Conference Proceedings

EuroSun 2016
Palma de Mallorca (Spain), 11 – 14 October 2016

Characteristics Experimental of A Photovoltaic Module in Tropical Climate

Dani Rusirawan[1], Liman Hartawan[1], Andi Juhaeri[1] and Istvan Farkas[2]

[1] Department of Mechanical Engineering, Institut Teknologi Nasional (ITENAS) Bandung Jl. PKHH. Mustapa No. 23 Bandung 40124, West Java (Indonesia)

[2] Department of Physics and Proces Control, Szent Istvan University

Pater K. u. 1., Godollo, H-2100 (Hungary)

Abstract

In the photovoltaic (PV) system, relations between current, voltage and power generated by system can be illustrated by photovoltaic characteristics, and it can be developed experimentally and/or theoretically. In this work, characterization of a PV module in Bandung – Indonesia, as one of tropical climates area, will be shown based on experimentals. Our works were carried out using a Laboratory scale PV system. Three sub systems, i.e. a PV module, measuring instruments and data acquisition, and PC for the monitoring system, were identified and determined. An Electrical Solar Module (ESM) of 50 Wp was used as the object. As an output of this work, characterization of a PV module in a tropical climate, represented by current-voltage-power relation will be shown.

Keywords: *current, voltage, power, experimental test, laboratory scale.*

1. Introduction

Presently, research in the photovoltaic (PV) field becomes interesting topic for many institutions, universities and companies, as a response to the crisis of energy and environmental problem all over the world.

Testing through experiments, modelling through numerical method or simulation using software package are typical to quantify the physical phenomenon. Testing and modelling of a PV system performance are very complicated and influenced by a variety of interactive factors related to the environment (temperature and irradiance), besides to solar cell physics (Rusirawan and Farkas, 2014).

In designing power generation system that incorporates PV modules, there is a basic requirement to accurately estimate outputs from the proposed PV system under a particular operating condition. PV modules are given a power rating at standard test conditions (STC) of 1000 Wm^{-2}, AM 1.5 and a module temperature of 25 ^oC, but these conditions do not represent what are typically experienced outdoor (Carr and Pryor, 2004).

A PV system (cell/module/panel/array) naturally exhibits non-linear *I-V* (current – voltage) and *P-V* (power – voltage) characteristics which vary with the radiant intensity and PV cell temperature (Tsai et al., 2008).

Referring to the state of arts of PV modules technology, currently, proven technologies in the commercial market are crystalline technology and thin film technology. From the PV module performance point of view, the eficiency of thin film technology is lower than crystalline technolgy. Nevertheless, an additional issue is the lower energy consumption for the production of thin film technology and consequently a shorter energy payback time for these technology. One should bear in mind that the total energy payback time for a given PV module does not only depend on the solar cell used, but also on the module design, e.g. framed module, glass/glass, metal foil, EVA, etc. The general features of commercial wafer based crystalline silicon and thin film are presented in the working material of Greenrhinoenergy (2012).

In this work, characterizations (*I-V-P*) of a PV module by experiments will be shown for some operating condition (solar irradiance and module temperature) in Bandung – Indonesia condition, as one of tropical/hot climate regions. As the first, characterizations of crystalline technology of PV module is performed.

doi:10.18086/eurosun.2016.08.02 Available at http://proceedings.ises.org

In the near future, characterization of thin film technology will be performed as well, therefore a comparison of two PV technologies between crystalline technology (mono and/or poly crystalline silicon) and thin film technology (amorphous silicon) can be performed.

As an outcome of this work, all required informations, especially related to characteristics of different types of PV modules technology can be acquired. Based on this outcome, a depth consideration in order to choose a type of PV module can be defined by countries in tropical region, as a response to the controversy in selecting the proper PV modules, based on their climates.

2. System Description and Methods

The photovoltaic module experiments apparatus is shown in Fig. 1 and the schematic diagram for photovoltaic module experiments along with the measuring features can be seen in Fig. 2.

