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Smart DC Fan Speed Controlling Using Passive Infrared Sensor and Temperature Sensor

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Due to people's hectic lives these days, electrical fans are frequently left on when they leave a room, which raises monthly electricity costs. To extend the fan's life, its speed must be adjusted according to the ambient temperature; otherwise, early wear and tear may result. By automatically turning the fan on and off when someone enters or exits the room, this invention solves these problems. Furthermore, it prevents continuous running at the same speed by adjusting the fan speed in response to variations in the ambient temperature. PIR and LM35 sensors are used in the proposed project, and an Arduino Uno is used for efficient control. These sensors send signals to the Arduino board, which uses them to do two main tasks: first, depending on the presence of humans, it can turn on or off the fan and changing the fan speed based on the temperature of the space.

Keywords: PIR sensor, LM 35 sensor, temperature, Arduino.

1. Introduction

Anywhere and at any time, forgetting to turn off the electrical fans after turning them on is a frequent problem. This is because physical switches are typically used to turn on or off fans. People in today's world are so preoccupied with their schedules that they often forget to switch off electrical gadgets when they leave a room. The world's temperature is rising quickly as a result of the fan running constantly. Therefore, in order to turn off the devices, automatic switching-off technologies are required. These days, there are numerous ways to control devices so they can turn on and off automatically. One of these ways is to use sensors in conjunction with an Arduino Uno, a manufactured component with programming built in, to manage desired functions with ease. Numerous studies utilizing various approaches concentrate on automatically managing DC fans based on temperature. As an illustration, the thermistor is employed as a transducer to regulate the functioning of the DC fan [1]. In a practical implementation, the temperature-based DC fan operation was managed by the microcontrollers [2]. Two fans and temperature sensors are controlled by a pic microcontroller that has a unique design for the smart automation of electrical fan operation [3]. In order to regulate the DC fan operation in accordance with variations in room temperature, the pulse width modulation technique was applied using MATLAB and Proteus software [4]. Relays and a temperature sensor are used in the Arduino-based automatic fan speed control system. Relay circuits are used to control the fan's on and off speeds, which are dependent on temperature [5]. Using a motion sensor and a microcontroller, a GSM-based electronic system was employed to monitor and manage household applications [6,16]. An electric fan's automatic speed controller is powered by an Arduino, a temperature sensor, and relays. An electric fan's speed was adjusted based on the temperature and requirement [7]. The Arduino interface is used to interface the ATmega328 microcontroller, PIR sensor, and motor driver to regulate the fan's speed automatically [8,17]. A temperature sensor and a low-resolution webcam are used to automatically manage the speed of the ceiling fan based on the occupancy and room temperature. The occupancy detection algorithm that was optimized was employed [9]. Using the Fuzzy Surgeon Logic approach, the fans were turned on and off using the PIR sensor and the DTH-22 temperature sensor [10]. The ultrasonic distance sensor tracks the position of the user, autonomously rotating a fan based on the user's movement and adjusting the fan's speed in response to temperature changes in the room [11]. Two different kinds of AC and DC power supplies, a motor, an Arduino, a sensor, and an electric fan were used to operate the electric fan with a human detection system automatically [12]. The use of passive infrared sensors, LM35 temperature sensors, and ultrasonic HC-SR04 sensors to automatically turn on and off electrical equipment such as fans, air conditioners, and lightbulbs in response to human motion [13]. Using a Raspberry Pi to sense room temperature using a humidity and temperature sensor as well as a motion sensor to detect human movement, lights and fans were controlled [14]. An Arduino board, a temperature and humidity sensor, and an opt coupler were used to control the fan speed automatically with embedded technology. The fan speed was effectively and consistently regulated by the closed-loop feedback-control system in accordance with the temperature [15].

Drawing from the aforementioned research papers, the suggested project aims to automate DC fan control through the use of PIR and LM35 temperature sensors in conjunction with an Arduino Uno. After receiving the signals from the sensors, the Arduino board acts appropriately. The circuit's primary duties include determining whether people are present first and controlling fan speed in accordance with ambient temperature.

2. Need of this Project

To conserve time and energy, it is essential and required to have the switches controlled automatically. Therefore, it is not necessary for individuals to double-check that the switches are on or off. In addition to helping to regulate the atmosphere's rising temperature, this effort saves money and time. The Arduino Uno is used in this project to turn on and off the Automatic Fan with PIR Sensor and LM35 Sensor.

