Wireless Monitoring System For Photovoltaic Generation With Graphical User Interface

Asnil Asnil, Krismadinata Krismadinata, Irma Husnaini, Fauzan Gunawan

Abstract: Monitoring Photovoltaic (PV) parameters is very important to see the performance of a PV in producing electrical energy. The energy produced from PV is greatly determined by changes in solar radiation and temperature from PV. The energy produced will vary according to the level of solar radiation and temperature changes. Monitoring in real conditions is required to improve reliability, evaluation, implementation and costs. Aside from that, the description of the characteristics obtained is also useful for determining the design of PV installation configurations and the determination of control algorithms to match the load requirements. So that the electric energy produced can be maximized and the efficiency of PV can be increased. This paper describes a technique for monitoring PV parameters (current and voltage generated and temperature on PV) using wireless nRF24L01 as a communication device between PV and PC as host. PV parameter monitoring uses the ACS712 current sensor, the voltage sensor uses the concept of a voltage divider and a DHT11 sensor for temperature detection. The parameters obtained (current and voltage generated and temperature on PV) are processed using Atmel AVR ATmega 328 MCU which is then transmitted to a PC using the nRF24L01 transceiver system as an intermediary. The test results show that the system built can monitor PV parameters in the form of voltage, current and temperature in real time.

Index Terms: wireless monitoring, photovoltaic, GUI, parameter measurement, ATmega 328 MCU, nRF24L01, DHT11, ACS712

1. INTRODUCTION

Massive use of fossil energy can cause energy crises, scarcity of fuel oil, such as kerosene, gasoline, diesel fuel and also cause global warming [1], [2]. Limitations and increased requirement for energy, climate change and environmental pollution cause alternative sources of clean energy and abundant availability are increasingly needed [3]. Minimum impact on the environment, abundant availability, low maintenance, no cost for fuel and no noise makes Photovoltaic (PV) increasingly popular as a clean and environmentally friendly energy source [4]–[6]. However, some problems remain in the case of PV utilization, including solar radiation conditions and low temperature and efficiency. The energy produced by PV is affected by changes in solar radiation and temperature. The higher the solar radiation, the greater the current generated, as well as the effect of rising temperatures on the PV will reduce the value of the voltage and power produced [7]. In Fig. 1 can be seen the form of a I-V curves whereas in Fig. 2 shows the P-V curve from PV for various irradiation with constant temperature. In the I-V curve, it can be seen that the current generated increases when there is an increase in irradiance received by PV. Whereas on the other hand the voltage looks relatively constant despite an increase in the value of the current.

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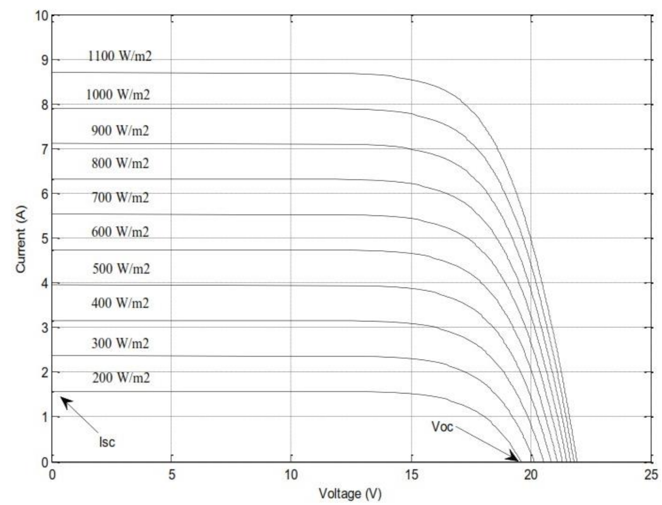

