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Implementation of Multi-sensors to Detect Corona Effects in Medium Voltage Distribution Cubicles

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Abstrak

Energi listrik merupakan salah satu energi yang sangat penting dalam kehidupan sehari-hari sehingga peralatan listrik tegangan tinggi mempunyai peranan yang vital dalam menjaga keandalan penyaluran tenaga listrik. Efek korona disebabkan oleh kegagalan isolasi pada peralatan tinggi yang mengakibatkan distribusi daya listrik terganggu. Tujuan dari kegiatan penelitian ini adalah menghasilkan alat multisensor untuk menguji kondisi peralatan pada bilik jaringan distribusi yang telah mengalami fenomena korona. Data masukan dari sejumlah sensor yang digunakan seperti sensor ozon akan mendeteksi gas ozon yang terpapar di bilik 20kv, deteksi sinar ultraviolet oleh modul sensor UV, dan deteksi frekuensi suara dari desis peralatan melalui sensor mikrofon yang mengalami korona akan diproses oleh Mikrokontroler dan jika nilai yang dideteksi melebihi nilai referensi yang telah di set maka output berupa LCD akan menampilkan tulisan peringatan gejala korona dan menginstruksikan alarm buzzer berbunyi. Hasil penelitian menunjukkan bahwa prototipe alat pendeteksi korona mampu mengidentifikasi nilai kadar ozon dengan nilai maksimum sebesar 21,88 ppb, nilai indeks UV terbesar senilai 336, dan frekuensi desis maksimum bernilai 157 dB pada kubikel distribusi yang mengalami efek korona.

Kata kunci: *efek korona, ozon, sinar ultraviolet, distribusi, sensor*

Abstract

Electrical energy is one of the most important energies in everyday life so high-voltage electrical equipment has a vital role in maintaining the reliability of electric power distribution. The corona effect is caused by insulation failure in high-rise equipment which results in disrupted electrical power distribution. The purpose of this research activity is to produce a multi-sensor tool to test the condition of equipment in distribution network booths that have experienced the corona phenomenon. The input data from several sensors used, such as the ozone sensor, will detect ozone gas exposed in the 20kv chamber, detection of ultraviolet light by the UV sensor module, and detection of sound frequency from the hissing of equipment through the microphone sensor experiencing corona will be processed by the Microcontroller and if the value is detected exceeds the reference value that has been set, the output in the form of an LCD will display a corona symptom warning message and instruct the buzzer alarm to sound. The results showed that the prototype of the corona detector was able to identify ozone levels with a maximum value of 21.88 ppb, the largest UV index value of 336, and a maximum hissing frequency of 157 dB in distribution cubicles that experienced the corona effect.

Keywords: corona effects, ozone, ultraviolet light, distribution, sensor

I. INTRODUCTION

Electrical energy is one of the most important energies in everyday life. The distribution of electrical energy from the generator to the consumer requires special attention in the distribution of electricity. One of the most important tools in the distribution of electricity contained in the distribution system is a cubicle which functions as a liaison, protector, and divider of electric power from an electric power source [1].

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One of the problems found in cubicles is the occurrence of insulation failure due to the high voltage phenomenon. One of the high-voltage phenomena that cause insulation failure is the corona, where this corona activity generally occurs in high-voltage systems [2]. Seeing the conditions of several cubicle problems in Indonesia, there are many disturbances due to insulation failure due to the absence of equipment and methods that can detect these symptoms as early as possible, so it is necessary to test with experimental methods on the occurrence of corona in the 20 kV cubicle system.

The Corona effect that occurs in the medium-voltage 20kv cubicle takes place gradually. When two electrodes whose cross-section is small compared to the distance between the two electrodes are given AC voltage, a corona phenomenon can occur [3]. When the applied voltage is still low, nothing will happen. However, if the voltage is increased, the corona will occur gradually. At first, it will be marked by electrodes that look glowing, the smell of ozone, and will make a hissing sound [4]. If the applied voltage continues to increase, it will be more visible, especially on the sharp, dirty, or rough parts, then the light will be increasingly visible, getting bigger and very bright. If the voltage is continuously increased, an arc will appear and heat will be released. When the air around the electrode is moist, the corona will produce nitrogen acid (nitrous acid) that can cause the electrode to rust if the power loss is large enough [5].

Previous research studies that discussed the corona phenomenon in insulators or distribution cubicles have been widely carried out [6]–[11]. In research [12] the test was carried out to compare the calculated value of the corona voltage on the effect of the electrode cross-sectional area with the actual condition by recording the hissing sound of the corona occurring with an interval of 20 cm and above.

Similar research was conducted by [13] to provide a new system that can be utilized by companies providing electricity services in terms of distribution. Based on the results of research that has been carried out with the new system, it can make the temperature and humidity conditions in the cubicle stable to reduce the corona effect on the 20 kV cubicle. Another study [14] analyzes the countermeasures of the corona effect on the cubicle, the losses caused by the corona phenomenon, and the effect on the cubicle caused by the corona effect.

