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Hotpoint Monitoring System Power Cable Termination Based On Internet of Things (IoT) Using Telegram Bot

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Abstract: Electricity is energy that is needed in any field, both industry and ordinary people. To be able to produce good quality electrical energy, it is necessary to monitor and maintain electrical power equipment to prevent equipment damage that can interfere with the electrical energy distribution system to consumers. One of the disturbances that are often experienced is the Hotpoint at the terminal connection section between the conductor cable and the equipment at the substation. Hotpoint is an increase in the production of acoustic pulses (sound) and an increase in temperature that causes energy dissipation resulting in the heating of a localized area. This Hotpoint will cause damage to the equipment if it occurs for a long time. In this research, a Hotpoint monitoring system for 20 kV power cable termination based on the Internet of Things was built to monitor the temperature condition of the 20 kV power cable termination in real-time. This system uses the MLX90640 IR Thermal Camera sensor as the cable termination temperature gauge and the DHT22 temperature sensor to measure the 20 kV cubicle panel temperature. This temperature value will be compared to determine whether there is a Hotpoint at the termination of the 20 kV power cable. This system uses a MySQL database and HTTP protocol for communication between the Raspberry Pi4 and the website dashboard, then for notifications using the Telegram bot. The sensor accuracy test is carried out by comparing the temperature value between the DHT22 sensor and the Hygrometer with an average measurement value difference of -1.7%, while the MLX90640 and Fluke Ir 568 sensor accuracy tests have an average measurement value difference of -1.13%°C. Based on the sensor accuracy testing, it can be concluded that all sensors have a fairly good performance in measuring the required temperature parameters.

Keywords: Terminasi, *Hotpoint, Internet of Things, HTTP, IR Thermal Camera, Raspberry Pi, Telegram Bot.*

1. Introduction

The condition of technological development for the needs of life in modern times today is very attached to the use of electrical energy. Electricity is energy that is needed in any field, both industry and ordinary people. To be able to produce good quality electrical energy, it is necessary to carry out regular monitoring and maintenance of electrical power equipment, to prevent disturbances that can damage equipment and disrupt the electrical energy distribution system to consumers.

One of the disturbances that are often experienced is the hot temperature at the terminal connection section between the conductor cable and the equipment at the substation. During operation, the substation equipment in the switchyard often experiences heating due to current losses flowing in the conductors caused by resistance and the number of old equipment. The interference factor from nature and the distance between adjacent switchyard equipment can also cause hot temperatures in the connection and terminal parts. This can be fatal to equipment if it occurs continuously without regular checks [1]. Therefore, observations and searches for object emissivity values are carried out with the Flir T250 type thermal imager, so that the equipment in the switchyard can be detected in a good or damaged condition [1].

In this study, an integrated system was built to monitor temperature conditions at the termination of the 20 kV power cable by applying Internet of Things technology. The system implementation uses the Adafruit MLX 90640 IR Thermal Camera Sensor, DHT22 temperature sensor, and Raspberry Pi 4.0 which will be installed on a 20 kV cubicle panel to monitor the temperature condition of the 20 kV power cable termination, then temperature data will be sent to the server via the internet network using the Hypertext Transfer protocol. Protocol (HTTP) so that the termination condition of the 20 kV power cable can be monitored in real-time. If there is a Hotpoint at the termination of the 20 kV power cable, the system will send a notification to the TelegramBot application. With this notification, the officer can immediately make repairs to the termination of the 20 kV power cable that experiences the Hotpoint, to minimize or prevent interference that may arise due to the Hotpoint at the termination of the 20 kV power cable.

Based on the background described above, it can be formulated that the problems that are the focus of this research are Frequent interruptions in the termination of the 20 kV power cable due to Hotpoint, which have an impact on equipment damage and problems in the distribution of electrical energy to consumers, How to build a system that can monitor the temperature at the termination of the 20 kV power cable in real-time, How to make the measurement data generated by the sensor can be displayed on the website dashboard, How can the system send notifications if there is a Hotpoint at the termination of the 20 kV power cable.

The aims of this thesis research are to Create a system that can monitor and detect Hotpoint at the termination of the 20 kV power cable using the MLX 90640 IR Thermal Camera Sensor, DHT22 temperature sensor, and Raspberry Pi 4.0 which will be applied to the 20 kV cubicle panel, The system built can store temperature sensor data in a MySQL database via the internet using the HTTP protocol, The system notifies the 20 kV power cable termination temperature conditions via TelegramBot so that officers can find out the 20 kV power cable termination in normal.

