possibility of using photovoltaic (PV).
- To design a universal portable solar battery charger.

1.4 Scope of studies

For this project, the scope of studies is:

- Studies about solar geometry and solar radiation
- Studies how to get maximum output from the solar panel
- Understanding the energy conversion from solar radiation to electrical energy
- Construct and design a universal portable solar battery charger prototype
- Understanding the solar panel operation to get the electrical energy
- Studies the solar panel connection

CHAPTER 2

LITERATURE REVIEW

2.1 Solar Radiation

Solar energy is chosen in this project because it had lot of advantages. One of the advantage of the solar energy is it availability. It just the intensity of the solar radiation differs from one place to the other places. The difference in solar radiation intensity happens due to several factors. First is the solar radiation path.

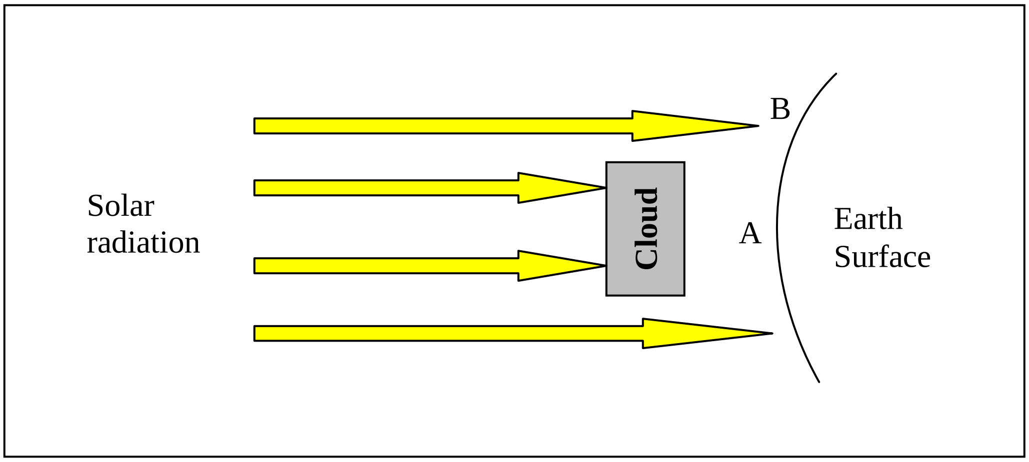

Figure 1: Solar radiation path affecting the intensity

From the figure 1, the solar radiation intensity will be difference depend on the path that the solar radiation past through. There have two reference point, point A and point B. Point A have the cloudy sky while point B face the clear sky. The solar radiation intensity at area A is less compare to the solar radiation at area B. This is because the cloud will absorb the solar radiation.

Second factor for the solar radiation intensity is the meteorological condition of the place. Comparison can be made between Malaysia meteorological condition and desert meteorological condition. Solar radiation intensity at Malaysia is low compare to at the desert because Malaysia has lot of clouds and high in humidity while at desert, the skies are always clear and low humidity. This clouds and hazes will absorb or reflect the solar radiation.

The third factor is the location on earth. The solar radiation intensity will be high at the place near the equator. This happen is due to the distance from the earth surface to the sun surface.

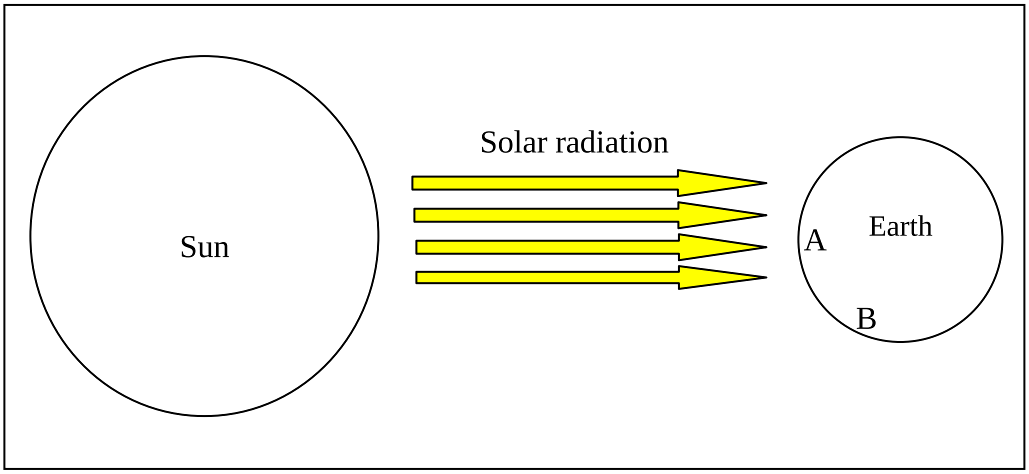

Figure 2: Location factor affecting the solar radiation intensity

From the figure 2, point A located near to the earth equator while point B located near the earth pole. Point A will have high solar radiation intensity compare to the point B.

The other factor that is affecting the solar radiation intensity is the sun trajectory. Sun position in the day is difference with time. Figure below show the sun position in the daylight.

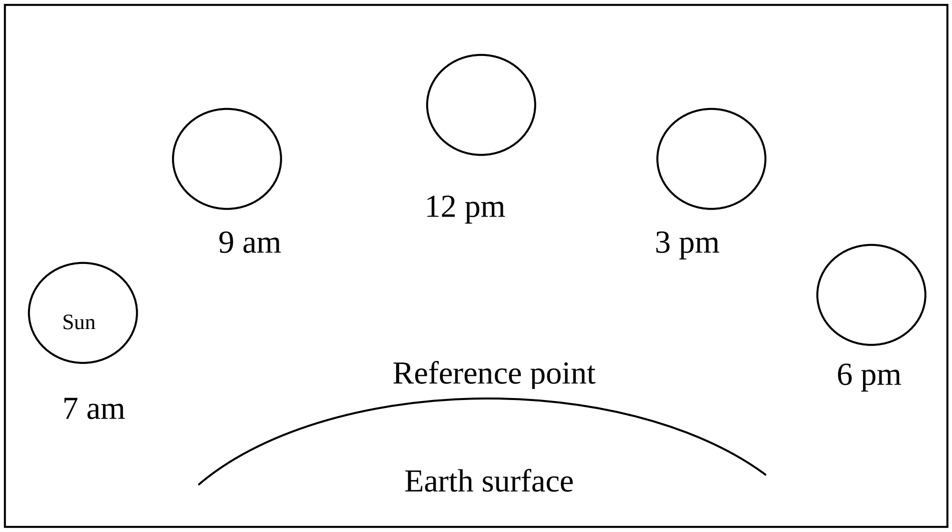

Figure 3: Sun trajectory

From the figure 3, the sun position differ from time to time. Then the solar radiation intensity at the reference point also will be difference from 7 am to 6 pm. The solar radiation intensity over time can be shown in figure below:

