This project aims to develop a wearable respiratory rate monitoring system using a flex sensor integrated into an elastic belt. The flex sensor detects the expansion and contraction of the chest or abdomen during breathing, converting these movements into electrical signals. These signals are processed using an ESP32 microcontroller, which calculates the respiratory rate in real time. The system leverages a smoothing algorithm to ensure real time monitoring. Data is transmitted wirelessly to a mobile device via Wi-Fi, enabling convenient monitoring through a web interface. The wearable belt is lightweight, non-invasive, and suitable for continuous monitoring in various settings, including home healthcare, fitness tracking, and clinical environments. The design emphasizes portability, cost-effectiveness, and ease of use, making it ideal for personal and professional applications. This innovation contributes to remote health monitoring, reducing the dependency on bulky and expensive medical equipment.

Keywords: Respiratory Rate Monitoring, Flex Sensor, Wearable Technology, Elastic Belt, ESP32 Microcontroller

INTRODUCTION

This project proposes the design and implementation of a wearable respiratory rate monitoring system using a flex sensor integrated into an elastic belt. The system is designed to be lightweight, portable, and easy to use, making it suitable for continuous monitoring in various settings, including home healthcare, sports and fitness, and clinical environments.

The flex sensor, a resistive-based component, is embedded in the belt and positioned around the chest or abdomen. It detects the expansion and contraction of the user's torso during inhalation and exhalation. These mechanical deformations cause changes in the sensor's resistance, which are converted into electrical signals. These signals are processed by an ESP32 microcontroller, which calculates the respiratory rate in real time using signal smoothing and thresholding techniques.

To enhance the user experience, the ESP32's built-in Wi-Fi capability is utilized to transmit the respiratory rate and sensor readings wirelessly to a mobile device. The data is displayed on a user-friendly web interface accessible via any internet-enabled device, enabling real-time monitoring and logging of respiratory patterns.

This innovation aligns with the growing trend of integrating wearable technology into healthcare and fitness. It contributes to improving patient outcomes, enhancing convenience, and enabling early detection of potential health issues. By offering a cost-effective and accessible solution, the project aims to make respiratory rate monitoring more widely available and impactful in promoting health and well-being.

MATERIALS USED IN THIS PROJECT

HARDWARES

- Flex Sensor
- ESP32 Microcontroller
- Elastic Belt
- Resistors
- Breadboard
- Mobile Device (Smartphone or Tablet)

SOFTWARES

- Arduino IDE

FLEX SENSOR

Figure 1 Flex sensor

A flex sensor is a device that measures bending by changing its resistance based on the angle of flex. It consists of a flexible strip coated with a conductive material, where resistance increases as the sensor bends. Typically used in a voltage divider circuit, its output can be read by a microcontroller to interpret bending angles. Flex sensors are widely applied in wearable devices, robotics, gaming, and medical rehabilitation to detect movement. Their versatility and simplicity make them ideal for motion tracking and control applications.

ESP 32

The ESP32 is a low-cost, power-efficient microcontroller with integrated Wi-Fi and Bluetooth capabilities, designed for IoT applications. It features a dual-core processor, multiple GPIO pins, and support for various communication protocols like SPI, I2C, and UART. With built-in analog-to-digital and digital-to-analog converters, it enables diverse sensor integrations. The ESP32 supports programming in Arduino IDE, MicroPython, and ESP-IDF for versatile development. Its rich feature set makes it ideal for smart devices, home automation, and wearable technologies.

