1480 W Plts (Solar Power Plant) Architecture With Solar Tracker For Controlling Microcontroller-Based Solar Panel In Tigaraja Village, Sub-District Of Tigadolok, Regency Of Simalungun

Robert Samosir, Trahman Sitepu ,Yosua Fransisko Sinaga

Abstract: Electrical energy has become a basic need for human being. In some remote areas, however, electricity is unreachable and poses a taboo subject and cannot be enjoyed by local people, such as in Tigaraja Village, Sub-District of Tigadolok, Regency of Simalungun. The sun is a renewable energy that it is beneficial for power plant use. With PLTS, solar energy can be changed into the sun through the solar panel. Battery Charge Regulator (BCR) operates stabilizing voltage from solar panel to battery. The battery will save electrical power to be distributed for household consumption. Since battery power has direct current, however, Inverter operates changing its direct current into alternating current. To optimize absorption of solar energy, a servo motor is used to make solar panel moving by following the sun's path. Arduino Uno as direct control of solar panel using solar sensor gives current for servo motor. Then, the servo motor can move in reverse and forward. Therefore, Household goods, like water pumps, lamps and televisions have been worked when people come home from their work.

Index Terms: Solar Panel, BCR, Battery, Servo Motor, Microcontroller.

1 INTRODUCTION

Problem of electrical supply in remote areas and islands is at a difficult category where PT.PLN (PERSERO) cannot handle. The problem is not only power plant of PT.PLN (PERSERO) unable to cover peak load in an area, but the infrastructure problem not sufficient to the location. Moreover, the remote areas is far from substation where the number of population is small and scattered and the need for electricity is relatively low. Those factors lead to the uninteresting investment for supply of power plant to be realized. Microcontroller is a control which can control a circuit having input for controlling and output for arranging to the circuit. Microcontroller can also operate to solar tracking making movement of solar panel automatically to follow the sun's path. We can mention using of this renewable energy cheap and free. Therefore, by knowing converting process of solar power into electrical power, it can become a consideration in developing alternatively renewable energy which cannot pollute the environment. Up to now, people in some remote areas can only see electrical energy in areas accessed by electric current and they do not also experience and obtain lighting from electric energy supplied by PT.PLN (PERSERO).

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2 REVIEW OF LITERATURE

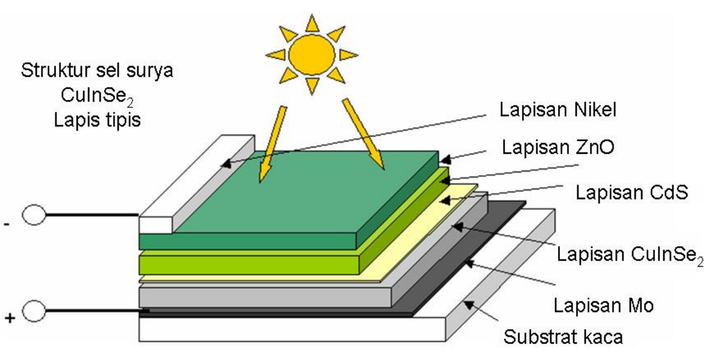
Energy constitutes one of the needs that human being must have. A great part of needs for energy are fulfilled by oil as its raw material. But, condition of oil is recently running low and the price is rising sharply. For that reason, we develop alternative energy resources. There are various energy resources which can be used as a substitute of fossil fuel (oil and coal) and they are renewable energy in which come from water, solar, tide, wind, wave and biomass. New and renewable energy is clean energy which is renewable and able to provide energy which is sustainable and relatively stable in long term. Resources of renewable energy are resources of energy made and invested by human that can be used and renewed at all times. They are numerous in nature. Some can be used economically and some cannot be used maximally. Supply of renewable oil is limited, but it becomes significant energy resource for foreign exchange that it will encourage for use of the new and renewable energy which can be grouped into: Energy Resources come from Wind, Water, Biomass, Tide and Solar.

History of Invention of Solar Panel

Literally, photovoltaic comes from Greek Language, photos, means light and volta is named after a physicist who found voltage. Simply, it can be defined as electricity and light. Photovoltaic constitutes a process which changes light power into electrical power. This process can be called as a reverse from invention of laser. Photovoltaic effect succeeded firstly to be identified by a French physicist, Alexandre Edmond Becquerel in 1839. In 1876, William Grylls Adam with his student, Richard Evans Day, invented that solid material of selenium was not able to convert electricity in the number expected. It was, however, able to prove that electricity could be resulted from solid material without heat or moving part. In 1883, Charles Fritz tried to research by covering selenium semiconductor with thin layer of gold. Photovoltaic made by him produced efficiency less than 1%. Then, relevant development was Albert Einstain's invention on photoelectric effect in 1904. In 1927, photovoltaic in type of new architecture used copper and copper oxide semiconductor. This combination could, however, also solely produce efficiency less than 1%. In 1941, a researcher named Russel Ohl succeeded to develop a technology of solar cell and known as the first person who made patent device of modern solar cell. Material used was silicon and able to produce efficiency about 4%. Then, in 1954, Bell Laboratories succeeded to develop it by reaching efficiency of 6% and finally 11 %. On the bright mid-day, radiation from the sun's rays was able to reach 1000 watts per meter square. If a semiconductor device in the width of one meter square had efficiency of 10%, this module of solar cell was able to give electrical power in the amount of 100 watts. By this day, the commercial module of solar cell has efficiency from 5% to 15% depending on its making material. Crystal silicon type is a kind of devices of solar cell having high efficiency, although its fee for making is relatively more expensive than others. This is a module type of solar cell which is distributed in the markets.

