Volume 1 Number 2 July 2024
E-ISSN: 3047-4337
https://journal.antispublisher.com/index.php/IPTEKS/index

DESIGN OF A LIGHTNING STRIKE COUNTER TOOL IN THE MOJOSARI ULP DISTRIBUTION NETWORK BASED ON IOT

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Article Info

Article history:
Received Jun 12, 2024
Revised Jul 17, 2024
Accepted Jul 22, 2024

Keywords:
ACS712;
DHT11;
ESP32;
20kv Distribution Network;
Telegram

ABSTRACT

General Background: Electrical distribution systems frequently face disruptions, particularly in tropical climates like Indonesia, where lightning strikes are prevalent due to high humidity. **Specific Background:** These disruptions necessitate effective monitoring tools to manage lightning impacts on power distribution networks. **Knowledge Gap:** Despite existing solutions, there is a lack of real-time monitoring systems tailored for the specific conditions of Indonesian distribution networks. **Aims:** This study aims to develop an Internet of Things (IoT) based lightning monitoring device that leverages ACS712, DHT11, and LDR sensors, facilitating real-time data acquisition and notifications. **Results:** The system achieved sensor accuracies of 95.2% for the ACS712, 98.5% for the DHT11, and a satisfactory performance from the LDR sensor. The processed data is displayed on a 16x2 LCD and sent as notifications via Telegram. The device also includes a buzzer for immediate alerts during lightning strikes and features buttons for data logging and resets. **Novelty:** The research presents a novel application of IoT technology to create a user-friendly monitoring solution for lightning strikes, specifically designed for the 20KV distribution networks in the ULP Mojosari work area. **Implications:** By enabling timely notifications and efficient localization of lightning-related disruptions, this tool significantly enhances the operational response of field officers, improving the resilience of power distribution systems during adverse weather conditions. However, it is essential to note that the device requires an internet connection for Telegram notifications, and the ACS712 sensor has a maximum current reading limit of 30 amperes.

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DOI : https://doi.org/10.61796/ipteks.v1i2.207

INTRODUCTION

The electric power distribution system is the main source of energy needed by humans in daily life, it is inevitable that the need for the use of electrical energy is increasing with the increasing amount of electrical energy needed, so it must be balanced with the reliability of the network so that the electricity supply always flows to the community without often experiencing problems and disturbances that cause blackouts [1]-[3].

Incidentally, people's activities and economy are now starting to recover with the mass vaccine and the implementation of the new normal, various sectors of economic activities such as households, industry and retail are also active. The industrial sector even recorded a significant growth in electricity consumption of up to 10.5% [4]-[6].

Not only here, the main problem that is often faced in the distribution network is none other than the disruption or outage of distribution channels which will result in the cessation of electricity supply to the community and especially in industries whose main source is electricity from PT. PLN (persero) [7]. There are many causes of disturbances that result in the blackout of the electricity distribution system and one of them is due to lightning strikes [8]-[10]. The rainy season is indeed a matter of concern, considering that the electricity distribution system is very vulnerable to lightning strikes which results in many losses experienced by both parties due to the interruption of the electricity supply [11]-[13].

As a solution to the importance of supporting equipment in the distribution system, the researcher will develop a Lightning Strike Counter Design on the IOT-Based ULP Mojosari Distribution Network using ESP32 board, ACS712 current sensor, DHT11 temperature sensor, and LDR sensor [14] [15]. As a form of external display of the tool, this tool utilizes an android smartphone as a display medium and an LCD measuring 16x2 [16]-[18].

Previously, this already existed and still used conventional (analog) equipment, so here I will make a system that can be monitored directly when lightning hits the GSW cable on the 20kv distribution network owned by PT. PLN (persero) [19].

Motivated by the difficulty of finding the cause of disturbances during rain and lightning due to the length of the network which can be up to several kilometers and the lack of officers in the field, the existence of this tool will help the cause of disturbances to be easier to find [20]. And at least it will be able to be used for evaluation of protection systems, especially in 20kv distribution networks. Hopefully in the future the tool that I am developing will be useful to monitor one of the causes of disturbances in the distribution network owned by PT. PLN (Persero) and will slightly minimize the time in searching for the cause of the power grid disruption.

