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Monitoring the Condition of the 20 kV Switching Substation in the Tual Rayon Saumlaki Area

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Abstract— **A 20 kV cubicle is a set of electrical equipment installed in a distribution substation as a distributor, circuit breaker, connector, controller, and protection system for the 20 kV voltage power distribution. The frequent issue in these cubicles is corona discharge on electrical equipment, which is a phenomenon occurring when the air around conductors or conductive materials becomes ionized, resulting in the release of charges that can lead to insulation failure in the equipment. The consequences are severe as it can damage the equipment inside the cubicle and cause power losses. This research analyzes the influence of humidity, temperature, sound, and light conditions inside the cubicle to identify the symptoms of corona discharge in the 20 kV cubicle and its accessories. The goal is to create a tool that can address and anticipate the issues related to corona discharge caused by the effects of humidity, temperature, sound, and light.**

Keywords: Cubicle, Corona, Humidity, Temperature, Sound

I. Introduction

In line with the increasing population growth rate and the development of information and technology in Indonesia, especially in large and small cities such as one of the cities in Maluku, namely the District of Southwest Maluku, the demand for electricity has sharply increased, especially in the industrial sector. According to data from the statistics bureau, the demand for electricity has increased by 18%, exceeding the planned 8.2%. Various efforts have been made by PT PLN (Persero), the state electricity company, to meet these needs. Among them is the construction of new power generation centers as energy sources and various innovations and improvements in both transmission and electricity distribution to the community [1].

One of the efforts made is the use of high voltage in transmission lines aimed at reducing power losses due to heat generated in the transmission lines [2, 3]. Currently, the application of high voltage in Indonesia for transmission lines has reached 500 kV [4, 5]. This can certainly reduce the power losses significantly compared to previous levels. However, new issues arise due to the use of high voltage, including problems with conductor insulation, equipment insulation, and corona discharge in the vicinity of the conductor [6, 7]. Not only in high-voltage and extra-high-voltage transmission lines, but corona phenomena are also frequently encountered in substations, distribution substations, and high-voltage cubicles [8, 9].

The corona discharge generated has effects that pose new challenges, both for the surrounding environment in terms of equipment and insulation, as well as for the cubicle where the conductor is placed. Additionally, the overall power quality of the electrical system is adversely affected [10]. The disturbances can be directly felt in the form of radio wave interference, loud noise, power losses, and a decrease in the insulation material's quality, as well as the reliability of the equipment and even the cubicle itself, which could potentially lead to fires or even explosions [11, 12].

Several related studies discuss the monitoring of conditions in substations. For instance, [13] presents a novel online substation instrument transformer health monitoring system. In the study [14] an analysis of vital parameters for MV (Medium Voltage) substations and LV (Low Voltage) transformers is conducted, proposing

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a system to monitor their operational conditions. Another research [15] manages substations with the necessary components to ensure remote control and monitoring through applied sensors. Electrical parameters, including current, voltage, and identification values, can be consistently compared to prevent future damage. In the study [16], monitoring and controlling substations aim for safe electrical automation for consumers. The results on the CAYENNE platform validate the performance of the proposed system in real-time monitoring, data logging, and control.

In this research, a device is proposed to detect signs of disturbances in 20 kV distribution cubicles and monitor their conditions. The designed monitoring device is intended solely for detecting indications of disruptions in distribution cubicles, utilizing sensors for Sound, Temperature, Light, and Humidity based on the AT-Mega 328 microcontroller.

II. Methodology

2.1. Device Fabrication

To facilitate the device fabrication, it is essential to create a circuit block diagram first. The circuit diagram is depicted in Figure 1. Based on the specified technical specifications, here is a detailed explanation of the functions and roles of each component in the corona monitoring system:

1. Arduino Atmega 32 Microcontroller System:
   Function: Serves as the main controller of the system.
   Role: Collects data from various sensors, processes data, and controls the LCD display and information transmission through the modem.
2. Modem:
   Function: Directly connected to the microcontroller system, responsible for transmitting information via SMS.
   Role: Sends SMS notifications when the microcontroller system detects conditions that meet the preset parameters.
3. Sound Sensor:
   Function: Detects the sound of hissing due to loose cable connections.
   Role: Provides information to the microcontroller system to take action if suspicious sounds are detected.
4. Humidity and Temperature Sensors:
   Function: Detects humidity and temperature inside the cubicle.
   Role: Provides information to the microcontroller system to take action if humidity or temperature exceeds the standard PLN service limits.
5. Light Sensor:
   Function: Detects sparks or flames inside the cubicle due to a short circuit.
   Role: Provides information to the microcontroller system to respond quickly to emergency situations if suspicious light is detected.
6. Voltage Sensor:
   Function: Detects the 20 kV voltage inside the cubicle.
   Role: Provides information to the microcontroller system to take action if the voltage exceeds or falls below PLN service standards.

