

Design and implementation of real-time monitoring based on Android and HMI of PV tower system for laboratory scale

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Abstract. The performance of photovoltaic (PV) cannot be described by the user, so it is difficult to anticipate when it's undesirable or fault condition occurs. Therefore, the monitoring of PV output parameters is needed. In this case, the parameters that can be displayed are current and voltage value. The parameter data are obtained from PV tracking of the sun position by MPPT Perturb and Observe (P&O) method used in a mechanical system of the dual axis solar tracker. In this experiment, there are two monitoring methods used, which are Real-time Online Monitoring Based on Android system and Human Machine Interface (HMI) display monitoring which is controlled by Arduino Mega 2560. Both methods are expected to show the performance of PV in real-time, remotely or not. The results of this experiment are Android apps and HMI that can monitor the PV output condition. To maintain the PV system in real-time, they keep the device under the supervision and extend its lifetime for more prolonged use.

1. Introduction

Solar energy is one of a renewable energy source that can be converted into electrical energy. Nowadays this energy source is getting a lot of world attention because it can replace the sources of energy that cannot be renewed resulting in pollution, one of them fossil fuel. To convert solar energy into electrical energy is to use photovoltaic cells (PV). Photovoltaic generates direct current (DC) and can be converted to alternating current (AC) using an inverter. The PV system demonstrates green technology that is environmentally friendly, easy installation, low maintenance cost, and also durable [1]. Therefore, this technology is growing very rapidly and become a large-scale system [2]. This large system of course will be found many problems in the future, generally they are under voltage, overvoltage, overcurrent or output power of PV. To solve this problem thus needed Human Machine Interface (HMI) [3]. HMI connect the user and the PV as manually or by visualization on devices. So the user can interact with the PV in real-time, they keep the device under the supervision and extend its lifetime for more prolonged use.

2. Literature review

Human Machine Interface commonly known as HMI referred to the user interface, terminal or operator panel. HMI functions are monitoring or visualizing, controlling, and managing device processes [4]. HMI implementation is based on Internet of Things (IOT) that provides access to users



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to be able to adjustly manage the device parameter in realtime.[5]. In the application, it can manage a system by setting the value of the motor, valves, temperature values, and display the data realtime data in a portable GUI. By using the GUI, the user can set the valve status open /closed.

A solar cell can be briefly described as pn (positive-negative) junction diode. When the light exposed the positive-negative junction there will be electricity generation from converted light energy. Where photon energy is enough to free the outer bonding of material's electron. PV produced open circuit voltage (V_{oc}) before it connected to the load when PV terminal is being shorted short circuit current (I_{sc}) will generate. When the PV connected with real load there will be real power generated depends on value and characteristic of voltage and current. Peak point from the end of V-I is the result of multiplying maximum voltage with maximum current and this called maximum power value. By the literature [6] the PV resulting optimum output value using the solar tracker. The solar tracker could follow the direction of sun motion and optimize the position of PV.

Arduino Mega 2560 is a microcontroller based on ATmega2560. It has 54 digital input-output pins there are 14 pins can be used for PWM outputs, a 16 MHz crystal oscillator, 16 analog inputs with larger space so this gives plenty room and opportunity, 4 UARTs, a power jack, a USB connection, an ICSP header and a reset button. The Mega 2560 has 256 KB flash memory for storing the code of which 8 KB used by the bootloader, 4 KB EEPROM and 8 KB SRAM. To get started is by connecting it to a computer with USB cable or power it with battery or AC-DC adapter [7].

Blynk is a Platform for Android and iOS apps to control microcontroller (hardware) Arduino, Raspberry Pi, Sparkfun, Particle and similar hardware on the internet. Blynk can build a graphic interface for the project by dragging and dropping widgets. The graphic interface can display sensor data, store data, and visualize it. It is supporting any hardware whether Arduino, Raspberry Pi or more as long as it is linked to the internet over Wi-Fi, Ethernet or ESP8266 chip, Blynk will get online and ready for the Internet of Thing (IoT)[8]. Blynk implantation as an Android application platform has been adapted as field schedule and plant growth monitoring in agriculture domain. Blynk in this study used to display commands from Arduino using Internet-based cloud system, by detecting the temperature, humidity, soil moisture, liquid float level, and magnetic float sensors [9].

3. Research method

3.1. Prototype design

The power plant experiment consists of two identical PV panels mounted in parallel with output power specification for 200+5%. The Human Machine Interface (HMI) is designed to monitor PV output condition using android app and Liquid-Crystal Display (LCD). Where both LCD and android app allows the operator to interact with the machine in the graphical user interface. With controls and graphical user interface displayed on the screen the user can control the machinery. The HMI used in machine and process control to connect the sensors, actuators and machines on the PV tower to input/output control system. This HMI contain a solar panel with dual axis solar tracker system, current and voltage sensors, Arduino Mega 2560, LCD and also android app platform, Blynk. PV will generate electricity (voltage and current) and then the sensors will detect the voltage and current before sent them to microcontroller Arduino Mega 2560. Arduino Mega 2560 process the data and give it to LCD and Blynk to be displayed. The HMI of PV Tower System for Laboratory Scale showed in figure 1.

