An Internet of Things system for measuring parameter of Photovoltaic Panel

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Abstract: Internet of Things (IoT) system is developing at an impressive rate nowadays. It is capable of performing machine-to-machine communication, cloud connection, data management and collection simultaneously. In this paper, the authors have designed an IoT system in a Photovoltaic (PV) panel with real time current and voltage measurement, cloud connection capability and measurement storage function into an IoT server. The graphical data stored allows evaluation of the PV Panel's overall performance. Our IoT systems were powered with Arduino-based microcontroller paired with current and voltage sensor, as well as WIFI wireless communications system and Bluetooth module. We paired our system with an android smartphone to display the data and stored it into the Blynk server. Blynk is a cloud-based IoT capable of controlling and storing data for Arduino-based microcontrollers over Wi-Fi or Ethernet connection. In our experiment for 50WP PV panel, we were able to store the parameter for over one week measurement ,that give us enough data to get the PV performance.

Keywords: IoT, Photovoltaic, Arduino, Performance

1. Introduction

The performance of a solar panel situated in certain economic conditions may be determined by directly monitoring the output parameters such as voltage, current and power (Muhammad Rizal Fachri, Ira Devi Sara, dan Yuwaldi Away, 2015).Based on such results, we can obtain information whether the solar panel installation has been operating properly and producing the expected power output. This current solar panel monitoring method is operating on a limited scope since it only collects the solar panel parameter output in form of text file with specific outputs and lacks the capacity to perform the same task in real time condition. In the event that the solar panel output parameter data is obtained real time in graphic charts, then solar panel technology users may personally manage their electrical energy and burden depending on conditions. Thus consumer's electrical supply will tend to be sustainable and reliable. This paper attempts to shed light on new techniques for direct and real time solar panel parameter output monitoring. Such techniques utilize voltage sensors and current sensors capable of displaying real time data without shutting down the Arduino board as data logger. The implementation of this monitoring technique is capable of reducing data processing time significantly.

2. Theoretical Reference

2.1. Solar Cell

Solar Cell is an equipment or component capable of transforming sunlight energy into electrical energy based on Photovoltaic effect principle. In 1839 Henri Becquerel discovered Photovoltaic Effect, which is a phenomenon where electrical voltage is generated due to the contact of two electrodes connected with solid or liquid system while obtaining sunlight energy. As such, Solar Cell is also referred to as Photovoltaic Cells (PV) which translates structurally as a Photodiode with an extremely wide surface. The total area of the Solar Cell is inversely proportional with the sensitivity of the Solar Cell towards incoming light and generated stronger Voltage and Current compared to other Photodiode in general. For example, a Solar Cell made from silicone semiconductor material is capable of generating up to 0,5V in voltage and 0,1 A in current during day light exposure. Currently this Solar Cell hardware is implemented into various appliances such as calculators, toys, battery charger until electric power plant and even as electrical source to operate Satellite within its orbit (Dunlop, James P. 2012).

2.2. Internet of Things

Internet of things or popularly known as IoT is defined as an idea where all objects in the real world is capable of communicating with each other as part of a single unified system using internet network as a hub.(Bahga, Arshdeep, Madisetti, Vijay, 2014). IoT may be demonstrated by a CCTV network installed along the road connected with internet connection and centralized in a control room which maybe dozens of kilometers away or a smart house managed via smart phone supported with internet connection. IoT wares comprised of sensors as data collection media, internet as communication media and the server shall act as information gatherer received by sensors and analysis unit. Originally, the implementation of IoT identification is widely used for computerized object identification using Barcode, QR Code and Radio Frequency ID (RFID). In its development, experts revealed that the object maybe identified by its IP address and to communicate with other object with IP address identifiers, under internet network ecosystem.