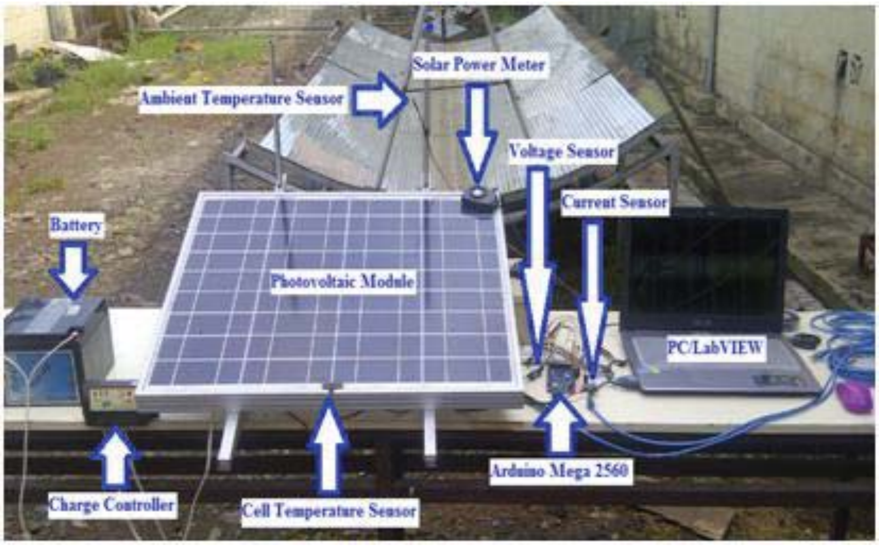


Fig. 1: The PV module experiment test

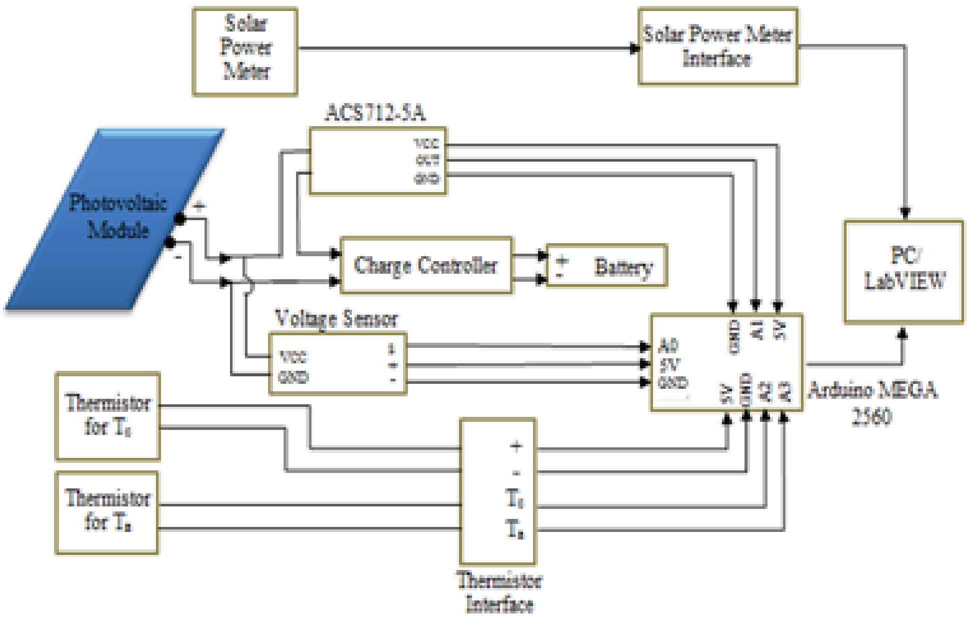


Fig. 2: Experimental test schematic diagram

The location for experiments is Bandung, West Java-Indonesia, with latitude 06°54'S and longitude 107°36'E. The type of the PV module in this research is ESM (Electrical Solar Module) 50 Wp with the optimum operation voltage 17.2 V and optimum current operation 2.91 A. The data acquisition system is Arduino

MEGA 2560 with LABVIEW Programming, and the sensors for: voltage, current and temperature are VCC<25V, ACSC712-5A, thermistor 10 kOhm, respectively. The system is equipped by solar power meter and its sensor.