***Fig. 1**. I-V Curves with constant temperature and various irradiance [8]*

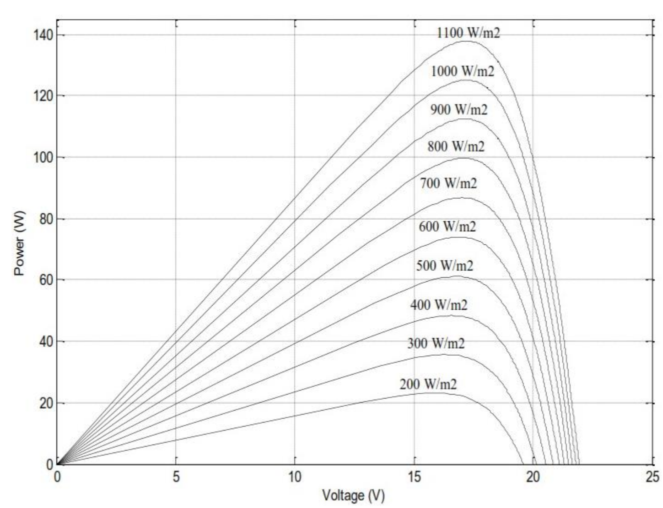

***Fig. 2**. P-V Curves with constant temperature and various irradiance [8]*

Apart from change in solar radiation, change in temperature also greatly affect the amount of energy produced as shown in

Fig. 3 and Fig. 4. The maximum energy produced is at the lowest temperature point, while the minimum energy is when the maximum value is temperature. The variation of temperature that occurs when radiation is constant does not affect the current generated in the sense that the current is relatively constant. If the temperature is lower, the maximum power is higher while the voltage of the open circuits is greater, but lower temperature give less short circuits current lower [8]

