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# ARDUINO BASED SMART SOLAR PHOTOVOLTAIC REMOTE MONITORING SYSTEM

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**Abstract:** The continuous monitoring system of the photo voltaic solar based energy model is currently highly crucial to monitor the overall performance and other related characteristics of energy solar energy systems from remote locations. For this, data loggers also play a vital role. These technologies are highly important to identify any malfunctions inherent in PV based solar energy systems. The proposed IoT based system is useful to obtain real time data from PV based solar energy systems from remote areas. An Arduino ATMEGA16 microcontroller was used to acquire real time data from the system, which is incorporated with the blynk app to transmit real time data to the destination through a webpage. The proposed system consists of a PV based solar system, Arduino controller board Wi-Fi module and the blynk app, in order obtain and transmit data from any remote location. We have developed a cost effective IoT based Smart monitoring system for PV based solar energy applications to monitor the various characteristics and performance of the system, as well as to carry out preventive maintenance and fault detection.

***Keywords:*** *Photo-Voltaic (PV), Internet of Things (IoT), solar energy system, monitoring system.*

## 1. Introduction

Renewable energy plays a vital role for fulfilling the energy requirements across the world. Nowadays, researchers are working on smart meter applications, whereby detecting performance and characteristics of PV solar energy systems can be done from a remote location to optimize the overall performance of solar power based applications. The use of renewable energy is required to reduce the environmental pollution generated from the various types of power plants, as well as to reduce greenhouse effects. In this current scenario, Internet of Things (IoT) plays a vital role in order to monitor various parameters from a remote location, and this technology is growing day by day to give application parts to users, due to its communication protocol with an internet connection. Thus, the various parameters of the PV solar energy system are electric potential, temperature, current and intensity of the sun light. These parameters decide the performance of the entire system. Currently, there are many research works that concentrate on the remote monitoring of the important characteristics of PV solar energy systems. A simple prototype model was developed to collect information related to the system without using any automation based tools. In addition, the author used the learning mechanism in order to provide better performance by the system (Hugo T.C et al., 2018). The various performance characteristics were obtained using real time data acquisition with LabVIEW. This method gives efficient performance characteristics by the system (Amit Kumar Rohit et al., 2017; N.A. Othman et al., 2010). The Microcontroller module was used to evaluate the various parameters of the PV based energy system, which was used to acquire various data from the system and display those data to the user (Kangkana Hazarikaa et al., 2017). An IoT based remote monitoring system was used to continuously acquire different types of characteristics of the PV solar system for the effective tracking of fault detection and maintenance (Soham Adhya et al., 2016). The author proposed an IoT based smart monitoring system for a photovoltaic based solar energy plant in terms prototype using Raspberry pi (Renata I. S. Pereira et al., 2017) . The various performance characteristics, including the light intensity and temperature to the solar panel, were analysed using LabVIEW (Aissa Chouder et al., 2013). The author was proposed a solar energy system using LabVIEW with tracking the sunlight intensity mechanism (Bipin Krishna et al., 2013). The smart metering with a control system strategy was proposed by the author, which includes various control units associated with the PV solar system in order obtain efficient preventive fault detection (R. Nagalakshmi et al., 2014). The PV based solar energy system parameters were monitored using both wired as well as wireless techniques, which were incorporated effectively in the IoT platform (P. Papageorgas et al., 2013). The Arduino based controller and the LabVIEW tool were used in order to monitor the real time data with the use of the inbuilt feature of LabVIEW tool from which the effective data was obtained from the PV system in a graphical manner (Haider-e-Karar et al., 2015). The cost effective IoT based smart monitoring of the PV system was

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proposed by the author in order to analyse the various important characteristics of the PV solar energy system (Bruno Ando et al., 2015). The author effectively used Arduino as well as the Blynk app to measure the various parameters from an agricultural land (Vinoth kumar V et al., 2017).

