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EXPERIMENTAL STUDY AND DESIGN OF MICROCONTROLLER BASED AN AUTOMATIC ROOM HEATER CONTROL SYSTEM

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ABSTRACT

This paper presents an automatic temperature controller based on microcontroller. The system is based on microcontroller PIC16F877A connected with temperature sensor LM35DZ, LCD display, switching transistors and relays. The system design is divided into two parts; hardware and software. The temperature sensor LM35DZ senses a certain room temperature and transmits it to microcontroller PIC16F877A which decodes it and compares it with a preset temperature value stored in it. The microcontroller in turn automatically turns on/off a heater or fan based on the comparison result. The measured room temperature is displayed on the LCD display accordingly. This design considered preset temperature values of 26°C as minimum and 29°C as maximum. The system was tested and the result showed that switching occurs at temperatures of 25°C and 300°C. Therefore, the system will be useful in rooms, offices, department stores and other places where temperature regulation is required.

Keywords: Automatic Air Heater; Fan Speed; Microcontroller.

I. INTRODUCTION

A temperature controller is a system that monitors and controls the temperature of a room or any place under study such that if the temperature is higher than the desired temperature, the system lowers the temperature. Similarly, if the temperature is lower, the system makes it higher as required. A temperature controller can be manual or automatic. The former requires complete human intervention to operate, while the latter requires little or no intervention at all.

Moreover, most of the previously designed temperature controllers and related systems use discrete component design such as timers, counters, decoders, and thermistor temperature sensor. Although some microcontrollers are used with an external analog-to-digital converter (ADC), these devices occupy large space, have more weight, consume a lot of power, and are less flexible such that modifying the system requires replacing hardware components. The temperature sensor is non-linear among other problems associated with it [1-4].

This paper presents an automatic temperature controller based on a microcontroller. It is based on PIC16F877A microcontroller. The block diagram of the system, which is in five modules; Power supply, temperature sensor, PIC16F877A microcontroller, display and switch modules. The LM35DZ temperature sensor senses a given room temperature and transmits it to the PIC16F877A microcontroller which decodes it and compares it with a preset temperature value stored in it. The microcontroller in turn automatically turns on/off the heater or fan based on the comparison result. This design considered preset temperature values of 26°C as minimum and 29°C as maximum, so the system turns on the heater when the room temperature is below 26°C and turns on the fan when the temperature is above 29°C and the measured room temperature is displayed on the LCD accordingly. For the temperature range; 26°C - 29°C, the circuit remained idle [5-8].

II. LITERATURE REVIEW

The availability of accurate weather data is vital for energy and environmental research and performance analysis of energy systems, especially renewable systems (**Duffie and Beckman, 2013**). For example, monitoring both operating parameters and weather conditions is one of the most important factors in measuring the performance of a solar system. Developing energy performance indicators and energy baselines for energy management purposes also requires historical data including meteorological variables (**Moghadasi et al., 2021**). In this regard, national weather data have been applied in most studies to analyze the performance of these systems. The use of this weather information may cause errors in the performance analysis due to potential discrepancies between national and local data. Therefore, local weather measurements can enhance energy performance analysis. In the past, all systems for measuring ambient variables such as temperature, humidity, and wind speed were mechanically operated. Therefore, to record them, the only way was to manually read and record the measurements at specific time intervals.

In previous years, with the development of semiconductors, electronic circuits were used to measure, display, and record meteorological parameters digitally. The advantages of digital systems include high accuracy, fast response, automatic operation, small dimensions, long life cycles and low price (**Rafiquzzaman, 2014**). In this regard, **Pashchenko and Rasadin** developed a microclimatic weather station with wireless sensors, a data collector and an analytical tool in 2022. This system was part of a project to model energy consumption in buildings. Data on temperature, humidity, CO2 concentration and light intensity parameters were collected on-site inside the studied building in Moscow during the period of the coronavirus quarantine lockdown. TD-11, Vega Smart-UM0101, ERS and ERS CO2 sensors were used to measure environmental parameters and an ELT-2 sensor was used to communicate via the LoRaWAN protocol (**Pashchenko and Rasadin, 2022**).