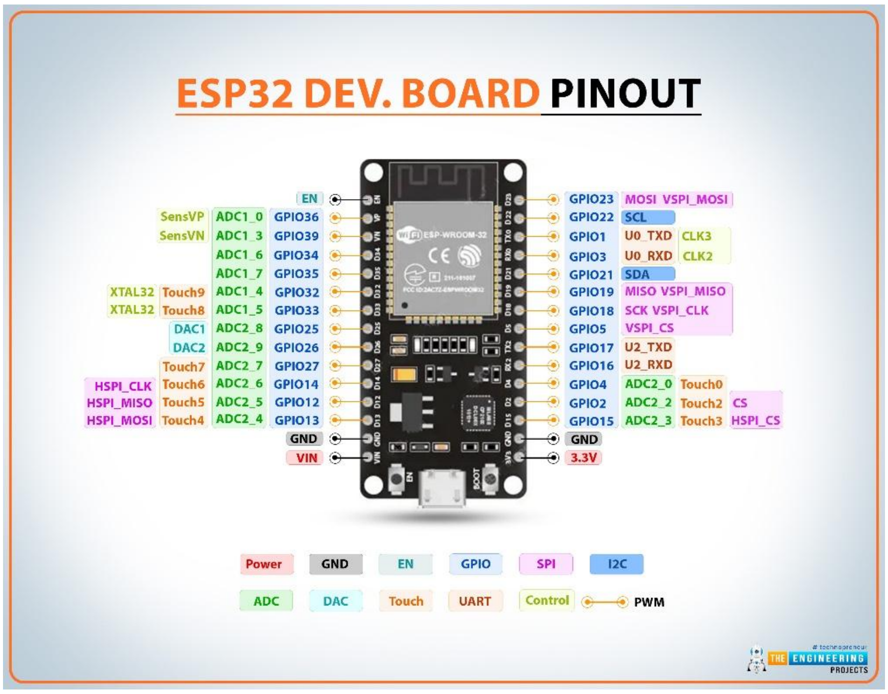
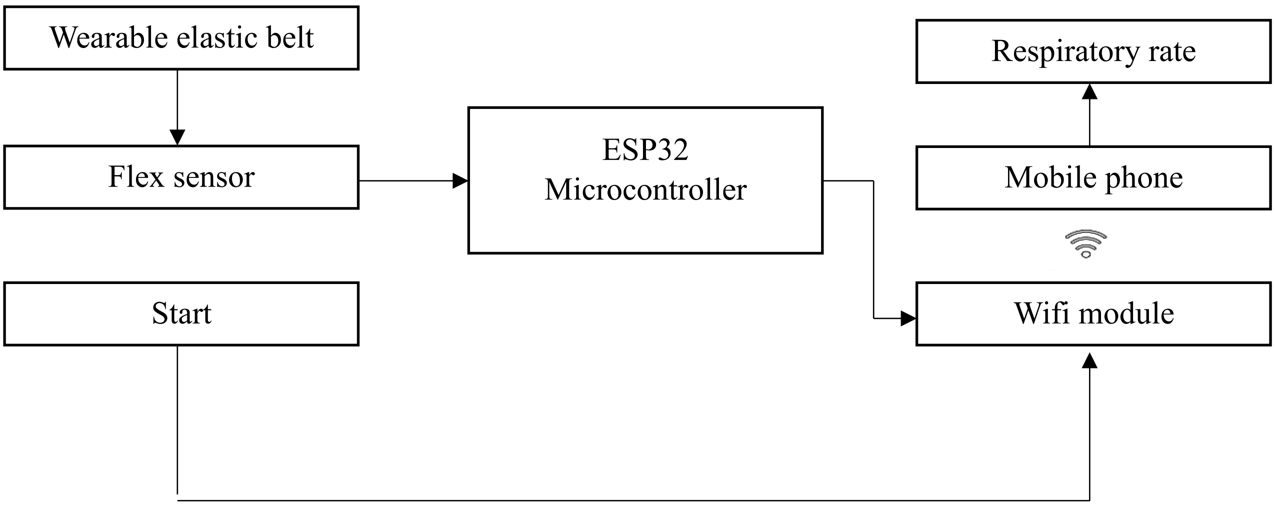
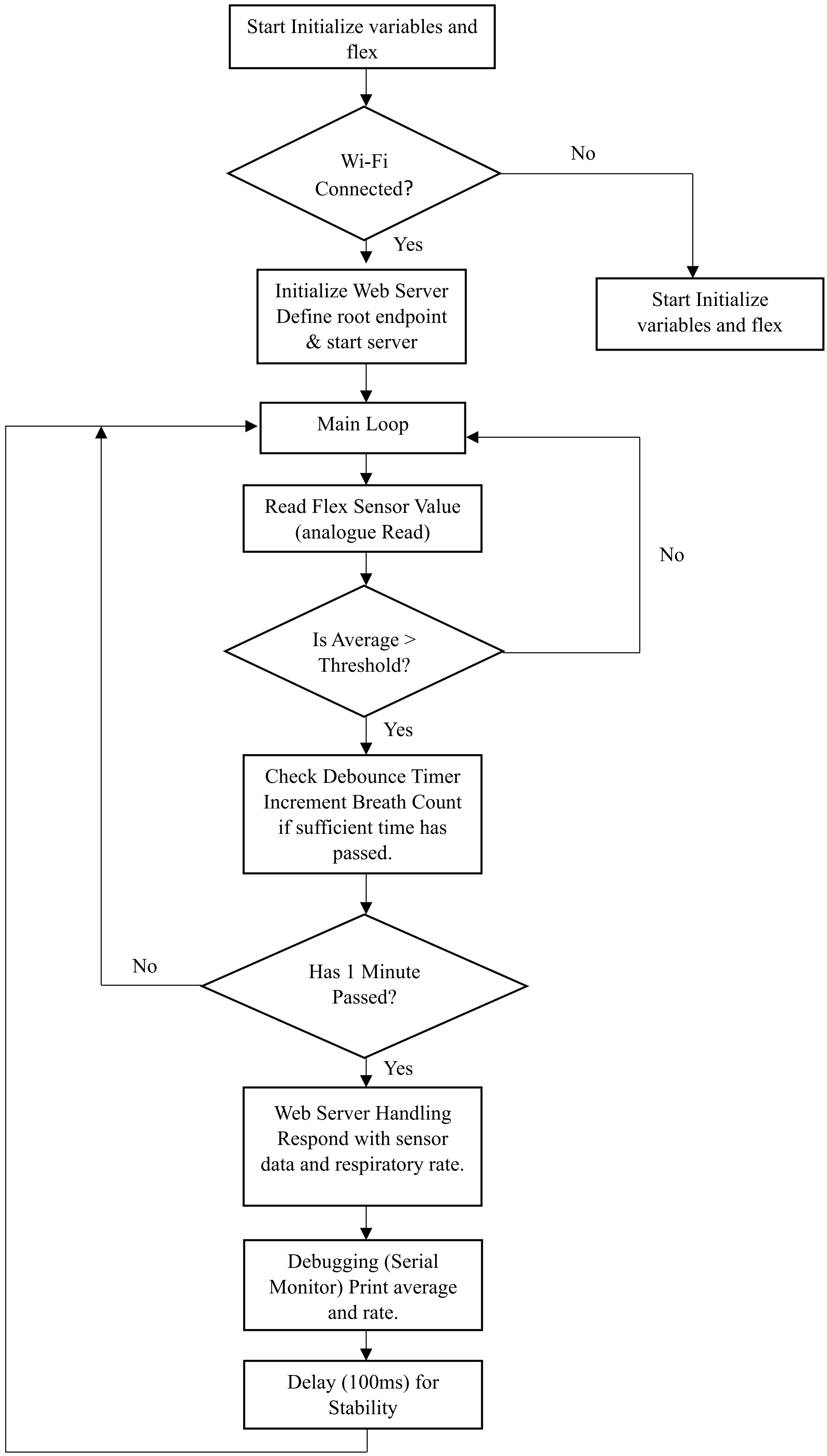


