Wearable Air Quality Monitor Project Proposal

Team Members

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1. Introduction

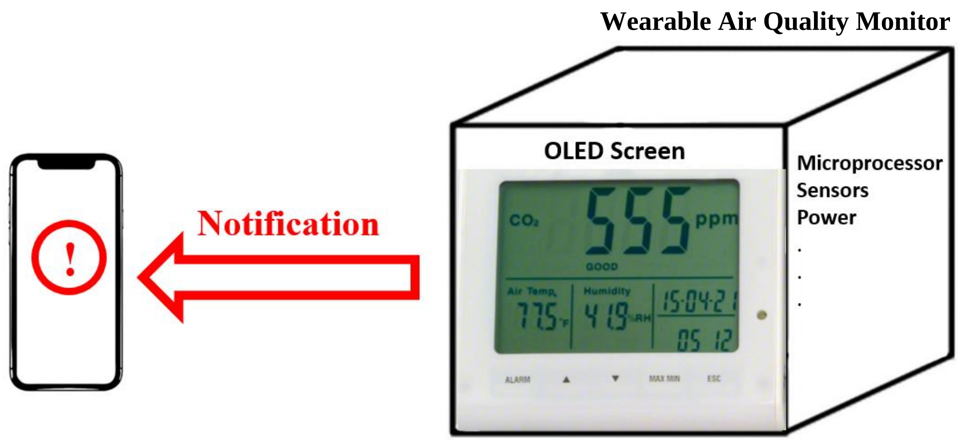
Problem:

Air pollution has been a growing global concern. The World Health Organization estimates the air breath by 9 out of 10 people containing high levels of pollutants, leading to billions of people suffering in health issue related to it. Despite this severe situation, most individuals lack real-time information about the air quality in their current environment. And existing air quality monitors are often expensive, with prices ranging from $100 to several hundred dollars, which is not affordable to every individual. In addition, most air quality monitors are designed for fixed location and often contains limited information.

Solution:

We propose a **Wearable Air Quality Monitor** to address the need for affordable, portable, and comprehensive air quality monitoring. This device will track key air pollutants such as **Particulate Matter (PM2.5, PM10)**, **Carbon Dioxide (CO2)**, and **toxic gases like Carbon Monoxide (CO), Nitrogen Dioxide (NO2), and Formaldehyde**. The monitor will connect to smartphones via Bluetooth or Wi-Fi to provide users with real-time data and notifications. We aim to make the device affordable to a wider audience by making the price between $50-80. The wearable nature allows users to monitor air quality wherever they want, and the device will offer guidance for user’s behavior, such as wear a mask or avoid outdoor activities when pollution levels are high.

Visual Aid:



High-level Requirements:

- The device must be able to detect and measure **PM2.5, PM10**, and **CO2** levels with an accuracy within **±10%** of common market air quality monitors.
- The toxic gas sensors for **CO**, **NO2**, and **Formaldehyde** must trigger alerts when gas concentrations reach harmful levels. We could test this by putting our device in a sealed container, and then fill the container with toxic gas.
- The device must be portable, with less than 500 gram's weight, and should maintain a stable Bluetooth or Wi-Fi connection with a smartphone within a **5-meter's range**.

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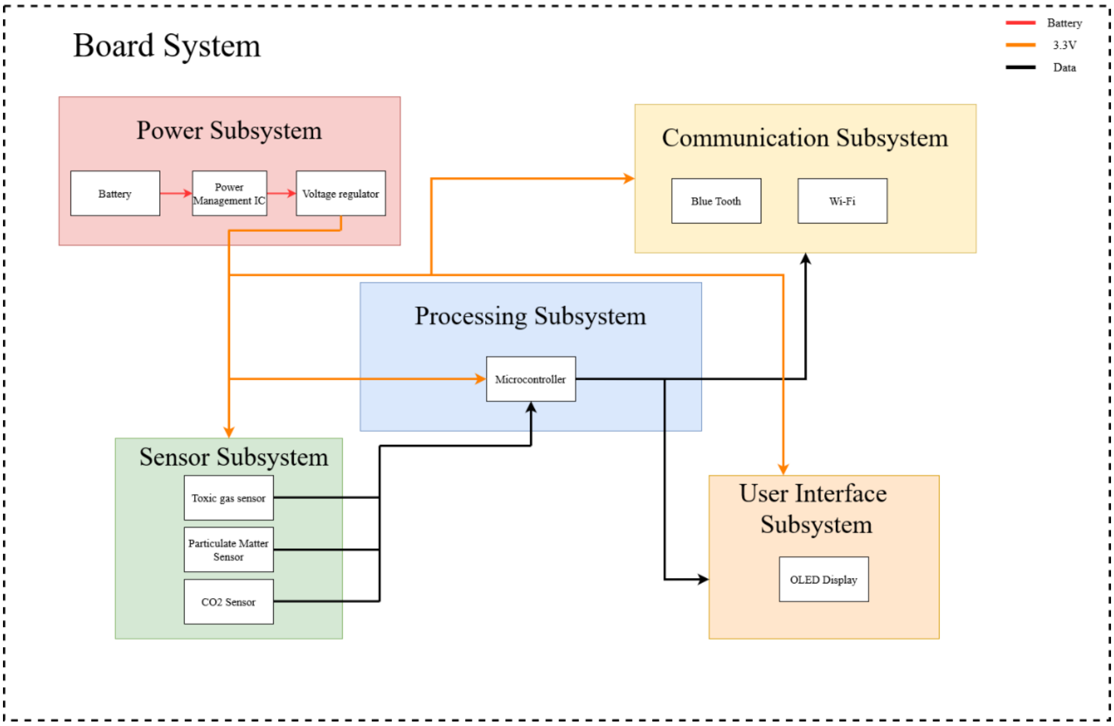
2. Design

