Solar Panel Drive Design Based Internet of Things

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Abstract

Indonesia is located on the equator which makes the island irradiated by the sunlight from 10 to 12 hours per day. The use of solar cell panels is generally placed in certain positions without change. For the optimal consumption of solar energy, then we need a system that follows the sun called a solar tracking system. Research the solar tracker automatically moves on an edge 0° - 180° and otherwise. To control or operate solar cells and easier the maintenance process of solar cell panels, then we need a system called IoT (Internet of Things) combine with microcontroller ESP8266 access on the Thingspeak application. The result of this study shows servo motors moved every 1 hour by 20 degrees from 6 am to 5 pm by the solar panels. Equipped with sensors INA219 to know the results of the solar energy that absorbs by the solar cells and shown on the Thingspeak application.

Keywords *— IoT, Solar Tracker, Solar Cell, Thingspeak Apps*

1. INTRODUCTION

Indonesia is located on the equator which makes our islands exposed to sunlight for 10 to 12 hours per day. Utilization of solar energy sources is very supportive in this tropical archipelago, but in 10 to 12 hours it is not all sunny, sometimes the weather is often unstable in the sense of cloudy, gloomy, and rainy conditions[1].

The problem that causes a decrease in photovoltaic performance other than weather is how to use solar cell panels to get optimal electricity output. The installation of solar cell panels is generally placed in a certain position with no changes[2]. Other problems that affect photovoltaic performance are dirt or dust adhering to solar panels, cables that do not match the capacity, corrosion components, damaged inverters, and disturbance of animals or birds[3].

Most of the installed solar cells are static or placed attached to one part of the building that allows it to receive light such as on the roof of a house or building wall. This results in optimal absorption of solar energy by solar cells at certain hours[4][5]. So that the absorption of solar energy can be received more optimally[6][7], a system that moves in the direction of the sun is needed, which is called a solar tracking system. Solar tracker is a device that drives solar cells that are made to automatically move at an angle of 0° - 180° and vice versa[8][9].

In this final project, a prototype of the solar panel driving direction will be made, where the driving component of the solar panel uses a servo motor and LDR sensor which functions to track the receipt of solar energy by solar cells[10][11]. For the convenience of controlling or operating solar cells as well as simplifying the process of maintaining solar cells 12][13], a control system using the IoT (Internet of Things) method was created combined with the ESP 8266 microcontroller which can regulate the direction of the solar cell panels in real time using NTP (Network Time Protocol)[14][15]. and the results of the absorption of solar energy by solar panels can be known using the INA219 sensor in real time through the Thingspeak application.

2. RESEARCH METHOD

2.1. Research Flow Process

There are several stages of research preparation for making prototypes of IoT-based solar panel control systems, following the stages of tool design:

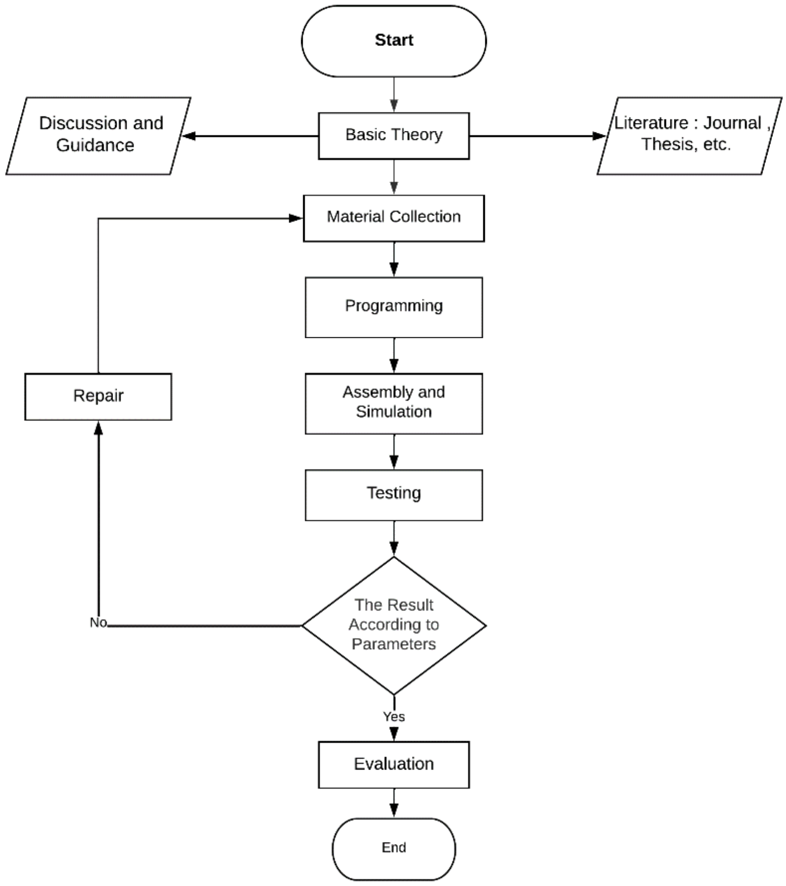

Figure 1. Research Workflow

1. The first stage is to start research. The research that will be carried out is regarding the design of a prototype solar cell panel control system based on IOT.
2. The second stage is to collect the theoretical basis, data and references related to the design made. This is done to simplify the design.
3. The third stage is the stage of collecting the required materials related to the design to be made.
4. The fourth stage is the design stage, in this case the block diagram and the wiring diagram of the solar cell panel control system are made using the Proteus application and programming using the Arduino application.

5. The fifth stage is the tool assembly and simulation stage, from the results of the prototype design being made and simulated.
6. The testing stage is the stage to check all components that are ready to be run, if they are not suitable then it is repeated again.

2.2. Block Diagram

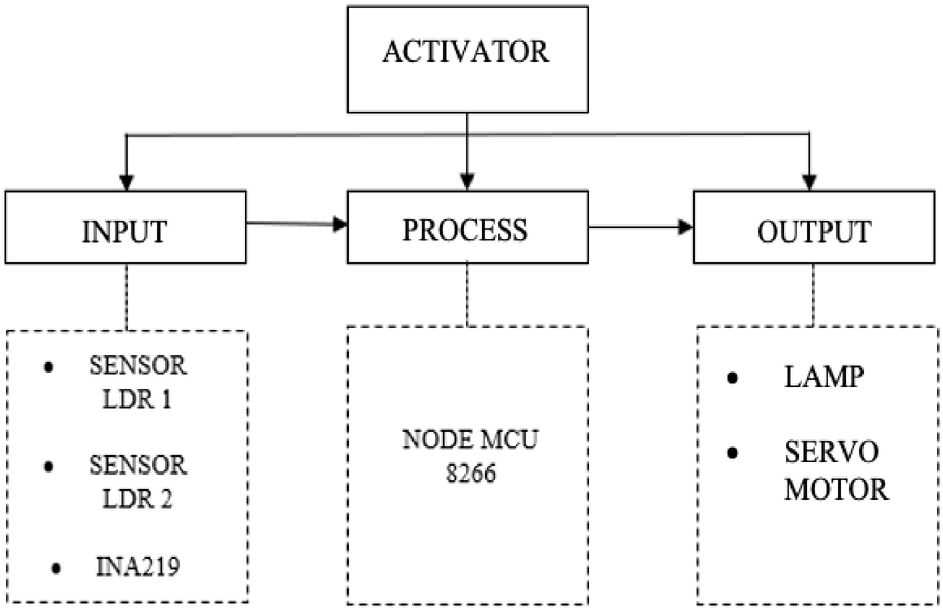

Figure 2. Block Diagram

Figure 2 is a block diagram to make it easier to understand the design system. Overall there are inputs, processes and outputs.

In the design scheme of the tool above, the solar panel does not function as a driving sensor for the solar cell control because the author focuses on monitoring the movement of the tilt angle of the solar panel and the condition of the lights with gadgets.