2. Research Methods

A. Related Work

Publications related to IoT-based remote temperature monitoring systems have already been used for Sistem Pemantauan Kubikel Tegangan Menengah Berbasis Internet of Things [2]. The background of the problem in this study is the frequent disturbances in the 20 kV cubicle caused by corona. Corona is a phenomenon that occurs when the air around a conductor is ionized. From that process, there is a discharge of charge which results in the failure of the insulation in the air. If this condition is not immediately addressed, it can result in disruption of the consumer electricity distribution system, as well as damage to equipment and loss to the company. This Internet of things-based medium-voltage cubicle monitoring method is designed using a DHT22 sensor to monitor temperature and humidity and NodeMCU as a microcontroller. This study aims to ensure that the temperature and humidity in the 20 kV cubicle can be monitored by officers through a web application that is connected to the sensor. From the results of the tests that have been carried out, the sensor can read the temperature and humidity according to the heater settings installed in the 20 kV cubicle. The error resulting from the temperature measurement by the sensor is 0.3 percent. The gaps that can be drawn from this internet of the things-based medium-voltage cubicle monitoring system are that The temperature monitored by the DHT22 sensor is the temperature of the 20 kV cubicle as a whole so that the individual temperature of the 20 kV power cable termination with corona and hot points in the cubicle is not monitored, The temperature range that can be captured by the DHT22 sensor is only -40 °C to 80 °C so the temperature outside is not detected, There is no analysis of the temperature obtained from the DHT22 sensor that can be used in decision-making, There is no notification to officers through the system that was built if the temperature has reached the maximum limit.

Based on this publication, researchers will develop a DHT22 temperature sensor with an MLX90640 thermal camera sensor that can capture the temperature of the 20 kV power cable termination based on the visual of the amount of infrared energy produced, so that the location of the corona and Hotpoint can be known. The NodeMCU that will be developed uses Raspberry Pi 4.0 so the memory and specifications are needed to support the sensors and programs that are created. The system will also be equipped with notifications via the TelegramBot application on smartphones so that officers can immediately make repairs if there are Hotpoint.

Publications related to thermal image processing have been carried out in a publication entitled Thermal Image Processing Using Artificial Neural Network for Boiler TV-Furnace (Thermal CCTV) Position Control System [3], this research has a background that the generator instrumentation system always has a possible problem with the measuring equipment, either with the sensor or other equipment. The combustion process must also be monitored optimally, especially in the efficiency of coal combustion which has been constrained by frequent overheating conditions. Monitoring the current combustion process is no longer compatible if it is still used furthermore, the conventional camera causes damage to the furnace itself due to delays in temperature information integrated with the user or operator. This study aims to be able to design a classification system and monitor the combustion process in a boiler or combustion furnace using thermographic analysis. The methodology used in this research is the application of Visual Process Technology and Artificial Intelligence. Image processing uses thermography to observe the temperature distribution in the boiler furnace. then processed using feature extraction to produce a histogram data table with 3 parameters, namely HSV (Hue, Saturation, and Value) to take significant difference values that will be used as input for classification using Neural Network. From this research, it can be concluded that image processing using thermographic analysis can be applied properly. The application of the NN method to the built system is carried out with the HSV classification, where the value of V is used as a parameter value because it has a significant difference in each cell so that the training and testing process can run well with 16 hidden neurons in the 10th iteration and produce an average error. the system average is 100%, but on testing the accuracy of the error decreases by 0.08559%. The gaps that can be drawn from this internet of the things-based medium-voltage cubicle monitoring system are that The sensor used has an 8x8 pixel grid so the resulting image quality is not good, The temperature range that can be captured by the AMG8833 sensor is only 0 °C to 80 °C so that the temperature outside is not detected, The system built is not based on the internet of things so the temperature cannot be monitored remotely, There is no notification to officers through the system that was built if the temperature has reached the maximum limit.

This publication will be used as a reference in building a Hotpoint monitor system on a 20 kV power cable that will be carried out. The 8x8 pixel AMG8833 sensor will be expanded to the MLX90640 sensor which has a better grid of 32x24 pixels. The system will also be developed using a Raspberry Pi 4.0 microcomputer so that it becomes an Internet of Things-based device. The system will also be equipped with notifications via the TelegramBot application on smartphones so that officers can immediately make repairs if there are Hotpoint.

B. Power Cable Termination

In cable systems, cable termination installation is of great importance for steady operation. It is necessary to prevent possible errors that may happen during installation to ensure system reliability. It is known that most of the failures occurring in distribution systems are related to cable terminations and joints [4].

