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Prototype Of Heater And Humidity Monitoring Device with Dehumidification Method and Auto Backup Feature In 20 KV Cubicle Based on Matlab GUI

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ABSTRACT

In the process of distributing electrical energy to customers, especially medium voltage (TM) customers, a cubicle is needed as a switching and metering device installed on a concrete substation owned by PLN. Inside the cubicle there is a component in the form of a heater that functions to heat the cubicle termination space so that the humidity is maintained. This condition is expected to prevent the occurrence of corona effects on the cubicle termination. The design of the temperature and humidity monitoring tool research in this cubicle aims to anticipate the occurrence of corona in the cubicle termination space. The results of the temperature and humidity monitoring tool research in the cubicle are monitored on the MatLab and Telegram applications. The tool works according to the program, where when the temperature and humidity are above the set point of 350°C and 75%, the fan will turn on to stabilize the cubicle termination space, and when the main heater has a problem, the backup heater will work, which gets power from the backup heater obtained from the battery.

1. INTRODUCTION

In the process of distributing electrical energy to customers, especially medium voltage (TM) customers, cubicles are needed as switching and metering devices installed on PLN's concrete substations. Inside the cubicle there is a component in the form of a heater that functions to heat the cubicle termination space so that its humidity is maintained. The temperature set point limit is not allowed to exceed 350 °C, and humidity is not allowed to exceed 75%. This condition can be expected to prevent the occurrence of corona effects on cubicle terminations.

However, when technicians perform cubicle maintenance, it is often found that the heater in the cubicle is not functioning or is damaged. This is certainly very dangerous and can have fatal consequences if the heater that is not functioning or is damaged in the cubicle is not known by the officer because it can cause the cubicle termination space to become damp and corona appears on the cubicle termination.

From these problems, a prototype of a heater and humidity monitoring tool was designed with a dehumidification method and an auto backup feature that can provide telegram notifications to officers that there is damage to the heater in the cubicle so that officers can immediately come to the location to repair it. While waiting for officers to come to repair it, this tool will provide a backup heater so that the humidity in the cubicle termination space is maintained. This tool also has a monitoring interface on the MatLab application. By making this tool, it is hoped that it can minimize and prevent disturbances in the cubicle caused by damage to the heater.

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2. LITERATURE REVIEW

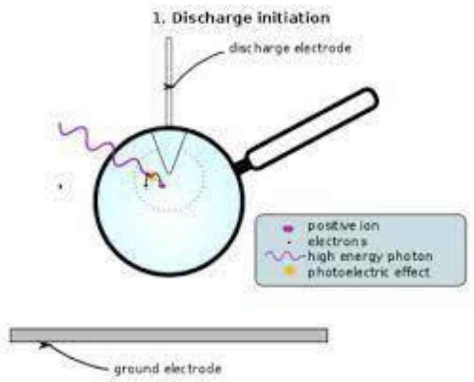
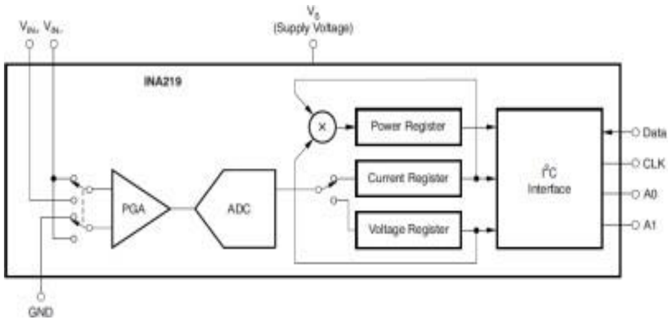


Figure 1. Corona

Corona is a phenomenon that occurs when the air around a conductor becomes ionized. This process releases charges that can cause dielectric breakdown in the air.

Figure 2. INA219 Sensor



INA219 is a sensor module that can monitor voltage and current in a circuit.

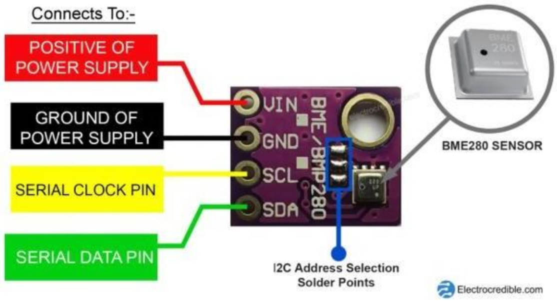


Figure 3. BME 280 Sensor

The BME280 is a 3-in-1 environmental sensor made by Bosch Sensortech. This sensor outputs digital data containing information about temperature, pressure, and humidity.

