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DESIGN OF AN AUTOMATIC ROOM TEMPERATURE-CONTROLLED FAN USING RASPBERRY PI AND LM75 SENSOR

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Abstract: In the contemporary context of smart home technologies, this project presents an innovative solution—a Raspberry Pi-based Automatic Fan Speed Controller integrated with a Temperature Display using an LCD. The system is designed to optimize energy consumption and enhance user comfort by dynamically adjusting fan speed based on real-time temperature readings from a chosen sensor. The hardware components, including a Raspberry Pi, temperature sensor (LM75), DC fan, and LCD display, are interconnected to create a responsive and intelligent environment. The Python script orchestrates the system, continuously monitoring ambient temperature, dynamically adjusting the fan speed, and concurrently updating the LCD display with real-time temperature information. The LCD serves as a user-friendly interface, offering instant visual feedback on the current temperature. The versatility of the project allows for easy customization of temperature thresholds and control parameters, catering to specific user preferences. Overall, this Automatic Fan Speed Controller contributes to energy efficiency, providing a seamless blend of functionality and user convenience in residential and commercial spaces. Future enhancements may involve integrating the system with IoT platforms for remote monitoring and control, further extending its applications in the realm of smart home automation.

Keywords: Raspberry Pi, LM75, automated fan, temperature

I. INTRODUCTION

Microcontrollers, compact integrated circuits designed for embedded systems, play a pivotal role in the evolution of smart technologies, reshaping our daily lives by imbuing devices with intelligence and automation. These miniature computing powerhouses, equipped with processing units, memory, and peripherals, form the backbone of countless applications, from household appliances to industrial machinery, facilitating seamless interactions and enhancing efficiency. In the real world, microcontrollers serve as the brains behind smart devices, enabling functionalities such as automation, real-time data processing, and connectivity. In smart homes, for instance, microcontrollers orchestrate the operation of intelligent thermostats, lighting systems, and security cameras, creating environments that adapt to user preferences and respond to changing conditions. Industrial automation relies heavily on microcontrollers to control processes, monitor sensors, and manage machinery with precision, leading to increased productivity and reduced human intervention.

The project at hand, the "Automatic Fan Speed Controller with Temperature Display using Raspberry Pi and LCD," exemplifies the practical application of microcontrollers. Here, a Raspberry Pi, a versatile single-board computer incorporating a microcontroller, serves as the brain of the system.

The project leverages the processing capabilities of the Raspberry Pi to read real-time temperature data from a sensor, dynamically adjust the speed of a DC fan, and display this information on an LCD screen. The use of microcontrollers in this project brings forth a range of benefits. The Raspberry Pi, functioning as a microcontroller, provides a cost-effective and accessible platform for developing intelligent systems. Its GPIO pins facilitate seamless interfacing with sensors and actuators, allowing for real-time control based on environmental variables. By utilizing a microcontroller, the project achieves energy efficiency through the automated adjustment of fan speed, promoting a comfortable and adaptive environment. Moreover, the LCD display, interfaced with the microcontroller, enhances user interaction by offering a visual representation of the current temperature. This not only aligns with the broader trend of human-centric design in smart systems but also showcases the versatility of microcontrollers in providing user-friendly interfaces.

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In summary, the integration of microcontrollers in the "Automatic Fan Speed Controller with Temperature Display" project reflects their pervasive role in shaping smart systems. This project not only exemplifies the utility of microcontrollers in real-world applications but also underscores their capacity to democratize the development of intelligent and responsive technologies in both domestic and industrial contexts.

In the domain of the "Automatic Fan Speed Controller with Temperature Display using Raspberry Pi and LCD," Pulse Position Modulation (PPM) emerges as a key digital modulation technique, contributing to the project's intelligent control system. PPM, a scheme where information is conveyed by altering the position of pulses within a fixed time period, plays a pivotal role in encoding fan speed information based on realtime temperature readings. The process commences with the conversion of temperature data into a duty cycle, establishing a direct correlation between temperature variations and pulse positions. Higher temperatures may correspond to a higher duty cycle, resulting in pulses positioned earlier within the time frame, while lower temperatures lead to a lower duty cycle, shifting pulses to later positions. This duty cycle, serving as a representation of the desired fan speed, is then modulated onto the control signal as shown in Fig. 1. The Raspberry Pi, acting as the control unit, sends the PPM-encoded signal to the fan control circuit. Here, the intricate dance of pulse positions is decoded, enabling dynamic adjustments in the fan speed. For instance, a rapidly changing environmental temperature may result in a series of pulses distributed across the time frame, prompting the fan to modulate its speed continuously.

