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Abstract. Practice related to Solar Panel for Electrical Engineering program students conducted in Physics Laboratory of Electrical Engineering Department of Politeknik Negeri Bali as the introduction of solar cell still use equipment separately so that the measurement result not yet optimal. Based on these conditions, this study aims to create a Solar Panel practice module as a student practice tool and increase student competence in performing measurements of Solar Cell output in Physics Laboratory. Methods in the manufacture of modules include: determining the types of measuring devices and solar cell specifications, drawing solar cell module designs and determining the position of solar cells with a slope of 0^0, 30^0, 60^0 and 90^0. Measurements include Open Circuit Voltage (Voc) and Short Circuit Current (Isc) from series of two solar panels in series and parallel. Based on the measurements made in the Solar Panel conditions the series circuit obtained Voc value changed 0 - 7 volts, Isc ranged from 1 to 6 Ampere, whereas in parallel series Voc measurement results change between 0 - 1 Volt and Isc value changes between 2- 11 Ampere. The output of physical parameters (angle) of influence is not significant because the slope angle of the Solar Panel is facing east (sunrise). The effect of Solar Panel Output Isc is a bright or sunny cloudy weather with a temperature level between 22 ^{0}C – 42 ^{0}C.

Keywords : Solar Panel,Series and Paralell Circuit , Open Circuit Voltage, Short Circuit Current

1. Introduction

In this modern era electrical energy is a major requirement to operate electrical appliances in households, transportation, industry and other service sectors. The source of electrical energy comes from renewable energy sources and non-renewable energy sources. Based on topography in Indonesia is ideal to develop solar module as a source of electrical energy [1]. The solar module is one of the electronic devices that can directly transform the energy of solar radiation into electrical energy. [2] The system, the size of the solar cell and the output parameters of a given region determine the magnitude of electric energy production [3]. Solar cells are arranged in several groups called solar panels with DC output units (Direct Current) where each solar cell is connected in parallel or series [4,5]. Placement of solar panels on the roof of the house [6] but on large generating systems placed in the field. To get the maximum solar panel output, the direction of the panel is changed according to the direction of sunlight [7]. In the laboratory of Physics, Department of Electrical Engineering, Politeknik Negeri Bali, there are practical materials related to solar cell for Electricity Study Program students as the introduction of solar cell as one of the alternative source of electrical energy. In the experiment, current and voltage measurements were conducted to find out the characteristics of the I-V curve that affect the efficiency of solar cells. The experiments were conducted outside the Physics lab by bringing practicum equipment such as solar cells, amper meter measurements,

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volt meter gauges and connecting cables. Existing conditions cause the experiment can not be performed optimally constrained pratikum equipment that is still separated from one another, this is correlated with the measurement results obtained are not optimal.To improve the condition it is necessary to create a permanent module with equipment measuring equipment installed and calibrated with either in accordance with the type of experiment / practice performed.

2. Methodology

This research is an experimental research, design and test by testing Solar Panel practice module on series and parallel relationship.

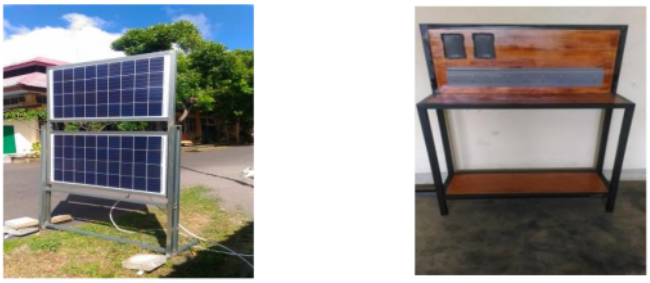

Figure 1. The Design of Solar Panel Modules

The data used in this study is the primary data in the form of Survey Panel output measurement results in series and parallel relationships conducted outside the Laboratory of Physics Department of Electrical Engineering Politeknik Negeri Bali

The data collection method is done by measuring the Solar Panel output which includes:

- Voltage (Voc) and current (Isc) measurements for Solar Panel series and multimeters at DC Volt range of 50 Volt and Ampermeter DC range of 10 A.
- Voltage (Voc) and current (Isc) measurements for parallel Solar Panels and multimeters at Volt DC range of 50 Volt and Ampermeter DC range of 10 A.
- Measurements are made every 2 minutes at each corner of the solar cell position (0^0 s / d 90^0) starting at 09.30 am - 12.30 pm.

The analysis is done from experiment data of solar panel practice module in the form of open circuit voltage (Voc) and short circuit current (Isc) at angle 0^0, 30^0 60^0 and 90^0. The analysis results determine the magnitude of the effect of the solar panel angle on the magnitude of the I-V curve and the influence of other parameters according to the measurement results.

3. Results and Discussion

The Solar Panel Practice Module Testing is conducted on two conditions solar panel connected series (2 solar panels) and in parallel. Parameters measured are Open Circuit Voltage (Voc), Short Circuit (Isc), Temperature on the surface of solar panels and outside weather conditions when taking data.

Tests on the solar panel practice module with series relationships are shown in Figure 2. The results of the Voc and Isc measurements are shown in Table 1. For the solar panel practice module test the parallel relationship is shown in figure 3, while the measured data is shown in Table 2.