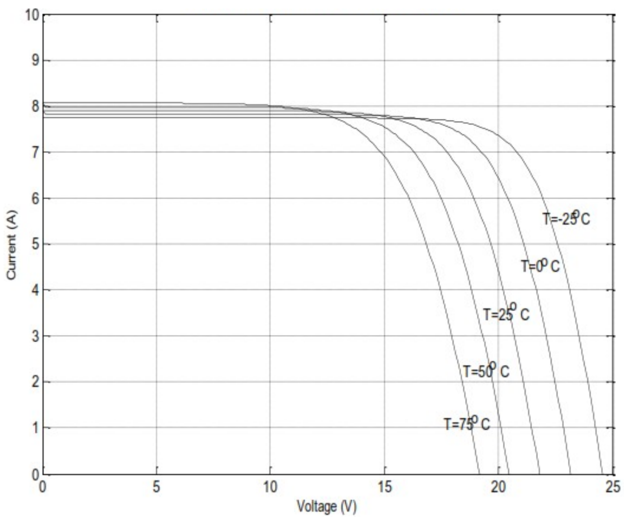

***Fig. 3**. I-V Curves with constant irradiance and various temperature [8]*

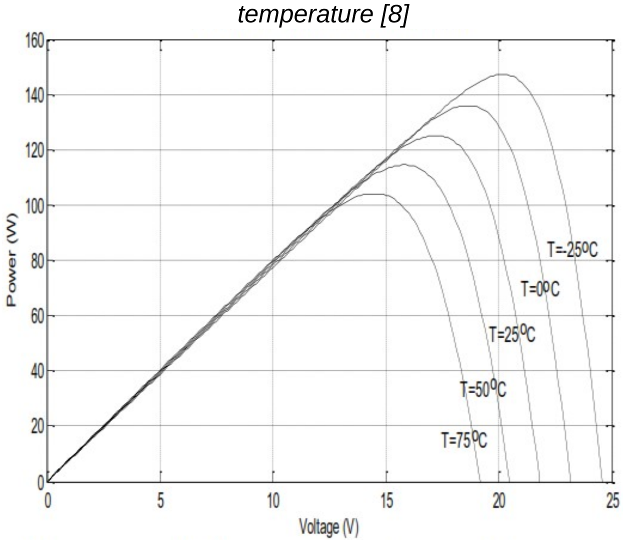

***Fig. 4**. P-V Curves with constant irradiance and various temperature [8]*

For better performance, system reliability, cost estimation, evaluation and implementation as well as analysis of the initial investment return of the PV system, it is necessary to have a system that can monitor important parameters of the PV in real time conditions [9]. In general, PV parameter monitoring systems can be classified into monitoring using wired and wireless systems [10]. Monitoring with a cable system typically uses the RS485 interface and CAN bus for local communication [11]. Because the wiring is complicated, takes more energy and costs, it is proposed monitoring PV parameters using a wireless system [12]–[15]. Wireless communication has grown very quickly, making it possible to design systems using wireless networks that can continuously gather data and other parameters required. This can make it easy to perform the analysis, evaluation and validation of the required parameters. Many devices can be used for PV monitoring systems using wireless systems, including Zigbee and XBee Znet [16], [17]. In this case, to monitor the parameters of the current and output voltage and temperature on the PV using the wireless device nRF24L01 as shown in Fig. 3 [18]. This device has an excess range of 1 km in open areas and 70 meters to 100 meters in closed areas [19]. The nRF24L01 device is a radio transceiver with 2.4 GHz capability and a maximum data speed of up to 2 Mbps. Apart from that nRF24L01 only requires a small power consumption to operate, which is 3.3 V. Meanwhile, to process the signal received from the sensor used ATmega 328 MCU. Then a PC is used to see the characteristics displayed in the form of graphs of the resulting voltage and current and temperature in PV. To see the graphic display on a PC using the help of the Graphic User Interface (GUI), namely Visual Studio 2012.

2 The Proposed System

Block diagram of the planned system for measurement of the current and voltage parameters produced and the temperature in the PV can be seen in Fig. 5. The proposed scheme is split into two sections, namely the system of data acquisition flow and strain generated and temperature data on PV with the help of ATMega 328 MCU, and PC as a host that is connected wireless using the nRF24L01 device. ATMega 328 acts as the brain of this system that will receive data from the input sensor, then convert from analog to digital then send data to the host PC through the intermediary nRF24L01.

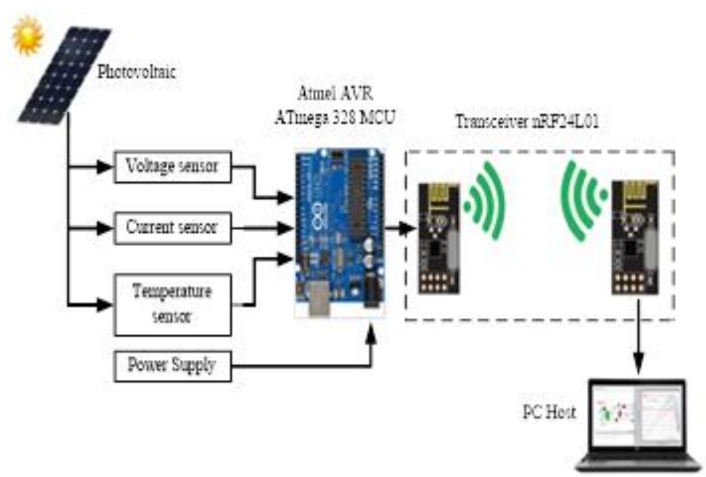

***Fig. 5**. Block diagram of the proposed system*

2.1 System Description

The type of PV used as a model in research for monitoring the parameters needed is a PV with mono crystal type ST-50-P6 model with a maximum power capability of 50 watts and a maximum output voltage of 16 volts, the name plate can be seen in Fig. 6. While the parameters to be monitored are the voltage and current generated and the temperature of the PV.

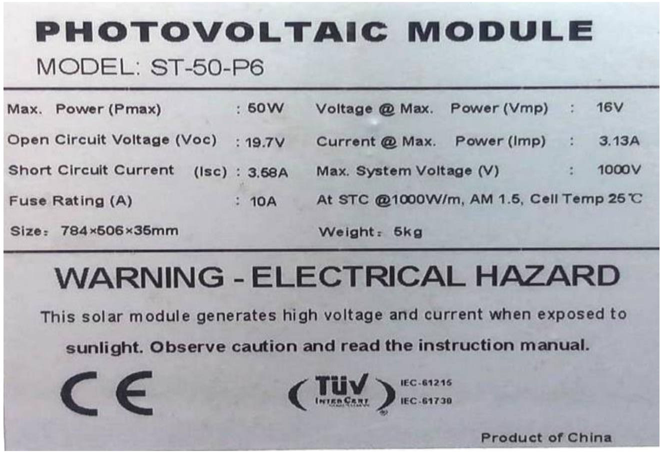

Fig. 6*. Name plate of PV module model ST-50-P6*

2.2 Hardware Implementation

The hardware of the system planned to take measurements of the current and voltage produced and the temperature of the PV can be seen in Fig. 7 and Fig. 8. The system used as a data acquisition device with the help of ATmega 328 and a nRF24L01 wireless device that functions as a transmitter that will send data to the receiver can be seen in Fig. 7. While Fig. 8 is a receiver system that serves to receive data transmitted from the sender to be forwarded to PC via a USB cable.

