DESIGN OF MONITORING SOLAR PUBLIC STREET LIGHTING (PJUTS) WITH LORA ESP32 NETWORK BASED ON INTERNET OF THINGS (IOT)

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ABSTRACT

One of the most popular renewable energy sources is the usage of solar panels, which have even been employed in some places as the primary source of power. Public Street Lighting and issues that frequently arise with Solar Cell Public Street Lighting, particularly during operating hours brought on by damage stored in the battery. Long distances become a concern in and of themselves, thus they must be monitored frequently.As a result, researchers are working to develop a Lo-Ra-based monitoring system for public solar street lights. According to the research, it is possible to track all data sent in real time, including battery voltage, LDR (Light Dependent Resistor) values, current data flowing from solar panels, and current data being delivered. Since the lights are only bright at night if a human object is identified using a PIR (Passive Infrared Receiver) sensor, the discussion's findings and conclusions can be applied to an energysaving system. The design of this instrument can make it easier for technicians to check because the maximum distance over which data can be sent in LoRa between the transmitter and receiver modules is 4 km.

Keywords: *Solar Public Street Lighting, LoRa, LDR, PIR*

1. INTRODUCTION

Lighting is one of the basic needs of today's society. Every living place of the community must always desire to have enough light. Indeed, all activities of the community, both indoors and outdoors, day and night, necessarily have light. (Hartono, et al., October 2021) A typical electricity crisis could arise at any time as a result of rising human demand. Many people are now beginning to transition to using alternative energy sources in an effort to avoid this problem.

The alternative energy source that is most frequently used is solar power, also referred to as PLTS. Solar Power Plants (PLTS) are an environmentally beneficial energy source that don't need fuel oil to generate electricity. Consequently, it is incredibly affordable because solar energy is a limitless supply of energy. PLTS is frequently used in solar-powered buildings, vehicles, pumps, streetlights, and other devices.

Drivers and pedestrians may have better visibility of the road and adjacent terrain in inclement weather or at night because to this PJU. If traffic safety is improved, road users will be better shielded from illegal behavior. Excellent lighting is one of the community's requirements when navigating the streets. A tax known as the Street Lighting Tax (PPJ), whose amount is determined by each local authority as long as it is not larger than 10%, is needed to be paid by individuals when they pay their electricity bills, in accordance with Regional Regulation No. 15/2010 on Street Lighting Tax. Solar public street lighting (PJUTS) is a solution for roads and areas outside the PLN network or for costeffective lighting.

Area and street lighting is provided via the Solar Public Street Lighting (PJUTS) Off Grid PLTS program, which uses solar-charged batteries. With the poles spaced 25–50 meters apart, solar public street lighting (PJUTS) for street lighting can be deployed in a number of ways. This will make the lighting more effective and reduce the amount of unlit space by distributing the light intensity on the ground fairly equally. To the detriment of those in charge, Solar Public Street Lighting (PJUTS) is intended to be lighted up to 12 hours per day, which results in very high electricity usage. There are additional challenges or issues that frequently arise with PJUTS, such as operations lasting just a short time due to the insufficient battery capacity and wasteful use, which results in lights turning off during operational hours. (Poliama, Surusa, & Abdullah, 2021)

2. METHOD

The ADDIE method itself is described in five stages of the development process:

1. Analyze

The initial stage of the ADDIE development research model is an analysis of the need for new product development (models, methods, media, training materials), as well as an analysis of the viability and needs for product development. A flaw in an applied or existing product might serve as the catalyst for the development of a new product. Because current or available products are no longer appropriate for the target audience's needs, the learning environment, technology, student characteristics, and other factors, problems can and do arise.

2. Design

The design activity in the ADDIE development research paradigm is a systematic procedure that begins with designing the concept and content of the product. Each product's content is written for the design. The product's assembly instructions are given in clear, precise detail. The product design is still conceptual at this point and will guide the development process in the following step.

3. Development

The realization of the previously developed product design is considered development in the ADDIE development research paradigm. A conceptual framework for putting a new product into use was created at the earlier stage. A finished product that is ready for implementation is created from the conceptual framework. Making equipment to gauge product performance is also required at this stage.

4. Implementation

The goal of product implementation in the ADDIE development research methodology is to get feedback on the developed or created product. You can get the first impressions (first appraisal) by posing inquiries about the goals of product development. Implementation is done in accordance with the created product design.

5. Evaluation

Phase V of the ADDIE model development study is the evaluation phase. In order to get feedback from product users and make adjustments in response to assessment findings or needs that the product cannot satisfy, the evaluation stage of the ADDIE model development study is carried out. Evaluation's main objective is to gauge how well development objectives have been accomplished.