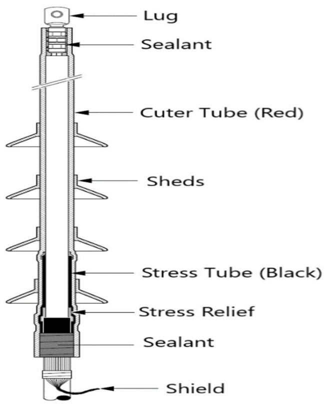

Figure 1. Part of cable termination [4].

Termination is a connection that connects the cable with other equipment or cable completeness that is needed to be installed at the end of the cable which is mandatory. Ensuring the completeness of the required cable is not easy, so research is needed on the cable as a basis for selecting the appropriate equipment to be used.

C. HotPoint

An electrical or insulation failure is accompanied by 2 events, the production of acoustic pulses (sound), and an increase in temperature owing to heating. Both these will lead to energy dissipation. There are many events that lead to such heat production and these localized areas are popularly known as hot spots or partial discharges in equipment insulation [5].

The hotspot is a source of high frequency (Harmonic) waves, when these waves accumulate in a location they will cause equipment damage by resonance phenomenon. Hot spots in Industrial plants are a major hazard that can lead to complete equipment replacement if left undetected for a long time [5].

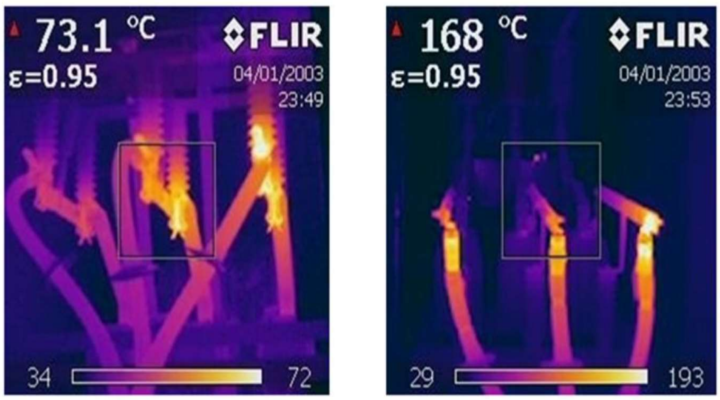

Figure 2. Hotspot at 20 kV power cable termination

Hotspots can occur when cable connections are not properly connected to other equipment in the power system. This hotspot emits light radiation and an increase in temperature that can damage the termination of the 20 kV power cable it will cause a fire accident and hamper the distribution of electrical energy to consumers.

D. Internet of Things

The Internet of Things is a platform where everyday devices become smarter, everyday processing becomes smarter, and everyday communication becomes informative [6]. Internet of Things (IoT) refers to the tight connection between the digital and physical worlds. An IoT architecture can be treated as a system that can be physical, virtual, or a hybrid of the two, consisting of a collection of multiple physically active things, sensors, actuators, cloud services, specific IoT protocols, communication layers, users, developers, and enterprise layers (Ray, 2018). The Internet is a global system of interconnected computer networks that use the Internet Standard Protocol Suite (TCP/IP) to serve billions of users worldwide. These are networks consisting of millions of private, public, academic, business and government networks, in local to global scope, which is connected by various electronic devices, in wireless and optical network technologies [7].

E. Raspberry pi

The Raspberry Pi is a low-cost, small-sized, single-board microcomputer that plugs into a computer monitor and uses general input and output peripherals such as a keyboard and mouse [8]. The Raspberry Pi was developed by the non-profit Rasberry Pi Foundation, led by Eben Upton, Rob Mullins, Jack Lang, and Alan Mycroft, of the University of Cambridge Computer Laboratory, UK. Raspberry Pi can replace desktop computers because it has similar components, such as memory, storage, GPU, system bus, and network modules embedded in the circuit board [8].

