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REAL TIME MONITORING SYSTEM ON SOLAR PANEL ORIENTATION CONTROL USING VISUAL BASIC

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ABSTRACT
Problems that often occur in the use of solar panels are the efficiency of solar panels and monitoring of solar panel generating systems. Monitoring of the output parameters of solar panels is very necessary to assess the performance and efficiency of a solar panel in real environmental conditions. Internet of Things (IoT) can make devices communicate with each other such as sending and receiving data. A monitoring system based on a wireless sensor network was created to make it easier to get direct and real time information on the output parameter data of the solar panels. The research objective is to create a monitoring system on a solar panel using Visual Basic and Blynk applications. This system is designed to determine the output parameters of the solar panel in the form of current, voltage, light intensity, and position which are processed directly and displayed in tables and graphs in Real Time conditions. The use of logger data in this monitoring system is very important. From the results of tests carried out on this monitoring system, the system is able to record and read the output parameters regarding the resulting current and voltage data as well as light intensity and the position of the solar panels. Information about measurement data from each sensor will be stored in the database and can be obtained directly through an excel spreadsheet.

Keywords *: Monitoring System, Solar Panel, Real Time, Database*.

1. Introduction

Indonesia is located in a tropical area which has a very large potential for solar energy, around an average of 4.8 kWh/m2/day or equivalent to 112,000 GWp, but its only 71.02 MWp has been utilized, both interconnected and off-grid (Pulungan et al., 2019). On the other hand, the growth of energy consumption in Indonesia averages 8.1% per year, not yet balanced with the growth of electricity generation which only grows on average 5.2% per year (Pradana, Windarto and Winardi, 2012). The performance of a solar panel that is placed in a certain environmental condition can be determined by direct monitoring of its output parameters such as voltage, current and power (Shariff, Abd Rahim and Hew, 2015, Yandi et al., 2017). Monitoring of the output parameters of solar panels is very necessary to assess the performance of a solar panel in real environmental conditions. A monitoring system based on a wireless sensor network was created to make it easier to get direct and real time information on the output parameter data of the solar panels. This research designed a solar panel monitoring system. The system is able to provide realtime information to users, so that users can find out and monitor the energy acquisition of solar panels, such as conditions of voltage, current, power, light intensity, and the position of the solar panels.

In the research conducted by (Aritonang and Hais, 2020, (Pulungan et al., 2020)), there are still shortcomings where Thinkspeak as the Web Server used in this tool requires a stable and fast internet connection. If the internet connection is not in accordance with the capacity required by Thinkspeak, then Thinkspeak will not update the output value data. The use of the Half Duplex system in data transmission between Thinkspeak and smartphone applications causes frequent problems when there is data transmission from the application to Thinkspeak. Then the research conducted by (Arwanda, 2017), in this study recorded data on the output parameters of the solar panels which can be seen in tabular form, with the amount of recording the output data from the solar panels depending on the memory capacity of the SD Card used. Based on these problems, it is the reason for researchers to make a real time monitoring system tool for controlling the orientation of the solar panels.

The manufacture of this system utilizes the ATmega 328 (Arduino Uno) microcontroller as control, the ACS 712 sensor module as a current reading, the INA 219 sensor module as a voltage reading, the LDR sensor as a light intensity reader, the ADXL345 accelerometer sensor as an angle reader, and the RTC DS1307 as the timer. The monitoring system is expected to be able to record and read the resulting current and voltage data, and also the light intensity and position of the solar panels are displayed in Real Time conditions in the form of tables and graphs, and can be obtained directly through an excel spreadsheet or database.

2. Literature Review

2.1. Solar Panel Orientation Monitoring System

The monitoring technique for solar panel output parameters that was introduced using the Arduino Atmega 328 microprocessor, PLX-DAQ data acquisition which can be integrated directly into Microsoft Office Excel (Fachri, Sara and Away, 2015), current sensor, voltage sensor, light sensor, time sensor, supply computer power and equipment. The parameters of the solar panel output, current and voltage, are obtained from the current and voltage sensor readings. Then the results of the sensor readings are sent to a microprocessor based on the Arduino atmega 328 (Arduino Uno) which is used to fully control the reading of the sensors and control the transmission to the data acquisition system or software on the computer. During the recording process, the data obtained is stored in an Excel database in real time.

