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# NDIR-Type $CO_2$ Measuring and Monitoring System

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***Abstract—*** In this paper, an IAQ monitoring system, which uses $CO_2$ sensor modules and a data processing module with CDMA communication capabilities for the transmission and management of the measurement results, was implemented. Through some experimental studies, we believe that the implemented IAQ monitoring system would be helpful in protecting many people from the dangers associated with indoor pollutants exposure.

***Keywords****-IAQ monitoring system; $CO_2$ sensor module; CDMA communication; NDIR; ATmega128*

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## I. INTRODUCTION

A nondispersive infrared sensor (or NDIR sensor) is a simple spectroscopic sensor often used as a gas detector. It is nondispersive in the sense of optical dispersion since the infrared energy is allowed to pass through the atmospheric sampling chamber without deformation. The main components of a NDIR sensor are an infrared source (lamp), a sample chamber or light tube, a light filter and an infrared detector. The IR light is directed through the sample chamber towards the detector. In parallel there is another chamber with an enclosed reference gas, typically nitrogen. The gas in the sample chamber causes absorption of specific wavelengths according to the Beer–Lambert law, and the attenuation of these wavelengths is measured by the detector to determine the gas concentration. The detector has an optical filter in front of it that eliminates all light except the wavelength that the selected gas molecules can absorb. Ideally other gas molecules do not absorb light at this wavelength, and do not affect the amount of light reaching the detector however some cross-sensitivity is inevitable [1]. The IR signal from the source is usually chopped or modulated so that thermal background signals can be offset from the desired signal.

There have been many researches toward NDIR-type $CO_2$ sensing system [2-5]. For our experiments, we used a NDIR-type $CO_2$ sensors attached to ATmega128 CPU module in order to monitor an indoor air quality, especially for subway stations.

## II. NDIR $CO_2$ SENSOR

The NDIR $CO_2$ sensors have more advanced technologies in terms of long-term life-time, accuracy, and low power consumption rate during $CO_2$ measurement because NDIR methods use the physical sensing principles such as a gas absorption in a particular wavelength. NDIR $CO_2$ sensors are based on the principle of a conversion method that measures the absorbance of gas like CO and $CO_2$ by using gas particles' characteristics which absorbs specific wave lengths of infrared ray. In a concept of the measurement of $CO_2$, molecules composed with two or more species of atoms absorb specific wavelength light in infrared region. Absorbance or transmittance has relations to concentration of gases. Equation 1 shows Beer-Lambart function of NDIR $CO_2$ sensors.

$$V = V_0 + A \cdot e^{-b \cdot L \cdot x} \tag{1}$$

where V is the measured light intensity of radiation detected at the given wave length, $V_0$ represents the intensity at the light source, b is the absorbance coefficient of $CO_2$, L is the optical length of moving light source and x is the average $CO_2$ concentration in ppm.

Fig. 1 shows the basic principle of NDIR sensors which shows how to get $CO_2$ concentration and the flow of data signal processing to calculate $CO_2$ concentration by using Beer-Lambert function. NDIR $CO_2$ sensors consist of several main parts which are a light source lamp, optical cavity, light detector and data signal analyzer that finally get $CO_2$ concentration by Beer-Lambart law. We show the NDIR $CO_2$ sensors are very useful for subway air quality monitoring. Fig. 2 shows the NDIR $CO_2$ sensor attached to an one-chip micro-controller board ATmega128 which has the CPU speed of 16MIPS and the flash memory size of 128kB.

## III. NDIR $CO_2$ SENSOR-BASED MONITORING SYSTEM

This paper presents the implementation of an IAQ monitoring system, which uses sensor modules for measuring $CO_2$ and a data processing module with CDMA (Code Division Multiple Access) communication capabilities for the transmission and management of the measurement results. The need for air quality measuring over large underground subway areas, such as waiting rooms, platforms and tunnels, necessitates wireless connectivity for the measuring device. Wireless sensor networks represent a vast and active research area in which a large number of applications have been proposed, including indoor air quality monitoring and control, structural health monitoring, and traffic monitoring. Fig. 3 shows an air quality monitoring system for subway stations. The sensor and CDMA modules were installed at a waiting room, a platform, an outdoor site, and tunnels. MDT-800 (Telit, UK) is used for CDMA communication modules, while the MDT-800 is a complete modem solution for wireless m2m applications. The MDT-800 with a frequency band of about 800MHz is ideally suited for real-time monitoring and control applications without the need for human intervention between remote machines and back office services. The measured air quality data were transmitted to the m2m platform via the CDMA Repeater and the BTS (Base station Transceiver

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Subsystem), eventually reaching the air quality monitoring server through the internet. Fig. 4, Fig. 5, and Fig. 6 show the $CO_2$ concentration in a platform, a tunnel, and an outdoor site of a subway station which were monitored for 1000 minutes.