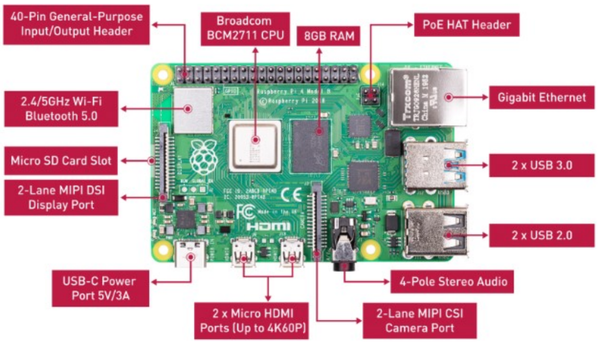

Figure 3. Raspberry Pi 4.0 Model B

F. Sensor MLX 90640 Ir Thermal Camera

In this study, the MLX90640 thermal camera was used for sensing the 20 kV power cable termination temperature conditions. The MLX90640 is a fully calibrated 32x24 pixels thermal IR array in an industry standard 4-lead TO39 package with digital interface. The MLX90640 contains 768 FIR pixels. An ambient sensor is integrated to measure the ambient temperature of the chip and supply sensor to measure the VDD. The outputs of all sensors IR, Ta and VDD are stored in internal RAM and are accessible through I2C [9]. his sensor will measure temperatures from -40 °C to 300 °C with an accuracy of ±2°C (in the 0-100 °C range). With a maximum frame rate of 16 Hz and capable of working in temperatures from -40 °C to 85°C, it is perfect for making human detectors or mini thermal cameras.

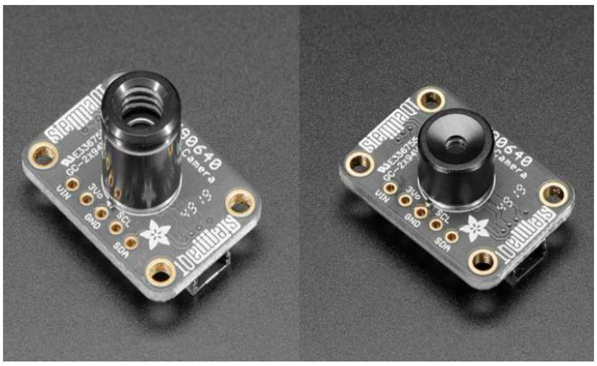

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Figure 4. Thermal Camera MLX90640 32x24 IR Array

G. Sensor DHT22

The DHT22 sensor is a sensor that can measure two environmental parameters at once, namely temperature and humidity. The DHT22 has advantages such as the output is already a digital signal with conversion and calculations carried out by an 8-bit MCU. Wider temperature and humidity measurement range and capable of transmitting output signals over long cables up to 20 meters [10].

Figure 5. Sensor DHT22

3. Result and Discussion

A. Current System Block Diagram

The form of the 20 kV power cable Hotpoint monitoring system consists of several parts, including the MLX90640 IR Thermal Camera sensor, the Raspberry Pi 4 microcomputer DHT22 temperature sensor, internet connection, database server, interface software (website), and system notification (TelegramBot). The plan overview of this system working can be seen in the following figure:

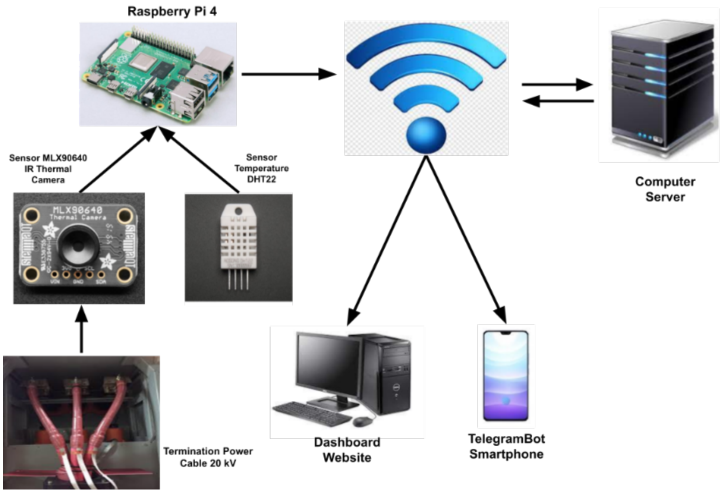

Figure 6. Hardware Design

From the picture of the system hardware design, it can be explained that Hotpoint monitoring and repair are carried out by:

1. This system is implemented on a 20 kV cubicle panel to monitor the presence or absence of hot points at the termination of the 20 kV power cable.
2. This system uses the MLX90640 IR thermal camera sensor to capture the 20 kV power cable termination temperature and the DHT22 Sensor to capture the ambient temperature.
3. The camera's MLX90640 IR thermal sensor and DHT22 sensor are connected to the Raspberry Pi 4 as its microcomputer.