2.2. Visual Basic 6.0

Visual Basic, apart from being referred to as a programming language, is also often referred to as a tool for producing windows-based application programs. Visual Basic allows the creation of a Graphical User Interface (GUI) application or programming that uses a graphical appearance as a communication tool (Basuki, 2006). In Visual Basic, creating a user interface is relatively easy to do because only need to put graphic objects into the source (form) that Visual Basic has provided. Some of the capabilities of Visual Basic include:

a. Create Window-based application programs.
b. Create program helper objects such as ActiveX controls, Help files, internet applications and others.
c. Testing the program (debugging) and producing a program ending in EXE that is Executable or can be run immediately.

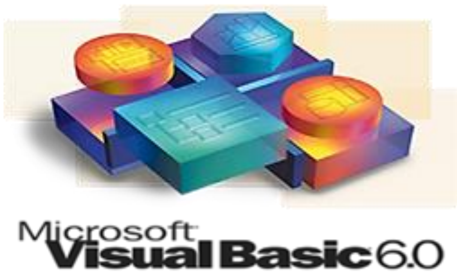

Fig. 1. Display of Microsoft Visual Basic

2.3. Blynk

Blynk is a new platform that makes it possible to quickly build interfaces for controlling and monitoring hardware projects from iOS and Android devices (Arafat, 2016). This application is a creative platform for creating graphical interfaces for projects that will be implemented by simply drag and drop widgets. It is easy to use to set everything up and can be done in less than 5 minutes. Blynk is not attached to any particular board or module. From this platform, we can control anything remotely, wherever we are and at any time, With a note that it is connected to the internet with a stable connection and this is what is called the Internet of Things (IOT) system.

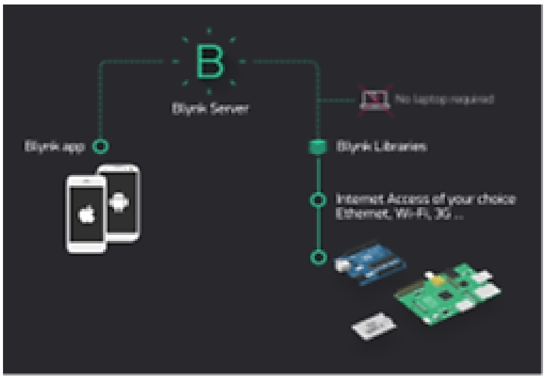

Fig. 2. Blynk Server

2.4. Arduino Uno

The ATMega328 microcontroller is an output from atmel which has a RISC (Reduce Instruction Set Computer) architecture which each data execution process is faster than the CISC (Completed Instruction Set Computer) architecture (Boando and Winardi, 2016). ATmega328 is a feature-rich processor. The chip has been built in the form of DIP-28, which has 20 Input / Output pins (21 pins if the reset pin is not used, 23 pins when not using an external oscillator), of which 6 are equipped with ADC pins (analog-todigital converter) so that no need to add an external ADC, and the other 6 have a PWM (pulse width modulation) function(Irawan, et al., 2021).

Fig. 3. Arduino Uno

2.5. NodeMCU ESP8266

NodeMCU ESP8266 is an electronic board based on the ESP8266 chip. ESP8266 functions for connectivity between the microcontroller itself and the wi-fi network. There are several I / O pins so that they can be developed into a monitoring and controlling application for the IoT project (Ambarita and Priramadhi, 2019). The ESP8266 NodeMCU can be programmed with the Arduino compiler, using the Arduino IDE. The physical form of NodeMCU ESP 8266, there is a USB port (mini USB) so that it will make programming easier.

Fig. 4. NodeMCU ESP8266 Module

2.6. Real Time Clock (RTC)

Real Time Clock (RTC) is a device that makes it possible to produce accurate time because it is equipped with a time generator and battery. The RTC module used in this study is the DS1307 which is a sensor that can store time, date, and year variables in real time. The communication used by the DS1307 sensor is 12C communication which only requires 2 SDA and SCL ports to read the register contents from the RTC sensor. (Mustar and Wiyagi, 2017).