Construction of Solar Cell

As development of science and technology, kinds of solar cell technology are also developed in many innovations. Some is mentioned solar cell in generation one, two, three and four with structure and parts of making cell different also (image 2.6). General structure of cell is in markets recently i.e. silicon material-based solar cell which is generally including structure and how to work silicon cell in generation one (silicon solar cell) and in generation two (thin layer).



Struktur sel surya = Structure of solar cell
CulnSe2 = CulnSe2
Lapis tipis = thin layer
Lapisan Nikel = Nickel Layer
Lapisan ZnO = ZnO Layer
Lapisan CdS = CdS Layer
Lapisan CulnSe2 = CulnSe2 Layer
Lapisan Mo = Mo Layer
Subtrat kaca = Glass Substrate

***Image 1:** commercial structure of solar cell using silicon material as semiconductor*

Substrate or Backing Metal

Substrate is a material supporting all components of solar cell. Substrate material need also to have good conduction of electricity in the reason of it also works as contact of positive terminal of solar cell. Therefore, it is generally used for metal material, like aluminum or molybdenum. For dye-sensitized solar cell (DSSC) and organic solar cell, Substrate also works as an entrance for light that the material used is conductive and transparent material such as indium tin oxide (ITO) and fluorine doped tin oxide (ITO).

Semiconductor material

Semiconductor material is a core from solar cell usually having density in hundreds-micrometer for solar cell in generation one (silicon) and 1-3 micrometers for solar cell of thin layer. Semiconductor material has function of absorbing light and the sun's rays. For the case of image above, semiconductor used is silicon material and generally applied in electronic industry. Part of the semiconductor comprises junction or combination from two semiconductor materials i. e. p-type and n-type semiconductors making p-n junction. This p-n junction becomes a key from principle of how to work solar cell. Definition of p-type and n-type semiconductors, principle of p-n junction and solar cell will be discussed in part of "how to work solar cell" Contact grid In addition to substrate as positive contact, a part of semiconductor material is usually covered metal material of transparent conductive material as negative contact.

Antireflective layer

Reflection of light has to be minimized in order to optimize light absorbed by semiconductor. By the reason, solar cell is usually covered by antireflective layer. This antireflective material is a material with thin layer in the amount of refractive index of optic between semiconductor and air causing the light turned over to semiconductor so that it can minimize the light reflected.

Encapsulation / cover glass

This part works as encapsulation to protect solar module from rain or dirt. How to work Solar Cell

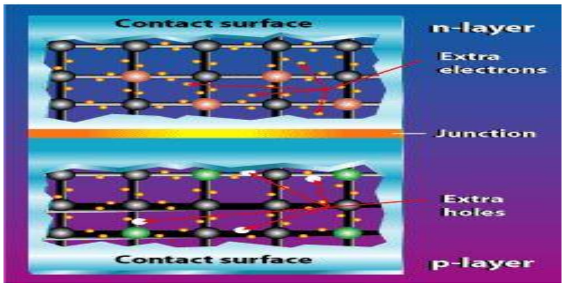
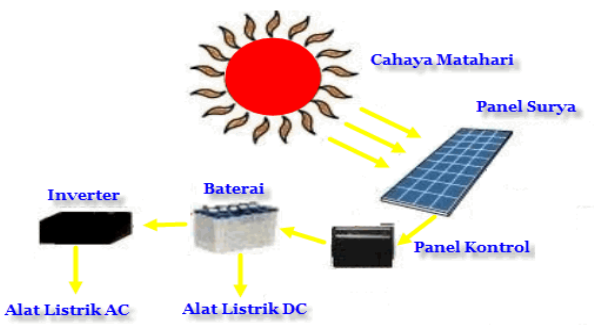


***Image 2:** Junction between p-type and n-type semiconductors*

Conventional solar cell performs its function using principle of p-n junction, i.e. junction between p-type and n-type semiconductors. Those semiconductors consist of atomic bonds in which there are electrons as basic components. The n-type semiconductor has excess electrons (negative load), but the p-type semiconductor has excess holes (positive load) in its structure of atom. To get p-type silicon material, silicon is doped by boron atom, but to get n-type silicon material, silicon is doped by phosphorus atom. Role from this p-n junction is to make electric field that electron and hole can be extracted by contact material to produce electricity. As p-type and n-type semiconductors contacted, excess electrons will move from n-type semiconductor to p-type semiconductor that it makes positive pole on n-type semiconductor and negative pole on p-type semiconductor. The result of this electron flow and hole can establish electric field in which it will push electrons moving from semiconductor to negative contact while the sun's rays reach structure of this p-n junction. Then, it can be used as electricity, but in reverse holes move to positive contact waiting dating electron.

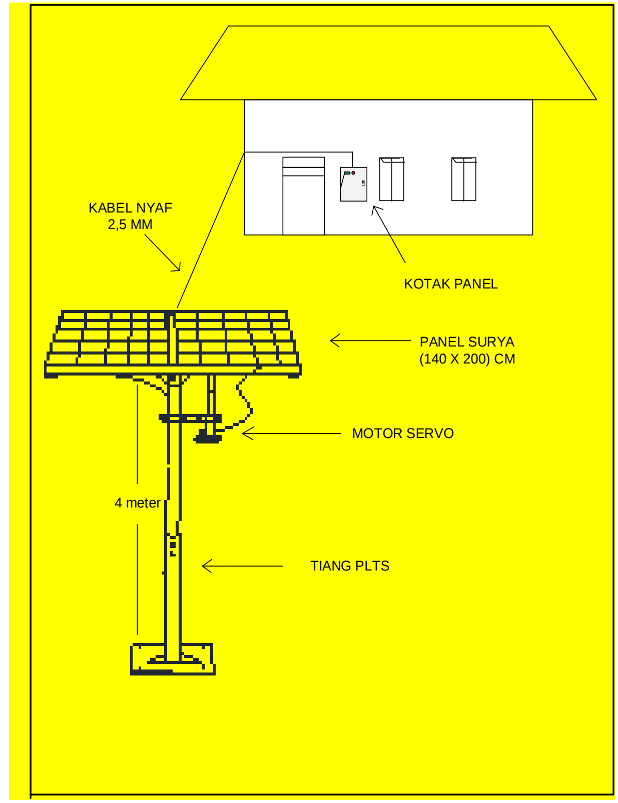


Cahaya matahari = the sun's rays
Panel surya = Solar Panel
Panel Kontrol = Controlling panel
Baterai = Battery
Alat listrik DC = DC Electrical Device
Inverter = Inverter
Alat listrik AC = AC Electrical Device

