# Illumination and Power Monitoring on Internet of Things-Based Solar Panels

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**Abstract**. In the research designed a monitoring system tool that is integrated online or often called IoT with the help of thingspeak as web monitoring for measurement, and resources using solar panels, which aims solar panels can be used with offgrid systems and t and light on the power generated with the ease of monitoring data used online., where with Polycrystalin panels derived from silicon materials with a temperature coefficient of -0.075 oC.with the load used is incandescent lamps with a power of 5W,where 54612 lux can generate 4.72A.so that environmental factors can affect solar panel power, and the benefits of IoT systems can facilitate monitoring anywhere and anytime.

## INTRODUCTION

In the era of modernization, technological advances can help human needs in everyday life, especially in the energy sector [1]. Electrical energy in this era is something that is very vital and important for everyone. all modern equipment requires electrical energy to operate on the other hand developments such as settlements and industries that run in each area make the supply of electrical energy needed increase, so that the demand for electrical energy is increasing day by day. Meanwhile, the amount of electrical energy derived from fossil fuels is very limited, so new and renewable energy is needed [2]. In the last decade in Indonesia, the use of photovoltaic for power generation is growing rapidly, especially in government efforts. to achieve an electricity ratio of >70% in 2012. This technology was chosen because the location to be electrified is in a remote or isolated location such as the outer islands and separated by mountains/hills, which technically draws the electricity network from the existing one. and economically is not the right decision [3].

On the other hand, the use of alternative energy needs to be controlled and monitored so that the use of this alternative energy can be exactly as needed. Where the existence of the Internet of Things can make it easier for us to control and monitor existing alternative and non-alternative electrical energy systems with the help of the internet and can be from remote places in real time. So that users who are far away from the control panel of their electrical energy system, can control and directly monitor the electrical system at home [4]. In its operation, solar power generation systems have several configurations that are commonly used. These configurations include on-grid, off-grid, and on-grid with battery backup. These configurations can be used to be able to operate a solar power generation system like a conventional generating system that can connect and supply energy to the grid [5].

By implementing a solar power generation system, it can reduce dependence on the use of non-renewable energy sources, as well as reduce carbon emissions generated from conventional plants. In addition, the energy produced by solar power plants can be sold to state power companies.

A Smart Grid is an electricity network that uses digital and other based technology to monitor and manage [6]. Meanwhile, the European Smart Grid Platform Technology (ETP) has a vision that the power system network in Europe must be flexible in meeting consumer needs, easy access, reliable and economical [7]. Meanwhile, according to the US Department of Energy, a smart grid is a power system based on technology sensing, communication, digital control, information technology (IT) and other field equipment that functions to coordinate the existing processes in making the electricity grid more effective and dynamic in its management [8].

The smart grid implementation needs a parameter that can connect values with transmit data online, that is ESP32, where ESP32 is a single 2.4 GHz Wi-Fi and Bluetooth combo chip designed with TSMC ultra-low power 40 nm. This

technology is designed to achieve the best power and RF performance, demonstrating robustness, flexibility, and reliability in a wide range of power applications and scenarios [9]. IoT is an internet network system that can provide, process, and transfer digital information obtained from sensor equipment such as radio frequency identification (RFID), infrared sensors, GPS, scanners, and smart meters [2].

