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Implementation of LoRaWAN on Energy Monitoring System on the Onion Leaf Pest Light Trap device

Implementasi LoRaWAN Pada Sistem Monitoring Energi Perangkat *Light Trap* Hama Daun Tanaman Bawang

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Abstract

Shallot cultivation is a significant livelihood for farmers due to the high selling value of the harvest. However, most farmers still control shallot pests by excessively spraying pesticides, leading to concerns about excess residue on the plants. Physical control methods, such as installing light traps on plantations, have been attempted, but their manual operation is inefficient for farmers' working time and prone to wasting electrical energy due to negligence. In this research, the light trap will be optimized by implementing an automatic light monitoring and control system, allowing farmers to estimate the cost of electricity used and adjust usage according to their needs. The LYNX32 BOARD LoRa plays an important role as a data processor, connected to the LDR sensor to enable automatic light activation, and the PZEM-004T sensor to monitor the voltage and current of the light trap, transmitting this data via LoRa communication. In this research, automatic control operates based on the light intensity, and LoRa can transmit data up to a distance of 250 meters under line-of-sight (LOS) conditions. The PZEM-004T sensor has good accuracy for voltage, with an error of 0.08%, while the error percentage for current and power is 13.26% and 5%, respectively.

Keywords: Internet of Things, LoRa Communication, LDR, PZEM-004T

Abstrak

Tanaman bawang merah menjadi salah satu mata pencaharian petani yang memiliki nilai jual yang tinggi dari hasil panennya. Namun, mayoritas petani masih mengendalikan hama tanaman bawang merah dengan penyemprotan pestisida secara berlebihan dan dikhawatirkan tanaman bawang merah mengalami kelebihan residu. Pengendalian fisik sudah diupayakan dengan memasang *light trap* di perkebunan tetapi pengoperasianya masih manual sehingga tidak efisien terhadap waktu kerja petani serta rawan terjadi pemborosan energi listrik akibat kelalaian. Pada penelitian ini *light trap* tersebut akan di optimasi dengan menerapkan sistem monitoring dan kontrol lampu otomatis supaya petani bisa mengetahui estimasi biaya dari listrik yang dipakai serta listrik yang dipakai bisa sesuai dengan kebutuhan. LYNX32 BOARD LoRa berperan penting sebagai pengolah data yang terhubung dengan sensor LDR agar lampu bisa menyala secara otomatis, sensor PZEM-004T agar bisa memantau tegangan dan arus yang ada pada *light trap* dan dikirimkan melalui komunikasi LoRa. Pada penelitian ini kontrol

otomatis dapat beroperasi berdasarkan intensitas cahaya, LoRa dapat mengirimkan data sampai jarak 250 meter dengan kondisi LoS. Sensor PZEM-004T memiliki akurasi yang bagus untuk tegangan dengan kesalahan 0.08% sedangkan untuk persentase kesalahan arus dan daya cukup tinggi yaitu 13.26% dan 5%.

Kata kunci: *Internet of Things*, Komunikasi LoRa, LDR, PZEM-004T

I. INTRODUCTION

Control and prevention of pests of onion leaves carried out by farmers mostly involve manual methods, such as directly removing larvae from the leaves. This method requires substantial human labor and incurs significant costs. Preventing moth larvae on onion leaves is generally done by spraying insecticides around the base of the plant stem at least once every 2-3 days, continuing until the harvest period. Continuous spraying of insecticides can lead to the development of pest immunity to these chemicals. Therefore, a tool is needed to help farmers control and reduce pests on onion leaves, thereby shortening farmers' work time, reducing costs, and being easy to use.[1].

Tools to help control pests on onion leaves already exist, such as light traps placed in the onion plantation area with buckets filled with soapy water positioned just under the lamps. This tool is simple but quite effective for preventing pests on onion leaves and can reduce cultivation expenses for farmers[1]. However, if the use of electricity in light traps is not managed wisely, it can lead to the waste of electrical energy[2]. According to Presidential Instruction Number 13 of 2003 concerning the saving of electrical and water energy, it is instructed for all communities to conserve electricity. One way to avoid the waste of electrical energy is to use electricity wisely and in a controlled manner, thus necessitating the monitoring of electrical power usage and associated costs.[3].

With advancements in technology, IoT has become very useful, including in the agricultural sector[4][5][6], Therefore, this research aims to implement IoT technology to save electrical energy in leek pest trap systems[7]. This research is expected to aid in monitoring the use of electrical energy in the light traps for onion leaf pests. The monitoring system using IoT technology will make it easier for farmers to monitor electrical energy usage and minimize energy waste due to negligence.