METHODS

To conduct this research, it is necessary to design a system to get maximum results, to achieve this target, several work steps are carried out as follows:

A. Wiring diagram

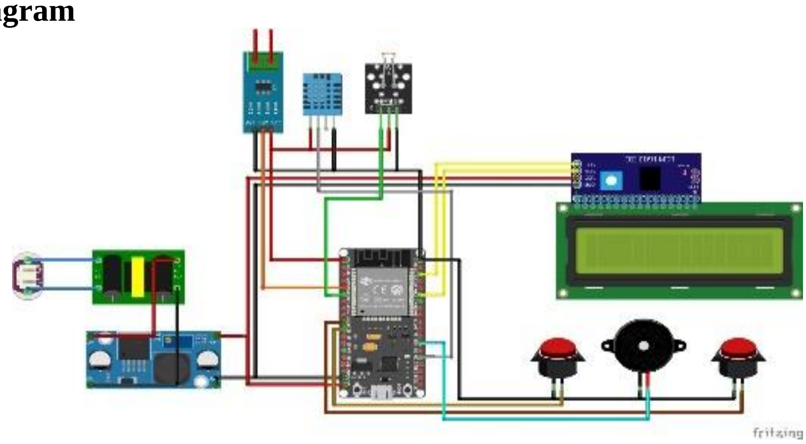

Figure 1. Wiring Diagram

Figure 1 is a design of a tool using the ACS712 sensor to measure the amount and amount of current obtained, the DHT11 sensor to measure temperature, and the LDR sensor to determine weather conditions. The three sensors are processed by the ESP32 and the results are displayed on a 16x2 LCD and a notification on a telegram. The buzzer works if the tool receives a strike from lightning and will sound for 10 seconds. Then there are 2 buttons that function to see the record of the number of lightning strikes and to reset the amount of saved strike data.

B. Creation of telegram bots

Figure 2. Telegram bot creation view

The image above is the process of creating a telegram display that will show the data sent from the ESP32 when the tool is working. There are 6 selection columns, which include, Condition, Time, Check, Reset, Temperature, Light. Each of these columns serves to control the remote tool so that we can find out the *data records* stored on the tool.

C. Flowchart

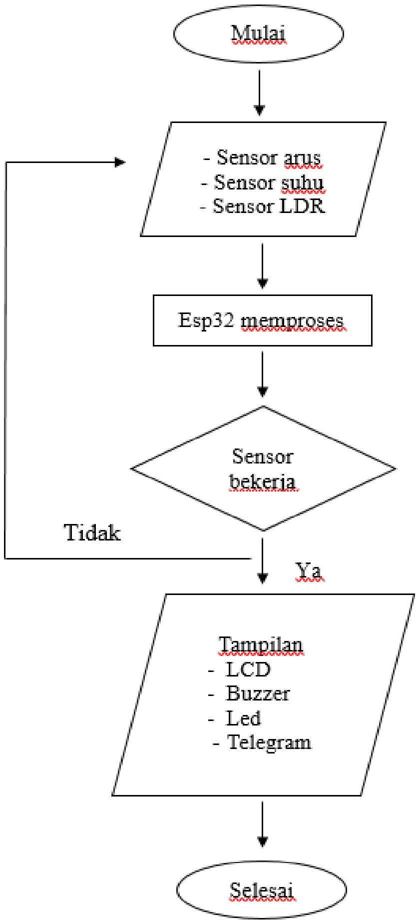

Figure 3. Flowchart Tools

The flowchart above starts with the input of values from three sensors, namely current, temperature, and LDR sensors. After that, the ESP32 Microcontroller will process data from the sensor which is then forwarded to the output components in the form of a 16x2 I2C LCD, buzzer, LED, and telegram application

RESULT AND DISSCUSION

A. Results of the realization of the tool

The results of the assembly and design of the tool can be seen in the picture below:

Figure 4. Tool realization form with components on the inside of the box as well as a display when the tool is working

The picture on the left side is the assembly of the entire tool where the tool is assembled and put into a black box measuring 12 cm long, 5 cm wide and 8 cm high. The results of the test of the tool and the results of the sensor test are displayed in the image on the right side with the text "lightning detected" accompanied by the *value* detected by the sensor.

B. ESP32 Wi-Fi connection test

The test was carried out to test the connection speed between the ESP32 microcontroller and the Wi-Fi network as an intermediary for sending data to Telegram.

Table 1. ESP32 to Wi-Fi Test Data

Testing to-	Wifi ESP32		Speed
	Condition	Waiting Time (s)	
1st Test	Connected	5	Medium
2nd Test	Connected	5	Medium
3rd Test	Connected	4	Medium
4th Test	Connected	5	Medium
5th Test	Connected	4	Medium
6th Test	Connected	5	Medium
7th Test	Connected	4	Medium
8th Test	Connected	5	Medium
9th Test	Connected	5	Medium
10th Test	Connected	4	Medium