Montero et al. A local weather station was built on the campus in 2019. This research focuses on the development of a wireless network of ocean monitoring stations using IoT technology to provide users with weather data for daily planning purposes. The DSM501A sensor was used in the proposed air pollution monitoring device. The parameters of CO2, CO2, temperature, humidity, and air pressure were also measured by the system (**Montero et al., 2019**). Wang et al. investigated the performance of the local climate monitoring system located on the campus of Southeast University with the help of long-term data from the urban weather station and Energy Plus software tools. The results indicated that there was a significant difference between the three data sets.

III. EXPERIMENTAL SETUP

The components were tested separately, assembled on a breadboard, and finally on a Vero board. A plastic enclosure was used to house the designed circuit after implementation. The enclosure was perforated on each side to allow for ventilation and heat dissipation.

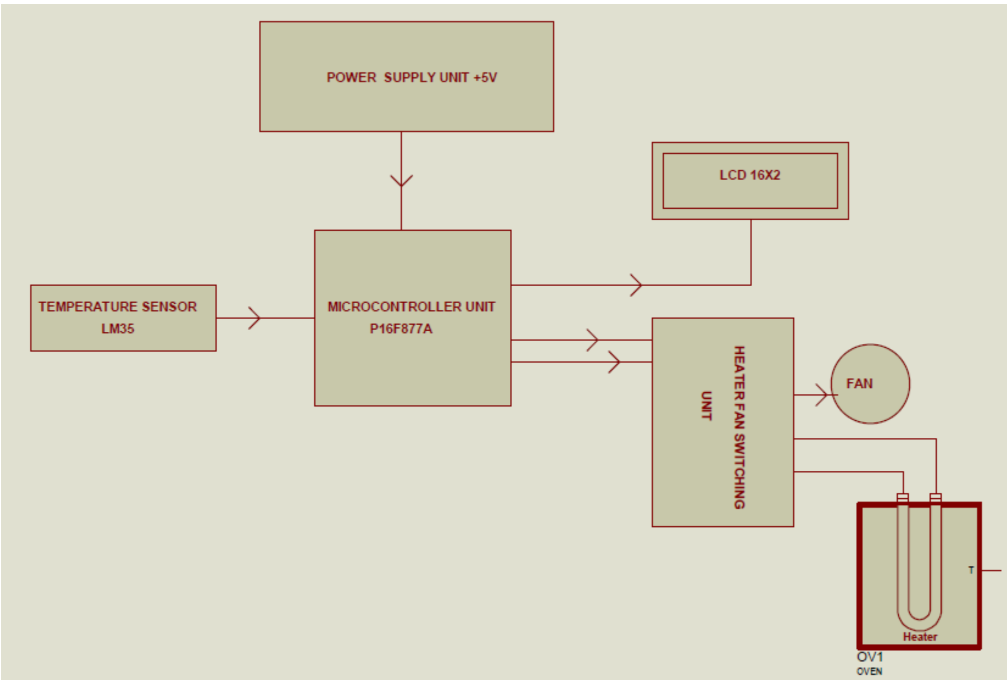

Figure.1 System block diagram

Figure.2 Experimental setup with digital temperature controller device

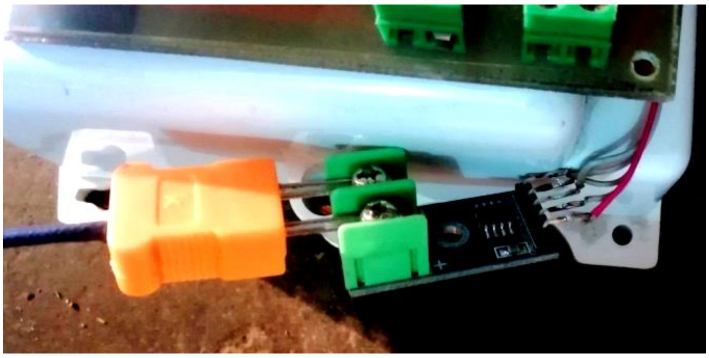

Figure.3 Connector for digital temperature controller device

Switching circuit

The switching circuits consist of transistors and relays that act as an interface between the low voltage controller and the high voltage loads i.e. heater and fan.

