Monitoring of Voltage and Load Current Integration of Solar Panels with Electric Grids Android-Based

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***Abstract*—Energy has been a human need since ancient times which has been an indicator of prosperity. However, that doesn't mean there won't be problems. The longer the petroleum reserves are getting depleted, so sooner or later humans must make more use of non-fossil alternative energy. An example is solar energy whose availability will never run out. Therefore, the application of Solar Power Generation (PLTS) technology to utilize its energy potential. The goal of the project is to develop a system for integrating solar power with electrical grids that can track the voltage and current of the applied load. The PZEM004T sensor produces an accuracy of 99.4 percent on the voltage variable test, which compares favorably with the ACS712 current sensor's accuracy of 97.8 percent. The lowest light intensity measured in the current variable test is 24351 lux with an output voltage of 17.32V at the time range between 4-5 pm, and the highest is 103901 lux with an output voltage of 18.9V at the time range between 11-12 am. Accuracy is 98.5 percent with light loads and 99.2 percent when the charger is used. Relays' ability to switch between resources has been tested, and the results have met expectations.**

***Keywords*— Solar panels, Electric Grids, ACS712 Sensor, PZEM004T Sensor, Android.**

I. INTRODUCTION

Energy has been a necessity for mankind from ancient times to the present, where it is used in practically every facet of daily life. Energy demand is increasing day-to-day according to the increase in population and industrial expansion [1]. The increase in energy demand can be an indicator of increasing prosperity, but at the same time it creates problems in the effort to supply it [2]. The drawback of modern fossil fuels is their difficulty in transportation to rural areas with little or nonexistent electricity. Solar energy is an unlimited source of energy and its availability will never run out and this energy can also be used as alternative energy that will be converted into electrical energy, using solar cells [3]. Solar panels are often used for areas that are not covered by electricity.

Solar panel is a device or component that can convert light energy into electrical energy with the principle of the photovoltaic effect or a phenomenon where the emergence of an electric voltage due to the connection or contact of two electrodes connected to a solid or liquid system when receiving energy [4]. This solar panel can be placed in an open area that gets direct sunlight such as the roof of a house or building is an ideal place to put the solar panel [5]. Parameters like voltage and current can be used to directly monitor solar panel performance. As a result, it is possible to determine from this monitoring whether the installation of solar panels is adequate and generates the anticipated production of power [6]. There is a need for automatic control of loads to ensure the efficient use of electrical energy by its consumers through automatic control of loads using a mobile app and a Bluetooth module [7].

In order to monitor the voltage and current of the load being used, this study approach involves building a system that integrates solar panels with electrical networks. Since the system is still merely a prototype, the load and tool's parameters are not too demanding. 100Wp solar panels, 500W inverters, 12A batteries, a solar charge controller to control the amount of extra current going into the battery, ACS712 and PZEM004T sensors, and a relay acting as a switch for the power source were all used.

The ACS712 sensor is a sensor for detecting current [8]. The ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging. [9]

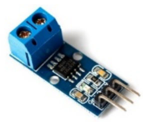

Figure 1. ACS 712 Current Sensor [10]

The power meter is mainly used for measuring AC voltage, current, active power, frequency, power factor and active energy, the module is without display function, the data is read through the TTL interface. PZEM-004T-10A built-in shunt have measuring range 10A, and PZEM-004T-100Awith external transformer have measuring range 100A. [11]

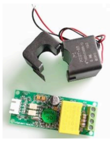

Figure 2. PZEM-004T [12]

Compared to other forms of power plants or conventional, PLTS planning is comparatively quite straightforward, but because this technology is still in its infancy, the procedure appears challenging and unfamiliar. The installation of PLTS equipment is plug-and-play because almost all of it is made up of systems with electronic components. In general, factors like the planned PLTS operating pattern and whether or not PLTS is connected to the electricity network at the planned location must be taken into account when planning a PV mini-grid. These factors have an impact on the choice of the type and capacity of the main components, such as solar modules (PV), inverters, and batteries. In PLTS, peak kilowatts are used to express capacity (kWp). The battery capacity is expressed in ampere hour (Ah) or kWh, whereas the inverter capacity is expressed in (kW). [13]

In general, there are three different types of PLTS designs: PLTS Off Grid/Stand Alone, PLTS on Grid, and PLTS Hybrid. PLTS Off Grid/Stand Alone is a PLTS system that is not connected to the grid/stands alone. PLTS On Grid is a PLTS system that is connected to the grid/existing system. On the other hand, PLTS Hybrid, is is an integrated PLTS system with one or several power plants with different primary energy sources, with an integrated operating pattern. [13]