Block Diagram:



Subsystem Overview:

1. **Sensor Subsystem:** This subsystem measures air quality parameters such as PM2.5, PM10, CO_2, and toxic gases like CO, NO_2, and formaldehyde. The sensors collect data and then output to the microcontroller for processing.
2. **Processing Subsystem:** This subsystem processes the data collected by the sensors, performs necessary calculations, and determines whether any air quality thresholds are exceeded. It is the brain of our device and act like a bridge to communicate between user interface and communication subsystems.
3. **Communication Subsystem:** This subsystem allows the device to connect to a smartphone via Bluetooth or Wi-Fi, sending real-time data and notifications. It interacts with the smartphone to display detailed air quality information.
4. **Power Subsystem:** This subsystem includes a 5V rechargeable lithium battery, a power management IC, and a voltage regulator. It ensures the device can operate for at least 24 hours on a single charge.
5. **User Interface Subsystem:** This subsystem includes an OLED display, providing users with visual feedback on air quality readings. It also allows users to navigate through various settings.

Subsystem Requirements:

1. **Sensor Subsystem:**
   - The CO sensor must measure concentrations up to 5000 ppm with ±10% accuracy.
   - The NO2 and formaldehyde sensors must detect low concentration levels to ensure safe exposure limits.
   - Each sensor must have an operational range of -5°C to 50°C to ensure reliable measurements across different environmental conditions.
2. **Processing Subsystem:**
   - The microcontroller must handle data from multiple sensors simultaneously and process readings within 10 seconds.
   - It must also trigger the communication subsystem to send alerts within 30 seconds of detecting hazardous levels.
3. **Communication Subsystem:**
   - The communication module must maintain a Bluetooth/Wi-Fi connection within a 5-meter range, to ensure stable data transfer.
   - It must send notifications when pollution levels exceed the pre-set thresholds within 60 seconds.
4. **Power Subsystem:**
   - The battery must be able to supply our system continuously for 24 hours.
   - The power management system should ensure efficient charging and prevent overcharging of the lithium battery.
5. **User Interface Subsystem:**
   - The OLED display must be readable in both low-light and outdoor conditions.
   - Users must be able to access real-time air quality data at a glance, with clear indications of hazard levels for different pollutants.

Tolerance Analysis:

One of the critical challenges is ensuring the accuracy and sensitivity of each sensors (CO, NO2, and Formaldehyde) under different environmental conditions. The sensors must maintain accuracy within ±10% across a temperature range of **-5°C to 50°C**. We plan to compare our custom air quality measurer with market level. We will also perform tolerance analysis within various temperature.

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3. Ethics and Safety

As mentioned in IEEE Code of Ethics I.1, we "hold paramount, the safety, health, and welfare of the public." Our device aims to improve public health by providing accurate air quality information. However, we need to ensure that our device does not give users a false negative alarm, making them felt safe in hazardous environment. Following with IEEE Code of Ethics, I.5, we commit to be honest and realistic in all experimental data. We will clearly communicate the accuracy limitations of our device and avoid overestimating its capabilities.

Moreover, since we plan to test our device inside hazardous environment, we must ensure all tests were conducted in sealed and controlled environment.

By adhering to these ethical and safety guidelines, we aim to develop a product that not only provides value to users but also apply to the ethical conduct.

Reference

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World Health Organization. (n.d.). *9 out of 10 people worldwide breathe polluted air, but more countries are taking action*. World Health Organization. https://www.who.int/news/item/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action