The strength of PPM in this context lies in its ability to provide a nuanced and responsive fan speed adjustment mechanism. By dynamically altering the position of pulses, the system ensures that the fan adapts seamlessly to fluctuating temperatures, optimizing energy consumption and enhancing user comfort. This real-time responsiveness aligns with the project's goal of creating an intelligent and adaptive environment. In essence, the integration of PPM into the fan speed control system demonstrates a sophisticated approach to digital modulation, enabling precise and fine-tuned control over the fan speed based on the ever-changing temperature conditions. This utilization of PPM underscores its significance in the realm of smart systems, showcasing its adaptability and effectiveness in achieving dynamic control in applications such as climate regulation and energy efficiency.

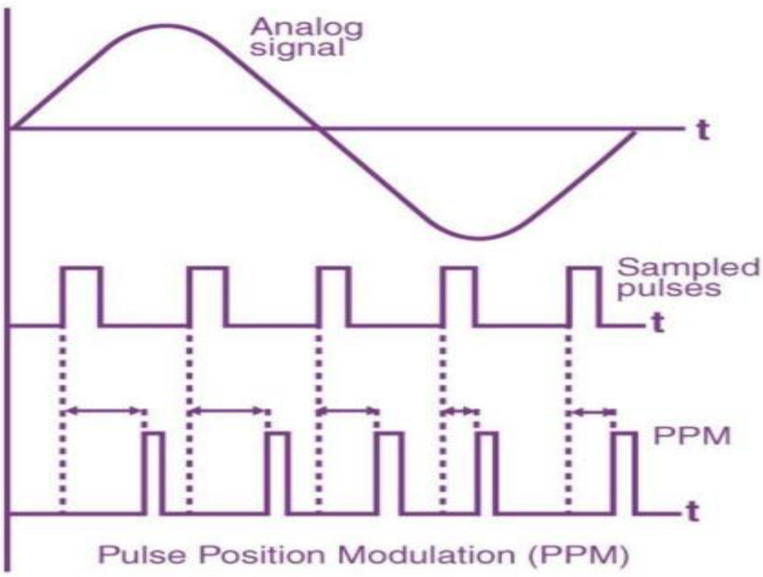

Fig 1.PPM signals

II. RELATED WORK AND PROBLEM STATEMENT

In 2022, the global landscape of electricity consumption exhibited a noteworthy 10% increase, reaching a total of 1390 terawatt-hours (TWh). This surge followed a 7% growth observed in 2021 and marked a departure from the trend of consistent 7% annual progression witnessed between 2010 and 2019. The year 2020, however, stood out with a 6.7% decline in electricity consumption, likely influenced by the unprecedented global challenges. The recent upswing in 2022 as shown in Fig. 2 suggests a rebound in energy demand, underscoring the resilience and adaptability of power consumption patterns.

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Understanding these fluctuations remains crucial for policymakers, industries, and energy stakeholders to navigate the complex interplay of economic, technological and environmental factors influencing global energy consumption. It emphasizes the need for ongoing vigilance and strategic planning in the dynamic realm of energy dynamics.