Fig. 7*. The first part of the system*

Fig. 8*. The second part of the system*

3 RESULT

The implementation of the system in the measurement of parameters from PV can be shown in Fig. 9. Before the parameters of the PV are measured, a test of the system is made to fin out the maximum distance of the system to work properly. Tests for data retrieval are performed in a closed area or there is a barrier (the receiver is in the room) and the system works well at a distance of 52 meters. However, at a distance of 52 meters to 55 meters there was a delay in the time for sending data from the transmitter to the receiver. These results are different from the results obtained by other researchers. The analysis of the researcher is a result of the type, thickness and number of obstacles used.

Fig. 9*. Implementation of the system in the measurement of parameters from PV*

In the Fig. 10 shows the GUI of the PV monitoring system using Visual Studio 2012. The GUI display shows the voltage, current, temperature and energy value that are recorded every second. The result of measurements is then stored in a database which can be recalled at any time to view the profile of the PV parameters according to the desired measurement time. Measurement data is stored in a database that can also be called and viewed using Microsoft Excel. The next stage shown the result of the measurement of PV parameters for one week using graphical on Microsoft Excel.

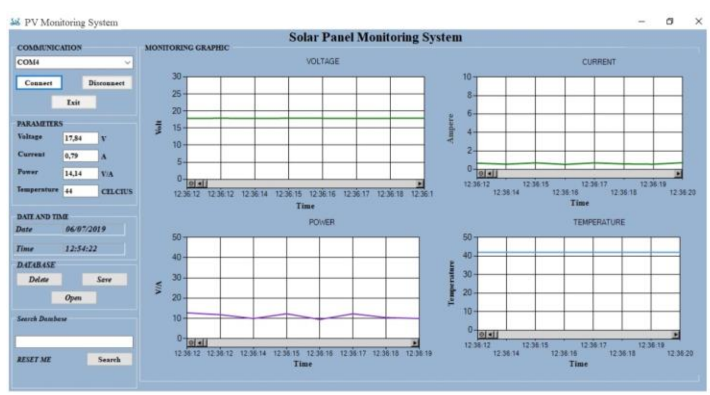

Fig. 10*. Display of PV monitoring using GUI*

Testing of PV parameters is carried out every day for one week starting at 09.00 until 15.00 WIB and sampling data for the graph that will be shown below is for data recorded every 5 minutes. The results of measurements for one week for the current and voltage parameters generated by the PV and temperature data on the PV itself can be seen in Fig. 11 to Fig. 17.

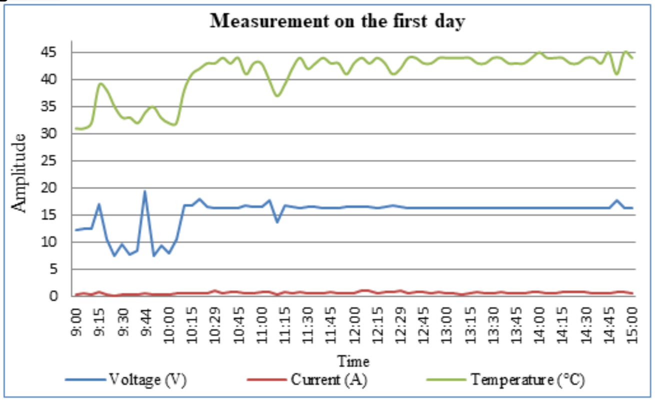

***Fig. 11**. PV parameters measurement result on the first day*

In Fig. 11 we can see that the voltage has stabilized after 10:00 a.m. with an average value of 16 volts. While the temperature value on the surface of the PV panel after 11.00 am on average exceeds 40^0 C. As for the current value, there is no significant change. Fig. 12 shows a significant temperature change during measurement, this is influenced by environmental factors when measuring many clouds that cover the sun exposure to PV. While the voltage value has started to stabilize above 09.30 am, although it is still undergoing a little modification. For the current value does not change significantly and looks still stable because the current value is determined by the value of the load used, as well as measurements in the following days.