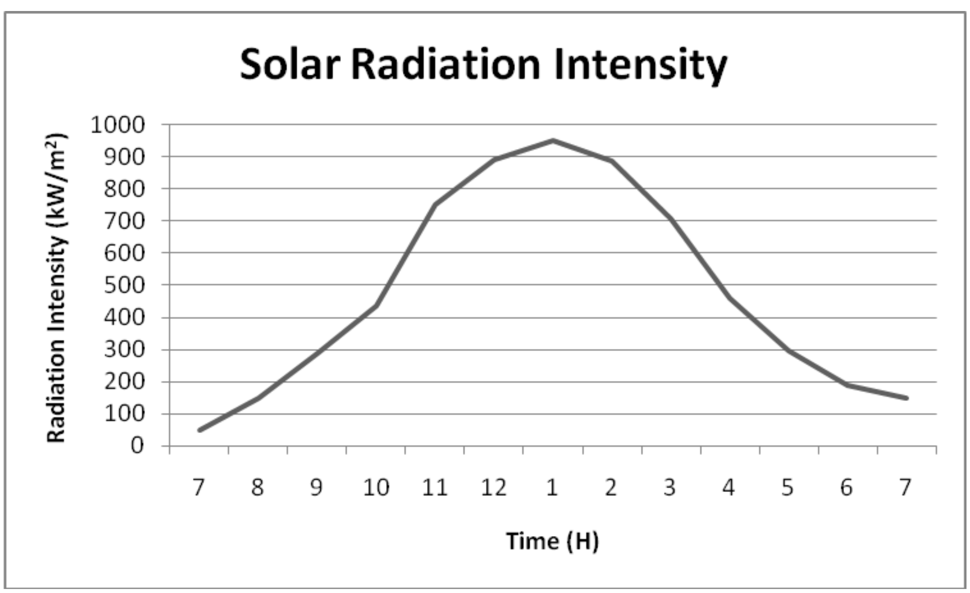

Figure 4: Solar radiation intensity over time

The figure 4 show that the highest solar radiation intensity happens between 11 am until 2 pm.

2.2 Solar Energy Conversion

Solar panel or photovoltaic panel is use to convert the solar energy to electrical energy. The energy conversion consists of two parts. First, the generation of an electron-hole pair by the absorption of light. Then, the second part is the generating of electrical power from the electrons and holes separation process [1].

When the electron-hole particle separated, the collected charge carriers (holes and electrons) produce a space charge that results in a potential difference (voltage) across semiconductor. This voltage is known as the photovoltaic. If the separated charge carriers are allowed to flow through an external load, they constitute a photocurrent. [7]

The typical solar panel used today is the crystalline silicon solar cell. This type of solar cell uses the p-n junction principle. The diagram of the typical solar cell shown in Figure 5:

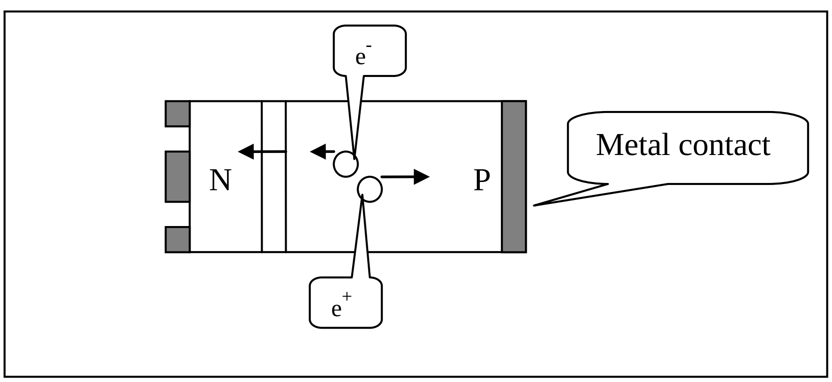

Figure 5: Typical Crystalline Silicon p-n Solar cell

The thick p-type is the bulk of the cell. After the light absorption process occurs, the minority carrier from the bulk (electrons) will diffuse to the junction before they will swept across the junction by the strong built-in electric field. This process produces the electrical power. The electrical power then being collects by the metal contact at the front and back of the solar panel [1].

2.3 Charger

Battery charging systems consist of two main components: the power supply and the charging circuitry. The power supply (are also called a wall pack or adapter) converts AC mains power to low-voltage DC, and may be external or internal to the device. A traditional power supply contains an iron core linear transformer, for which losses are on the order of 40–70% [9].

Charging circuitry controls the current and voltage provide to the battery at each moment. The simplest controls provide a constant charge to the battery, and thus create the possibility of high proportional losses if the user fails to unplug the device after an appropriate time. Newer battery chemistries (NiMH, Li-ion or Li-polymer) generally do not allow use of the simplest charge controller for reasons of safety and battery health, and their chargers tend to be somewhat more efficient [5].

2.4 Electrical Energy Storage

Battery can be separated into two groups, primary battery and secondary battery. Primary battery can only be use once and cannot be charge up to restore its energy. The secondary battery is the rechargeable battery, it made this group of battery prefer most in the electronics devices such as mobile phone and other handheld electronic devices.

The common battery use in the electronics devices are the Nickel-Metal Hydrate (NiMH) and lithium base battery. NiMH battery uses nickel oxide hydroxide and alloy as the electrodes. Because of the lower volumetric energy density and higher self-discharging compare to the lithium base battery, the NiMH battery not widely use in the electronics devices.

Lithium base battery has two types. The first type is the Lithium-Ion battery and the other one is the Lithium-Polymer battery. For the first type battery (Lithium-Ion type), it operation is base on the moving of Lithium ion particle between anode and cathode. For the charging purpose, the Lithium ion move from cathode to anode and for the discharge purpose, it moves from anode to cathode.