Fig. 5. RTC

2.7. Current Sensor ACS712

The current sensor used is an ACS712 module to detect the amount of current flowing through the terminal block. This sensor can measure positive and negative currents in the range -5A to 5A. This sensor requires a power supply of 5V. To read the middle value (zero Ampere) the sensor voltage is set at 2.5V which is half the power supply voltage VCC = 5V. On the negative polarity the current reading of -5A occurs at a voltage of 0.5V. The degree of change in voltage has a linear correlation with the current of 400 mV / Ampere.

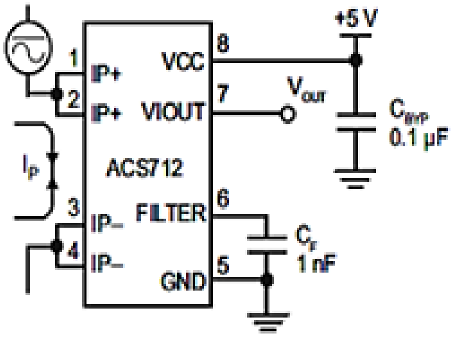

Fig. 6. Current Sensor ACS712 Circuit

2.8. Sensor INA219

INA219 is a sensor module that can monitor voltage and current in an electrical circuit. INA 219 is supported by an I2C or SMBUS-COMPATIBLE interface where this equipment is able to monitor shunt voltage and bus voltage supply, with times and filtering program conversions (Monda, Feriyonika and Rudati, 2018). INA 219 has a maximum input amplifier of ± 320mV this means it can measure currents of up to ± 3.2A. With the internal 12 bit ADC data, the resolution in the 3.2A range is 0.8 mA, the internal gain is set at minimum div8, the max is ± 400mA and the resolution is 0.1 mA. INA 219 identifies the shunt voltage on buses 0-26 V.

Fig. 7. Voltage Sensor INA219

2.9. Sensor Accelerometer Adxl345

An accelerometer is a tool used to regulate acceleration, detect and measure vibrations, and measure acceleration due to gravity (inclination). The Adxl235 accelerometer has x, y, and z axes. This module also has low power and 13bit resolution. The resolution of the accelerometer is able to measure differences in angles below 1 degree (Liandana and Nirmala, 2020).

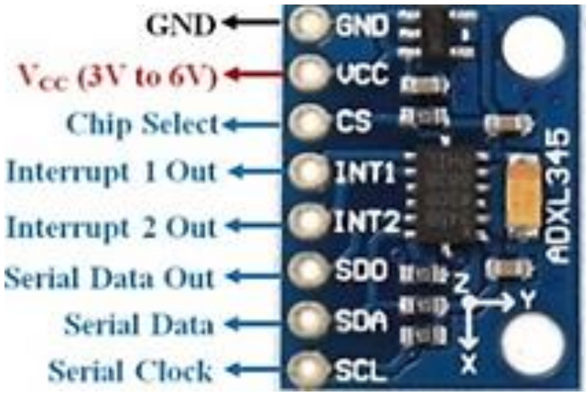

Fig. 8. Accelerometer Sensor Adxl345

3. Research Methods

3.1. Block Diagram

In this study, the Real Time monitoring system on controlling the orientation period of the solar panel using Visual Basic consists of several parts including the ATmega328 Microcontroller, DS1307 RTC, ACS712 current sensor, INA219 voltage sensor, nodeMCU ESP8266, Visual Basic and Blynk.

