Basic Design of A Charging Circuit for Mobile Phone Using Solar Panel

LianlyRompis
UniversitasKatolik De La Salle Manado
KombosKairagi I Manado, Sulawesi Utara - Indonesia
lrompis@unikadelasalle.ac.id

Julie Rante
UniversitasKatolik De La Salle Manado
KombosKairagi I Manado, Sulawesi Utara - Indonesia
jrante@unikadelasalle.ac.id

***Abstract*—Currently the learning process cannot be separated from the exchange of digital information and online interaction. Initially using computer technology and internet, then growing with the existence of mobile phone technology. The demand of Digital Learning for efficient and environmentally friendly energy is very important and urgent because of the increasingly expensive price of fuel and the high utilization of mobile phones as a learning tool for the society. Our government itself supports the discoveries, researches, and technologies that use renewable energy such as energy from sunlight and biomass energy. The city of Manado which located in North Sulawesi province has a good hot climate every year and a fairly high solar energy. This is very good if it can be used as a source of energy for certain equipment such as mobile phones. This paper describes a basic research that has been done where the energy of sunlight becomes alternative energy to charge a mobile phone. The research method is literature study, theory comparison, block diagram design, assembly, and testing. The results obtained give hope that in the future there are opportunities to develop further research and design a solar energy source for mobile phones charging, by using solar cells that have specific current and voltage specification.**

***Keywords*—charging circuit,mobile phone technology, digital learning, solar energy, solar cell**

I. INTRODUCTION

1.1 Reason for Research

Introduction contains background research, the purpose of research, review studies that have been conducted, the purpose of the A learning process is a part of academic world and one of the essential role in education. Nowadays the learning process cannot be separated from digital information exchanges and online interactions. Using computer technology and internet, sources of teaching materials and assignments can be upload to a cloud server that will be easier for teachers, lecturers, and students to communicate and put a flexible time for learning.

Digital technology development also brings wireless and cellular technology which is mobile and more efficient for learning anywhere through a smart device called mobile phone. The demand of Digital Learning for efficient and environmentally friendly energy becomes very important and urgent because of the increasingly expensive price of fuel and the high utilization of mobile phones as a learning tool for the society. Indonesian government since millennium year has supported the discoveries, researches, and technology innovations that use renewable energy such as energy from sunlight and biomass energy.

In relation to these main reasons and because our city of Manado which located in North Sulawesi province has a good hot climate every year and a fairly high solar energy, a basic research and feasibility study has been conducted for the possibility of using sunlight energy in certain equipment such as mobile phones.

1.2 Scope of Problem

Our research is a basic research to derive a basic design of a charging circuit for mobile phone, using solar panel. Many practitioners have created their own charging circuit and it works well, but through this research we would like to share from its scientific body of knowledge, from our scientific points of view. Hopefully this will become one of the best references for academicians and students in making a solar panel based mobile phone charging circuit, and further improvements can be taken for good.

II. LITERATUR REVIEW

2.1 Previous Studies

Previous studies have been conducted with the help of our students. The main purpose was to learn about solar panel module and how to measure its supply voltage, and then came to an idea for charging a mobile phone related to energy issue that arrives importantly for its availability and sustainability. The results of measurement varied between 5 to 7 DC Volt, depends on the intense of the sunlight. For another experiment, a series of Light Emitting Diodes (LED) has been connected to the output of solar panel, and all the LEDs are light up.

Because mobile phone battery needs a charge voltage around 4 – 5 DC Volt, and our solar panel reaches 7 DC Volt when the intense of sunlight is highest, so there should be another module or circuit being connected to the solar panel so it can output voltage and current that match mobile phone battery specification. Actually, when a Samsung mobile phone was connected directly to the solar panel during previous research, nothing happened except slow charging as the effect of low current. But for the battery durability and lifelong usable, it is necessary to have a research to find out about a basic design for charging circuit [1].

