ALTERNATIVE SOLAR CHARGER FOR THE CELL PHONE

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***Abstract*—solar energy is a renewable energy source. Source of energy produced directly by sunlight can be converted into electrical energy using solar cells. One of the applications using this system is mobile phone battery charger. This solar battery charger can save energy compared charger existing electrical socket while not contributing to environmental pollution. By the way, the disadvantage of this energy source is due to the dependence on the presence or brightness of sunlight. The purpose of this project is to produce a mobile phone battery charger using solar energy in other cases to reduce electricity consumption. This project uses two methods namely the comparator circuit and PIC16F877A to observe the voltage of the solar cells on a continuous basis. If the voltage drops below the permissible limits, the system will transfer the connection to the battery. If the allowed, the voltage will be set to normal use voltage setter. As a result, devices will get the energy going and protected from the effects of the lack of voltage and Over-voltage.**

I. INTRODUCTION

The solar energy which directly produced by the sun and it can be converted to electricity by using solar cell. For example, one of the application that using photovoltaic technology is battery charger cell phone. Solar energy can also be collected, stored and put to work by converting it to pollution-free thermal (heat) energy and electricity [1].Solar cell is a device that converts the energy of sunlight directly into electricity by the photovoltaic effect. The main focus of this project is to design the charger with environmentally friendly materials and powered by renewable energy sources. The energy savings for battery charger cell phone is important in order to make sure that energy resource can be used for a long term. This project consists of three main elements which are voltage comparator, PIC microcontroller and relay switch. The voltage comparator is used to set and monitor the voltage level at solar cell and cell phone battery. The PIC microcontroller acts as the brain of the system that monitors the voltage from cell phone battery and control the switching of relay accordingly. The relay is used to switch on or off the solar cell as the main supply or to the battery as the backup supply.

I. THEORY

A .Photovoltaic charge

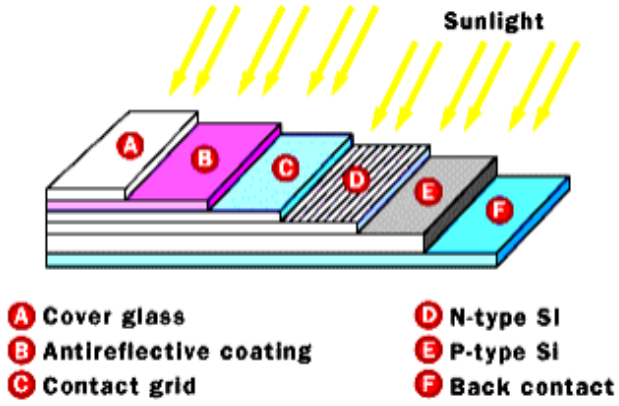


Figure 1: Photovoltaic cell structure

The Photovoltaic cell structure consists of six layers which is cover glass at the top of the layer. Then the second layer is antireflective coating, contact grid, n-type Si, P-type Si and the back contact.