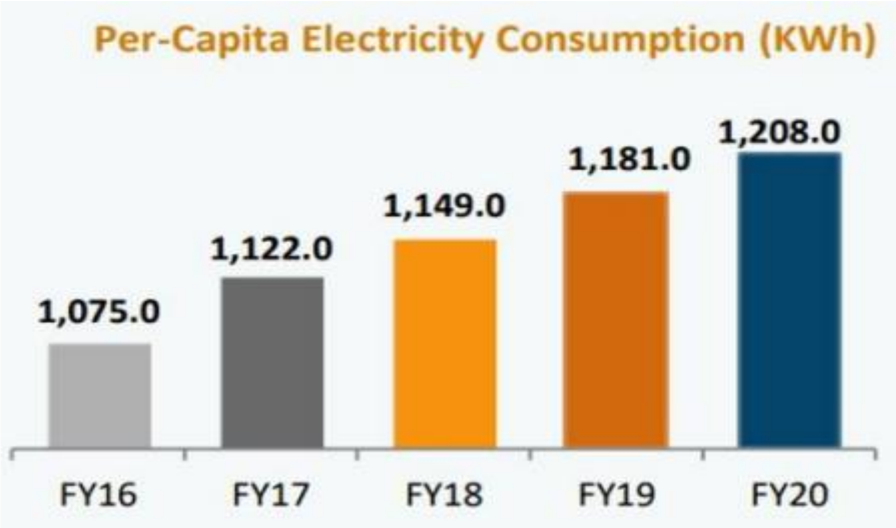

Fig 2. Power consumption in India

Many individuals find it inconvenient to manually adjust fan speed levels in response to fluctuations in room temperature due to poorly designed systems. Consequently, it is recommended to develop an automated fan system that autonomously varies the speed level based on changes in temperature to address this issue.

III. METHODOLOGY

To create an affordable and user-friendly automated temperature-controlled fan regulator that not only minimizes power consumption but also aids individuals facing challenges in remotely adjusting fan speeds. The proposed block diagram is shown in Fig. 3.

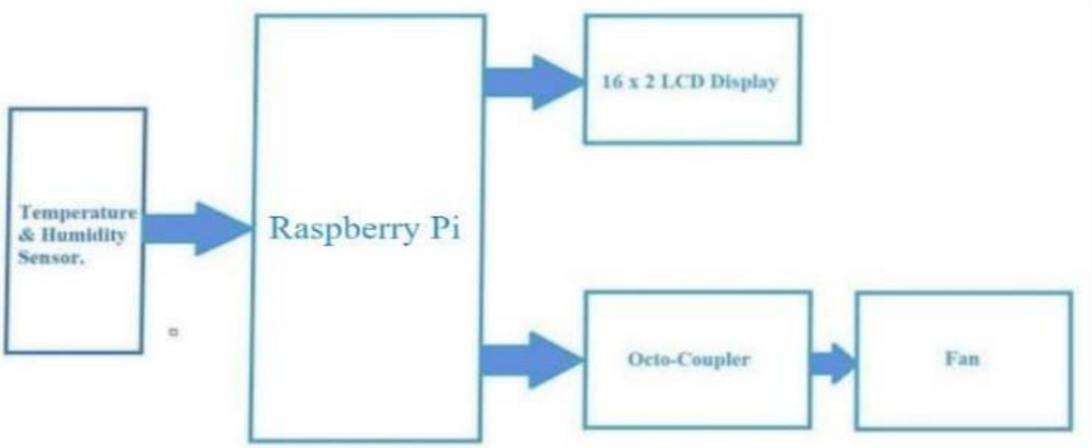

Fig. 3 Block diagram of the proposed method

The temperature-controlled fan regulator, integrated with Pulse Position Modulation (PPM), employs a microcontroller, temperature sensor, and fan. The microcontroller, such as the Raspberry Pi, continually monitors room temperature using the sensor. The acquired temperature data is then translated into PPM signals, where the position of pulses within a fixed time frame signifies specific fan speed levels. This dynamic adjustment optimizes energy consumption based on temperature fluctuations, contributing to enhanced efficiency. The PPM-modulated signals drive precise fan speed control, ensuring responsiveness to changing environmental conditions.

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A user-friendly LCD interface offers real-time temperature feedback, enhancing user interaction. Rigorous testing validates the accurate interpretation of PPM signals, refining the system for optimal performance. This comprehensive approach combines automated temperature sensing, PPM modulation, and user-friendly interfaces to create an intelligent and adaptive fan regulation system. The utilization of PPM signals adds a layer of sophistication to the control mechanism, providing a nuanced and responsive solution to fan speed adjustments, thus achieving the project's goal of energy efficiency and ease of use, particularly beneficial for individuals facing challenges in manually regulating fan speeds.