## IMPLEMENTATION OF RESEARCH RESULTS AND DATA

The system testing in this study is online monitoring of light intensity and power data with the Thingspeak application, the testing data taken including on solar panels. In its implementation, research can be included in a block diagram, to see how the system works as shown in Figure 1.
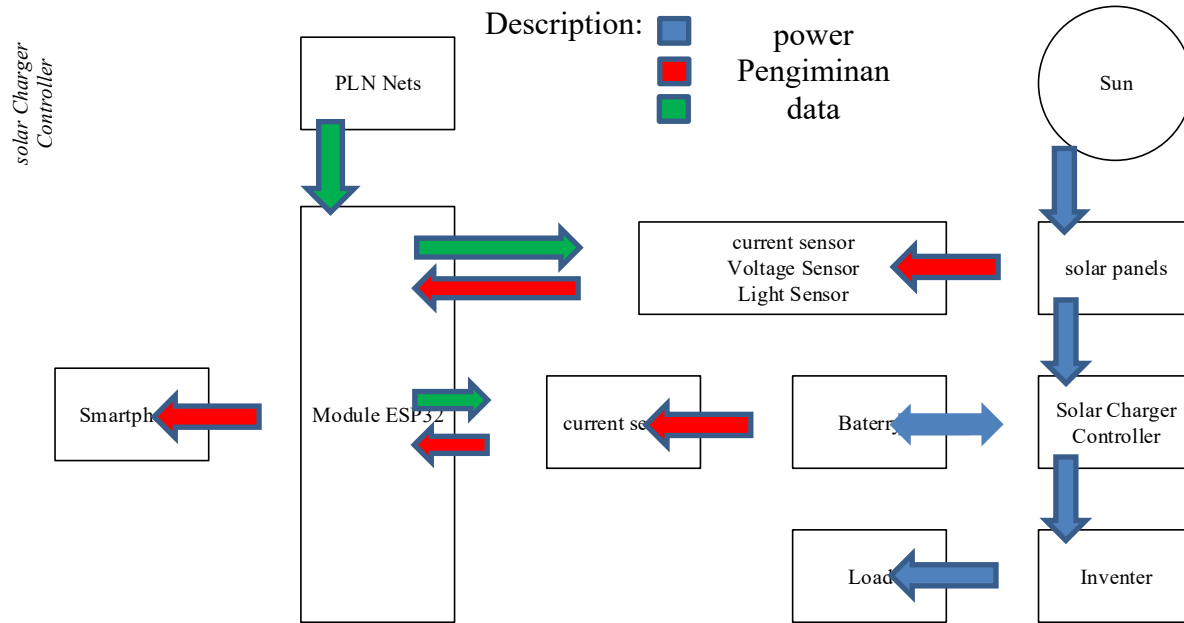


**Figure 1**. System Block Diagram

Figure 1 shows that the solar panel will absorb light and be converted into a dc source, after conversion the sensor will work to retrieve data, the output of the solar panel to the solar charger controller will then go to the battery to charge the battery, the battery output will be sent to the solar charger controller which will be used by the inverter to convert the DC source into an AC source which will then be used by the load. while each sensor used to turn it on uses PLN grids with the intention of not losing power. The data value taken by the sensor will go to the ESP32 module, where the ESP 32 module has a Wi-Fi chip installed that is connected to the network so that the data can be sent online to the Thingspeak server which can be accessed via smartphones or laptops.