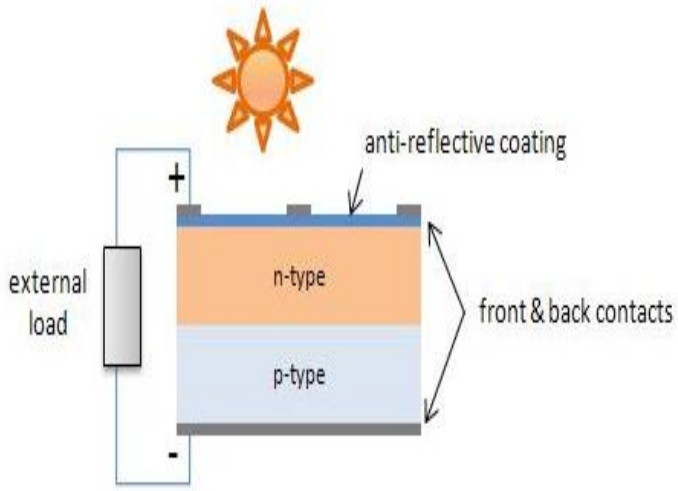


Figure 2: Cross-Section of the PV Cell

A photovoltaic cell transforms energy provided by the sun into electric energy. This is possible thanks to the photovoltaic effect. Solar cells are made of semiconductor materials, typically silicon. Solar cell works like a diode it is made by a PN junction that is formed by combining N-type and P-type semiconductors together in much closed contact. Due to the movement of electrons and holes (recombination) in the contact zone there is an electric field. The contact zone is called depletion zone. When solar light, in form of photons, strikes the cell the electrons in the outer shell of the silicon's atoms are moved by the electric field to the N-type layer. At the same time, for each free electron there is a hole that moves to the P-type layer thanks to the electric field [2].

B. *Voltage regulator*

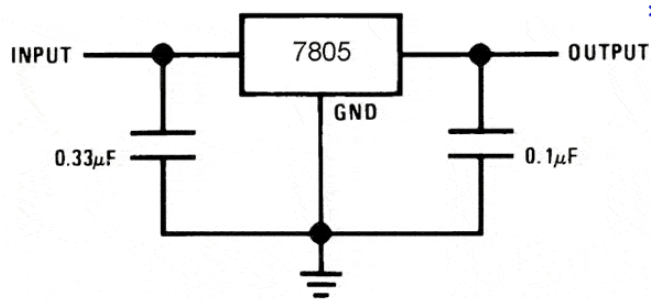


Figure 3: Voltage regulator circuit

The solar panel produces 12 v voltage but the voltage need to supply to the comparator circuit is 5v v, so voltage regulator need to use to regulate 12 v voltages to 5v voltage. The voltage regulator circuit consists of LM 7805, and the capacitor which are 0.33μf and 0.1μf.

C. *Comparator circuit*

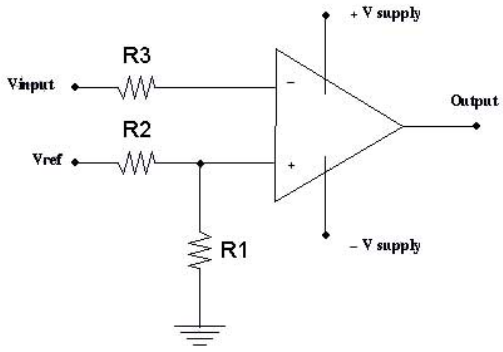


Figure 4: Basic circuit for the comparator circuit

Figure 4 represented a basic unit of voltage comparator circuit. It consists of an operational amplifier, often called an op-amp, that compares input voltage and provides switches its digital output to indicate which is input is larger. The output will stays at a high voltage level when the non-inverting (+) input is greater than the voltage level at the inverting (-) input and switches to a lower voltage level when the non-inverting input goes below the inverting input voltage.

II. RESEARCH METHODOLOGY

The simulation part should be running before doing the hardware part in order to make sure that the circuit can operate correctly and achieve the purpose of the project.

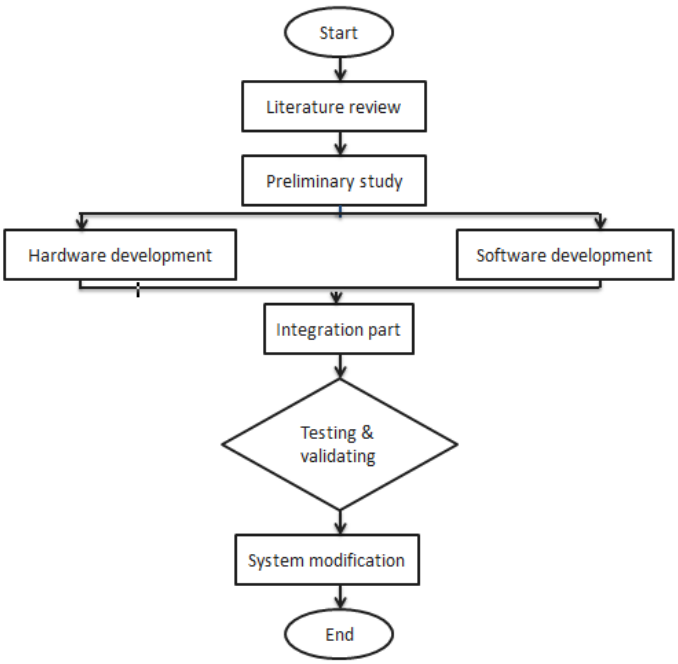


Figure 5: Methodology for Design the Alternative Solar Charger for the Cell Phone