IV. HARDWARE DESIGN

A.Raspberry Pi

The Raspberry Pi is defined as the small, cost efficient, and super capable, credit card size computer. It is considered as the one of the most versatile tech ever created and it was developed by Raspberry Pi foundation. The main aim of Eben Upton who was the creator of this Raspberry Pi was to create a low-cost device that would improve the programming and hardware interpretation. Due to the compactness in the size and price of the device, it has become the significant and most used product in wide range of projects by electronics enthusiasts. Now Raspberry Pi is being used all across the world for the development projects, home automation, implementation of Kubernetes clusters, and edge computing, and even apply them in industrial applications.

Raspberry Pi is a programmable device that has certain features like a motherboard in an average computer but without internal storage. For the storage and memory purpose a SD card with installed OS is inserted. After setting up the operating system, the Raspberry Pi is ready to connect to the output devices through a High-Definition Multimedia Interface (HDMI). There are different models of Raspberry Pi available in the market. The selection of specific type of Raspberry Pi depends on its exact use and specifications. The top Raspberry Pi models available are Raspberry Pi Zero, Raspberry Pi 1, Raspberry Pi 2B, Raspberry Pi 3, Raspberry Pi 400, Raspberry Pi 4B etc...,

B.Raspberry Pi Zero

The Raspberry Pi zero as shown in Fig. 4 is one of the cheap programmable devices and also small enough to be embedded in a project. There are different versions in Pi zero but the latest Version has the Bluetooth and wi-fi connectivity. Low power computer is also one of the key features of Raspberry Pi zero.

Raspberry Pi needs a power supply of 5V. If the power exceeds then it can't be guaranteed to work properly. Also, the power supply should be at least 500 milliamps (mA), preferably 1 amp(A). Reduction in the specification of the supply leads to malfunction of keyboard and mouse. Hence Raspberry Pi requires a Micro-USB connection which can provide at least 700 mA at 5 V.

Fig 4. Raspberry Pi Zero

C.Open Thonny IDE

Open Thonny IDE plays a crucial and multifaceted role in the development of the temperature-controlled fan regulator project using a Raspberry Pi. Its design and features make it an ideal environment for coding, testing, and debugging Python scripts tailored to control the fan based on temperature fluctuations.

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Firstly, Thonny provides a streamlined and beginner-friendly interface. Its simplicity makes it accessible to users with varying levels of programming experience, enabling both novices and seasoned developers to work on the project efficiently. The inclusion of an integrated Python interpreter within Thonny simplifies the process of testing and running scripts, allowing developers to iterate quickly and observe the real-time effects of their code.

Thonny's built-in package manager is instrumental in managing dependencies, facilitating the seamless integration of libraries required for sensor communication, fan control, and other functionalities. This feature simplifies the installation of necessary Python packages, ensuring that the project's codebase remains organized and efficient.

Moreover, Thonny offers a comprehensive set of debugging tools. Developers can identify and rectify errors in their code directly within the IDE, promoting efficient troubleshooting. This capability is particularly beneficial during the development phase, allowing for the creation of a robust and reliable system.

Thonny's compatibility with the Raspberry Pi environment is essential for this project. Its ease of use makes it a suitable choice for developing Python scripts that interact with the GPIO pins of the Raspberry Pi, facilitating the integration of temperature sensors, fan control mechanisms, and other components.

In addition to its technical attributes, Thonny contributes to the educational aspect of the project. Its user-friendly nature makes it an excellent tool for learning and teaching programming concepts, making the development process accessible and engaging for educational purposes.

In conclusion, Open Thonny IDE serves as the central hub for coding, testing, and debugging the Python scripts that power the temperature-controlled fan regulator. Its user-friendly interface, integrated interpreter, package manager, debugging tools, and compatibility with Raspberry Pi collectively make it an indispensable tool for developers working on this project.

D.LCD

The LCD (Liquid Crystal Display) in the temperaturecontrolled fan regulator project using a Raspberry Pi is instrumental in providing a visual interface, enhancing user interaction, and displaying real-time temperature information. Its multifaceted role extends beyond mere temperature feedback, contributing to the overall functionality and user experience of the system.