Image 3: *illustration of how to work solar panel with principle of p-n junction*

1480 W PLTS ARCHITECTURE WITH SOLAR TRACKER FOR CONTROLLING MICROCONTROLLER-BASED SOLAR PANEL IN TIGA RAJA VILLAGE, TIGA DOLOK DISTRICT, SIMALUNGUN REGENCY
Architecture for Solar Power Plant is required a detailed planning commencing configuration of system, devices and used materials, as well as calculation of used power in architecture of this Solar Power Plant to have good result.

Configuration of System



KABEL NYAF 2,5 MM = 2.5 MM NYAF CABLE
KOTAK PANEL = PANEL BOX
PANEL SURYA (140 X 200) CM = (140 X 200)CM SOLAR PANEL
MOTOR SERVO = SERVO MOTOR
TIANG PLTS = PLTS POLE
4 METER = 4 METERS

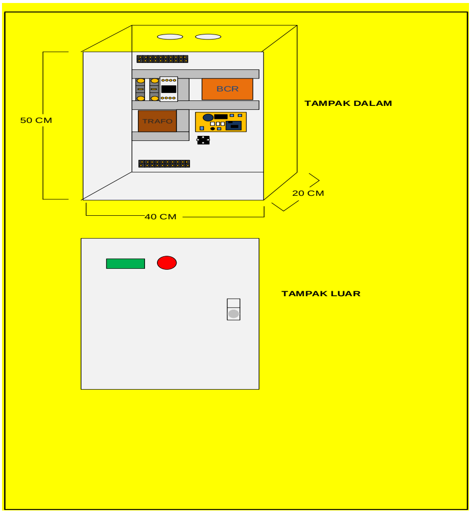
Image 4. *Configuration of System*

Making architecture is strictly necessary a configuration of system. The configuration of system can represent all forms of architecture. In this 1480 W PLTS architecture with solar tracker for controlling microcontroller-based solar panel in tiga raja village, tiga dolok district, simalungun regency, the writer makes this like at image 3.1.

Description this 1480 W PLTS architecture
In this 1480 W PLTS architecture, the PLTS is designed with Pole with 4 meters in height and each solar panel with 100 X 68 cm in size having 12 volt-output voltage. We use two solar panels connected in series, having objection to obtain 24 volt-output voltage. Installation of two solar panels connected in series is caused by input from Inverter, Battery and BCR used on this circuit of 24 volts. In this PLTS architecture, panel box is installed not on PLTS pole, but at one of homes of person in Tiga Raja Village, Tiga Dolok District, Simalungun Regency. This is aimed to consider that some PLTS components have large size as same as inverter and battery having size that enables to be installed in Panel box. Therefore, installation of Panel box is installed at one of homes of person having distance between PLTS Pole and panel box installed at the home is about less than 10 meters. This PLTS uses servo motor (Actuator) as activator from solar panel which is aimed to follow the sun's rays in order to maximize the absorption of

the sun's rays. Servo motor is controlled by Arduino Uno-branded microcontroller having LDR input as a sensor of the sun's rays. LDR is constructed with horizontal and vertical position to get accurate data.

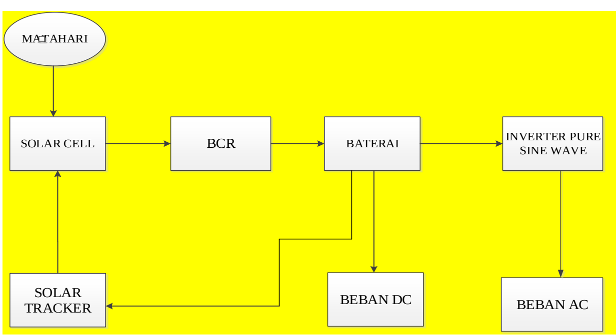
Controlling Panel



50 CM = 50 CM
TAMPAK DALAM = INTERNAL APPEARANCE
TAMPAK LUAR = EXTERNAL APPEARANCE

Image 5. *Lay out of panel box*

Diagram Block



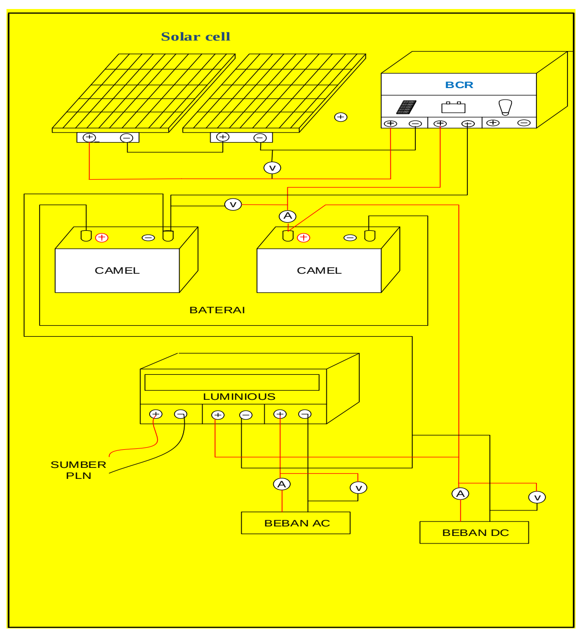
MATAHARI = THE SUN
SOLAR CELL = SOLAR CELL
BCR = BCR
BATERAI = BATTERY
INVERTER PURE SINE WAVE = INVERTER PURE SINE WAVE
BEBAN AC = AC LOAD
BEBAN DC = DC LOAD
SOLAR TRACKER = SOLAR TRACKER