A. *System design using comparator circuit*

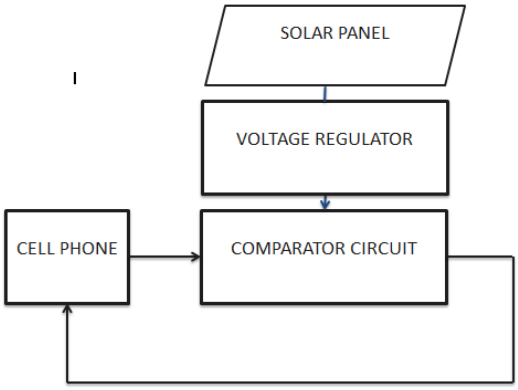


Figure 6: Block diagram for the system using comparator circuit

Figure 6 is the combination of the cellphone, comparator, and solar panel to the load. During the time, solar panel will get the energy from the sun and the circuit charging will control the charging rate to the battery. The charging circuit will control the charging until the battery reaches the floating condition that is the full condition of the battery

B. *System design using PIC microcontroller*

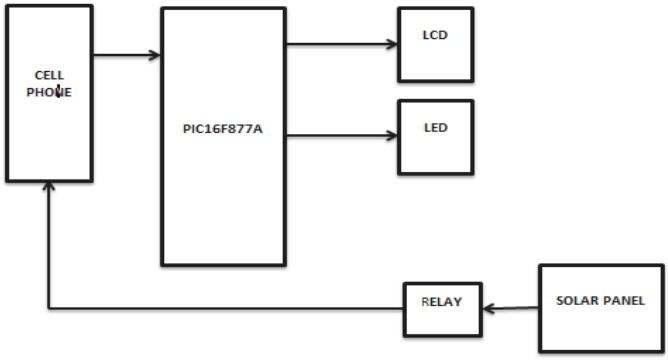


Figure 7: block diagram for the system using PIC controller

The block diagram show in Figure 7 is the combination of the cellphone, PIC16F877A, LCD display, relay and solar cell. During day time, solar panel will obtain the energy from the sun and the circuit charging will control the charging rate to the battery of cell phone.

The charging circuit will control the charging until the battery reaches the floating condition that is the full condition of the battery. To control the switching of the load it is depend on the battery voltage at cellphone that will give the input to the PIC, then PIC will give the output to the relays the same as the coding build in. For this circuit, the photovoltaic will determine whether the situation is needed to switch on battery or not.

C. *Software development*

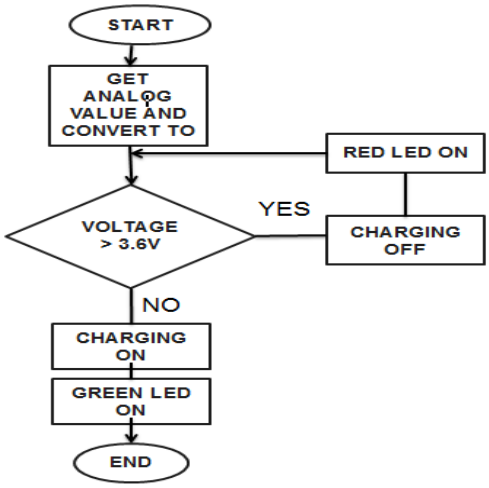


Figure 8: Process of writing PIC program using C language and simulate the system.

Figure 8 shows a software part that includes processes of writing PIC program using C language and simulates the system. After the program is success, it is burned into the PIC16F877A chip. Then proceed to hardware design to show the output of this project.

