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Wireless Mass Air Flow Device for Thermal Comfort Data Acquisition

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ABSTRACT

This paper aims to build and implement an IoT-based mass air flow sensor device using the FS7 sensor from IST Innovative Sensor Technology and the ESP32. The scope of the project includes design and implementation of the device, the evaluation of its performance, and the presentation of the results. To achieve its objective, the project will employ literature evaluation, hardware design, programming, testing, and data analysis methodologies. The IoT-based mass air flow sensing device has the potential to improve the performance of air flow-dependent systems by providing real-time data, remote monitoring and control, and enhanced precision and dependability. In addition, it will be calibrated, maintained, and upgraded remotely, decreasing the need for on-site maintenance and extending the device's lifespan.

Keywords: Thermal comfort, Mass Air Flow, Wireless.

1. INTRODUCTION

Sensor technology is the use of tools that can recognise and react to environmental changes. Temperature, pressure, humidity, light, sound, and a host of other physical and chemical characteristics can all be measured using sensors. They are utilised in a wide range of applications, such as consumer electronics, transportation, medical equipment, and industrial automation.

With the creation of novel sensor types, materials, and fabrication techniques, as well as innovative signal processing and data analysis tools, sensor technology has advanced significantly in recent years. These developments have produced sensors that are superior to anything previously available in terms of sensitivity, accuracy, and versatility. Additionally, the development of sensors that can be incorporated into bigger systems and connected to the internet as a result of the internet of things' (IoT) expansion has made it possible to collect and analyse data on a massive scale.

HVAC, automobile, and aerospace are just a few of the areas where air flow sensing is crucial. Air flow sensors are used in HVAC systems to detect the rate of air flow through ducts and vents. This information is utilised to control the functioning of the system and maintain ideal levels of humidity and temperature. Air flow sensors are employed in the automotive sector to gauge the volume of air entering the engine, which is then utilised to regulate the fuel injection system and enhance engine performance. Air flow sensors are used in aerospace to monitor air speed and direction, which is utilised to control aircraft flight.

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Although air flow detection is crucial to these businesses, conventional mechanical sensors and anemometers have drawbacks in terms of accuracy, price, and usability. Due to these restrictions, it is challenging to collect precise and trustworthy data on air flow in real-time, which can result in inefficiencies and expensive errors when operating systems that depend on air flow. As a result, research into the creation of new, more precise, and dependable air flow sensing technology is crucial because it has the potential to significantly enhance the functionality of systems that depend on air flow. Furthermore, there is a lack of IoT-based devices for specialised air flow sensors, making it difficult to collect accurate and reliable data on air flow in real-time, leading to inefficiencies and costly mistakes in the operation of systems that rely on air flow. The development of new, more accurate, dependable, and IoT-based air flow sensing technology is thus an important topic of research that has the potential to significantly improve the performance of air flow-dependent systems.

An IoT-based mass air flow sensing device measures the mass flow rate of air travelling through a specific point in a system. It is a crucial piece of equipment for numerous industries, including HVAC, automotive, and aerospace. The device calculates the mass flow rate by detecting the air's velocity and cross-sectional area and then applying these measurements to the mass flow rate.

2. MATERIAL AND METHODS

2.1 Hardware Design

The hardware design and implementation phase are essential to the development of an IoT mass air flow device utilising the FS7.0.1L.195 mass air flow sensor and the ESP32. This phase consists of constructing and configuring the device so that it can accurately measure mass air flow.

Circuit assembly is the initial phase in the hardware design and implementation process. This includes integrating the mass airflow sensor FS7.0.1L.195 to the ESP32. Connecting the sensor to the ESP32's input pins will enable the sensor to send data to the ESP32. In addition, the ESP32 must be connected to a power source, such as a battery or power supply, to ensure that it has the necessary energy to function.

2.2 Programming

The next stage is to develop the code for reading sensor data and transmitting it to the cloud. Using a programming language such as Python or C++, this code will be used to control the sensor and gather data. The built-in Wi-Fi capabilities of the ESP32 will be used to transport data to the cloud. In addition, the code should be built to process the data in real-time, allowing for precise and efficient mass air flow measurement.