3. Working of Project

The LM35 temperature sensor and PIR motion sensor are used in the construction of the Arduino-based fan switch to automatically turn on and off the fan. There are two distinct tasks that this project circuit does. First, the fan's control is turned on and off when a person enters the room based on human detection, and second, the fan's speed is adjusted based on the temperature of the space. The PIR sensors are used to detect human movement and send a signal to the Arduino board, which then uses that signal to control the fan's on and off functions.

The fan's speed will be automatically adjusted based on the temperature that the LM35 temperature sensor registers. When someone enters the room, the fan will activate based on the temperature that the user has specified. When people leave the room, the fan will switch off. The fan speed and measured temperature will be shown on the LCD. Using the PWM approach, the fan speed is adjusted based on the ambient temperature.

4. Goals, Objective, Scope and Limitation.

Goals

The primary objective of the project is to use the Arduino to create a smart fan control that is dependent on temperature and motion.

Scope And Limitation

The suggested project can be used to intelligently regulate electrical fans in homes, businesses, and factories. This project can also be utilized in an area where fans need to be automatically controlled due to temperature variations. This project's primary drawback is the PIR sensor's inability to detect moving things when it malfunctions.

5. System Description

Block Diagram

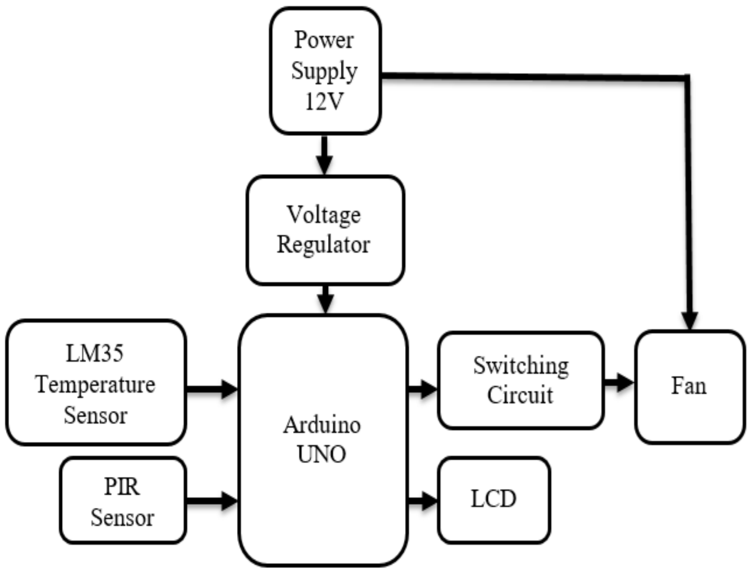

Fig. 1. Block diagram for project

Block Diagram Description

An Arduino Uno board, an analog LM35 temperature sensor, a generic PIR motion sensor, a 12-volt battery, a voltage regulator, an LCD display, and a switching circuit are all shown in the project block diagram. The following is a description of each block's function in the figure.

Power supply: The battery powers the circuit's 12 power supply.

Voltage regulator: It supplies the Arduino board with a constant 5V.

1. Arduino Uno board: This board's microcontroller is its core component. An Arduino board is attached to an LCD, an L298N motor driver, and an IR sensor. After receiving the IR sensor's output, the Arduino board signals the LCD's measuring value.

2. LM35 sensor: This temperature sensor measures temperature by providing an analog output voltage that is proportionate to temperature. It doesn't need any extra calibration circuitry and offers output voltage in Celsius (Celsius). The output voltage rises with temperature; for instance, 250 mV corresponds to 25°C. The LM35 has a sensitivity of 10 mV/°C. The temperature ranges that this 3-terminal sensor measures is -55 °C to 150 °C.

3. Liquid-Crystal Display (LCD): Liquid crystals and polarizers are used in flat-panel displays and other electronically controlled optical devices to regulate light. It shows the measured value after receiving a signal from the Arduino board.

4. PIR sensor: It is composed of a Pyroelectric sensor, which produces energy in the presence of heat. This means that when an animal or human body comes into the sensor's field of view,

it will detect movement because these objects release thermal energy in the form of infrared radiation.