Additionally, two LED lamps (with the same specification: 12 V and 3.5 W) are provided as an external load.

The specifications of all component used in the experimental test are shown in Figs 3-8.

Fig. 3: ESM PV module and Its specification

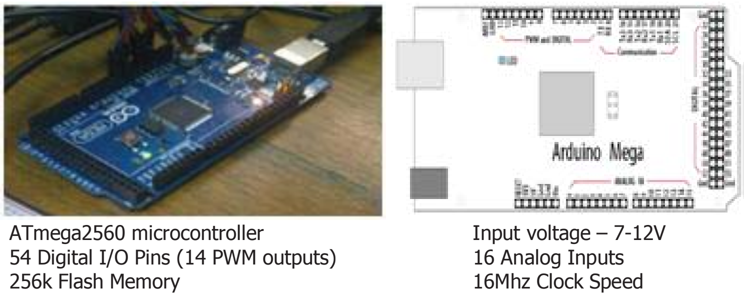


Fig. 4: Arduino mega 2560

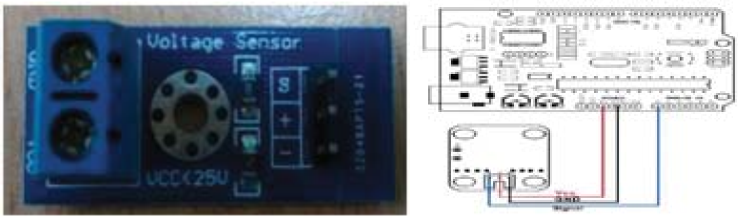


Fig. 5: Voltage censor and conection diagram to arduino

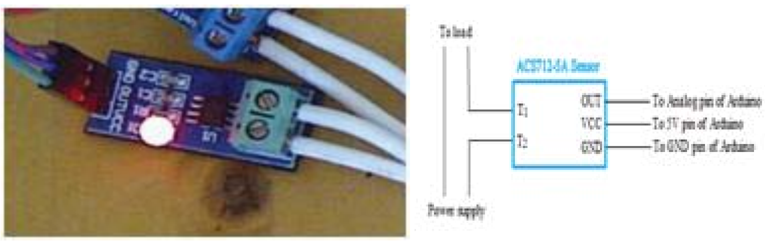


Fig. 6: Current sensor and connection diagram to arduino

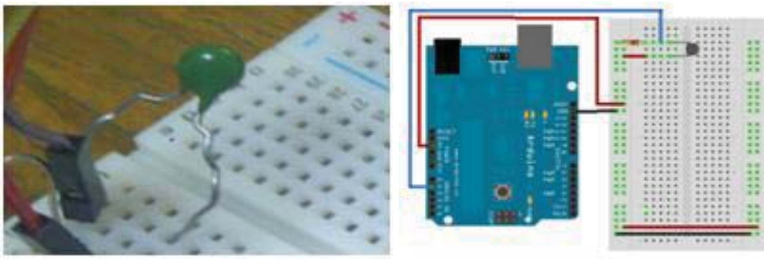
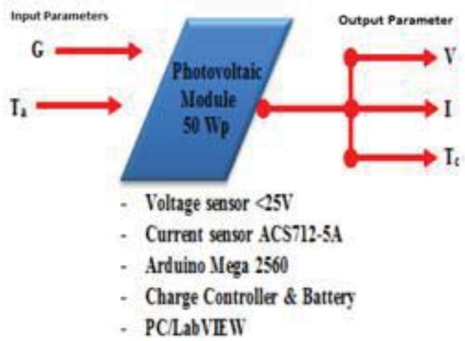


Fig. 7: Temperature sensor and connection diagram to arduino

Fig. 8: Solar power meter

Results

The PV module experimental system was installed in the ITENAS campus area in Bandung. The data acquisition was performed during 1 day experiments, January 16, 2016, from 09:00 a.m. to 05:00 p.m. The input – output parameters and the principle of measurement can be seen in Figs 9 and 10.



