Automatic Fan Speed Controlled Laptop Cooling Pad System using Microcontroller

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Abstract*— A human way of life increasingly relies on automatic controls. The development of control techniques that boost system performance is the main goal of the large field of automatic control technology. The elimination of the human operator is the distinctive feature of automated control. The fan is one of these devices. The majority of fans come with speed controls, and the speed is adjusted according to the situation. Typically, a fan is run at a lower speed when the temperature is lower and at a higher speed when the temperature is higher. This is carried out manually by people. The fan speed is advised to be automatically controlled in this study in order to regulate a laptop's temperature. To automatically adjust the fan speed, a circuit comprising a brushless DC motor, DHT11 temperature sensor, Atmega328p microcontroller, and a few other electronic components is created and constructed. The temperature and fan speed are shown on LCD as an extra function. The developed system circuit is then tested several times and operated flawlessly

***Keywords*— Laptop cooling Pad, Atmega328p, DHT11, Fan Speed, BLDC motor and circuit design.**

I. Introduction

Electric fans are a widely used and popular electrical device, thanks to their cost effectiveness and low power consumption. They have been a common circuit for many applications and continue to be available in the market. Fans offer a sensible solution to create a comfortable and energy-efficient environment. However, with the increasing demand for accurate temperature control and air freshening, many industries, including automotive, industrial, and office buildings, have embraced the use of fan systems to maintain a comfortable environment for their occupants. Achieving the desired temperature and optimizing energy consumption is a critical concern in heat-sensitive areas. The traditional manual control method involves pressing a switch button to turn the fan on or off, and the fan speed remains constant regardless of temperature changes. Therefore, there is a need for automatic temperature control systems to regulate fan speed based on temperature changes.

A. Literature Review

Research studies have explored the application of automatic temperature control systems in various fields, offering numerous benefits. The authors of [1] presented a Design and Implementation of Automatic Room Temperature Controlled Fan using Arduino Uno and LM35 Heat Sensor. In this project, a DC fan control system based on room temperature is designed and simulated utilizing the PWM technology, temperature sensor LM35, and Arduino Uno Microcontroller. The temperature of the room will be lowered to a specific degree using the fan. LM 35 Temp Sensor is used to sense the temperature. The LED will be turned on, value fan is switched on when the room temperature sensed by the sensor crossed the threshold. Until the temperature drops below the threshold, the fan will continue to run.

The authors of [2] presented a Speed Control of Ceiling Fan Using PWM Technique. This research proposes a novel method for controlling ceiling fan speed in relation to ambient temperature and the number of people in the room. The microcontroller PIC16F877A and optocoupler are utilized to regulate the fan speed. The temperature of the area, the motor's speed, and the number of people present in the room are all displayed on an LCD panel. The temperature sensor detects the ambient temperature and changes the fan speed accordingly.

The authors of [3] presented a Temperature Controlled DC Fan using Microcontroller. The fundamental concept behind this project is to activate the DC motor fan whenever the temperature detected by the temperature sensor exceeds a certain threshold. In this project, an Arduino board was used for USB-based microcontroller programming. The hex file is used by the microcontroller to run the program. The microcontroller receives the output from the temperature sensor and sends it to the motor driver IC, which drives the motor. In this manner, the project's main goal is accomplished.

The authors of [4] presented an Automatic Speed and Light Intensity Control by Sensing Atmospheric Parameters. Another research from explores as Arduino based project. It is aimed at controlling AC fan speed based on room temperature and displaying the parameters on 16x2 LCD display. This project utilizes the DHT22 sensor to sense temperature and humidity. And use TSL2561 sensor module to control LED bulb intensity. The Arduino board is used for data processing and control. The review emphasizes the importance of energy conservation and highlights the benefits of automatic fan speed and light intensity control.

The authors of [5] presented an Automatic Fan Speed Control using Temperature and Humidity Sensor and Arduino. The literature paper presents a project that automatically control fan speed based on the surrounding environment by utilizing Arduino, temperature sensor and humidity sensors. Here the DHT22 sensor is used to measure the temperature and humidity, while Arduino board processes the data and adjusts the fan speed using PWM technique. And LCD displays the temperature and fan speed. This project aimed to enhance comfort and eliminate manual fan speed control. Overall, the project combines IoT concepts with temperature-based fan speed control.