Image 6. *diagram block of planning of solar cell*

How to work

Based on block diagram above (Image 3.3), it can be explained how to work circuit of PLTS architecture, as follows: The sun shines, then the radiation produced by the sun's rays is caught by solar panel. This solar panel constitutes a combination from some solar cell with small size, whether in series or parallel or also combination from the both. From the combination becomes a sufficiently big panel solar to produce voltage and current. If solar panel catches the sun's rays, the electrons in solar cell will move from N to P that at output terminal from solar panel will produce electrical energy. The amounts from electrical energy produced by solar panel are different depending on the number of solar cell that is combined in the solar panel. The output of this solar panel is in form of Direct Current (DC) electricity with the amount of output voltage depending on the number of solar cell installed in the solar panel and the amount of the sun's rays shining on the panel. Voltage produced by this solar panel can be used directly at loads requiring DC voltage with small value of current. Energy produced can be used at night, if the energy produced is saved first in saving media. In this matter, the saving media used is battery. Before the energy is saved in the battery, it has to flow through a set of regulator. In the set of regulator, there is a set of filling the battery automatically. It has function as regulator of voltage entering to battery (charge) automatically. Regulator has also function as protection for battery and load. Power saved in battery can be used directly for DC load. And, battery can be connected directly in parallel on load. For use on AC load, however, the current on battery needs to be converted first. This is to convert DC current into AC current used by inverter Pure Sine Wave, in which the converted voltage is like pure siusoida. This is done because the used load is load having circumlocution.

Controlling Diagram



Solar cell = Solar cell
BCR = BCR
CAMEL = CAMEL
BATERAI = BATTERY
LUMINIOUS = LUMINIOUS
SUMBER PLN = RESOURCES OF PLN
BEBAN AC = AC LOAD
BEBAN DC = DC LOAD

Image 7. *Controlling Diagram*

Arduino Controlling Diagram

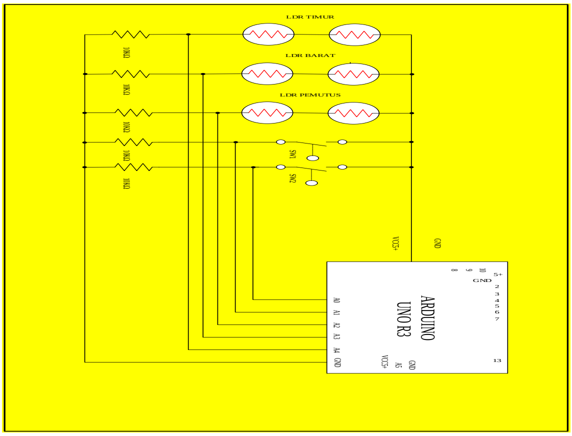


Image 8. *Controlling Diagram of Solar tracker*

Controlling System

System can be defined as follows: "System is combination from some components working together and doing a current target". System is not limited for physical system only. The concept of system can be used for abstract and dynamic indication such as known in economy. Therefore, the term of "system" need to be interpreted to express physical, biological, economical systems, etc. From the definition above, it can be concluded that system constitutes a unit of elements relating each other, conceptually or physically. Then, it can be concluded that Controlling System is structure of physic components connected in such a way to arrange condition / other system in order to reach expected condition. The controlling system consists of two, i.e. Open Loop Controlling System and Close Loop Controlling System. Close loop controlling system is a system having its controller is free from its output. Open loop controlling system is a system having its controller is depending on its output. At this PLTS set, solar tracker is set out by using close loop controlling system in which solar tracker works in accordance with response given by LDR to Aurdino UNO R3 Microcontroller. When a LDR installed on the Solar Panel caught by the sun's rays and the other is not caught by the sun's rays, this output LDR will give information to Aurdino UNO R3 Microcontroller programmed to draw Solar Tracker (Servo Motor) up to the sun's rays. When the both of LDRs (east LDR and west LDR) are caught by the sun's rays, Aurdino arranges solar tracker to stop work. It can be said that solar Tracker stopping work, if the position of solar panel is perpendicular to the sun's rays.

Solar Tracker Control System

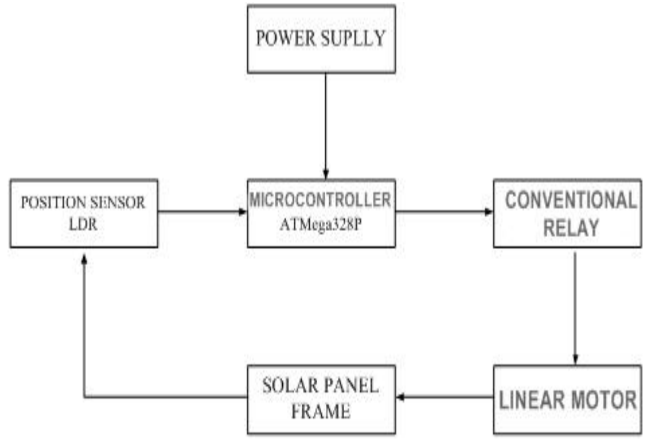


Figure 9. *Solar Tracker Control System*

Calculation of Total Power Consumed

The load power and working time of each load to be used by the household in Tigaraja Village, Tigaglodok District are as follows:

Tabel 1. *Power Consumed*

No	Load	Total	Power (Watt)	Working time (hour)	Total Power (Wh)
1	Lamp	9	7	12	756
2	Water pump	1	250	2	500
Jumlah Daya Total					1256

Here is the formula to calculate the total power amount:

Pt = Pb + (Pb x 15 %)
Pt = 1256 + (1256 x 15 %)
Pt = 1256 + 188.4
Pt = 1444.4

Description : Pt : Total Power (Wh)
Pb : Load Power (Wh)

Note : 15% is a multiplier factor when the equipment used is new equipment (Mark Hanskin 1991 : 68)

Calculation of Battery Capacity

The power unit (Watthour) was converted into Amperhour according to the unit of battery capacity. This can be shown in the equation of batteries capacity as follows:

$$AH = \frac{Pt}{VB}$$

$$AH = \frac{1444,4}{24}$$

AH = 60,183 Ah

Calculation of Solar Panel Capacity

The capacity of solar module power can be calculated by taking into account several factors, covering the calculated system power requirement of 509.45 Wh and the average solar insolation of 2,365 KWh/m^2/day (Source: BMKG – Meteorological, Climatological, and Geophysical Agency – of Medan). The average data of solar insolation was taken to make the Solar Power Plant able to meet the needs of the load at any time. The solar insolation data would be multiplied by the adjustment factor on the Solar Power Plant standard of 1.1 (Mark Hakins 1991:68). To convert the BMKG data from watt/m^2/day unit into KWh/m^2/day, it should use the following formula:

$$KWh / m^2 / day = \frac{BMKG\ data\ (watt/m^2/day)\ x\ 3{,}600\ s}{3{,}600\ x\ 1000}$$

***Table 3.2** Data of Solar Insolation from BMKG class 1 of Sampali, Medan*

Solar Insolation from BMKG class 1 of Sampali - Medan											
Jan	Feb	Mar	April	May	June	July	Aug	Sep	Okt	Nov	Des
2.14	2.40	2.45	2.45	2.37	2.63	2.45	2.30	2.39	2.38	2.11	2.20

$$K.P\ Solar\ Cell = \frac{Pt}{Solar\ Insolation}\ x\ Adjusment\ factor$$

$$K.P\ Solar\ Cell = \frac{1444.4}{2.365}\ x\ 1{,}1$$

K.P Solar Cell = 671.813

In this case, the solar cell used was two (2) modules with a power rating of 100 WP paralleled to generate a module power of 200 WP.

Specification of solar cell module :
TPS (Solar Power Plant) model of 105S – 100 W – MONO
MAX Power 100 W of approximately 5%
Rated voltage (Vmp) of 17.20 V
Rated current (Imp) of 5 & 1 A
Open circuit voltage (Voc) of 22.5 V
Short circuit current (Isc) of 6.18 A
Maximum system voltage of 1000 V

Calculation of BCR Capacity
The load on the Solar Power Plant took the power of the batteries. The current capacity flowing on the battery charger could be determined by knowing the maximum load. The planned maximum load was the load when all the equipment operated simultaneously as much as 210 W. Thus, the BCR capacity used can be determined by the following formula:

$$CBCR = \frac{P\ max}{VB}$$

$$CBCR = \frac{210}{24}$$

$$CBCR = 8.75$$

Description : P max : maximum power (W)
CBCR : BCR current rating (A)
VB : battery voltage (V)

Based on the value of the flowing current, it could be determined that the BCR capacity was 12 V/20 A using MPPT technology.

BCR Specification :
Rated charge current of 20 Amperes
System voltage of 12/24 Auto Volts
Max solar panel voltage of 40 Volts
Self consume < 6Ma
Equalize charging voltage of 14,8 volts
Temperature of 35^{0}C – 55^{0}C

AC System Ways of Working
The AC voltage of 220 V was used for the lamp and water pumps. To change the DC voltage of 24V from the batteries, a pure sine wave inverter was used. On the panel box, a sign light then was placed. The sign light had some functions as follows: The red light served as an indicator of the battery charging process. If the red light was on, it indicated that the charging process was in progress. The display screen on the panel served to monitor the total power and the used power amount. In the implementation of this Solar Power Plant design, the first thing to do was determining the materials and tools to be used during the design process. The list of tools and materials used is shown in the following tables.

***Table 2.** List of Tools*

No	Name of Tool	Specification	Quantity
1	Screwdriver	Plate/Flower	2
2	Test Pen	_	1
3	Combination Pliers	_	1
4	Cable peeler Pliers	_	1
5	Electric drill	220 V	1
6	Drill bit	3 mm, 5 mm	
7	Roll Meter	10 m	2
8	Fan	220 V / 75 W	1
9	Laptop	_	1

***Table 3.** List of Materials*

No	Name of Material	Specification	Quantity
1	Solar Panel	12 V / 100 WP	2
2	Battery	100 Ah	2
3	Inverter	1500 W	1
4	BCR	12 V / 20 A	1
6	Multimeter	Analog	1
7	Multimeter	Digital	1

3. RESULTS AND DISCUSSION

Test Analysis and Measurement
Test analysis and measurement were conducted to determine the characteristics of solar panels and also the ability of the batteries to serve the load. Some tests performed included the open circuit voltage measurement of solar panels, zero load test, and AC load test with a 300 Watt-pump, 10 lamps of 14 W. The open circuit voltage test of solar panels was done without using Solar Tracker. This test was performed to determine the characteristics and values of voltage that could be generated by the solar panels.