Firstly, the LCD serves as a user-friendly output display as shown in Fig. 5, offering a clear and readable presentation of the current room temperature. This visual feedback provides users with an immediate understanding of the environment and allows them to gauge the system's responsiveness to temperature changes.

Secondly, the LCD contributes to the project's accessibility, particularly for users who may not have direct access to digital interfaces. By presenting information in a tangible and visible format, the LCD accommodates a broader user base, including those with varying technical proficiencies.

Additionally, the LCD can be leveraged to display system status messages or prompts, aiding in troubleshooting and user guidance. This ensures that users are informed about the system's actions, enhancing transparency and user confidence in the device's operation.

In summary, the LCD is integral to the temperature-controlled fan regulator project, offering a visual representation of temperature data, improving user accessibility, and providing valuable feedback for a more intuitive and user-friendly experience.

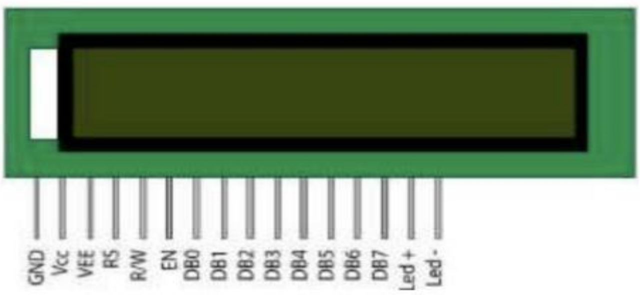

Fig 5. Liquid Crystal Display

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E.LM75 sensor

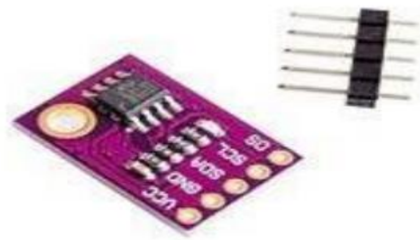

Fig 6. LM75 Sensor

The LM75 sensor shown in Fig. 6 plays a crucial role in the temperaturecontrolled fan regulator project, enhancing precision and versatility. As a digital temperature sensor with an I2C interface, the LM75 seamlessly integrates with the microcontroller, such as the Raspberry Pi, providing accurate and real-time temperature readings. Its compact design and compatibility make it an ideal choice for temperature monitoring applications. The LM75 sensor allows for finer temperature control due to its 11-bit resolution, providing more detailed data for the microcontroller to process. This precision ensures that the fan speed adjustments are closely aligned with subtle temperature changes, optimizing the system's responsiveness. Moreover, the I2C interface simplifies the wiring and communication process, reducing the complexity of the circuitry. The LM75's digital output, ease of interfacing, and wide temperature range contributes to the overall reliability and efficiency of the temperature-controlled fan regulator.

In summary, the LM75 sensor enhances the accuracy and responsiveness of the system by providing high-resolution temperature data through a user-friendly I2C interface. Its integration with the microcontroller elevates the project's capabilities, allowing for precise fan speed adjustments based on nuanced temperature variations, ultimately contributing to energy efficiency and user comfort. The hardware prototype of the proposed design is shown in Fig. 7.