II. LITERATURE REVIEW

Research [8] discusses pests and diseases that attack onion plants. The study was conducted by direct observation in three villages in Brebes Regency with an average observed land area of 0.5 ha with a plant age of 14 HST. Pests that often attack onion plants are armyworms (Spodoptera exigua Hbn) which are active at night and have a natural nature attracted to light. From the results of interviews in this study, the most effective pest control measures are by installing light traps with white lights. Light trap lamps are installed on bamboo poles along approximately 50 cm between the beds of onion plants and are lit for 12 hours there is a plastic container under the lamp that is used to accommodate trapped pests

Research [9] designed an automatic light system using Arduino that sends commands to the real-time clock (RTC) to read the time and will display the time data on a liquid crystal display (LCD). In this study, it was explained that this research was caused by farmers using lamps to repel pests so as not to disturb onion plants, but the lights were still manual in operation. The conclusion of this study is real-time clocks (RTC) and relays work well according to the time input program set. From this research, the author will design a smart light system to help farmers overcome onion leaf pests, namely light traps, and optimize the light trap. The thing that distinguishes this study from previous studies, is this study combines the light trap with the Internet of Things technology so that it can help farmers more this research will add a monitoring system and automatic control system to the light trap so that it is more efficient in operating it.

Then research [10] explains the control and monitoring system can be done more simply and easily via smartphone. This research explains if the smart light system will be run using a smart home application and connected to the user. Applications installed on smartphones are created using MitApp Inventor then the resulting data will be stored in a database called Firebase. The data tested in this study includes electrical power, electric voltage, electric current, and the cost of electricity use which will later be monitored by users via smartphones. With the monitoring system from these data, it will certainly be more efficient and more flexible in use, especially in terms of costs incurred from the use of electrical energy. In this study, the author will use a smartphone as a monitoring medium in the design of the light trap system but does not use an application but a web dashboard so that it can monitor without having to install an application.

The research journal [11] made a smart lamp design with a website as its monitoring media and made it so that the monitoring system can be monitored in real time. In this study explained for the working system, the smart light system will begin with an LDR sensor as a medium to respond if there is light intensity entering. The result of the response will have an impact on the connected lights to turn on or off. The readings from the sensor will then be processed by Arduino and sent through a technology called LoRa. The smart lights produced from this research will be applied to the public street lighting system, and then the website that was created earlier will be set up to be able to send a notification via email containing notifications if there is damage to the smart lights. This is very helpful for users because they can find out the damage without having to go to the location of the smart light earlier.

The research journal [12] discusses the quality of LoRaWAN protocol services in agricultural soil moisture monitoring devices. Based on the findings it is possible to conclude that the propagation used at the time of transmission influences the success rate of data transmission via LoRaWAN communication. Line of Sight (LOS) propagation has a higher success rate than Non Line of Sight (NLOS) propagation. The LOS value is 17% greater than the NLOS at a distance of 100 meters. The LOS value is 24% greater than the NLOS at a distance of 150 meters. The LOS value is 3% greater than the NLOS value at a distance of 200 meters. LOS propagation measurement throughput is higher than NLOS propagation measurement throughput.

Referring to the research, the author was inspired to design a smart lighting system where power input is generated from the PZEM-004T sensor with a communication network through LoRa. In this study, smart lights are applied for the use of public street lighting, while the author will apply them to light traps of onion leaf pests which will make it easier for farmers to monitor the lights installed along the onion plantation plots remotely

III. RESEARCH METHOD

This research will be carried out in several stages to ensure a structured approach. The stages of this research will begin with problem formulation, followed by designing software and hardware systems, creating the software and hardware systems, testing, and finally analyzing the results and drawing conclusions from the design. The research flowchart can be seen in Figure 1.

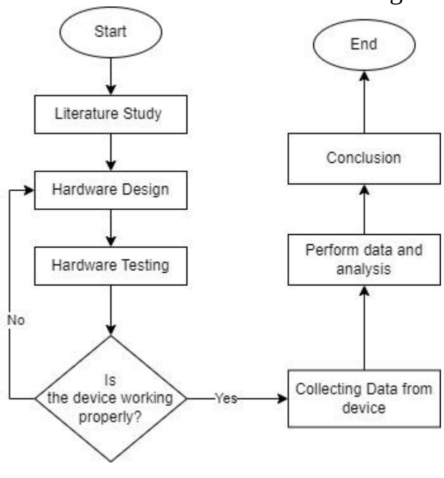

Figure 1. Research Flowchart

Based on Figure 1, the research begins with a literature study. Then, the hardware is designed based on the information obtained. After that, the hardware is built and tested. If the test fails, the design is revised and tested again. If the test is successful, data from the device is collected and analyzed to conclude.