5. Fan: The fan's two main purposes are to alter the air and chill the space. The LM35 and PIR sensors' signals will cause it to turn on. The fan is regulated by the temperature, per the input that Arduino receives from the PIR and LM35 sensors.

6. Switching circuit: For switching, a MOSFET, the IRF350N, is utilized. The main task is to adjust the voltage delivered to the gate terminal in order to control the current flow between the drain and source terminals.

Description of Components

There are variable amount of components in this project. Each of these components' specs is described along with an image.

1. Arduino Uno Board

One of the most well-known development boards based on microcontrollers in the world is Arduino. Given that a large number of amateur and student electronics users use Arduino boards in their daily tasks. One of the key elements influencing Arduino's appeal is that it is open source hardware and software. The Arduino Uno, which is an open source microcontroller board based on the Microchip ATmega328P (for Arduino UNO R3) micro-controller, is the first USB-powered board made by Arduino, and it will be utilized in our project.

We will be writing the code using an IDE, which is a free tool, and the programming languages used to program the Arduino board are C and C++. Integrated Development Environment is what the acronym IDE stands for. The Uno Arduino may interface with external electronic circuits via its fourteen digital input or output ports, six analog input pins, and USB connector. To regulate electronic devices, designers and engineers could use this. Determining its mechanism is simple.

Using a USB cord, it can be connected directly to the computer, and the codes can then be uploaded into the IDE program. There are many uses for the Uno Arduino, but the most popular ones are as scientific research sensors and equipment folding. As mentioned before, the board has an Atmega328 controller, which has several functions, such as a CPU, input/output pins, interrupts, timers, and counters. Figure 1 shows the pins on the Arduino Uno.

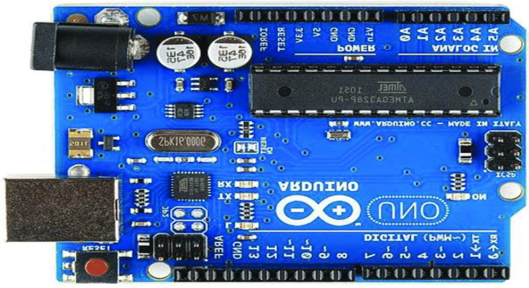

Fig. 2. Arduino Uno Board

2. USB B Socket and Cable Power Supply

The Arduino is powered by the UNO's USB connector, which also allows it to connect to a computer and load software from the Arduino IDE. You can use any USB port to power the Uno straight through the USB port.
USB devices are used to transmit power and data. There was a time when energy could only move from the host to the device. Since energy transmission technologies have advanced, it can now be transferred in both directions. For our project, we used a "USB Power Supply" to connect the laptop and Arduino.

3. LM35 Sensor

LM35 is a temperature sensor that outputs an analog signal which is proportional to the instantaneous temperature. The output voltage can easily be interpreted to obtain a temperature reading in Celsius. The advantage of lm35 over thermistor is it does not require any external calibration. The coating also protects it from self-heating. It is linear + 10-mV/°C Scale Factor and 0.5°C Ensured Accuracy (at 25°C). The LM35 Sensor is rated between -55°C to 150°C though it operates from 4 V to 30 V.

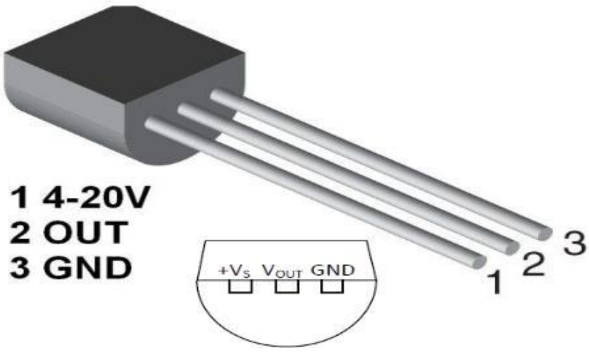

Fig. 3. LM35 Sensor

4. PIR Sensor

Pyroelectric sensors, which produce energy when subjected to heat, are the component of PIR sensors. If an animal or human is in the sensor range, the sensor will detect their movements since they release heat energy in the form of infrared radiation. The sensor operates by sensing the energy emitted by the other items; it does not use any energy itself. The pyroelectric sensor receives infrared signals through a Fresnel lens in the sensor. Its two potentiometers allow you to set the delay period and sensitivity from 0 to 5 minutes.