In the design and realization of the hardware system used in this system, there are several components used, which can be seen through the single line series Figure 2 for the implementation monitoring internet of things.
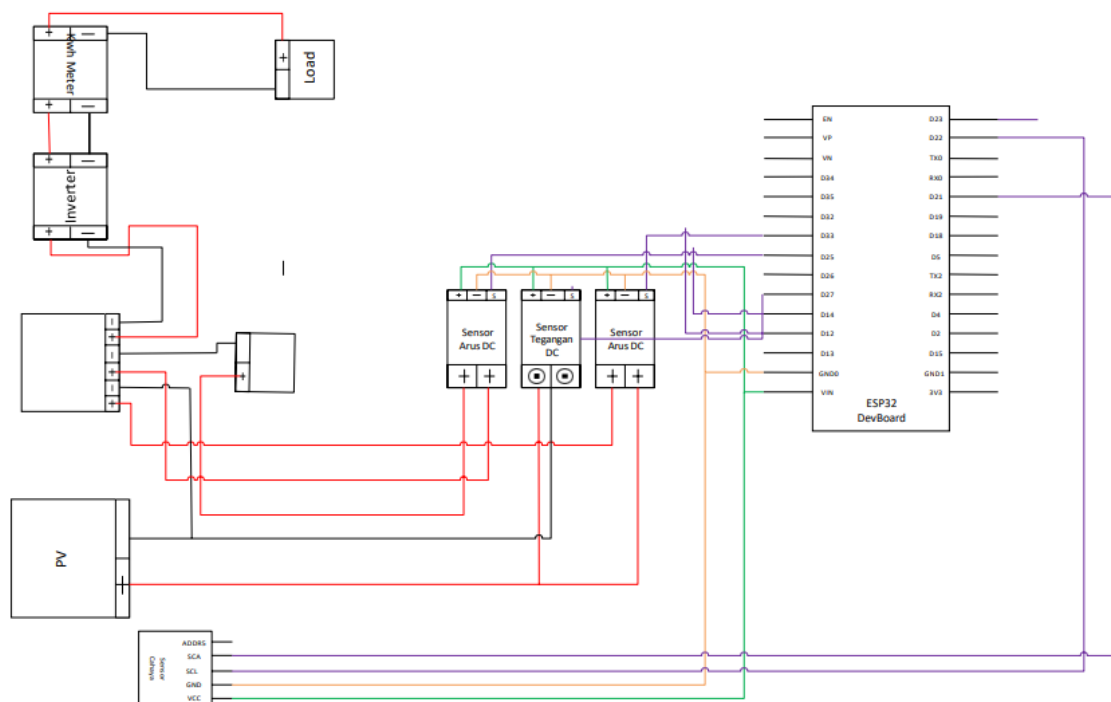
**Figure 3**. Single Line Diagram

To realize the internet of things system, it requires a sensor which will be connected to the ESP32 microcontroller. With sensors used as follows:

A. Current Sensor ACS712

ACS712 is a current sensor that works based on field effects. This sensor can be used to measure AC or DC current. This sensor module is also embedded with an operational amplifier circuit, so that the sensitivity of current measurement increases and can measure small current changes, with a physical shape and circuit as shown in Figure 3. ACS712 Current Sensor Specifications:

1. Time of increase in output change = 5 s.
2. Wide frequency up to 80 kHz.
3. Total output error of 1.5% at working temperature TA= 25°C.
4. Internal conductor resistance 1.2 mΩ.
5. Minimum isolation voltage of 2.1 kVRMS between pins 1-4 and pins 5-8.
6. Output sensitivity 185 mV/A.
7. Capable of measuring AC or DC current up to 5 A.
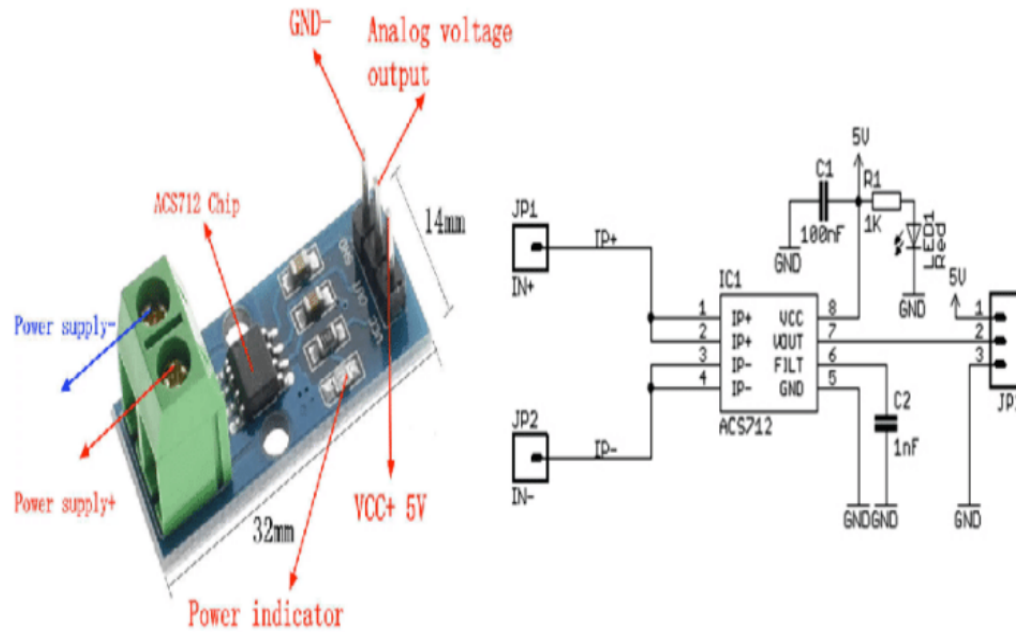8. The output voltage is proportional to the input AC or DC current

