[1]Aas Wasri Hasanah

Maulana Azro Azqolani[2]

Hendrianto Husada[3]

Tri Joko Pramono[4]

# Monitoring Battery and Load Control of Solar Power Plants Using Internet of Things (IoT) Technology

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***Abstract: -*** At present Indonesia has a large potential Solar Power Plant. This study aims to design a battery monitoring system at Solar Power Plant that can monitor battery performance in real time based on the Internet of Things (IoT) using the blynk platform. By using the INA219 sensor as a measurement of current, voltage, and battery capacity measurements using the Open Circuit Voltage (OCV) method and ESP32 microcontroller as a liaison between research tools and the blynk platform using an internet network connection and relays as a regulator of electricity flow to load-based (IoT). This test focuses on current and voltage parameters when loaded and when not loaded. For the accuracy value of no-load stress testing of 99.89%, stress testing using a load of 96.75%, no-load current testing of 97.16%, and current testing using a load of 97.17% of 20 data collections. For testing battery capacity by method (OCV) obtained an accuracy value of 99.79%. So that the INA219 sensor has a high accuracy value.

***Keywords:*** PLTS, INA219, ESP32, relai, Internet of Things (IoT).

## 1. INTRODUCTION

According to Indonesian Ministry Energy and Mineral Resources, Indonesia has own very big of solar energy potential around 4.8 kWh/m$^2$, but only around 10 MWp that has already been used. The Indonesian Government has already made a roadmap about utilization of solar energy with the capacity of solar power plant till 0.87 GW or around 50 MWp/year on 2025. It shows that the market potential of the development of solar energy would be very big in the future. Because of Indonesia is located at the equator line so the intensity of sun ray quite high to develop Solar Power Plant as a renewable energy resources that eco friendly with the environment. One of the most important component of Solar Power Plant is battery. Battery is used for energy storage that is produced by solar power plant, so the reliability of the battery must be paid attention or took care very well. The battery that is not monitored very well can give damaged on the solar power plant and will decrease the performance of the solar power plant systems and decrease also the efficiency energy of the solar power plant.

To overcome that problem, so it is necessary needed a monitoring systems for the battery of The Solar Power Plant. Monitoring the performance of the solar power plant especially the voltage and the current continuously based on real time systems using microcontroller circuit. With this systems not just only monitoring battery besides that it is needed also control systems of the load for solar power plant systems by using Internet of Things. By using blynk someone can turn on and turn off the load of the solar power plant, besides that we can also using the smartphone based on android to turn on or turn off the load of the solar power plant.

## 2. The Design of the System

**2.1.** Diagram System Configuration of the monitoring and load control system can be seen on figure 1

[1] Institute of Technology PLN, aas@itpln.ac.id

[2]Institute of Technology PLN, maulanaasco@gmail.com

[3]Institute of Technology PLN, hendrianto.husada@itpln.ac.id

[4]Institute of Techonology PLN, tri.joko@itpln.ac.id

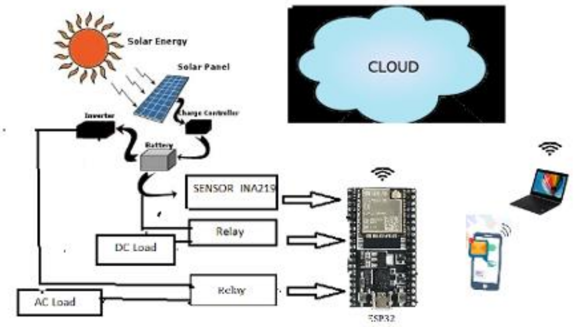


Figure 1 Diagram Of The Monitoring and Control load System for Solar Power Plant

## 2.2. The Component of the System

1. ESP32
2. Sensor INA219
3. Relay Module
4. Blynk
5. Battery Management Systems

## 2.3. Flowchart of the Systems

The Flow Chart of the System can be seen on figure 2.