More examples of such studies include Automatic temperature controllers for multi-element array hyperthermia systems [6], multi-loop automatic temperature control system designs for fluid dynamics [7], automatic temperature control circuit module designs for tunnel microwave heating systems [8], and automatic temperature systems with Fuzzy self-adaptive Proportional-Integral-Derivative (PID) control in semiconductor lasers [9].

The outstanding difference between the result in this research and the others is that it has separately designed and developed the Atmega328P circuit board using 2 DHT11 sensors to get the average temperature reading to vary the speed of the motor accordingly and indicate the real time temperature and fan speed in the LCD. This paper aims to demonstrate how Atmega328p microcontrollers can be practically utilized in a real-world application. One such application involves integrating a microcontroller in a temperature control system that automatically regulates surrounding temperature.

II. FAN SPEED CONTROL SYSTEM COMPONENTS .

The Atmega328p microcontroller serves as the central component of the temperature control system, receiving inputs from the temperature sensor, DHT11, which measures the current room temperature. Based on this data, the controller determines the required fan speed to maintain the desired temperature. The LCD is utilized to display both the fan speed and the current room temperature. A diagram of the fan speed controlled laptop cooling system is shown in Fig. 1.

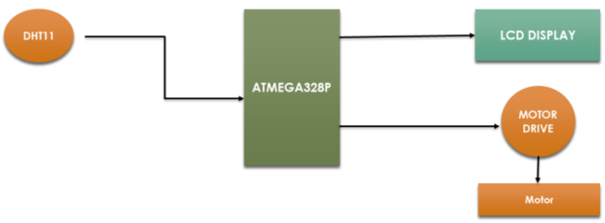

Fig. 1. *Block diagram of the fan speed controlled laptop cooling system*

A. Atmega328p Microcontroller

A microcontroller is a computer control system that is integrated onto a single chip. It contains several electronic circuits capable of decoding written instructions and converting them into electrical signals. The microcontroller then executes these instructions one by one. Here a microcontroller has used to control the fan speed according to the temperature of the room. Microcontrollers have revolutionized electronic designs, replacing the need to hardwire several logic gates to perform a specific function. Instead, we now use instructions to electronically connect the gates. The set of instructions provided to the microcontroller is known as a program. There are various types of microcontrollers, but this research focuses solely on the Atmega328P microcontroller, as illustrated by the pin diagram in Fig. 2 [10].

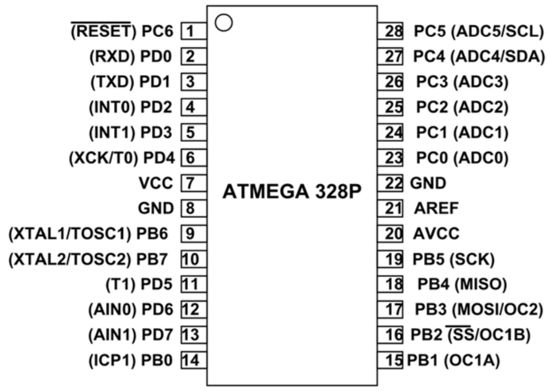

Fig. 2. Pin diagram of Atmega328p

B. Power Supply

PS-5161-1D1 power supply is a component designed to provide reliable and stable power.

Fig. 3. Power supply

power supply has an AC voltage input range of 100-240V, making it compatible with a wide range of power outlets worldwide. It operates at a frequency of 50-60Hz and consumes a maximum power of 3.5A at 115V AC or 2A at 230V AC.

In terms of output voltage, PS-5161-1D1 power supply provides +5V, +12V, -12V, and +3.3V DC voltage rails. The +5V rail provides a maximum output of 14A, the +12V rail provides a maximum output of 12A, the -12V rail provides a maximum output of 0.3A, and the +3.3V rail provides a maximum output of 8A.

It's worth noting that the power supply is designed to automatically adjust its output voltage and current based on the power draw of the connected components, ensuring a stable and efficient power supply

C. Temperature Sensor (DHT11)

The DHT11 Temperature and Humidity Sensor is equipped with a temperature and humidity sensor complex that produces a calibrated digital signal output. It utilizes a digital signal acquisition technique to sense temperature and humidity to guarantee high reliability and exceptional long-term stability.