II. METHOD

A. System Design

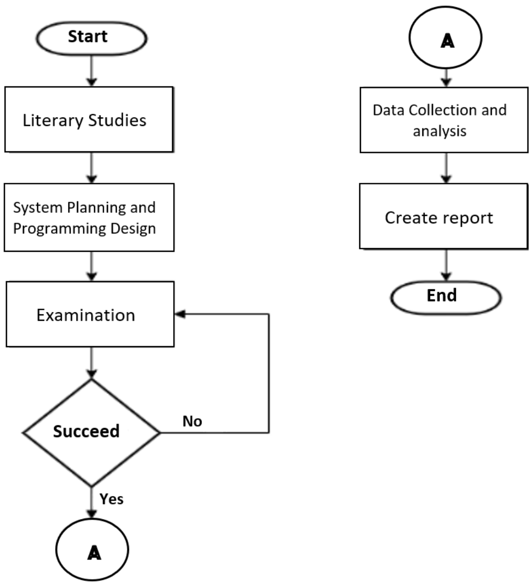

Figure 3. Research flowchart

In the figure 3 is a research design that will be carried out in making the system, in the first stage the identification of problems and literature studies are carried out to try to understand the existing problems so as to determine the right solution to overcome the problem. Then in the second stage, analyze the system requirements in the form of stages in studying sensors, microcontrollers, software, as well as the needs and specifications of the tools the that will be used in designing the system. In the third stage is system design, namely the process of making a work design of the system to be made. At the fourth stage is the implementation of the system, namely the stages in making the system in accordance with the system design that has been made previously. In the fifth stage is system testing, This stage is carried out to test the system that has been made whether it runs according to the plans that have been made previously. However, if the system testing is not appropriate, it will return to stage three, namely system design. The sixth stage is data retrieval, namely the stage of data collection when the system is working.

B. System planning

The following is a design of a voltage and current monitoring system for the integration of solar panels with Android-based electricity grid.

From the picture of figure 4 there is a block diagram of the research stages described for each block including solar panels capturing light to be converted into electrical energy that has been processed then passing through the solar charger controller as a safety so that there is no excess voltage that can damage the battery then the sensor must reads the value on the solar panel source and the voltage sensor reads the value that has been converted to the battery source to be flowed to the load, the voltage sensor is used to detect the voltage at PLN whose function is to be connected to the switch if a voltage is detected at PLN then the switch will make the incoming electricity flow sourced from PLN.

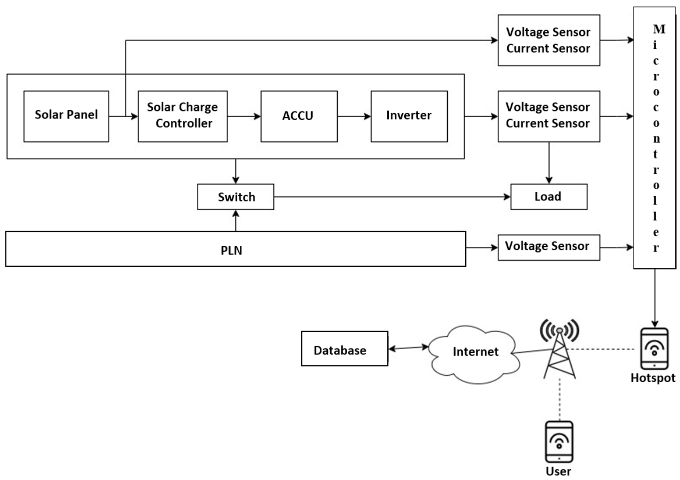

Figure 4. System block diagram

III. RESULTS AND DISCUSSION

A. Implementation Result

The results of the implementation of monitoring the voltage and load current of the integration of solar panels with Android-based electric grids are shown in the image below.