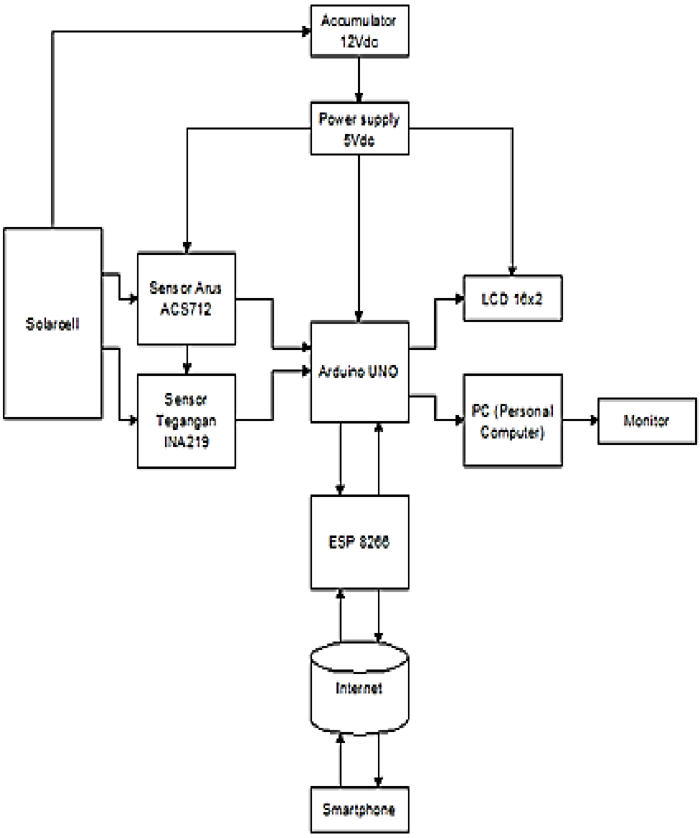

Fig. 9. Block Diagram

Based on the block diagram in Figure 9, the function of each block diagram is as follows

a. Arduino UNO

Arduino Uno is a part that functions to process input in the form of reading the voltage and current generated from the solar cell which is sent to Arduino and produces output in the form of activation on the LCD, sending data to the internet via wireless with the esp8266 MCU node module, and sending current and voltage data to a PC to be monitored.

b. RTC DS1307

Functioned as a timer in setting the detection of sunlight against the slope of angle or position of the solar panel.

c. Sensor Tegangan INA219

Functioned as a reader of the output voltage from the solar cell control module to the accumulator, from this current, it can be seen that the voltage generated from the solar cell from detecting sunlight is converted into an electrical signal.

d. Sensor Arus ACS712

Functioned as a reader of the output current from the solarcell control module to the accumulator, the current detected by the ACS712 Current Sensor when it detects sunlight by the solarcell which is converted into an electrical signal.

e. Node MCU Esp 8266

Functioned as a medium for receiving data from current and voltage detection and then sending the data information via wireless to the internet line so that the user can find out the voltage current data generated.

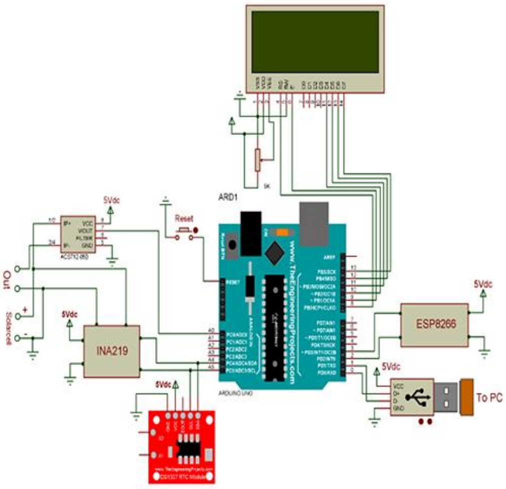

Fig. 10. Electronic Circuit

3.2. Hardware Design

Hardware design is very important in making this final project. With the hardware, the system can be tested for real whether this tool can work properly or not.

3.3. Software Design

The design of the software in this study is divided into several stages. There are the design of the Visual Basic communication system, Blynk server communication and programming on the Arduino IDE (Integrated Development Environment).

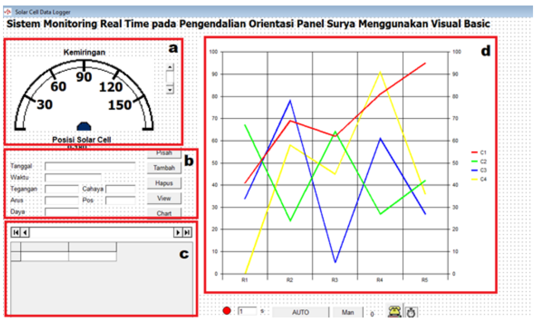

Fig. 11. Overall Visual Basic Application Appearance Design

From Figure 11 it can be seen that the Visual Basic display of the monitoring system is made. For more details, it can be seen the following information :

