A Project Report

on

TEMPERATURE TUNED FANS

ECB1223-MICROCONTROLLERS AND INTERFACING

Submitted by

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BONAFIDE CERTIFICATE

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INTERNAL EXAMINAR

INSTITUTION VISION AND MISSION

Vision

To emerge as a leader among the top institutions in the field of technical education.

Mission

M1: Produce smart technocrats with empirical knowledge who can surmount the global challenges.

M2: Create a diverse, fully -engaged, learner -centric campus environment to provide quality education to the students.

M3: Maintain mutually beneficial partnerships with our alumni, industry and professional associations

DEPARTMENT VISION, MISSION, PEO, PO AND PSO

Vision

To empower the Electronics and Communication Engineering students with emerging technologies, professionalism, innovative research and social responsibility.

Mission

M1: Attain the academic excellence through innovative teaching learning process, research areas & laboratories and Consultancy projects.

M2: Inculcate the students in problem solving and lifelong learning ability.

M3: Provide entrepreneurial skills and leadership qualities.

M4: Render the technical knowledge and skills of faculty members.

Program Educational Objectives

PEO1: **Core Competence:** Graduates will have a successful career in academia or industry associated with Electronics and Communication Engineering

PEO2: **Professionalism:** Graduates will provide feasible solutions for the challenging problems through comprehensive research and innovation in the allied areas of Electronics and Communication Engineering.

PEO3: **Lifelong Learning:** Graduates will contribute to the social needs through lifelong learning, practicing professional ethics and leadership quality

Program Outcomes

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO1: Applying knowledge in various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of Engineering application.

PSO2: Able to solve complex problems in Electronics and Communication Engineering with analytical and managerial skills either independently or in team using latest hardware and software tools to fulfil the industrial expectations.

Abstract	Matching with POs, PSOs
Temperature-tuned fans improve cooling system efficiency by adjusting fan speed based on ambient temperature. This method reduces energy consumption and enhances system performance. It is especially effective in HVAC and data center applications. The approach supports sustainability by lowering operational costs and carbon emissions	PO-1, PO-2, PO-4, PO-5, PO-7, PO-10 PSO-1,PSO-2

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ABSTRACT

Efficient thermal management is essential in modern systems where energy consumption, system stability, and performance are tightly linked to environmental conditions. Conventional fan-based cooling mechanisms operate on fixed-speed settings or rely on manual control, often resulting in energy waste, excessive noise, and inadequate temperature regulation. This paper presents the design and implementation of an intelligent, temperature-tuned fan system that dynamically adapts fan speed in response to ambient temperature variations. The core of the system is a thermistor sensor interfaced with an Arduino microcontroller, which processes real-time temperature data and modulates fan speed through PWM (Pulse Width Modulation) signals. A MOSFET acts as a switching component to drive the DC fan according to the PWM input. A 16x2 LCD module displays current temperature readings, enhancing system visibility and user monitoring. Additionally, a 7805 voltage regulator ensures consistent power supply, and a trimmer potentiometer enables tuning of the thermistor's sensitivity range. As temperature increases, fan speed is proportionally elevated, offering optimized cooling performance with improved energy efficiency. The proposed system is cost-effective, compact, and scalable, making it highly suitable for applications in smart homes, data centers, industrial automation, and personal computing devices. By employing adaptive control logic, this approach demonstrates a practical solution for sustainable cooling with potential integration into larger IoT and smart energy frameworks

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LIST OF ABBREVIATIONS

ACRONYM	ABBREVIATION
DC	Direct Current
GND	Ground
HVAC	Heating, Ventilation, and Air Conditioning
IoT	Internet of Things
LCD	Liquid Crystal Display
MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistor
PCB	Printed Circuit Board
PWM	Pulse Width Modulation
VCC	Voltage Common Collector
VFD	Variable Frequency Drive

CHAPTER 1

INTRODUCTION

1.1 Objective

The primary objective of this project is to develop a Temperature-Tuned Fan System that automatically adjusts the speed of a DC fan based on real-time ambient temperature. This system aims to optimize cooling performance while minimizing energy consumption, offering a more efficient alternative to traditional fan systems. By using a thermistor sensor to detect temperature, an Arduino microcontroller to process the data, and PWM control to adjust fan speed, the system ensures that cooling is provided only when necessary, enhancing energy efficiency. Additionally, the integration of a 16x2 LCD display for real-time temperature feedback further improves user interaction and system transparency. The project offers a cost-effective, scalable solution suitable for diverse applications, such as in smart homes, industrial spaces, and electronics cooling, where adaptive temperature regulation is essential for both performance and energy conservation. Through this system, we aim to contribute to more sustainable, intelligent thermal management solutions in various domains.