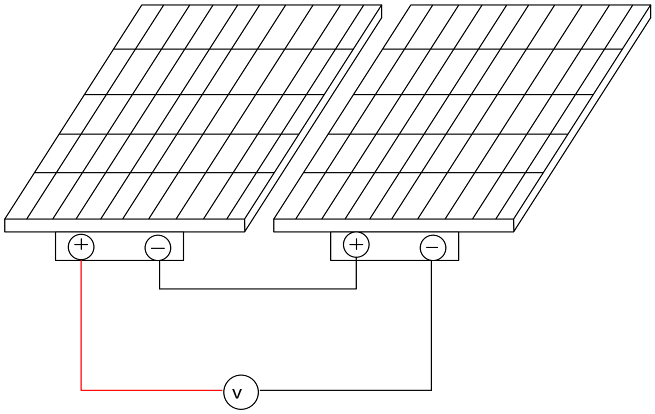


Figure 10. *Diagram of Solar Panel-Open Circuit Voltage Test*

First Test : Open Circuit Voltage
Location : Housing of Scott Regency

Table 5. *Result Data of Solar Panel-Open Circuit Voltage Measurement*

Friday, August 18, 2017		
Time	Voltage (V)	Description
07.00	36.08	Sunny
08.00	37.45	Sunny
09.00	40.27	Sunny
10.00	39.27	Sunny
11.00	39.21	Sunny
12.00	39.11	Sunny
13.00	40.12	Sunny
14.00	41.6	Sunny
15.00	36.7	Cloudy
16.00	38.3	Cloudy
18.00	36.4	Cloudy
19.00	36.08	Cloudy

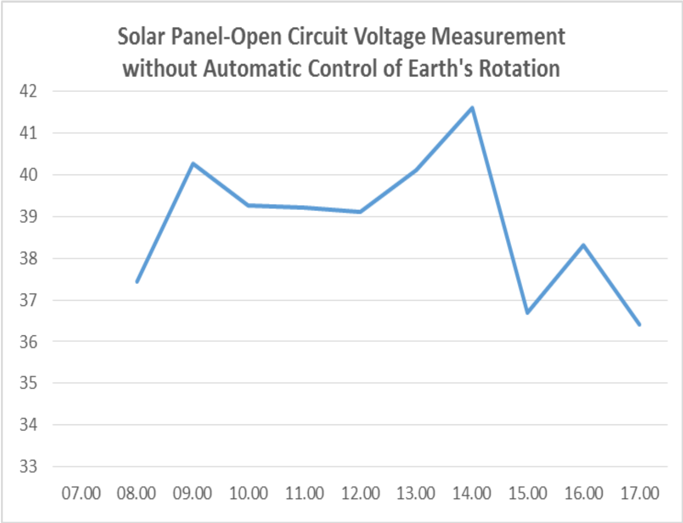


Figure 11. *Chart of Open Circuit Voltage Measurement*

Second Test : Solar Panel-Open Circuit Voltage
Location : Housing of Scott Regency

Table 6. *Result Data of Solar Panel-Open Circuit Voltage Measurement*

Saturday, August 19, 2017		
Time	Voltage (V)	Description
07.00	36.12	Sunny
08.00	37.32	Sunny
09.00	40.4	Sunny
10.00	39.3	Sunny
11.00	39.2	Sunny
12.00	39.1	Sunny
13.00	37.9	Sunny
14.00	41.6	Sunny
15.00	36.7	Sunny
16.00	38.3	Sunny
17.00	36.4	Sunny
18.00	35.45	Sunny

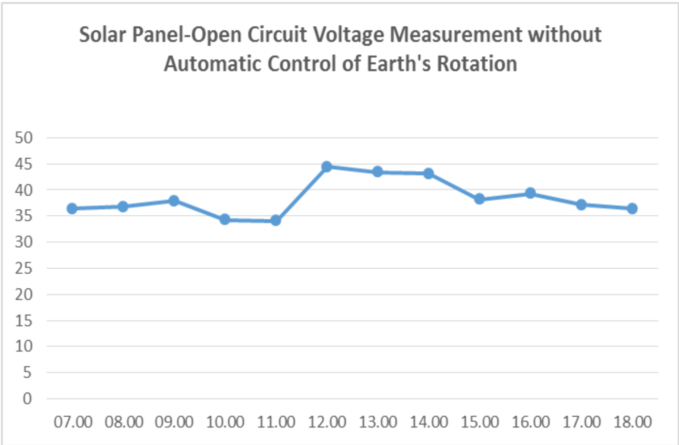


Figure 12. *Chart of Open Circuit Voltage Measurement*

Based on the measurements conducted on the 18th and 19th of August 2017, located at Saudara St, the housing of Scott Regency, it was obtained results as explained in the tables and charts above. The tables and charts show that the sun started being perpendicular to the panels and gave the maximum voltage at 12.00 until 14.00 because the solar panels only led to ^{0}the angle of 900. The voltage was not stable due to the sun's closure by the cloud and the rainfall on the measurement day.

Open Circuit Voltage Test of Solar Panels Using Solar Tracker

This test was conducted to find out the characteristics and values of voltage that could be generated by solar panels.
First Test : Open Circuit Voltage
Location: Housing Area of Scott Regency

Table 6. *Result Data of Solar Panel-Open Circuit Voltage Measurement*

Sunday, August 20, 2017		
Time	Voltage (V)	Description
07.00	36.45	Sunny
08.00	36.78	Sunny
09.00	37.9	Sunny
10.00	35.1	Cloudy
11.00	36.2	Cloudy
12.00	42.35	Cloudy
13.00	42.65	Sunny
14.00	43.12	Sunny
15.00	40.3	Sunny
16.00	39.34	Sunny
17.00	37.13	Sunny
18.00	36.45	Cloudy