3. RESEARCH METHOD

3.1. Research Design

The method used in this study is a descriptive method with a quantitative approach that will be delivered using the ADDIE model.

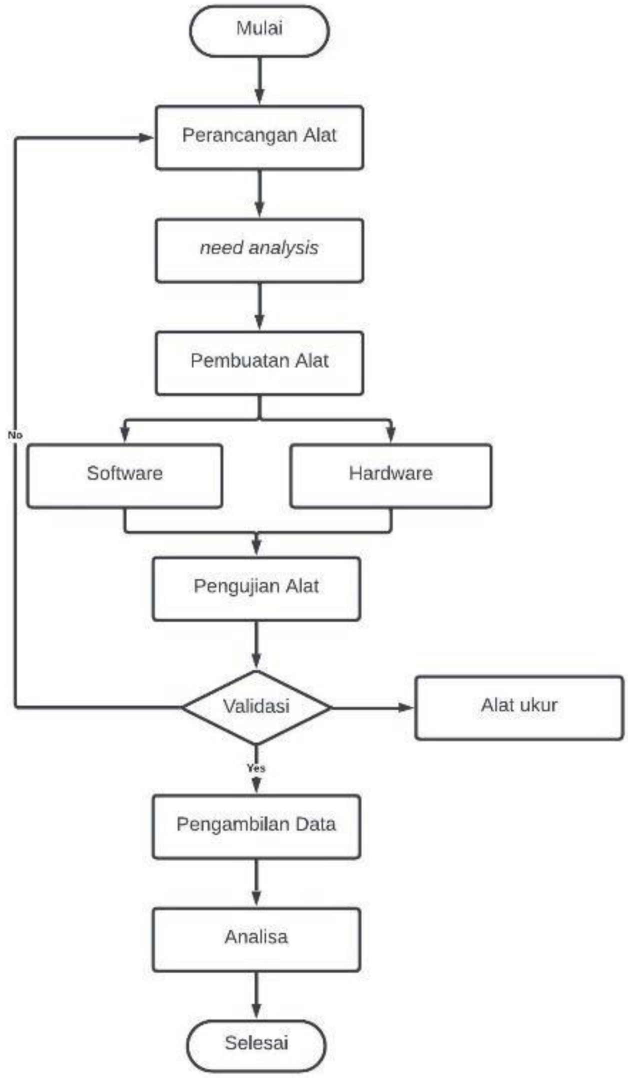


Figure 4. Research Design

3.2. Tool Design

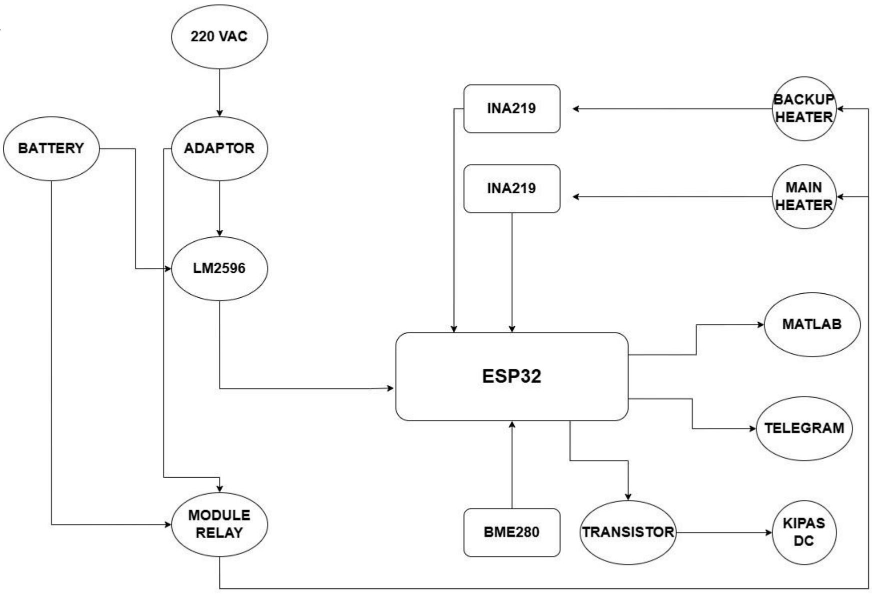


Figure 5. Tool Block Diagram

It can be seen that the 220 VAC voltage will be converted into 12 VDC voltage by the adapter; the output of the adapter will go to the LM2596 stepdown, which will be reduced to 5 VDC, which is used as power from the ESP32, and to the relay module. The INA219 sensor will read the current and voltage results that will be sent to the ESP32; the results of the reading will be forwarded by the ESP32 to MatLab so that the current and voltage data can be displayed on the monitoring interface. Then, when the main heater is damaged, the INA219 sensor will also send a signal to the ESP32, which will order the relay to turn on to order the backup heater to work, where the backup heater will be supplied by the battery as its power. Then the BME280 sensor will collect data on the termination conditions in the cubicle, which will be sent to the ESP32 microcontroller and then forwarded to MatLab to display the results of the temperature and humidity monitoring readings in the cubicle. When the temperature in the cubicle is above the set point that has been determined, namely for the temperature set point above 35oC and for humidity above 75%, the transistor will order the fan to turn on to stabilize the humidity temperature in the cubicle. Then, when the temperature and humidity are below the set point, the fan will turn off again.

3.3. Tool Components

In making this tool, several components are needed that are designed to produce the desired tool. These components are:

3.3.1. Hardware

1. ESP32
   The microcontroller used in this final project is ESP32, which functions to regulate the entire system, read input data from current, voltage, and temperature sensors, send to telegram and MatLab, and regulate switching on the relay.
2. INA219 Sensor
   This sensor functions to read current and voltage data on the heater.
3. Relay
   In this final project, the relay functions as a switch to provide supply to the backup heater if damage occurs to the main heater. The function of the relay here is similar to the ATS (Automatic Transfer Switch) system.
4. BME280 Sensor
   This sensor works to collect and send data in real time to the microcontroller, and this tool also works when the humidity is too low or too high, so that this sensor will activate the fan used to stabilize the humidity in the cubicle.