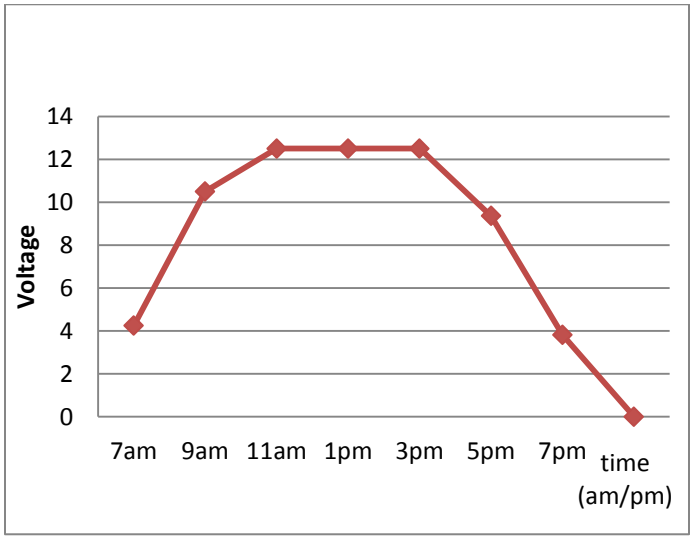
III. RESULT AND DISCUSSION

A. Data for Solar panel.

Time	Voltage (V)	Current (mA)
7.00 am	4.25	230
9.00 am	7.67	130
11.00 am	12.50	80
1.00 pm	12.50	80
3.00 pm	12.50	80
5.00 pm	9.36	100
7.00 pm	3.82	260

Table 1: data from the solar panel 12v

Based on the data from the table 2, the maximum voltage receive from the sun is 12.50v and the minimum voltage receive is 3.82v. Then the maximum current is 0.26v and the minimum current is 0.08A.



Graph 1: voltage (V) versus time (24hrs)

At the 7a.m the lighting receives by solar panel produce 4.25v. This voltage not enough to ON the cell phone because the minimum voltage required by the cell phone is 5.0v. The solar charger did not charging the cell phone at this time. Then at the 9a.m, lighting from the sun is enough to receive by solar panel to produce 7.67v. This voltage will be step down by voltage regulator to supply to solar charger. The cell phone can be charge at this time until 7pm.

B. Simulation for Comparator circuit

By using multisim software this design consist of 3 parts. The first part is about voltage regulator, LM317. Voltage from solar cell is 12v need to convert to 5v to supply to comparator circuit.

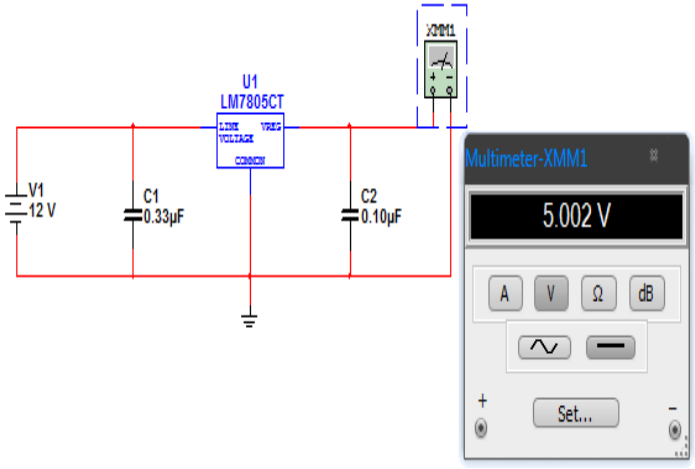


Figure 9: circuit of voltage regulator to regulate 12v to 5v.

This method used IC LM339 to compare the voltage battery cell phone and reference voltage. The maximum voltage set to 3.6v by R2 and the minimum voltage set to 0.5v by R3.