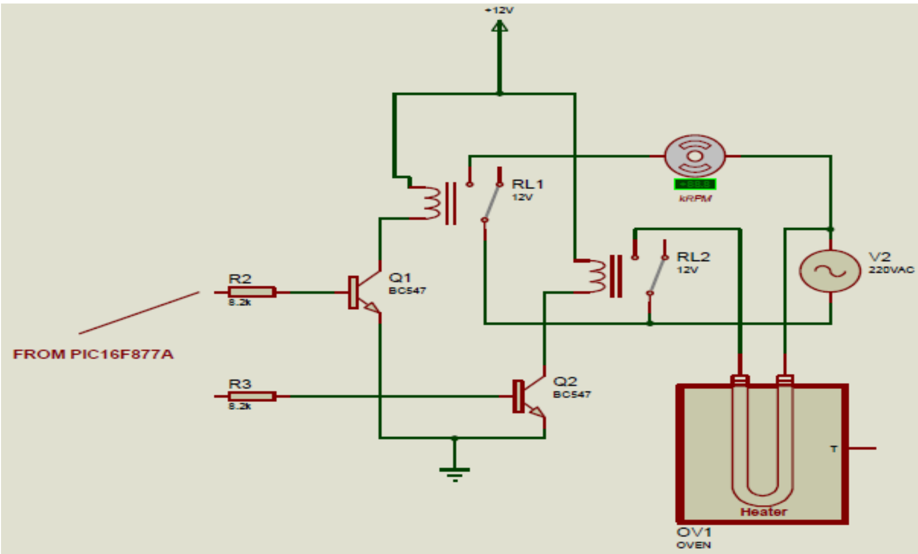

Figure.4 Switching circuit interfaced to heater and fan

IV. METHODOLOGY

The design of the microcontroller-based automatic temperature controller is divided into many parts;

4.1 Hardware design

The hardware design is divided into five modules; power supply, temperature sensor, PIC16F877A microcontroller, display and switch modules. The power supply is the main one and is not discussed in this paper.

4.2 Microcontroller module

The microcontroller selected is PIC16F877A. It is an 8-bit, 40-pin dual in-line (DIP) package, with five (A-E) ports, 8 input channels (ADC module), and many other features. It was chosen because of its integrated analog-digital module and easy availability in the market.

4.3 Temperature sensor module

The LM35DZ temperature sensor was selected for this work. Its output is linearly proportional to the Celsius (C) temperature scale, so the user does not need any calibration to get a suitable Celsius temperature scale. Its linear output, low output impedance, inherent calibration accuracy, easy connectivity and availability make it the ideal choice for this work.

4.4 Display Unit

A liquid crystal display (LCD) (16×2) capable of displaying 32 alphanumeric characters is used in this work to display the measured room temperature. It is configured as a 4-bit interface capable of sending or receiving data in 4 bits. It was chosen because of its low power consumption and ability to display a high-resolution result.

V. RESULT AND DISCUSSION

After final assembly, the system was tested. The test was performed by disassembling the control switch sections of a dual-operated heater/fan system and integrating it into an automatic temperature control system. The combined systems were then placed in a room where the air conditioning system was operating. It can be seen from the above result that the system does not behave as expected. This is probably due to the ADC conversion process not covering the full resolution i.e. using 8-bit resolution instead of 10-bit. This also shows the linearity of the temperature sensor.

Table.1 Recorded Temperature (°C) using constant fan speed of 200 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	41.2
2	20	43.6
3	30	45.9
4	40	46.8
5	50	48.7
6	60	53.2