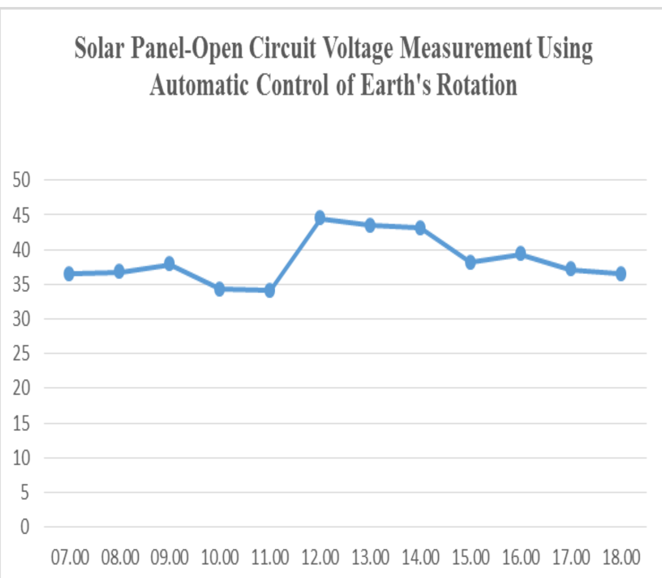


Figure 4.4. *Chart of Open Circuit Voltage Measurement*

Second Test : Open Circuit Voltage
Location : Housing of Scott Regency

Table 7. *Result Data of Solar Panel-Open Circuit Voltage Measurement*

Monday, August 21, 2017		
Time	Voltage (V)	Description
07.00	36.8	Sunny
08.00	37.12	Sunny
09.00	38.23	Sunny
10.00	39.54	Sunny
11.00	40.35	Sunny
12.00	44.56	Sunny
13.00	43.46	Sunny
14.00	43.12	Sunny
15.00	40.67	Sunny
16.00	39.7	Sunny
17.00	38.13	Sunny
18.00	36	Sunny

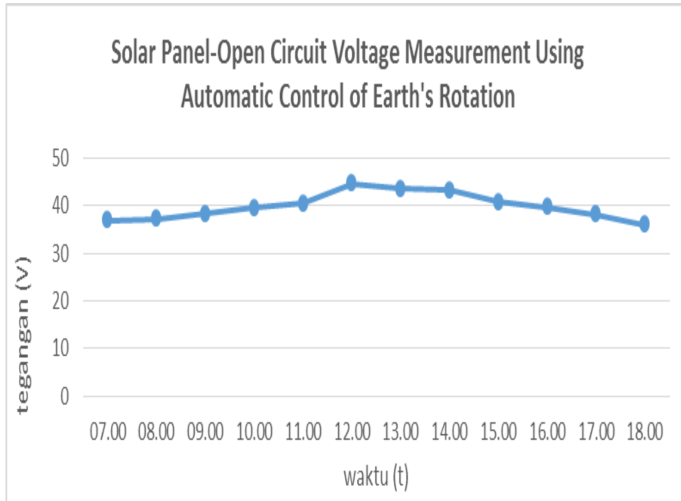


Figure 14. *Chart of Open Circuit Voltage Measurement*

Based on the solar panel-open circuit voltage test using automatic control of the earth's rotation conducted on the 20th and 21st of August 2017, located at Saudara St, the housing area of Scott Regency, it was obtained the results as outlined in the tables and charts above. From the tables and charts, it can be seen that the voltage generated by the solar panels was higher at 07.00 until 11.00, and also at 15.00 until 18.00. This proves that the absorption efficiency of solar panel-open circuit voltage test using automatic control of the earth's rotation is better than that without automatic control of the earth's rotation.

Battery Charging and Zero Load Test

The test was aimed to prove the ability of solar panels to charge and stop the charging process when the batteries had been fully charged with the help of regulator. If the batteries are fully charged but the solar panels still supply voltage, it can damage the batteries. Thus, it should be anticipated.

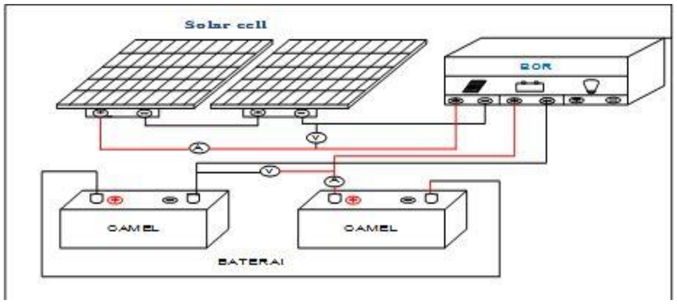


Figure 15. *Circuit of Battery Charging and Zero Load*

First Test : Battery Charging and Zero Load Battery
Location : Housing of Scott Regency

Table 8. *Battery Charging*

Time	Tuesday, August 22, 2017				
	Solar Panel		Output of BCR/Battery Charging		Description
	Voltage (V)	Current (A)	Voltage (V)	Current (A)	
08.00	31.9	0.3	24	0.6	Sunny
09.00	31.9	0.3	24	0.7	Sunny
10.00	32.2	0.5	24	0.8	Sunny
11.00	34.4	0.5	24	1.0	Sunny
12.00	38.6	0.0	24	0.1	Cloudy
13.00	39.6	0.0	23.9	0.1	Cloudy
14.00	40.6	0.0	23.9	0.1	Cloudy
15.00	38.3	0.7	24.2	1.5	Sunny
16.00	39.4	0.4	24.1	0.7	Sunny
17.00	32.4	0.0	24	0.3	Cloudy

Table 9. *Zero Load Test*

Date	
Time	Voltage (V)
07.30	25.4
17.30	25.4

Second Test : Battery Charging and Zero Load Battery
Location : Housing of Scott Regency