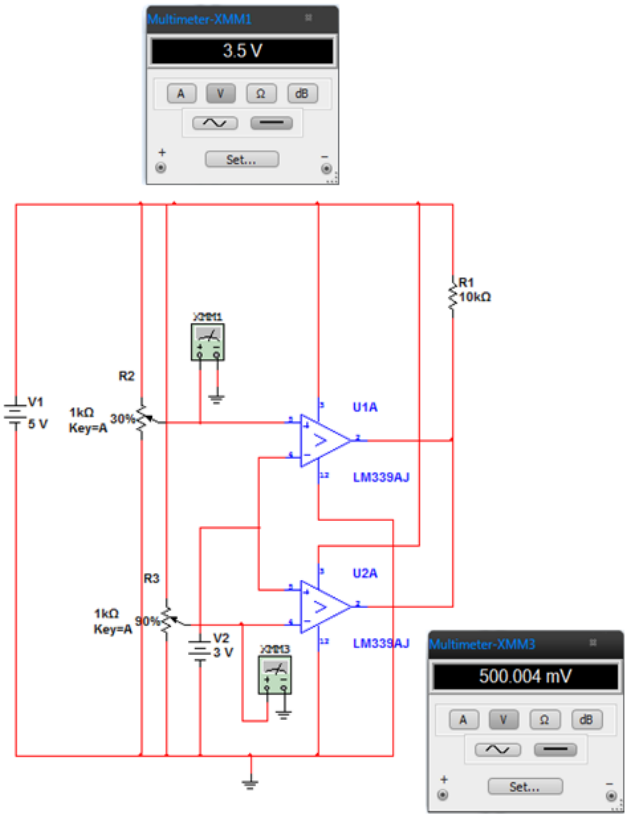


Figure 10: comparator circuit with reference voltage

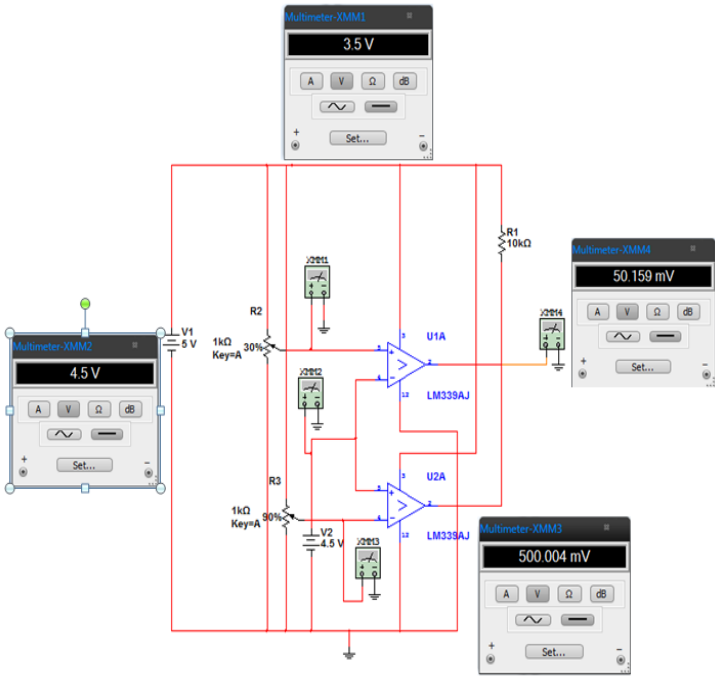


Figure 11: comparator circuit without output voltage (no charge)

The voltage from voltage regulator is 5v supply to the comparator circuit. This battery voltage needs to compare by voltage reference. Base on the figure 11, the voltage from battery (XMM2) is 4.5v compare to reference voltage. Means the battery voltage is high than voltage reference so the comparator not allow the supply voltage as an output voltage. So the battery not charges.