**Figure 3**. System Block Diagram [10]

B. DC Voltage Sensor 25V

Voltage sensors are used to measure AC and DC voltages. The working principle of this voltage sensor module is based on the principle of suppression of resistance and can change the input voltage reduced to 5 times of the original voltage. The form of the voltage sensor module is as shown in Figure 4 below:



**Figure 4**. DC Voltage Sensor [11]

The features and advantages:
1. Variation of input voltage: DC 0 - 25 V
2. Voltage detection with range: DC 0.02445 V - 25 V
3. Analog resolution voltage: 0.00489 V
4. DC voltage input interface: positive terminal with VCC, negative with GND
5. Output Interface: "+" 5 / 3.3V connection, "-" connected GND, "s" connected Arduinopin A0
6. DC input interface: red terminal positive with VCC, negative with GND

C. Light Sensor BH1750

BH1750 is a light sensor IC with IC interface. This module provides digital output through the IC bus, so there is no need to add an ADC converter [1]. With a sensor shape like Figure 5.

**Figure 5**. Light Sensor BH1750 [1]

Specification:
1. Power Supply: 4.5 V
2. Resolution: 0 - 65535 lux
3. Interface: IC
4. Output Type: Digital
5. Sensor Chip: BH1750FVI
6. Dimensions: 13.9 x 18.5 mm

D. ESP32

ESP32 functions as a module that connects sensors to the network with the Thingspeak application as a data monitoring center so that the Internet of Things system occurs.



**Figure 6**. Specification ESP32 [9]

The ESP32 module has the following specifications:
1. Microprocessor                                    Xtensa Dual-Core 32 Bit LX6
2. Freq Clock                                           up to 240 MHz
3. SRAM                                                  520 kB
4. Wi-Fi transceiver                                  11b/g/n
5. Flash memory                                       4 MB
6. Bluetooth                                             4.2/BLE
7. GPIO                                                   48 pin
8. Channel ADC (Analog to Digital Converter)   15 pin
9. PWM (Pulse Width Modulation              25 pin
10. Channel DAC (Digital to Analog Converter)   2 pin

By looking at these specifications, usage becomes easier and simpler because in 1 ESP32 module the performance is better than other modules and has several ADC, PWM and DAC pins to connect to sensors. In addition, the

ESP32 module has connectivity in the form of Bluetooth and Wi-fi which can be seen from the module block diagram in Figure 7.
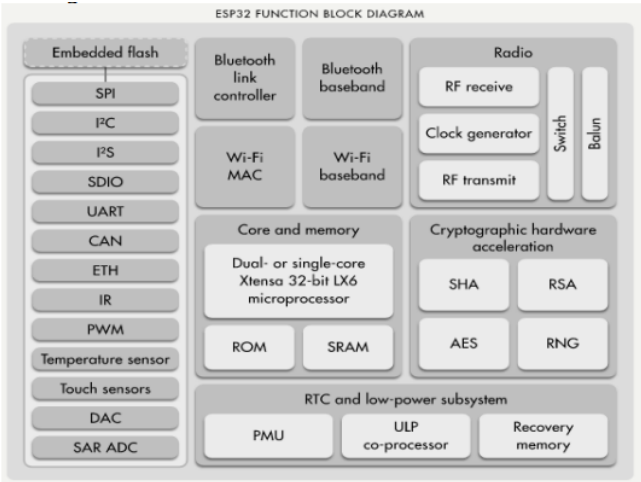