1.2 Project Details

The Temperature-Tuned Fan System Using Arduino is a project that falls under the domain of Embedded Systems, Thermal Management, and Automation. It utilizes a combination of hardware components including an Arduino Uno, an NTC thermistor for temperature sensing, a DC fan, an IRF540 MOSFET (or its equivalent) for fan control, a 7805 voltage regulator for stable power supply, a 16x2 LCD display for real-time feedback, a potentiometer for calibration, and supporting components such as resistors, capacitors, a breadboard or PCB, and an external power supply. The system is programmed using the Arduino IDE and employs techniques such as Pulse Width Modulation (PWM) for fan speed regulation, Analog-to-Digital Conversion (ADC) for reading analog signals from the thermistor, and real-time sensing to adapt the fan's performance dynamically. The final output is an intelligent fan system that adjusts its speed in response to temperature changes, ensuring efficient thermal management and energy conservation, with all relevant data displayed live on an LCD screen.

1.3 Description

Temperature regulation is essential in systems like industrial automation, home electronics, and computing environments. Traditional fan systems often run at a constant speed, leading to excessive energy consumption during low thermal demand and inadequate cooling during heat surges. This inefficiency not only raises energy costs but also shortens the lifespan of devices due to inconsistent thermal management.This project introduces a Temperature-Tuned Fan System that adapts to temperature fluctuations. An NTC thermistor senses ambient temperature and sends data to an Arduino Uno microcontroller, which adjusts the PWM signal to control the speed of a DC fan via a MOSFET. As temperature rises, the fan speed increases, providing efficient cooling only when necessary. A 16x2 LCD display shows real-time temperature readings, while a 7805 voltage regulator ensures stable power. A potentiometer allows for thermistor sensitivity calibration.This compact, cost-effective system optimizes energy use, making it ideal for scalable, energy-efficient application

CHAPTER-2

LITERATURE SURVEY

1.TITLE: Optimization of Fan Systems in HVAC for Energy Efficiency

AUTHOR: Li, J., Zhang, X., Wang, L.

This study, published in Energy Conversion and Management (2024), explores the importance of optimizing fan systems in HVAC (Heating, Ventilation, and Air Conditioning) systems to enhance energy efficiency. The authors emphasize the role of adaptive fan control, where fan speed is dynamically adjusted based on varying thermal loads. It highlights several methods for improving fan system performance, including variable frequency drives (VFDs) and energy-efficient fan motors. One key takeaway is the importance of tailoring fan speed to the actual cooling or heating demand, as opposed to traditional methods where fans operate at a fixed speed.While the study shows that such systems can significantly reduce energy consumption, it also points out the complexity and cost associated with integrating these technologies into existing systems. Despite these challenges, the paper stresses the future potential of adaptive fan systems to achieve sustainable energy savings in residential, industrial, and commercial applications.

2. TITLE: Energy-Efficient HVAC Systems: Smart Fan Control with IoT Integration

AUTHOR: Ko, J.-S., Huh, J.-H., & Kim, J.-C.

Published in Electronics (2019), this paper discusses the integration of smart technologies, such as IoT, into HVAC fan systems to improve their energy efficiency. By incorporating temperature sensors and real-time data analysis, the system adjusts fan speed based on the environment's temperature fluctuations, thereby optimizing energy use. The study demonstrates how intelligent control systems can reduce overall energy consumption by adjusting fan operations in real-time to align with actual heating and cooling needs.Though the concept proves promising, the paper also mentions that the upfront costs of installing IoT- enabled devices and smart controls can be prohibitive for certain applications. Nevertheless, the long-term benefits of reduced energy consumption and enhanced system performance offer substantial advantages for industries seeking sustainable cooling solutions.

3. TITLE: Dynamic Control of HVAC Fan Systems Based on Real-Time Environmental Data

AUTHOR: Yao, F., Yao, Y.

This research, published in Efficient Energy-Saving Control and Optimization for Multi-Unit Systems (2024), investigates the application of real-time environmental data to control HVAC systems. Specifically, the study looks at how temperature sensors can be used to control fan speed through dynamic algorithms, enabling fans to operate efficiently based on fluctuating environmental conditions. The approach uses a feedback loop that adjusts the fan's operation to optimize both energy consumption and cooling performance.While the approach shows great promise for reducing HVAC system energy consumption, the paper highlights challenges in terms of the complexity of implementation and the need for precise control algorithms. Additionally, integrating these systems into older buildings presents logistical and financial hurdles. Despite these challenges, this work contributes significantly to understanding how adaptive fan control can be leveraged for smarter, more efficient HVAC systems.

4. **TITLE**: Enhancement of HVAC Energy Efficiency Through Variable Speed Fans and Predictive Control Strategies

AUTHOR: Lin, C.-M., Liu, H.-Y., Tseng, K.-Y., & Lin, S.-F.