The DHT11 sensor is designed to provide accurate temperature and humidity measurements, with a temperature measurement range of 0 to 50 degrees Celsius and a humidity measurement range of 20% to 90% relative humidity. The DHT11 Temperature and Humidity Sensor employs a Negative Temperature Coefficient (NTC) thermistor to measure temperature, which exhibits a decrease in resistance value with an increase in temperature. This sensor is typically composed of semiconductor ceramics or polymers to obtain a larger resistance value for even the smallest change in temperature. [11]

The DHT11 sensor communicates with microcontrollers such as Arduino through a single-wire digital interface, using a simple protocol to transmit the measured data. It requires a 5V power supply and can operate at a low power consumption of less than 5mA. Pin diagram is illustrated in Fig. 4 [11].

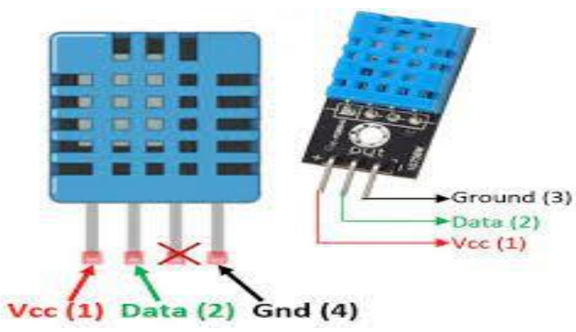

Fig. 4. Temperature sensor DHT11

D. Brushless DC Motor

Brushless DC (BLDC) motors are electronically commutated motors that do not utilize brushes, hence the name brushless DC motor. These motors offer superior speed versus torque characteristics, operate quietly, and exhibit higher efficiency compared to brushed DC motors. The magnetic fields generated by both the stator and rotor have the same frequency, making BLDC motors synchronous motors. A transverse section of a BLDC motor is depicted in Fig. 5.

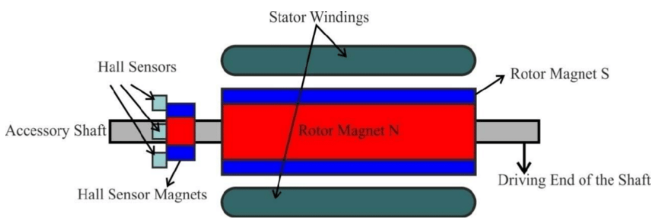

Fig. 5. Transverse section of BLDC motor

BLDC motors are composed of two primary components: the stator and the rotor. Some BLDC motors also include hall sensors. Compared to other types of fans, BLDC fans do not experience issues associated with sparking, brush wear, or electromagnetic interference (EMI) because they use electronic commutation [12]. The BLDC fan used for this research is shown in Fig. 6.

Fig. 6. BLDC Motor

The rotor is the rotating part of the motor, and in a BLDC motor, it is made of a circular core with alternate North (N) and South (S) poles over a permanent magnet. As BLDC fans use permanent magnets, their rotors are lighter than those of conventional DC fans, making them suitable for cooling fan applications in laptops and desktop computers. Hall sensors are used to detect the position of the rotor by detecting the south and north poles. Based on this information, the exact commutation sequence is determined, which is important in rotating BLDC motors as they use electronically controlled commutation [13].

E. Liquid Crystal Display (LCD)

This component (LCD - Liquid Crystal Display) is specifically manufactured to be used with microcontrollers, which means that it cannot be activated by standard IC circuits. It is made to display different messages on a miniature liquid crystal display. It can display messages in two lines with 16 characters in each line. Also it can display all the types of letters of the alphabet, punctuation marks, mathematical symbols, Greek letters, and more. Fig. 7 illustrates the LCD (2 x 16 characters) and its connection [14].

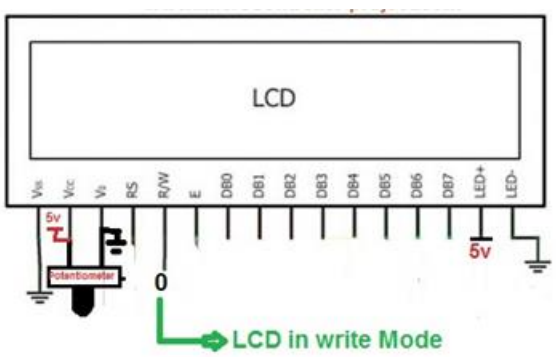

Fig. 7. LCD

F. *Motor Driver Module (L298N)*

The L298N module is a type of motor driver board commonly used in robotics and other projects that require precise control of DC motors. It consists of an L298N dual H-bridge chip, which is capable of driving two DC motors simultaneously. The L298N module allows for bidirectional control of the motor speed and direction, as well as protection against over-current and over-temperature conditions.

