A Portable Oxygen Concentration Detection and Monitor System Using a Smartphone and a Portable Sensor Module

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***Abstract*-- In this paper we use both a smartphone and a portable oxygen sensor module to detect and monitor the amount of oxygen concentration by means of Bluetooth communication. When the oxygen concentration exceeds the normal range our portable oxygen concentration detection and monitor system will notify the user immediately. We use an oxygen sensor both to detect ambient air and to generate the relative voltage value with respect to the oxygen level. This voltage value is amplified first through an instrumentation amplifier and the input to a MCU (Micro Controller Unit). The MCU calculates and transfers the oxygen value to a percentage of data. This design is easy to read and know how much oxygen concentration is present in the air. When the time interval of low oxygen concentration in the environment is longer than the value setting, the smartphone will set off an alarm to remind the user in order to prevent harm to human health.**

I. INTRODUCTION

The oxygen concentration in the air of an average environment on the earth is about 20.9%. Oxygen is both important and necessary to maintain human life. An insufficient amount of oxygen concentration easily leads to either a coma, or dizziness or both, and often will lead to a more serious situation such as a heart attack, a stroke and other dangers. In many public places an insufficient amount of oxygen can affect human health. For example, a child may become unconscious in a restaurant when we eat a hot pot. If we can detect the amount of oxygen in the air in our daily life, we can avoid any low oxygen impact on our health status.

Currently, many people use a health monitoring system with a smartphone wireless transmission [1]. A smartphone can detect additional physical situations such as human blood pressure [2] or serve both as a human ECG (Electrocardiogram) monitor, a temperature measurer or a fall monitor [3]. A smartphone can analyze data generated by the human body.

Currently, there are portable O_2 meters on the market which usually only detect and display the oxygen percentage in the air. However these meters are not integrated with a smartphone, and do not have either a reminder or an alarm function. This design integrates a smartphone with a portable oxygen sensor module to conduct real-time oxygen concentration monitoring. Besides, this design uses the smartphone built-in software and hardware functions to achieve alarm functions. It not only detects the oxygen concentration but also includes some useful features such as low oxygen reminders, and oxygen concentration data records. If the hypoxia alarm alert lasts too long, the software module will send an SMS (Short Message Service) and transfer maps containing the location obtained from the GPS (Global Positioning System) information to family, friends, or a help center.

II. HARDWARE ARCHITECTURE

The block diagram of our design is shown in Fig. 1. The portable oxygen sensor module uses oxygen sensors to detect ambient oxygen concentration in the air. The detection results are converted into corresponding voltage values, which will first be input into the instrumentation amplifier to amplify the sensed voltage and then input into the MCU with a built-in ADC (Analog Digital Converter) to obtain the digital level of the oxygen concentration. The MCU output connects to the Bluetooth module to send the data of the oxygen concentration to a smartphone. This sensor module is small, battery powered, and portable.

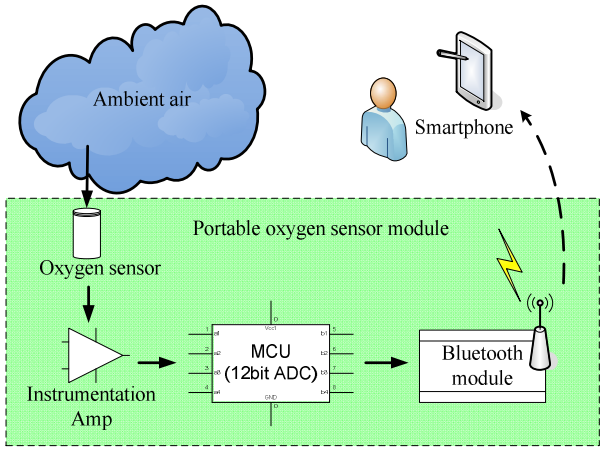

Fig. 1. Diagram of hardware architecture.

Fig. 2 shows the output voltage variation which corresponds to the oxygen concentration variation. Hypothesis V_0 is the sensor output voltage at O_2 of 0%, V_{100} is the sensor output voltage at O_2 of 100%, and V_a is the sensor output signal in the air. The voltage change from 0% to 100% has been tested. The range of this value $(V_a\text{-}V_0)/(V_{100}\text{-}V_0)$ is 0.21 ± 0.01 with an accuracy of ± 1% in full scale.

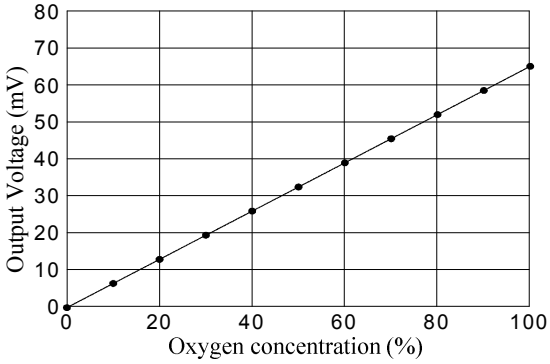

Fig. 2. Output voltage vs. oxygen concentration.