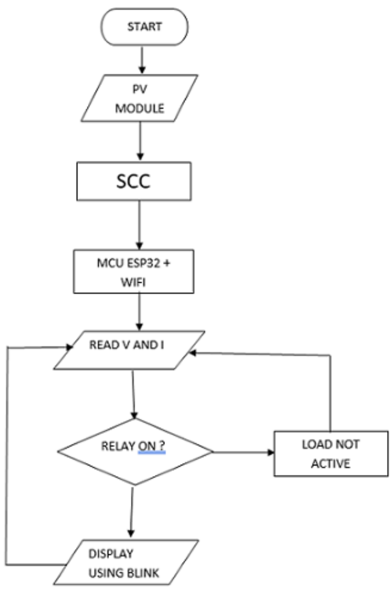


Figure 2. Flow Chart of The Systems

## 3. Result and Discussion

On this research There are some testing for the battery and load control system that can be seen using handphone or laptop through internet with software blynk. The display of output Blynk can be seen on figure 3.

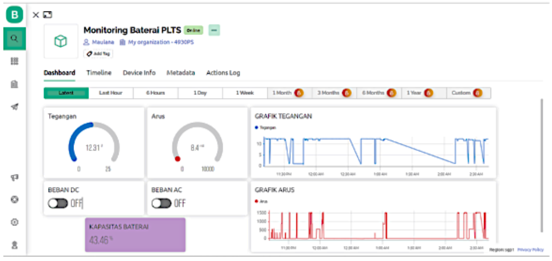

Figure 3. The Display of monitoring using Blynk

### 3.1. The Result of Voltage and Current Testing

The measurement of Voltage and Current in this testing was done using Sensor INA219 through Platform Blynk and using Digital Clampmeter Fluke 345 PQ directly . The measurement was done 20 times so that it can be gotten more accurate value.

#### 1. Voltage Measurement Without Load

It can be seen on table 3.1 the result of measurement voltage using IAN219 Sensor and Clampmeter. On the Figure 4 it is showed the Graphic of Comparison voltage measurement between sensor INA219 through Blynk and directly using Clampmeter Fluke directly.

Table 3.1 Voltage Measurement Without Load

| No | The Result of Voltage Measurement Platform Blynk (V) | Clampmeter (V) | Difference | Error Percentage (%) | Accuracy (%) |
|---|---|---|---|---|---|
| 1 | 12.41 | 12.44 | 0.03 | 0.24 | 99.75 |
| 2 | 12.43 | 12.43 | 0 | 0 | 100 |
| 3 | 12.41 | 12.44 | 0.03 | 0.24 | 99.75 |
| 4 | 12.41 | 12.43 | 0.02 | 0.16 | 99.83 |
| 5 | 12.41 | 12.43 | 0.02 | 0.16 | 99.83 |
| 6 | 12.40 | 12.42 | 0.02 | 0.16 | 99.83 |
| 7 | 12.42 | 12.44 | 0.02 | 0.16 | 99.83 |
| 8 | 12.43 | 12.43 | 0 | 0 | 100 |
| 9 | 12.42 | 12.45 | 0.03 | 0.24 | 99.75 |
| 10 | 12.39 | 12.40 | 0.01 | 0.08 | 99.91 |
| 11 | 12.39 | 12.39 | 0 | 0 | 100 |
| 12 | 12.38 | 12.38 | 0 | 0 | 100 |
| 13 | 12.39 | 12.40 | 0.01 | 0.08 | 99.91 |
| 14 | 12.40 | 12.40 | 0 | 0 | 100 |
| 15 | 12.40 | 12.40 | 0 | 0 | 100 |
| 16 | 12.40 | 12.41 | 0.01 | 0.08 | 99.91 |
| 17 | 12.40 | 12.41 | 0.01 | 0.08 | 99.91 |
| 18 | 12.39 | 12.40 | 0.01 | 0.08 | 99.91 |
| 19 | 12.40 | 12.40 | 0 | 0 | 100 |
| 20 | 12.40 | 12.42 | 0.02 | 0.16 | 99.83 |
| Average | | | | 0.10 | 99.89 |

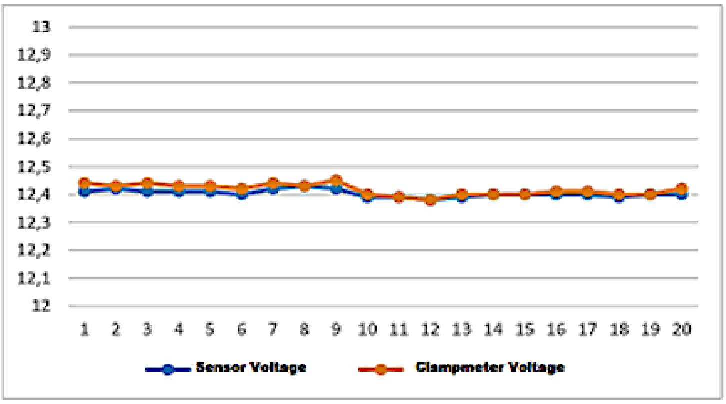


Figure 4 The Graph of The Comparison Voltage Measurement using Blynk and Clampmeter Without Load