2.3. Arduino

Arduino is a platform for open source physical computing since it functions not only a development tool, but also capable of sophisticated hardware programming language and Integrated Development Environment (IDE). Academician and professionals have developed and relied upon multiple projects and equipment using Arduino. Aside from that, other parties also constructed multiple supporting modules (sensors, layout, controller, etc) bridged by Arduino. Along the way, Arduino evolved into a platform since it became a reference for many practitioners. From the myriad of available Arduino boards, the UNO R3 Arduino board stands out considerably. Arduino UNO is a microcontroller board based on ATmega328 Atmel microcrontoller. "Uno" translates into "one" based on Italian language and aims to signify the next (product) release of Arduino 1.0. Arduino UNO and version 1.0 became reference for the next Arduino versions. Currently Arduino UNO is the latest series of Arduino USB board and reference model for Arduino board.

2.4. Voltage Sensor

Voltage Sensor is DC or AC voltage measurement instrument that generates discreet numbers. Voltmeter is constructed from circuits with specific IC such as ICL7107 / ICL7106 or using IC controller by utilizing ADC (Analog to Digital Converter). The Voltage into ADC0 or Vs should be < 5 volt (users should be aware that voltage exceeding 5 volts will damage the microcontroller). If the user would like to measure AC voltage, then the current should be transformed into DC voltage beforehand.

2.5. Current Sensor

Current sensor is measurement equipment in electronic devices. The sensor is usually comprised of electronic circuits which transforms current unit into electrical unit. One of the most common current sensors used is usually ACS712 chip. It operates by analyzing the current via copper cable which generates magnet field captured by integrated Hall IC and transformed into proportional voltage.

2.6. ESP8266 WiFi Module

ESP8266 ESP-01 is a Wi-Fi module enables microcontroller access to the Wi-Fi network. This module is and independent System On a Chip (SOC) which does not require a microcontroller to manipulate the input and output as generally used with Arduino, for example, since ESP-01 acts as a mini computer.

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3. System Design

3.1. Diagram Blocks

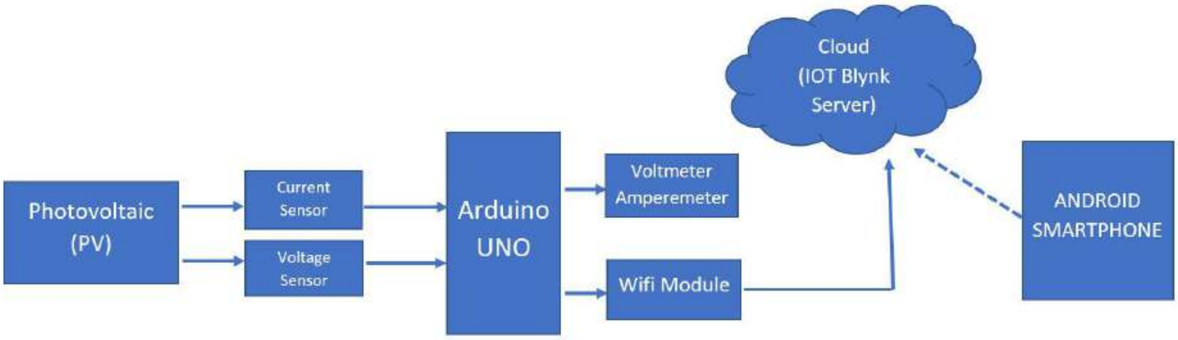

Figure 1. Diagram Block

Based on the diagram above, the current and voltage sensors are installed in parallel with the solar panel. Then those sensors are relayed to the Arduino Uno microcontroller. The voltmeter and ampere meter will act as counter balance to the data displayed in the smartphone. Any android smartphone equipped with ESP 8266 WiFI module connected to IoT Blynk server and internet connection should be able to directly monitor the solar panel parameters.