G : Global irradiance (W.m^{-2})

T_a : Ambient temperature (^{o}C)

V : Voltage (Volt)

I : Current (Ampere)

T_c : Cell temperature (^{o}C)

Fig. 9: Input – output parameters

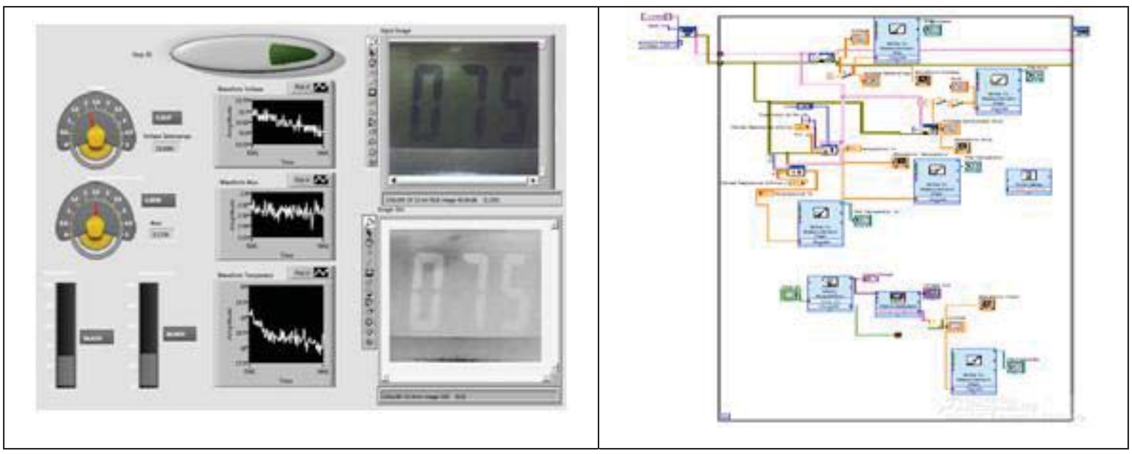
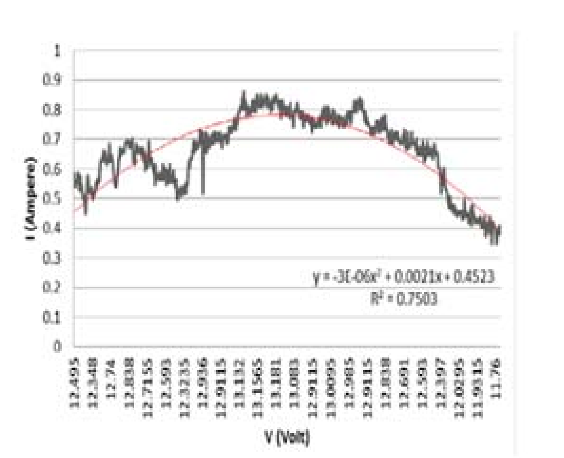
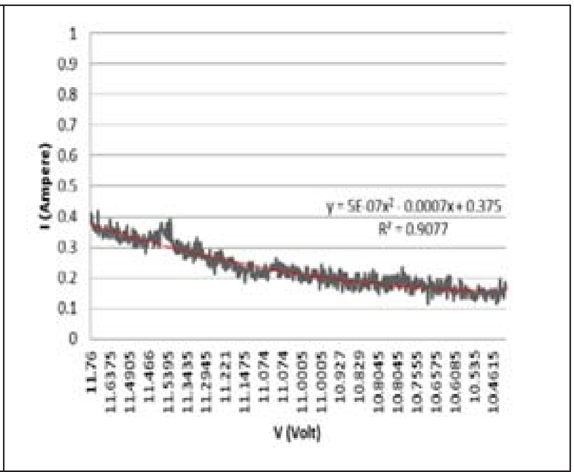