This research uses several devices to produce parameters or data for analyzing the performance of the monitoring and control system on the light trap for onion leaf pests through an IoT-based web dashboard. In this study, both software and hardware are developed. An illustration of the device implementation can be seen in Figure 2. Based on Figure 2, when the node is activated, the process of reading electrical parameters begins. The node will also send the reading data wirelessly, and it will be received by the gateway to enable communication.

Figure 2. Device Implementation Scenario Illustration

System design in this study contains 3 stages, namely input stages, process stages, and output stages. Each stage has a different function and different components. At the input stage, there are 2 components, including the PZEM-004T sensor which is used to measure the voltage and electric current in the light trap tool later[13]. Then the last is the LDR sensor which is used to provide input according to the state of the light around the light trap which will affect the on and off of the lights used. Furthermore, at this stage of the research process using the LYNX32 BOARD LoRa as a data processing microcontroller, the data that has been selected by the microcontroller will be sent to the relay as a command to the switch in it to produce output for the lights at the output stage as instructed from the input stage. In addition, the LYNX32 BOARD LoRa microcontroller will send sensor reading data through the LoRa network and receive it from the gateway [14]. The data received by the gateway can be seen on the Telkom IoT Platform. Receiving data from microcontrollers and relays by lamps is the output stage of the results of previous processes. The diagram of the system design blocks can be seen in Figure 3 and the wiring diagram hardware can be seen in Figure 4.

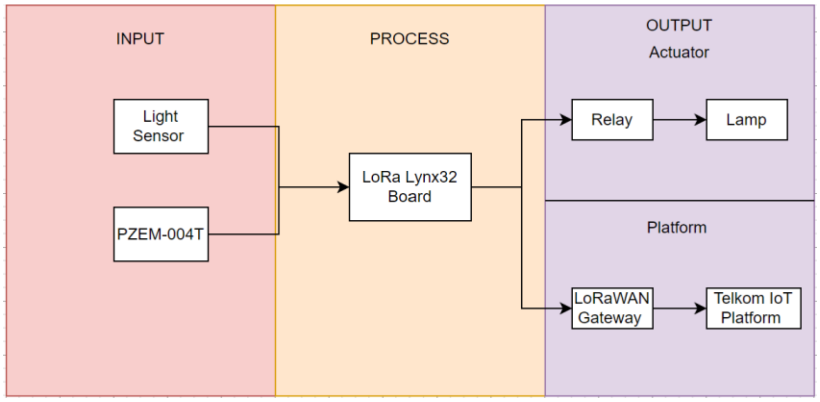

Figure 3. Diagram Block System

Based on Figure 3, the input section includes a light sensor and a PZEM-400T sensor, which functions as an electricity sensor. These sensors are integrated with the LoRa lynx32 board, which acts as a data processor and sends sensor information to the Telkom IoT Platform using the LoRaWAN protocol. Additionally, the designed device can control the lights via a relay connected to the board.

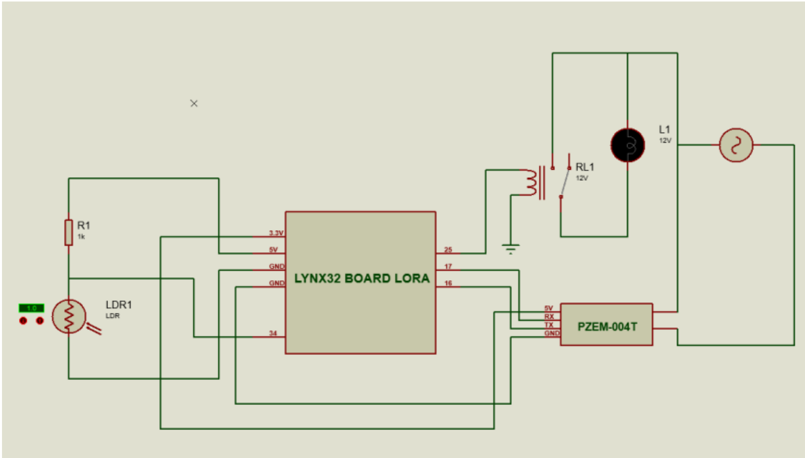

Figure 4. Hardware Wiring Diagram

Based on Figure 4, the Light Sensor is connected to Digital Pin 14 on the LoRa Lynx32 Board. Then the PZEM-004T sensor is connected to Digital pins 16 and 17 which are configured as a serial protocol via Serial Software. and the Relay is connected to Digital pin 25.