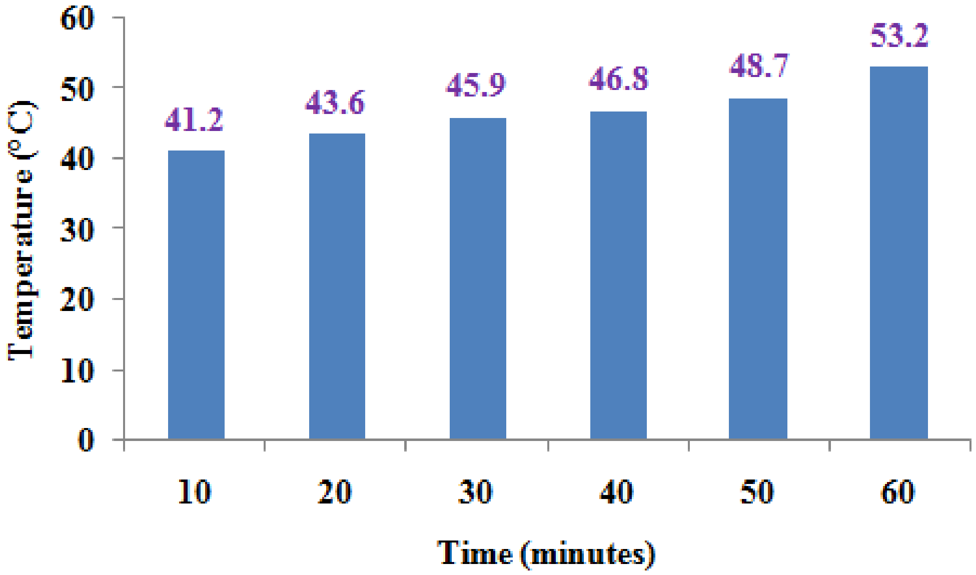

Figure.5 Recorded Temperature (°C) using constant fan speed of 200 RPM

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Table.2 Recorded Temperature (°C) using constant fan speed of 400 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	42.3
2	20	44.5
3	30	46.9
4	40	47.8
5	50	49.9
6	60	54.6

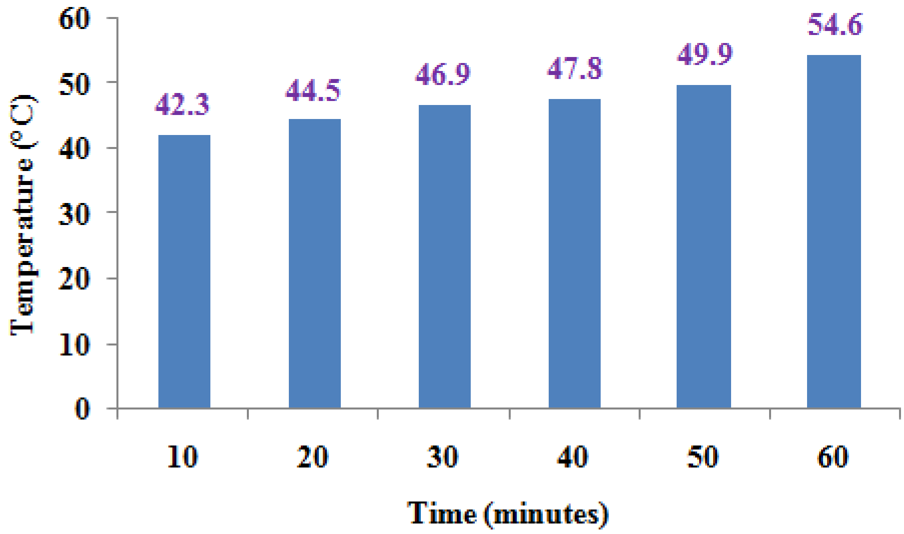

Figure.6 Recorded Temperature (°C) using constant fan speed of 400 RPM

Table.3 Recorded Temperature (°C) using constant fan speed of 600 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	43.5
2	20	45.8
3	30	47.1
4	40	49.2
5	50	52.6
6	60	56.7