**Figure 8**. ESP32 Module Block Diagram [12]

Based on Figure 8, the ESP32 has an analog to digital converter (ADC) system. ADC is a converter of analog inputs into digital codes. Generally, ADC is used as an intermediary between sensors which are mostly analog with computer systems such as temperature sensors, light, pressure / weight, flow and so on and then measured using a digital system (computer). The ADC system itself has a waveform with a timing diagram of a trace sequence with a sequence to convert analog to digital as shown in Figure 9.
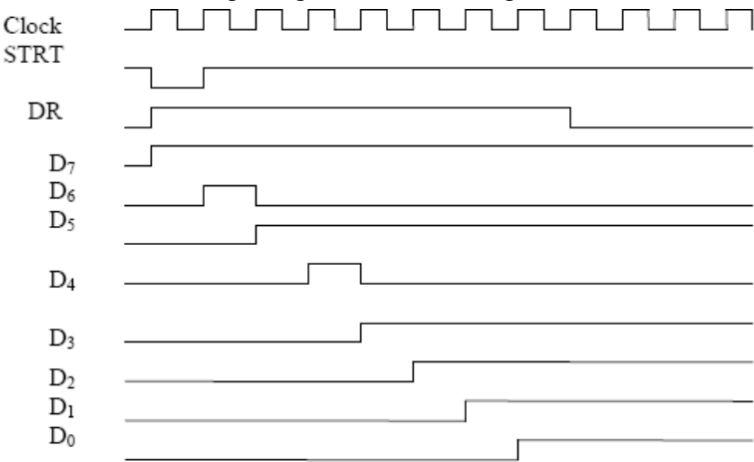


**Figure 9**. Timing Diagram of a Trace [13]

## Tool Calibration

In the calibration used to see the current and voltage using a multimeter to see the comparison results obtained by the multimeter and sensor, this measurement was carried out to see the feasibility of the sensors used in the study. The values obtained are as shown in Table 1 comparison of the sensor with a multimeter.

**Table 1.** Monitoring and Measurement Results

| Measurement To | Panel Flow Monitoring Results | Measurement Results | Error | Battery Current Monitoring Results | Measurement Result | Error |
|---|---|---|---|---|---|---|
| 1. | 0.03379 | 0.07 | 2.07% | 0.02319 | 0.023 | 1% |
| 2. | 0.05801 | 0.046 | 0.79% | 0.09582 | 0.014 | 0.14% |
| 3. | 0.2937 | 0.12 | 0.40% | 0.08474 | 0.03 | 0.35% |
| 4. | 0.32444 | 0.2 | 0.61% | 0.02699 | 0.07 | 2.59% |
| 5. | 0.0992 | 0.67 | 6.75% | 0.03823 | 0.11 | 2.87% |
| 6. | 0.08485 | 0.01 | 0.11% | 0.05913 | 0.06 | 1.01% |

**Table 1.** Monitoring and Measurement Results (continue)

| Measurement To | DC Voltage Monitoring Result | Measurement Result | Error |
|---|---|---|---|
| 1 | 12 | 12,1 | 0,98% |
| 2 | 12 | 12,2 | 0,99% |
| 3 | 11 | 12,6 | 1,16% |
| 4 | 11 | 12,9 | 1,20% |
| 5 | 12 | 12,3 | 1,06% |
| 6 | 12 | 12 | 1% |

From the comparison table, we get the error value generated from the mutmeter against the sensor, an error value that exceeds 10% can be categorized that the sensor must be replaced. While in the table the value that exceeds 10% error is only 1 and the other error values are below 10%, so it can be interpreted that the sensor is feasible to use.

## Thingspeak Monitoring Data

In monitoring via thingspeak, the sensor will read the results to be later distributed to esp32 as a program and on esp32 it will be sent to the network which will eventually enter thingspeak, with data like Figure 10–Figure 12. Where data retrieval takes 10 minutes apart, in addition, monitoring can be viewed directly through the Thingspeak website.