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III. SOFTWARE ARCHITECTURE

A. Micro controller unit with a 12bit ADC converter and a software module

This design, which uses a low-power microprocessor, has a built-in a 12bit ADC converter to receive the oxygen sensor output and translate the detection results into a percentage of the oxygen concentration. The flowchart of the software module is shown in Fig. 3. After turning on the power the MCU always reads the input voltage value which is converted by a 12bit ADC converter consisting of 4096 steps and a percentage display of four decimal digits. After the transfer of the result into the UART (Universal Asynchronous Receiver/Transmitter) format entry in the Bluetooth module, this result is transmitted to the smartphone.

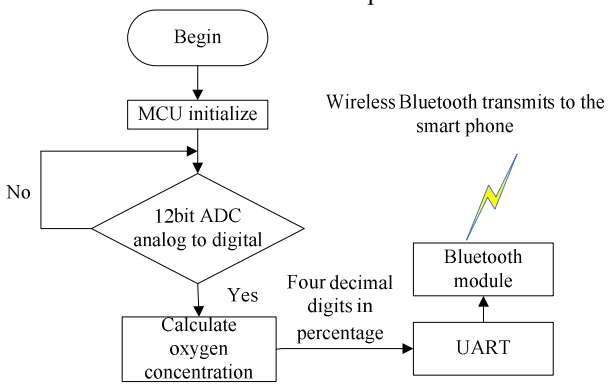

Fig. 3. The MCU software module flowchart.

B. Open source app development of the smartphone

We have selected an open platform in our software design with JAVA to accomplish the user interface of the software requirements. Fig. 4 shows the screenshot of the smartphone.

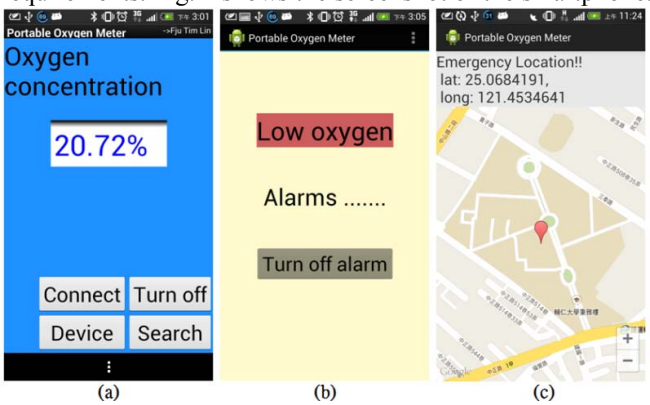

Fig. 4. The screenshot of the smartphone.

First we put the battery in and turn on the portable oxygen sensor module. Then we start the smartphone APP of our design to receive the Bluetooth data from the sensor module. The system will be activated to complete the pair automatically in cooperation with our Bluetooth function. We can see the percentage of oxygen concentration in the air on the screenshot as shown in Fig. 4(a). If there is no device to search the user can click the "Search" button to search the device again. If the main devices been searched the user can click "Device" to choose a specific device. If there is no device connected the user can click the "Connect" button to connect a device again or click "Turn off" to disconnect the Bluetooth communication. Moreover, our program will trigger the alarm system to remind the user that the oxygen concentration is insufficient. This smartphone screen will be changed as shown in Fig. 4(b). A picture of when the oxygen concentration is still low and the alarm has not yet turned off is shown in Fig. 4(c). When the oxygen concentration is dangerous and lasts too long and the user keeps neglecting the alarm, the software module will send an SMS and transfer maps containing the location from the GPS information to a specific designated person.

IV. EXPERIMENT RESULTS

Currently on the market there are some handheld oxygen detection meters or oxygen analyzers, but none are integrated with a smartphone. Table I shows a comparison of our design with other air detection designs.

TABLE I
COMPARISON WITH OTHER AIR DETECTION DESIGNS

	Our design	Monitoring of CO_2 [4]	Personal protective equipment [5]
Wireless transfer	Yes	Yes	None
Unusual air reminder	Yes	None	None
Send SMS	Yes	None	None
GPS positioning	Yes	Yes	None

V. CONCLUSION

This design uses the popular smartphone with a portable oxygen sensor module to detect and display the ambient oxygen concentration. It is very convenient and has a friendly user interface. In addition, this design can include a reminder function for the people who are not feeling well and when there is danger it can automatically send a SMS or transmit the GPS map location either to family, or to a help center.

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