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An Automatic Temperature Monitoring and Control System for Electric Power Distribution Panel

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ABSTRACT

A power distribution panel plays an important role in the distribution of electrical power in factories or buildings. Through separate wirings, the electrical input that comes into the distribution panel is split up and sent to different parts of the building. At certain temperature, some electric distribution panel components may be highly flammable, posing a fire or explosion risk. As a solution to the issue of excessive temperature rise in the distribution panel, an automatic temperature control system was designed and implemented. The prototype design includes a mechanical thermostat that also functions as a sensor, an electric fan, and a miniature circuit breaker. The design works in such a way that the temperature controller actuates the cooling system when the panel's temperature reaches 40 degrees Celsius. The results of the test show that the designed system can detect changes in temperature and turn on the cooling fan to ensure the panel's temperature does not exceed the safe level temperature of 40 0C. This system serves as a tool for solving temperature recognition issues in electric power distribution panels.

KEYWORDS: *Temperature control, mechanical thermostat, distribution panel, voltage, fire hazard, electric power*

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INTRODUCTION

Electricity unquestionably plays an unparalleled role in everyday sustenance, whether in urban or rural areas, in this 21st century. Electricity is used in buildings for running lights, cooking, charging/running electrical appliances, and so on. Electrical wirings are used to transfer electricity safely throughout the building without endangering anyone or any electrical appliances. Because of this, electrical wiring has evolved into one of the most fundamental aspects of our day-to-day lives [1]. Numerous electrical appliances are connected to a network of electrical wiring in almost every building. However, to guarantee that the electricity is distributed uniformly and evenly throughout the building, an electric power distribution panel is installed alongside the electrical wiring [2].

For the proper distribution of electrical power in factories or buildings, electrical power distribution panels are used. Through separate wirings, the electrical input that comes into the distribution panel is split up and sent to different parts of the building. Power distribution panels typically have a single central switch that is used to control the flow of electricity throughout a building [3]. When the main switch is turned off, all subsidiary wiring and miniature circuits loses power. As a result, consumers place a high value on ensuring the safety of distribution panels because its malfunction will prevent the continuous supply of electric power to various parts of the building where they are installed. It is stated by [4] that electrical power outages frequently caused by insulation failure in electric power distribution panels have not been significantly reduced despite all ongoing preventative measures. This may be due to a lack of information regarding the temperature rise of distribution panels above the safety level (40°C). Furthermore, due to the risk of accidental fire outbreaks in shunt circuits caused by temperature-related insulation breakdown of conductors and to avoid conductor burnout accidents and save money on maintenance, distribution panels require a fully operational temperature monitoring and control system. To guarantee the panel's and the entire electrical installation's safety, a smart system capable of measuring information about general electrical conditions like current, voltage, power, power factor, and temperature is required.

According to [5], temperature control systems are systems that are made to monitor and control the temperature of a room, body, or component under a particular consideration, and they are used by modern electrical and smart home devices to control and direct the operation of electrical appliances. They are designed using either programmable thermostat or mechanical thermostat [6]. Moreover, exposing a body or enclosure to a wide range of environmental stimuli alters the temperature (a fundamental measurement unit that expresses how hot or cold an enclosure, room, body, or environment is) of that body and hence, the materials used in building it [7]. As a result, the distribution panel's automatic temperature control system is beneficial because it keeps the temperature within the safe range for the design's materials. This paper develops a temperature-based electric distribution panel safety temperature control system.