Fig. 4. PIR sensor

5. LCD Display

Only single ASCII characters of a particular size can be seen on an LCD character display, a unique type of display. When we examine the display more closely, we can see little rectangular parts made up of a 588-pixel grid, which can be used to form text. Because every pixel in a grid can light up individually, we can create characters inside of them. There are two rows and sixteen columns in the 16X2 LCD. Starting with zero, the rows and columns are indexed.

6. I2C- LCD

A straightforward display module that can improve convenience of display is the I2C- LCD. If you utilize it, it might facilitate establishing a connection. If the I2C adapter is already attached to the board, wiring is straightforward. It should normally only have four fastening pins. Naturally, there are GND and VCC. Five volts are needed for the LCD panel to function. We will now go on to pin 5V. The I2C pin information are as follows:

7. IC 7805

The IC 7805 is a voltage regulator integrated circuit that produces a stable output voltage of +5 volts. It's commonly used in electronic circuits to ensure a consistent power supply.

8. IRF530N (MOSFET)

A metal-oxide-semiconductor field-effect transistor (MOSFET) with N-channel power is the IRF530N. It can regulate high-power devices like motors or lights and is frequently utilized in electronic circuits for switching applications. As an N-channel MOSFET, denoted by the "N" in IRF530N, it conducts when a positive voltage is supplied to the gate in relation to the source terminal.

9. Axial fan 12V DC

An electronic cooling fan known as an axial fan, 12V DC, is made to run on a 12 volt direct current (DC) power source. Axial airflow is present, which means that the air flows parallel to the fan shaft. These fans are frequently used to remove heat and keep components from overheating in electrical gadgets and equipment. It is shown by the 12V DC specification what voltage is needed to run the fan.

Circuit Diagram

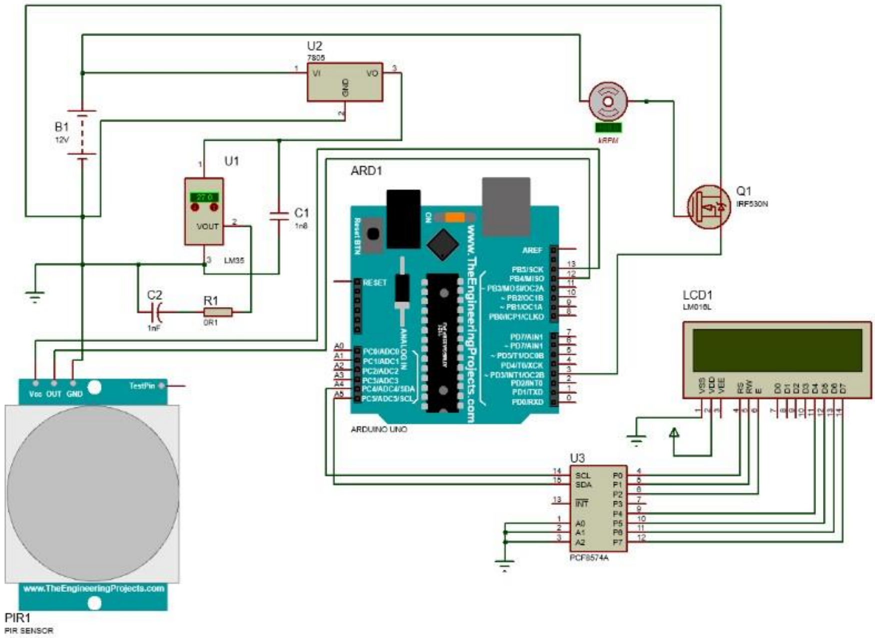

Fig. 5. Circuit diagram of the Project

Circuit Diagram Explanation

The basic components of the circuit diagram are shown in Figure 3.1.

1. Arduino UNO Board
2. 16*2 LCD
3. PIR Sensor module
4. 12V DC Power Supply
5. Fan
6. LM35 Temperature Sensor
7. Jumper Wires
8. Switching circuit: IRF350N (MOSFET)
9. 7805 regulator

The fan was turned on and off by the circuit using a PIR sensor, and its speed was adjusted by an LM35 sensor in response to PWM values.