**2. Voltage Measurement With Load**

On the Table 3.2 below ,it can be seen voltage measurement using sensor INA219 through Blynk and Clampmeter Fluke 345 PQ with DC load 5 Watt and AC load 8 Watt .And on the figure 5 it canbe seen the graphic of the comparison voltage measurement between sensor INA219 through Blynk and Clampmetr Fluke directly with load .

Table 3.2 Voltage Measurement with Load

| No | The Result of Voltage Measurement | | Difference | Error Percentage (%) | Accuracy (%) |
|---|---|---|---|---|---|
| | Platform Blynk (V) | Clampmeter (V) | | | |
| 1 | 11.60 | 11.25 | 0.35 | 3.11 | 96.88 |
| 2 | 11.60 | 11.23 | 0.37 | 3.29 | 96.70 |
| 3 | 11.60 | 11.22 | 0.38 | 3.38 | 96.61 |
| 4 | 11.60 | 11.22 | 0.38 | 3.38 | 96.61 |
| 5 | 11.60 | 11.23 | 0.37 | 3.29 | 96.70 |
| 6 | 11.60 | 11.23 | 0.37 | 3.29 | 96.70 |
| 7 | 11.60 | 11.23 | 0.37 | 3.29 | 96.70 |
| 8 | 11.60 | 11.24 | 0.36 | 3.20 | 96.79 |
| 9 | 11.59 | 11.25 | 0.34 | 3.02 | 96.97 |
| 10 | 11.59 | 11.24 | 0.34 | 3.02 | 96.97 |
| 11 | 11.59 | 11.23 | 0.36 | 3.20 | 96.79 |
| 12 | 11.59 | 11.23 | 0.36 | 3.20 | 96.79 |
| 13 | 11.60 | 11.23 | 0.36 | 3.20 | 96.79 |
| 14 | 11.60 | 11.23 | 0.37 | 3.29 | 96.70 |
| 15 | 11.60 | 11.22 | 0.38 | 3.38 | 96.61 |
| 16 | 11.59 | 11.22 | 0.37 | 3.29 | 96.70 |
| 17 | 11.59 | 11.23 | 0.36 | 3.20 | 96.79 |
| 18 | 11.58 | 11.22 | 0.36 | 3.20 | 96.79 |
| 19 | 11.59 | 11.23 | 0.36 | 3.20 | 96.79 |
| 20 | 11.59 | 11.22 | 0.37 | 3.29 | 96.70 |
| Average | | | | 3.24 | 96.75 |

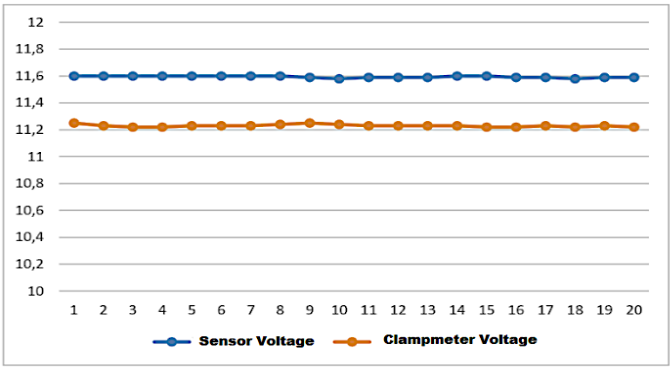


Figure 5 The Graph of the Comparison Voltage Measurement between Blynk and Clampmeter Fluke with load

### 3. Current Measurement Without Load

On Table 3.3 below it can be seen Current Measurement without load using sensor Ina219 through Blynk and using Clampmeter Fluke 345 PQ.The graph for current measurement without load can be seen on figure 6.