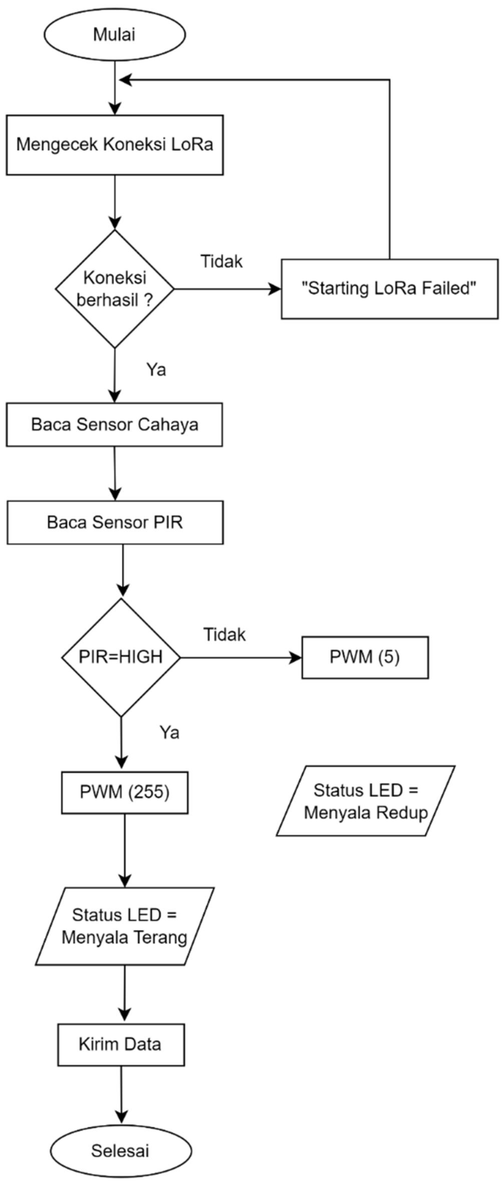

Figure 2.1 How the LoRa Transmitter Works

According to the created flowchart, this process serves as the tool's starting process. Checking the LoRa connection to ensure it is connected to the receiver is the first step in the LoRa module transmitter process. The LED lights will turn on faintly when the light sensor detects an LDR value of less than 600 once the transmitter and receiver have established a connection. The PIR sensor (Passive Infrared Receiver) will continue to be read once the LDR value is discovered to be greater than 600. This PIR sensor will determine if there is object movement or not, and if there is none, the LED lights will dimly come on. The LED lights will become brilliantly illuminated when the PIR sensor picks up movement of an object. The LoRa module receiver will communicate information collected from the transmitter, such as current from the solar panel, voltage from the battery, LDR value, and whether or not an object is moving.

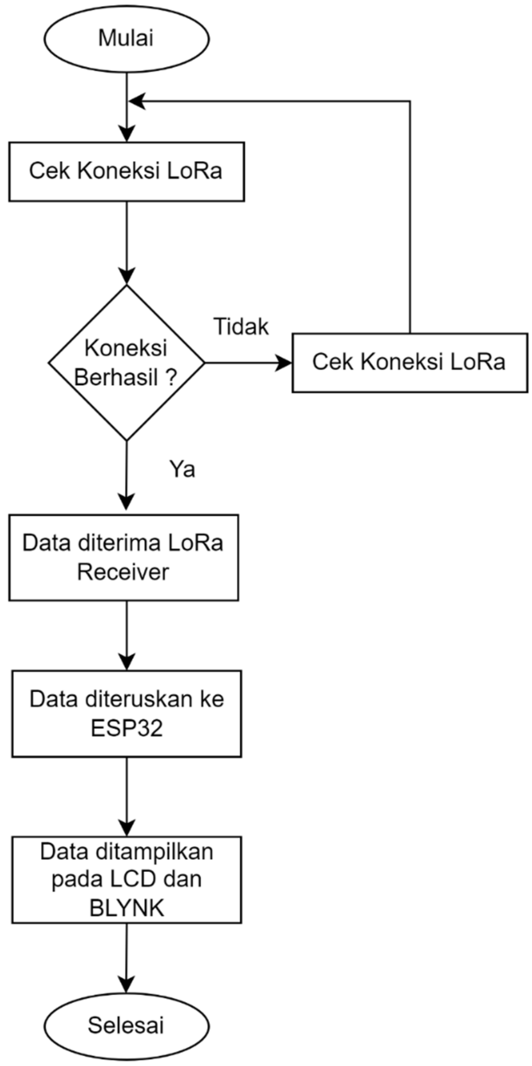

Figure 2.2 How the LoRa Receiver Works

Data supplied from the transmitter is received by the LoRa module during the receiver operation. Additionally, it begins by examining the connection between the Lora transmitter and receiver. The data it receives will keep sending after the LoRa connection is established. The information will be shown on both the LCD and the device's associated BLYNK application.