Solar panels are supplied with a 220vac/vdc power supply unit (PSU) as the main source of electricity. LDR sensor 1 serves for feedback when the system is running normally but there is a problem with the lights. The LDR 2 sensor here has a function, namely to turn on the lights automatically when the weather is night and turn off the lights in the morning. The INA219 sensor functions to determine the results of solar energy absorbed by solar cells. From several conditions, changes that occur in the tool will automatically be displayed in the Thingspeak application and monitored on an updated basis.

In this design, it describes the circuit process flow from the input to get a command or signal in the form of a sensor which is then received and processed by the ESP 8266 for further execution of both driving the motor and monitoring with the android application. the device will be simulated using the Thingspeak application, this design is useful for knowing all circuit paths are running according to the desired plan and there are no errors in making the actual path or on the Printed Circuit Board (PCB)

2.3. Flowchart of System Design

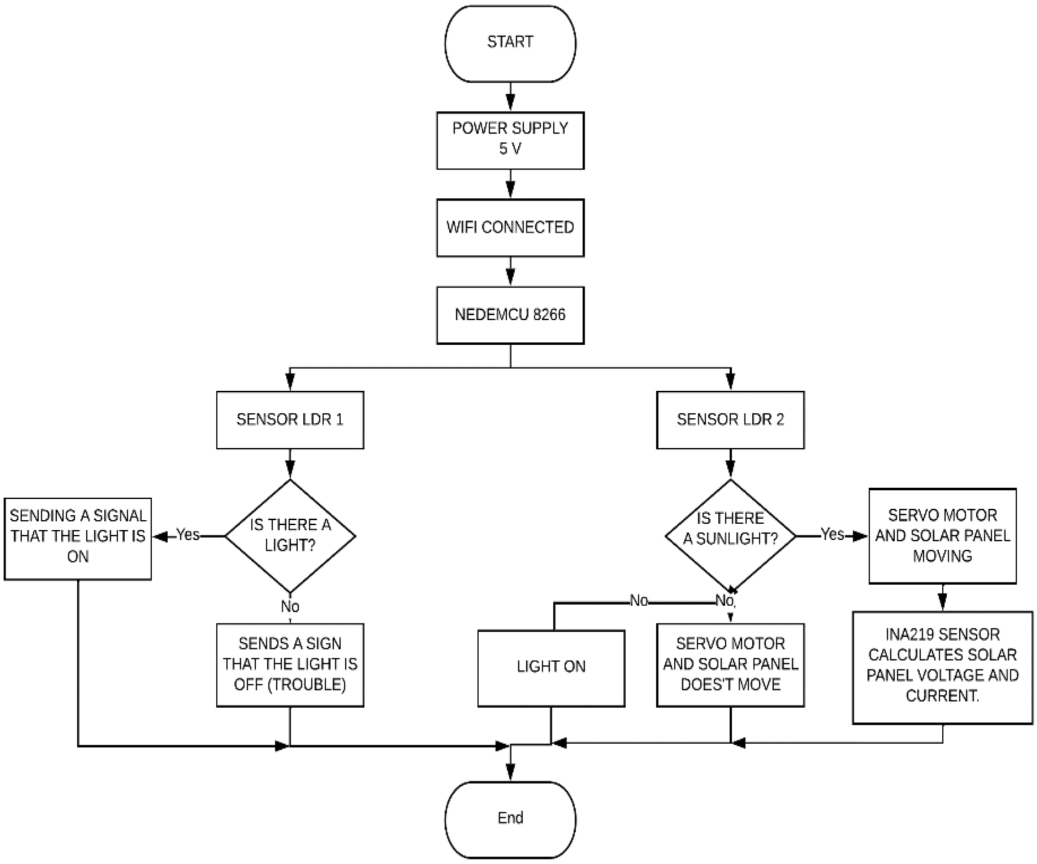

Figure 3. Flowchart of System Design

In this design two systems are made, the first is a 220 V lamp control system using an LDR sensor which can give commands to the relay to turn on and off the lamp based on the light intensity read by the sensor and the second control system is a servo motor drive. In the servo motor control system, it can be done manually by using a push button to give orders to the servo motor to move according to the needs, namely the servo motor moves based on the user's command by pressing the + or - servo motor so that it moves according to the command. The second method is automatic, namely the servo motor moves according to the programmed periodic time with changes in movement per 1 hour and will increase the angle by 20˚ and will return to the specified initial angle. The results of the absorption of solar energy by solar cells can be known through the INA219 sensor and the maximum charging degree and time can be known. Both changes in conditions are monitored through the Thingspeak application in real time.