Published in Applied Sciences (2019), this paper explores the impact of variable speed fans in HVAC systems and how predictive control strategies can enhance energy efficiency. The authors discuss the role of sensors and algorithms that predict thermal loads and adjust the fan speed accordingly. These systems can optimize the balance between energy consumption and cooling needs, making HVAC systems more efficient than traditional constant-speed fan systems. The study concludes that predictive models can significantly reduce energy waste by adapting fan operations in real-time based on anticipated temperature changes.Despite its promising results, the paper emphasizes that implementing such systems requires sophisticated sensor networks and accurate predictive models, which can increase the initial cost and complexity of the installation. However, the long-term energy savings and environmental benefits are substantial, suggesting that this technology holds potential for widespread adoption in commercial and industrial buildings.

5. TITLE: Smart Fan Control in Data Centers: Energy Efficiency and Thermal Management

AUTHOR: Dhanush, M., Hiremath, S., & Prabhu, S. R.

This study, published in Trends in Machine Design (2024), focuses on the application of smart fan control in data centers, where efficient thermal management is crucial for energy savings. The paper presents a smart fan system that adjusts the fan speed based on real-time temperature data, minimizing energy consumption while ensuring optimal cooling. The authors highlight the use of temperature sensors, integrated with a microcontroller, to regulate fan speed dynamically and improve cooling performance. Additionally, the system features adaptive algorithms to predict temperature variations and preemptively adjust fan operations.While the study shows that intelligent fan control can lead to significant reductions in energy use, the paper points out that challenges remain in integrating such systems with existing data center infrastructure. Moreover, the precision required for accurate temperature measurements and adjustments can increase the complexity of the system. Nevertheless, the approach offers a potential solution to enhance data center efficiency and sustainability.

CHAPTER - 3

EXISTING SYSTEM

3.1 Fixed-Speed Fan Systems

Fixed-speed fan systems are the most basic and traditional type of fan control used in many appliances, HVAC systems, and industrial setups. These systems are designed to operate at a constant speed, regardless of the temperature or environmental conditions. Once turned on, the fan runs at the same speed throughout its operation, whether there is a high or low thermal demand. The simplicity of fixed-speed fans makes them cost-effective and easy to implement, as they don't require sophisticated sensors or controllers. However, they are highly inefficient in dynamic environments, as the fan often operates at full power even when cooling demands are minimal. For example, in scenarios where the ambient temperature is low, the fan continues running at full speed, leading to excessive energy consumption. Similarly, during periods of high temperature, a fixed-speed fan may not provide sufficient cooling, as it cannot adjust to the increasing demand for airflow. This constant operation can result in unnecessary power usage, reducing the overall efficiency of the system and increasing operating costs. In comparison, a temperature-tuned fan system provides a more adaptive approach by adjusting fan speeds based on real-time temperature readings, optimizing energy usage and cooling performance.

3.2 Manual Control Fan Systems

Manual control fan systems allow users to adjust the fan's speed through a manual interface, such as a dial, remote control, or a switch. These systems are commonly found in household appliances, desktop computers, and older HVAC systems where users can set the fan speed according to their comfort or cooling needs. While manual control offers some level of flexibility, it comes with several drawbacks. First, it relies on user intervention, meaning that the fan speed must be manually adjusted whenever the environmental conditions change. This can lead to inefficient cooling, as the user might not be aware of the optimal fan speed at any given time, especially in rapidly fluctuating temperature environments. In addition, these systems do not have the capability to adapt to temperature changes automatically, which can lead to both undercooling or overcooling, depending on the settings. For instance, when the temperature rises unexpectedly, a user might forget to increase the fan speed, resulting in inadequate cooling. Conversely, in cooler environments, the fan may continue to run at a higher speed than necessary, leading to wasted energy. In contrast, the temperature-tuned fan system automatically adjusts its speed based on ambient temperature, ensuring more accurate and energy-efficient cooling without manual intervention.

3.3 Basic Thermostat-Controlled Fan Systems

Basic thermostat-controlled fan systems are designed to maintain a target temperature by turning the fan on or off, depending on whether the room temperature reaches a predefined threshold. These systems often use a simple thermostat sensor that detects the temperature in the room. If the temperature goes above a set point, the thermostat triggers the fan to start running. Conversely, once the temperature falls back below the set point, the fan is turned off. While this approach does help manage the temperature to some extent, it lacks precision and is not highly efficient. Since the fan is either on or off, there is no middle ground to adjust the airflow according to varying cooling requirements. During times when the temperature fluctuates around the set point, the fan may be unnecessarily activated, consuming energy without effectively providing cooling. Additionally, these systems are not adaptive enough to respond to rapid temperature changes, as they often have a delay in detecting and reacting to temperature shifts. The temperature-tuned fan system, on the other hand, continuously adjusts the fan speed in real-time, allowing for more precise control of airflow based on the current ambient temperature, thus providing better energy efficiency and temperature regulation.