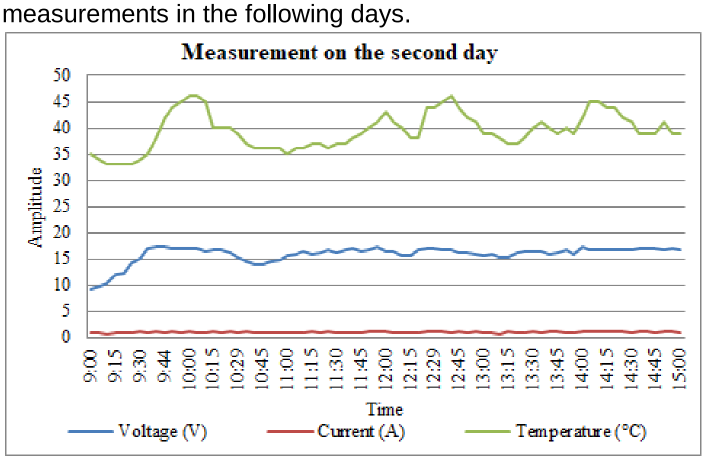

***Fig. 12**. PV parameters measurement result on the second day*

In Fig. 13, it can be determined that the temperature on the PV surface rises even reaching 45^0C above 10.30 a.m. which then slowly decreases to 35^0C at 03.00 p.m. Likewise with the value of the voltage generated by the PV generates an average of 16 volts from 10:00 a.m. to 2:15 p.m. Whereas in Fig. 14 we see an increase in the temperature value on the PV surface, as well as a voltage value. The increase in temperature and voltage parameters starts at 09.00 a.m. and then stabilizes after 10.30 a.m. until the measurement is finished.

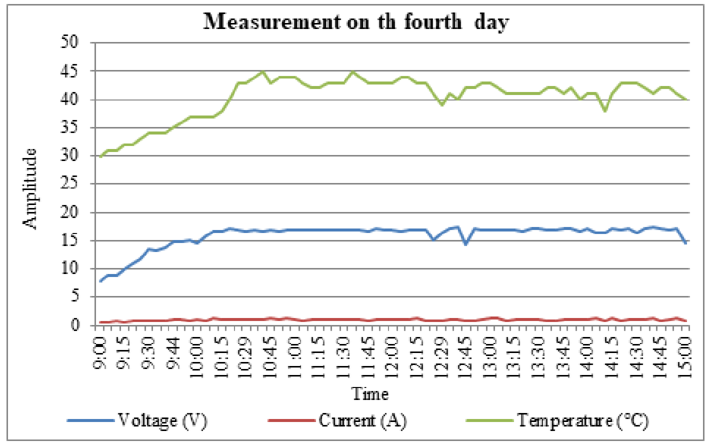

***Fig. 13**. PV parameters measurement result on the third day*

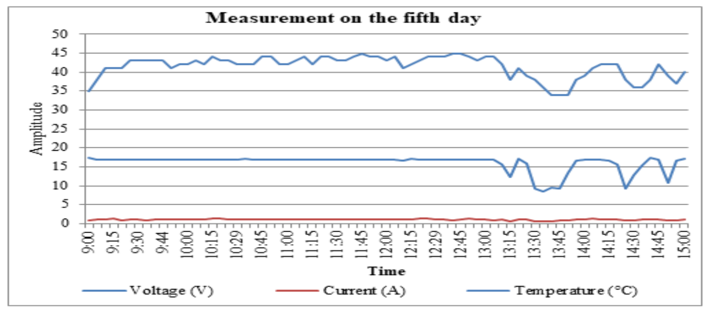

***Fig. 14**. PV parameters measurement result on the fourth day*

Measurements on the fifth day obtained a graph like in Fig. 15. The resulting voltage occurs stable from the beginning of the measurement, but fluctuations after 01.00 p.m. until the measurement is complete. This is due to the fact that at that time the sun had begun to cover the clouds. Also, the temperature measured along the panel surface, despite the fluctuations in the average measured temperature is still above 35^0C. Fig. 16 shows the value of the generated voltage starts to stabilize at 10.30 a.m. to 01.20 p.m. Before and after the measured value there are fluctuations due to weather conditions that are not sunny so there are many clouds that cover the lighting from the sun to the PV. Similarly, the temperature along the PV surface also has the same matter.