4. The Raspberry Pi 4 will process temperature data, compare the temperature data captured by the MLX90640 IR thermal camera sensor and the DHT22 temperature sensor and then send it to the database via the internet using the HTTP protocol.
5. The system will display the temperature data that has been stored in the database on the website dashboard in real time.
6. The system also sends notifications via the telegram bot application, temperature data from the MLX90640 sensor and DHT22 sensor that have been stored in the database, and justification for the results of the comparison of the temperature values.

B. Flowchart Software Design

In this study, an IoT-based 20 kV power cable termination Hotpoint monitor system was created through the website dashboard and sent notifications through the TelegramBot application. The main variable being monitored is the temperature difference of the termination of the power cable in the 20 kV cubicle panel with the ambient temperature.

The temperature measurement variables at the termination of the 20 kV power cable used are as follows:

Formula $\Delta T = T1 - T2$
ΔT = Temperature difference
T1 = Termination temperature
T2 = Ambient temperature

Condition justification are:
If T < 1°C then Normal condition
If T 1°C < T 10°C then condition I
If T 11°C < T 20°C then condition II
If T 21°C < T 40°C then condition II
If T > 40°C then condition IV

The flowchart of the microcontroller program that will be made is as shown in the picture:

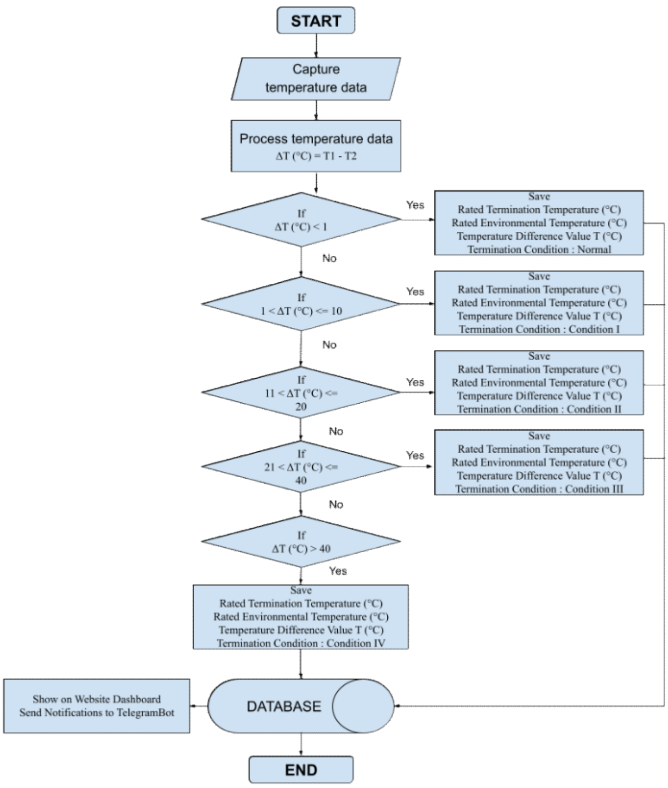

Figure 7. Software Design

E-ISSN: 2798-4664

C. Notifikation Design

To give a warning message about a hot point at the termination of the 20 kV power cable to officers, this study uses the Telegram application which is applied to the Raspberry Pi. Telegram is a free and open-source social media application that provides chat and bot services [11]. The developer of this application also builds an API that can be used to produce bots. This study uses a Telegram bot to automate the sending of temperature data taken by the thermal camera sensor to the telegram group as notification of the presence or absence of Hotpoint.

D. Sensor Accuracy Test Model

This sensor accuracy test is carried out to determine the accuracy of the MLX90640 Ir Thermal Camera sensor in measuring the 20 kV power cable termination temperature and also to determine the accuracy of the DHT22 sensor in measuring air temperature and humidity.

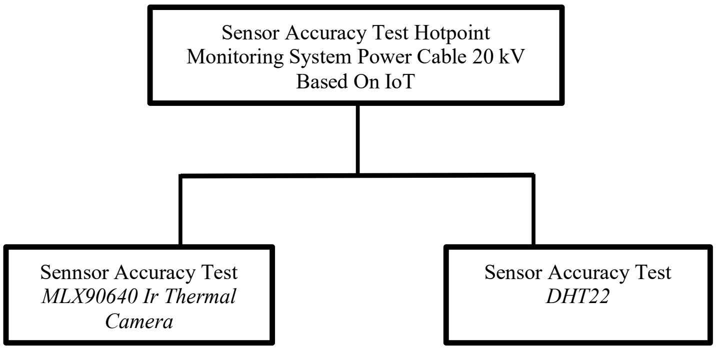

Figure 8. Sensor Accuracy Test

In the image testing the accuracy of the sensor Hotpoint monitoring system for the termination of the IoT-based 20 kV power cable above, it can be seen that there are two sensor tests used, namely:

Testing the accuracy of the MLX90640 Ir Thermal Camera sensor by comparing the 20 kV power cable termination temperature value read by the MLX90640 Ir Thermal Camera sensor with the value read by the Fluke 568 Ir Thermometer. The accuracy value is obtained by dividing the readings of the Fluke 568 Ir Thermometer with the MLX90640 Ir Thermal Camera sensor multiplied by 100%.