5. Adapter
   In this final project, the adapter is used to convert AC voltage to DC voltage.
6. Buck Converter LM2596
   In this final project, the LM2596 stepdown is used to lower the voltage to 5VDC; this is needed to provide a power supply to the ESP32 microcontroller as the brain in this tool.

3.3.2. Software

1. Telegram Application
2. Telegram is a communication application that can send and receive text, photos, and files. In the design of this tool, telegram functions to receive notifications about the condition of the heater.
3. MatLab (Matrix Laboratory)
4. Matlab has a development option in the form of a GUI (Graphic User Interface). The GUI designer includes menus, buttons, text, graphics, and others that users can change interactively using the mouse and keyboard. In this final project, Matlab functions as an interface for monitoring the control of the heater and humidity in the cubicle.

3.4. Testing Technique

This testing technique is carried out to determine the performance of the tool that has been made whether it is working properly according to its function. So this testing is carried out on each part, including hardware and software. This testing includes testing the INA219 sensor and BME280 sensor, testing switching relays, testing telegram communication with ESP32, testing monitoring on MatLab, and testing the temperature humidity regulator. By conducting this test, the capabilities of each part of this final project will be known, and from the results of this test, it will be easier to make repairs if problems occur.

3.5. Data Analysis Technique

Based on the problems that have been described, the researcher has compiled a tool to find solutions to the problems found. The analysis techniques that can be used are:

1. Literature study method, namely by exploring, researching, and considering supporting theories to solve the problems being studied.
2. Library method, namely information from reference books, instructors, friends, and internet sites that help obtain the theoretical basis for this text, including questions asked by the researcher.
3. The observation method, namely conducting field observations to find supporting data and information that cannot be obtained from literature or laboratory studies.
4. Calculation analysis method, namely conducting design analysis of the designed components.
5. The experiment method, namely an experiment that obtains data from the results of an experimental program made in the form of a simulation, can help solve existing problems.
6. Discuss, namely providing guidance with lecturers and other parties who can help implement this design.