Table 3.3 Current Measurement Without Load

| No | The Result of Voltage Measurement | | Difference | Error Percentage (%) | Accuracy (%) |
|---|---|---|---|---|---|
| | Platform Blynk (V) | Clampmeter (V) | | | |
| 1 | 0.46 | 0.45 | 0.01 | 2.22 | 97.77 |
| 2 | 0.47 | 0.46 | 0.01 | 2.17 | 97.82 |
| 3 | 0.46 | 0.46 | 0 | 0 | 100 |
| 4 | 0.46 | 0.44 | 0.02 | 4.54 | 95.45 |
| 5 | 0.46 | 0.44 | 0.02 | 4.54 | 95.45 |
| 6 | 0.46 | 0.45 | 0.01 | 2.22 | 97.77 |
| 7 | 0.46 | 0.44 | 0.02 | 4.54 | 95.45 |
| 8 | 0.46 | 0.44 | 0.02 | 4.54 | 95.45 |
| 9 | 0.46 | 0.45 | 0.01 | 2.22 | 97.77 |
| 10 | 0.46 | 0.43 | 0.03 | 6.97 | 93.02 |
| 11 | 0.46 | 0.46 | 0 | 0 | 100 |
| 12 | 0.46 | 0.43 | 0.03 | 6.97 | 93.02 |
| 13 | 0.46 | 0.45 | 0.01 | 2.22 | 97.77 |
| 14 | 0.45 | 0.44 | 0.01 | 2.27 | 97.02 |
| 15 | 0.46 | 0.46 | 0 | 0 | 100 |
| 16 | 0.46 | 0.44 | 0.02 | 4.54 | 95.45 |
| 17 | 0.46 | 0.46 | 0 | 0 | 100 |
| 18 | 0.46 | 0.45 | 0.01 | 2.22 | 97.77 |
| 19 | 0.46 | 0.45 | 0.01 | 2.22 | 97.77 |
| 20 | 0.46 | 0.45 | 0.01 | 2.22 | 97.77 |
| Average | | | | 3.24 | 97.16 |

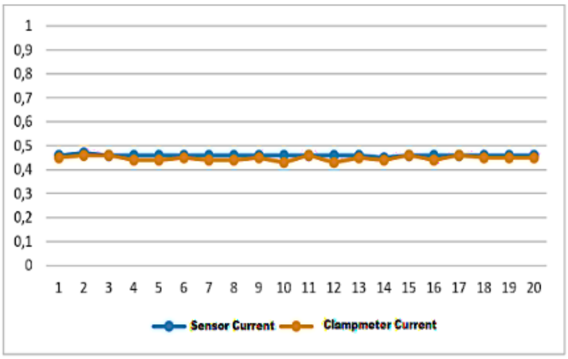


Figure 6 The Graph of The Comparison Current Measurement Between Blynk and Clampmeter Fluke Without Load

### 4. Current Measurement With Load

On The Table 3.4 below , it can be seen the record of current measurement with load using sensor INA219 and Clampmeter Fluke 345 PQ. The Graph for current measurement with Load can be seen on figure 7.

Table 3.4 Current Measurement With Load

| No | The Result of Voltage Measurement | | Difference | Error Percentage (%) | Accuracy (%) |
|---|---|---|---|---|---|
| | Platform Blynk (V) | Clampmeter (V) | | | |
| 1 | 1.25 | 1.21 | 0.04 | 3.30 | 96.69 |
| 2 | 1.25 | 1.22 | 0.03 | 2.45 | 97.54 |
| 3 | 1.24 | 1.21 | 0.03 | 2.47 | 97.52 |
| 4 | 1.25 | 1.23 | 0.02 | 1.62 | 98.37 |
| 5 | 1.25 | 1.21 | 0.04 | 3.30 | 96.69 |
| 6 | 1.23 | 1.23 | 0 | 0 | 100 |
| 7 | 1.25 | 1.20 | 0.05 | 4.16 | 95.83 |
| 8 | 1.24 | 1.18 | 0.06 | 5.08 | 94.91 |
| 9 | 1.25 | 1.20 | 0.05 | 4.16 | 95,83 |
| 10 | 1.24 | 1.23 | 0.01 | 0.81 | 93.02 |
| 11 | 1.25 | 1.22 | 0.03 | 2.45 | 97.54 |
| 12 | 1.24 | 1.20 | 0.04 | 3.33 | 96.66 |
| 13 | 1.24 | 1.20 | 0.04 | 3.33 | 96.66 |
| 14 | 1.23 | 1.18 | 0.05 | 4.23 | 95.76 |
| 15 | 1.24 | 1.20 | 0.04 | 3.33 | 96.66 |
| 16 | 1.24 | 1.20 | 0.04 | 3.33 | 96.66 |
| 17 | 1.24 | 1.23 | 0.01 | 0.81 | 99.18 |
| 18 | 1.24 | 1.21 | 0.03 | 2.47 | 97.52 |
| 19 | 1.23 | 1.20 | 0.03 | 2.50 | 97.50 |
| 20 | 1.25 | 1.20 | 0.04 | 3.33 | 96.66 |
| Average | | | | 2.82 | 97.17 |

