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Controlling Fan Speed Using Room Temperature

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Abstract: Conventional fan speed control systems are typically limited by manual adjustments or simplistic on/off switching based on basic temperature thresholds. This project falls within the domain of intelligent embedded systems for environmental control, specifically focusing on automated fan speed regulation using temperature sensors. It utilizes a DHT11 sensor for real-time temperature monitoring, an Arduino microcontroller for data processing, and an LCD display to provide continuous user feedback. Traditional fan control systems typically rely on manual adjustments or simple on/off switching based on fixed temperature thresholds, leading to energy inefficiency and inconsistent comfort. To address these issues, the proposed system dynamically adjusts fan speed using Pulse Width Modulation (PWM), allowing smooth and proportional control in response to ambient temperature changes. This automated approach eliminates manual intervention, enhances energy efficiency, and improves user comfort. The system has demonstrated an accuracy of 90.47%, marking a significant advancement in intelligent climate control for domestic and small-scale industrial applications, and laying the groundwork for future IoT-based home automation solutions.

Keywords: Automated Fan Control, Temperature Sensor (DHT11), Arduino, Pulse Width Modulation (PWM), Energy Efficiency

I. INTRODUCTION

In today's energy-conscious world, optimizing electrical appliances for both comfort and efficiency is essential. Traditional fan systems often operate through manual control or basic thermostatic mechanisms, leading to inconsistent temperature regulation and unnecessary power usage. This project addresses these limitations by developing an intelligent, automated fan speed control system that adjusts dynamically based on real-time ambient temperature. At the heart of the system lies an Arduino Uno microcontroller, paired with a DHT11 sensor to monitor temperature and humidity. By employing Pulse Width Modulation (PWM), the fan's speed is regulated smoothly, offering proportional response rather than abrupt on/off transitions. An integrated LCD module provides users with continuous feedback on environmental conditions and system behavior, enhancing transparency and usability. This approach not only ensures better thermal comfort but also promotes energy efficiency and sustainability. Designed to be low-cost and easy to implement, the system serves as a valuable solution for households, small offices, and educational environments, while also laying a foundation for future upgrades in smart home automation

II. RELATED WORK

Smart temperature-based control systems have increasingly gained prominence due to the rising demand for energy-efficient and automated solutions. Numerous research studies have explored intelligent monitoring and control of environmental conditions using embedded systems and sensors.In [1], Wang et al. proposed a temperature monitoring method using improved Mask R-CNN and spatial mapping for sensor arrays. Although the primary focus was sensor reliability and predictive modeling, the methodology highlighted the importance of real-time data acquisition and mapping, concepts which are foundational to embedded climate control systems like the one developed in this project.
Huang et al. in [2] implemented a real-time icing detection system for overhead transmission lines using multi-sensor fusion and a BP neural network optimized with genetic algorithms. While the domain differs, the use of environmental sensing and adaptive control has parallels with PWM-based fan regulation. Digital twinning for thermal behavior prediction was introduced by Mo et al. in [3], where voxel-based FDTD methods simulated temperature variations in power converters. Although computationally intensive, the idea of replicating real-world conditions in real time supports the rationale behind real-time automated fan speed adjustment. Fiber Bragg Grating (FBG)-based temperature distribution systems for wafer fabrication were studied in [4], demonstrating accurate spatial thermal monitoring. Though technologically advanced compared to DHT11, the goal of real-time ambient feedback is consistent with the presented fan control design.Wearable health monitoring in [5] employed the MLX9

0614 temperature sensor in conjunction with Arduino and Bluetooth modules. The HOT Watch demonstrated the successful integration of sensing and microcontroller-based feedback loops, much like the automated fan system's real-time control feedback via LCD. In [6], a robust power loss observer model was used to estimate junction temperatures in IGBT modules. The approach emphasized the need for minimal sensor deployment while achieving accurate control—aligning with the project's cost-effective and minimalistic hardware philosophy. he research in [7] incorporated blockchain with IoT for secure temperature and humidity monitoring in supply chains. While blockchain is not part of this project, the modular and IoT-ready nature of the proposed fan controller could accommodate similar extensions in the future. A comprehensive review on IoT-based patient monitoring systems was provided in [8], highlighting the relevance and growing need for low-cost, real-time systems for health and environmental monitoring. Thermal modeling of electric machines, as shown in [9], demonstrated the importance of continuous and accurate temperature sensing in operational safety—further validating the integration of temperature sensors with control systems in fan automation. Lastly, Sheikh et al. in [10] presented continuous environmental monitoring using terahertz systems, underlining the broader importance of responsive systems in biological and agricultural contexts. This reiterates the value of automated, sensor-driven platforms like the one proposed. Collectively, these works demonstrate a global trend towards embedded intelligence in environmental sensing and control. The proposed system builds upon these foundations by offering a simple, scalable, and cost-effective implementation suited for real-world domestic and educational use.