4. RESULTS AND DISCUSSION

4.1. Research Results

This chapter explains how to test the system plan that has been made in the previous chapter. This test is carried out to determine the work of the tool and to determine whether the tool works according to plan.

4.2. Analysis Results

At this stage, an analysis is carried out regarding the problem, identifying the tool, and developing the tool to be made. In making this tool, the researcher found a problem, namely the ineffectiveness of monitoring the temperature and humidity in the cubicle space, so that the technicians carried out manual monitoring, and this was ineffective. In this condition, it is feared that the temperature and humidity in the cubicle will not match, which can cause corona in the cubicle.

4.3. Design

After carrying out the analysis stage, the next stage is the planning stage (design) regarding the tool to be made.

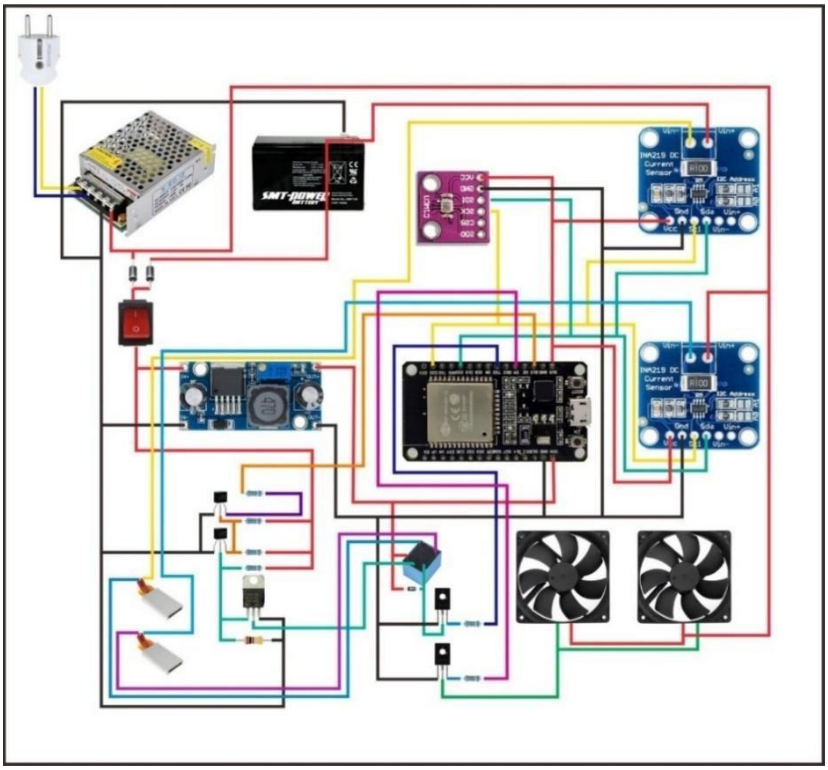


Figure 6. Tool Design

4.4. Development

The development stage is the stage where the design or system plan that has been made previously will be realized to become the desired product. At this development stage, what has been designed at the design stage will begin to be actualized into a tool that meets expectations.

Figure 7. Overall tool

4.5. Research Discussion

4.5.1 Adapter Testing

In this final project, the author needs an adapter that is used to convert AC (Alternating Current) voltage to DC (Direct Current) voltage, then the voltage is used for the relay module source. Measurements are made on the output side of the adapter, this is done to find out the results of the adapter. Measurements are made using a multimeter measuring instrument. The following are the results of measuring the adapter output using a multimeter.

Table 1. Adaptor Test

Test	Input Voltage (VAC)	Output Voltage (VDC)
1	221	12, 13
2	220	12, 49

Test	Input Voltage (VAC)	Output Voltage (VDC)
3	222	12, 20
4	220	12, 78
5	220	12, 59

From the experimental results in the table above, it can be concluded that the power supply is working normally because it can reduce the average voltage of 220 VAC to 12.43 VDC.

4.5.2 . Testing the Buck Converter LM2596

The Buck Converter here works by reducing the voltage of 12 VDC to 5 VDC. Testing the Buck Converter is useful for determining whether this tool is working according to its function or not. This test is carried out by connecting the red probe to the positive terminal and the black probe to the negative terminal of the Buck Converter LM2596. The following are the results of the Buck Converter LM2596 measurement.