The Arduino Uno board is in charge of the circuit's overall functionality. When the input senses human movement, the PIR sensor functions as an on/off device. Depending on the temperature in the room, the LM35 sensor turns on the fan. The temperature in degrees Celsius is obtained from the output of the LM35 sensor. Next, the Arduino Uno board's ADC (Analog to Digital) converter pin receives the analog value from the LM35 sensor. The digital value obtained from the analog value will be transformed to temperature scale using the Arduino program's conversion rule [(+Vcc * 1000 / 1024) / 10]. The Arduino produces PWM when the temperature value exceeds the predetermined threshold.

The IRF530N MOSFET receives the PWM output that the Arduino generates. The fan's MOSFET switching circuit regulates the fan's speed in accordance with the PWM output. The temperature and DC fan speed are displayed on the 16x2 I2C LCD display. A separate 12 V DC power supply is included with the fan. The circuit's other components receive their 5V power from the 7805 regulator.

Hardware Connection of Description:

- The Vin pin of the LCD-I2C is connected to the pin 5V of the Arduino.
- The GND pin of the LCD-I2C is connected to the GND of the Arduino.
- The SDA pin of the LCD-I2C is connected to the pin A4 of the Arduino.
- The SCL pin of the LCD-I2C is connected to the A5 of the Arduino
- The output pin of the PIR sensor is connected to the pin 12 of the Arduino.
- The Vcc pin of the PIR sensor is connected to the pin 13 of the Arduino.
- The GND pin of the PIR sensor is connected to the GND pin of the Arduino.
- The output pin of the LM35 is connected to the A0 of the Arduino
- The Vcc pin of the LM35 sensor is connected to the 5V pin of the Arduino
- The GND pin of the LM35 sensor is connected to the GND pin of the Arduino
- The gate of IRF530n is connected to the PWM pin 3 of the Arduino
- 12 V DC supply positive terminal is given to the 7805 voltage regulator input
- 12 V DC negative terminal is given to the common ground
- 7805 voltage GND connected to common ground
- 7805 voltage regulator output is connected to the LM 35 Vcc pin.

6. Results and Discussion

An LM35 sensor, a PIR sensor, and an Arduino Uno were used to test the project circuit. The circuit primarily uses the PWM set values of 50 (19.60% duty cycle), 100 (3921% duty cycle), 150 (5882% duty cycle), 200 (7843% duty cycle), and 255 (100% duty cycle) to adjust the speed of the DC fan in accordance with the room temperature.

Calculation of duty cycle and average voltage from the PWM values are as follows,

$Duty\ cycle = \frac{Pulse\ Width}{Time\ Period} \times 100\ (or)\ \frac{Set\ Value\ of\ PWM}{PWM\ \ Maximum\ Value} \times 100$ Duty cycle and average voltage calculation for the PWM set values 50,100,150,200 and 255:

$$Duty\ cycle = \frac{50}{255} \times 100 = 19.6\%$$

$$Duty\ cycle = \frac{100}{255} \times 100 = 39.2\%$$

$$Duty\ cycle = \frac{150}{255} \times 100 = 58.82\%$$

$$Duty\ cycle = \frac{200}{255} \times 100 = 78.43\%$$

$$Duty\ cycle = \frac{255}{255} \times 100 = 100\%$$

The average input voltage to the fan is calculated manually by using the above duty cycle values obtained from the PWM set values as per the above formula's as following,

Average voltage = Peak value of fan input voltage x Duty cycle

$$Average\ Voltgae = 12\ V \times \frac{19.6}{100} = 2.35V$$

$$Average\ Voltgae = 12\ V \times \frac{39.2}{100} = 4.70V$$

$$Average\ Voltgae = 12\ V \times \frac{58.82}{100} = 7.05\ V$$

$$Average\ Voltgae = 12\ V \times \frac{78.43}{100} = 9.41\ V$$

$$Average\ Voltgae = 12\ V \times \frac{100}{100} = 12.00\ V$$

The voltage input to the fan calculated manually based on the PWM's set values is quite similar to the voltmeter's recorded reading for the same PWM. The sample images below illustrate the fan regulated speeds in Figures 6 and 7 in relation to the low and high PWM set settings. Based on the findings, it is evident that the fan speed is automatically adjusted to maintain room temperature. The fan receives low input voltage and slow speed when the PWM set values are low. Conversely, when the PWM set settings are high, the high input voltage delivered to the fan causes it to speed up to a high level. Figure 6 & 7 displays sample values for the fan's low and high speeds in relation to the DC fan's input voltage, the PWM duty cycle, and the ambient temperature. It is evident that the fan's speed is automatically adjusted according to the ambient temperature. Figure 8 illustrates how the suggested project's hardware connection functions.