This monitoring system works when the system is turned on, the WiFi on the ESP 8266 connected to the wifi is in "on" mode, then the system will try to connect to the WiFi that has been programmed on the system, if the connection is successful then the ESP8266 will be connected to the Thingspeak application, and the system ready to use (online). The status data on the device will always be sent through the Thingspeak application so that monitoring can be directly connected to the gadget.

2.4. Controller Design

This wiring diagram illustrates the system circuit running from power to power supply as a process of input voltage 220 VAC which is reduced to 5 VDC, then Node MCU 8266 as a data process.

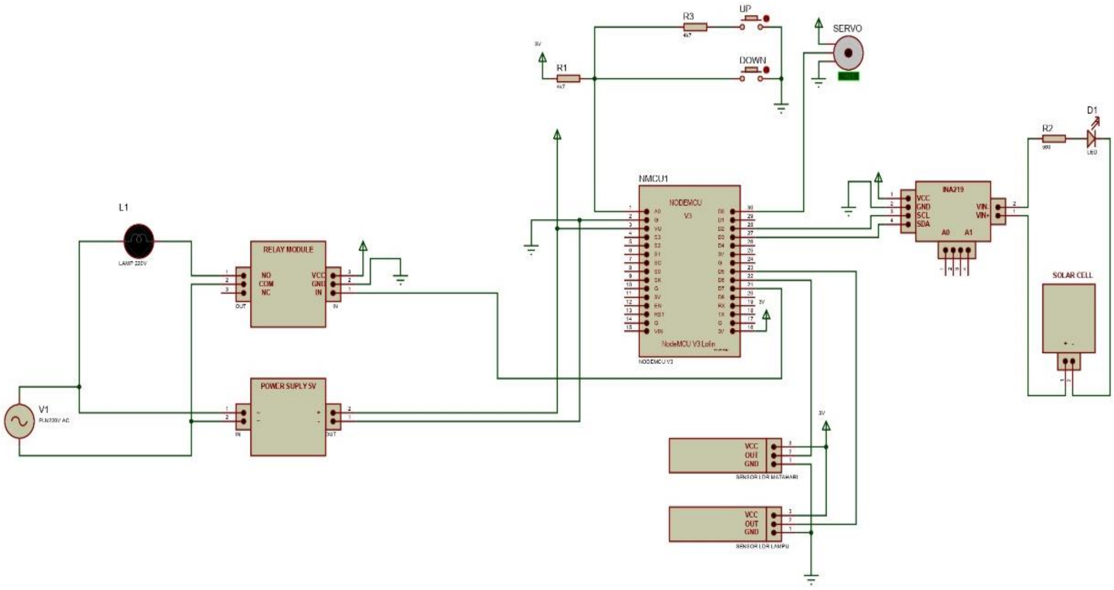

Figure 4. Wiring Diagram Design

Figure 4 describes,Automatic conditions, namely the servo motor moves according to the settings from the start of the clock 06.00 WIB to 18.00 WIB with an initial tilt angle of 10 ° moving every 1 clock with a 20° shift position monitored on the Thingspeak app so that facilitate system monitoring. The second method is in manual conditions by hovering the Up And Down buttons on the tool. User always set the two buttons to keep the solar panel moving according to the planning and as an Optional when the automatic system cannot work. Results The absorption of solar energy by solar panels can be known through the INA219 sensor. System circuit running from the start the power supply as a process of input voltage 220 VAC which is reduced to 5 VDC, then Node MCU 8266 as process data. Figure 4 also depicts the Solar Panel Prototype system circuit and Ina219 sensors. Pins D2 and D3 on Nodemcu8266 are connected to Pins SCL and SDA on the Ina219 sensor, the VIN+, and VIN- pins on the INA219 sensor are connected to the Pin 1 Solar cell and LED.