3.4 Variable Speed Fan Systems (Without Temperature Control)

Variable speed fan systems provide an advanced level of control compared to fixed-speed systems. These systems allow users to adjust the fan speed across a range of settings, providing more flexibility and control over airflow. Variable speed fans are commonly used in modern HVAC systems and ventilation systems in commercial buildings, where users can manually set the fan speed to match their comfort level or cooling needs. While these systems offer more flexibility than fixed-speed fans, they still suffer from limitations when compared to the temperature-tuned fan system. Variable speed fans do not automatically adjust based on real-time environmental changes like temperature. Instead, the user must manually set the desired fan speed based on their perception of the current temperature, which may not always be accurate or efficient. Additionally, these systems can be energy inefficient if the fan speed is set too high or too low for the actual cooling demand. If the fan is running at high speed when not needed, energy is wasted. The temperature-tuned fan system provides a more adaptive and energy-efficient solution by automatically adjusting the fan speed in real-time according to the ambient temperature, ensuring that cooling is always optimized based on actual needs.

3.5 Smart Thermostat-Controlled HVAC Systems

Smart thermostat-controlled HVAC systems are an upgrade to basic thermostat-controlled systems, offering more sophisticated features and automation. These systems use advanced sensors and algorithms to monitor the indoor temperature and make adjustments to the HVAC system to maintain the desired temperature. Smart thermostats can be programmed to change fan speeds or turn the system on or off based on time of day, weather forecasts, or other environmental conditions. Some of these systems can also be controlled remotely via mobile apps, allowing users to monitor and adjust their HVAC settings from anywhere. While smart thermostats offer greater convenience and efficiency than basic thermostats, they still have limitations when compared to a temperature-tuned fan system. Smart thermostats typically control the HVAC unit as a whole, turning it on or off based on a set temperature. However, they do not dynamically adjust the fan speed in response to changes in ambient temperature or cooling needs. This can lead to inefficiency, as the system may be running at full capacity when the temperature is only slightly above the target, or it may be too slow to react to temperature fluctuations. In contrast, the temperature-tuned fan system can precisely adjust fan speeds based on real-time temperature readings, improving both energy efficiency and cooling performance without requiring manual input or complex programming.

CHAPTER - 4

PROPOSED SYSTEM

4.1 Proposed System Description

The system begins with the NTC thermistor, which detects the ambient temperature and converts it into an analog signal. This signal is sent to the Arduino microcontroller, where it is processed and converted into a digital value using the Arduino's Analog-to-Digital Converter (ADC). Based on the temperature data, the Arduino generates a Pulse Width Modulation (PWM) signal to control the speed of the DC fan.

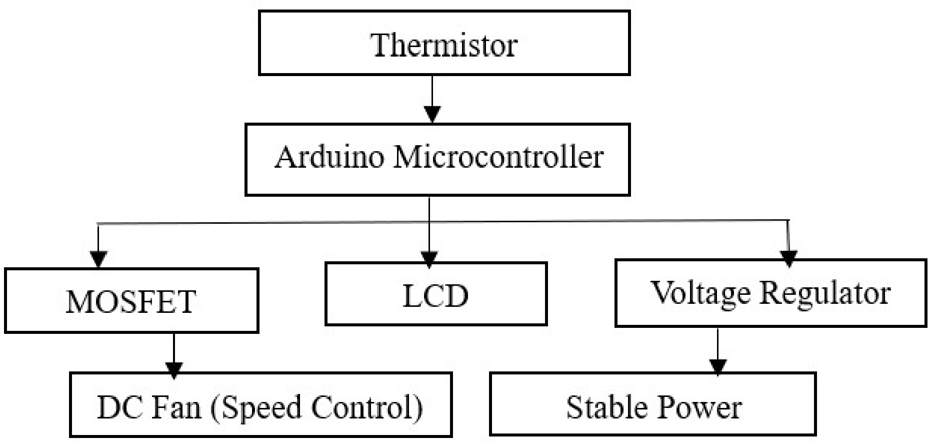

Fig.4.1 Proposed System block diagram

This PWM signal is then passed to a MOSFET, which acts as a switch to regulate the power supplied to the fan. As the temperature rises, the PWM signal increases, allowing more current to pass through the MOSFET, which increases the fan speed to provide enhanced cooling. To ensure that the entire system receives stable voltage, the 7805 voltage regulator is used to provide a constant 5V output, protecting the components from voltage fluctuations.