(a)
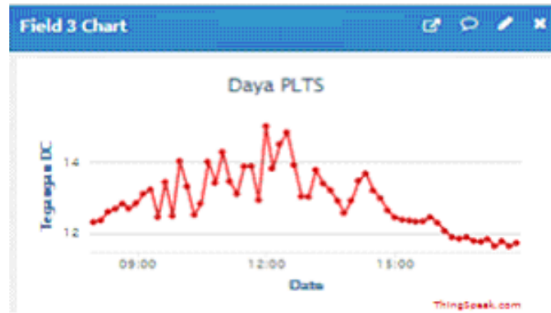
(b)

**Figure 10**. Current and Voltage Graph Thingspeak App

Figure 10(a) shows the current data generated by the solar panel, from a solar panel with a capacity of 100wp. The value obtained is due to the influence of light absorbed by the panel, the effect of the panel not only on light but also on the voltage Figure 10(b). The higher the light absorbed and converted by the panel, the higher the current and voltage values produced.
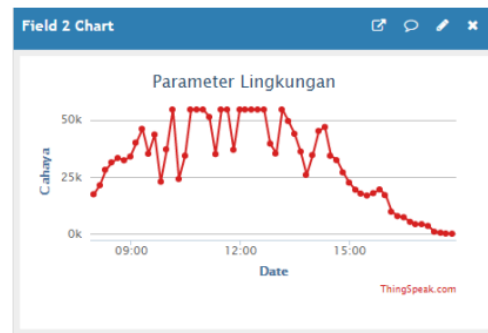


**Figure 11**. Light Graph Thingspeak

Figure 11 is a graph of the light intensity that obtained. Where research for light intensity is carried out with the same position and angle as the solar panel to the sun, so that the light data obtained will be in accordance with what is obtained on the solar panel. The light data obtained are influenced by the light shining on the solar panel, while the increase or decrease in the value of the data is influenced by the weather around the research site, when the clouds cover the light absorbed by the panel, the data value obtained will be small, but if the cloud conditions do not cover the absorption of light, the value of the data obtained will be high.

The effect of the highest light is during the day from 10.00 am to 14.00 pm because at that time the sun is right above the earth, so that more light is produced which will be absorbed by solar panels and converted into energy needed to turn on the load.
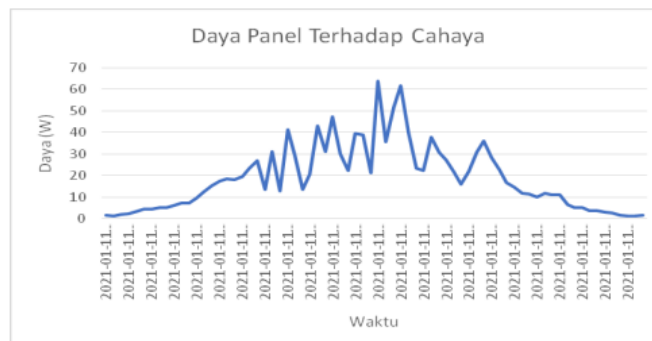


**Figure 12**. Power vs Time Graph

Figure 12 shows the value of the power that obtained, the power obtained by the solar panel for 12 hours with an interval of 10 minutes. The power results are obtained using the P = I x V formula, which is done manually, the data results shown in the graph tend to be larger starting from 10.00 WIB to 14.00 WIB because at that time the sun is in the best condition producing light so the value obtained is will be greater than at 6.00 WIB to 10.00 WIB and 15.00 WIB to 18.00 WIB.

## CONCLUSION

1. Monitoring data by IoT is more effective than measuring manually, because when using IoT we can monitor data anywhere without having to look directly at the tool.
2. Data results for current, voltage and light intensity can be monitored using the Thinkspeak application, because the system has been integrated online through the ESP32 module hardware.
3. The use of ESP32 which already has an ADC system makes it easier for the system to work, because it can directly convert analog to digital in 1 microcontroller, compared if using a microcontroller module that doesn't have an ADC chip inside.

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