LITERATURE REVIEW

Warren S. Johnson developed the idea of automatic temperature control in 1880 [8] and patented the first pneumatic temperature control in 1895 [9]. This research area has undergone numerous advancements and innovations since then. To this, [10] developed a temperature controller system using a Proportional Integral Derivative (PID) controller and Lab VIEW. According to [11] temperature control system for home used Peripheral Interface Controller (PIC) Microcontroller 16F877A to decide when to turn on or off the heater or air conditioner to keep the temperature of the room between 20^0C and 28^0C. A practical approach to operating a temperature control system for a computer room was provided by utilizing the AT89C51 Single-Chip Microcomputer (SCM, MCU), which is capable of controlling both the temperature of the room and the cooling system by [12]. [13] designed a temperature control system that adjusts the temperature of any device in accordance with its requirements for any industrial application using a PIC16F887A microcontroller. A seven-segment display shows the temperature of the environment that the thermocouple sensor has detected. The heater is turned off if the temperature is higher than the user-stored value for this temperature, which varies between 0°C and 750°C. A relay and an NPN transistor serve as interfaces between the system's switching state and the microcontroller. Research by [13] resulted in the development of a temperature-controlled system for an air-filled chamber with less than 10K overshoot and steady-state temperature error in the real chamber temperature step response. The system was designed to handle the target chamber temperature within a specified time frame. The development of a dual-sensor heat monitoring system was the primary focus of the study of [14]. While monitoring temperature from an external input, the circuit describes the current temperature to a predetermined temperature value. According to the findings of the test, an alarm was set off and the power output of the circuit was turned off whenever the temperature of the device exceeded a predetermined threshold [15].

DESIGN METHODOLOGY

A novel method for controlling and monitoring the temperature of an electrical power distribution panel is presented in this paper. A temperature sensor, a cooling system, and a power supply made up the system. The mechanical thermostat maintains the ability to turn on and off the cooling system. The system is set up in such a way that the temperature sensor bulb serves as the mechanical thermostat's input, which it uses to control the distribution panel's cooling fan. For this system, the danger alarm would go off and the circuit breaker would trip if the temperature continued to rise above 50^0C. The block diagram of the temperature monitoring and control system (ATMCS) for electric power distribution panel is shown in Figure 1.

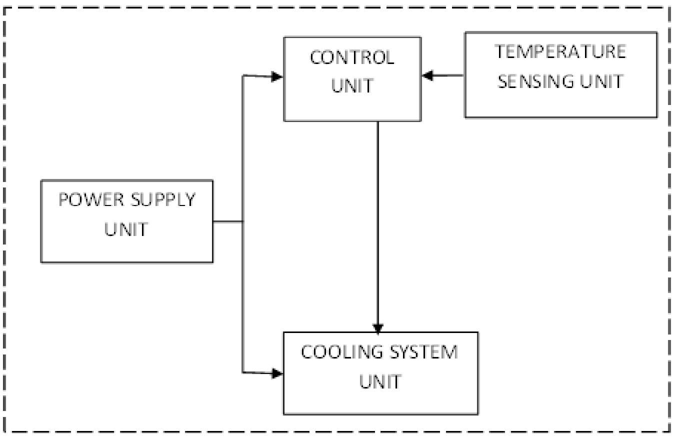

Figure 1: Block Diagram of ATMCS for electric power distribution panel

Power Supply

To provide the required power, each electronic circuit requires a power source, which could be a battery or a mains supply. To obtain input power from the mains supply and supply a DC source to the monitoring and control circuits, the design makes use of a 220 V AC/DC miniature circuit breaker.

Control unit

Temperature sensors such as Thermistors, Resistance Temperature Detectors (RTDs), LM335 and/or AD590 are frequently utilized to keep systems at a constant temperature. A precision temperature controller uses a current or voltage source to supply power to these actuators based on data from a temperature sensor. According to [16], these kinds of sensors can frequently achieve stability ranging from 0.01°C to 0.001°C. For dependable qualities of 1°C, other less precise sensors like thermocouples can likewise be used. Nevertheless, the architecture of the system determines the stability. Hence, with the end goal of this plan, the temperature regulator utilized is the Mechanical thermostat. To keep the distribution panel at the safe temperature, this mechanical thermostat precisely controls when the cooling fan comes on and off. The used mechanical thermostat can be set to a temperature between 30 and 110 degrees Celsius. The internal architecture of the mechanical thermostat and its physical appearance are depicted in Figures 2 and 3, respectively.