Table 10. *Battery Charging*

Time	Wednesday, August 23, 2017				
	Solar Panel		Output of BCR/Battery Charging		Description
	Voltage (V)	Current (A)	Voltage (V)	Current (A)	
08.00	31.5	0.3	24	0.6	Sunny
09.00	31.8	0.3	24	0.7	Sunny
10.00	32.0	0.5	24	0.8	Sunny
11.00	34.0	0.5	24	1.0	Sunny
12.00	38.2	0.4	24	0.1	Sunny
13.00	39.3	0.4	23.9	0.1	Sunny
14.00	40.2	0.6	23.9	0.1	Sunny
15.00	38.5	0.7	24.2	1.5	Sunny
16.00	39.6	0.4	24.1	0.7	Sunny
17.00	32.8	0.5	24	0.3	Sunny

Table 11. *Zero Load Test*

Date	
Time	Voltage (V)
07.30	25.4
17.30	25.4

Based on the measurements conducted on the 22nd and 23rd of August 2017, located at Saudara St, the Housing area of Scott Regency, it was obtained two tables of measurement results covering the table of battery charging and zero load test. The measurements were conducted with the aims of observing the condition of the batteries used and examining the effect of resistance in the battery to the value of the battery resistance. According to the data obtained, the battery resistance did not affect the battery voltage. During the test, the current obtained was 0.4 A and the battery voltage was 25.4 V. Moreover, the voltage did not experience a decrease during the test because the battery was in new condition.

Testing with AC Load

This test was performed to determine the characteristics of voltage changes in the Solar Power Plant given AC load. In this test, the AC load used was a pump of 300 W and 10 lamps of 14 W.

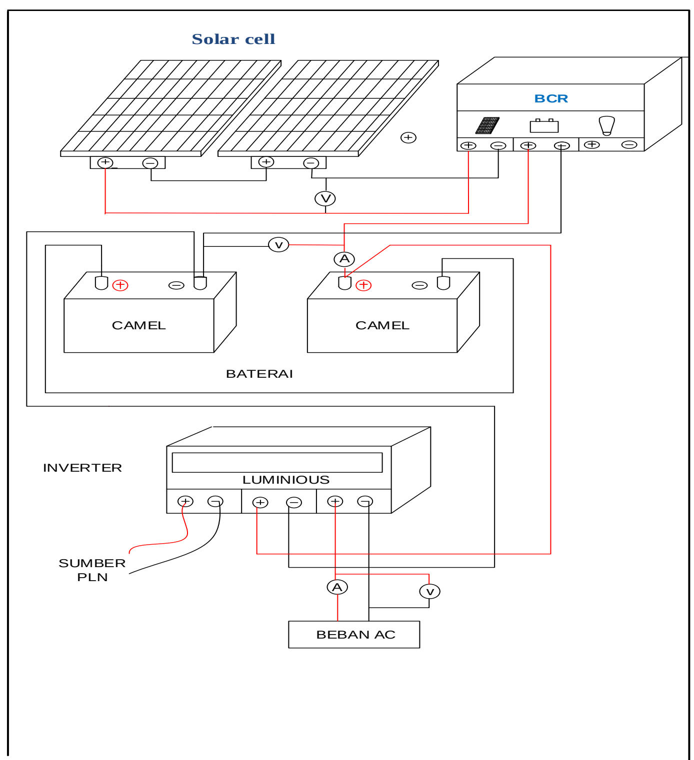


Figure 15. *Circuit of Testing with AC Load*

Description : The above test used a lux meter to know the light intensity when the test took place

Table 12. *Testing with AC Load*

Saturday, August 26, 2017							Light Intensity (lux)
Time	Solar Panel		Battery		AC Load		
	Voltage (V)	Current (A)	Voltage (V)	Current(A)	Voltage (V)	Current (A)	
09.00	40.4	1.7	25.1	1.95	213	2.36	54000
10.00	39.3	1.5	24.9	1.72	214	2.34	52500
11.00	39.2	1.4	24.9	1.61	215	2.33	52000
12.00	39.1	1.4	24.8	1.61	215	2.33	51500
13.00	38.1	0.9	24.01	1.035	213	2.3	51000
14.00	41.6	0.9	24.0	0.92	213	2.3	55000
15.00	38.0	0.89	23.8	0.92	214	2.28	51000
16.00	38.3	0.89	23.6	1.023	213	2.3	51000

According to the measurement results obtained, it can be observed that the highest voltage on the solar panels and batteries was recorded at 14.00. The highest voltage on the solar panels was 41.6 V and that on the batteries was 24.0 V. The decreased voltage on the solar panels and batteries started at 15.00 until 16.00 because the sun had been already closed by a thick cloud that affected the charging process. During the rain, the sunlight intensity decreased dramatically.

5. CONCLUSION AND SUGGESTION

CONCLUSION

After conducting a series of analysis and tests on the Solar Power Plant, it can be concluded that the solar panel voltage without solar tracker is 41.6 V at 14.00 while the solar panel voltage using solar tracker is 43.12 V at 14.00. When it is sunny, the resistance value of East LDR is 752Ω while the resistance value of West LDR is 769Ω. Meanwhile, the resistance value of the breaker LDR in the same sun status is 973Ω. The duration of the power supply depends on the current strength/hour as follows:
The average use = 300 watts,
24 volt x 100 AH= 2400 watts/hour
2400/300 = 8 hours

SUGGESTION

Based on the research results and discussion explained above, the researchers would like to give a suggestion as follows: The development of the Solar Power Plant should be subsidized by the government as it requires costly expenses, and serves as a community service. The development of Solar Power Plants with automatic control of the earth's rotation should be empowered for solar panels with a large capacity in order to generate maximum power. It is recommended that the testings of the equipment or tools be undertaken in the planned placement location to fit the actual conditions.://www.ijstr.org.

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