Meanwhile, the 16x2 LCD display provides real-time feedback by showing the current temperature, giving the user visibility into the system’s operation. The fan speed is thus dynamically adjusted according to the ambient temperature, ensuring energy-efficient and optimized cooling. This comprehensive setup operates autonomously, offering a reliable and scalable solution for temperature management across various applications

4.2 Components and Their Functions

Table.4.2 Components Details

Component Name	Quantity	Range	Price
NTC Thermistor	1	10kΩ	₹15
Arduino UNO	1	ATmega328P Microcontroller	₹500
12V DC Fan	1	12V, 0.15A	₹100
IRF540N MOSFET	1	N-Channel, 100V, 33A	₹30
7805 Voltage Regulator	1	5V Output, 1.5A Max	₹10
16x2 LCD Display	1	HD44780 Driver, Green Backlit	₹120

1. Arduino Uno

The Arduino Uno serves as the central control unit of the system. It processes data from the thermistor to determine the ambient temperature and uses this information to control the fan speed. Through the use of Pulse Width Modulation (PWM), the Arduino adjusts the duty cycle of the signal sent to the MOSFET, which controls the fan’s speed. The Arduino is programmed using the Arduino IDE and ensures the system’s responsive behavior by continually adjusting based on real-time temperature readings.

2. NTC Thermistor

The NTC thermistor is a temperature-sensing device that changes its resistance according to the temperature. In this system, the thermistor's resistance decreases as the temperature rises. The Arduino reads this change in resistance as an analog signal and converts it to a digital value to adjust the fan speed accordingly. It is essential for real-time temperature monitoring and helps the system make necessary adjustments for efficient cooling.

3. DC Fan

The DC fan is the core cooling element of the system. It generates airflow to reduce temperature when required. The fan speed is regulated by the PWM signals from the Arduino. When the temperature increases, the Arduino adjusts the fan speed to higher levels to cool the environment, and conversely, reduces the speed when the temperature drops. This dynamic control ensures the fan operates efficiently, conserving energy when high cooling isn't necessary.

4. MOSFET (IRF540 or equivalent)

The MOSFET acts as a switch between the Arduino and the DC fan. It receives the PWM signal from the Arduino, and based on this signal, it controls the power supplied to the fan. By regulating the voltage, the MOSFET adjusts the fan speed accordingly. It's chosen for its high efficiency and ability to handle the power required by the fan, ensuring minimal energy loss.

5. 7805 Voltage Regulator

The 7805 voltage regulator ensures that the system receives a constant 5V supply, regardless of fluctuations in the input voltage. The Arduino and other components like the thermistor and LCD display require a stable voltage for proper operation. The 7805 converts higher voltage (e.g., 12V) to 5V, preventing damage to the components and ensuring the smooth functioning of the system.

6. 16x2 LCD Display

The 16x2 LCD display is used to provide real-time feedback on the temperature detected by the thermistor. It displays the ambient temperature, allowing the user to monitor the system's performance and make any necessary adjustments. This adds an interactive and transparent aspect to the system, ensuring the user is informed about the cooling system's operation.

4.3 System Architecture

The system architecture of the Temperature-Tuned Fan System is designed to ensure efficient thermal management through intelligent, sensor-based fan control. At its core lies the Arduino Uno microcontroller, which acts as the central processing unit that coordinates the entire operation. The system begins with an NTC thermistor that continuously senses the ambient temperature and sends analog signals to the Arduino's analog input pin. This input is then processed using the Arduino's built-in Analog-to-Digital Converter (ADC), allowing the temperature to be interpreted numerically.Based on the sensed temperature, the Arduino generates a Pulse Width Modulated (PWM) signal to control the gate of a MOSFET transistor. The MOSFET acts as a switch that adjusts the power supplied to the DC fan, effectively modulating its speed. As the temperature increases, the duty cycle of the PWM signal increases, causing the fan to spin faster to dissipate more heat. Conversely, at lower temperatures, the PWM duty cycle reduces, slowing down the fan and conserving energy.To provide the user with real-time system feedback, a 16x2 LCD display is integrated, which shows both the current temperature and the fan speed percentage. A 7805 voltage regulator is used to ensure a constant 5V power supply to the microcontroller and peripheral components, protecting the system from power fluctuations. All components are interconnected on a breadboard or PCB, forming a closed-loop feedback system where temperature inputs directly influence fan operation. This modular and scalable architecture ensures that the system can be expanded or integrated into larger automation frameworks, making it ideal for applications in smart homes, electronic cooling, or industrial automation.