IV. RESULTS AND DISCUSSION

The final result of designing the tool has been made, there are several components in the tool with different functions. LYNX32 BOARD LoRa functions to control and process input data from the PZEM-004T sensor where the data is in the form of reading values of electrical parameters such as voltage, current, power, and electrical energy equipped with a current transformer (CT). The data will be sent by the LYNX32 LoRa BOARD to the Telkom IoT platform using the LoRa network. In addition to processing data from the PZEM-004T sensor, the LYNX32 BOARD LoRa will also process data from the LDR sensor in the form of reading light intensity values and forward to the relay to perform the ON/OFF command based on the LDR value limits that have been made in the program. For monitoring the output of the tool, you can see the personal dashboard on the Telkom IoT Platform. The design results of the device can be seen in Figure 5.

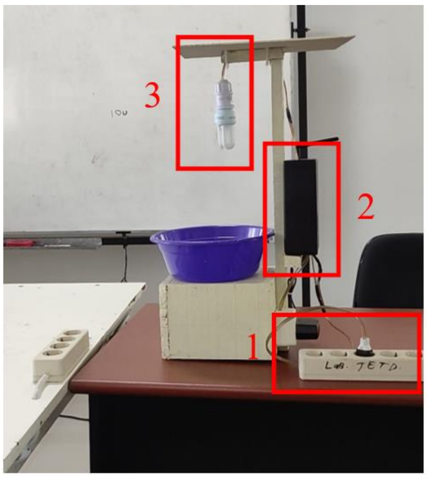

Figure 5. System Design Results, (1) Electric Source, (2) IoT Device , (3) Lamp

Based on Figure 5, the result of the overall design of the device, there are 3 parts in the design. The first part is the power input that comes from an electrical energy source, then the second part is the core part which contains the PZEM-004T sensor to read electrical energy parameters such as voltage, power, and current. In addition to the PZEM-004T sensor, there is also an LDR sensor, as well as a relay used for automation systems on light trap lights. The last part is the output part in the form of an 11-watt lamp as an output in this research.

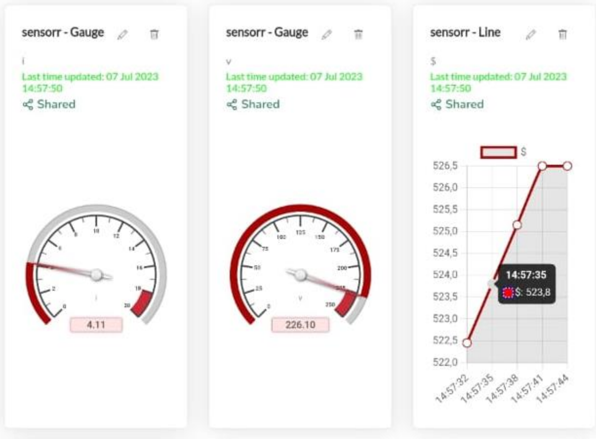

Figure 6. Sensor Data in IoT Dashboard

Based on Figure 6, the dashboard displayed is integrated with data on the IoT Platform and the dashboard can be displayed in the form of a Time Series Chart and gauge.

A. PZEM Sensor Accuracy

Parameter testing is carried out as many as 15 times measurements from each electronic device then the data from the measurement of these parameters will be averaged to facilitate data comparison. PZEM sensor compared with the Tekiro Digital Clamp Meter MS-DC1905 device. The results of measuring each electronic device are entered into a table that can be seen in the attachment section. After each electronic device produces measurement data, it is then calculated for the error value with calculations as in Table 1.

Table 1. PZEM sensor accuracy testing results

Load	Power (Watt)			Current (Ampere)			Voltage (Volt)		
	PZEM	Watt Meter	Error	PZEM	Watt Meter	Error	PZEM	Watt Meter	Error
Lamp	11.08	12.2	9%	0.08	0.06	33%	230.20	230.41	0.09%
Phone Charger	17.56	16.6	6%	0.14	0.11	27%	233.24	233.96	0.30%
Electric Kettle	458.99	475.6	3%	2.02	2.09	3%	226.66	226.60	0.02%
Rice Coocker	205.62	212.3	3%	0.90	0.92	2%	227.89	227.9	0.00%
Fan	21.51	21.2	1%	0.152	0.134	13%	231.06	230.41	0.2%
Laptop Charger	54.00	50.2	8%	0.41	0.41	0.00%	232.24	232.3	0.1%
Average Error	5%			13.26%			0.08%		