Fig. 10: Data acquisition method and block diagram

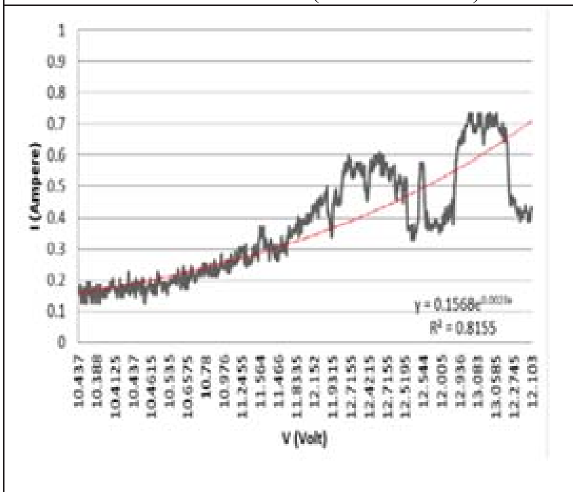
Input parameters, G, T_a and output parameters I, V, P and T_c recorded. All parameters data was taken every 3 minutes, for 8 hours (09:00-17:00), except solar irradiance data. The solar irradiance data was taken manually every hour, because the signal from solar power meter could not be processed by Lab VIEW. Figs 11-13 show the relationship between *I-V-P* data based on the experiments.The average of all data at each hour is summarized in Table 1.



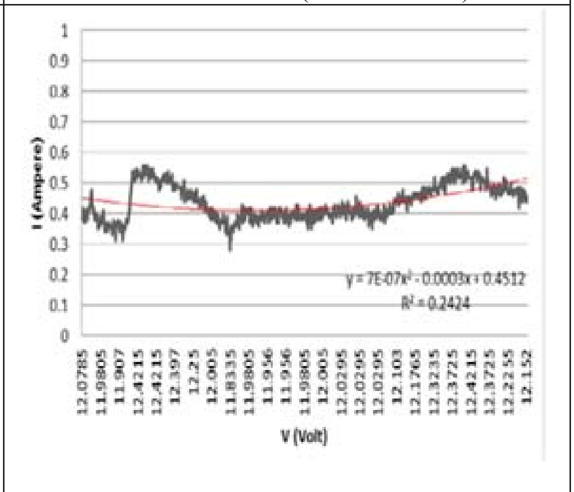
Time: 09:00 – 10.00 (G = 622 W.m^{-2})



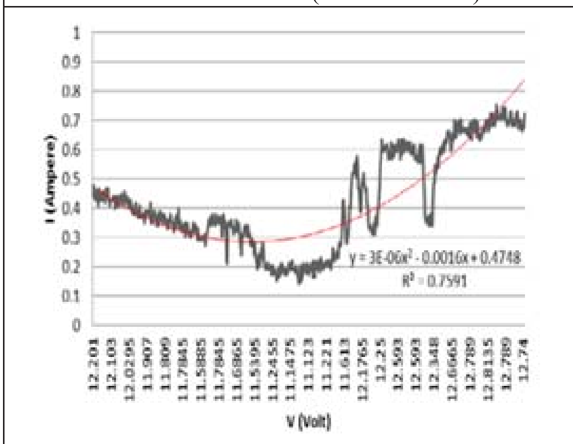
Time: 10:00-11.00 (G = 421 W.m^{-2})



