IoT Application for Monitoring and Recording Solar Power Plant Data

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Abstract. The availability of fossil energy sources to produce electricity for the purposes of providing electricity used by industry and society is increasingly limited. Alternative sources of electricity that do not depend on fossil energy sources as an energy source to drive prime mover generators for power plants have been mobilized and developed as alternative sources of electricity, one of which is solar cells. The use of solar cells as a device that can convert sunlight into electrical voltage and then store it in a battery, becomes an alternative source of electrical energy to meet various electrical power needs. Monitoring the current and voltage produced by solar cells is very necessary to find out how much power the solar cells we use produce. We can determine the intensity of light absorbed by solar cells by measuring light intensity. The goal of this project is to monitor and track the electrical power generated by solar power plants using Internet of Things (IoT) technologies. A web server, an ESP32 to process data from the current and voltage sensors mounted on the solar cell and then transfer it to the web server, and a smartphone to monitor the current and voltage produced by the solar cell make up the built Internet of Things system. Smartphones can access the data that is sent from the ESP32 because it is saved on a web server. Data from measurements from the IoT system that we created for monitoring power on solar panels taken on 6 November 2023 until 12 November 2023 Obtained data of average/day 140.2 VA and measurements of average light intensity 31,380 lux. This data describes the power produced per day from a place with the intensity of light received by solar cells to produce electrical power as a result of monitoring data from the IoT system that we developed. From the case above, the IoT system that we have developed can monitor initial data for a place where solar panels will be installed to be used as a solar power plant.

1 Introduction

The reduction in fossil energy sources is a challenge to provide adequate sources of electric power, because up to now fossil fuels are still used as an energy source that is used as fuel to drive turbines as the initial starter for generating electricity. If dependence on fossil fuels is not immediately replaced with other energy sources to meet the availability of electrical energy, then a shortage of electricity supply will become a problem. Efforts

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to find alternative energy sources other than fossil energy sources have been attempted and developed. Alternative energy sources as raw materials for producing electrical energy include solar cells which are used to convert sunlight energy into electricity. Renewable energy sources (RES) are regarded as an important alternative for significantly contributing to the sustainable energy supply in the world. Photovoltaic (PV) energy generates electricity from solar radiation and it is typical of emerging RES technologies because of its continuous technological progress and its cost reduction [1]. In recent decades there has been a renaissance in renewable energies due to the proximity of the exhaustion of fossil energy sources, the progressive increase in their cost, the environmental problems derived from their exploitation, transport and consumption and, of course, due to the great external dependence of many countries on this type of energy sources, which also implies that energy supply and the economy are directly linked to the geopolitical instabilities that may exist between different countries [2]. Due to the increasing demand for electrical energy throughout the world and the decreasing supply of energy originating from fossil fuels, solar energy is a real alternative to abundant environmentally friendly energy sources and can guarantee future development [3]. Photovoltaics (PV), wind, biomass, and microturbines are examples of renewable energy sources that are often used to replace fossil fuels [4].

Knowing the electrical power produced by solar panels is very necessary if we want to know the power capacity produced by solar panels. The need to know the performance of the solar panels used and to know the economic value of the solar power plant that we are developing is to know its efficiency compared to other generating systems. Internet of Things (IoT) technology is developing rapidly, in this research we try to build an IoT system to be applied in monitoring the electrical power produced by solar panels as well as the light intensity and temperature of the solar panels. The aim of this research is to apply IoT technology to solar power plants. The object of this research is a solar power generator used at home as research material. From the results of this research study, it is hoped that it can be expanded to a larger scale to apply power monitoring to solar power plants on a wider power scale to determine the technical characteristics and efficiency values of solar power plants.

IoT is a term that describes a system consisting of several devices that can take data and receive it from one device to another via the internet [5][6][7]. IoT systems are developing rapidly, widely used in actuator control processes [8][9]. An invention in technology known as the Internet of Things, or IoT, allows data to be sent between computers, machines, and everyday things using networks and unique identifiers without the need for a human-to-human or human-to-PC connection. This technology facilitates data sharing between devices connected to a network. Through the internet, users may control devices and access data from anywhere in the globe [10][11]. IoT systems typically comprise multiple microcontroller-based devices linked to multiple sensors to collect data for processing on the microcontroller. Once the microcontroller has been programmed as needed, the data is transferred to a web server to be stored in a database or checked for modifications on the controlled or monitored device. [12]. IoT runs the specific program to control these objects through the network [13]. The implementation of IoT technology for monitoring and controlling electric power networks has been developed in several countries [14]. The data collected during the operation of a PV
system is very interesting, not only for determining whether the design goals were met, but also for improving the PV system's design and operation, as well as a general assessment of the PV technology's potential[15]. The conventional monitoring system method is carried out via cable, this has several disadvantages such as being time consuming and complicated cable installation. The existence of monitoring techniques using communication technology called the Internet of Things (IoT) offers new things and convenience[16].