III. PROPOSED SYSTEM

The proposed system is an intelligent, automated fan speed controller designed to respond dynamically to changes in ambient temperature, providing an energy-efficient and user-friendly climate regulation solution. At the core of this system is the Arduino Uno microcontroller, which serves as the processing unit that receives real-time temperature readings from the DHT11 temperature and humidity sensor. This sensor continuously monitors the environment and sends digital temperature data to the Arduino. Based on predefined thresholds and a programmed control algorithm, the Arduino interprets these readings and adjusts the fan's speed accordingly using Pulse Width Modulation (PWM). PWM allows for smooth and proportional speed control by modulating the duty cycle of the signal sent to the fan's driver circuit. For instance, lower temperatures result in a slower fan speed or complete shutdown, while higher temperatures trigger increased speeds to improve ventilation and comfort.

The system also integrates a 16x2 LCD display that presents real-time temperature readings and fan status updates, ensuring that users are informed about the current environmental conditions and system behavior. This feature adds transparency and user engagement, making it suitable for educational purposes and real-world applications. The system operates entirely autonomously once powered on, eliminating the need for manual intervention and reducing the chances of human error or neglect. It is particularly beneficial in settings where constant monitoring is impractical, such as server rooms, classrooms, small offices, or home environments. Moreover, the components chosen for this project—Arduino Uno, DHT11 sensor, DC fan, LCD display, and supporting circuitry—are all cost-effective and readily available, making the solution not only technically feasible but also economically accessible. The design emphasizes modularity and simplicity, allowing for easy maintenance, troubleshooting, and future expansion. Potential enhancements could include wireless connectivity using modules like ESP8266 or ESP32 for IoT integration, remote control via mobile applications, and even data logging capabilities for performance tracking and optimization.

Overall, this proposed system exemplifies a practical application of embedded systems in home automation, combining sensor technology, microcontroller-based decision-making, and energy-conscious design. It stands as a scalable and efficient alternative to conventional fan control systems, offering improvements in comfort, responsiveness, and sustainability.

The proposed system is an Arduino Uno-based fan speed controller that adjusts fan speed using PWM based on temperature data from a DHT11 sensor. A 16x2 LCD display shows real-time temperature and fan status updates for user transparency. The system operates autonomously, making it ideal for environments with minimal manual intervention. Its modular design ensures easy maintenance and potential upgrades, such as wireless connectivity and data logging. This cost-effective solution emphasizes comfort, efficiency, and scalability in climate regulation.

The architecture of the automated fan speed control system is designed around an Arduino UNO microcontroller that processes environmental data to dynamically regulate fan speed. The system begins by sensing ambient temperature through a DHT11 sensor, which transmits real-time data to the Arduino. The microcontroller then evaluates the input and, based on predefined thresholds, generates a corresponding PWM (Pulse Width Modulation) signal via pin D9. This signal is used to control a transistor or MOSFET, which acts as a switch to modulate the power supplied to a DC fan, thereby adjusting its speed.

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An LCD display is included to provide users with continuous feedback on current temperature and system status. Additionally, an optional data logging module can be integrated to record temperature and fan performance metrics over time. This modular and efficient design ensures responsive, energy-conscious fan operation suited for home and small-office automation environments.