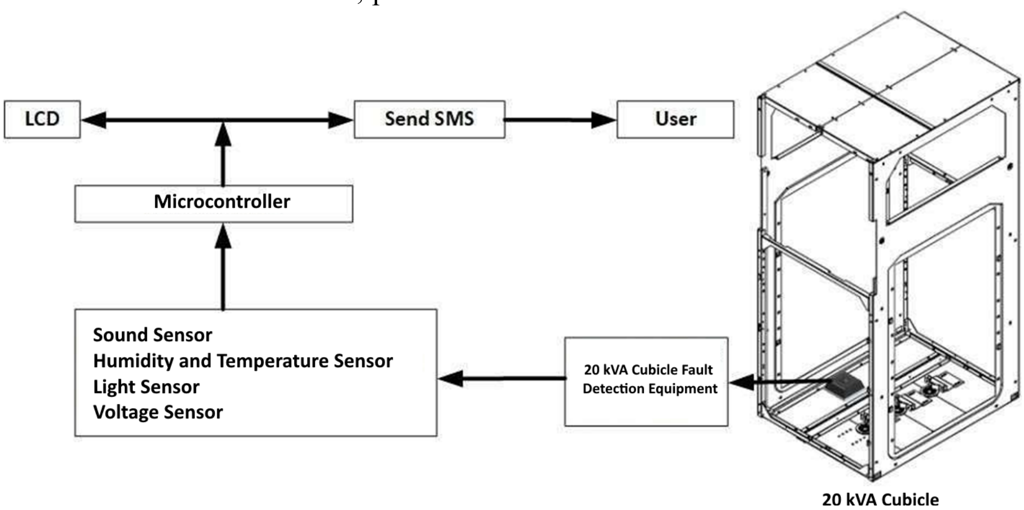

Figure 1. Circuit system block diagram

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7. LCD (Liquid Crystal Display) and LCD Shield:
   Function: Serves as a display during the control process.
   Role: Displays real-time information about the monitoring conditions and status to authorized users or operators.
8. Power Supply:
   Function: Supplies power to the entire system.
   Role: Ensures a stable power supply for all components to ensure the proper functioning of the system.

With the integration of these components, the corona monitoring system can detect, process, and respond to specific conditions inside the 20 kV distribution cubicle in real-time.

2.2. Tool Specifications

The specifications for the tools made in this research are:

1. DHT11 Sensor:
   - Power Supply: 5 V DC
   - Temperature Range: 0-50 °C with an error of ± 2 °C
   - Humidity Range: 20-90% RH with an error of ± 5% RH
2. Analog Sound Sensor
3. LDR (Light Dependent Resistor)
4. Voltage Sensor
5. Microcontroller ATMega32
6. LCD Character Matrix 2x16:
   - Display with 192 character variations
7. Power Supply Voltage:
   - 5 Volt DC
8. Relay 1 Channel:
   1 Normally Open (NO)
   1 Normally Closed (NC)
9. Modem and Downloader

2.3. Data Analysis Methods

The common issue in the field is the shortage of personnel and the considerable distance to the substation. Consequently, real-time monitoring of the cubicle conditions at the substation takes a significant amount of time. Meanwhile, tasks related to maintaining the electrical system must also be carried out, leading to the frequent neglect of monitoring the cubicle conditions. Figure 2 illustrates the Root Cause Problem Solving (RCPS) analysis of cubicle disturbances, while the priority scale is presented in Table 1.

Table 1. Priority Scale Table

Potential Impact	Big			1
	Medium		2	3
	Low			
		Difficult	Medium	Easy
	Ease of Implementation			

The priority scale for each of them is as follows: scale 1 is changing the operating pattern to automatic, scale 2 is increasing the number of operators, and scale 3 is creating SOP (Standard Operating Procedures). From the analysis above, the proposed idea is to transform the manual cubicle condition checking and switching operation into an automated process called Smart Detection Cubicle Condition.