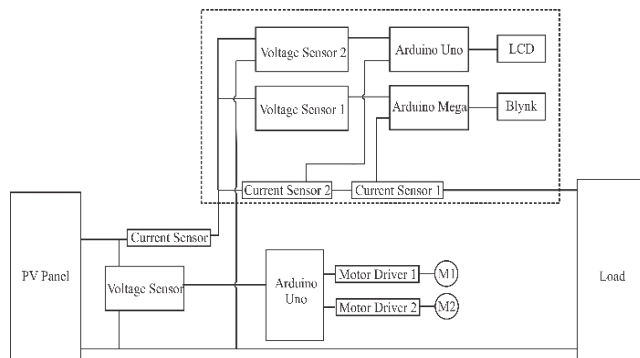


Figure 1. The HMI of PV Tower System for Laboratory Scale.

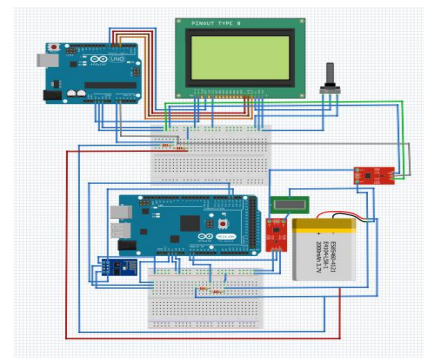


Figure 2. Schematic Design of the Monitoring System.

Monitoring system that is showed in figure 2 divided into two blocks, remote monitoring system and non-remote monitoring system. The remote monitoring system is using Blynk application, where the users could manage the data from any sensors to be displayed (voltage and a current sensor). To acquire the expected data, both the Blynk app and the Arduino device must connect to the Blynk server by internet connection. The Android application connects to the internet by Wi-Fi or cellular data, while the Arduino device is using Wi-Fi module ESP8266 connected to the local wireless network. The non-remote monitoring system is using LCD as the interface. The current value is retrieved using an ACS712 sensor with a max rating of 20A in series. While the voltage sensor is using a voltage divider circuit with a certain resistance value, so the Arduino can measure the voltage 0-50V. To connect to a local wireless network using ESP8266 which is integrated with Arduino Mega 2560.

3.2. Flowchart of the Human Machine Interface system

Start with the acquisition of current data then the PV output voltage flow to the charge controller and to the battery. Current and voltage sensors begin to detect data values to be sent to the microcontroller. Arduino Uno is the LCD display controller to process and give the command to display the data on the LCD. On the other hand, the display on smartphone application controlled by Arduino Mega 2560 to command Blynk server to display the data on smartphone application using internet connectivity. Flowchart of the HMI system is showed in figure 3.

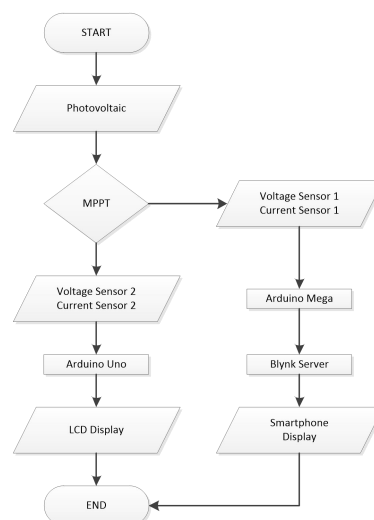


Figure 3. Flowchart of the Human Machine Interface system.

4. Analysis & results

The experiments were performed for three days in cloudy weather. The result showed that the PV produces fluctuate power value shown in table 1 from November 5 until November 7, 2017 with time interval 1-hour start from 6:00 until 19:00. Then, the result of LCD interface and Blynk platform could be seen in figure 4 and figure 5.

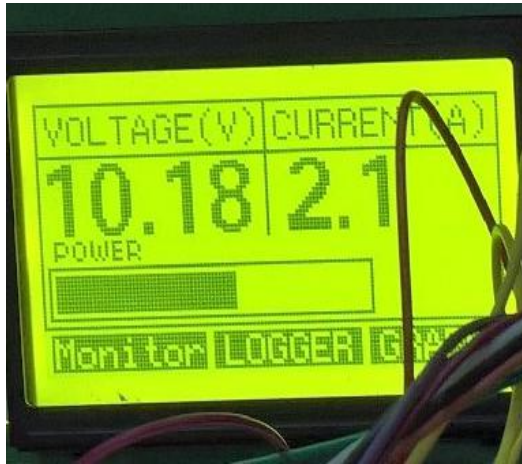


Figure 4. LCD display.