4.4 Key Features of the System:

The Temperature-Tuned Fan System presents a robust set of features that make it a smart and energy-efficient solution for thermal management applications. The fan speed is controlled via Pulse Width Modulation (PWM), which allows for smooth and precise modulation of the DC fan through a MOSFET, ensuring efficient performance without unnecessary power wastage. An integrated 16x2 LCD display enhances user experience by providing live feedback on current temperature and fan speed, offering a transparent view of the system's operation. Furthermore, the system incorporates a 7805 voltage regulator to maintain a stable 5V power supply essential for consistent Arduino and component performance, even under fluctuating input conditions. A trimmer potentiometer is included for manual calibration of the thermistor's sensitivity, enabling the user to fine-tune how the system reacts to different temperature ranges, thus ensuring adaptability across diverse environments. The entire setup is compact, cost-effective, and built using widely available hardware, making it scalable for use in both simple home applications and more complex industrial systems. Together, these features make the system not only energy-conscious but also practical, responsive, and highly suitable for modern automated cooling needs.

CHAPTER - 5

METHODOLOGY

5.1 System Flowchart

The system flow begins with initializing the components after powering on the setup. Once the system starts, the Arduino microcontroller immediately begins monitoring environmental conditions by reading the ambient temperature through the connected NTC thermistor. The thermistor outputs an analog voltage corresponding to the surrounding temperature. This analog signal is captured by the Arduino and converted into a digital value using its Analog-to-Digital Converter (ADC).

After acquiring the temperature data, the Arduino processes it and uses the map() function to convert the temperature reading into a corresponding PWM (Pulse Width Modulation) value. This mapping is essential to ensure that the fan speed is proportionally adjusted according to the temperature — higher temperatures result in higher PWM duty cycles and thus higher fan speeds, while lower temperatures produce lower duty cycles and reduced fan speeds.

The calculated PWM signal is then sent to the MOSFET, which functions as an electronic switch controlling the power supplied to the DC fan. The MOSFET modulates the fan speed based on the PWM duty cycle received from the Arduino, allowing for precise speed control without mechanical wear or power waste.

Simultaneously, the system outputs the real-time temperature and fan speed data to the 16x2 LCD display. This feature enhances user interaction by providing immediate feedback on system performance. The user can easily monitor how the system reacts to temperature changes in the environment.

Once this loop is completed, the process doesn't end. The Arduino continues to monitor the temperature and repeat the entire sequence in real time, ensuring continuous and adaptive fan control. This cyclical process ensures energy efficiency and optimal cooling, adjusting instantaneously to any changes in ambient temperature.

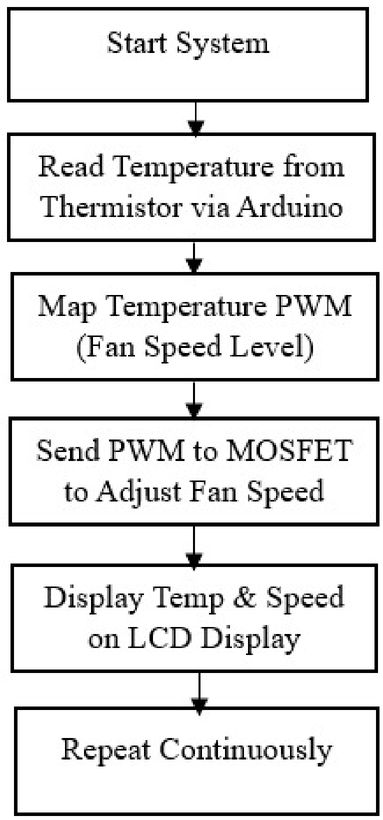

Fig.5.1 System Flowchart

5.2 System Design

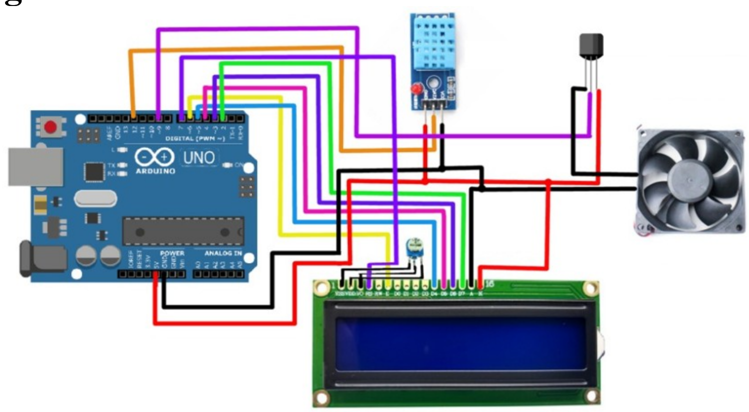

Fig.5.2 System circuit design

Explanation of the Circuit:

- **Arduino UNO (Microcontroller):**

➢ The central unit that reads temperature data, processes it, and controls the fan speed accordingly.

➢ It receives input from the temperature sensor and controls output to the LCD display and fan via PWM.

- **Temperature Sensor (DHT11 or DHT22):**

➢ This sensor (blue module in the image) measures ambient temperature and sends the data to the Arduino.

➢ It is connected to one of the digital input pins (usually D2 or D3), with VCC and GND for power.