Testing the accuracy of the DHT22 sensor by comparing the temperature and humidity read by the DHT22 sensor with the temperature and humidity values read by the SANFIX TH-308. The accuracy value is obtained by dividing the reading of the SANFIX TH-308 with the DHT22 sensor multiplied by 100%.

E. Hardware Design Model

The hardware that has been built to monitor the 20 kV power cable termination temperature consists of electronic circuits and several other components. The following are the results of the hardware design that has been implemented.

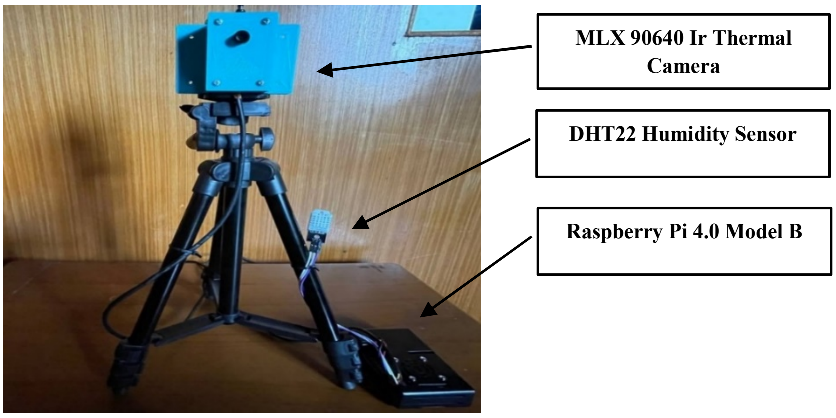

Figure 9. Power Cable Termination Hotpoint Monitor Tool

The system or the workings of the tools that have been designed are as follows:

1. The sensors used are MLX90640 Ir Thermal Camera and DHT22 temperature sensor. The MLX90640 Ir Thermal Camera sensor is connected to the digital pin on the Raspberry Pi 4, to get temperature readings in the -40 °C to 300 °C range. Likewise the DHT22 temperature sensor will use a digital pin.
2. After the Raspberry Pi 4 receives the measurement data from the sensor, then the data will be processed and converted according to the required range. The temperature value of the 20 kV power cable termination generated by the MLX90640 Ir Thermal Camera sensor will be compared with the value of the DHT22 temperature sensor, to determine the status of the 20 kV power cable termination condition.
3. The temperature value and temperature comparison value that has been processed by the Raspberry Pi 4 will be sent to the MySQL database, then it will be displayed again on the website dashboard.
4. The temperature comparison value that has been processed by the Raspberry Pi 4 will then be used for notifications to the Telegram application.

F. Sensor Accuracy Test MLX 90640 Ir Thermal Camera

The MLX90640 Ir Thermal Camera sensor is a sensor used to measure the temperature of a termination 20 kV power cable. As a comparison of sensor measurement data, an infrared temperature measuring instrument will be used, namely the Fluke 568 Ir Thermometer.

Testing the MLX90640 sensor with the Fluke 568 was carried out 5 times by measuring the temperature of different objects. The test results can be seen from the temperature value on the Fluke 568 and the temperature changes displayed by the MLX90640 sensor through the website dashboard and telegram bot notifications. The resulting temperature values can be seen in the table below:

Table 1. Test results temperature sensor MLX90640 and fluke 568

Test to	Sensor Camera Ir MLX90640	*fluke 568 Ir Thermometer*	Temperature Difference (%)
1	25,24 °C	25,8 °C	- 2,17
2	24,41 °C	24,7 °C	- 1,17
3	25,06 °C	25,3 °C	- 0.94
4	46,90 °C	47,4 °C	- 1,05
5	56,85 °C	57,3- °C	- 0,78
Average	35,69 °C	36,1 °C	- 1,13