Table 2. Buck Converter Test

No	Voltage Input (VAC)	Voltage Output (VDC)
1	12, 13	5, 11
2	12, 49	5, 10
3	12, 20	5, 14
4	12, 78	5,16
5	12, 59	5, 12

The results of the LM2596 Buck Converter test in the table above show that the Buck Converter works according to its function, namely it can reduce the voltage from 12 VDC to 5 VDC.

4.5.3. INA219 Sensor Testing

The INA219 sensor test is carried out to determine whether the sensor is functioning properly or not. The INA219 sensor is used to measure the current and voltage flowing to the heater on this device. This device works when there is voltage and current flowing to the heater. The results of the INA219 sensor measurements will be displayed in the MatLab application. To further ensure the accuracy of the data from the sensor, the author also uses an AVometer to compare the results of the sensor measurements with the measuring instrument.

Table 3. INA219 Sensor Testing

No	Monitoring MatLab	Avometer
1	12, 05VDC	12, 07VDC
2	12, 02VDC	12, 01VDC
3	12,18VDC	12, 20VDC
4	12, 11VDC	12, 10VDC
5	12, 14VDC	12, 12VDC
6	12, 10VDC	12, 12VDC
7	12, 09VDC	12, 12VDC
8	12, 11VDC	12, 12VDC
9	12, 04VDC	12, 10VDC
10	12, 09VDC	12, 11VDC

The results of the INA219 sensor test can be concluded that the sensor works according to its function. Where the sensor can monitor in real time the voltage and current flowing to the heater. In this experiment, the author used an Avometer as a comparison between the results of sensor measurements and the results of Avometer measurements. The results obtained were not much different between sensor measurements and Avometer measurements.

4.5.4BME280 Sensor Testing

Testing the BME280 temperature and humidity sensor needs to be done in order to find out whether this sensor is working according to its function or not. This BME280 sensor is used to measure temperature and humidity in the cubicle prototype. Testing of this tool is carried out using a hairdryer and air purifier to find out whether this sensor is working or not.

Table 4. Temperature Sensor Testing

No	Temperature	Hygrometer	Condition
1	26, 2^{0}C	26^{0}C	Fan Off
2	30, 2^{0}C	30, 4^{0}C	Fan Off
3	33, 9^{0}C	33, 8^{0}C	Fan Off
4	35, 5^{0}C	35, 4^{0}C	Fan On
5	37, 6^{0}C	37,5^{0}C	Fan On
6	40, 7^{0}C	40, 4^{0}C	Fan On
7	38, 7^{0}C	38, 5^{0}C	Fan On
8	35, 8^{0}C	35, 6^{0}C	Fan On
9	34, 1^{0}C	34, 3^{0}C	Fan Off
10	33, 78^{0}C	33, 5^{0}C	Fan Off

Tabel 5. Humidity Sensor Set Point Testing

NO	Kelembapan	Hygrometer	Kondisi
1	55, 2%	55, 4%	Fan Off
2	66, 4%	66, 2%	Fan Off
3	68, 15%	68, 10%	Fan Off
4	69, 10%	69%	Fan Off
5	70%	70, 1%	Fan Off
6	71, 89%	72%	Fan Off
7	73, 10%	73, 15%	Fan Off
8	74, 54%	74, 50%	Fan Off
9	75,1%	74, 57%	Fan Off
10	74, 80%	79%	Fan Off

From the test results, it can be concluded that the BME280 sensor works according to its function, where the reading results via the sensor with the hygrometer tool are not much different.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

From the planning and creation of the system that has been done and then tested, the following conclusions are obtained:

1. This prototype is made using an ESP32 as its microcontroller, then this tool uses an INA219 sensor to read the current and voltage from the heater, and this tool uses a BME280 sensor to read the temperature and humidity at the cubicle space termination.
2. This tool has successfully worked according to its program, where when the main heater has trouble, the backup heater will work where the backup heater power is obtained from the battery. Then this tool can also stabilize the temperature and humidity, where when the temperature is above the set point of 350C and the humidity is above 75%, the fan will work to re-stabilize the cubicle termination space. When the temperature and humidity are below the set point, the fan will stop working.

5.2. Further Research

It is expected that further research will add an LCD as monitoring on the tool and add remote control to make it easier for users to monitor.

5.3. Acknowledgements

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