Figure 2 ESP32

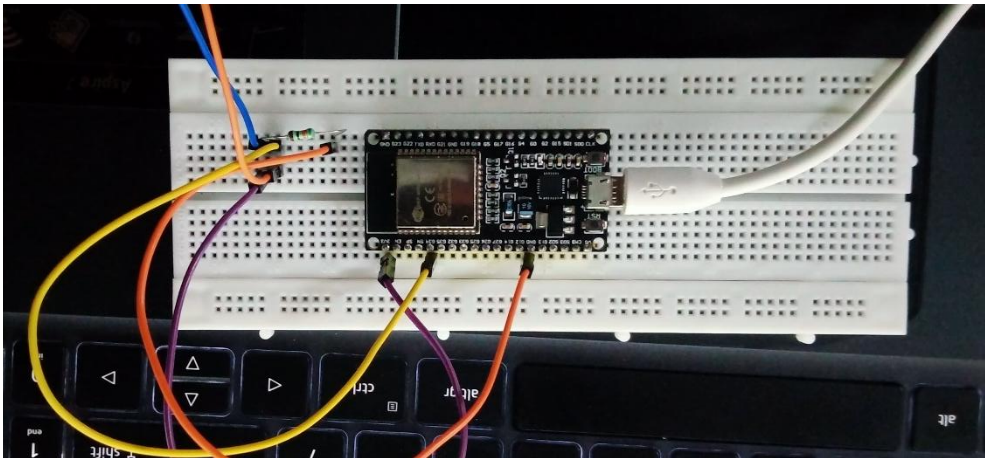
BLOCK DIAGRAM



FLOW CHART


Start Initialize variables and flex
Wi-Fi Connected?
No
Yes
Initialize Web Server Define root endpoint & start server
Start Initialize variables and flex
Main Loop
Read Flex Sensor Value (analogue Read)
No
Is Average > Threshold?
Yes
Check Debounce Timer Increment Breath Count if sufficient time has passed.
No
Has 1 Minute Passed?
Yes
Web Server Handling Respond with sensor data and respiratory rate.
Debugging (Serial Monitor) Print average and rate.
Delay (100ms) for Stability

CIRCUIT SETUP



ELASTIC BELT

RESULT

INFERENCE

From this working it is inferred that Flex sensor not suitable for real – time monitoring, as it sensitive to artifacts. If a user laughs or speak it provide inaccurate readings. And, after prolonged use it gives error in readings due to its change in flexibility of sensor. Though it not suitable for respiratory rate monitoring, it has other wide use in wearables system applications such as use in gloves in VR, goniometer etc.

CONCLUSION

this project successfully demonstrates the design and implementation of a wearable respiratory rate monitoring system that is both practical and versatile. By integrating a flex sensor into an elastic belt and leveraging the processing power and wireless capabilities of the ESP32 microcontroller, the system offers real-time, accurate respiratory rate monitoring. Its lightweight, portable, and user-friendly design ensures adaptability for diverse applications, including home healthcare, fitness, and clinical environments.

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