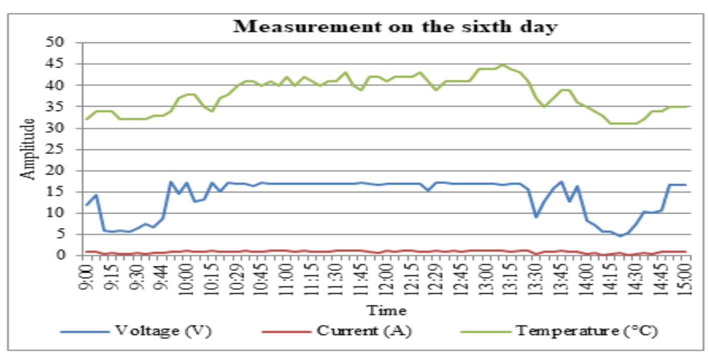

***Fig. 15**. PV parameters measurement result on the fifth day*

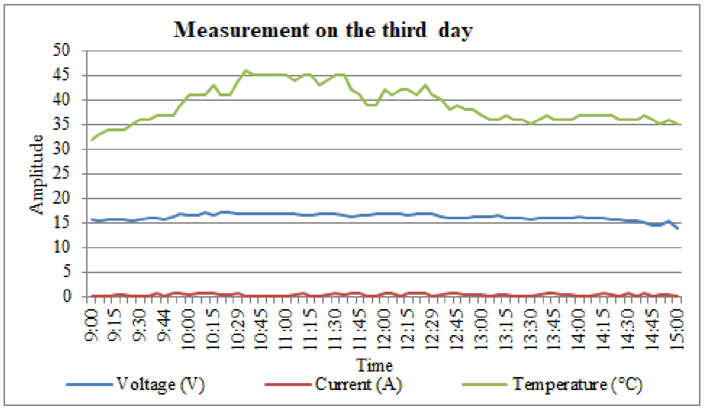

***Fig. 16**. PV parameters measurement result on the sixth day*

While the measurement on the seventh day, the output voltage is static from the beginning to the end of the measurement as shown in Fig. 17. Likewise, the measured temperature is above 30^{0}C even at 01.20 p.m. the temperature at PV reaches 45^{0}C. On the seventh day, starting from the beginning until the measurement ends the weather is clear so that no clouds cover the sunlight to PV.

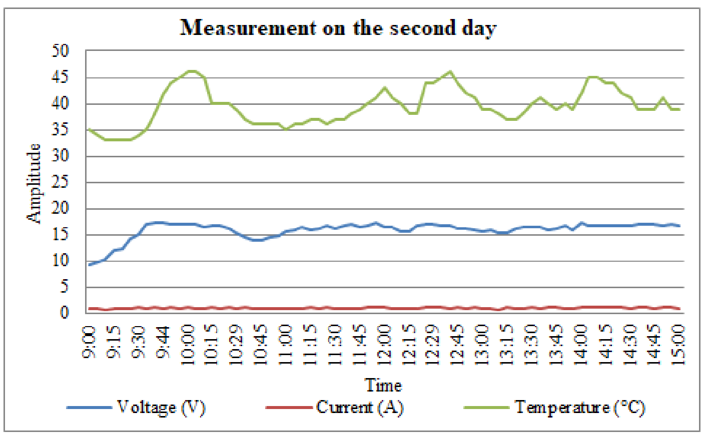

***Fig. 17**. PV parameters measurement result on the seventh day*

4 Conclusion

From the results of research and testing conducted for one week it can be concluded that the wireless monitoring system that has been designed can be implemented properly. Then the fluctuation of the measured value of the observed parameters is determined by environmental conditions. When the sun shines on the panel covered by clouds, there will be a decrease in the observed value of the parameters. Vice versa if the sun's irradiation is not covered by clouds, the voltage generated by PV can be maximized. However, the panel surface temperature will rise, which in theory can affect the efficiency and energy produced by PV.

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