2.5. Program Analysis (Testing)

Software testing is carried out to ensure that the software created is in accordance with the design and all functions can be used properly without any errors. This test includes compatibility testing for each of its features both on the tool and on the website application used.

```
File  Edit  Sketch  Tools  Help
koding §
    if(sudut==5) myservo.write(110);
    if(sudut==6) myservo.write(130);
    if(sudut==7) myservo.write(150);
    if(sudut==8) myservo.write(170);
  }
  if(analogRead(A0)<=100) {
    sudut--;
    if(sudut<0)sudut=0;
    if(sudut==0) myservo.write(10);
    if(sudut==1) myservo.write(30);
    if(sudut==2) myservo.write(50);
    if(sudut==3) myservo.write(70);
    if(sudut==4) myservo.write(90);
    if(sudut==5) myservo.write(110);
    if(sudut==6) myservo.write(130);
    if(sudut==7) myservo.write(150);
    if(sudut==8) myservo.write(170);
  }

    if(jam==6&&menit==0&&detik==0) myservo.write(10);
    if(jam==9&&menit==0&&detik==0) myservo.write(30);
    if(jam==10&&menit==0&&detik==0) myservo.write(50);
    if(jam==11&&menit==0&&detik==0) myservo.write(70);
    if(jam==12&&menit==0&&detik==0) myservo.write(90);
    if(jam==13&&menit==0&&detik==0) myservo.write(110);
    if(jam==14&&menit==0&&detik==0) myservo.write(130);
    if(jam==15&&menit==0&&detik==0) myservo.write(150);
    if(jam==16&&menit==0&&detik==0) myservo.write(170);
```

Figure 5. IF and AnalogRead Functions in the Program

The analogRead() function on Arduino read data from the analog pin and then store it in a variable. Where the reading data is an integer value with a range of 0 to 1023. The IF function of this command is used when there is only one statement to be executed. So if the condition is met then the statement will be executed and if not fulfilled then the statement is not executed. In this programming, the Servo Motor moves every 2 hours by 20 degrees, starting at 06.00 until 17.00.

```
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koding §

  unsigned long currentMillis = millis();

  if (currentMillis - previousMillis >= interval) {
      previousMillis = currentMillis;

  ThingSpeak.setField(1, myservo.read());
  ThingSpeak.setField(2, arus);
  ThingSpeak.setField(3, tegangan);
  ThingSpeak.setField(4, digitalRead(ldr2)^1);
  // write to the ThingSpeak channel
  int x = ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);
  if(x == 200){
    Serial.println("Update Ok");
  }
  else{
    Serial.println("Update error code " + String(x));
  }

  }

  if (currentMillis - previousMillis1 >= interval1) {
      previousMillis1 = currentMillis;
      digitalWrite(led,digitalRead(led)^1);
      run_program();

  }

}
```

Figure 6. Thingspeak Setfield

This command functions to display data on the monitor, the displayed data will continue to appear downwards. So the data that appears is not in just one row. This is because every time the program finishes displaying data, the program will automatically give the enter command or move to the next line.

2.6. Journal References

There are several previous studies to be used as a reference for this research, as follows:

1. Qory Hidayati, Nur Yanti and Nurwahidah Jamal, Year 2020, Source journal.poltekba, Dual Axis Solar Tracking System for Power Generation. In this study, the dual axis solar tracker method is used where by using this method the absorption of solar energy is more optimal. The dual axis solar tracker is used as an optimization of solar energy reception by solar panels, there are 4 light sensors. As a result, the amount of solar energy produced is greater than static solar panels, which is up to 30%[3].
2. Jhefri Asmi, Oriza C in 2020 made a two-axis Solar Tracker Prototype based on the Arduino Nano microcontroller with an LDR sensor. This research designs a two-axis solar tracker with an LDR sensor. The voltage measurement results obtained from the solar cell placed on the solar tracker are more constant than the solar cell placed static or stationary[5].
3. Dhanu, Rama, Year 2019, Source Repository.usu. Light Intensity Measurement System Utilizing LDR Using Arduino Pro-Mini Microcontroller. This research was conducted to measure the level of turbidity of water by converting the amount of electric voltage into the amount of the level of turbidity (turbidity) of water. The series of tools consists of an LDR sensor to detect turbidity. Measuring the intensity of light using an LDR sensor that the greater the intensity of light captured by the tool, the higher the index displayed on the LCD[7].
4. Wahyu A.M Silalahi, Year 2020, Source Jurnal.pancabudi. Analysis of the Effect of Sunlight Intensity and Surface Temperature of Solar Panels on the Energy Produced. The voltage and current generated by the solar cell will be measured directly using a DT830D digital multimeter. Voltage and current are analyzed from the measurement results by a multimeter to get Electrical Power (Watts). The light intensity is measured using a luxmeter which is placed parallel to the solar cell so that the light intensity on the solar cell matches what is stated on the luxmeter. The highest light intensity occurred at 14:00 WIB with the light intensity reaching 107890 lux[10].
5. I Wayan Yoga Widiana, I Gusti Agung Putu Raka Agung, Pratolo Rahardjo, 2019, Source Spectrum. Design and Build Automatic Lighting and Air Conditioning Control in a Lecture Room Based on an Arduino Nano Microcontroller. By using PIR (Passive Infra Red) and LDR (Light Dependent Resistor) sensors in the automatic control system of lights and air conditioners, it is expected to reduce excessive electrical power consumption. The PIR sensor can work to detect the presence of people in the room and the LDR sensor can detect the light intensity so that it can control the lights and air conditioning automatically[11].
6. Mira Martwati, Year 2018, Source journal.pnm. Simulation Analysis of the Effect of Light Intensity Variations on Power From Solar Panels. The simulation of the solar panel module is intended to determine the maximum working point of the solar panel.

In the module by utilizing two solar panels that have an irradiance value of 1000 at a temperature of 25^0 C, it is able to produce 61.2 Watts of power[12].

7. Evrita Lusiana Utari, Year 2018, Source . Utilization of Renewable Energy for the Design of a Rotary Dryer System at the Green Tea Leaf Drying Stage in Kulonprogo. ENT sensors are used to detect room temperature and humidity in the dryer, pushbutton switches are used as switches to determine temperature and humidity limits. The design of the tool design uses several basic components including Solar Cell, MPPT, Battery, Inverter, Motor, Control System, Temperature, and Rotary Dryer[13].

3. RESEARCH RESULTS AND DISCUSSION

3.1. Voltage and Current Test Results

The results of the tool test, the voltage and current absorbed by the solar cell can be seen using the INA219 sensor and displayed through the Thingspeak application

Table 1. Voltage and Current Testing on Solar Panels

NO	HOUR (WIB)	27/07/22		28/07/22		29/07/22	
		VOLT	CURRENT	VOLT	CURRENT	VOLT	CURRENT
1	06.00	1,8 V	1,7 A	2,2 V	1,1 A	2,1 V	0,8 A
2	09.00	4,8 V	2,2 A	4,5 V	2,2 A	2,2 V	1 A
3	10.00	5,2 V	2,3 A	2,8 V	2,1 A	2,6 V	1,7 A
4	11.00	5,8 V	2,2 A	5,1 V	2,4 A	4,2 V	2,3 A
5	12.00	5 V	2,1 A	5,1 V	2,6 A	5,1 V	2,3 A
6	13.00	6,1 V	3,1 A	5,1 V	2,5 A	5,1 V	2,4 A
7	14.00	7,2 V	3,2 A	6,1 V	2,7 A	6,2 V	3,1 A
8	15.00	5,4 V	2,2 A	5,3 V	2,1 A	5,8 V	2,2 A
9	16.00	3,1 V	2,5 A	3,2 V	1,8 A	4,1 V	2,1 A
AVERAGE		4,9 V	2,4 A	4,4 V	2,2 A	4,1 V	2 A

Data in table 1 is data on measuring the voltage and current of solar energy absorbed by solar cells using a solar panel driving device which was carried out for 3 days. It can be concluded that the average voltage and current on the first day was 4.9 V and 2.4 A, on the second day it was 4.4 V and 2.2 A, on the third day it was 4.1 V and 2 A.