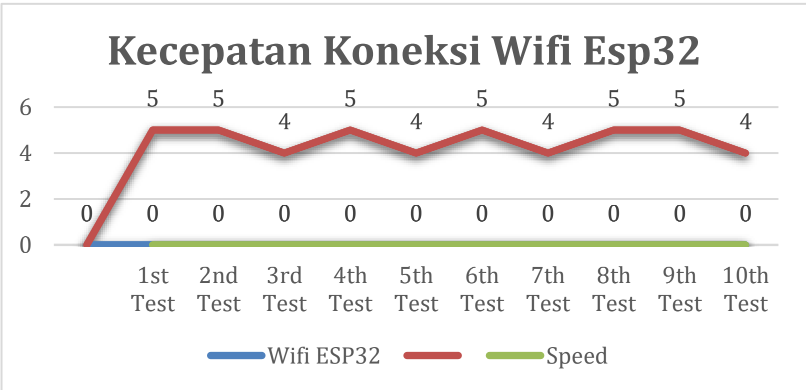

Figure 5. ESP32 Connection Speed Graph

Table 1 is a test table of the speed of the ESP32 connection to Wifi. The test was carried out with 10 experiments to get maximum results. As can be seen from the results of the time test, the average time needed for the device to connect to the internet is 5 seconds.

C. DHT11 temperature sensor testing

Testing on the DHT11 temperature sensor was carried out to measure the accuracy of the sensor in detecting temperature in the residential environment. The test comparison was carried out using a digital thermometer.

Table 2. DHT11 Sensor Test Results

Testing to -	**Time**	**Output Sensor (^oC)**	**Termometer (^oC)**	**Accuracy (%)**
1	05.00	23	22	95,5
2	07.00	31	31	100
3	09.00	31	32	96,8
4	11.00	34	34	100
5	13.00	34	34	100
6	15.00	33	33	100
7	17.00	30	30	100
8	19.00	29	28	96,6
9	21.00	27	27	100
10	23.00	26	25	96,2
Average				98,5

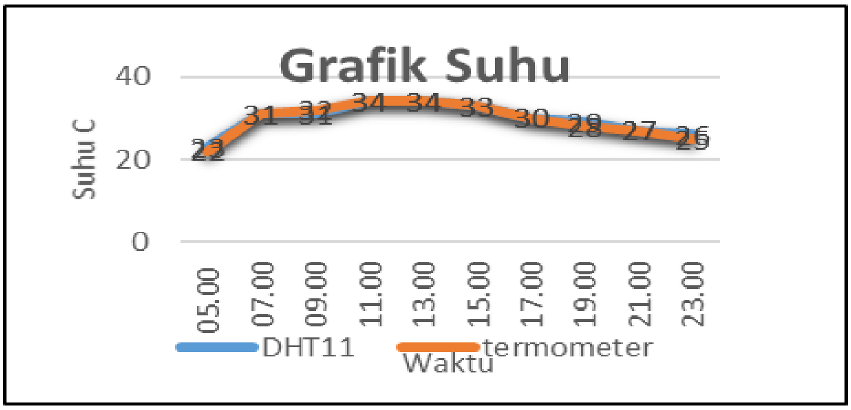

Figure 6. Temperature Graph Between DHT11 Sensor and Digital Thermometer

Table 2 is a table of temperature sensor results testing which is carried out in stages every 2 hours starting from 05.00 to 23.00. From the results of the data above, it can be known that the amount of temperature obtained is in accordance with the temperature conditions in the environment around the residence.

As a material for comparing levels to accuracy, the following formula is included with explanations:

$$\% \text{ Accuracy} = \left|1 - \left|\frac{Yn - Xn}{Xn}\right|\right| \times 100\%$$

Information:

Yn = Measurement result with manual tool

Xn = Sensor-read value

As a comparison material, temperature measurements were also carried out using a digital thermometer, so the results of the comparison test of the thermometer and the DHT11 sensor were obtained. The accuracy of the measurement results is not much different, which is 98.5%.

D. LDR sensor testing

LDR sensor testing is intended to test the accuracy of sensors in detecting dark and light conditions in the surrounding environment.

Table 3. LDR Sensor Test Results

Testing to -	Time	Output Sensor	Condition
1	05.00	4095	Dark
2	07.00	41	Terang
3	09.00	119	Terang
4	11.00	188	Terang
5	13.00	287	Terang
6	15.00	325	Terang
7	17.00	1034	Terang
8	19.00	4095	Dark
9	21.00	4095	Dark
10	23.00	4095	Dark

Table 3 is a table of LDR sensor results testing which is carried out in stages every 2 hours starting from 05.00 to 23.00. From the results of the data above, it can be known that the results of the sensor output are in the form of a number that shows information about the condition of Dark and Light. If the sensor output shows <3000 then the light condition is bright, and if the sensor output shows >3000 then the light condition is dark.

E. ACS712 current sensor test

The ACS712 sensor test is intended to measure the accuracy of the sensor in detecting currents with various electrical loads. A digital multimeter is used as a comparison with the measurement results of the ACS712 sensor.