The IoT system created in the research consists of an ESP32 microcontroller which has the ability to process analog and digital signals equipped with a WiFi communication feature which can be used as a control device and can be connected to the internet network. ESP32 is programmed to read data from voltage sensors, current taken from the outside of the solar panel, then temperature sensors and light intensity sensors placed on the surface of the solar panel to determine the temperature and intensity of light received on the solar panel. Programs for displaying on the web to record data and display graphics are created by web programs that are stored on a web server and can be accessed via the internet via PC, Laptop and Smartphone.

Solar panels are the main device that converts sunlight into voltage and electric current in solar power plants. Measuring and monitoring the main data on solar panels in the form of voltage and current resulting from the light source received on the solar panel board is the focus of this research as the object of the application of the IoT system that the researcher created.

2 Method

2.1 Solar panel specification

In this research, solar panels are used in a household-scale solar power plant as a device for testing parameter monitoring on solar panels. The parameters studied include the intensity of light received on the solar panel, the temperature on the surface of the solar panel, the current and voltage produced by the solar panel. The solar panels used in this research have a capacity of 400 WP 24 Volts.

2.2 Sensor and circuit control

The control circuit as a data processor for known parameters from the monitored solar panel, consists of voltage, current, temperature sensors and light intensity sensors. The sensor is connected to the ESP32 which is already filled with a program to read the voltage and current produced by the solar panel, the temperature on the surface of the solar panel and the intensity of light received by the solar panel. Data from the sensor is processed by the ESP32 and then sent to the web server. The sensors and control circuit installed on the solar panel are shown in the Fig. 1.
Fig. 1 Sensors and control circuit installed on a solar panel: (a) Voltage and current sensor; (b) Temperature sensor and Lux; (c) Solar panel.

2.3 Developed IoT system

The IoT system that was built and developed uses the PZEM 017 voltage and current sensor, DS18B20 temperature sensor and Lux BH1750 sensor using an ESP32 microprocessor. As is known, the ESP32 GPIO can be used to access analytical data from sensors, data from sensor readings is processed and sent to the server. The program flowchart in ESP32 is shown in Fig. 2 and the IoT system block created is shown in Fig. 3.

Fig. 2 Flowchart program in ESP32
3 Result and Discussion

3.1 Result data monitoring with developed IoT system

The display of solar panel monitoring data in a web browser is shown in Fig. 4. Data from sensor readings processed by the ESP32 which is sent to the server is shown in the Fig. 4. Graphs of light intensity, temperature, voltage and current are shown in Fig. 5-8.
The results of monitoring parameters on solar panels for voltage, current, temperature, light intensity and power for seven days using the IoT system that we created are shown in Table 1.

**Table 1.** Results of monitoring solar panel parameter data

<table>
<thead>
<tr>
<th>Date</th>
<th>Voltage (V)</th>
<th>Current (I)</th>
<th>Temperature (°C)</th>
<th>Intensity (Lux)</th>
<th>Power (VA)</th>
</tr>
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<tr>
<td>06-Nov-23</td>
<td>24.62</td>
<td>5.50</td>
<td>48.49</td>
<td>32,348.13</td>
<td>142.00</td>
</tr>
<tr>
<td>07-Nov-23</td>
<td>24.40</td>
<td>5.40</td>
<td>47.82</td>
<td>30,903.63</td>
<td>139.77</td>
</tr>
<tr>
<td>08-Nov-23</td>
<td>24.58</td>
<td>5.42</td>
<td>51.15</td>
<td>32,087.79</td>
<td>140.93</td>
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<tr>
<td>09-Nov-23</td>
<td>24.33</td>
<td>5.53</td>
<td>49.46</td>
<td>32,959.21</td>
<td>144.64</td>
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<tr>
<td>10-Nov-23</td>
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<td>48.72</td>
<td>31,679.75</td>
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<td>4.48</td>
<td>42.75</td>
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<td>5.91</td>
<td>49.10</td>
<td>33,723.69</td>
<td>154.81</td>
</tr>
</tbody>
</table>

### 3.2 Wider Utilization of the IoT System Created

The use of the IoT system that we created from the example of collecting data from solar panels used by household-scale solar power generation panels can be used to measure the power produced in the area where the solar power plant is applied/used. The tools we developed can be used to determine the feasibility of using solar power plants in the sense that the area where the solar panels will be installed has enough sunlight to be able to process the solar panels into electrical power.
4 Conclusion

Solar power plants are an option to reduce electrical energy sourced from fossil fuels. The use of solar power plants has begun to be widely used both at the household user level and for large-scale use in areas that experience difficulties in distributing conventional electricity. Utilization of IoT technology is needed to monitor the power produced by solar panels in solar power plants. By monitoring data from solar panels, data on electrical power produced from solar panels is obtained. In this research, an IoT system has been created to monitor the parameters that must be known on a solar panel. From the results of measurements on the solar panel using current, voltage, temperature and light intensity sensors and data collection was carried out for 7 days, data on the power produced per day was obtained of 140.2 VA, the temperature on the panel during the day is 48.21 °C with a light intensity of 31,380 Lux. This data describes the power produced per day from a place with the intensity of light received by solar cells to produce electrical power as a result of monitoring data from the IoT system that we developed. From the case above, the IoT system that we have developed can monitor initial data for a place where solar panels will be installed to be used as a solar power plant.

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References


