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IMPLEMENTATION OF NDIR CO2 SENSOR MODULE

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ABSTRACT

CO2 sensors may be classified in two major categories depending on measuring principles of sensors. NDIR (Non-Dispersive Infrared)-based CO2 sensors are commonly used in monitoring indoor air quality due to relatively high accuracy compared with chemical CO2 gas sensors. NDIR CO2 sensors have more advanced technologies in terms of long-term life-time, accuracy, and low power consumption rate during CO2 measurement because NDIR methods use the physical sensing principles such as a gas absorption in a particular wavelength. In this paper, we attempt to implement the NDIR CO2 sensor modules to obtain smaller measurement errors and use ROM table for these calibration sensor data. We show the NDIR CO2 sensors are very useful for subway air quality monitoring.

Keywords- *NDIR (Non-Dispersive Infrared), CO2, calibration sensor data, air quality monitoring.*

I. INTRODUCTION

The NDIR CO2 sensors have more advanced technologies in terms of long-term life-time, accuracy, and low power consumption rate during CO2 measurement because NDIR methods use the physical sensing principles such as a gas absorption in a particular wavelength. NDIR CO2 sensors are based on the principle of a conversion method that measures the absorbance of gas like CO and CO2 by using gas particles' characteristics which absorbs specific wave lengths of infrared ray. In a concept of the measurement of CO2, 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 CO2 sensors.

(1)

where V is the measured light intensity of radiation detected at the given wave length, represents the intensity at the light source, b is the absorbance coefficient of CO2, L is the optical length of moving light source and x is the average CO2 concentration in ppm.

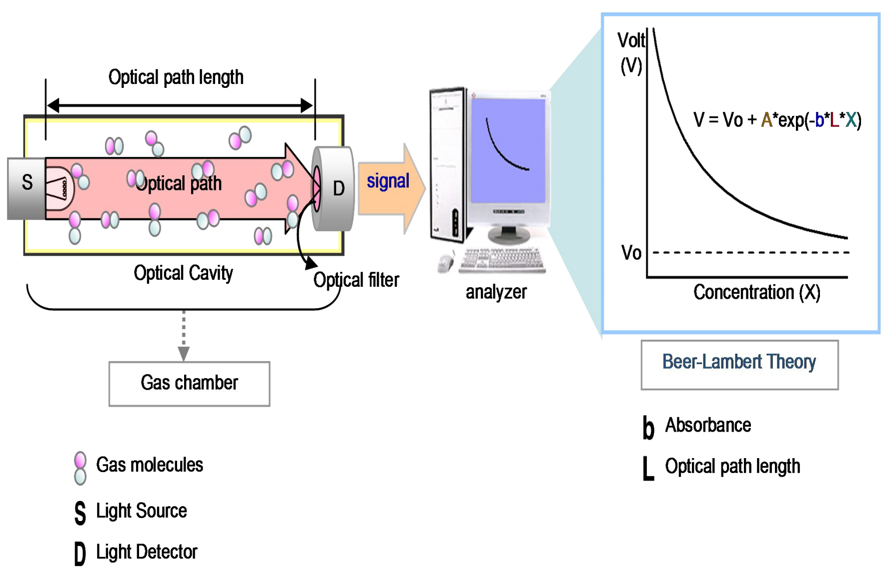
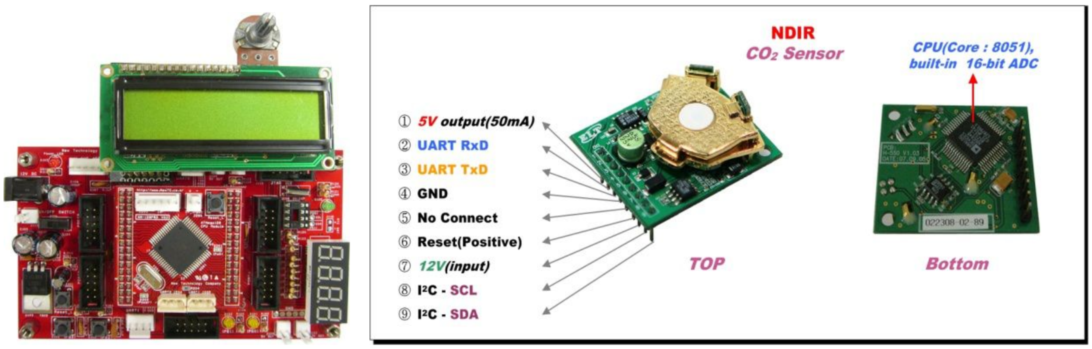