3. RESULT AND DISCUSSION

In this final project, a gadget is created that uses a solar panel to collect sunlight, which is then sent to a battery, which stores the electrical energy the solar panel produces. From the battery to the SCC (Solar Charge Controller), which controls the voltage drawn from the battery and sent to the load—in this case, the solar lamp—by use of a solar charge controller. Following that, the voltage sensor and ACS712 sensor are used to measure the current and voltage obtained from the solar panel and battery, respectively. The BLYNK program will use the LoRa module as a data sender with a frequency signal, and the results of the current sensor and voltage sensor will be shown on a 16 x 2 LCD.

In this final project, tool design, in addition to employing hardware, also requires software for programming using Arduino Uno and BLYNK. The Arduino IDE is used to program hardware components so that the microcontroller-connected device's circuit can function as intended. The data obtained from the sensor is monitored using the BLYNK application.

3.2.1.1 Solar Cell Testing

On July 9, 2023 Charlie, testing was done using the necessary tools, including solar panels, an SCC (Solar Charge Controller), batteries, and multimeters. The testing lasted from 8 a.m. until 16 p.m.

3.2.1.2 Battery Testing

Figure 3. 1 Battery Testing

The purpose of testing a battery is to determine whether it is in excellent condition and whether it meets the written requirements. Using an avometer to measure the battery voltage yields values of 12.56 V and 2.2 A, indicating that the battery complies with the published requirements and is in good condition.

3.2.1.3 SCC (Solar Charge Controller) Testing

Testing on the SCC (Solar Charge Controller) is used to determine the condition of the SCC can function as a regulator of voltage and current flowing from the solar panel to the battery so that the battery is not overvoltage or overcharging.

Figure 3.2 SCC (Solar Charge Controller) Testing

3.2.1.4 ACS712 Sensor Testing

Testing of the ACS712 sensor is done to see if it is in good enough condition to read data from solar panels or not. The sensor's ability to transmit readings to the ESP32 and show them on the BLYNK application is tested in this test.

3.2.1.5 RTC (Real Time Clock) Testing

Real-time clock (RTC) tests are performed by contrasting the time information on the RTC with calibrated time information. When used as a digital clock timer, RTC will display hours, minutes, and seconds of time information. In this circuit, the RTC serves as a timer that is displayed on the LCD and listed in the BLYNK program.

Table 3.1 RTC (Real Time Clock) Testing

No.	Waktu	
	Modul RTC	Jam Sesungguhnya
1.	14:2:5	14:3:1
2.	14:58:36	14:59:32
3.	19:26:18	19:27:14
4.	19:27:4	19:28:00

4.2.1.6 LDR sensor Testing

When testing the LDR (Light Dependent Resistor) sensor, measure the strength of the sun's rays. If it's strong, the LDR (Light Dependent Resistor) will indicate that the outside environment is bright; if it's weak, it will indicate that the environment is dark or covered

.Table 3.2 LDR Sensor Testing

Waktu	Nilai LDR
14:01	36
14:02	37
19:26	557
19:27	752

3.2.1.7 PIR sensor Testing

The table above indicates that a PIR (Passive Infrared Receiver) sensor can detect human movement up to a maximum of 4 meters away. PIR sensors cannot be detected at distances greater than 4 meters.

Table 3.3 PIR Sensor Testing

Jarak (m)	Sensor PIR
1 m	Terdeteksi
2 m	Terdeteksi
3 m	Terdeteksi
4 m	Terdeteksi
5 m	Tidak Terdeteksi
6 m	Tidak Terdeteksi

3.2.1.8 LoRa Module Testing

This test involves setting up the transmitter module in the T lab and the reception module in a certain location, then waiting until the transmitter module stops transmitting data.

Table 3.4 LoRa Module Testing

No.	Jarak Pengujian	Beban	Hasil Pengujian
1.	2 km	Lampu LED	A= 0.85 A V=12.36 V
2.	2,5 km	Lampu LED	A= 0.62 A V=12.35 V
3.	3 km	Lampu LED	A = 0. 8A V = 12.3 V
4.	3,5 km	Lampu LED	A = 0.85 A V = 12.35 V
5.	4 km	Lampu LED	A = 12.45 A V = 12.36 V

6.	4,5 km	Lampu LED	A=Tidak Terdeteksi V=Tidak Terdeteksi
7.	5 km	Lampu LED	A=Tidak Terdeteksi V=Tidak Terdeteksi

3.2.1.9 Overall Testing

A. Daylight Condition

When sunlight is shining directly on the earth, it is said to be in a daylight situation. The LDR sensor's resistance value will rise in certain circumstances, increasing the value that the Arduino reads. A high ADC value causes the SCC (Solar Charge Controller) to automatically cut off the supply voltage to the LED driver, which causes the LED lights to turn off (OFF).