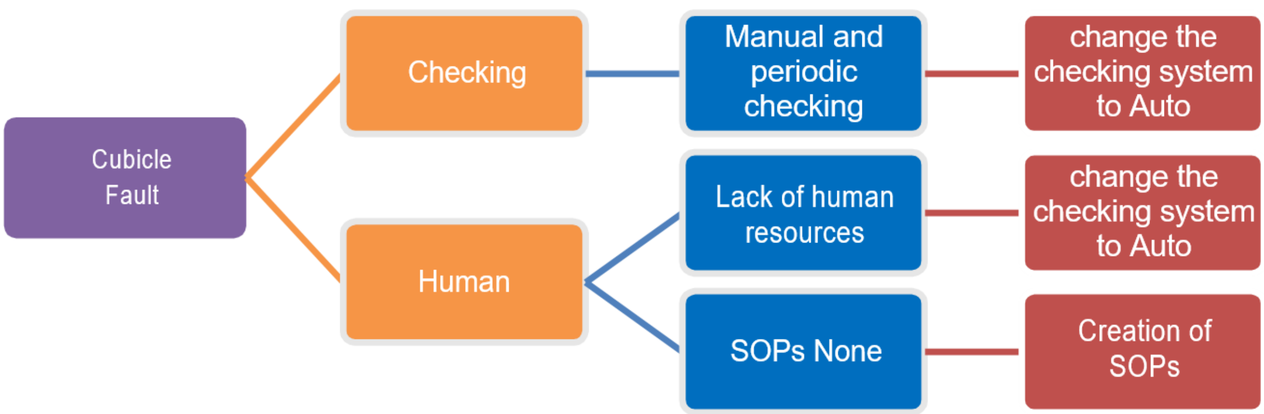

Figure 2. RCPS Cubicle Disturbance

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2.4. Research Flow Chart

The research flow diagram is shown in figure 3.

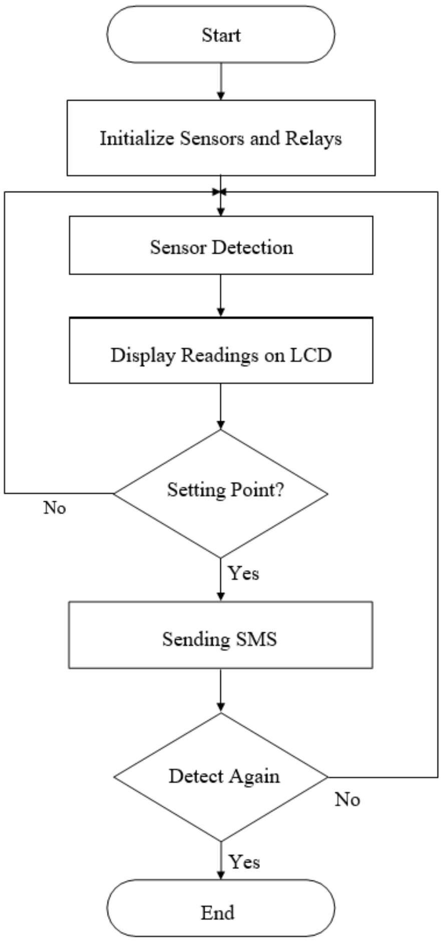

Figure 3. Research Flowchart

III. Results and Discussion

The testing was conducted at the Ilngei Substation of PT PLN (Persero) Rayon Saumlaki using a 20 kV Corona Detector tool. This tool is designed to detect various parameters such as the temperature inside the cubicle, cubicle humidity, hissing sounds occurring in the cubicle, and the light conditions in case of sparks or flames inside the cubicle.

3.1. Testing of the Corona Detection Device Sensor Circuit (Temperature and Humidity Sensor (DHT11), Sound Sensor and Light Sensor)

From the test results on the cubicle using the corona detector tool (Temperature, Humidity, Sound, and Light) on the first day, it can be observed that the highest humidity occurred at 12:00 with a value of 81%, while the lowest humidity was recorded at 00:00 with a value of 78%. Additionally, the highest temperature was recorded at 06:00 at 30°C, and the lowest temperature occurred at 00:00 with a value of 27°C. As for the hissing sound, the highest detected value occurred at 18:00, reaching 67 dB, while the lowest value was recorded at 12:00 with 62 dB.