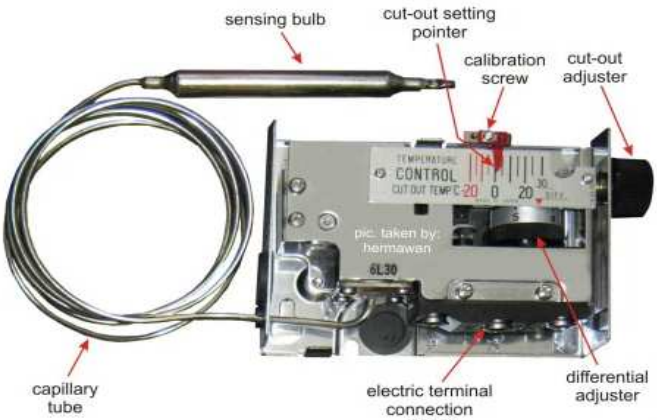

Figure 2: An internal view of a Mechanical Thermostat

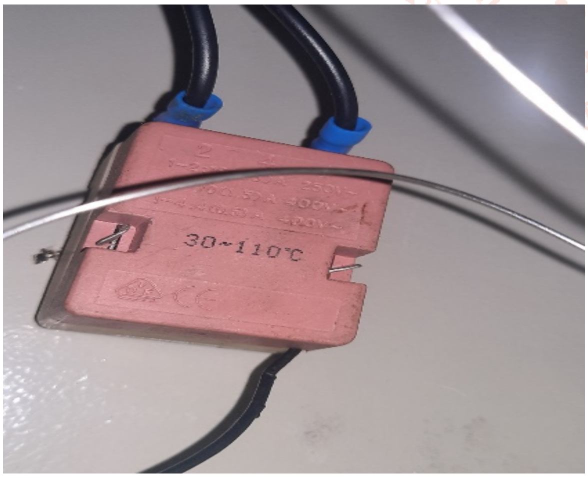

Figure 3: Physical outlook of the mechanical Thermostat

Temperature Sensing Unit

A temperature sensor is a device that converts the input data into electronic data and keeps track of the surrounding temperature. Some temperature sensors, known as "contact temperature sensors," require direct contact with the physical object whose temperature is to be monitored to gather information. On the other hand, some temperature sensors, known as "non-contact temperature sensors," do not require direct contact to measure an object's temperature. There are various kinds of temperature sensors, including Resistance Temperature Detectors (RTDs),

Thermocouples and thermistors, and infrared (IR) sensors - a non-contact temperature sensor. A temperature sensor for a thermostat is used in this design. The thermostat's sensing bulb is responsible for detecting the temperature in the panel. The temperature-sensing bulb is depicted in Figure 4.

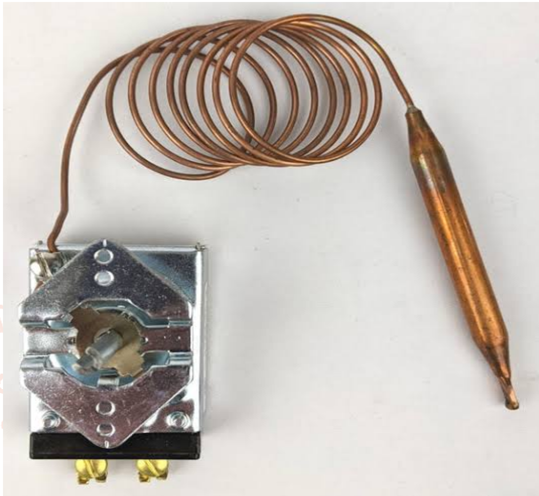

Figure 4: Temperature Sensing Bulb of the Thermostat

The cooling system

A cooling system is one that maintains the temperature of an engine or structure. The purpose of cooling systems is to remove too much heat from the area they are supposed to cool, thus keeping the temperature of the compartment at the desired level. A 220 Vdc Axial Industrial Fan is used to achieve the type of cooling system that is utilized in this design. The industrial cooling fan's physical structure is shown in Figure 5.

Figure 5: An Industrial Cooling Fan.

MATERIAL SELECTION

To accomplish the study's goal, various materials were chosen and are listed in Table 1.

Table 1: Selected Materials for the ATMCS

S/N	Components	Features	Specification
1	Miniature circuit breaker	input voltage	220 Vac
		Current	13 A
		Output voltage range	220 – 400 Vdc
2	Industrial cooling fan (an axial type)	Current	5A
		Voltage	220 Vdc
3	Mechanical Thermostat	temperature range	30°C to 110°C
		Voltage range	220 – 400 Vdc

SYSTEM IMPLEMENTATION

The selected components were connected in the manner illustrated in Figure 6.