## IV. Conclusion

Wireless sensor networks represent a vast and active research area in which a large number of applications have been proposed, including indoor air quality monitoring and control, structural health monitoring, and traffic monitoring. In this paper, an IAQ monitoring system, which uses $CO_2$ sensor modules and a data processing module with CDMA communication capabilities for the transmission and management of the measurement results, was implemented. Through these experimental studies, we believe that the implemented IAQ monitoring system would be helpful in protecting many people from the dangers associated with indoor pollutants exposure.

## Acknowledgment

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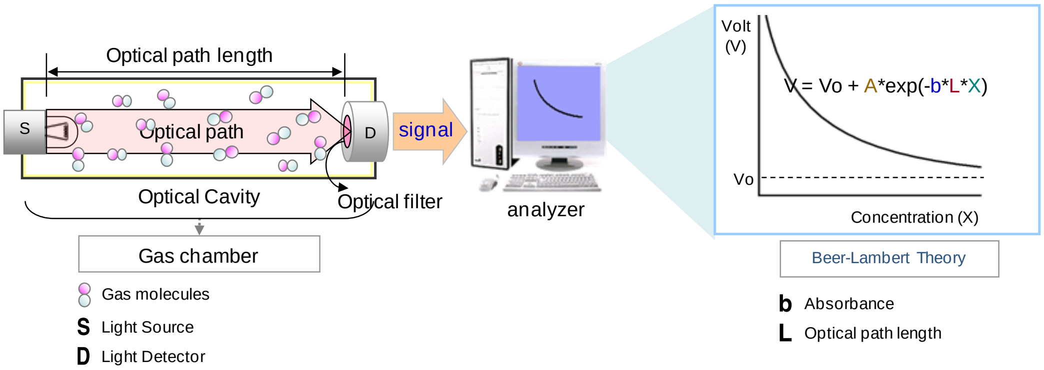