- **NTC Thermistor (Black component near the fan):**

➢ In some versions, an NTC thermistor may be used in place of or alongside the DHT sensor for analog temperature readings.

➢ It's part of a voltage divider circuit connected to an analog input pin (A0), allowing the Arduino to read temperature as a voltage level.

- **LCD Display (16x2):**
  - This module is connected to the Arduino to display real-time temperature readings and fan speed status.
  - It uses multiple digital pins for data (D4–D7) and control (RS, EN), powered by 5V and GND.
- **DC Fan:**
  - The output actuator of the system.
  - Its speed is controlled via a MOSFET that receives a PWM signal from the Arduino, allowing dynamic adjustment based on temperature.
- **MOSFET (likely IRF540 or similar):**
  - Acts as a switch to control the power supply to the fan.
  - It receives PWM signals from the Arduino to modulate fan speed and is connected between the fan and power source.
- **Power Connections:**
  - The entire system runs on 5V DC, either supplied via USB or an external power adapter.
  - Proper GND connections ensure all components share a common ground.

CHAPTER - 6

RESULT AND DISCUSSION

6.1 Prototype Description

The prototype model of the Temperature-Tuned Fan System effectively demonstrates the integration of multiple hardware components for intelligent thermal regulation. At the core of the system is the Arduino Uno microcontroller, which acts as the brain of the setup. It receives analog signals from the NTC thermistor sensor, which detects real-time ambient temperature. The sensor is connected through a voltage divider configuration using resistors and a potentiometer to fine-tune sensitivity. This input is processed by the Arduino, which converts the analog temperature data into a digital signal through its ADC (Analog-to-Digital Converter).

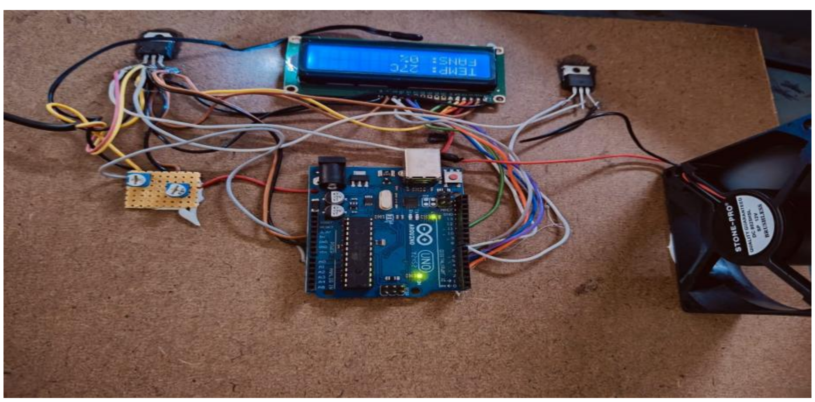

Fig.6.1 Prototype Model

Based on the sensed temperature, the Arduino generates a PWM (Pulse Width Modulation) signal that is sent to a MOSFET (IRF540). The MOSFET functions as a switch that controls the power supplied to the DC cooling fan. As the ambient temperature rises, the PWM signal increases the duty cycle, causing the fan to spin faster. This dynamic speed control ensures optimal cooling only when necessary, thus conserving energy and enhancing system efficiency.

A 16x2 LCD Display is included in the model to provide real-time feedback to the user. It shows the current temperature and the corresponding fan speed, offering clear system transparency and usability. A 7805 Voltage Regulator is used to ensure a stable 5V power supply to the microcontroller and other components, protecting them from voltage fluctuations. The entire setup is built on a compact plywood board, using jumper wires and a breadboard or custom PCB to interconnect the modules.

This hands-on prototype successfully brings the theoretical concept into practice, demonstrating how embedded systems and sensor-based automation can be utilized to create an energy-efficient cooling mechanism. The model not only reflects practical skills in circuit design, programming, and real-time control but also serves as a scalable blueprint for future industrial or home automation applications.

CHAPTER - 7

CONCLUSION AND FUTURE WORK

Conclusion:

The Temperature-Tuned Fan project demonstrates an effective application of dynamic cooling through a feedback loop driven by temperature measurements. The system, built around an Arduino Uno, adjusts the speed of a 12V DC fan based on the temperature read by a thermistor, with the MOSFET acting as a switch to control the fan's voltage. The voltage regulator ensures stable power delivery, and the LCD display shows real-time data, providing useful insights into the system's performance.