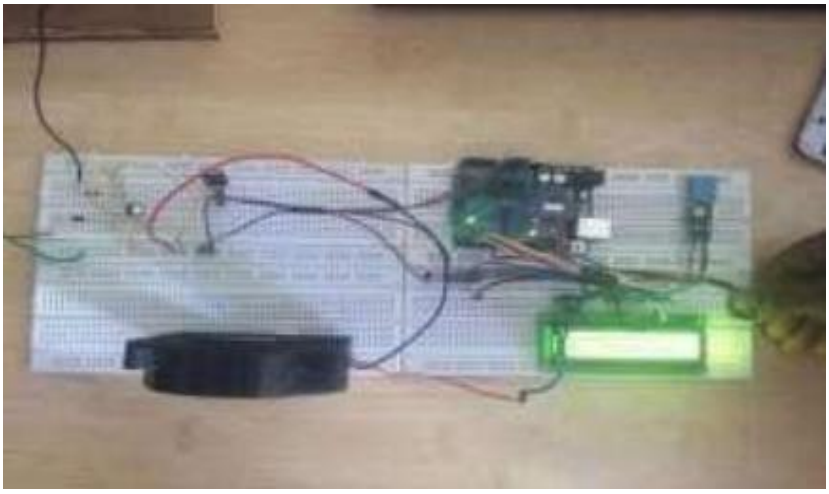

Fig 7. Hardware Prototype

In the real-time working of the temperature-controlled fan regulator project, the LM75 digital temperature sensor constantly senses the room temperature. The Raspberry Pi, programmed using Python in the Thonny IDE, interprets the temperature data received from the sensor through the I2C interface. The system employs Pulse Position Modulation (PPM), dynamically adjusting the fan speed based on the real-time temperature information. For example, let's consider a scenario where the room temperature rises above a predefined threshold. The Raspberry Pi, processing this information, modulates the fan speed using PPM signals.

If the temperature increase is substantial, the fan speed is adjusted to a higher level, promoting efficient cooling. This dynamic adjustment ensures that the fan responds promptly to changes in environmental conditions, optimizing energy consumption and maintaining a comfortable room temperature. Simultaneously, the LCD connected to the Raspberry Pi serves as a user-friendly interface, displaying the current temperature.

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Users can observe the immediate impact of the fan speed adjustments, enhancing their understanding of the system's responsiveness. The real-time interaction between the LM75 sensor, Raspberry Pi, and the fan creates an intelligent and adaptive environment. As the temperature fluctuates, the system orchestrates seamless adjustments in fan speed, demonstrating the practical application of Pulse Position Modulation and the Thonny IDE in achieving energy-efficient climate control. This project not only showcases technical prowess but also provides tangible benefits in terms of user comfort and resource optimization.

V. SOFTWARE IMPLEMENTATION

A.Algorithm

• Establish a serial communication baud rate of 9600. • Integrate the LCD.h and LM75 header files into the sketch for enhanced functionality.
• Capture temperature data from the LM75 sensor and store it in the variable temp_sensor.
• Evaluate the stored value against a predefined threshold to activate the fan.
• Keep the motor in the OFF state if the temperature sensor reading is below 25°C. • Activate the motor at 25°C, propelling it at 25% of its maximum speed for optimal efficiency.
• Engage the motor at 26°C, driving it at 50% of its maximum speed for a balanced response.
• Initiate the motor at 27°C, propelling it at 60% of its maximum speed for increased performance.
• Power up the motor at 28°C, setting it in motion at 75% of its maximum speed for effective cooling.
• Elevate the motor speed to 100% if the temperature surpasses 28°C, ensuring maximum cooling efficiency.
• Continuously monitor the temperature and dynamically adjust motor operations based on the sensor's real-time data.

VI. EVALUATION RESULTS

Table 1 illustrates the outcomes derived from running the prototype model across a range of temperatures. It outlines the performance of the embedded system and its response to realtime temperature variations. The results presented in Table 1 provide insights into the functionality of the designed embedded system.

Table I outcomes derived from running the prototype model across a range of temperatures

Temperature In degree Celsius	Duty Cycle In %	PPM Value	Fan Speed In rpm
less than 26	0%	0	0
26	20%	51	277
27	40%	102	428
28	60%	153	654
29	80%	204	826
Greater than 29	100%	255	1000

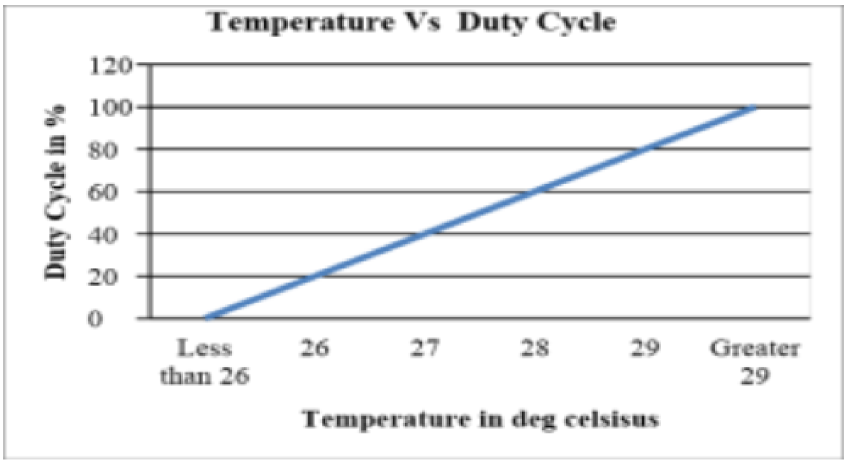

Fig 8. Variation in temperature and corresponding duty cycle.