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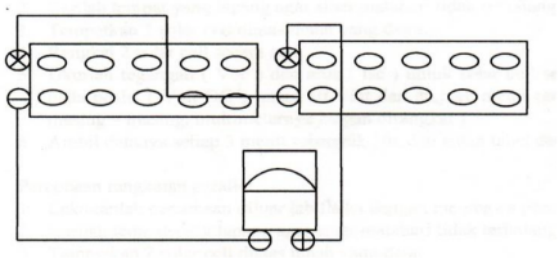

Figure 2. Solar Panel Series relationships

Table 1. Voltage (Voc) and Current (Isc) Series Relationships
(Wednesday, 8-8-2017)

No.	Time (Wita)	Tilt Angles (o)	Voc (Volt DC)	Isc (Ampere DC)	Temp (◦C)	Weather
1	9,32	90	41,4	3,2	35,0	Briht-Cloudy
2	9,34	60	38,9	1,1	31,5	Bright-Coudy
3	9,36	30	39,9	1,4	27,9	Cloudy
4	9,38	0	41,7	4,5	31,9	Briht-Cloudy
5	10,04	0	38,3	1,9	28,6	Cloudy
6	10,06	30	39,1	2,2	30,1	Cloudy
7	10,08	60	38,7	2,1	30,8	Cloudy
8	10,10	90	41,3	3,4	33,1	Briht-Cloudy
9	11,00	90	41,1	3,3	32,3	Bright
10	11,02	60	42,3	3,2	31,2	Bright
11	11,04	30	42,4	6,2	33,2	Bright
12	11,06	0	41,7	6,0	35,4	Bright
13	12,00	0	35,5	1,2	32,9	Cloudy
14	12,02	30	42,9	6,4	33,8	Briht-Cloudy
15	12,04	60	38,9	4,0	31,1	Briht-Cloudy
16	12,06	90	38,4	3,2	32,3	Briht-Cloudy

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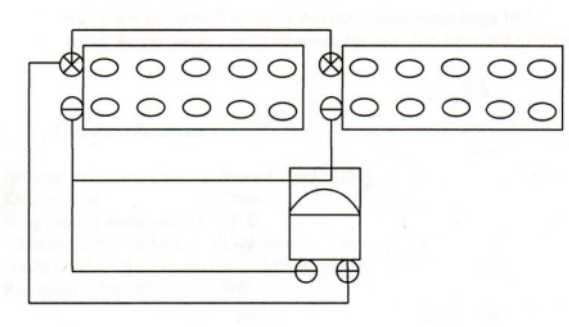

Figure 3. Solar Panel Parallel relationship

Table 2. Voltage (Voc) and Current (Isc) Parallel Relations
(Tuesday, 18-8-2017)

No.	Jam (Wita)	Tilt Angles (o)	Voc (Volt DC)	**Isc** (Ampere DC)	**Temp** (◦C)	Weather
1	9,32	90	19,0	7,8	32,2	Bright-Coudy
2	9,34	60	20,9	10,2	30,2	Bright-Coudy
3	9,36	30	19,2	7,4	30,3	Bright-Coudy
4	9,38	0	20,6	9,0	30,1	Bright-Coudy
5	10,04	0	19,7	6,5	33,2	Cloudy
6	10,06	30	20,1	3,0	34,2	Cloudy
7	10,08	60	20,0	2,1	31,7	Cloudy
8	10,10	90	19,2	2,0	33,1	Bright
9	11,00	90	20,4	4,0	34,3	Bright
10	11,02	60	19,4	2,0	34,4	Cloudy
11	11,04	30	19,8	7,5	32.7	Bright
12	11,06	0	19.6	2,0	30,6	Cloudy
13	12,00	0	20,7	10.1	39,6	Bright
14	12,02	30	20,6	11,2	35,5	Bright
15	12,04	60	20,4	7,5	31,0	Bright
16	12,06	90	19,0	2,0	32,2	Cloudy

In Table 1 the results of the solar panel practice module test show that the voltage range (Voc) ranges from 35 volts to 42 volts, while the current value (Isc) varies considerably between 1.1 ampere - 6.4 amperes. The largest current output value in bright weather conditions with 30^0 solar panel angles at 12.02

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wita. The output value of solar panels is highly dependent on the direction of solar panel placement and the angle of sunlight. In the solar panel condition the series relationship of voltage variation is quite large and the current value also experienced a considerable difference.
Table 2 shows the test of solar panel practice module parallel relationship obtained output measurement with voltage parameters (Voc), current (Isc) and temperature. The voltage values range from 19 volts - 20 volts. Measurement of current output obtained values between 2 amperes - 11 amperes. The output voltage of the solar panel is quite stable even though the weather conditions change (bright - cloudy). While the output current fluctuations in value is large enough due to the influence of weather factors. In sunny conditions with a tilt angles 30^0 obtained the greatest current value. From table 1 and table 2 we get quite different values that the solar panel measurements for the parallel relationship of current measurement value (Isc) are quite large compared to the measurement of the current value (Isc) of the series relationship.

4. Conclusion

Open Circuit Voltages and Short Circuit Flows are influenced by the intensity of sunlight that affects the surface of the solar cell. The effect of solar panel angle change slightly plays on the short circuit current value in bright conditions whereas in cloudy conditions and overcast the panel angle is quite influential. The current measurement value (Isc) in the parallel relationship reaches 11.2 Amper at an angle of 30^0 compared to the solar panel relationship in series with the value of 6.4 Amper at the measurement at 12.02 Wita.

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