a. In Figure (a), is an indication of the tilt position of the solar panel at 5 positions which shows the tilt angle positions of 300, 600, 900, 1200, and 1500.
b. In Figure (b), is the data that VB receives from the data sent by Arduino, the data consists of time, voltage, current, light intensity, and position data.
c. In Figure (c), is data received by VB which is arranged in the form of a table connected to the VB database, the data will automatically be stored in the database in Excel.
d. In Figure (d), is data received by VB and converted into a line graphical display. The red line represents voltage, blue for power, and green for current. In this graphic the data displayed is only the latest 10 data.

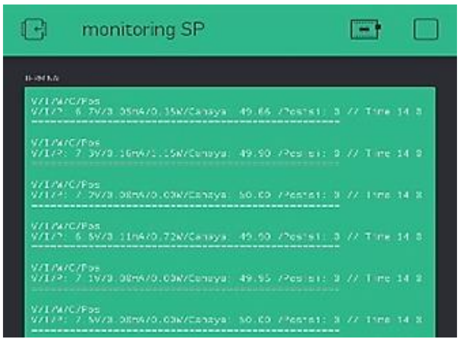

Fig. 12. Blynk Application Appearance Design

The software design in this study used visual basic and Blynk. Where visual basic is used to display data and graphs of measurements made in real time. Figure 11 shows the Visual Basic display where there are data tables and graphs used for grouping the output parameters from the solar panel in real time as well as being stored and useful for viewing previous measurement results. On the other hand, the appearance of Blynk as in in Figure 12 is in the form of time data, voltage, current, power, light intensity, and the position of the solar panels which are packaged in tabular form.

3.4. Flowchart

Flowcharts in program design will be made as the basic concept of the system. The following is a flowchart of the Solar Panel Orientation Controller.

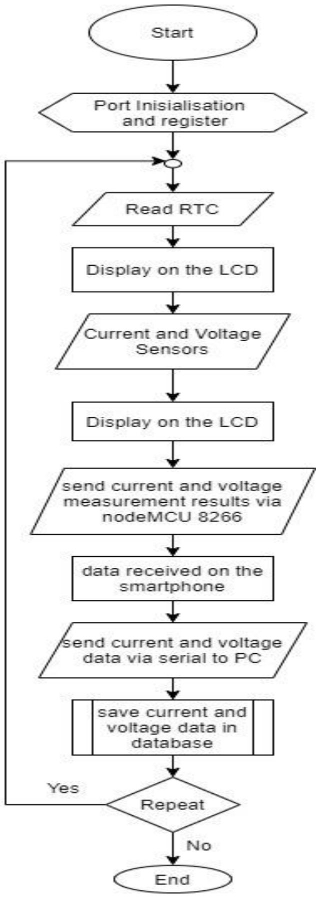

Fig. 13. Flowchart of Arduino System

Figure 13 shows a flowchart of how the whole tool works. The system is started by activating the tool and activating the tool will turn on the tool and then the system will display the hour, minute and second information. From this time display, the system will activate the reading of the voltage and current sensors from the detection of the solar panels. Then the system sends data via ESP8266 where the data can be accessed via the internet network. The data will be connected to a smartphone, so that the user can receive data and monitor the solar panel, and the data is sent to a PC via serial communication which is received by the Visual Basic application and processed, then the data is stored in a Visual Basic database in the form of excel. When it is finished, the system will repeat the reading of the RTC, and when it has finished measuring data or monitoring the system can be terminated.

4. Results and Discussions

The purpose of testing this tool is to see the results of the work of the software that has been made whether it is running according to plan or not, so that results and comparisons are obtained from what was previously planned. In accordance with the outline of the research objectives, namely to create a monitoring system on a solar panel using Visual Basic and Blynk. This system is designed to determine the output value of current, voltage, light intensity, and the position of the solar panels in real time.

The manufacture of this system or software utilizes the ATmega 328 (Arduino Uno) microcontroller as control, the ACS 712 sensor module as a current reader, the INA 219 sensor module as a voltage reader, the LDR sensor as a light intensity reader, the ADXL345 sensor as a tilt angle reader, and the RTC DS1307 as the timer. The creation of this monitoring system is expected to be able to help record and read the resulting current and voltage data as well as light instances and the position of the solar panels which are displayed in real time in the form of tables and graphs.