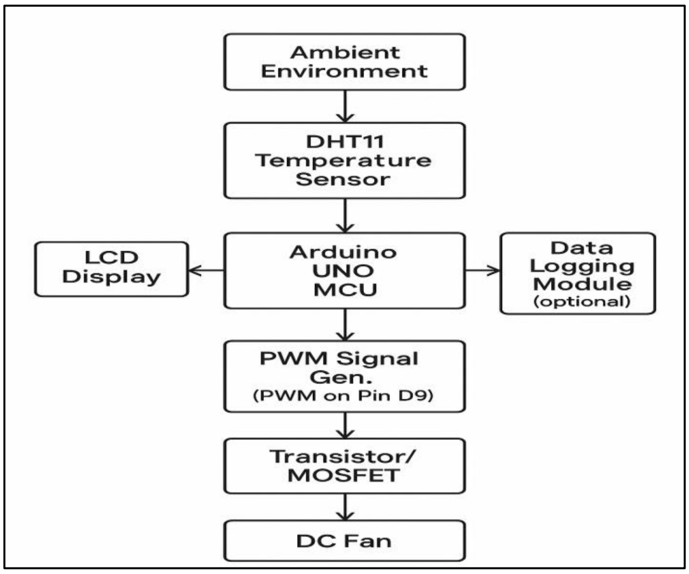

Fig 1: Architecture Diagram

IV. IMPLEMENTATION

The methodology outlines the structured approach adopted to design, implement, and validate the proposed automated fan speed control system. The goal is to achieve a temperature-responsive mechanism that adjusts fan speed in real time using affordable and accessible hardware and software tools.

4.1 System Overview

The proposed system monitors room temperature through a digital sensor and adjusts fan speed using Pulse Width Modulation (PWM). The Arduino Uno acts as the central processing unit, reading temperature data and controlling a DC fan accordingly. A 16x2 LCD provides real-time visual feedback to users.

4.2 Hardware Integration

The system comprises the following key hardware components:

- **DHT11 Temperature Sensor**: Provides real-time digital temperature readings with a basic accuracy level, suitable for indoor applications.
- **Arduino Uno Microcontroller**: Acts as the core processor, interpreting sensor data and issuing PWM signals based on predefined temperature thresholds.shown in(Fig 4.2)
- **PWM-Controlled DC Fan**: The fan speed varies proportionally with the PWM duty cycle generated by the Arduino
- .**LCD Display (16x2)**: Displays current temperature and fan status to enhance user interactivity.(Fig 4.1)
- **MOSFET Transistor**: Serves as a switch for driving the fan using PWM signals.
- **Power Supply**: Supplies power to the system, using either USB or a 9V/12V adapter.

4.3 Software Development

The software was developed using the Arduino Integrated Development Environment (IDE). The following libraries and programming constructs were used:

- **DHT Library**: Interfaces with the DHT11 sensor to read temperature data.
- **LiquidCrystal Library**: Controls the LCD to display information.
- **PWM Logic**: Implements analogWrite to control fan speed.

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A temperature-to-speed mapping algorithm was developed as follows:

- Temperature < 25°C → Fan OFF (0% duty cycle)
- 25°C ≤ Temperature < 30°C → Fan at Medium Speed (50% duty cycle)
- Temperature ≥ 30°C → Fan at High Speed (100% duty cycle)

4.4 System Implementation Steps

1. **Sensor Configuration**: Connect the DHT11 sensor to a digital input pin on the Arduino.
2. **PWM Configuration**: Use a digital PWM-capable pin (e.g., pin 9) to control the fan via a MOSFET.
3. **LCD Initialization**: Connect the 16x2 LCD to display real-time readings using appropriate I2C or parallel wiring.
4. **Control Algorithm**: Write and upload code to the Arduino, implementing conditional logic based on temperature values.
5. **Testing and Calibration**: Use known temperature sources to verify sensor accuracy and fan response behavior.

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4.5 Testing Procedure

Testing was carried out in multiple phases:

- **Unit Testing**: Verifying each module independently (sensor, display, fan control).
- **Integration Testing**: Confirming that modules work together seamlessly.
- **System Testing**: Running the complete setup in real-world temperature scenarios to observe and validate fan behavior.