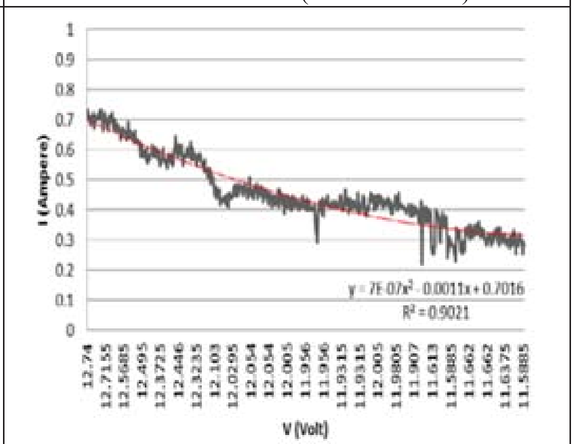
Time: 11:00 – 12.00 (G = 444 W.m^{-2})



Time: 12:00-13.00 (G = 494 W.m^{-2})

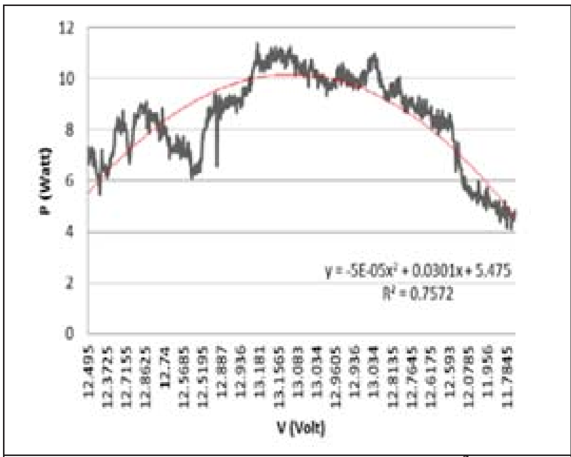


Time: 13:00 – 14:00 (G = 475 W.m^{-2})

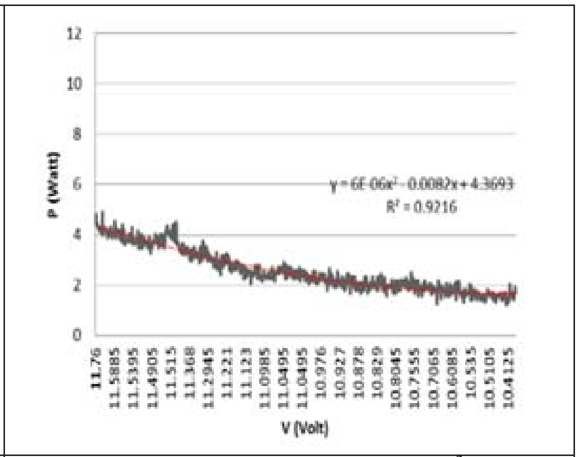


Time: 14:00-15.00 (G = 343 W.m^{-2})

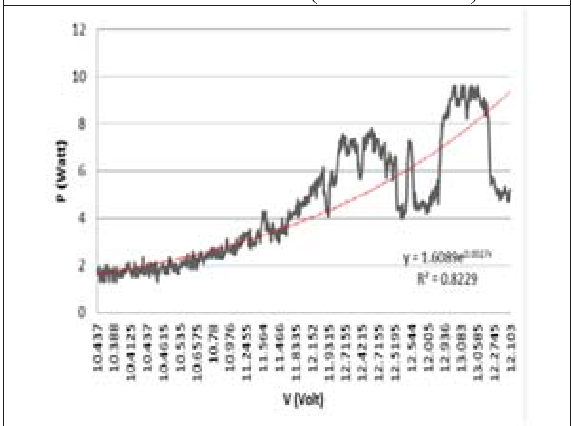
Fig. 11: *I-V* Data in interval time 09:00-15:00