2.2 Theoretical Framework

2.2.1 Solar Cell Panel

A solar cell panel is an energy panel based on the energy of sunlight. A solar panel consists of solar cells which is arranged in a series or parallel connection that will determine its output voltage and also the output current. Each solar cell usually generates a voltage of 0.45 – 0.5 DC Volt and an electric current of 0.1 A upon receiving a bright light beam. As with the battery solar cells assembled in series will increase the voltage while the solar cells in parallel will increase the current, as shown in figure 2.1 and figure 2.2. [2][3][4][5][[6]

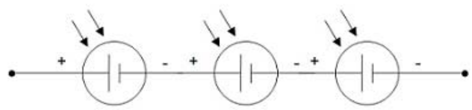

Fig.2.1. Solar Cell in Serial Circuit
(teknikelektronika.com, 2017)

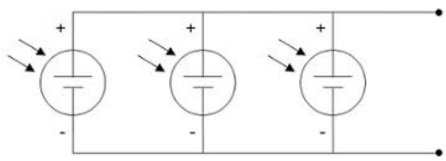

Fig.2.2. Solar Cell in Parallel Circuit
(teknikelektronika.com, 2017)

2.2.2 Secondary Battery

Secondary Battery is a rechargeable battery.This battery generates electric current using the same principle as primary battery, but chemical reactions can be reversible. When thisbattery is in charging process (connected to energy source), the electrons will flow from positive to negative, and when the battery is in discharging process (connected to a load), the electrons will flow from negative to positive. The types of rechargeable batteries we often find include

p ISSN 2355-8253 | e ISSN 2442-7888 | DOI 10.24167/sisforma

Ni-cd (Nickel-Cadmium) Ni-MH (Nickel-Metal Hydride) and Li-Ion (Lithium-Ion) batteries, as shown in figure 2.3.

2.2.3 Ni-Cd (Nickel-Cadmium) Battery

Ni-Cd (Nickel-Cadmium) batteries use Nickel Oxide Hydroxide and Metallic Cadmium as an electrolyte material. This battery able to operate in wide temperature and long cycles. However, this battery also contains 15% toxic, Carcinogenic Cadmium, that could be harm for human life and environment. Currently, the use and distribution of this battery in the marketplace has been prohibited by European Union under the "Directive 2006/66/EC" regulation.

2.2.4Ni-MH (Nickel-Metal Hydride) Battery

Ni-MH (Nickel-Metal Hydride) batteries have a 30% higher capacity compared to Ni-Cd Batteries. Ni-MH batteries can be recharged up to hundreds of times so that it can save money on battery purchases. Ni-MH batteries are widely used in Camera and Radio Communication. Although they do not have a cadmium hazardous substance, these batteries still contain few harmful substances that can damage human health and the environment so it needs to be recycled and should not be disposed of in any place.

2.2.5Li-Ion Battery (Lithium-Ion)

Li-Ion Batteries are widely used in portable electronic devices such as digital camera, mobile phone, and laptop. These batteries have higher cycle endurance and also 30% lighter as well as providing a higher capacity of about 30% when compared to Ni-MH batteries. Li-Ion batteries are more environmentally friendly because do not contain harmful substances Cadmium, but still contain little harmful substances that can damage human health and the environment so it needs to be recycled and should not be removed in any place.

Fig.2.3. Secondary Batteries
(teknikelektronika.com, 2017)

2.2.6DC to DCConverter

A DC to DC converter is an electronic circuit built for direct current input voltage conversion. The input voltage can be converted into a lower DC voltage, or a higher DC voltage, sets by a step-down transformer or a step-up transformer in the circuit. We can see the parts of this converter from the diagram shown in figure 2.4.

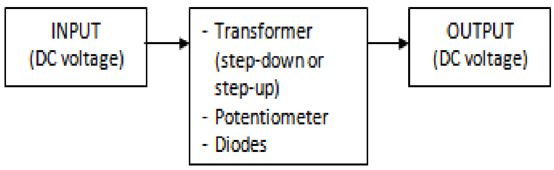

Fig. 2.4. DC to DC Converter Block Diagram

2.2.7Voltage Regulator

A voltage regulator is an electronic Integrated Circuit (IC) component used for regulating a positive or negative direct current voltage. The most common voltage regulator ICs are 78XX and 79XX. The XX value is the desired output voltage value, for example 7805 will output a voltage of 5 Volts and 7905 will output a voltage of -5 Volts. Minimum supply voltages are 7 DCV or -25 DCV, maximum supply voltages are 40 DCV or -7 DCV, voltage regulation type is linear, and the maximum output equals to

1 Ampere [7]. Figure 2.5 shows the model of voltage regulator ICs.

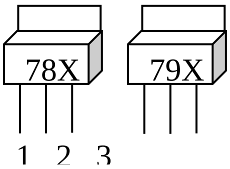

Figure 2.5. Voltage Regulator IC (1= input, 2 = ground, 3 = output)

III. RESEARCH METHODOLOGY

Several methods are taken for this basic research:

3.1 Literature Study

Before starting this research, the author started collecting references and information related to solar panel basic concept and mobile phone charging circuits.