2.3 Mass Air Flow Sensor

The FS7.0.1L.195 mass air flow sensor measures the mass flow rate of a gas. It is a thermal mass air flow sensor, which measures mass air flow using the technique of hot wire anemometry. This sensor is designed for use in a variety of applications, including HVAC and automotive systems.

The sensor is comprised of a small wire heated to a certain temperature and put in the airflow. As air passes across a wire, the wire is cooled. The sensor measures the change in wire temperature and uses this data to compute the gas's mass flow rate. The sensor is also fitted with a temperature sensor, allowing it to compensate for temperature variations, hence ensuring accurate and dependable measurements. This sensor can measure mass air flow in a wide range of temperatures and pressures, and in situations with high degrees of vibration and shock. The FS7.0.1L.195 sensor is a highly accurate and dependable device that is suitable for a variety of industrial and automotive applications.

Flow sensors are based on the relationship between flow speed and heat transfer via convection. Heat is transferred away from the heater area by the medium as it flows through the heated sensor area. The amount of heat transported increases as flow increases. A constant temperature difference between the heater and the temperature sensor can be accomplished in the Constant Temperature Anemometer (CTA)-Mode by modifying a Wheatstone-bridge.

2.4 Microcontroller

The ESP32 is a powerful microcontroller and Wi-Fi module popular in Internet of Things (IoT) applications. Espressif Systems created it, and it has acquired popularity due to its variety and powerful features. The ESP32 has dual-core processing, allowing it to tackle numerous tasks at once and increase overall performance.

The ESP32 has built-in Wi-Fi connection, which lets it to connect to the internet and communicate with other devices. This makes it an excellent solution for IoT applications that require wireless communication. Furthermore, the ESP32 has a large number of GPIO pins that can be utilised to connect to numerous sensors, actuators, and other devices. This adaptability enables simple integration with various hardware components.

The ESP32 also supports a variety of communication protocols, including Bluetooth, BLE, and CAN, which increases its compatibility and connectivity possibilities. It also includes a comprehensive set of libraries and development tools, making it simple for developers to programme and deploy programmes on the ESP32 platform.

Finally, the ESP32 is a flexible microcontroller and Wi-Fi module with dual-core processing, built-in Wi-Fi connectivity, and a large number of GPIO ports. Because of its extensive capabilities and interoperability with multiple communication protocols, it is widely utilised in IoT applications. Because of its ease of programming and vast development ecosystem, it is a popular choice among developers for developing novel IoT solutions

3. RESULTS AND DISCUSSION

3.1 Hardware

The circuit were designed using locally acquirable component with the addition of a voltage divider to allow connectivity with the ESP32. As the ESP32 only allows a max input analog voltage of 0 – 3.3V, the voltage divider will stepdown the output voltage from the circuit then later a calculation is made to revert back to the original voltage value using the equation Vout = Vin * (R2 / (R1 + R2)). From the figure 1, multiple wire is visible going out of the circuit. These wires are connected as follows, Orange = power supply 10 VDC, Grey = ground, yellow = D34 on ESP32, Blue = temperature sensor, Grey on resistor = heater and Green = ground on FS7.0.1L.195 sensor.

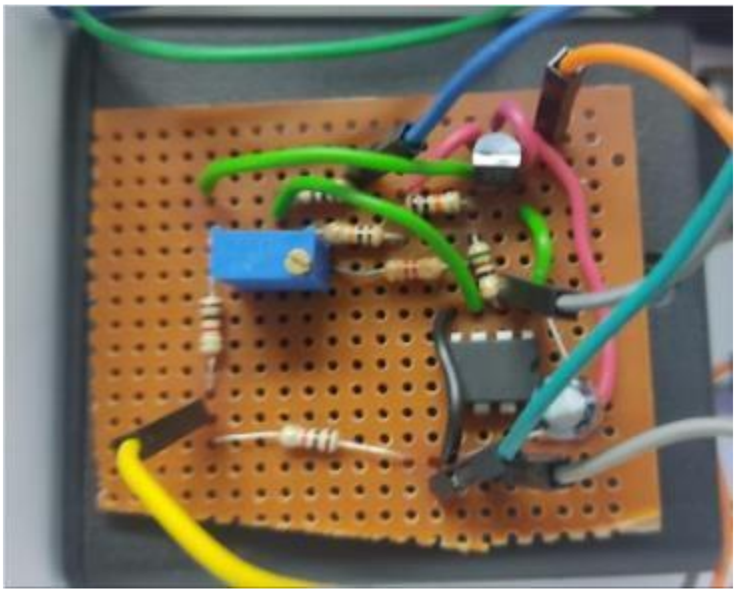

Figure 1. Circuit of FS7 Evaluation Board.