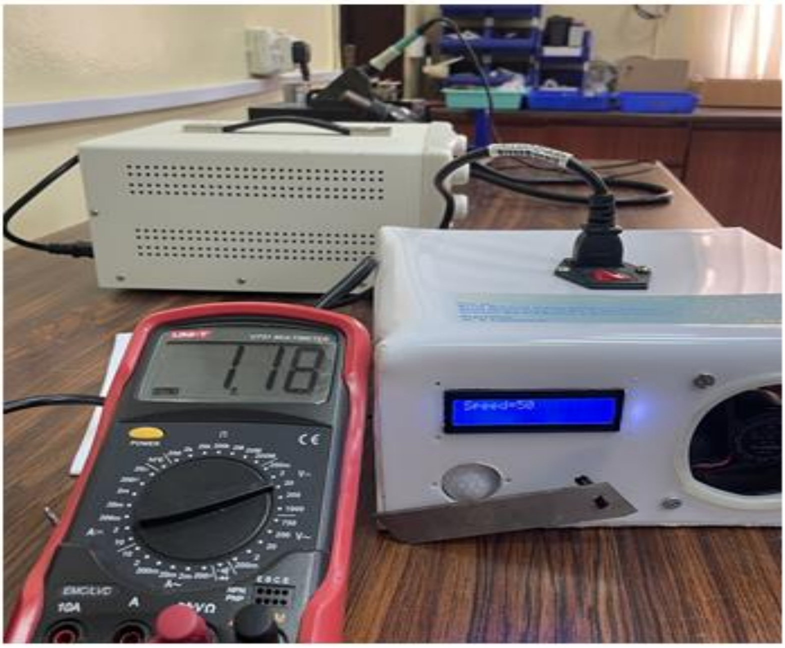

Fig. 6. Fan speed at room temperature >= 25° C

Fig. 7. Fan speed at room temperature >= 45$\circ$ C

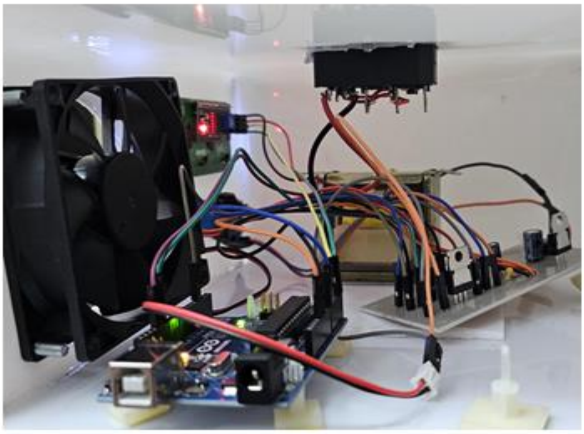

Fig. 8. Hardware connection of the Project

Table 1 displays the recorded temperature values, the DC fan's input voltage, the PWM set values, and the matching fan speed. It is evident that altering the PWM set values also affects the analog voltage that corresponds to the dc fan voltage input from the Arduino. The DC fan speed is automatically adjusted by the Arduino programming in accordance with the ambient temperature.

Table 1. PWM set values, room temperature, Fan input voltage and Fan speed.

PWM set values	DC fan input voltage received	Fan speed rpm	Room Temperature
50	2.35 V	50	temperature >= 25° C
100	4.70	100	temperature >= 30° C
150	7.05	150	temperature >= 35° C
200	9.41	200	temperature >= 40° C
255	12	255	temperature >= 45° C

7. Conclusion and Future Scope

The project "Arduino Based Smart Controlling Fan Using PIR and LM35 Sensor" was designed and tested with success. The controllers of the system were the LM35 and PIR sensors. The fan turns on and off in response to human detection and automatically modifies its speed in reaction to temperature variations in the room. The Arduino program was successfully programmed and tested by comparing the temperature range and the speed of the fan. The variable speed of the DC fan and the room temperature are shown on the LCD.

Future work should incorporate an alert circuit with the current one, which is effectively employed in large apparatuses where explosions and overheating are major concerns in numerous industries.

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