Table 4. ACS712 Current Sensor Test Results

Testing to -	Load	Output Sensor (A)	Multimeter (A)	Accuracy (%)
1	Fan	0,09	0,09	100,0
2	Solder	0,19	0,18	94,7
3	Glue Gun	0,1	0,09	90,0
4	Printer (printing)	0,045	0,048	93,4
5	Charger HP (Charging)	0,75	0,8	93,4
6	Charger Laptop (Charging)	0,55	0,54	98,2
7	PC(Stand by)	0,88	0,87	98,9
8	Router Wifi	0,045	0,047	95,6
9	25W lamp	0,12	0,11	91,7
10	60W lamp	0,28	0,27	96,5
Average				95,2

Table 4 is a table of the results of testing the current sensor for 10 experiments using the load of electrical equipment. It can be seen that the results of the current measurement show different values. As a material for comparing the level to the accuracy of the sensor, measurements are also carried out using a multimeter (amper meter). The average level to accuracy shows 95.2%.

As a material for comparing the measurement results, it is also explained by the following formula,

$$\% \text{ Accuracy} = \left|1 - \left|\frac{Yn - Xn}{Xn}\right|\right| \times 100\%$$

Information:

Yn = Measurement result with manual tool

Xn = Sensor-read value

F. Testing the speed of sending data to Telegram

The test was carried out to test the speed of sending data from the tool processed by the ESP32 microcontroller to the Telegram server and application.

Table 5. Results of Data Transmission Speed Test to Telegram

Testing to-	**Telegram**		**Speed**
	Condition	Waiting Time (s)	
1st Test	Send	3	Medium
2nd Test	Send	3	Medium
3rd Test	Send	3	Medium
4th Test	Send	3	Medium
5th Test	Send	3	Medium
6th Test	Send	4	Medium
7th Test	Send	3	Medium
8th Test	Send	4	Medium
9th Test	Send	4	Medium
10th Test	Send	3	Medium

Table 5 is a table of results from the ESP32 sending speed test to Telegram. From the data above, the experiment was carried out 10 times with different time frames. The average delivery speed recorded is 3 seconds using the Infinix Note 8 cellphone with MediaTek Helio G80 chipset specifications, 6GB RAM, and 128GB storage.

G. Overall testing

The overall test is aimed at measuring the accuracy of the system of the tool made adapted to the initial purpose of the research.

Table 6. Overall Test Results

Experiment	Time	Light Conditions	Temperature	Large Currents and Lightning Strikes	Telegram Notifications
1	14:19|| Wednesday, 6 /9/2023	Terang	30*C	15,2 A || ke 1	Success
2	2:52 PM || Wednesday, 6 /9/2023	Terang	30*C	11 A || ke 2	Success
3	04:07 PM || Wednesday, 6 /9/2023	Terang	27*C	17,2 A || ke 3	Success
4	05:27 PM || Wednesday, 6 /9/2023	Dark	26*C	13,9 A || ke 4	Success
5	07:57 PM || Wednesday, 6 /9/2023	Dark	26*C	25,5 A || ke 5	Success
6	9:29 PM || Wednesday, 6 /9/2023	Dark	25*C	9,4 A || ke 6	Success
7	11:06 PM || Wednesday, 6 /9/2023	Dark	23*C	21,4 A || ke 7	Success

Table 6 is the result of testing the overall function of the tool 7 times in a time frame of 14.19 WIB to 23.06 WIB on Wednesday, 6/9/2023. The results obtained from the test of the large current received equipment depend on the magnitude of the lightning strike received. Temperature readings are used for ambient temperature conditions to find out whether the weather is cloudy or bright. Every time there is a lightning strike, the tool will send a notification to Telegram to report the data read at that time in real-time.

CONCLUSION

In conclusion, this study successfully developed a real-time lightning monitoring device for the 20KV distribution network system in the ULP Mojosari work area, demonstrating a **Fundamental Finding** that the integration of ACS712, DHT11, and LDR sensors with IoT technology significantly enhances the monitoring of lightning strikes, achieving sensor accuracies of 95.2% and 98.5% respectively. **The Implication** of this research is that the tool provides field officers with timely notifications through the Telegram application, facilitating swift localization of network disruptions during adverse weather, thereby improving operational efficiency and system resilience. However, **the Limitation** of the current system includes its dependence on an internet connection for notification delivery and the maximum current reading limit of the ACS712 sensor, which may restrict its application in higher-current scenarios. Future research should focus on enhancing the device's capabilities by exploring alternative communication methods that do not rely on internet connectivity and investigating sensors with higher current capacities to broaden the applicability of the monitoring system in varied operational contexts.

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