3.2 Data

The ESP32 is programmed to calculate the air velocity based on the input voltage using the reverse function from the circuit then transmit the data to the IoT platform (ThingSpeak). The input voltage was averaged according to the multisampling method. Figure 2 shows the graphical output data at ThingSpeak where the airflow speed obtained from the circuit are the same as the real-time air flow in the room.

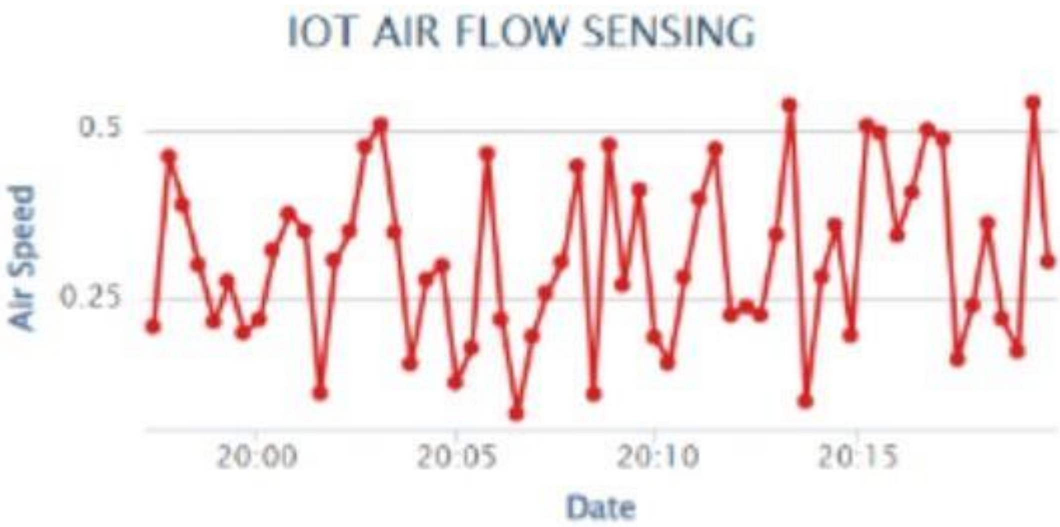

Figure 2. Airflow Output of the Room.

4. CONCLUSION

In conclusion, the IoT-based Mass Air Flow Sensing Device project has yielded excellent results in terms of sensor accuracy, air flow sensing interface circuit, thermal comfort, IoT platform (ThingSpeak), and overall device performance.

To begin, the sensor accuracy of the designed device, which employs the FS7.0.1L.195 mass air flow sensor, has demonstrated consistent performance in detecting air flow rates. The calibration and linearization processes used have helped to reduce measurement errors and provide exact readings. This precision is critical in applications requiring precise air flow control, such as HVAC systems and environmental monitoring.

Second, the air flow sensing interfacing circuit, which includes components such as the ESP32 and operational amplifiers, has enabled the sensor and the microcontroller to communicate in real time. These components' appropriate setup and integration have resulted in effective data gathering and transmission, enabling for real-time monitoring and analysis of air flow patterns. Third, by analysing air flow data near specific locations such as the bed and the door, the study has addressed the critical topic of thermal comfort. This information provides insights into air flow and circulation within the environment, allowing for potential comfort improvements by optimising air distribution and ventilation.

Furthermore, the incorporation of the IoT platform, ThingSpeak, has proven to be extremely beneficial. ThingSpeak's data storage, visualisation, and analysis capabilities have permitted the seamless transfer and administration of air flow data. It has given a dependable and user-friendly platform for monitoring and analysing air flow trends, allowing for additional insights and decision-making.

Overall, the built IoT-based Mass Air Flow Sensing Device performed admirably. Its precise sensor readings, efficient interfacing circuit, the rmal comfort considerations, a00000nd integration with ThingSpeak have all contributed to a dependable and effective device for air flow measurement and analysis. This project has lot of potential for a variety of applications, such as indoor air quality monitoring, energy efficiency optimisation, and environmental control systems..

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