Based on a previous literature review, there has never been an implementation of the use of two types of sensors to detect the corona effect that occurs in medium voltage cubicles. The use of MQ 131 sensor in similar research is used to measure air quality, not to detect the presence of ozone gas that arises when the corona occurs in the cubicle conductor [15].

In this study, a corona effect detection tool based on the Arduino Mega microcontroller will be made as the main controller in determining the parameters for the occurrence of the corona effect. The use of the MQ131 sensor is because this sensor is sensitive to the type of ozone gas that is often produced by conductors when a corona occurs, the Ultron sensor is to detect the presence of ultraviolet light that is not visible to the human eye [16], then a microphone is to detect the frequency of hissing sounds in the environment. equipment experiencing the corona effect.

Previous studies have not made many designs of tools to detect the corona effect, the research carried out was only up to the stage of analyzing the formation of the corona effect in the cubicle. The use of sensors used also has different characteristics to be measured, for example, the use of the DHT22 sensor to measure humidity and temperature in the cubicle and also the use of two types of sensors MQ7 and MQ131 for air quality monitoring [17]. This research has a novelty of the Corona effect detection control algorithm and the use of three types of sensors to observe the corona effect according to the signs of the corona effect from the literature that has been studied.

II. Research Method

A. Methods

This research is experimental with experimental stages as follows: (1) the planning stage which includes problem identification, literature study, draft preparation, and alternative designs; (2) the design of the control program; (3) the design and manufacture stage of the tool which includes the mechanical and electrical system design drawings, (4) testing and analysis phase which includes hardware testing, software testing, machine testing, and analysis.

B. Design of the Control Program

Figure 1 is a flowchart of the control of the program that has been applied for the detection of effect corona effect in a medium distribution cubicle. The MQ131 sensor functions to detect ozone gas in the cubicle conductor, the UV module sensor detects ultraviolet light, and the microphone detects the sound frequency caused by hissing on the conductor surface. The control program is made on the computer and then uploaded to the microcontroller. The microcontroller functions as a brain that manages data and determines whether the three previous parameters have met the criteria for equipment experiencing corona phenomena.

C. *Design and Specifications*

Figure 2 is a block diagram of the corona detection tool in the cubicle. The inputted data is processed in such a way and stored in memory as a program of the desired output condition value. If the measured data exceeds the value that has been set through the program, the LCD output will display a corona warning in the cubicle along with the value of each parameter, and the buzzer alarm will also be activated.

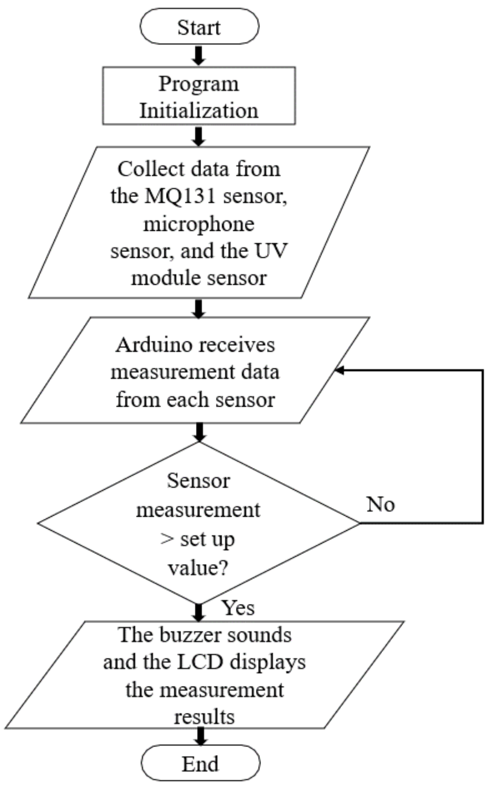

Figure 1. Flowchart of the control program

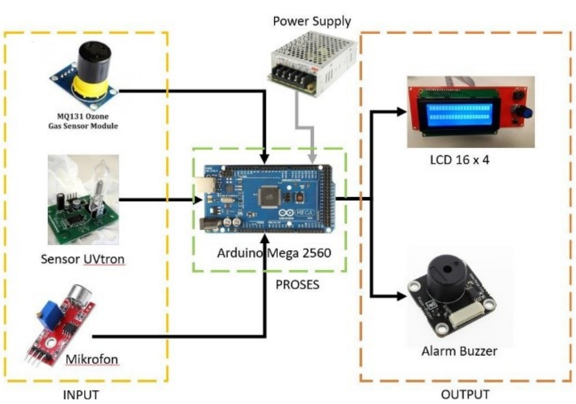

Figure 2. Block diagram of the corona detection tool

III. Result and Discussion

A. *Experimental Set-Up*

Data collection testing experiments were carried out by placing a corona effect detection device at the bottom of a medium voltage cubicle as seen in Figure 3. The corona effect detection tool has been programmed through the Arduino IDE so that it can detect some sensor data that is characteristic of the occurrence of a corona effect such as ozone levels, ultraviolet light wavelengths, and the frequency of the hissing sound of equipment. If the microcontroller detects a value that exceeds the specified value, the buzzer will sound and the LCD will display the measurement results of each sensor according to the characteristics of the corona effects.