To determine the temperature difference between the MLX90640 sensor and the Fluke 568, we use the formula for calculating the percentage difference in temperature, namely:

$$\text{Temperature difference value} = \left| \frac{score\ MLX90640 - Score\ Fluke\ Ir\ 568}{Score\ Fluke\ Ir\ 568} \right| x\ 100\ \%$$

$$\text{The average temperature difference} = \left| \frac{score\ average\ MLX90640 - score\ average\ Fluke\ Ir\ 568}{score\ average\ Fluke\ Ir\ 568} \right| x\ 100\ \%$$

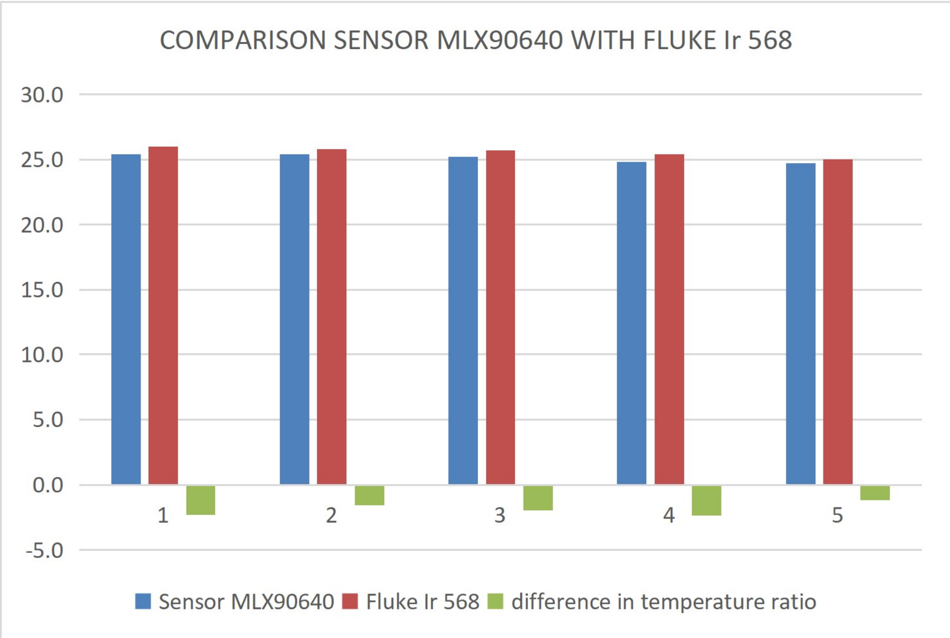

Figure 10. Chart sensor testing MLX90640 with Fluke Ir 568

From the table and graph above, it can be seen that the temperature reading captured by the MLX90640 Ir Thermal Camera sensor is slightly lower than the Fluke 568, but the difference is not too significant.

G. Sensor Accuracy Test DHT22 Humidity

DHT22 sensor testing is carried out outdoors and indoors to determine differences in environmental temperature and humidity conditions. As a comparison of sensor measurement data, an instrument for measuring humidity and air temperature will be used, namely the SANFIX TH-308 hygrometer.

The test was carried out 5 times indoors and 5 times outdoors, by comparing the temperature data obtained by the SANFIX TH-308 hygrometer.

Table 2. Test results temperature sensor DHT22 and hygrometer SANFIX TH-308

No.	Room Condition	Sensor DHT22	Hygrometer SANFIX TH-308	Temperature Difference (%)
1	Indoor	25,4	26,0	-2,3
2		25,4	25,8	-1,5
3		25,2	25,7	-1,9
4		24,8	25,4	-2,3
5		24,7	25,0	-1,2

6	Outdoot	32,2	32,9	-2,1
7		31,8	32,4	-1,8
8		32,5	33,0	-1,5
9		30,6	31,2	-1,9
10		31,2	31,7	-1,5
Average		28,4	28,9	-1,7

To determine the temperature difference between the DHT22 sensor and Sanfix TH-308, we use the formula for calculating the percentage difference in temperature, namely:

$$\text{Temperature difference value} = \left| \frac{score\ DHT22 - Score\ Sanfix\ TH308}{Score\ Sanfix\ TH308} \right| x\ 100\ \%$$

$$\text{The average temperature difference} = \left| \frac{score\ average\ MLX90640 - score\ average\ Sanfix\ TH308}{score\ average\ Sanfix\ TH308} \right| x\ 100\ \%$$