3.2 Theory Comparison

A theory comparison has been conducted to get the right information and have best references for the research.

3.3 Choose Sample

This research use 2 (two) solar panel as a sampling, both have 5 DCV output but packed in different model or panel (the other one already equipped with rechargeable battery).

3.4 Select Instrument

For measurement, an analog multimeter and a digital multimeter is used to get accurate results and can make a comparison. A DC to DC converter with voltmeter module is also helpful in getting accurate observation results.

3.5 Derive Tables for Observations and Measurements

The next step that is very important for data analysis is derives tables that required for observations and measurements. These tables should be in accordance with sampling and instrument being used.

3.6 Block Diagram Design

A sketch of block diagram has been made to bring clearly understanding upon the input, process, and output of a charging circuit.

3.7 Assembly and Testing

The last step is to assembly and conduct testing. A conclusion is made which summaries the research output that points out to research aim, whether already appropriate or not.

IV. RESULTS AND DISCUSSION

4.1 Solar Cell Panel Module

A solar cell panel module is constructed into two blocks; each block has several solar cells that are connected to give an output of 5 DC Volt, as shown in figure 4.1. Their specifications are given in table 4.1 and table 4.2.

Fig. 4.1.Solar Cell Panel Module

Table 4.1. Specification of the Solar Cell Panel Module A

Parameter	Range/Setting
Voltage Output	5 Volt
Current Output	240 mA
Power Output	1,2 Watt
Size	11 x 6.9 x 0.3 cm

Table 4.1. Specification of the Solar Cell Panel Module B (equipped with Li-polymer Battery 2600 mA)

Parameter	Range/Setting
Voltage Output	5 Volt
Current Output	500 mA
Power Output	0,8 Watt
Size	10 x 6 x 0.3 cm
Input to Mobile Phone	4.5V 800 mA

4.2Adjustable DC-DC Step Up Step Down with Voltmeter Module

An adjustable DC-DC Step Up Step Down LM2577 LM 2596 with Voltmeter module (figure 4.2) is a DC-DC converter module which convert input voltage into lower or higher output voltage, depends on the output setting where IC Step Down (LM 2596) and Step Up IC (LM 2577) will adjust to each other. This module is equipped with 7-segments display and its specification is shown in table 4.3.

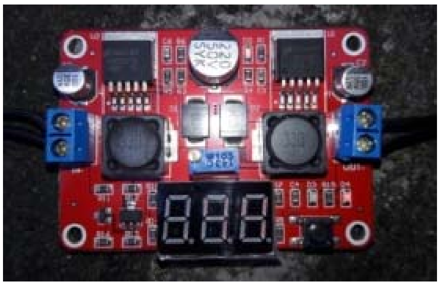

Fig.4.2. Adjustable DC-DC Step Up Step Down with Voltmeter Module

Table 4.3. Specification of the Adjustable DC-DC Step Up Step Down Module

Parameters	Range/Setting
Input	3.5 – 28 Volt
Output	1.5 – 26 Volt
Input / Output Current (mx.)	Max peak 3A, continuous 1A
Step Up Regulating Mode	Potentiometer rotates in clockwise
Step Down Regulating Mode	Potentiometer rotates in anticlockwise
Size	6.6 x 4.7 x 1.4 cm

Table 4.4. Initial Observations and Measurements taken in Telecommunication Laboratory and at the top of the university's building.