B. *Ozone Gases Measurement*

The results of measurements of ozone with a constant voltage of three-phase voltage were carried out to see the value of ozone production based on the provision of a constant input voltage with increasing time. For more detail, the measurement results can be seen in Figure 4.

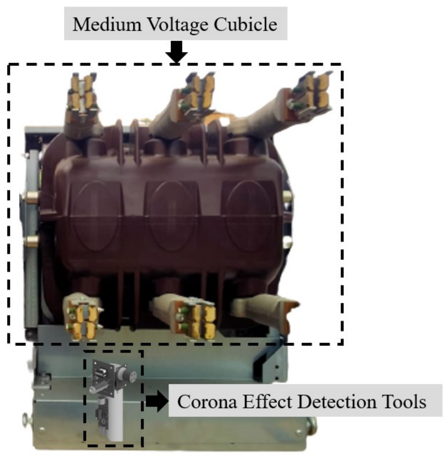

Figure 3. Experimental setup

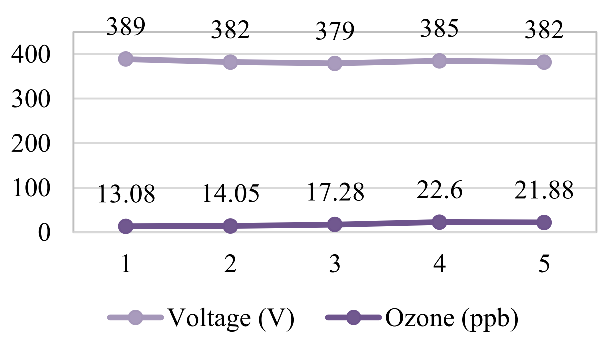

Figure 4. Ozone measurement

Based on Figure 4, the highest ozone produced in the 5th measurement was 22,60 ppb and it increased from the 1st minute to the 15th minute. After that, the ozone measurement gradually dropped back over time in the 20th minute. Then the ozone measurement is continued by giving the source of three phases of voltage.

C. UV Light Measurement

The results of measurements of ozone with a constant voltage were carried out to see the value of UV index production in the apparatus of distribution voltage. based on the measurement, it can be seen that the UV index is directly proportional to increasing time. The maximum UV index value from the measurement is 336 and which can be seen in Figure 5.

D. Corona Hiss Frequency Measurement

Corona hiss frequency formed because of ozone production applied in high voltage equipment. based on the measurement, it can be seen that the maximum corona hiss frequency value is 157 dB and occurred in the maximum ozone value of 22,6 ppb. the measurement results can be seen in Figure 6.

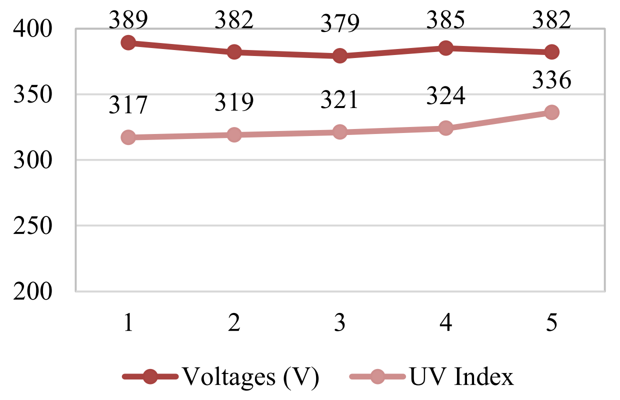

Figure 5. UV light measurement

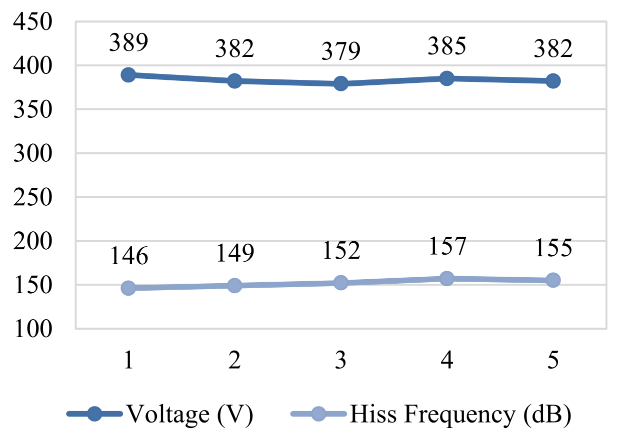

Figure 6. Corona hiss frequency measurement

IV. CONCLUSION

The results showed that the concentration of ozone gases was proportional to the voltage that was applied to the electrical equipment. based on the measurement, it can be seen that the UV index is directly proportional to increasing time. The measurement also showed that the maximum corona hiss frequency value (157 dB) occurred in the maximum ozone value which has a value of 22,6 ppb. Ozone gases, UV index, and hiss frequency are three major factors that indicate distribution equipment has a corona effect, and this prototype of a multi-sensor tool to test the condition of the equipment in the distribution network cubicle can detect the corona effect.

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