Figure 1. Basic principle of NDIR $CO_2$ Sensors

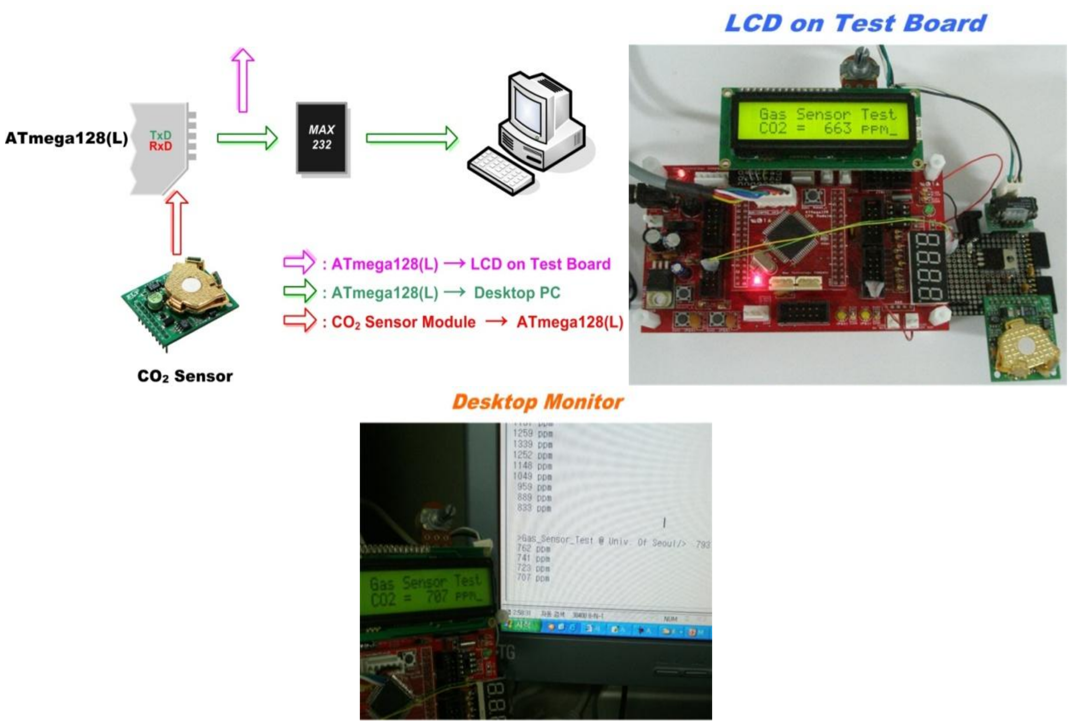


Figure 2. Implemented NDIR CO2 sensor module attached to ATmega128 CPU board

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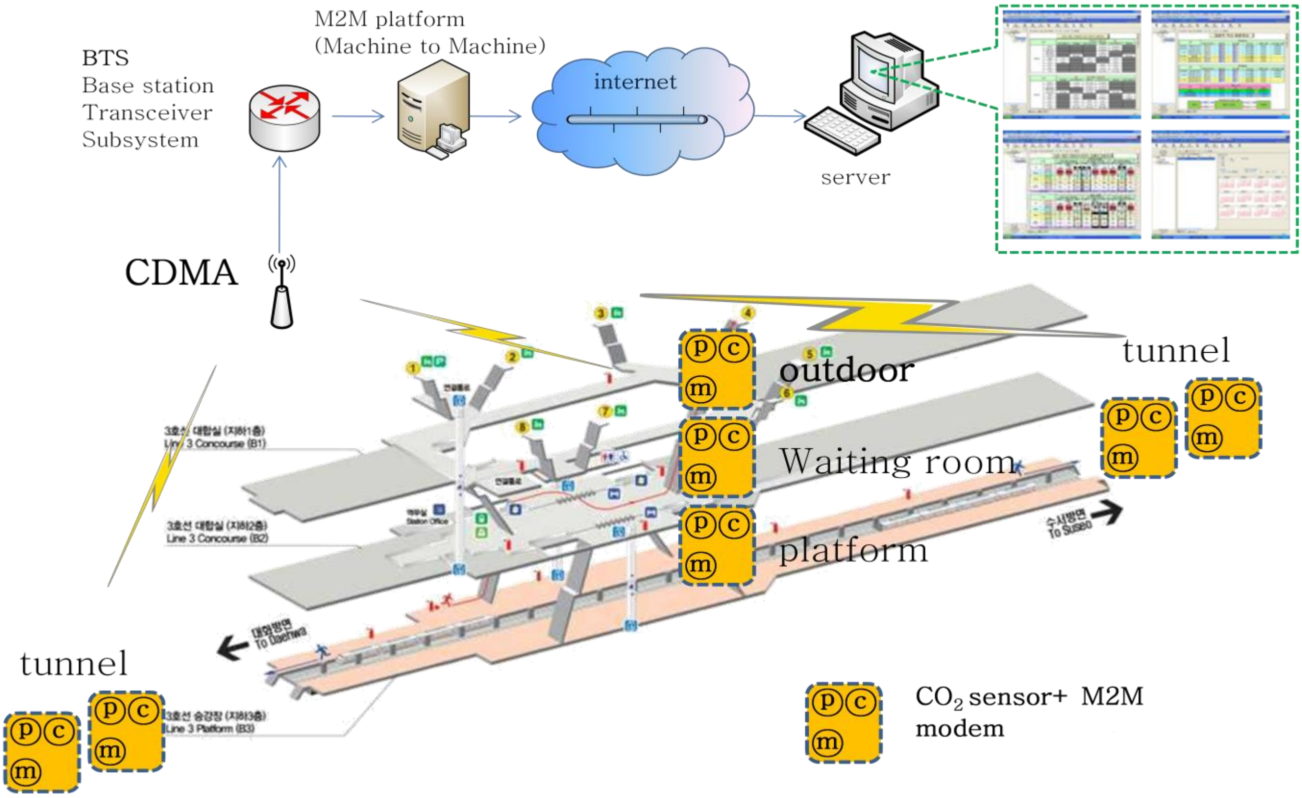
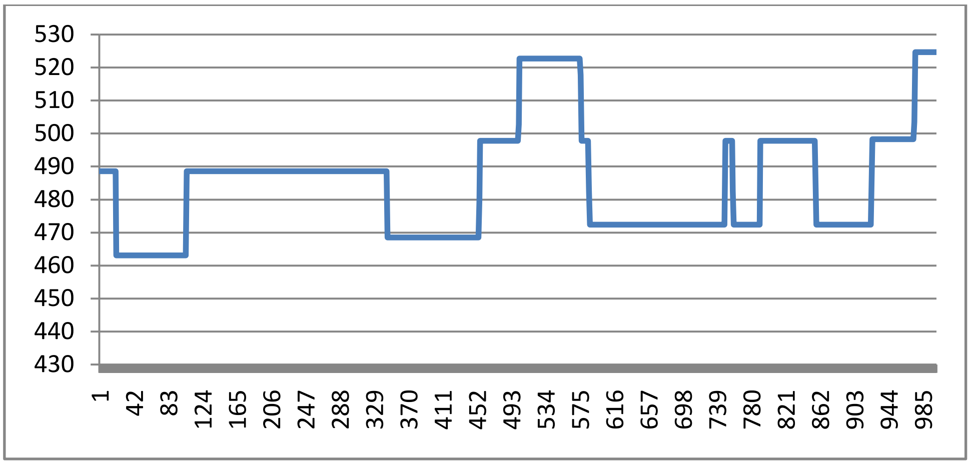