## 2. Proposed System

The three-layer architecture of IoT was used for our proposed system in order to transmit the various parameters associated with PV solar energy system. Figure 1 shows the simple three-layer architecture of the IoT device. The first layer of the IoT architecture was used for measuring real time data using various sensors and actuators. In this proposed system, the lower level consists of the sensing unit such as temperature sensor to measure the temperature, an ammeter to measure the current, volt meter to measure the electric potential, and a light intensity sensor in order to measure the intensity of sun light. The various parameters were effectively measured from the PV solar energy system and the measured data was given to the next layer of the IoT architecture, which is the middle layer. The middle layer of the IoT architecture is known as the network and transport layer, and the measured real time data is transmitted through the IoT protocol. The second layer of the IoT architecture is the responsible layer to transmit the measured data to the cloud. Finally, the data pockets are received by the upper layer of the IoT architecture, where the collected data will be displayed to the user using the internet. The Blynk app was effectively used in the application layer of the IoT architecture.

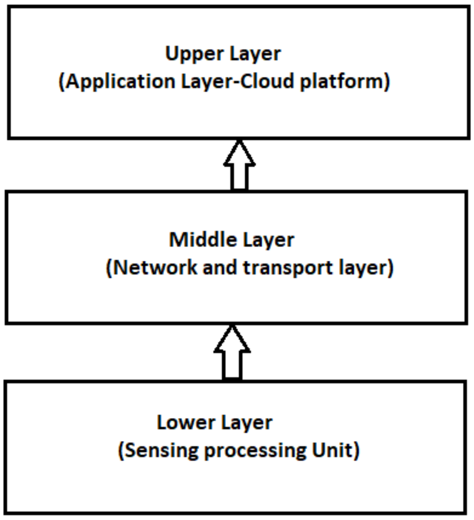


**Figure 1.** Three layer architecture of IoT

The proposed system block diagram is shown in Figure 2. The parameters such as voltage, current, temperature and light intensity of the PV solar energy system are measured using a voltmeter, ammeter, LM235 temperature sensor and LDR, and those data are given to the arduino controller board. The these measured data are given as a input the LCD display, which shows the real time data to the user on the field. Simultaneously, the same information is transferred to the cloud platform with the help of the IoT protocol, which is the representation of the Wi-Fi module. Finally, the measured data are transmitted to the user.

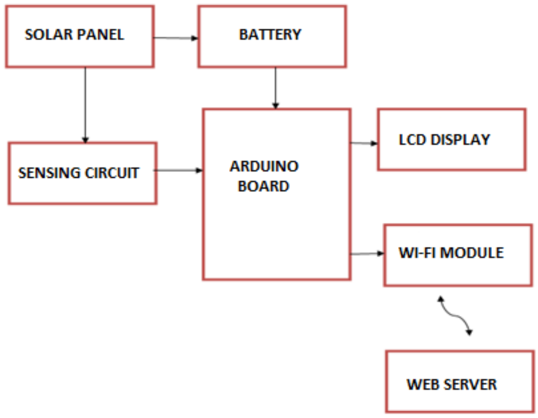


**Figure 2.** Block diagram of proposed system

An Arduino compiler was used for effective programming, The Arduino IDE was used to upload the embedded C program into the ATMEGA 16 microcontroller chip. The Blynk IoT platform is user friendly, since the data can be easily understandable to the user on the other end. The ESP8266 chip was used to obtain remote information related to the system.

**Figure 3.** Overall Circuit connection of proposed system

Figure 3 shows the overall prototype setup of the proposed system, which consists of various sensing unit Solar panels as well as the Cloud based devices with the ATMEGA 16 microcontroller unit. The Wi-Fi module ESP8266 was used for reducing the overall system cost, and to get an efficient wireless data transmission. The DC to AC converter was used in the proposed system in order to store the alternating


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current in the battery. There is an increase in 10mV of electric potential for every 1°C.