This type of battery has several advantages compare to other battery type. The advantages are best in energy to weight ratio, no memory effect and slow loss in charge in idle mode. But if have mistreating on the battery, it can explode. Inside the battery, there are three major parts which are anode, cathode and electrolyte.

The material for anode is usually graphite. The material for the cathode can be either one of this three: a layered oxide, such as lithium cobalt oxide, one based on a polyanion, such as lithium iron phosphate, or a spinel, such as lithium manganese oxide. Liquid electrolytes in Li-ion batteries consist of lithium salts in an organic solvent, such as ether. A liquid electrolyte conducts Li ions, acting as a carrier between the cathode and the anode when a battery passes an electric current through an external circuit. [3]

Lithium-Polymer battery is another type of rechargeable battery. It still uses the Lithium-Ion technology but the difference is the electrolyte that use in this battery. The electrolytes for this battery type not exist in the organic solvent, but in a solid polymer composite such as polyethylene oxide. The advantages of Li-poly over the lithium-ion design include lower cost manufacturing and being more robust to physical damage. [4]

CHAPTER 3

METHODOLOGY

3.1 Project Procedure and Methodology

Figure 6 shows the summarization of the project procedure and methodology that happened in the project timeframe. The project cover from the project selected until the product prototype.

In the early development stage, research in several topics was done to get deep understanding about the project. This includes the solar geometry, solar panel operation and the circuitry involve in the charger. The purpose of solar geometry research is to understand how the solar radiation behavior and understand how to get the optimum solar radiation intensity. The purpose for do research and study about the solar panel is to know the operation that involve inside the solar panel when the energy conversion happen. Then understand the charger specification will help the prototype design process.

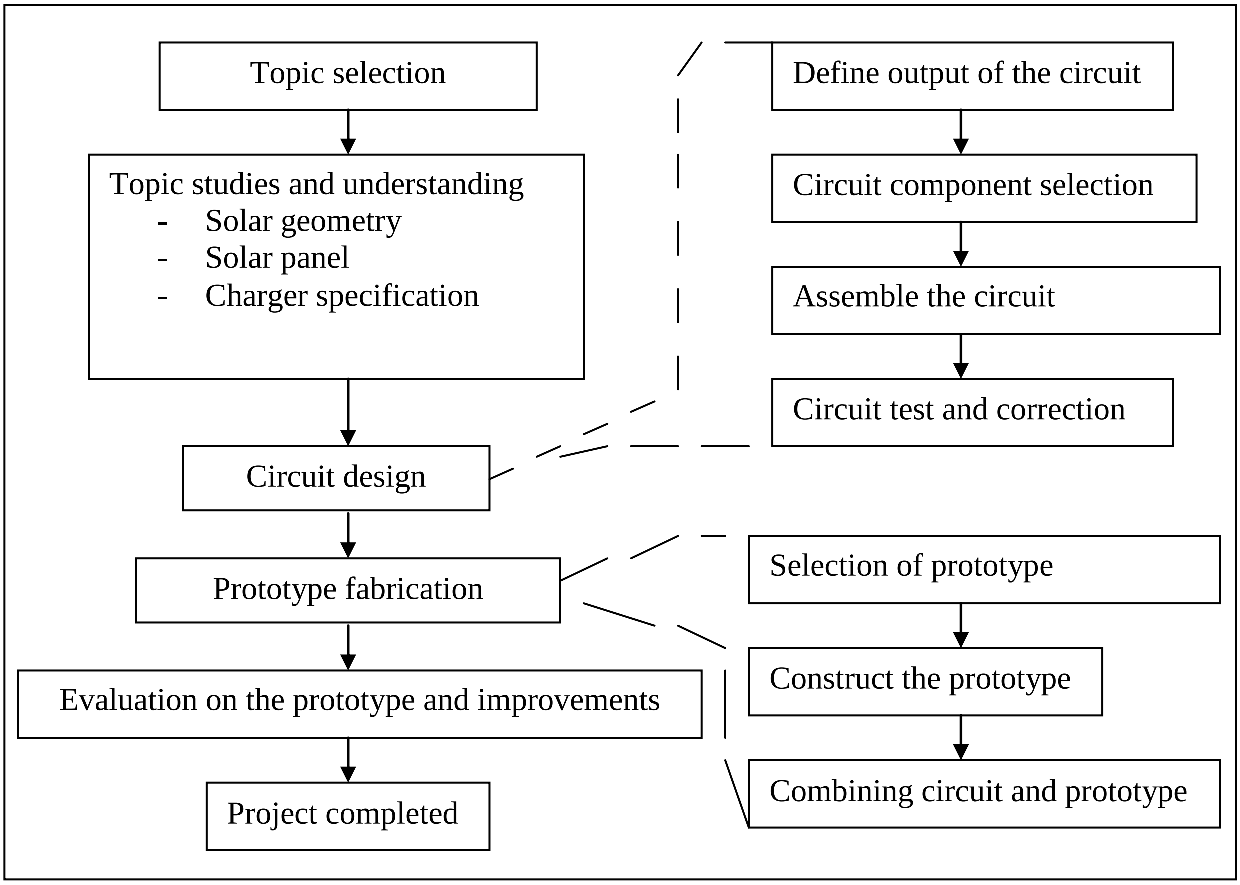

Figure 6: Project Procedure and Methodology

In the circuit design stage, the charging requirement need to be define first before proceed to the circuit design. It is useful to identify charging requirement for various difference electronics devices and would provide useful information to design the charger circuit. Two type of circuit being used and modified to get the desired output. The first type of circuit is the charger circuit. The circuit is the specific charger circuit built for lithium base battery (lithium ion and lithium polymer type). The second circuit was the voltage selector circuit. The purpose of this circuit was to regulate the output voltage and current to get the desired output. This circuit then be attach to the output of the charger circuit.

After the circuit construction finished, the next stage was the prototype fabrication process. In this stage, the circuit was construct using the breadboard and been tested. This procedure was crucial because it ensure that the circuit was working properly. Then the circuit was constructed in the printed circuit board (PCB) and the circuit then be attach to the prototype box. The next stage was the evaluation of the prototype. The prototype be tested and made some improvement to make the prototype working successfully.

3.2 Product Overview

The Universal Solar Battery Charger has three main components. First component is the solar panel. Some consideration must take into account when choosing the solar panel. The project prototype is a portable device that can be carrying to everywhere. For this criterion, the solar panel needs to be small and light so that it would not burden the user.