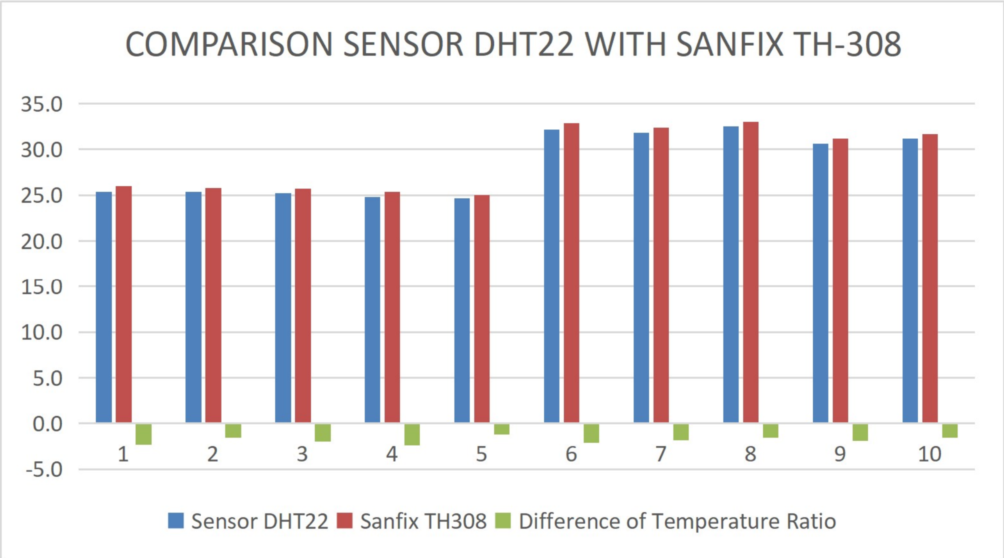

Figure 11. Chart sensor testing DHT22 with Sanfix TH-308

From the table and graph above, it can be seen that the temperature reading captured by the DHT22 sensor is lower than the Sanfix TH-308 Hygrometer, but the difference is still within tolerance limits.

H. ANALISYS

a. Sensor Accuracy Analysis MLX90640 Ir Thermal Camera

Tests on the MLX90640 sensor were carried out using a Fluke 568 Ir Thermometer as a comparison tool. Based on the test results data contained in table 1, it is known that the highest temperature difference value from the 20 kV power cable termination temperature test is -2.13%, while the average temperature difference value is -1.13%. Based on the data from the tests carried out, the temperature difference value and the average temperature difference value of the test found that the temperature measurement produced by the MLX90640 sensor was lower than the temperature value produced by the Fluke 568 Ir Thermometer, but the difference was still relatively small. From the analysis results, it is known that the MLX90640 sensor is able to measure the 20 kV power cable termination temperature with a temperature value that is not much different from the Fluke 568 Ir Thermometer. The resolution of the MLX90640 sensor which is only 32 x 24 pixels is still too low to be displayed directly on the LCD screen but does not affect the temperature value captured.

b. Sensor Accuracy Analysis DHT22

Tests on the DHT22 sensor were carried out using the SANFIX TH-308 hygrometer as a comparison tool. Based on the test data contained in table 2, it is known that the highest temperature difference value from the temperature test is -2.3%, while the average temperature difference value is -1.7%. Based on the data from the results of the tests carried out, the temperature difference value and the average temperature difference value of 10 tests inside and outside the room it was found that the temperature measurement produced by the DHT22 sensor was lower than the temperature value produced by the SANFIX TH-308 hygrometer, but the difference it is still relatively small. From the results of the analysis, it can be concluded that the DHT22 sensor is as expected and can be used on the system is built.

c. Response Time

There is a delay of 5.03 ms in sending temperature data from the sensor to the telegram bot, this is due to the internet network connection used.

4. Conclusions

Based on the results of the thesis research on the development of the Internet of Things (IoT)-Based Hotpoint Monitoring System for Power Cable Disconnection Using the Telegram Bot, it can be concluded that the website dashboard and telegram bot features which are functional requirements of the system have been running well, through this system users can monitor the condition of disconnection of the 20 kV power cable from a distance as long as the device used is connected to the internet network, the application that is built can determine the justification for the condition of disconnection of the 20 kV power cable, and based on sensor accuracy testing, it can be concluded that all sensors have a fairly good performance in measuring parameters. required temperature.

Acknowledgement

This paper uses Mendeley as a reference management tool. Finally, I would like to thank all those who have participated in supporting the success of this research. This paper is far from perfect but is expected to provide benefits for the readers, for that the author needs criticism and suggestions from the readers so that this paper can develop better in the future.

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