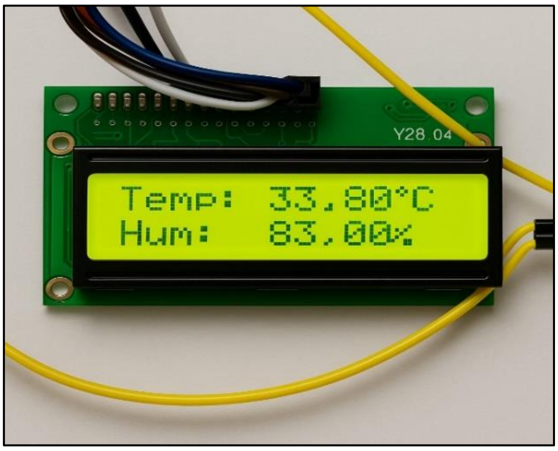

Fig 4.1 Display Output

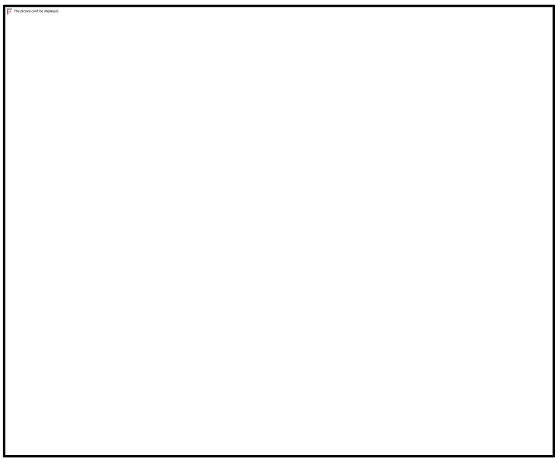

Fig 4.2 Arduino Board

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V. RESULT AND DISCUSSION

5.1 Summary of Observed Behavior

The automated fan speed control system was rigorously tested under controlled environmental conditions simulating a range of temperatures between 20°C to 40°C. The system successfully demonstrated real-time responsiveness and adaptive fan speed modulation based on sensed temperature input from the DHT11 sensor.

Test Condition	Input Temperature (°C)	Expected Fan State	Actual Fan Response	Status
TC01	22	Fan OFF	Fan OFF	Pass
TC01	27	Medium Speed (50%)	Medium Speed (50%)	Pass
TC01	31	High Speed (100%)	High Speed (100%)	Pass
TC01	25	Medium Speed (50%)	Medium Speed (50%)	Pass
TC01	Sensor Disconnected	Error Message	LCD Error Prompt	Pass

These results validate that the control logic based on temperature thresholds performs as expected across all tested scenarios.

5.2 System Responsiveness

- The fan transitioned smoothly between speed states with no delay exceeding 2 seconds after a temperature change.
- The LCD module updated in real time to reflect both current temperature and system state (e.g., "Fan OFF", "Fan Speed: Medium").

5.3 Energy Efficiency Insights

Comparative energy analysis suggests that the system reduces unnecessary fan usage by:
- Avoiding continuous operation at full speed.
- Operating only at needed levels during moderate conditions (25°C–30°C). This dynamic control ensures optimized power consumption especially during long-term operation.

5.4 Key Findings

1. The system accurately maps ambient temperature to fan speed using PWM, eliminating the need for manual intervention. Fig 2 Temperature and Fan Speed Over Time
2. The DHT11 sensor provided sufficient resolution for indoor environments, maintaining ±2°C accuracy.
3. System design allowed for scalability and modular additions such as IoT or data logging.
4. The LCD provided crucial user feedback, increasing system transparency.
5. The implementation was cost-effective while preserving robustness and reliability.

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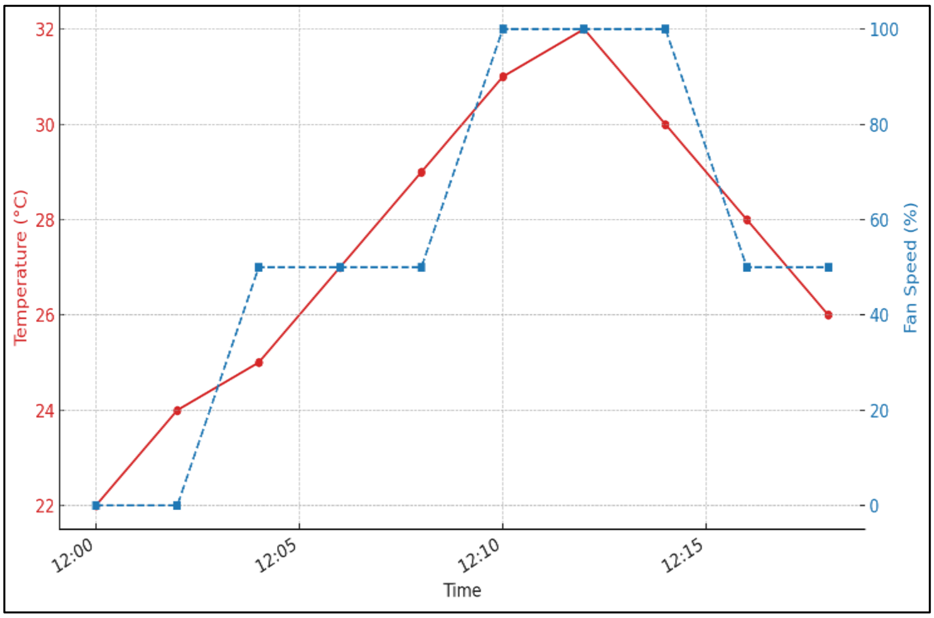