The second component of this prototype is the electronics circuit portion. The main circuits are the stabilizer circuit, battery regulator and the charge controller. The stabilizer circuit function is to stabilize the voltage and current value that generated from the solar panel. Battery regulator circuit function is to control the output voltage and current from the electronics circuit portion so that it can supply enough value to the electronic devices.

The other circuit is the charge controller circuit. The function of this circuit is to prevent the electronic devices battery (load) from overcharging. This is important so that the battery will not damage. Some specification must be follow to design the circuit. All the circuit must be small so that they can fit on a small boxes or container.

This is because to make the user easier to bring it anywhere. Addition feature can be combine together with the main circuit like meter indication.

The last component from this product is the storage battery and the load. The storage battery function is to store energy when the charger does not charge up any device. It can be use in the night period for the backup purpose. Figure 3 show the summarization of the product of the project.

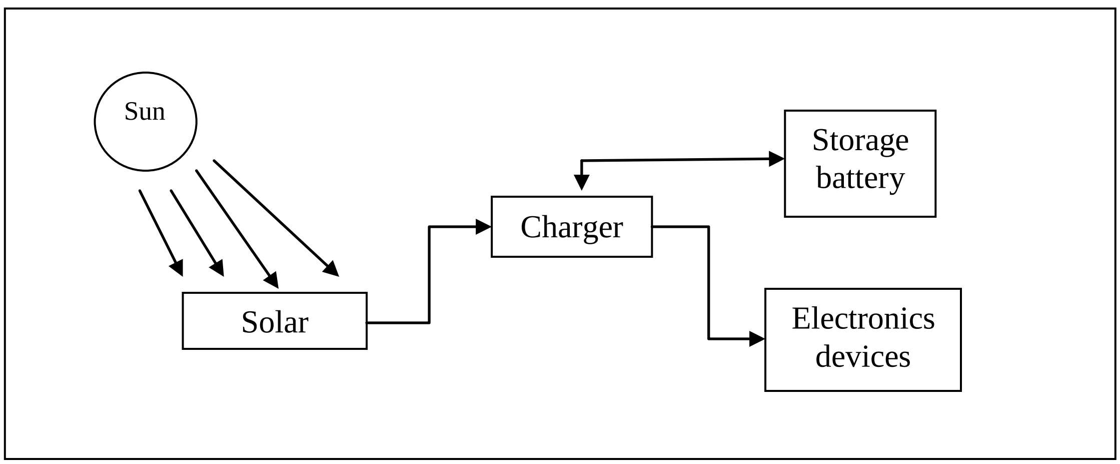

Figure 7: process flow to show how photovoltaic can be integrated with a conventional charging system.

3.3 Circuit Construction

3.3.1 PSPICE Simulation

There were two types circuit that had been constructed. The first circuit is the charger controller circuit. This circuit function was to control the input current to the devices.

The circuit that been constructed were taken from journal "A simple and low-cost charger for lithium-ion batteries" [6] but this circuit had been modified to get the desired output. The circuit schematics for the charger are shown in the Figure 8.

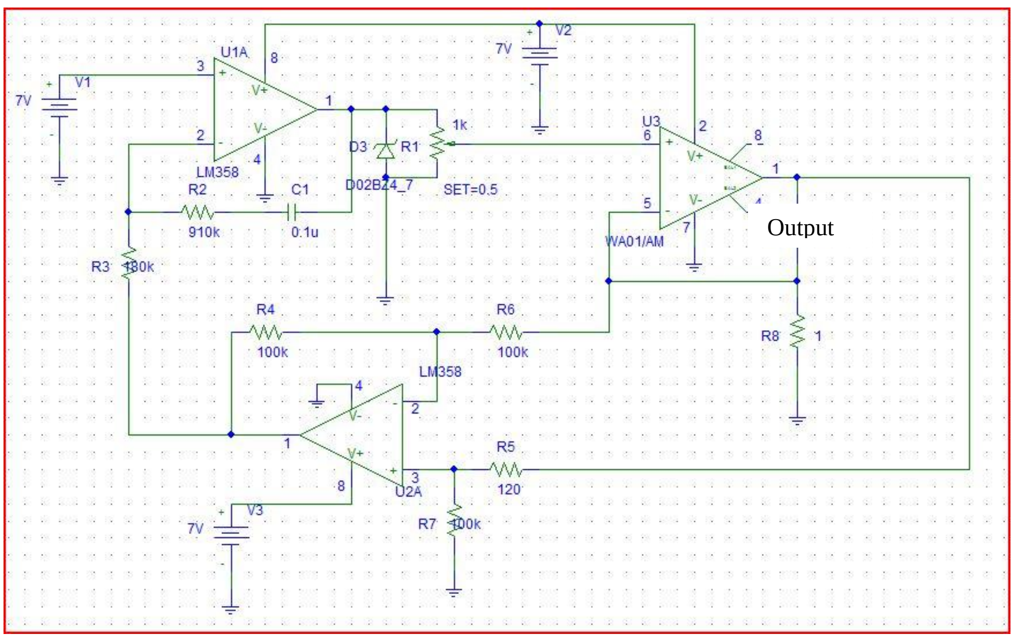

Figure 8: Charger Circuit

The second circuit was the voltage regulation circuit. The purpose of this circuit was to varying the output voltage output to match the desired voltage value to charge up difference type of devices. The voltage regulation circuit shown in the Figure 9:

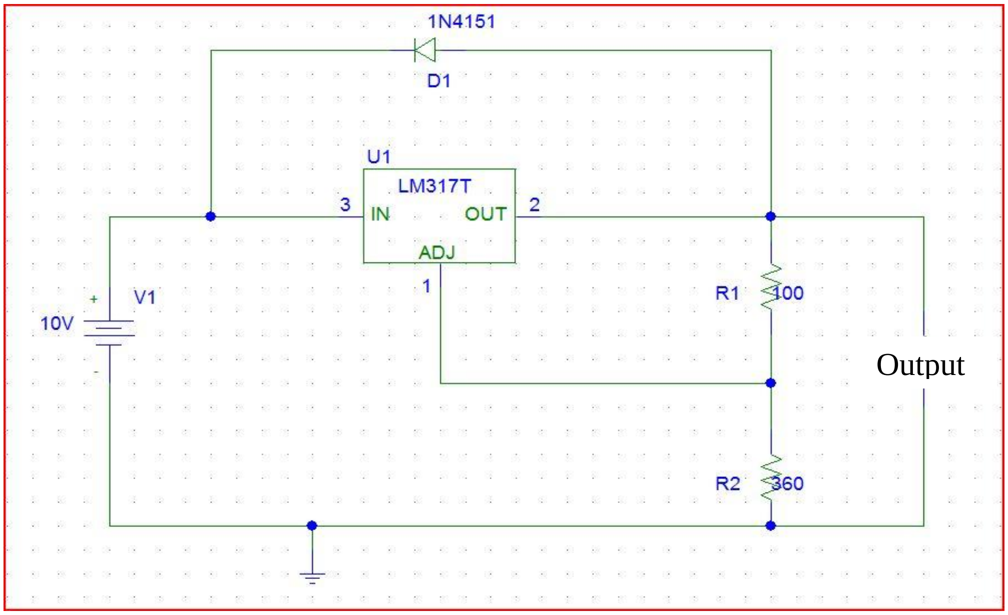

Figure 9: Voltage Selector Circuit

R2 in the voltage selector circuit was the variable resistor. The output voltage value can be varied when varying the R2.

3.3.2 Circuit construction in Breadboard

The charger circuit and voltage selector circuit were constructed at the breadboard to test it. The purpose of the test was to take the voltage reading at the output point of the circuit and compare the result with the simulation circuit in the PSPICE. Both circuits on the breadboard picture were shown below:

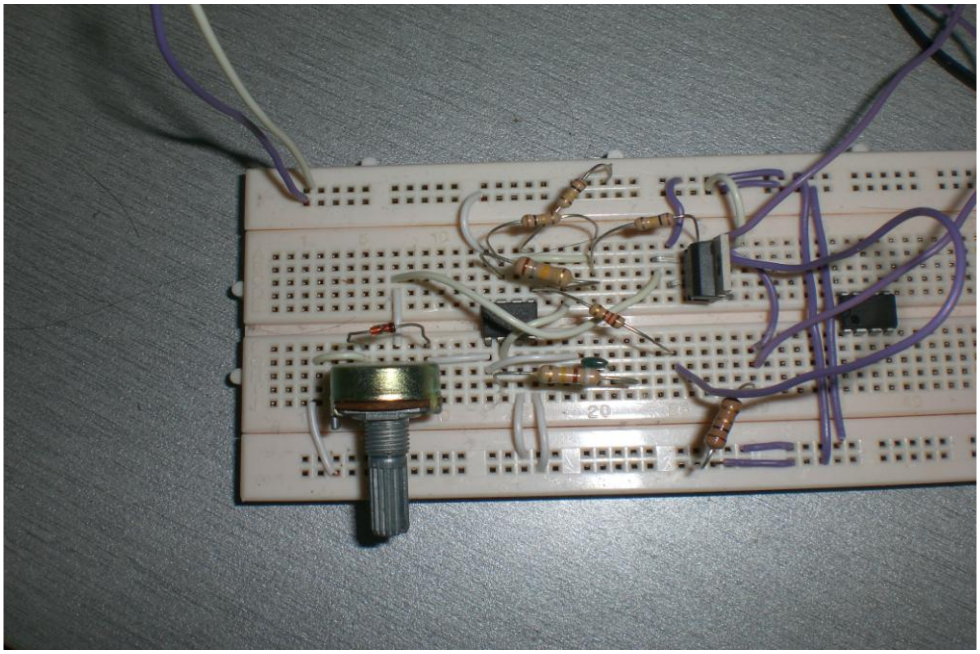

Figure 10: Charger Circuit on Breadboard

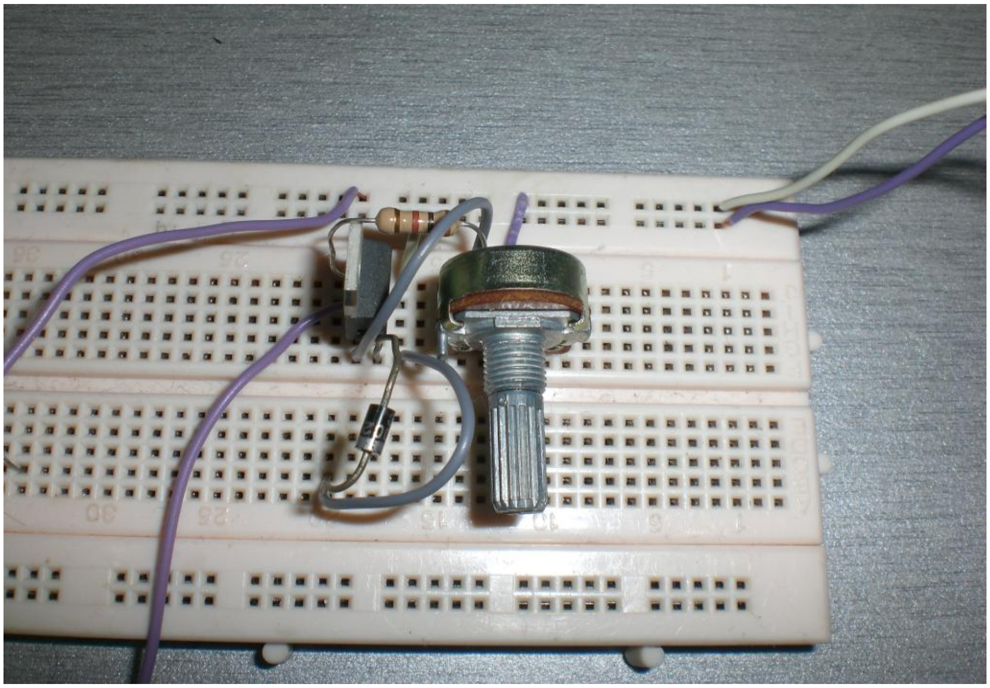

Figure 11: Voltage Selector Circuit on Breadboard

3.3.3 Circuit Component

The list of component used for the circuit construction shown below:

For charger circuit:

Table 1: Charger circuit component list

No.	Component	Quantity
1	LM358 Op-Amp	1
2	L165 Power Op-Amp	1
3	R 100K	5
4	R 910K	1
5	R 1	1
6	Zener diode 4.7V	1
7	Potentiometer 1K	1

For voltage selector circuit

Table 2: Voltage Selector Circuit component List

No.	Component	Quantity
1	LM317T Voltage regulator	1
2	Diode	1
3	R 100	1
4	Potentiometer 1K	1