From the test results on the cubicle using the corona detector tool (Temperature, Humidity, Sound, and Light) on the second day, it can be observed that the highest humidity occurred at 18:00 with a value of 82%, while the lowest humidity was recorded at 00:00 with a value of 78%. Additionally, the highest temperature was recorded at 12:00 at 30°C, and the lowest temperature occurred at 00:00 at 78°C. As for the hissing sound, the highest detected value occurred at 12:00, reaching 67 dB, while the lowest value was recorded at 06:00 with 62 dB.

From the obtained data, it can be seen that the measurement results align with the conditions in the cubicle, identifying the presence of corona. This demonstrates that higher humidity corresponds to lower temperatures in the cubicle, indicating the occurrence of corona. Therefore, maintenance is necessary for the 20 kV cubicle.

3.2. Testing the condition of the 20 kV Cubicle after maintenance

From the test results after maintenance was performed on the cubicle using the corona detector tool (Temperature, Humidity, Sound, and Light) on the first day post-maintenance, it can be observed that the highest humidity occurred at 12:00 with a value of 48%, while the lowest humidity was recorded at 06:00 with a value of 45%. Additionally, the highest temperature was recorded at 00:00 at 39°C, and the lowest temperature occurred at 06:00 at 37°C. As for the hissing sound, the highest detected value occurred at 06:00, reaching 60 dB, while the lowest value was recorded at 12:00 with 59 dB.

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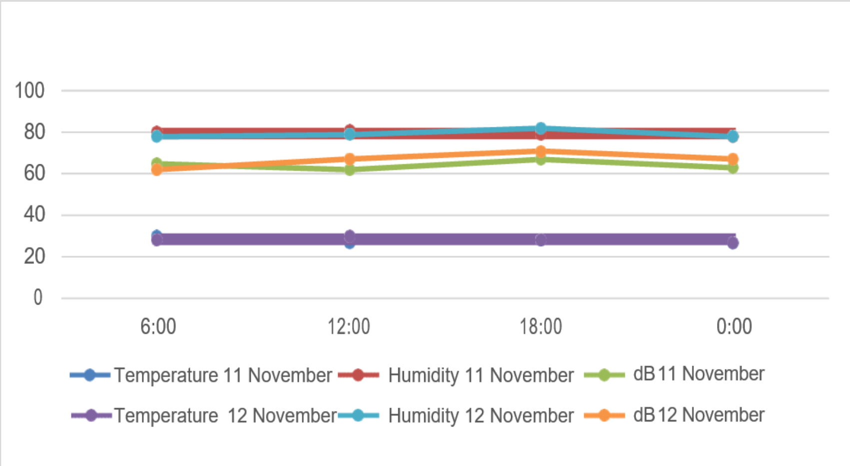