3.2. Hardware Design

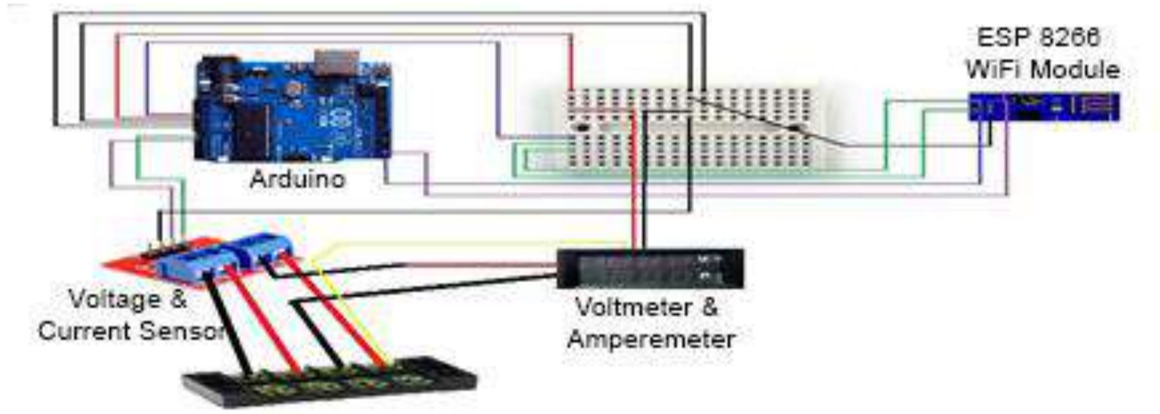

Figure 2. Hardware Schematic

Table 1. Hardware Specific

Device	*Arduino*	*Details*
Current Sensor	*A0 / GND*	Analog Input 0
Voltage Sensor	*A1 / GND*	Analog Input 1
Voltmeter / Amperemeter	*5 v / GND*	Directly from sensor
WiFi Module	*3.3 v / GND / (D1)TX /(D0) RX*	Pin 1 (Tx) and Pin 2 (Rx)

3.3. Software Design

To support this research, the author utilized Blynk as an open source software which can be downloaded for free from Google Play Store. After completing the installation and registration steps, user can easily manage the current and voltage data displayed based on the table below. Graphical display refers to the value display setting, whose input is based on the hardware design table above.

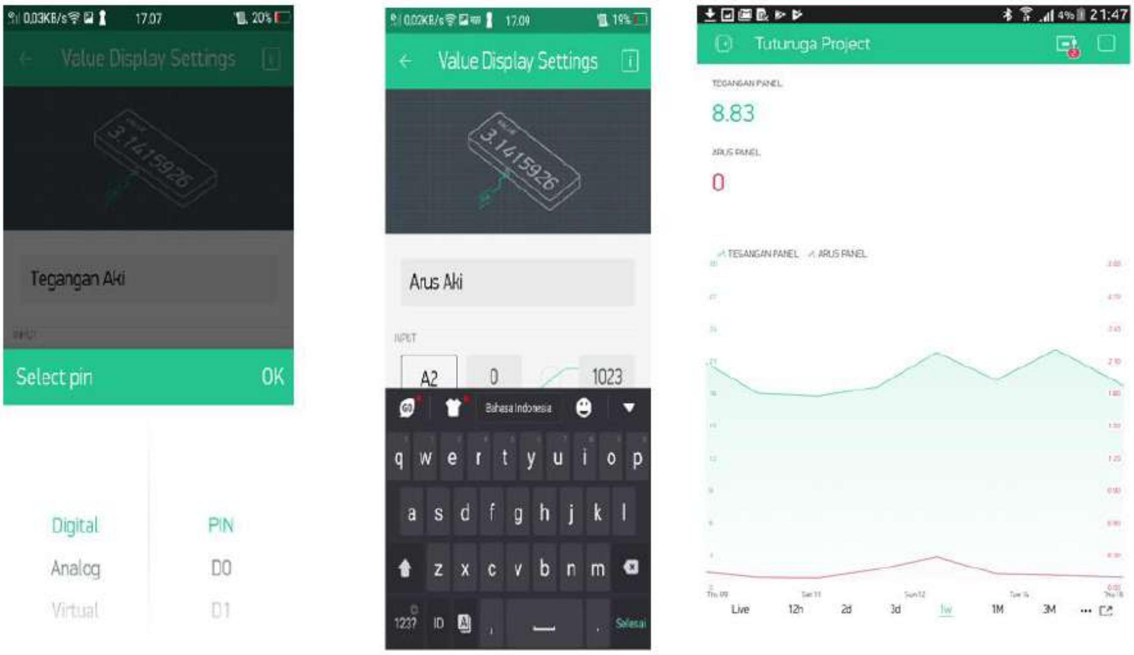

Figure 3. Software Design

4. Result and Discussion

Data collection began from 4 August 2018 until 11 August 2018. The average duration for data collection per day is 5 hours. The following table revealed the minimum and maximum value from the solar panel current and voltage.