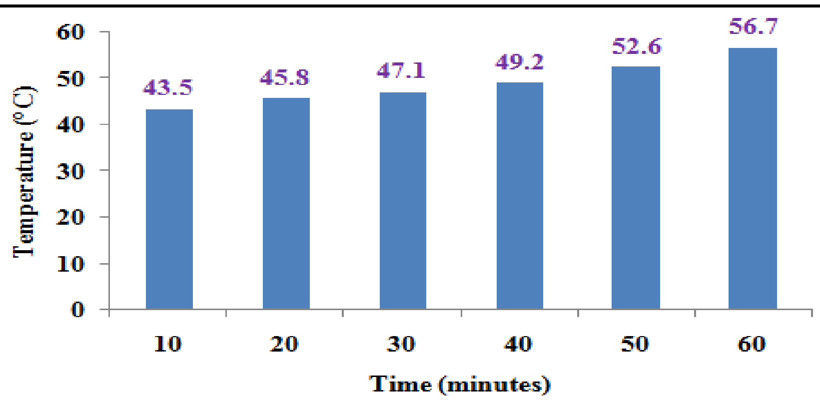

Figure.7 Recorded Temperature (°C) using constant fan speed of 600 RPM

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Table.4 Recorded Temperature (°C) using constant fan speed of 800 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	44.8
2	20	46.8
3	30	48.1
4	40	50.4
5	50	53.7
6	60	58.9

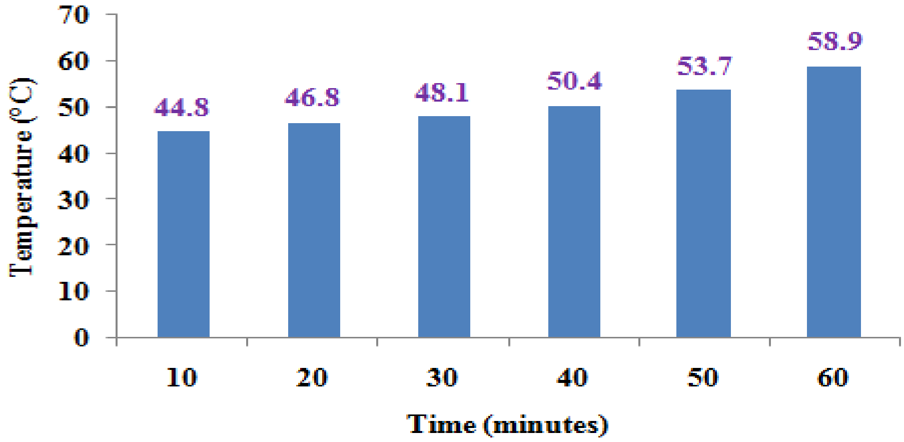

Figure.8 Recorded Temperature (°C) using constant fan speed of 800 RPM

Table.5 Recorded Temperature (°C) using constant fan speed of 1000 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	45.7
2	20	47.8
3	30	49.1
4	40	51.3
5	50	54.7
6	60	59.7

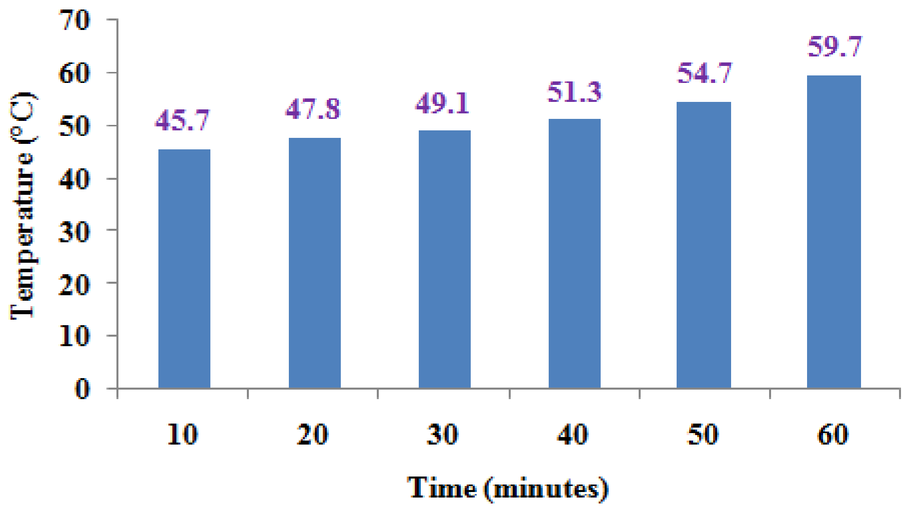

Figure.9 Recorded Temperature (°C) using constant fan speed of 1000 RPM

Table.6 Recorded Temperature (°C) using constant fan speed of 1200 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	48.7
2	20	50.2
3	30	55.4
4	40	61.7
5	50	62.4
6	60	62.4

