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AN IOT PROTOTYPE FOR TEMPERATURE MONITORING AND AUTOMATIC CONTROL OF ELECTRIC MOTOR

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Abstract: The continuous use of an electric motor in some industries causes the electric motor to malfunction early. Such damage is generally caused by overheating. Therefore, to overcome the problem of overheating, most industries use two motors that work alternately. Both electric motors function as running and standby which are generally controlled manually by the operator or using a time delay relay (TDR). However, the control of both motors by the operator is not effective because it allows human error to occur. The use of TDR is also ineffective because it does not make the temperature of the electric motor a reference in controlling the work of the two electric motors. This research aims to produce a prototype that can monitor the temperature of the electric motor in real-time and control the electric motor based on the temperature of the electric motor. The Wemos D1R2 is used as a processor to control both electric motors and transmit the temperature of the electric motor to a smartphone via the internet. The MLX90614 sensor is used as an infrared-based temperature sensor. Based on the results of testing the overall performance of the prototype, it is known that the temperature readings of the electric motor are quite accurate with mean error and standard deviation of 0.13°C and 0.15°C, respectively. The prototype is also capable of controlling both electric motors automatically and controlling a cooler via a smartphone.

Keywords: Electric Motor; MLX90614; Overheating; Wemos D1R2.

Abstrak: Penggunaan sebuah motor listrik secara terus menerus pada sebagian industri menyebabkan motor listrik tersebut mengalami kerusakan lebih awal. Kerusakan tersebut umumnya disebabkan oleh panas berlebih. Oleh karena itu, untuk mengatasi masalah panas berlebih tersebut maka sebagian besar industri menggunakan dua buah motor yang bekerja secara bergantian. Kedua motor listrik tersebut difungsikan sebagai *running* dan *standby* yang mana umumnya dikendalikan secara manual oleh operator atau menggunakan *time delay relay* (TDR). Namun, pengendalian kedua motor oleh operator tidaklah efektif karena memungkinkan terjadinya *human error*. Penggunaan TDR juga tidak efektif karena tidak menjadikan suhu motor listrik sebagai acuan dalam mengendalikan kerja kedua motor listrik tersebut. Penelitian ini bertujuan menghasilkan sebuah prototipe yang mampu mengawasi suhu motor listrik secara *real-time* dan mengendalikan motor listrik berdasarkan suhu motor listrik. Wemos D1R2 digunakan sebagai prosesor untuk mengendalikan kedua motor listrik dan mengirimkan suhu motor listrik ke *smartphone* melalui internet. Sensor MLX90614 digunakan sebagai sensor suhu berbasis infra merah. Berdasarkan hasil pengujian kinerja prototipe secara keseluruhan diketahui bahwa hasil pembacaan suhu motor listrik cukup akurat dengan *mean error* dan standar deviasi masing-masing 0,13°C dan 0,15°C. Prototipe juga mampu mengontrol kedua motor listrik secara otomatis dan mengontrol sebuah pendingin melalui *smartphone*.

Kata kunci: Motor Listrik; MLX90614; Panas Berlebih; Wemos D1R2.

INTRODUCTION

The use of electric motors has been widely applied to airports. These uses are generally applied to pumping machines, such as clean water irrigation systems, drainage systems, compressor systems, refueling systems, air circulation systems, and so on. Thus, electric motors have a significant role in supporting airport operations so that they can work properly. However, the use of electric motors continuously can cause overheating of the electric motor. Thus, it can cause a reduction in the service life of the electric motor [1].

The problem of overheating in the pump motor is generally overcome by using two pump motors, one of which is the pump motor running while the other pump motor is a standby. However, the operation of the two pump motors is generally still done manually by the operator. Thus, the operation of the two pump motors is still not optimal. On the other hand, there is another method of operating both pump motors, namely automatically. However, the operating method is not based on motor temperature but based on a timer that has been programmed on a relay. Thus, even though the electric motor is too hot, the motor still works until a certain time. So that it can cause damage to the motor [2], [3].

In this study, a prototype was proposed that can operate and supervise both pump motors automatically based on the Internet of Things (IoT). The parameter that is a reference for the work of the prototype is the temperature of the electric motor. This prototype works by measuring the temperature on an electric motor using an infrared temperature sensor. If the temperature on the electric motor that is working (running electric motor) is more than 40^oC then the motor stops and the standby motor works automatically. At the time, the prototype also sent notifications to users via email. The prototype is also equipped with a liquid crystal display (LCD) to display the temperature of both electric motors [4]–[6].

Several relevant studies have been conducted in previous studies related to electric motor control devices on pumps. In Research [7] a remote water pump protection and monitoring system has been produced to be applied in the pump house of Mutiara Sis Al-Jufri Airport Palu. To protect the motor, three sensors are used, namely a current sensor, a voltage sensor, and a water flow sensor. The research is also based on the Internet of Things (IoT). The study is different from this study which uses infrared temperature sensors to control electric motors.