3.3.4 Design Circuit in PCB

Then, the circuit was constructed in the printed circuit board (PCB). The design operation can be done using the Eagle version 5.1.0 software. The first procedure in this process was designing the circuit using the schematics file. The circuit in the eagle schematics file was shown below:

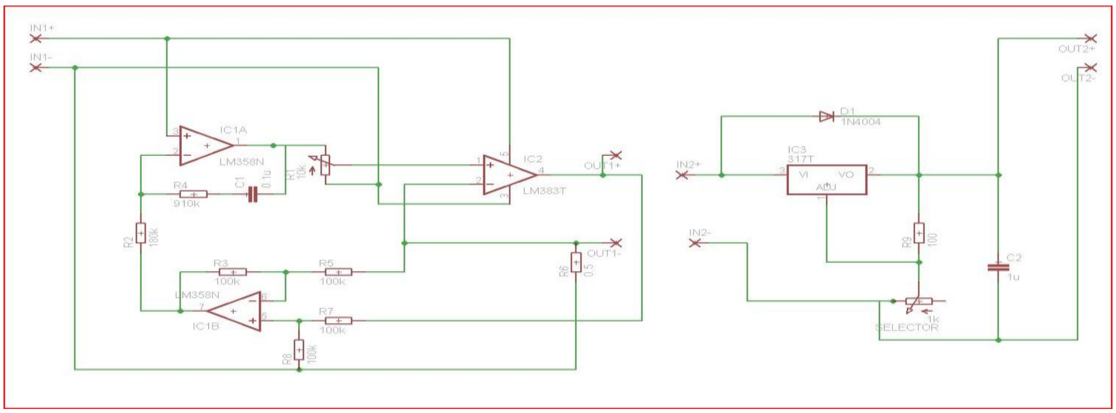

Figure 12: Charger Circuit in Eagle Schematic File

After the circuit design in the schematic was complete, the next step was to convert the circuit to become the board file before it were sent to the PCB construction laboratory. The circuit in the eagle board file was shown below:

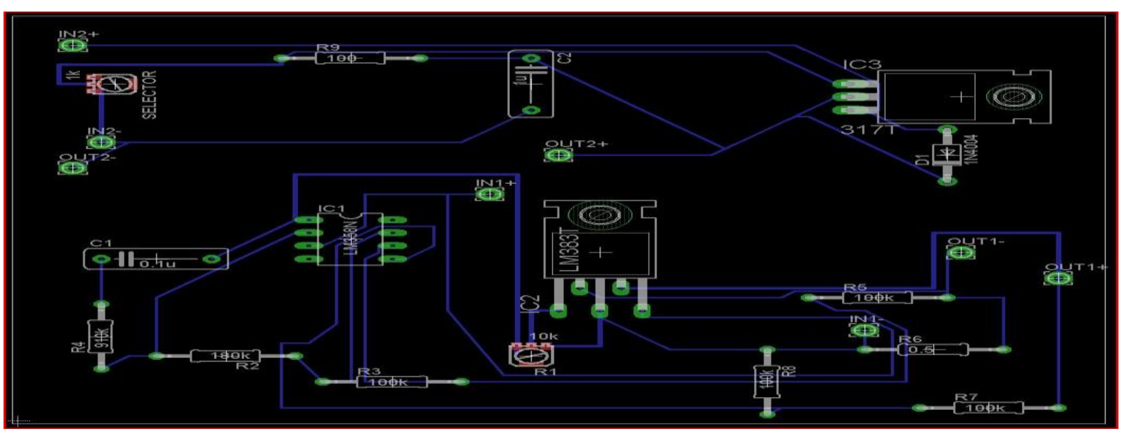

Figure 13: Charger Circuit in Eagle Board File

3.4 Solar Panel Connection

For this project, two types solar panel were used. Both from the same material (amorphous solar panel) but the difference between those two were their output and size. Table below shown the solar panel detailed.

Table 3: Solar Panel Details

Type A solar panel	Type B solar panel
Size: 16x14 cm Vout: 8.1V Iout: 0.17A No of item: 1	Size: 6x6 cm Vout: 4.05V Iout: 0.09A No of item: 4 = connect in parallel and series to get the desired output

Below was the solar panel connection for both type A and type B solar panel.

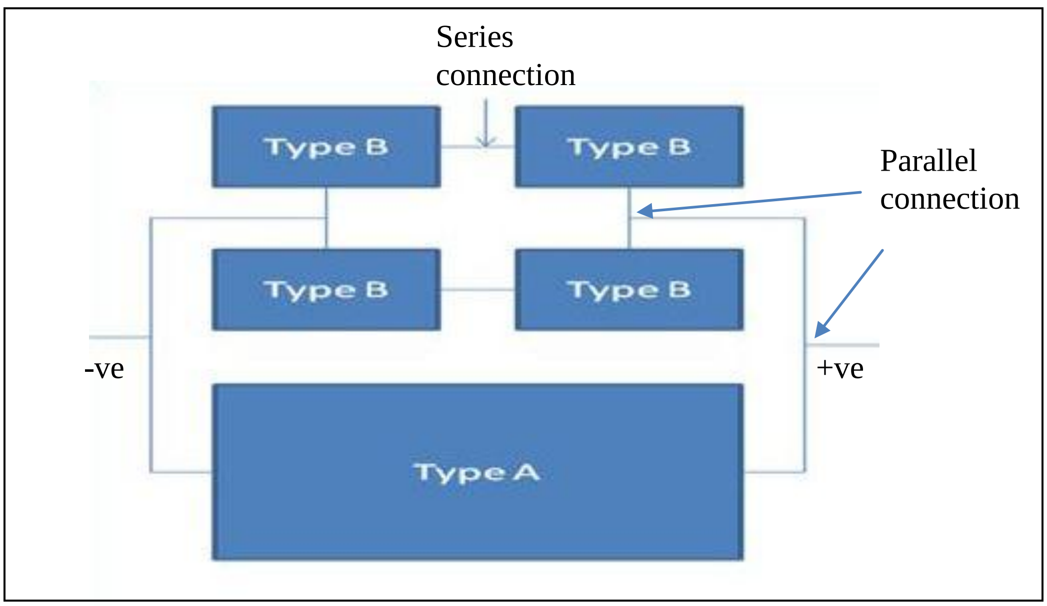

Figure 14: Solar Panel Connection

From the connection, the total outputs for the solar panel were:

Vout: 8.1V

Iout: 0.35A

The maximum output current for the solar panel was 0.35A. This can supply enough current to charge up the electronic devices because the minimum current that can charge up electronic devices was 0.28A (for Sony Ericsson W880i mobile phone and other type of mobile phone). The picture of prototypes solar panel was shown below:

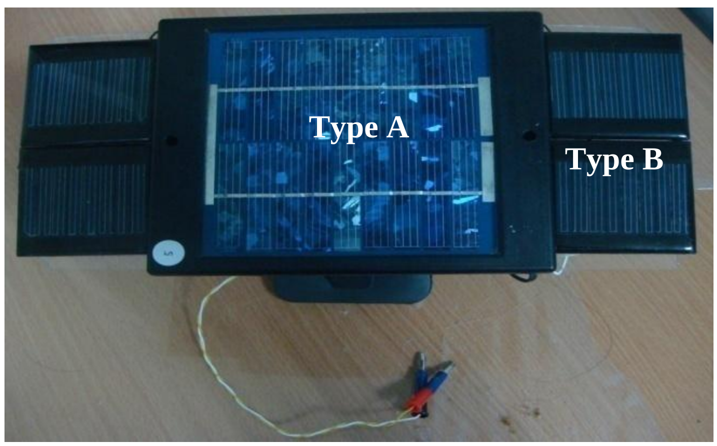

Figure 15: Prototype Solar Panel

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Devices Load and Specification

The analyses were done on the several electronic devices which the devices battery and charger were being inspected.

4.1.1 Battery specification

Difference devices had difference battery specification. Table 3 shows the result from the battery device analysis.

Table 4: Battery specification

Products	Product brands	Battery Type	Rated voltage	Rated Current
Handphone	Sony Ericsson w880i	Li-Pol	3.7V	950mAh
	Sony Ericsson k810	Li-Pol	3.7V	900mAh
	Nokia 6500 slide	Li-Pol	3.7V	900mAh
	Nokia N70	Li-ion	3.7V	1020mAh
Laptop	HP Presario C700	Li-ion	10.5V	3.3Ah
	Local brand	Li-ion	11.1V	4.4Ah
MP3	Sony Walkman NW1000	Li-ion	5V	0.8A
	unbranded	Li-ion	5.2V	0.5A
Camera	Sony Cybershot T200	Li-ion	3.5V	0.24Ah
	Casio Exilim	Li-ion	3.7V	0.7Ah

The product of this project was expected to charge difference type of devices. To design the charger, the data from charger devices charger need to be measured and inspected.

4.1.2 Charging Requirement

There had difference value between the device charger and its' battery. This was because to charge up the battery, the voltage and current value need to be set higher than the voltage and current value that state in the battery. The difference between the voltage and current value was depending on the device specification. Table 4 shows the result from the devices charger inspection.

Table 5: Charging requirement

Products	Product brands	Rated voltage	Measured voltage
Mobile phone	Sony Ericsson w880i	4.9V	7.1V
	Sony Ericsson k810	4.9V	6.9V
	Nokia 6500 slide	5V	6.5V
	Nokia N70	5V	7.8V
Laptop	HP Presario C700	18.5V	19V
	Local brand	18V	19.5V
MP3	Sony Walkman NW1000	5V	5.5V
	unbranded	5.2V	5.9V
Camera	Sony Cyber shot T200	4.5V	5.2V
	Casio Exilim	4.2V	4.8V

According to the result in the table, the best value of charge output was the highest value 18.5V. To get the lower value for other devices, the output of the charger can be regulate by the regulator circuit. The rated and measured voltage values were different because the rated value is the expected charger output value by the manufacturer while the measure value was the one that the charger supplies from the wall socket power supply.

4.1.3 Battery type

Another thing, there were two type of battery that usually use in the portable electrical device. The first one was the Lithium-Ion battery and the other one was the Lithium-Polymer battery. From the Table 3, most the device that use the Lithium-Ion battery was the old portable electronic device and most of the new device use the Lithium-Polymer battery. For example, take the Nokia brand mobile phone the old Nokia N70 used the Lithium-Ion Battery while the new Nokia 6500 slide used the Lithium-Polymer battery.

4.1.4 Battery Charging Stage

The “miracle charge” can be done to both of Lithium-Ion and Lithium-Polymer battery type. This was because both of the battery is in the Lithium base category. The “miracle charge” had several stages to be completed. The charging stage can be differentiates by stage 1, stage 2 and stage 3.

In the stage 1, maximum current were applied to the battery until the battery voltage limit reach. At the second stage, after the cell maximum voltage has reach, the current value will drop. And at the last stage, topping charge procedure will happened until the battery fully charge [5]. Figure 12 and figure 13 have the graph for battery charging stage.

The battery can be charge in the fast charging method. In this method, the stage 2 was eliminated and the battery can end up charge at the end of stage 1. The charge level at this point is about 70%. The topping charge typically takes twice as long as the initial charge [5].