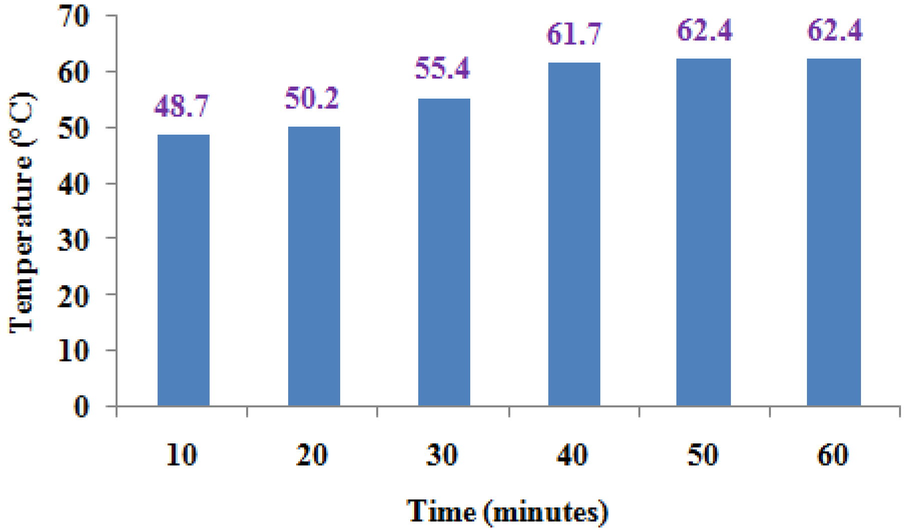

Figure.10 Recorded Temperature (°C) using constant fan speed of 1200 RPM

Table.7 Recorded Temperature (°C) using constant fan speed of 1400 RPM

Sl. No.	Time (minutes)	Temperature (°C)
1	10	52.1
2	20	59.5
3	30	63.4
4	40	63.4
5	50	63.4
6	60	63.4

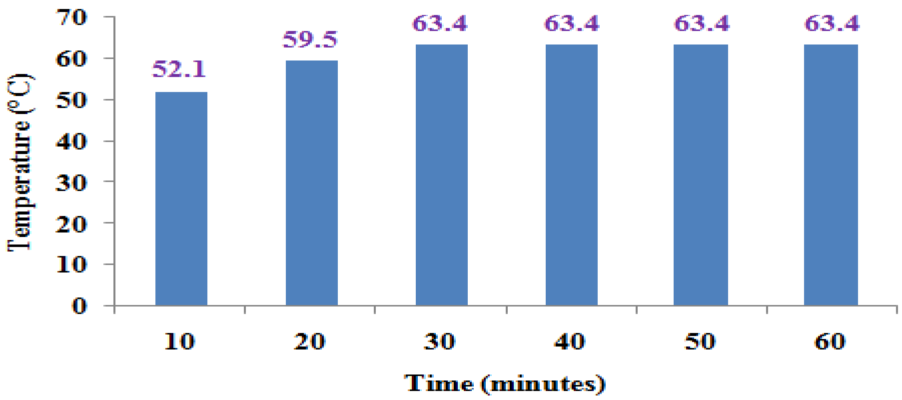

Figure.11 Recorded Temperature (°C) using constant fan speed of 1400 RPM

VI. CONCLUSION

This paper presents an automatic temperature controller based on microcontroller. The temperature sensor LM35DZ senses a given room temperature and transmits it to PIC16F877A microcontroller which decodes it and compares it with a preset temperature value stored in it. The microcontroller in turn automatically turns on/off a heater or fan based on the comparison result. It is observed that the temperature increases with time (10-20 min) using a fan at 1400 rpm and the temperature remains constant at 63.4 °C with time (30-60 min) using the same fan speed. It is concluded that the temperature remained at 63.4 °C during the time (30-60 min).

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