In Research [8] an IoT-based DC brushless motor monitoring tool with Fuzzy Logic control has been produced. The study aims to regulate the speed of the DC brushless motor based on input from rotational speed, electric current, and temperature sensors. The working principle of the tool resulting from the study is if the rotational speed of the motor, the current flowing in the motor and the temperature in the motor exceed the predetermined set point value. Then the motor will be arranged in such a way that the parameters of the motor return to the predetermined set point value.

Thus, the service life of the pump motor becomes longer. Unlike the case with the prototype produced from this study, the prototype results of this study do not regulate the speed or amount of electric current entering the pump motor. But it only replaces the work (handover) of the main pump motor (running) that has passed the set point temperature automatically to the stand-by pump motor. This is done because there is a pump motor in charge of flowing fluid with a certain discharge that has been set for production purposes.

In Research [1] an IoT-based DC motor rotational speed monitoring system has been designed using the Blynk IoT application. The study aims to monitor the temperature, current, and speed of DC motors. In this study, a waterproof DS18B20 temperature sensor was used to measure the temperature of the motor. In contrast, this study uses the MLX90614 GY-906 sensor and is applied to a 1-phase motor for electric water pumps.

In Research [9] a remote control and observer of motor conditions with Arduino-based IoT has been produced. The study used a 1-phase motor in its testing but used a DHT 11 temperature sensor attached to the motor body to measure the temperature of the motor. Unlike the case with the tool that will result from this study that uses non-contact sensors to measure temperature so that it is more efficient in its use. In addition, Wemos D1 R2 is also used as a processor that has been equipped with IoT capabilities [10]–[12].

METHOD

This research has three stages of research, namely making programs and simulations, hardware design, and prototype testing.

Making Programs and Simulations

At this stage, research begins with creating a program to connect the processor to the internet network. Thus, the processor can connect to a smartphone via the internet. The Blynk IoT application used as a platform on existing smartphones can connect to prototypes. Next, a program is created for temperature sensor readings and displays the temperature readings on a liquid crystal display (LCD). Last is the program to control both electric motors automatically and control the cooler using a smartphone. The entire program is built on the Arduino IDE software and embedded in the Wemos D1R2.

The next stage is to determine the parameters and characteristics of the electronic components used. The parameters include the working voltage and working current of the components as well as the function of each input pin and output pin of the component. Furthermore, proteus simulators are used to design and simulate prototype circuits. The working parameter used in the prototype is the temperature of the electric motor. If the temperature of the electric motor is> 40^oC then the processor will instruct Electric Motor B as the electric motor stand by to work and Electric Motor A as the running electric motor stops working. Furthermore, the Wemos D1R2 also instructs the LCD to display the readings of the temperature sensor for each electric motor. A notification in the form of "electric motor temperature A overheated" is also sent to the user's smartphone via the internet [13]–[15].

Hardware Design

This stage is carried out after the stages of making programs and simulations are completed. At the simulation stage, the entire system circuit is simulated according to the real state of the circuit. This was done to minimize the cost of hardware design due to errors during experiments.

Hardware design began by connecting temperature sensor pins, LCDs, and relays to Wemos D1R2 pins. Then connect the relay pins to the electric motor. In this study, two 1-phase electric motors were used as a water pump drive. The two electric motors are used interchangeably based on the temperature set by the Wemos D1R2. The block diagram of the prototype in this study is shown in Image 1 below.

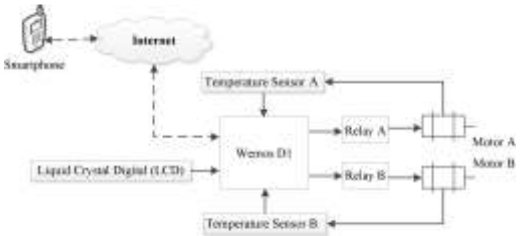

Image 1. Circuit Block Diagram

Functional Needs

This research has several functional needs in the form of tools and materials. The functional requirements of this study are shown in Table 1 below.

Table 1. Functional Needs

Device	Quantity
Adaptor 9 Volt	1 pcs
Blynk IoT app	1 pcs
LCD 2x16	1 pcs
Relay Module	2 pcs
Wemos D1R2	1 pcs
Proteus Simulator	1 pcs
MLX90614 GY-906	2 pcs
Smartphone	1 pcs
Connecting Cable	to taste

Based on Table 1 and Image 1 there are 9 types of devices with each function as follows: Wemos D1R2 functions as a processor to process incoming signals from temperature sensors and control several electronic components such as LCDs and Relays [16], [17]. The MLX90614 GY-906 sensor is an infrared sensor placed on the second winding of the electric motor. The placement of the sensor is non-contact, that is, without contact between the sensor and the pump body [18]. LCD functions to display the temperature of both electric motors in units of ^{o}C. Two relay modules are used as switches to connect a voltage source (220 Volt AC) to each electric motor. A 9 Volt adaptor was used as a power source for the resulting prototype. The 9 Volt voltage was chosen because it was still within the recommended voltage range for the processor.

RESULT AND DISCUSSION

The overall prototype resulting from this study is shown in Image 2 below. There are three lights as indicators to represent both an electric pump and a coolant. Furthermore, a smartphone is used to monitor temperature changes in real-time on both electric motors as well as control the coolant to work.