3.2. Application Function Test

To display the data and status that has been processed by the solar cell controller, here the author uses the Thingspeak application through the same internet-connected gadget that has been programmed on the MCU Node on the solar panel control device.

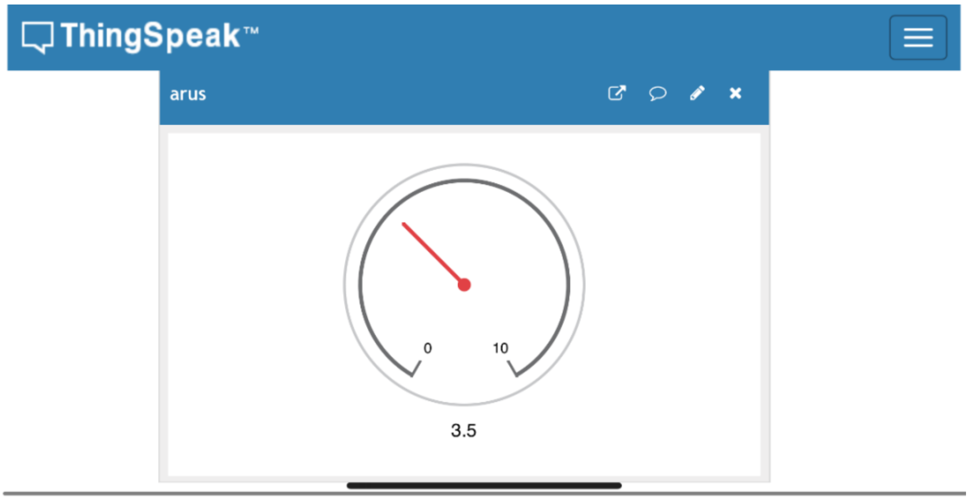

Figure 7. Current Field

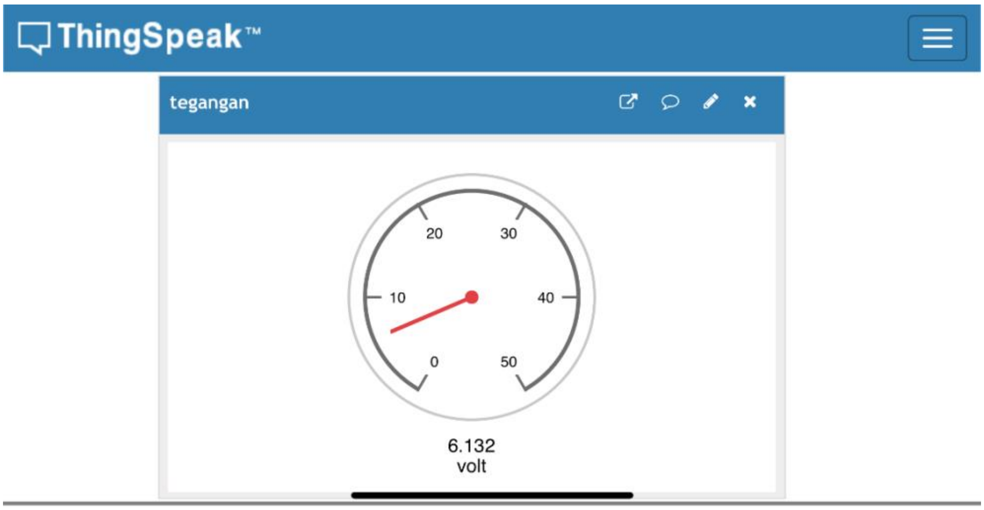

Figure 8. Voltage Field

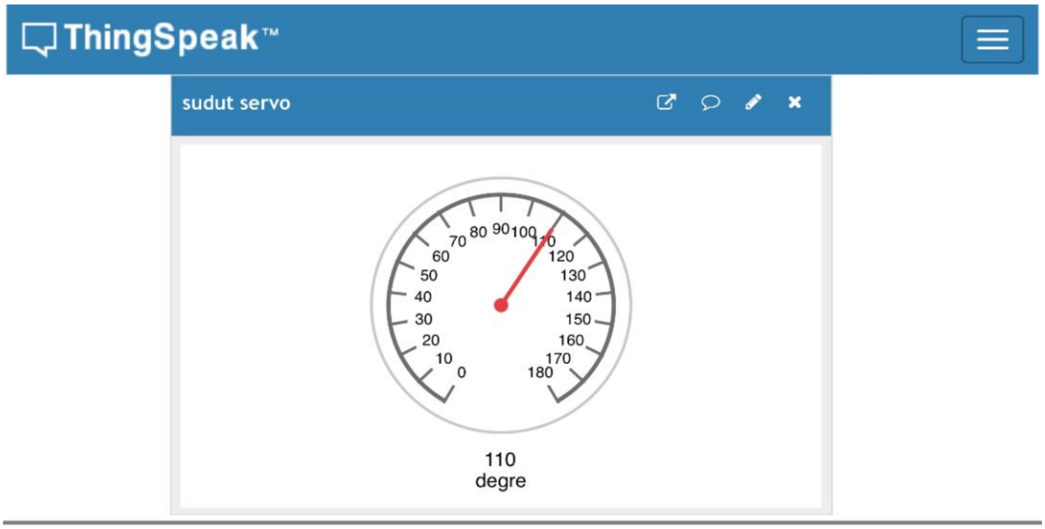

Figure 9. Servo Angle Field

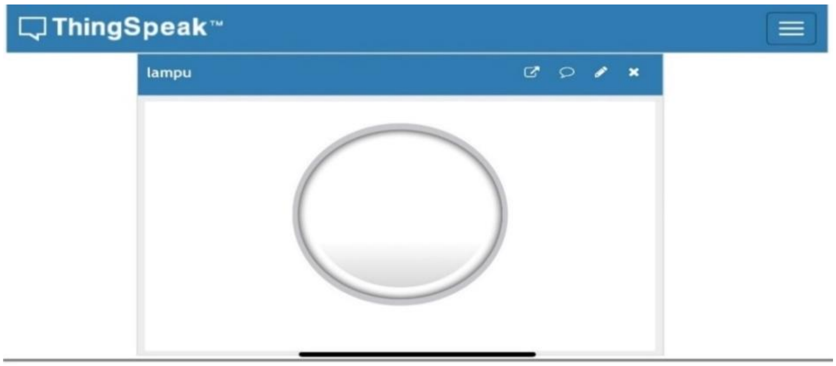

Figure 10. Field Feedback Lamp

Table 2. Daytime Status

Hour (WIB)	Servo Angle	Motor Servo Way	Sunlight	Lamp On/Off	Lamp Status	Current	Volt
13.55	**110°**	**CW (Clock Way)**	**Yes**	**Off**	**Normal**	**3,5 mA**	**6,13 V**

In the table above shows the condition of the tool that works at 13:55 the conditions listed are LDR 2 which signals that it is light and gives orders for the lights to turn off and the LDR 1 sensor gives the status of the lights being off in normal conditions and there is a current of 3.5 Ma, voltage 6.13 V, servo angle 110 degrees.

4. CONCLUSION

From the design that has been carried out, several conclusions can be drawn. The design of this prototype is satisfactory, the solar panel drive uses a servo motor because it has excellent resolution and accuracy as a driver for the solar panel because the servo motor has a large power or torque, so that in its development later it can move quite a heavy load. In general, servo motors are used as driving the ideal angle of 180 °.

The IoT-based monitoring system works well, the system uses ESP 8266 because it is a wifi module that functions as a microcontroller enhancement so that it can connect directly to wifi and make TCP/IP connections for monitoring the solar panel prototype.

5. SUGGESTED

The LDR 1 sensor should be further developed in terms of its placement design so that it can work according to the desired function and can distinguish sunlight and light.

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