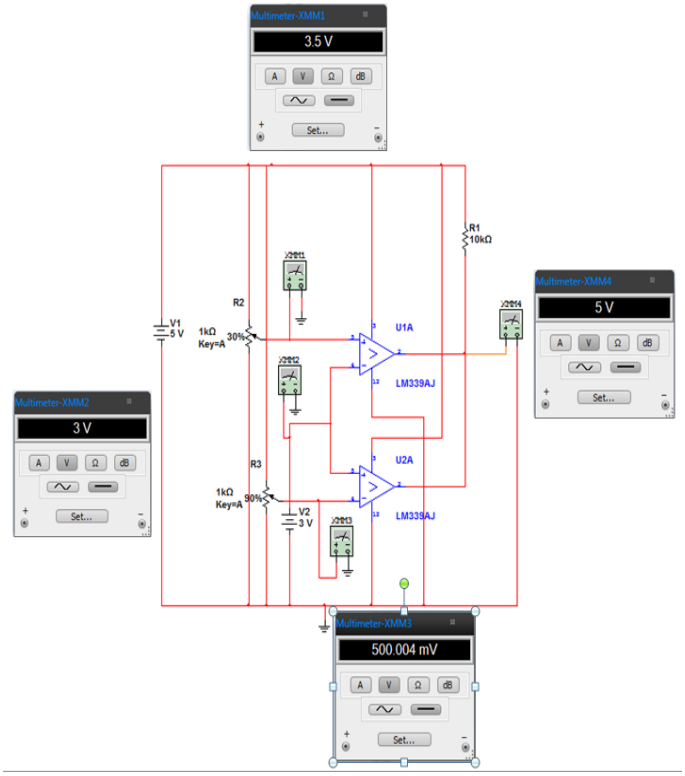


Figure 12: comparator circuit with output voltage (charge)

The voltage from voltage regulator is 5v supply to the comparator circuit. This battery voltage needs to compare by voltage reference. Base on the figure, the voltage from battery (XMM2) is 3v compare to reference voltage. The value of battery voltage is between the voltage references so the comparator allows the supply voltage as an output voltage. So the battery is charge.

The output voltage connect to the cell phone until the battery voltage high than 3.6v

Input voltage (V1)	Voltage from battery (V2)	Output voltage (V3)
5.0	0.6v	5.0v
5.0	1.0v	5.0v
5.0	1.5v	5.0v
5.0	2.0v	5.0v
5.0	2.5v	5.0v
5.0	3.0v	5.0v
5.0	3.5v	5.0v
5.0	4.0v	0.5v
5.0	4.5v	0.5v

Table 2: Output Voltage from the comparator

C. *System Design for PIC microcontroller*

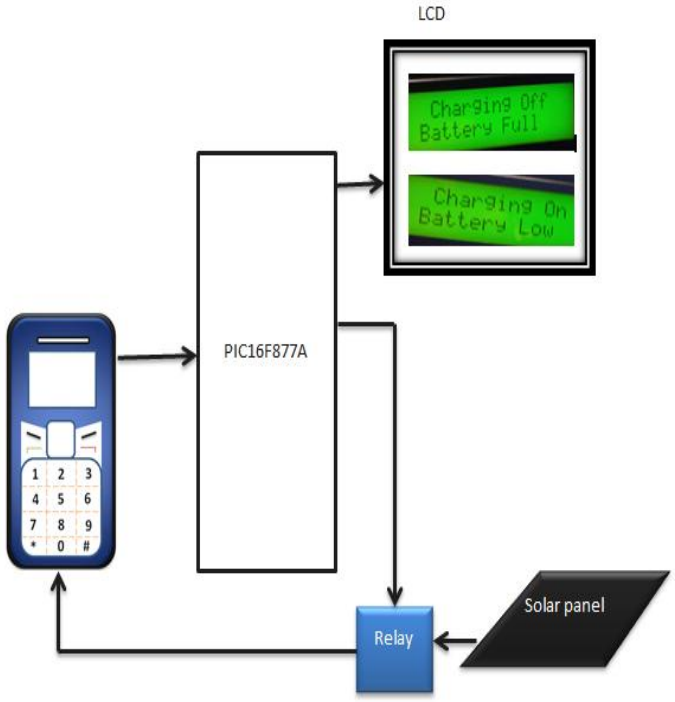
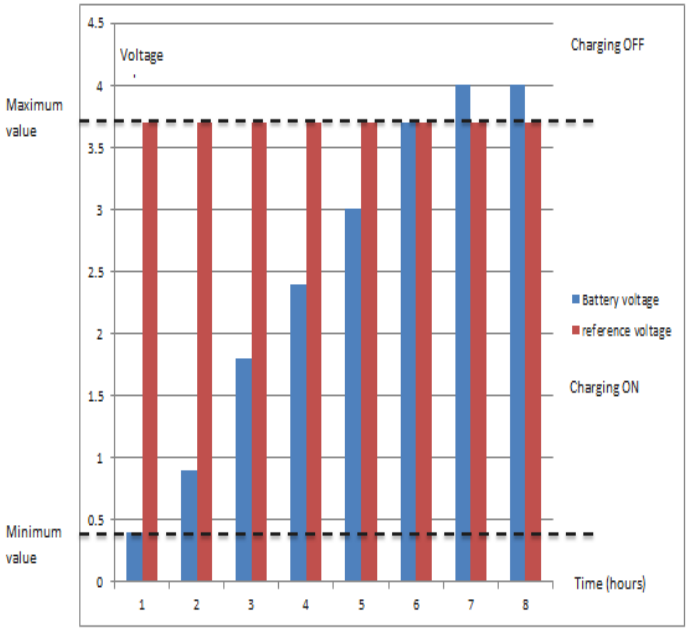