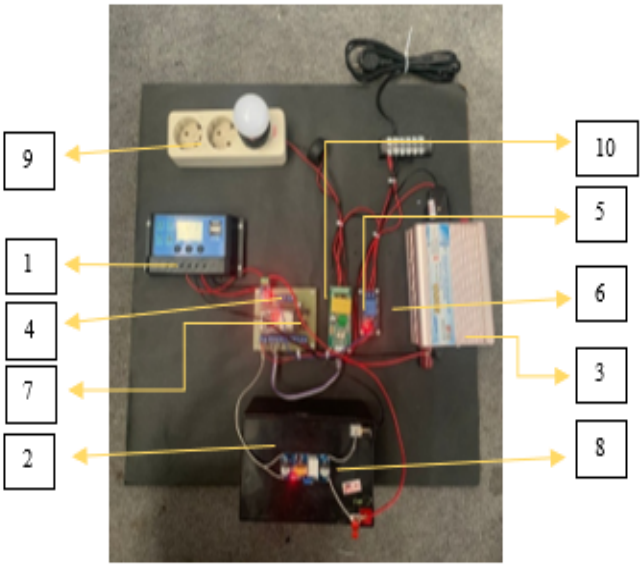

Figure 5. Hardware implementation

The following is an explanation of the image above:

1. Solar charger controller, serves to protect and automate battery charging, also to optimize the system and keep battery life maximized.
2. Batteries, to store the power that has been generated by the solar panels.
3. Inverter, to convert DC flow into AC so that it can be flowed to the load. In high current, the input DC wire may produce voltage drop, therefore, the operating voltage should be subject to the value on the terminals[14].
4. ACS-712 sensor, serves to read the value of the electric current that passes through it.
5. The PZEM 004T sensor is used to read the current and voltage values for the load used.
6. Relay, to connect and disconnect electric current in a circuit.
7. ESP32, is a microcontroller that functions to transmit data from the readings of the sensors used. ESP32 is a single 2.4 GHz Wi-Fi-and-Bluetooth combo chip designed with the TSMC ultra-low-power 40 nm technology [15].
8. Buck converter, serves to lower the voltage. Here it is used as the power used to run ESP32.
9. The outlet, is used to transmit power from the solar panels stored in the battery, which is then converted from DC to AC by the inverter and can be used to supply power to the load.
10. DC voltage sensor and AC voltage sensor, the DC voltage sensor is used to read the voltage value generated by the solar panel, while the AC voltage sensor functions to monitor the flow of electricity to the electric grids.

TABLE I
OVERALL SYSTEM TEST

Time (am)	Status PLN/PV	Solar Panel		Load		Note
		Voltage (V)	Current (A)	Voltage (V)	Current (A)	
10.22	PLN	16.18	1.42	218	0.13	30W cell phone charger load
10.23	PLN	17.44	1.41	216	0.13	30W cell phone charger load
10.25	PLN	16.55	1.44	217	0.22	45W laptop charger load
10.25	PLN	16.31	1.42	217	0.21	45W laptop charger load
11.40	PV	17.4	1.48	218	0.11	30W cell phone charger load
11.42	PV	17.2	1.5	218	0.11	30W cell phone charger load
11.45	PV	18.1	1.62	220	0.19	45W laptop charger load
11.48	PV	18	1.61	219	0.27	45W laptop charger load

From the table above, it can be seen that the system is running well and the largest output voltage of the solar panel is at 11.48 am or at noon when the solar panel is directly facing the hot sun, at that time it produces the largest voltage of 18.1V with a current of 1.62A. Then the power generated at that time can be calculated by the following equation;

P = V x I (1)
P = 18.1 x 1.62
P = 2.93 watts

Then the results of the average power generated during the test carried out at 10.22-11.48 am can be calculated by the equation below.

$$P_{average} = \frac{P_1 + P_2 + \dots + P_n}{n} \quad (2)$$

$$= \frac{22{,}97+24{,}59+23{,}83+23{,}16+25{,}75+25{,}8+29{,}32+28{,}98}{8}$$

$$= \frac{204{,}4}{8}$$

$$P_{average} = 25{,}55 \text{ watt.}$$

IV. CONCLUSION

The system is designed using ESP32 microcontroller and relay as a control system. The data obtained is stored in the database and can be monitored in real time on the android application. The results of the calibration of the voltage and current monitoring system for the integration of solar panels with android-based power grids are data in the form of ACS712 current sensor values, PZEM004T sensors for load voltage and current. The results of testing the accuracy of the ACS712 current sensor is 97.8%, the PZEM004T sensor in monitoring the voltage and current at the load produces an accuracy of 99.4% in the voltage variable test. The current variable test results in an accuracy of 98.5% with the use of a lamp load, and 99.2% on the use of a laptop charger load. In testing the light intensity on the output voltage, it can be seen that the lowest light intensity is worth 24351 lux by producing an output voltage of 17.32V at a time range between 16.00-17.00 pm, and the highest is 103901 lux by producing an output voltage of 18.9V at the time range between 11.00-12.00 am.

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