Table 3.5 Daylight Condition

No.	Waktu	I (A)	LDR	V (V)	LED
1.	12:07	0.86	35	12.56	Off
2.	12:30	0.75	35	12.53	Off
3.	13:15	0.90	36	12.55	Off
4.	13:55	0.81	35	12.53	Off
5.	14:00	0.81	36	12.54	Off
6.	15:00	0.82	37	12.54	Off

B. Nighttime Condition (No object)

The resistance value of the LDR will decrease at night, or when there is no sunshine, causing the ADC value to be read at its lowest and the lights to switch on. In this system, there are two ways to activate the LED lights. The first is by reading the PIR sensor's output conditions, which will look for human or object movement close to the LED lights. The PIR sensor is inactive when there are no human objects visible next to the lamp, therefore the lights will weakly come on.

Table 3.6 Nighttime Condition (No Object)

No.	Waktu	I (A)	LDR	V (V)	LED
1.	18:00	0	693	12.48	Redup
2.	18:30	0	532	12.48	Redup
3.	19:45	0	465	12.35	Redup
4.	20:00	0	563	12.30	Redup
5.	21:30	0	532	12.30	Redup
6.	22:45	0	587	12.34	Redup

C. Nighttime Condition (Objects present)

The PIR sensor will be active and send a HIGH signal to the Arduino when there is human or object movement near the LED lights on the road. In order to turn on the LED lights to their full brightness when the Arduino receives a HIGH signal, pin 5 will supply PWM with a value of 100%.

Table 3.7 Nighttime Condition (Object Present)

No.	Waktu	I (A)	LDR	V (V)	LED
1.	18:00	0	709	12.40	Terang
2.	18:30	0	752	12.32	Terang
3.	19:45	0	800	12.32	Terang
4.	20:00	0	709	12.32	Terang
5.	21:30	0	973	12.30	Terang
6.	22:45	0	825	12.37	Terang

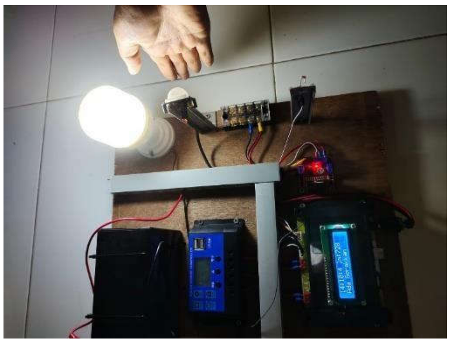

Figure 3.3 Nighttime Condition (Object Present)

Following extensive testing of various system components and the integrated system as a whole, the benefits and drawbacks of the tool are explained in order to provide a summary of the discussion's findings.:

3.2.2.1 Tool Disadvantages

1. BLYNK cannot be used to monitor bulb current
2. Inability to remotely check light voltage

4.2.2.2 Advantages of the Tool

1. The ability to remotely monitor means that you can keep an eye on the state of solar public street lighting without physically visiting the area.

2. Because of this design's ability to control dim lighting, the lifespan of the battery or batteries utilized is anticipated to be increased.

3. Is able to monitor directly through the installed 16 x 2 LCD.

4. This tool's design has one advantage over the previous one: monitoring is now possible using a smartphone and the BLYNK app.

4. CLOSING

A. Conclusion

From the observation of the Design of Solar Public Street Lighting Monitoring System (PJUTS) with LoRa Network Based on the Internet of Things, as described in the previous chapter, conclusions can be drawn, among others:

1. This tool's architecture allows it to track the voltage from the battery, the LDR value, the current coming from the solar panel, whether or not an object is moving around the LED lights, and the current. Because the LDR value indicates strong light intensity during the day, the LED lights will switch off. Since the LDR value indicates low light intensity at night, the LED lights will only come on weakly. However, if an item moves at night, the LED lights will come on brilliantly. Because lights are only used when necessary, the battery will last longer as a result.
2. This tool's design makes advantage of the LoRa network as a means of remote communication. The LoRa network can monitor the state of solar public street lighting up to a distance of roughly 4 km, but at distances beyond that, it is unable to determine the battery's current or voltage. This gadget will assist technicians in remotely monitoring conditions.

B. Advice

Modification and development are required to enhance and perfect a tool's performance function. The author offers the following suggestions, among others, to enhance and grow this tool:

1. By adding an extended antenna as a signal amplifier, the LoRa communication module may deliver data farther and with higher stability by using it as a signal amplifier.

2. In order to monitor when the lights are out from a cellphone, perhaps the voltage from the lamp can be incorporated as part of additional research.

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