Table 2. Voltage and current measurement

Voltage (Volt)			Current (Ampere)		
Average	Min	Max	Average	Min	Max
19,16971	0,0167	25,057	0,138708	0,000833	0,53275

Displayed below is the voltage graph and current in the duration of one week

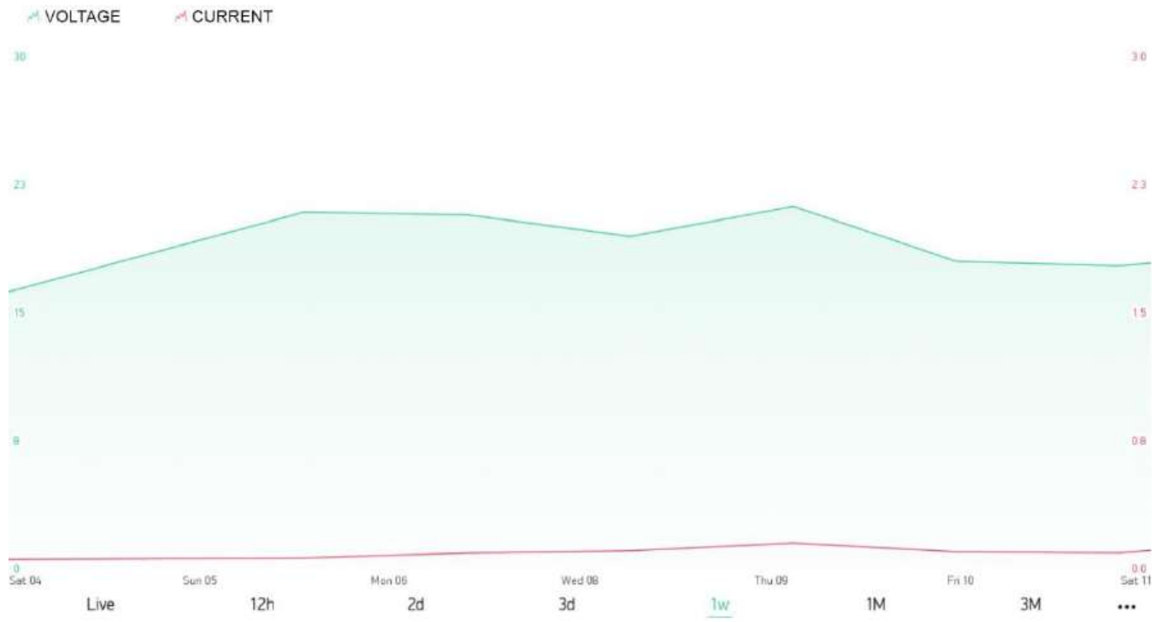

Figure 4. Voltage and Current (one week duration)

From the graphic above, the photovoltaic generates a stable current, with minimum value of 0.13A. The voltage measurement tends to fluctuate more between 6- 8 August 2018. This fact is due to the rain occuring during such period, which reduces the photovoltaic light absorbing effectiveness. However the fluctuation remains tolerable, with the average voltage of 19,16 Volt.