## 3. Results and Discussions

The acquired parameters are shown in Figure 4, for different times in a day. Figure 4(a) shows the real time data at 12:31 pm, during which the acquired parameters were 15.23 V of electric potential, 6.47 A of electric current, and 63.86 W/m2 of light intensity, at 31.58 °C. Figure 4(b) shows the measurements taken at 1:10 pm. During this time, the various PV parameters were 16.23 V of electric potential, 7.09 A of electric current, and 65.10 W/m2 of light intensity, at 32.23 °C. Figure 4(c) shows the measurements taken at 2:10 pm. During this time, the various PV parameters were 15.98 V of electric potential, 6.91 A of electric current, and 64.86 W/m2 of light intensity, at 31.93 °C. Figure 4(c) shows the final measurements which were taken at 3:06 pm. During this time, the various PV parameters were 14.23 V of electric potential, 5.19 A of electric current, and 58.12 W/m2 of light intensity, at 28.87 °C. The PV parameter variation was observed with respect to the different temperature levels of the day. In the measurement of the first two timings, the electric potential, electric current as well as the intensity were increased. In the last two measurements, it is observed that the electric potential, electric current and light intensity decreases due to the decrease in the temperature level. Those PV solar energy system parameters were observed through the IoT platform using the Blynk app.

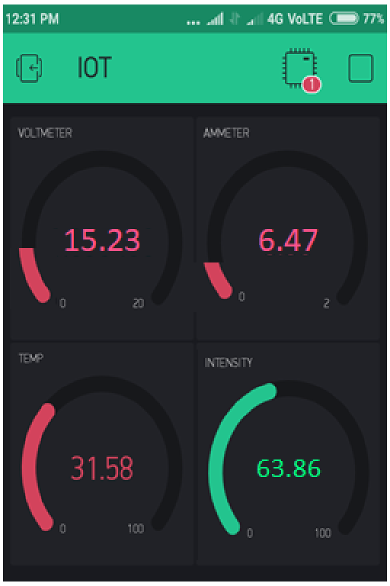



**Figure 4.(a)** Acquired PV parameters at 12:31 PM

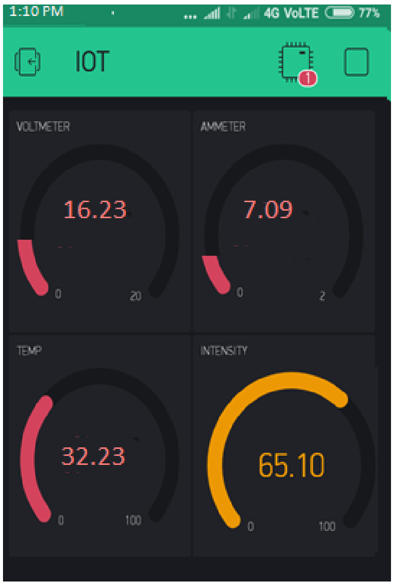
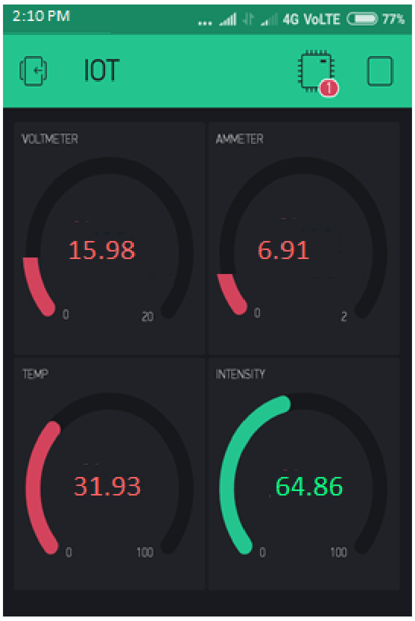



**Figure 4.(b)** Acquired PV parameters at 1:10 PM




**igure 4.(c)** Acquired PV parameters at 2:10 PM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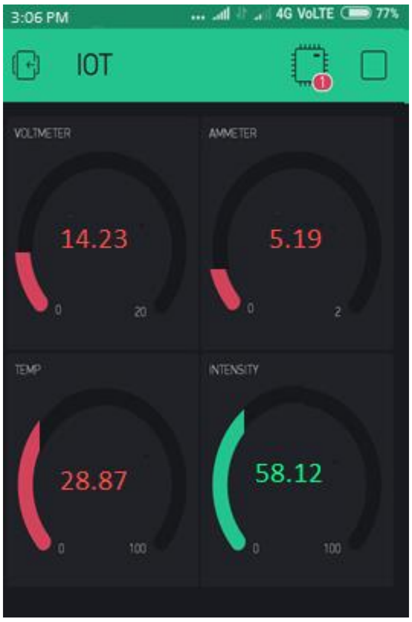