Condition	Taken in Laboratory		Taken under the sun	
	Output from Solar Panel	Output from Converter	Output from Solar Panel	Output from Converter
Solar Panel covered with a book	0 Volt	-	2 Volt	-
Solar panel uncovered, and given no intense of light	2 Volt	-		
Solar panel is given an intense of light	2.4 Volt	-	-	-
Solar panel is given no intense of light, and connected to DC-DC converter	1.2 Volt	0 Volt (no display and diodes light off)	-	--
no intense of light, and connected to DC-DC converter		(no display and diodes light off)		
Solar panel is given an intense of light, and connected to DC-DC converter	1.4 Volt	0 Volt (no output display, and no diodes light up)	-	-
Solar panel covered with shadow	-	-	Varies between 4 – 4.5 Volt, depends on the shadow coverage	-
Solar panel uncovered	-	-	5 Volt	-
Solar panel connected to DC-DC converter	-	-	4.2 Volt (Diode D0 and Diode D3 were light up, display showed 4.1 Volt for input)	-
Solar panel connected to DC-DC converter, output was set to 4.8V	-	-	4.0 Volt (Diode D0 and Diode D3 were light up, display showed 3.9 Volt)	4.78 Volt (Diode D0 and Diode D4 were light up, display showed 4.8 Volt for output)

Note :outputs are measured using analog/digital multimeter and 7-segments display

Table 4.5. Observations and Measurements when connected to a Mobile Phone

Condition	Results
Current without load	0 ampere
Current with a load	2.5 milliamperes
Battery Percentage: 70% (initial condition, output from charging circuit 4.2 Volt)	From 11:09 – 11:12 am (3 minutes), it dropped 1% to 69%
Battery Percentage: 69% (output from charging circuit 4.2 Volt)	From 11:12 – 11:15 am (3 minutes), it dropped 1% to 68%

Note :data was taken at 10.46 am, a little cloudy but clear blue sky. Type of battery: Samsung Li-ion battery. Nominal voltage 3.85 VDC/11.55 Wh. Charge voltage 4.4 VDC/3000 mAh. Input from charging circuit 4.8 Volt

Table 4.6. Observations and Measurements when connected to a Mobile Phone

Condition	Input Voltage (from converter to mobile phone)	Input Current (when connected to mobile phone)	Charging Process
Normal (without charging)	-	-	No charging Battery drops from 73% to 72% in 7 minutes (12:40 – 12:47)
Solar Panel A is connected with converter (input to mobile phone is set to 4.4 Volt), a diode is connected series with positive terminal	4.41 Volt	20 – 30 mA	Battery drops from 72% to 71% in 6 minutes (12:47 – 12:53)
Condition	**Input Voltage (from converter to mobile phone)**	**Input Current (when connected to mobile phone)**	**Charging Process**
Solar Panel B is connected with DC-DC converter (input to mobile phone = 4.42 Volt)	4.42 Volt	0.31 – 0.35 A	Battery percentage keeps point in 68% in 21 minutes (13:09 – 13:30) – never change
Normal (without charging)	-	-	No charging Battery drops from 68% to 67% in 5 minutes (13:30 – 13:35), and it drops again to 66% in 6 minutes) (13:35 – 13:41)
Solar Panel B is connected with DC-DC converter (input to mobile phone = 4.41 Volt)	4.42 Volt	0.39 – 0.42 A	Battery percentage goes up to 67% in 8 minutes (13:41 – 13:49), and up again to 68% in 21 minutes (13:49 – 14:10)
Solar Panel B still connected with DC-DC converter (input to mobile phone = 4.41 Volt) A you tube video has been played for around 15 minutes	4.42 Volt	0.39 – 0.45 A	Battery percentage keeps pointing 68% (14:10 – 14:25)
Normal (without charging)	-	-	No charging Battery drops to 67% in 1 minute (14:25 – 14:26)

Note :Data was taken at 12.11 – 14.26 pm, a little bit cloudy, sometimes the sun shines brightly and sometimes it only partially shines. Output voltage from solar panel varies between 2.98 – 4.22 DC Volt, and the output current varies between 0.09 – 0.16 A.

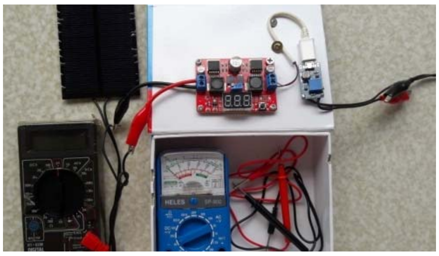

Fig.4.3. A Mobile Charging Circuit built for Observations and Measurements

From all the observations and measurements result shown in table 4.3 to table 4.6, we can conclude that a mobile phone needs higher current to have a faster charging, also added with DC-DC converter for stepping down the output voltage from solar panel if it's too higher, so it will meet the specification of battery charge voltage. Voltage regulator can be used for getting a constant and stabilize input voltage for mobile phone, besides adding an appropriate diode at solar panel so it will block the reverse flow of electrons from the battery [8][9][10].