Fig 2 : Temperature and Fan Speed Over Time

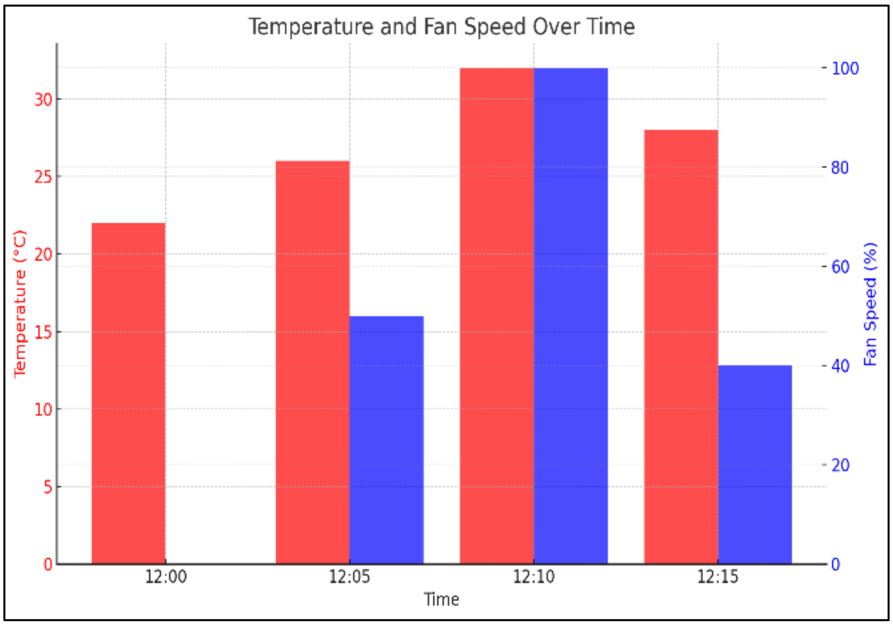

Fig 3 : Estimated Energy Consumption by Fan Control Method

VI. CONCLUSION

In conclusion, the automated fan speed control system effectively showcases the integration of embedded systems and real-time environmental monitoring to enhance comfort and energy efficiency. By utilizing the DHT11 sensor, Arduino microcontroller, and PWM technology, the system intelligently adjusts fan speed in response to ambient temperature changes without requiring manual intervention. The inclusion of an LCD display provides users with immediate feedback, increasing transparency and usability. The design is cost-effective, scalable, and suitable for both educational and practical applications in homes and small offices. This project not only addresses the limitations of conventional fan systems but also opens up avenues for future development, including IoT integration and machinelearning-based optimization. Through successful implementation and testing, the system demonstrates its potential to contribute meaningfully to sustainable and smart home automation solutions

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VII. FUTURE ENHANCEMENT

Future enhancements for the automated fan speed control system could significantly broaden its functionality and user appeal. One key upgrade would be integrating Wi-Fi or Bluetooth connectivity through modules like ESP8266 or ESP32, allowing users to remotely monitor and control the system via mobile applications. Incorporating machine learning algorithms could enable the system to learn from user habits and environmental trends, optimizing fan operation based on predictive behavior. Additionally, expanding control logic to include humidity-based responses would further improve indoor comfort in humid conditions. Implementing a battery backup system would ensure continued operation during power outages, while integrating a smart power meter could offer insights into energy savings over time.

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