Figure 3. $CO_2$ sensor-based IAQ monitoring system for subway stations




(x-axis : minute, y-axis : ppm)

Figure 4. $CO_2$ concentration in a platform of a subway station

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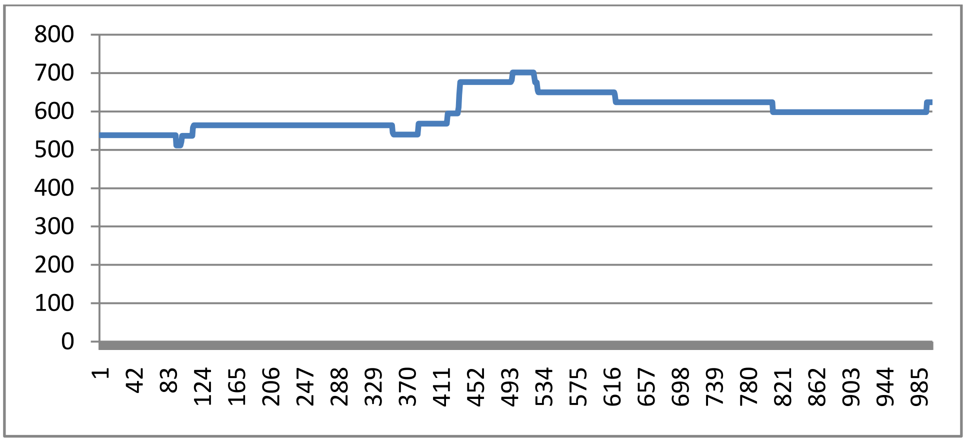
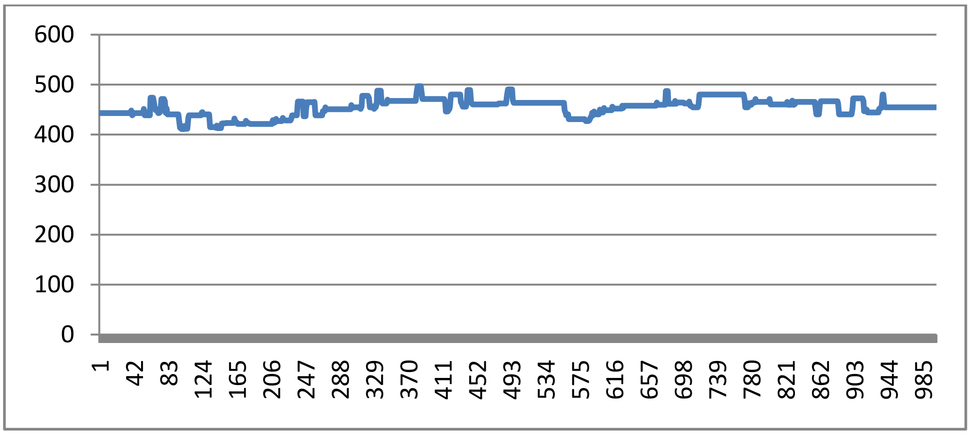



(x-axis : minute, y-axis : ppm)

Figure 5. $CO_2$ concentration in a tunnel of a subway station




(x-axis : minute, y-axis : ppm)

Figure 6. $CO_2$ concentration in an outdoor site of a subway station