It accepts a wide range of input voltages, from 7V to 35V, and can deliver a continuous current of up to 2A per channel, with a peak current of up to 3A per channel. The module features four input pins for controlling the motor speed and direction, as well as four output pins for connecting the motors.

The L298N module can be controlled by microcontrollers such as Arduino, Raspberry Pi, or other similar devices, using pulse-width modulation (PWM) signals to control the motor speed and direction. The module also includes a built-in voltage regulator that provides a stable 5V output to power other components on the board.

Overall, the L298N module provides a simple and efficient way to control the speed and direction of DC motors in various projects, with its bidirectional control, over-current and over-temperature protection, and compatibility with a wide range of input voltages and microcontrollers. Fig. 8 illustrates L298N Motor Driver Module and its connections [15]

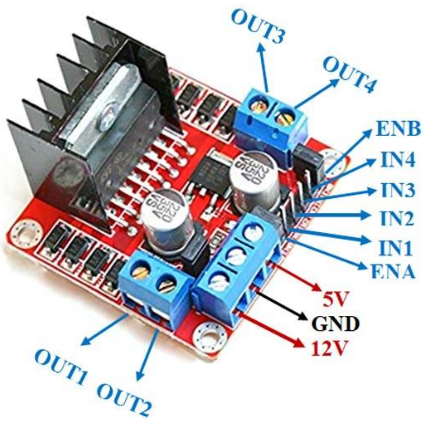

Fig. 8. Motor Driver Module L298N

III. FAN SPEED CONTROL SYSTEM CIRCUIT DESIGN

The section describes the method of controlling the speed of the fan with the change in room temperature using a PWM output from the microcontroller. The system uses a schematic circuit diagram, as shown in Figure 8, to control the speed of the fan.

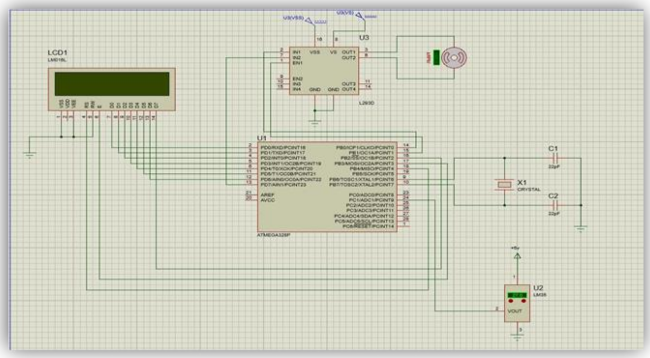

Fig. 9. Schematic circuit diagram of the fan speed control system

In this project, the Atmega328p microcontroller is used to control the speed of the fan according to the laptop temperature. The voltage from the mains (220/240V AC) is converted to 12V DC and 5V DC by the power supply, and then the. The DHT11 temperature sensor is used to measure the changes in the surrounding temperature. All operations are controlled by the Atmega328p to produce the output. The LCD and fan are the outputs where they are set with the pseudo code of Atmega328p. The LCD is used to measure and display the changes in the temperature value.

As a working principle, the temperature sensor senses the temperature and displays it on the LCD. The speed of the fan is controlled according to the PWM technique for the temperature change. For processing analog signals, the Atmega328p microcontroller has an analog to digital converter, which converts analog signals to digital ones.

The DHT11 gives 1 bit for each 1°C change in the temperature; this value is a digital value and does not need to be converted. Any change in the temperature will be sent to the Atmega328p via the DHT11 sensor. The microcontroller (Atmega328p) has an inbuilt PWM module, which is used to control the speed of the fan by varying the duty cycle. According to the temperature sensor readings, the duty cycle changes while controlling the fan speed. The PWM signal is sent via pin 9 (PB1) in port B to the L298N motor driver, which controls the voltage across the motor.