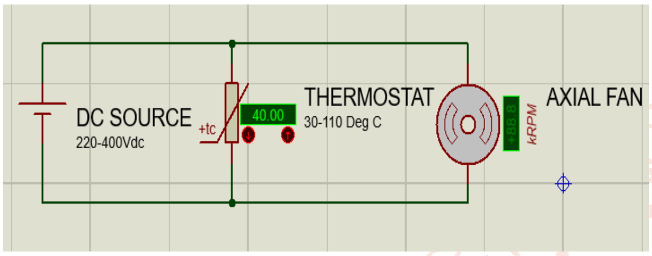

Figure 6: The wiring diagram of the system.

The temperature sensing bulb automatically monitors the temperature of the distribution panel. The obtained data is fed into the mechanical thermostat, where it will be processed and used to turn on and off the cooling fan. Figure 7 depicts the installed ATMCS in the distribution panel.

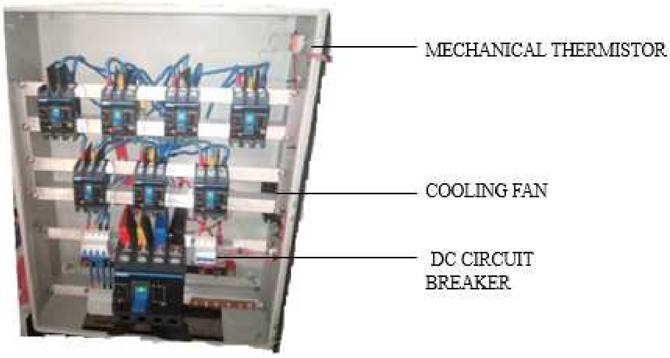

Figure 7: The Picture of the ATMCS installed in Electric Distribution Panel

RESULTS AND DISCUSSION

The ATMCS was made to function when the temperature in the enclosure is above 40^0C. The ideal working temperature for the majority of the electric distribution panels lie between the range of 40°C and 50°C. The lifespan of the components decreases as the internal temperature rises. In this design, any temperature above 40°C is regarded as abnormal and is not anticipated to occur under normal operating conditions. As a result, the cooling fan is activated to evacuate the thermal energy from the enclosure. An artificial heating element was used to simulate the performance of ATMCS. The enclosed panel's temperature was raised by this heating element and the ATMCS's performance was observed and recorded as the temperature rose. As the temperature was raised or lowered by 5°C increments, the fan's state was observed and recorded. Tables 2 and 3 summarize the findings.

Table 2: The performance Test of the ATMCS as temperature increases

Temperature (°C)	State of the Cooling Fan	Operating Test Time (S)
30	OFF	600
35	OFF	600
40	ON	300
45	ON	300
50	ON	300

Table 3: The performance Test of the ATMCS as temperature decreases

Temperature (°C)	State of the Cooling Fan	Operating Test Time (S)
50	ON	300
45	ON	300
40	ON	300
35	OFF	600
30	OFF	600

The time allotted for the system to function under each temperature value is represented by the operating test time in Tables 2 and 3. To ensure safety, the operating test time was reduced as the temperature rises. According to Table 2, the cooling fan was turned ON when the temperature reached 40^0C, changing its state in the table from OFF to ON. This corresponds with the set time on the mechanical thermostat. At this point, the test time was reduced to 5 minutes as against the initial 10 minutes used initially. The cooling fan's status also changed from ON to OFF when the panel's temperature dropped to 35^0C as shown in Table 3. Here, the operating test time was then increased back to 10 minutes.

CONCLUSION

The electric power distribution panel's automatic temperature monitoring and control system has been successfully implemented in an electric distribution panel. The system performance is satisfactory. As a result, the project's aim was achieved. This system can be utilized in bakeries, incubators, houses, halls, offices, and other locations where a particular constant temperature is required. For enclosure bigger than the sized used, a three-phase induction motor fan may be utilized because of its robustness and heat handling capacity and good performance under other climatic variables. Moreover, a digital thermometer that only allows a temperature variance of plus or minus 0.1°C should be used as the temperature controller, to increase the cooling system's efficiency, length of service, and for better precision.

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