**Figure 4.(d)** Acquired PV parameters at 3:06 PM

The low cost of the proposed system gives effective measurements for the PV solar energy system. Figure 5 shows the plot between temperature and other PV parameters. Figure 5(a) shows the plot between temperature and the electric potential from the PV solar system, from which it is observed that the electric potential increased for first two set of values, and then tends to decrease due to the decrease in the temperature level. Figure 5(b) shows the plot between temperature and the electric current from the PV solar system, from which it is observed that the electric current increased for first two sets of values. It then tends to decrease due to the decrease in the temperature level. Similarly, Figure 5(c) shows the plot between temperature and the light intensity from the PV solar system. It is observed that the light intensity increased for first two sets of values, and then decreases due to the decrease in the temperature level.

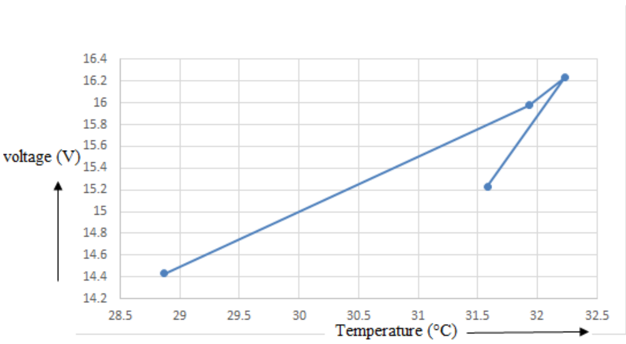


**Figure 5(a).** Voltage plot for different temperature.

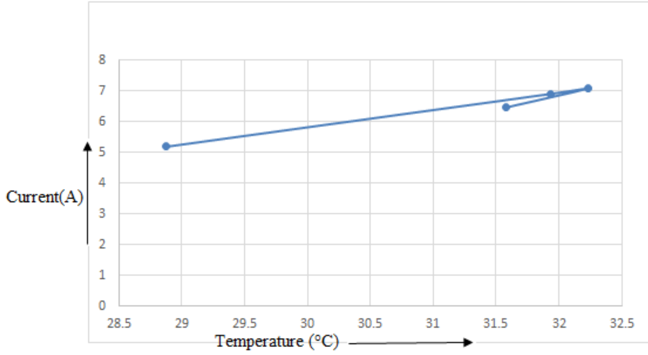


**Figure 5(b).** Current plot for different temperature.

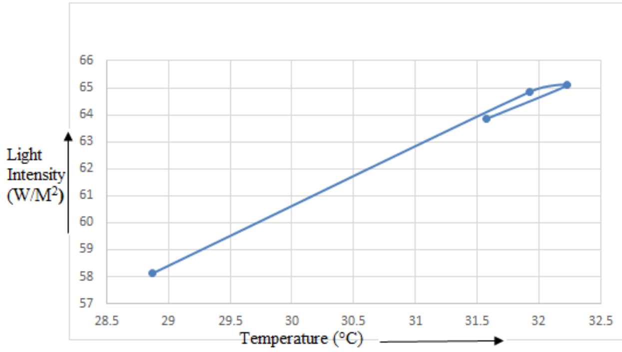


**Figure 5(c).** Light intensity plot for different temperature.

## 4. Conclusion

A cost effective IoT based PV solar energy parameter measuring system was developed in order to avoid faults in the PV solar system, as well as for easy maintenance of the system. Thus, the measured PV parameters such as electric potential, electric current, and light intensity were observed by the user with his smart phone at a remote location, without any interference. The optimized results were observed through the IoT platform using the Blynk app. The proposed system gives effective PV parameter measurements to the user. The parameters can be monitored by the user accurately, quantitatively as well as graphically, and the measurements can be observed effectively by the user.

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