The following tests were carried out.

4.1. Testing of RTC

This RTC test is carried out in order to find out whether the RTC is able to display and send data on the correct time and according to the real time.

Fig. 14. Testing of RTC

This RTC test is done by providing real timing data input received by Arduino which is then displayed on the LCD. If the time data received by the LCD is in accordance with Figure 14, it can be concluded that the circuit is working properly.

4.2. Testing of ADXL345 Accelerometer Sensor

This test is done to adjust the X, Y and Z axes of the sensor with Arduino. The gravitational acceleration detected by the ADXL345 sensor is used as information on the orientation angle of the solar panel.

```
if (jam >= jam1 && jam < jam11) {
  if ((x <= -210 && x >= -220) && (y >= 10 && y <= 20))
    pos=1;
    //Serial.println("==========");
    //Serial.println("Posisi 1");
    //Serial.println("==========");
```

Fig. 15. Testing of ADXL345 Accelerometer Sensor

This ADXL345 sensor test aims to ensure the position of the tilt angle of the solar panel with the X, Y, and Z axes detected by the sensor. After the data received by Arduino from the sensor matches the position of the tilt angle of the solar panel, the testing process can be continued.

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4.3. Testing of ACS712 Current Sensor

Current sensor testing is carried out by varying the measurement time at each position of the solar panel against the arrival of sunlight. The current value is obtained from the measuring instrument and sensor, the current from the measuring instrument is made literate and the comparison of the results from the sensor. The results of the current sensor test can be seen from the results of current measurements at five conditions when the solar panel changes to the arrival of sunlight and the detection results of the ACS712 sensor, as for the difference in the percentage of error to the reading of the measuring instrument, this difference occurs due to differences in the sensitivity of the readings between the current sensor and the amperemeter.

4.4. Testing of Voltage Sensor

Voltage sensor testing is carried out at different times, the voltage value from the voltmeter measuring instrument is used as a comparison for the voltage value from the sensor. The results of the voltage sensor test can be seen from the results of the voltage measurement at the five conditions when the solar panel changes to the arrival of sunlight and the INA219 sensor detection results, as for the difference in the percentage of error between the reading of the measuring instrument and the reading of the sensor, this difference occurs due to differences in the sensitivity of the readings between the current sensor and the sensor readings. Voltmeter measuring instrument. Sensor testing aims to ensure the data sent by Arduino to the software so that no errors occur during measurement.

4.5. Testing of Monitoring System

This test is done to test the performance of the monitoring system. The data collection process was carried out for 1 day, namely on October 27, 2020 for 10 hours in the time range from 07.00 – 17.00 WIB. Data were collected in sunny and cloudy weather conditions. Design Monitoring data delivery time in this monitoring system is every 300 seconds or 5 minutes. Testing is done by connecting the Arduino USB cable to the laptop, after connecting it is continued with activation in the Visual Basic 6.0 application, after activating the GUI (Graphic User Interface) Visual Basic 6.0 design, Arduino will send data to VB and process it then displayed in tabular and graphical forms. The following are the results of the monitoring system testing.

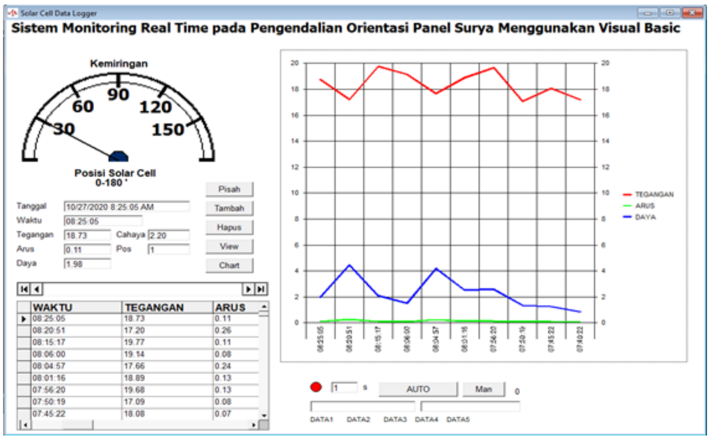

Fig. 16. Position 1 (angle 300)