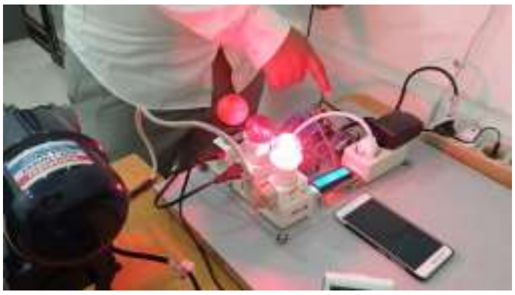

Image 2. Overall Prototype

LCD and Temperature Sensor Testing

LCD testing is carried out by comparing the temperature sensor readings from the prototype represented through the LCD against the temperature measurement results using a thermocouple sensor. LCD testing as shown in Image 3 shows that there are two measurement results, namely ambient temperature and object temperature. Ambient temperature is the reference temperature to determine the temperature of the object being measured.

Image 3. LCD Testing

Based on Image 3, it is known that the ambient temperature is 24.85°C while the object temperature is 26.71°C. Testing of the temperature sensor on the prototype, namely the MLX90614 GY-906 Sensor was carried out using a soldering heater.

Testing of temperature sensors using solder is carried out to obtain rapid temperature changes to the temperature of the measured object. Based on the results of testing the temperature sensor on the prototype using solder as shown in Image 4, it is known that the ambient temperature is 29.19°C and the object temperature is 55.15°C. Thus, when compared to Image 3 there has been an increase in object temperature from 26.71°C to 55.15°C. So, it can be known that the MLX90614 GY-906 Sensor can work well because the sensor can read temperature changes.

Image 4. MLX90614 Sensor Testing

Sensor Accuracy MLX90614 GY-906 was tested using a comparison sensor as shown in Image 5 below. In this study, an instrument in the form of a thermocouple sensor was used inside the Fluke device. Based on the results of the comparison of temperature readings from the two sensors, temperature change data has been obtained on the running motor and standby motor.

Image 5. Thermocouple Testing

Both measurement data are analyzed using statistical formulas in the form of mean error and standard deviation. It is known that the mean error of the sensor from the prototype is 0.13°C, while the standard deviation is 0.15°C.

Blynk IoT Application Testing

The IoT implementation of the prototype uses an auxiliary application on a smartphone, namely the Blynk IoT application. The application is downloaded for free on the Application Store or Play Store. The Blynk IoT application that has been installed on the smartphone is then connected to the prototype via the same WiFi network. After Blynk IoT on the smartphone and prototype is connected, then the smartphone does not need to have to use the same WiFi network as the prototype. The smartphone is only connected to the internet to be able to connect to the prototype. Smartphones can use other WiFi networks or use standalone internet networks.

Image 6 and Image 7 are respectively testing the Blynk IoT application at the time of presence and without any temperature change in the electric motor. Based on Image 6, it is known that the sensor reads the temperature of the running electric motor at 28.11^{o}C. Meanwhile, based on Image 7, it is known that the sensor reads the temperature of the running electric motor at 70.53^{o}C. The temperature increased from 28.11^{o}C in Image 6 to 70.53^{o}C in Image 7.

Image 6. Electric Motor Stop Testing

Image 7. Electric Motor Running Testing

The representation of temperature measurement results via smartphone shows the same results as the display on the LCD and Fluke devices. Thus it can be seen that the Blynk IoT application for motor temperature monitoring has worked well. Measurement data is carried out in periods to produce measurement results that can be analyzed using statistical formulas. Based on the results of the analysis using statistical formulas, namely, mean error and standard deviation, it is known that temperature monitoring using applications on smartphones provides accurate results. This is evidenced by the mean error value of smartphone temperature reading of 0.15^{o}C and standard deviation of 0.18^{o}C.

Automatic Motor Control Testing

Electric motor control testing is represented using two lights. Based on the test results that at the temperature of the running electric motor >40oC, the lamp representing the running electric motor turns off. While at the same time, the lights representing the standby electric motor turn on automatically. However, if the temperature of the standby electric motor has reached >40oC then the standby electric motor stops, and the running electric motor returns to work. Likewise, coolers in the form of fans can work based on instructions from smartphones.

Image 8. Motor Control Testing

Image 9. Cooler Control Testing

CONCLUSION

IoT-based prototypes to control electric motors can be arranged by several main components, namely Wemos D1R2, MLX90614, Relay, and LCD. The MLX90614 temperature sensor facilitates the installation process of the electric motor body because it works infrared-based. This prototype has a mean error and standard deviation of 0.13oC and 0.15oC respectively. This prototype can monitor the temperature in real-time and control the motor automatically. The cooler can be controlled via a smartphone. The prototype can be applied to a waterwheel/shrimp farming aerator driven by an electric motor. In addition, this prototype can also be applied to oil pumps, water pumps (booster pumps), blower fans and exhaust fans, conveyors, and others. For further research, it can be integrated with three-phase motors and the addition of current and voltage sensors.

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