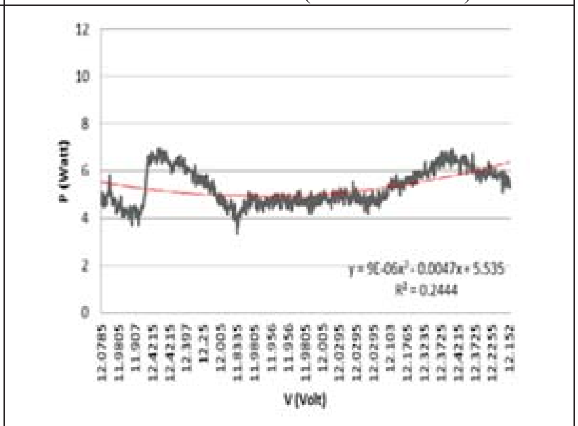
Time: 09:00 – 10.00 (G = 622 W.m^{-2})



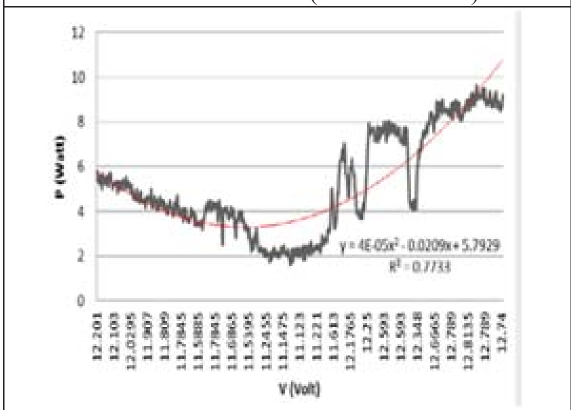
Time: 10:00-11.00 (G = 421 W.m^{-2})



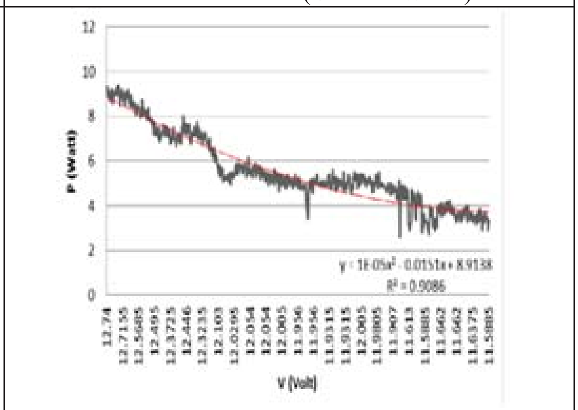
Time: 11:00 – 12.00 (G = 444 W.m^{-2})



Time: 12:00-13.00 (G = 494 W.m^{-2})



Time: 13:00 – 14:00 (G = 475 W.m^{-2})



Time: 14:00-15.00 (G = 343 W.m^{-2})