Figure 4. Graphic of Monitoring Cubicle Conditions Before Maintenance

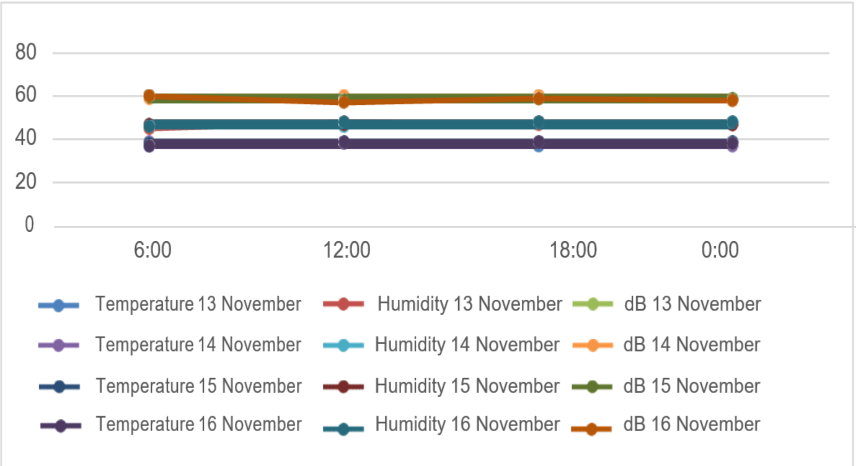

Figure 5. Cubicle Condition Monitoring Graph After Maintenance

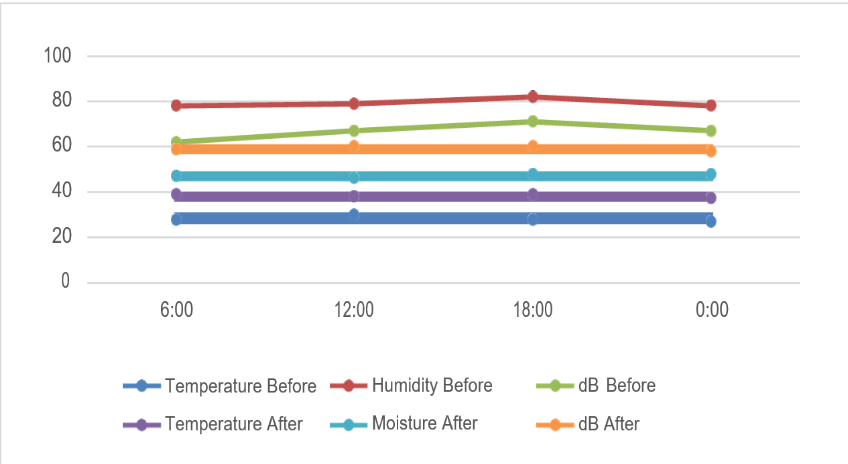

Figure 6. Cubicle Monitoring Graph Before and After Maintenance

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On the second day after the maintenance of the 20 kV cubicle, it can be observed that the highest humidity occurred at 18:00 with a value of 48%, while the lowest humidity was recorded at 12:00 with a value of 46%. Additionally, the highest temperature was recorded at 18:00 at 39°C, and the lowest temperature occurred at 00:00 at 37°C. As for the hissing sound, the highest detected value occurred at 12:00, reaching 60 dB, while the lowest value was recorded at 00:00 with 58 dB.

3.3. Comparison graph between the condition of the 20 kV cubicle before and after maintenance

Images 4-6 show the monitoring results of the cubicle before and after maintenance using the Corona Detector tool on the 20 kV cubicle. In Image 6, there are changes in the parameters of the cubicle conditions. During the initial monitoring, the cubicle conditions were obtained with the highest temperature parameter at 30°C, the highest humidity at 82%, the highest sound level at 71 dB, and the absence of detected light conditions, indicating a high possibility of corona and disturbances in the 20 kV cubicle. After the maintenance, there were significant changes in the parameters of the 20 kV cubicle. The highest temperature recorded was 39°C, the lowest was 38°C. The highest humidity reached 48%, while the lowest was 46%. The highest detected sound was 60 dB, and the lowest was 58 dB. Light conditions in the cubicle were not detected.

3.4. Corona Monitoring Sensor

The corona monitoring tool is shown in Image 7, and its operational principle is as follows:

- The corona monitoring tool is placed inside the 20 kV cubicle and powered by AC 220 Volts, which is then converted to DC 12 Volts.
- The monitoring tool reads the conditions inside the 20 kV cubicle with 4 parameters: Temperature, Humidity, Sound, and Light.
- The monitoring tool will consistently provide periodic notifications to the operator every 8 hours in a day, specifically at 00:00, 06:00, 12:00, and 18:00. Additionally, the tool will send an automatic SMS notification to the operator or generation supervisor in real-time if it detects a temperature below 35°C, humidity above 60%, sound above 60 dB, and if light is detected.

Figure 7. Design of Corona Monitoring Tool

Switching Substation Cubicle at PT PLN (Persero) Tual Area Saumlaki Branch has been identified with symptoms of corona. In the initial installation of the Corona Detector Tool, the highest temperature in the cubicle was recorded at 30°C, the highest humidity at 82%, and the detected hissing sound at 71 dB. After maintenance and continuous monitoring of the cubicle condition, the highest temperature recorded in the 20 kV cubicle was 39°C, the highest humidity was 48%, and the detected hissing sound was 58 dB.

The corona detector tool sends information about the cubicle to the user at 00:00 WIT, 06:00 WIT, 12:00 WIT, and 18:00 WIT. It also sends real-time information if the tool detects abnormalities in the 20 kV cubicle.

IV. Conclusion

From the results of the testing of the 20 kV Substation Condition Monitoring Tool at PLN Tual Area Saumlaki Branch, the use of this monitoring tool by PT PLN (Persero) in the Tual Area Saumlaki Branch has proven to be very beneficial for monitoring the condition of substations that are difficult to access and challenging to physically monitor. After the installation of the substation

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condition monitoring tool at PT PLN (Persero) Tual Area Saumlaki Branch, it was evident that a cubicle required maintenance to prevent more significant corona processes.

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