Figure 5. Blynk display.

Table 1. The result of tracking PV displayed by Blynk app with time sampling 1-minute. To minimize the table, the time interval is changed into 1-hour.

	November 5, 2017			November 6, 2017			November 7, 2017		
Hour	Voltage (Volt)	Current (Ampere)	Power (Watt)	Voltage (Volt)	Current (Ampere)	Power (Watt)	Voltage (Volt)	Current (Ampere)	Power (Watt)
6:00	32.67	0.30	9.80100	32.65	0.98	31.9970	38.31	1.23	47.1213
7:00	32.86	1.19	39.1034	32.78	1.50	49.9950	40.80	1.67	68.1360
8:00	32.98	3.20	105.536	33.02	3.12	103.022	40.13	2.31	92.7003
9:00	33.07	5.40	178.578	33.33	4.46	148.652	40.14	5.78	232.009
10:00	32.87	6.68	219.572	32.26	7.13	230.014	40.29	7.37	296.937
11:00	35.28	4.15	146.408	35.20	3.19	112.288	40.16	7.21	289.554
12:00	32.98	1.93	63.6514	34.29	1.57	53.8353	39.97	5.29	211.441
13:00	32.80	1.20	39.3600	33.83	1.38	46.6854	40.52	4.54	183.961
14:00	32.37	0.36	11.6532	33.69	0.95	32.0055	40.42	4.37	176.635
15:00	32.49	0.43	13.9707	32.17	0.64	20.5888	31.44	2.01	63.1944
16:00	31.27	0.22	6.87940	30.63	0.35	10.7205	6.900	0.72	4.96800
17:00	13.78	0.17	2.34260	14.69	0.13	1.90970	2.380	0.22	0.52360
18:00	1.520	0.19	0.28576	2.200	0.14	0.30800	1.900	0.18	0.34200
19:00	1.400	0.19	0.26600	2.200	0.14	0.30800	1.860	0.10	0.18600

The first experiment performed on the first day, start when PV in the initial condition on 06:00 generated 9.8 W of power value, 32 V of voltage current, and 0.3 A of current value. In subsequent hours, the resulting current is higher with voltage value tends to be stable which causes the resulting

power is also greater. From the graph, we can obtain that the PV will generate the greatest power value in the time range of 09:00 until 12:00 in the peak hour at 10:00 with a power value of 219.572 Watt.

After reach the peak power value, the power generated by PV will slowly decrease. The second experiment performed on the next day with results that resemble the first experiment. In the initial condition at 06:00, PV produces a voltage of 32.65 V, a current of 0.98 A, and generate power of 31.997 Watt. Power will increase over time and reach the peak of 230.014 Watt at 10:00. The third day also shows similar results based on the overall data, this can be seen in figure 6.

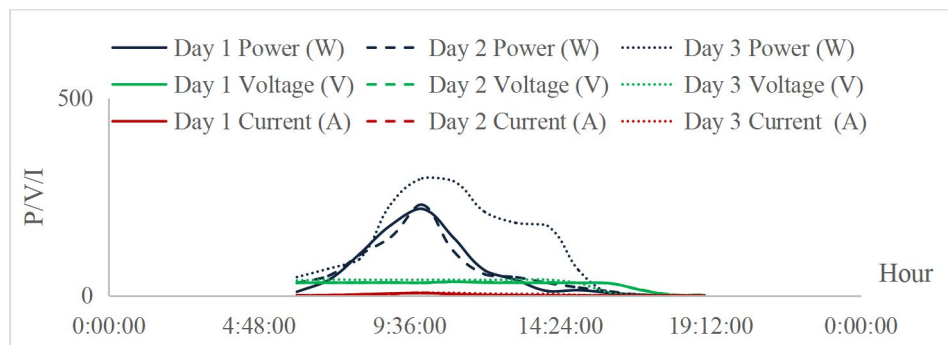


Figure 6. Comparison graph of output current, voltage and power value generated by PV during November 5 – November 7, 2017.

5. Discussion & conclusion

In this paper, design and implementation of real-time monitoring based on android and HMI of PV tower system for laboratory scale has been shown. HMI design is implemented in the PV tower monitoring system where the process starts by detecting voltage and current value using the sensor in the PV output. Then the data is processed and displayed in LCD using Arduino Uno controller device. While the display on the smartphone application controlled by Arduino Mega 2560 to commands Blynk server via the internet before it is displayed on smartphone applications.

The result retrieved by three-days experiment shown that the real-time monitoring based on android and HMI of PV tower system can be applied and displayed the voltage and current value of PV tower output. Power value displayed on the experiments shown overall similar result at 10:00. Within this result, it can be concluded that real-time monitoring based on android and HMI could be implemented in PV tower for laboratory scale to optimized the device using.

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