Future Work:

- **Improved Fan Control Algorithms**: The current system adjusts the fan speed based on a basic temperature-to-speed relationship. Future improvements could include implementing more complex algorithms that adjust fan speed more precisely based on environmental factors (e.g., humidity, airflow) or predictive models to anticipate temperature changes.
- **Integration with IoT**: Incorporating Wi-Fi or Bluetooth modules could allow the system to be controlled remotely via a mobile app or through a cloud-based platform. This would make it possible to monitor and control fan settings from any location, which could be especially useful for applications in large-scale systems or smart homes.
- **Energy Harvesting**: Consider adding an energy-harvesting mechanism (like a small solar panel) to power the fan or recharge the system's power supply, making the system more sustainable and off-the-grid.

- **Advanced Sensor Technology**: Using more precise sensors like digital temperature sensors (e.g., DHT22 or DS18B20) could improve the accuracy of temperature readings, especially in varying environmental conditions.
- **User Customization**: Future iterations could include features that allow users to set a threshold temperature at which the fan will start adjusting speed or turn on/off, offering more flexibility for different environments.
- **Fan Speed Feedback Mechanism**: You could add a tachometer to measure the actual speed of the fan and provide feedback, ensuring the system is adjusting the fan speed accurately and efficiently.
- **Noise Reduction**: As the fan speed increases to cool the system, the noise may also increase. Investigating noise reduction technologies or designing quieter fan systems could make the project more suitable for environments where noise is a concern (e.g., offices, homes).
- **Application in Other Systems**: The project's principle could be adapted to cooling systems for industrial equipment, electronics, or even renewable energy systems (such as optimizing cooling for solar panels).

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OUTCOME

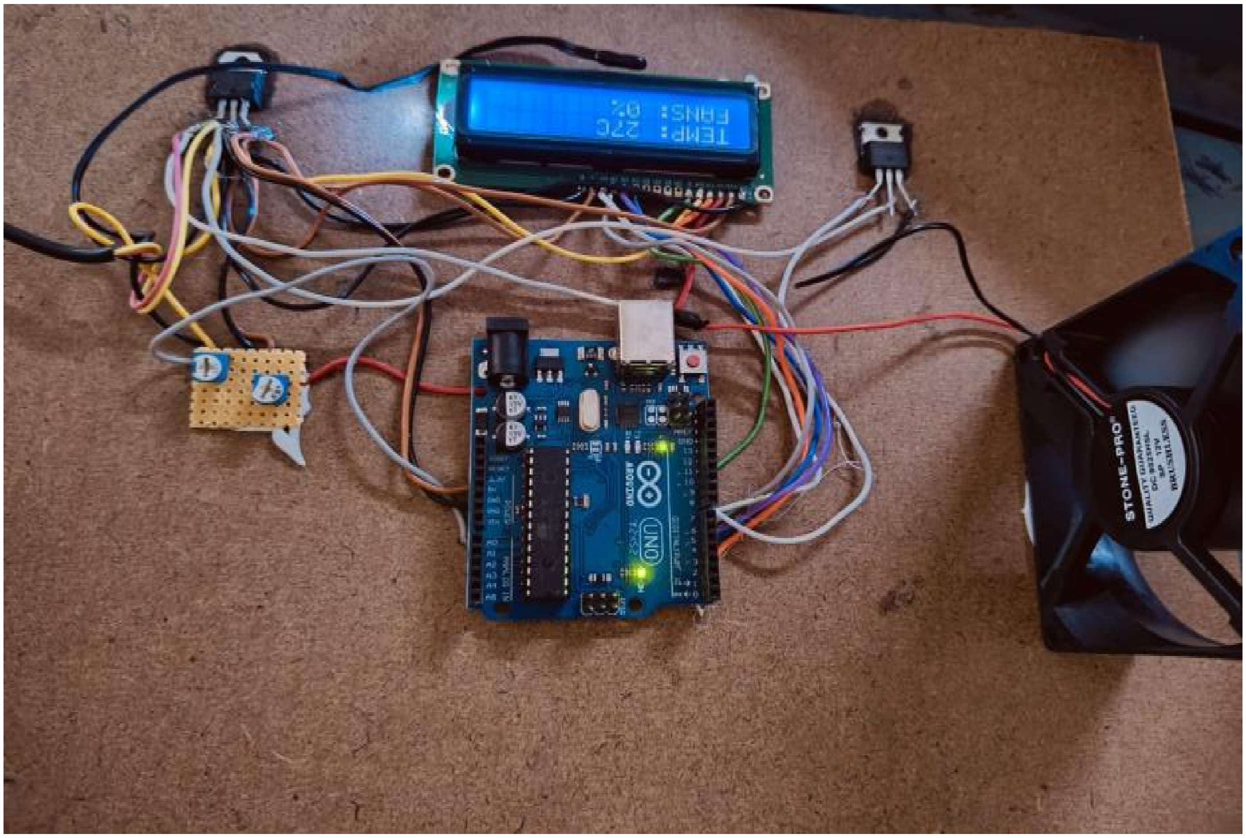

Figure Shows Developed prototype for Temperature Tuned Fans