Because this charging circuit works with solar panel and, the sun only shows up half of the day, some people usually like to add a rechargeable battery so it can store energy and doing charging at night. Based on this study and conclusion, a basic design for a mobile charging circuit using solar panel can be derived in Figure 4.4.

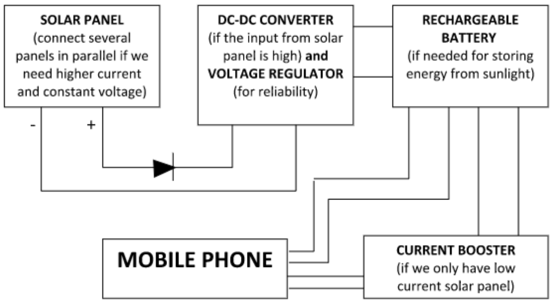

Fig.4.4. Basic Design for Mobile Phone Charging Circuit using Solar Panel

Further research and improvements can be done for analyzing parameters, components, and reliability of this basic charging circuit, to have a solution for better re-design.

V. CONCLUSIONS

From the result, it can beconcluded that a basic circuit of a charging circuit for mobile phone using alternative energy from the sun is possible to be designedusinga DC-DC converter and voltage regulator, with appropriate parameters and measurements. It is necessary to have a good charging and raise the battery percentage efficiently, so the output needs higher current with recommended charging voltage. Input voltage which does not exceed a battery charge voltage is more desirable. The higher the current, the better and faster the charging will be, while low voltage and lower current only make the charging slows down or even stop working. More current can be obtained by constructing an array of two or more solar panel into a form of parallel circuit, that will keep maintaining the value of voltage.

This is a basic design research that need further improvement in measurements and high stability for its voltage and current outputs, in order to obtain a good and optimal charging for a mobile phone.

ACKNOWLEDGMENT

Part of the research is funded by our institution, UniversitasKatolik De La Salle Manado. Thank you for the support, and also contributions from our students (VicklyZachawerus and IdrionoTado).

REFERENCES

[1]. B. Anto, E. Hamdani, and R. Abdullah,“Portable Battery Charger Berbasis Sel Surya”, *in Jurnal Rekayasa Elektrika, 11(1), 19-24,* 2014.

[2]. W. Hayt, *Rangkaian Listrik Jilid 1*, 6th ed. Jakarta: Penerbit Erlangga, 2006.

[3]. W. Hayt, *Rangkaian Listrik Jilid 2*, 6th ed. Jakarta: Penerbit Erlangga, 2010.

[4]. A. Joewono, R. Sitepu, and P. Angka,“Perancangan Sistem Kelistrikan Hybrid (Tenaga Matahari dan Listrik PLN) untuk menggerakkan pompa air submersibel 1 phase”,*in Seminar Nasional Ritektra VI Unika De La Salle Manado*, 2016.

[5]. A. Gunadhi and J. Mulyono, “Prototipe Penyatuan Sumber Tegangan DC pada Sistem Hybrid PLN dengan Energi Terbarukan”, *in Seminar Nasional Ritektra VI Unika De La Salle Manado*, 2016.

[6]. D. Kho, (2017). *Pengertian Sel Surya dan Prinsip Kerjanya.* Teknik Elektronika. Available: http://teknikelektronika.com/pengertian-sel-surya-solar-cell-prinsip-kerja-sel-surya/

[7]. D. Arifianto, *Kamus Komponen Elektronika.* Jakarta: Penerbit PT. Kawan Pustaka, 2011.

[8]. D. Rusmadi, *Mengenal Teknik Elektronika.* Bandung: Pionir Jaya, 1999.

[9]. O. Bishop, *Dasar-Dasar Elektronika*. Jakarta: Penerbit Erlangga, 2004.

[10]. M. Abdillah, *Pengetahuan Dasar Elektronika Analog dan Digital*. Pontianak: Yayasan Kemajuan Teknik, 2017.

[11]. M. Hapudin and Andika, “Rancang Bangun Alternatif Charger Handphone Tenaga Surya”, *in Jurnal ICT Penelitian dan Penerapan Teknologi. 12-23*, 2017.