From the average measurement of power, current, and voltage parameters in the average error percentage table, calculations were made to find the average value of error on the PZEM-004T sensor. The average error obtained from each parameter is 5% on the power parameter, 13.26% on the current parameter, and 0.08% on the voltage parameter. The error in measuring the current obtained is quite large because the measurement sample in the trial uses a very small value which can cause the difference and divider to be large, besides that the current capacity that can be measured by Current Transform reaches 100 Ampere, which is a very high value when compared with a measurement value of 0.08 Ampere. To overcome this, an algorithm is needed to increase the accuracy value of the current reading which is quite small, so that it can minimize the error value obtained in small current measurements. From the average error error, the current and power parameters have a fairly high error percentage. This happens because the electrical load used for measurement does not have so much power. Based on that, the accuracy level of the PZEM-004T sensor is not good for electrical loads that have small power and can be seen in Table 1, for lamps that have 11-Watt power the percentage of error obtained is the highest compared to other electronic devices.

B. LoRaWAN Testing

Quality of service testing on LoRa communication aims to determine the quality of delivery services carried out, Qos testing in this study will test delay, throughput, and packet loss. The test will be carried out around the public gateway owned by IT Telkom Purwokerto by sending data, but each data transfer will be measured with different distance variations. Variations in the distance used include 50, 100, 150,200, and 250 meters from the gateway. The test results of QoS parameters can be seen in Table 2.

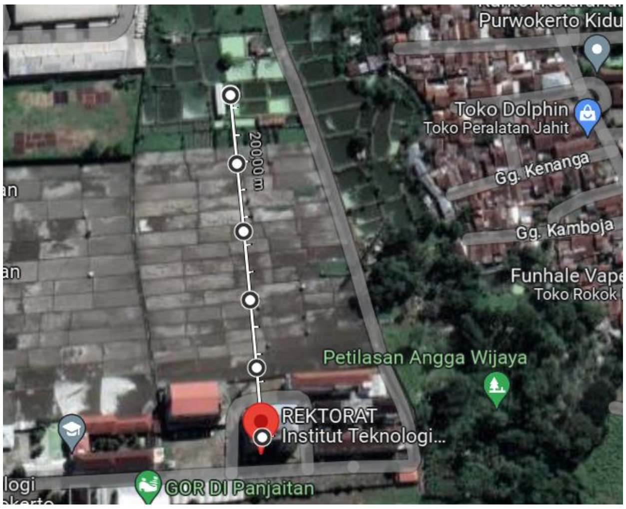

Figure 6. LoRaWAN Testing Scenario

Table 2. Comparison LoRaWAN QoS to TIPHON Standard

No	QoS Parameter	QoS average	Information	
			TIPHON Index	TIPHON Category
1	RSSI	-97.61 dBm	3	Moderate
2	Packet Loss	0.036%	4	Very good
3	Delay	1166.938 ms	1	Very bad
4	Throughput	2.584 bps	1	Bad
Average			2.25	Moderate

Based on Table 2, it can be seen that the packet loss value is at a very good value with an index of 4, then the RSSI value in the measurement results is at a fairly good index with an index of 3, but in terms of throughput and delay, a bad index is obtained with an index of 1. TIPHON standard. This is because the LoRaWAN protocol is a low-power protocol that does not transmit data with large throughput and does not rely on very fast data transfer speeds, so in this test, the throughput and delay index values were not good.

V. CONCLUSION

Based on the results of the study, it is known that the accuracy value of the PZEM-004T sensor readings on electrical parameters is tested using electronic devices with different power. For voltage parameters, the sensor accuracy obtained is quite good, the average error is 0.08%. Meanwhile, in measuring current and power, the average error obtained is quite high at 13.26% and 5% so the accuracy measurement results are not appropriate. This is because the measurement sample is too small, so that the difference in values in a small sample results in a high error. It is hoped that future research can improve the algorithm to minimize errors in measuring small current loads. Then the performance of the Quality of Service value in the communication network for each QoS parameter against distance variations when compared to the standards issued by TIPHON include: the average delay obtained is 1166,938 ms with the very bad category, the average throughput is 2,584 bp with the bad category and packet loss gets an average of 0.036% with the very good category. The received signal strength indicator (RSSI) in this study has a medium category with an average of -96.61 dBm.

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