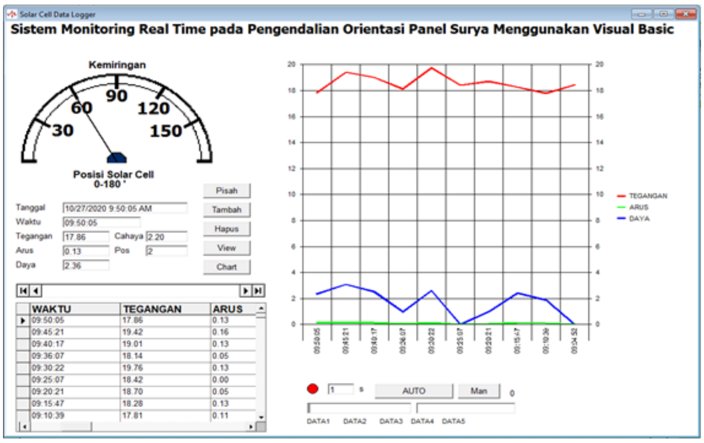

Fig. 17. Position 2 (angle 600)

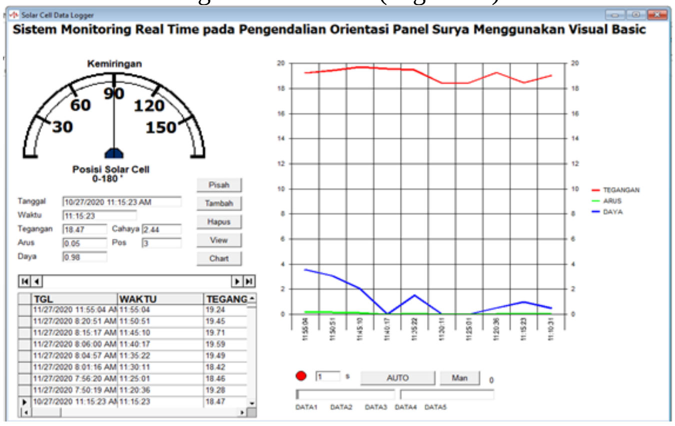

Fig. 18. Position 3 (angle 900)

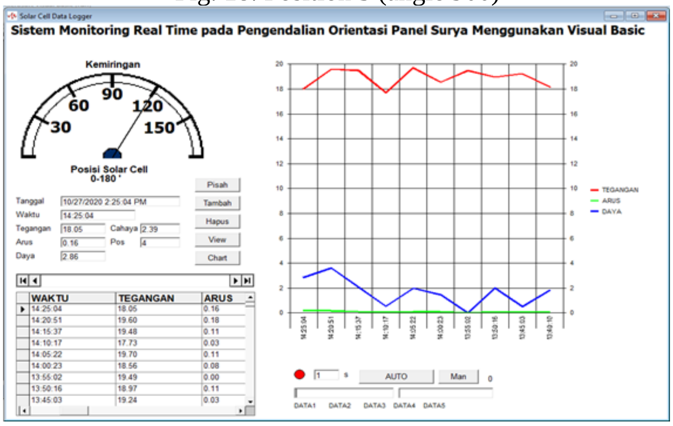

Fig. 19. Position 4 (angle 1200)

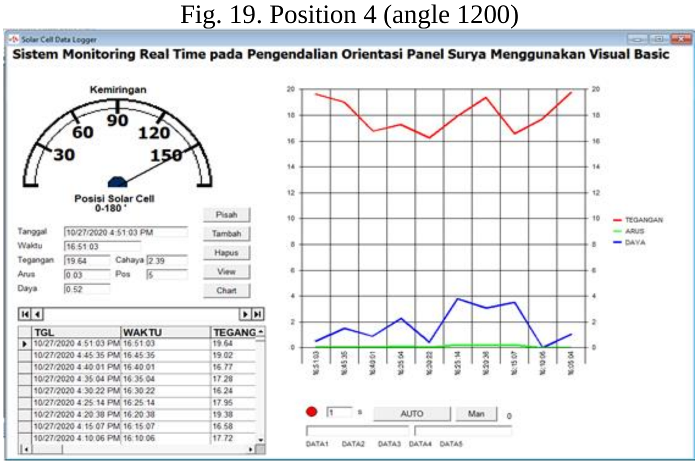

Fig. 20. Position 5 (angle 1500)