Crystal oscillator is connected to pins 9 (PB6) and 10 (PB7) of Atmega328p, which are pins to provide external clock to the microcontroller. A 0.1 μF bypass capacitor is used on the output pin +5 V of the voltage regulator to smooth out the supply voltage to the microcontroller and LCD. The Vout pin of the temperature sensor DHT11 is connected on pin 23 (PC0) which is ADC0 of all ADC input pins. Pins from 16 to 21 are connected to remaining LCD pins used for data and control signals between LCD and microcontroller.

The PWM output is given to the enable pins of the L298N motor driver from the Atmega328p. The L298N motor driver controls the voltage across the motor. When the enable pin is high, the motor starts to gain speed, and when the enable pin is low, the motor loses speed. The hardware circuits that have been designed for the controlled fan speed system in this project, which consists of the DHT11, Atmega328p microcontroller, BLDC motor, and LCD as shown in Fig. 10, which also include the crystal circuit.

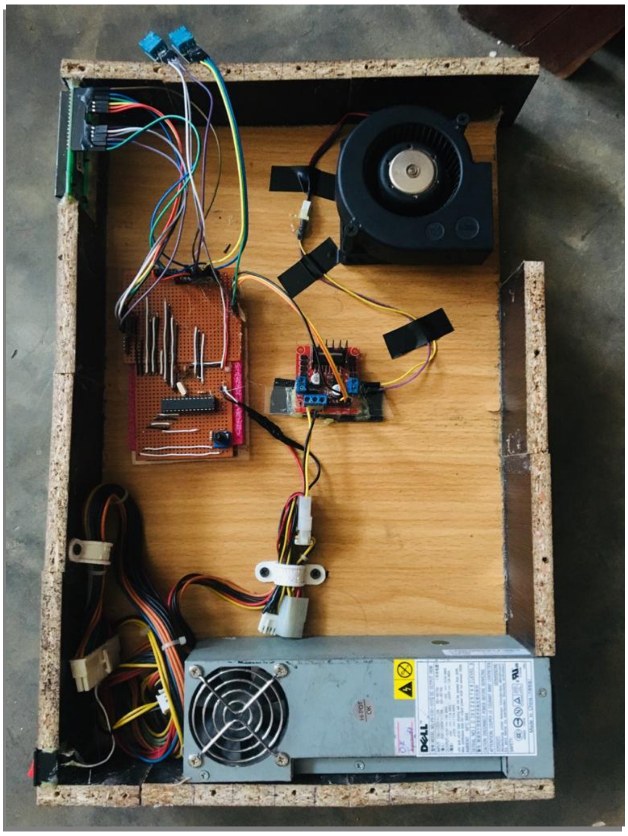

Fig. 10. Hardware circuit of the fan speed controlled laptop cooling system

IV. RESULT AND DISCUSSION

Since the calibration process maintains accuracy while assuring reliable benchmarks and results of the research project. Used an external temperature sensor (thermometer) to gauge the laptop temperature while working with the laptop. The calibration process was done in different times as shown in Fig. 11, which can be summarized in Table I.

TABLE I. CALIBRATION PROCESS

Calibration No:	*Time*	*Temperature from LCD*	*Thermometer*	*Fan Speed*
1	1.00	29°C	28.6°C	580 rpm
2	1.10	31°C	30.8°C	620 rpm
3	1.20	33°C	32.7°C	660 rpm
4	1.30	34°C	33.8°C	680 rpm

Fig. 11. Hardware calibration process

The fan speed control system using Atmega328p microcontroller, DHT11 temperature sensor, and L298N motor driver was successfully designed and implemented. The system is capable of controlling the speed of a DC fan based on the temperature variation of the laptop.

The temperature sensor was used to measure the changes in the laptop temperature and displayed it on the LCD screen. The Atmega328p microcontroller was used to process the digital signals from the DHT11 temperature sensor. The PWM output signal from the microcontroller was used to control the speed of the fan by varying the duty cycle.

The motor driver used in this project was the L298N, which is a dual H-bridge driver that can control the direction and speed of two DC motors. The L298N motor driver was used to control the speed of the fan by varying the voltage across it.

The system was tested by varying the temperature of the room and observing the changes in the fan speed. The fan speed increased as the temperature increased and decreased as the temperature decreased. This demonstrated that the system was able to control the speed of the fan based on the temperature variation of the laptop. Final prototype of the system is shown in Fig 12.

Fig. 12. Final prototype

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