Figure 5. Voltage and Current (three day duration)

Based on 3 day graphic intervals, the voltage graphic tends to fluctuate more with a stable current graph

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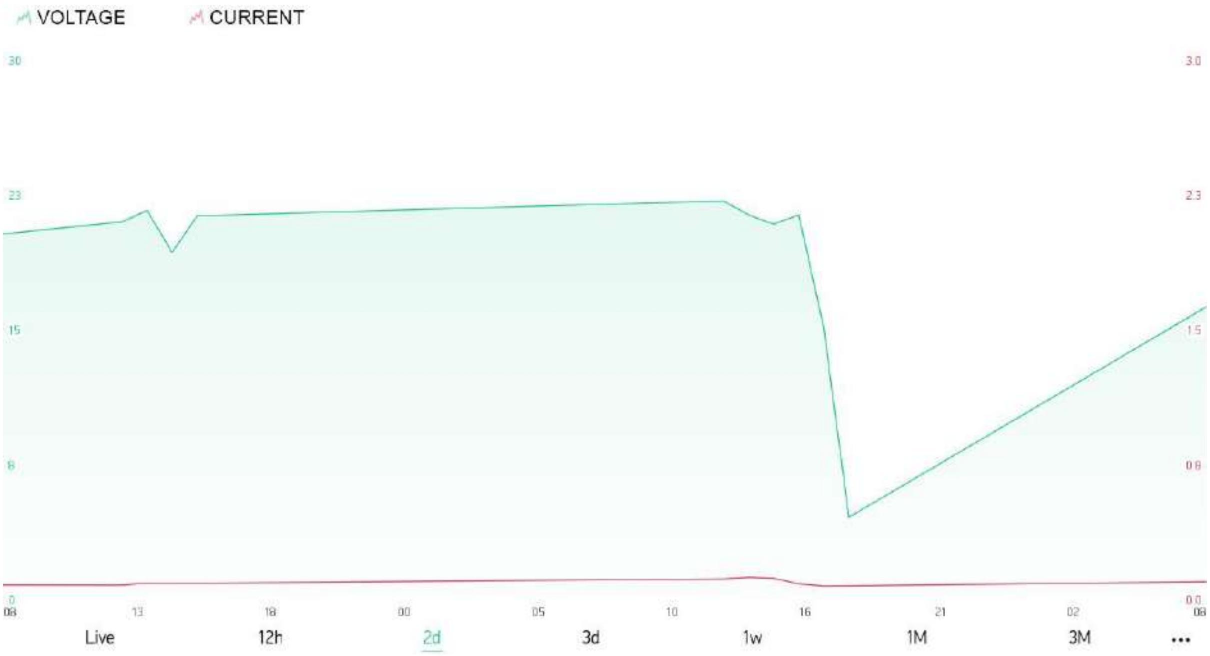

Figure 6. Voltage and Current (two day duration)

Based on the 2 day graphic intervals, the voltage measurement on 16:00 WITA displays a large gap due to the limited calculation term of 5 hours per day and the deadline for the day was at 4 pm.

Figure 7. Voltage and Current total (enlarge scale)

The picture above demonstrated the graphic of total current and voltage with enlarged scale. Current and voltage output presents stable results, which led to the conclusion that the performance of utilized photovoltaic is extremely good.

The internet connection used for this IoT data analysis, applies Smartfren as 4G provider. Based on speed test evaluation results, the average data download and upload speed reached up to 5 Mbps and 10 Mbps respectively. The speed was deemed adequate, since the IoT required a sustainable upload speed. The current data package delivery and voltage from Arduino to Blynk IoT platform was successfully real time conducted to smartphone , so long as internet connection was available. There was 2-3 seconds delay from the voltmeter/amperemeter measurement in Arduino and voltage/current reading in the android smartphone. This delay is tolerable, considering the unstable rate of internet connection.

5. Conclusion

1. The IoT for solar panel parameter calculation has been successfully conducted.
2. Blynk Server is a viable option for IoT establishment system due to its simple implementation and open source nature.
3. The data collected in a weekly basis yielded result of average voltage of 19,16 Volt and current of 0,13 Ampere.
4. The graphic for voltage and current data presents stable results in a week's interval.
5. Based on the 2 day graphic interval, that voltage measurement gap is visible since the measurement is only conducted on average of 5 hours per day.
6. The performance of utilized solar panel presents an extremely well result and potential to be developed further by future researchers.

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