Figure 13: solar charger using PIC microcontroller

Figure 13 shows the solar charger using PIC16F877A to control the circuit. If the input voltage (battery cell phone) give the value for this PIC microcontroller, the PIC's software will compare the reference voltage to turn on or turn off the output voltage. The reference voltage will be set in this program and this program will compare the voltage in digital value. If the value from battery is in range between reference values, the PIC read the program and activates the relay.

When the relay is turn on, voltage from solar will charging the cell phone and the LCD will display 'CHARGING ON BATTERY LOW'. Otherwise the LCD will display 'CHARGING OFF BATEERY FULL'



Graph 2: the maximum and minimum value of reference voltage

The minimum value is 0.45V and the maximum value is 3.6V. The output value when the cell phone charging is 5.5V and the value when cell phone are not charging is 0.00V base on the graph 2.

IV. CONCLUSION

Solar technology is an alternative that can be commercialized in order to replace nonrenewable fuel sources. From solar technology, many applications have been introduced such as solar charger, solar car, solar heater and solar street light. In order to develop the solar technology, several factors must be considered like weather, the environment factor, reliability of solar module, controller system and the load. Therefore, this solar technology still needs further improvement in order to achieve higher performance. Solar charging using comparator circuit need low price compared with SK40C

circuit because comparator circuit just use a simple component to build this circuit. SK40C used a complex component compared with comparator circuit. The advantages of SK40C is it can add more function in software because PIC 16F887A at SK40C have a big memory.

V. PROJECT LIMITATION

This project is not suitable for use during dark environment for example during the night because, there is no lighting intercity to produce the voltage and supply to the cell phone.

VI. FUTURE DEVELOPMENT

This project can be modified by adding a spare battery. This spare battery can be used during night with low light intensity. Solar panel received energy from the sun during a day, then the voltage battery received the maximum voltage, the solar charger was unplugged and that energy can charge the spare battery and this battery should be charge the cell phone during the night.

VII. REFERENCES

[1] Eric Epstein, "Solar Energy Lesson Plan" EFMR Monitoring Group, Inc, 2009

[2] A. Salata, "Appendix A: operation of photovoltaic cell" unpublished

[3] National Instrument, Omp Amp Electronic, *tutorial: Part 1-Photovoltaic Cell Overview*. Dec 2009

[4] Specmat" [Online] Available
http://specmat.com/photovoltaic%20cell%20specmat.html

[5] C. Murphy and S.Rahman, "Photovoltaic Operatiom", School of Electrical and Information Engineering Liaoning Institute of Science and Technology, 2011

[6] Fairchild Semiconductor, LM78XX/LM78XXA, *3-terminal 1A Positive Voltage Regulator*, August 2012

[7] National Semiconductor, Application Note 31, *Op-Amp Circuit Collection*, Sept 2002

[8] Prof. Neureuther, Lecture 9, The operational amplifier ("op amp"), Feedback, Comparator circuits, Ideal op amp, Unity-gain voltage follower circuit, 2003