Fig. 12: *P-V* Data in interval time 09:00-15:00

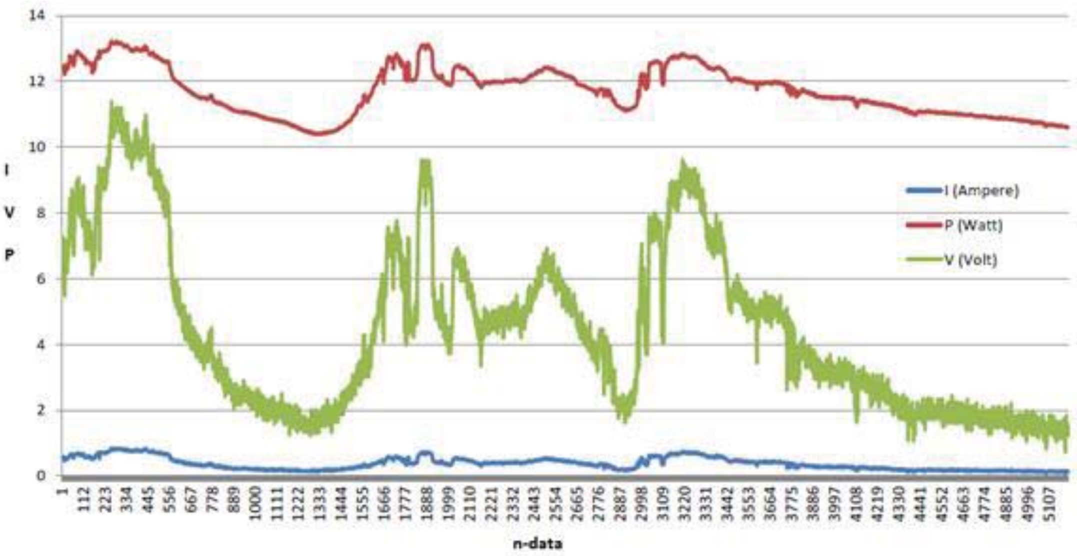


Fig. 13: *I-V-P* Data in interval time 09:00-15:00

Table 1: Experiment Results at 09.00-17.00 in Western Indonesian Time

Time	G (W/m^2)	T_a (^{o}C)	T_c (^{o}C)	V (Volt)	I (Ampere)	P (Watt)
09:00-10:00	622	33.72645	44.62749	12.7001	0.6634	8.42525
10:00-11:00	421	30.37906	35.66878	11.5366	0.2316	2.67188
11:00-12:00	444	31.10322	36.99411	11.6797	0.3731	4.35769
12:00-13:00	494	32.22211	39.10253	12.1597	0.4429	5.38553
13:00-14:00	475	32.14042	38.8852	11.9814	0.4246	5.08731
14:00-15:00	343	29.73048	35.10191	11.3350	0.1917	2.17292
15:00-16:00	295	29.06154	33.90926	11.2879	0.1624	1.83315
16:00-17:00	242	28.85283	31.60192	10.8493	0.1542	1.66729

3. Conclusions

A progress on characterization of a PV module in tropical climate is reported in this paper. The PV module observed was polycrystalline and the type was ESM (Electrical Solar Module) 50 Wp. In this preliminary experiments, characterization of the PV module was performed in the real Bandung weather condition in one day, for 8 hours. It is found that current, voltage and power of PV module is influenced by the fluctuation of temperature and solar irradiance. Conducting to main purpose, in the future work, characterization of PV modules based on thin film technology will also be performed.

4. Acknowledgement

This research is carried out with the support of the Research Institution Itenas and the Ministry of National Education of the Republic Indonesia under contract No. 146/B.05/LPPM-Itenas/VI/2016.

5. References

Carr, A.J., Pryor, T.L., 2004. A comparison of the performance of different PV module types in temperate climates, Solar Energy. 76, pp. 285–294.

Greenrhinoenergy. Solar Power – Technologies, PV cells and modules, on line at: www.greenrhinoenergy.com/solar/technologies/pv_modules.php, accessed on December 19, 2012.

Rusirawan, D., Farkas, I., 2014. Identification of model parameters of the photovoltaic solar cells. Energy Procedia. 57, pp. 39-46.

Rusirawan, D. and Farkas, I., 2014. Photovoltaic technology characteristics in hot weather conditions, Energy and the Environment, /ed. by B. Frankovic/, Croatian Solar Energy Association, Opatija, Croatia, October 21-24, 2014. pp. 151-157.

Tsai, H.L., Tu, C.S., Su, Y.J.: Development of generalized photovoltaic model using Matlab/simulink, Proceeding of the World Congress on Engineering and Computer Science (WCECS) October 22 – 24, 2008, San Fransisco, USA, 2008, 846-851.

Online at: http://www.iaeng.org/publication/WCECS2008/WCECS2008_pp846-851.pdf, accessed on September 25, 2016.