data

TGL	WAKTU	TEGANGAN	ARUS	DAYA	CAHAYA	POS
10/27/2020 5:09:43 PM	:09:43	17,31	0.05	0.92	2.39	0
10/27/2020 5:00:08 PM	17:01:08	16,39	0.00	0.00	2.30	5
10/27/2020 4:55:21 PM	16:55:21	16,66	0.05	0.88	2.20	5
10/27/2020 4:51:03 PM	16:51:03	19,64	0.03	0.52	2.39	5
10/27/2020 4:45:35 PM	16:45:35	19,02	0.08	1.51	2.20	5
10/27/2020 4:40:01 PM	16:40:01	16,77	0.05	0.89	2.54	5
10/27/2020 4:35:04 PM	16:35:04	17,28	0.13	2.28	2.30	5
10/27/2020 4:30:22 PM	16:30:22	16,24	0.03	0.43	2.20	5
10/27/2020 4:25:14 PM	16:25:14	17,95	0.21	3.79	2.20	5
10/27/2020 4:20:38 PM	16:20:38	19,38	0.16	3.07	2.20	5
10/27/2020 4:15:07 PM	16:15:07	16,58	0.21	3.51	2.20	5
10/27/2020 4:10:06 PM	16:10:06	17,72	0.00	0.00	2.44	5
10/27/2020 4:05:04 PM	16:05:04	19,77	0.05	1.04	2.20	5
10/27/2020 4:00:03 PM	16:00:03	18,12	0.00	0.00	2.39	5
10/27/2020 3:55:00 PM	15:55:00	17,05	0.00	0.00	2.54	5
10/27/2020 3:50:09 PM	15:50:09	18,14	0.00	0.00	2.44	5

Fig. 21. Record data stored in the database

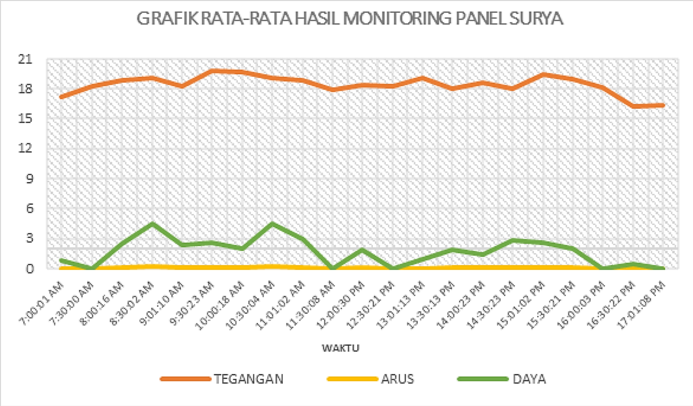

Fig. 22. Graph of Solar Panel Monitoring Results

Figure 22 is the result of measurements in the form of graphic visualization of all measurement data stored in the database. On the x-axis, it is the time for data collection, while on the y-axis, the unit or value of each electric quantity that has been measured. In the monitoring system display, the graph display is only for the 10 most recent data that can be displayed to determine the current output of the solar panel.

After testing, the system is able and can work as the purpose of making this monitoring system. Where the system is able to display current data, voltage, light intensity, and the position of the solar panels which are displayed in tables and graphs, in Figure 21 the system is also able to read and record measurement data and show the results of record data in a field database in the form of excel. The data that has been displayed is still stored in the database so that it can be retrieved and displayed again.

5. Conclusion

Based on the experiments conducted, it can be concluded that the solar panel real time monitoring system that has been designed can record and read data on current, voltage, power, light intensity, and position of the solar panels in real time. The system can work properly and successfully transmits measurement data to the database. The accuracy of the reading of the solar panel output parameters is largely determined by the accuracy of the current and voltage sensors that used in the solar panel performance monitoring system. Current and voltage sensors that are used get the difference in reading within normal limits.

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