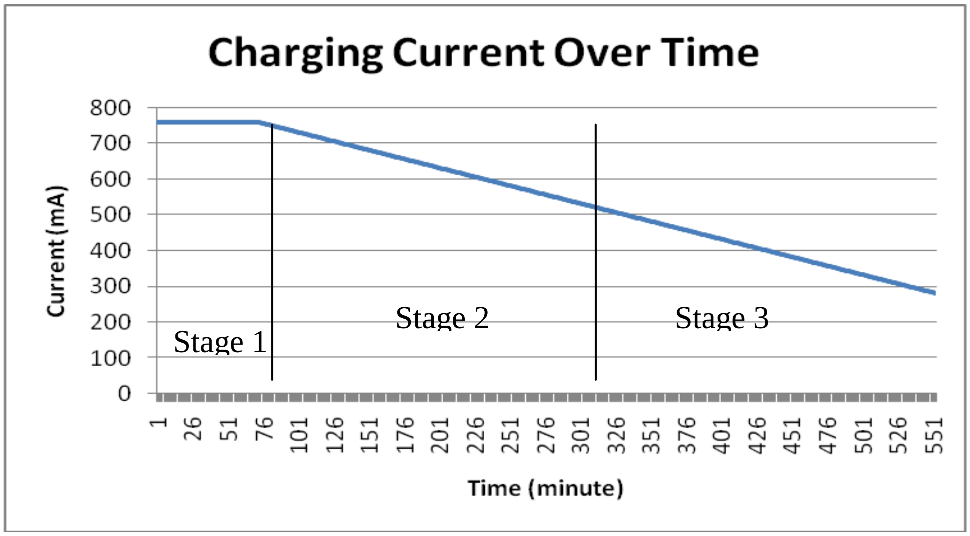

Figure 16: Charging current over time

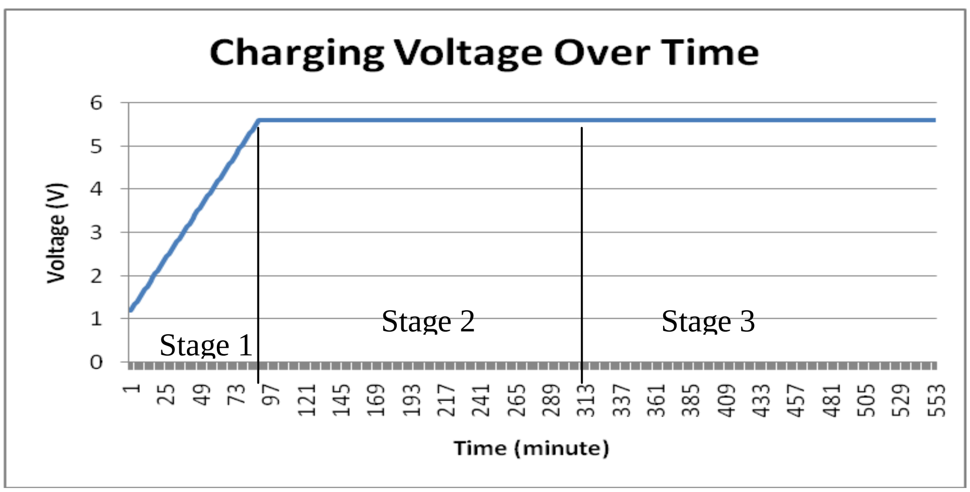

Figure 17: Charging voltage over time

4.2 Constructed Circuit

The constructed circuit in the PSPICE and on the breadboard be tested and compare the output value.

4.2.1 Circuit Test

There were several tests that the circuit had undergone. The first test was the comparison between the simulation output value and the measure output value. The result shown in table below:

Table 6: Simulation circuit vs. Constructed circuit result

Input (V)	Output (V)	
	Simulation(PSPICE)	Measure(breadboard)
3	1.6	1.8
4	2.3	2.5
5	3.4	3.5
6	4.8	4.5
7	6.8	5.5
8	7.4	6.3
9	8.0	7.4
10	8.7	8.3

The second test was determined the minimum value for input voltage to charge up Sony Ericsson W810i mobile phone using the constructed charger circuit. The result of the test shown below:

Table 7: Constructed Circuit charging Indicator result

Input (V)	Output		Charging Indicator X for not charging Y for charging
	Voltage(V)	Current (mA)	
3	1.8	230	X
4	2.5	250	X
5	3.5	250	X
6	4.5	260	X
7	5.5	280	Y
8	6.3	330	Y

For the third test, voltage selector circuit being tested and compare between the simulation and the self measured at the breadboard. The variable for this test was the value of the variable resistor (R2) in the voltage selector circuit (figure 9). The input for this circuit was constant at 10V. The result for the test shown below:

Table 8: Voltage selector circuit comparison

R2 Value (ohm)	Output	
	Simulation(PSPICE) (V)	Measure(breadboard) (V)
1000	8.3	8.1
800	8.2	7.9
500	7.5	7.1
200	3.7	3.5
50	1.8	1.6

4.2.2 Charging Time

This test was the comparison test between the original mobile phone chargers with the charger that had been constructed. The test result shown below:

Table 9: Charging time comparison test

Types	Original Charger	Constructed Charger Circuit
Input Supply	Wall Power Supply	Amorphous solar panel
Output Voltage	5.6V	5.5V
Output Current	790mA	330mA
Charging Time	2 hrs 15 min	3 hrs 45 min

Refer to the appendix II for further detail about the test setup and completed result value.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As for the conclusion, the project was successfully completed. The load and devices charging specification had been fully utilize in the circuit design process. The universal portable solar battery charger prototype has been design fabricated and tested. The project objectives have been achieved.

This product can be commercialized in Malaysian because Malaysia received lot of solar radiation intensity every year. With this product, the reliability of the electronics devices can be increase because of the charger mobility. This product hopefully will bring a lot of benefit to society.

Figure 18: Universal portable solar battery charger prototype

5.2 Recommendation

Photovoltaic that being used in this project is less efficiency. If the PV panel efficiency can be increase, more energy can be supply to the devices. It will generate more current to the devices and as the consequences, the time to charge up is reduces. The need to get the higher efficiency solar panel is crucial that it can give them enough energy to charge up high energy requirement devices such as laptop.

The new battery type is underdevelopment right now. It is call the ultra capacitor. It could be good to design the charge controller to this battery type, because in the future this type of battery will widely use in the electronics devices.

REFERENCES

[1] T. Markvart and L. Castañer, "Solar Cells Materials, Manufacture and Operation", Oxford: Elsevier Publishing, 2005.

[2] John A Duffie, William A Beckman, "*Solar Engineering of Thermal Process"*, 1st Ed, john Wiley & Sons, Madison, Wisconsin, 1980

[3] Isidor Buchmann, "The high-power lithium-ion", March 2006 http://www.batteryuniversity.com/partone-5A.htm

[4] Aaron Moore, "Lithium Polymer (Lipo) Battery Guide", 14 Nov 2008 http://prototalk.net/forums/showthread.php?t=22

[5] Isidor Buchmann, "Charging lithium-ion batteries", 25 March 2009 http://batteryuniversity.com/partone-12.htm

[6] K.M. Tsang, W.L. Chan, "A simple and low-cost charger for lithium-ion batteries", 28 October 2008, www.elsevier.com/locate/jpowsour

[7] Richard C. Neville, Solar Energy Conversion, "The Solar Cell, 2nd edition", Elsevier Science B.V, Amsterdam, Netherland

[8] J. Andrew McAllister, Alexander E. Farrell,"Electricity consumption by battery-powered consumer electronics: A household-level survey", 13 February 2006, www.elsevier.com/locate/energy