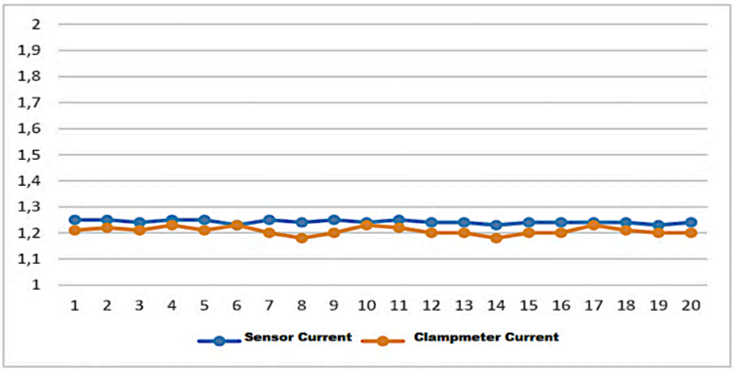


Figure 7 The Graph of The Comparison Current Measurement Between With Load Blynk and Clampmeter Fluke

### 3.2. Relay Testing

The reason of Relay Testing is testing the reliability and the performance of the relay when turn on or Turn off the lamp using relay remotely or through internet of things.The result of the testing was recorded on table 3.5.

Table 3.5 The result of relay testing

| No | DC Relay | AC Relay | DC Load | AC Load |
|---|---|---|---|---|
| 1 | HIGH | HIGH | OFF | OFF |
| 2 | HIGH | LOW | OFF | ON |
| 3 | LOW | HIGH | ON | OFF |
| 4 | LOW | LOW | ON | ON |

### 3.3. The Testing of Battery Capacity

The Battery that is used in this testing has 12 V, 7.2 Ah. This testing use OCV (Open Circuit Voltage) Method with the Minimum voltage from SCC is 10.7 V and The Maximum voltage is 14.4 V. On Table 3.6, it can be seen The Comparison of the result for Battery Capacity Testing

Table 3.6 The Result of the Battery Capacity Testing

| No | Battery Capacity blink Platform (%) | Battery Capacity by Calculation (%) | Difference | Error Percentage (%) | Accuracy (%) |
|---|---|---|---|---|---|
| 1 | 56.22 | 56.48 | 0.26 | 0.46 | 99.53 |
| 2 | 53.22 | 53.24 | 0.38 | 0.71 | 99.28 |
| 3 | 52.65 | 52.70 | 0.05 | 0.09 | 99.90 |
| 4 | 50.38 | 50.27 | 0.11 | 0.21 | 99.78 |
| 5 | 46.59 | 46.48 | 0.11 | 0.23 | 99.76 |
| 6 | 43.24 | 43.24 | 0 | 0 | 100 |
| 7 | 39.68 | 39.72 | 0.04 | 0.10 | 99.89 |
| 8 | 36.54 | 36.48 | 0.06 | 0.16 | 99.83 |
| 9 | 32.43 | 32.65 | 0.22 | 0.67 | 99.32 |
| 10 | 25.41 | 25.40 | 0.01 | 0.03 | 99.96 |
| Average | | | | 0.27 | 99.79 |

## 4. Summary

- The Result of The Voltage Testing Without Load Has the accuracy of 99.89 %
- The Result of The Voltage Testing With Load Has the accuracy of 96.75%
- The Result of The Current Testing Without Load Has the Accuracy of 97.16%
- The Result of The Current Testing With Load Has The accuracy of 97.17%
- The Result of The Battery Capacity Testing Using OCV Method Has The Accuracy of 99.79%

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