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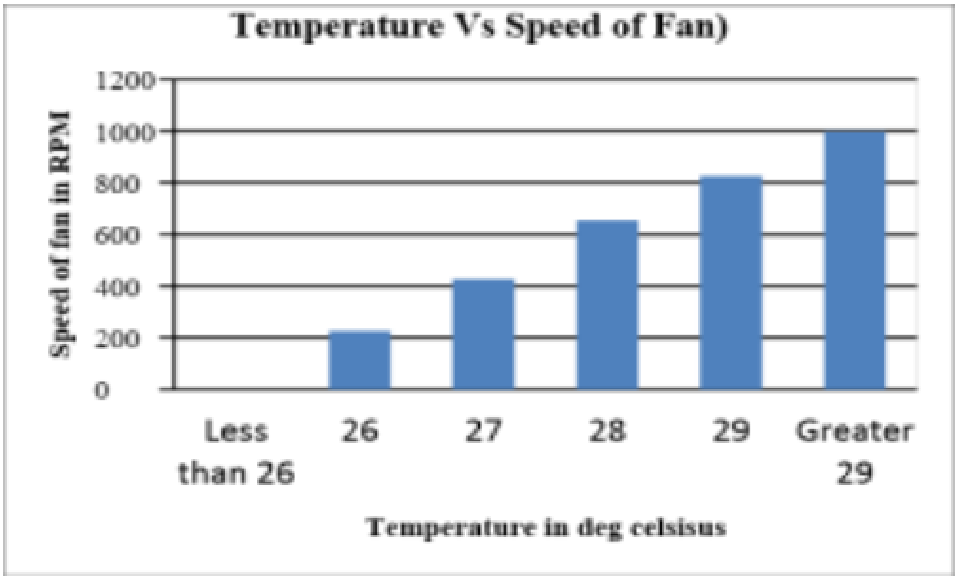

Fig 9. Relationship between temperature and fan speed.

Fig. 8 and Fig. 9 represent the temperature Vs duty cycle and temperature Vs fan speed graphs with different range of values.

VII. CONCLUSION AND FUTURE DEVELOPMENT

In conclusion, this paper successfully addressed the dynamic control of a fan based on real-time temperature variations. Raspberry Pi based automatic temperature-controlled fan is designed and carried out. The Revolution Per Minute (RPM) of the fan is controlled by using Pulse Position Modulation and Raspberry Pi in accordance with the temperature sensor. PPM is found to a effective technique in controlling the speed of the fan. The system is implemented and working well. The speed of the fan is changed according to the temperature, so manual regulator is not necessary.

Looking ahead, there are several exciting possibilities for the future development of this project. One avenue for enhancement involves the integration of additional sensors, such as humidity or air quality sensors, to create a more comprehensive environmental monitoring system. Another promising direction is the implementation of wireless connectivity, enabling remote monitoring and control, which could significantly enhance user accessibility and convenience. Moreover, the incorporation of smart control algorithms, like PID, could fine-tune the fan's response to temperature changes, ensuring more precise and efficient regulation. To further optimize energy usage, integrating energy-efficient components and algorithms is crucial.

Additionally, developing a user-friendly interface, possibly through a mobile app or web portal, would empower users to customize temperature thresholds and receive real-time system status updates. Exploring machine learning integration for predictive temperature adjustments and investigating energy harvesting technologies, such as solar panels, could contribute to sustainability and reduced reliance on external power sources.

Finally, attention to the aesthetics and form factor could make the system not only functionally advanced but also visually appealing, ensuring seamless integration into various environments. These future developments collectively aim to propel the project into a more sophisticated, adaptable, and user-centric solution.

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