Fig.1 Basic principle of NDIR CO2 Sensors

Fig. 1 shows the basic principle of NDIR sensors which shows how to get CO2 concentration and the flow of data signal processing to calculate CO2 concentration by using Beer-Lambert function. NDIR CO2 sensors consist of several main parts which are a light source lamp, optical cavity, light detector and data signal analyzer that finally get CO2 concentration by Beer-Lambart law. In this paper, we attempt to implement the NDIR CO2 sensors to obtain smaller measurement errors and use ROM table for these calibration sensor data. We show the NDIR CO2 sensors are very useful for subway air quality monitoring.

II. IIMPLEMENTATION OF CO2 SENSOR MODULE

Fig. 2 (a) shows the one-chip micro-controller board ATmega128 which has the CPU speed of 16MIPS and the flash memory size of 128kB. Fig. 2 (b) shows a NDIR CO2 sensor. The NDIR CO2 sensor module implemented for experimental study is shown in Fig. 3.



(a) ATmega128 CPU board (b) NDIR CO2 sensor

Fig. 2 ATmega128 CPU board and NDIR CO2 sensor

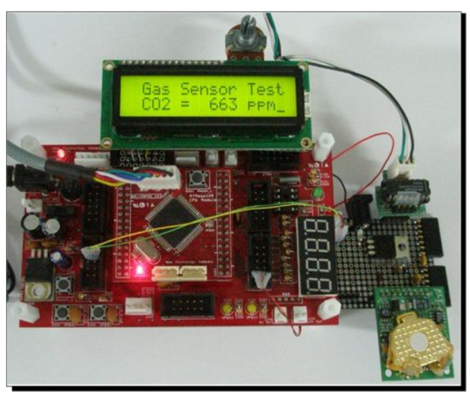


Fig. 3 Implemented NDIR CO2 sensor module for experimental study

Beer-Lambert theory is the basic theory for calibration of NDIR gas sensors. The effective calibration algorithms reduce the cost and time of development. The two correlation values in CO2 concentration are recorded into data table and mathematical functions on CPU. Fig. 4 shows a data table type calibration method. In Fig. 4, many referenced points indicate CO2 concentration levels, calculate these levels into output voltage levels, and finally transform to real CO2 concentration levels. This method causes high cost, long development time, and large scale of manufacturing system.

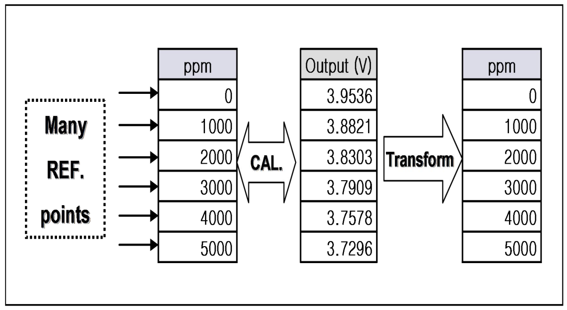


Fig. 4 Data table type of CO2 concentration and temperature calibration

Fig. 5 shows a function type calibration method. In Fig. 5, few referenced points are used to be calculated, calibrated and transformed into CO2 concentration levels. This method causes low cost, shortened development time and small scale of manufacturing system.

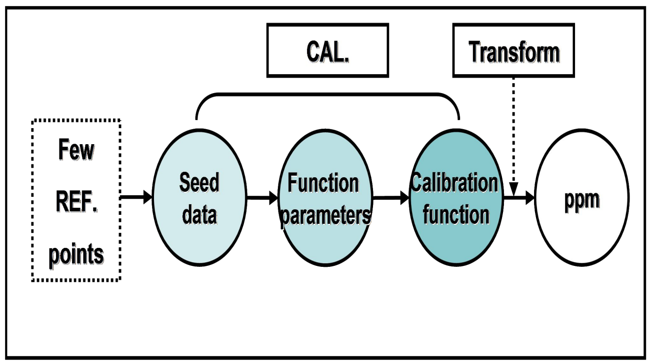
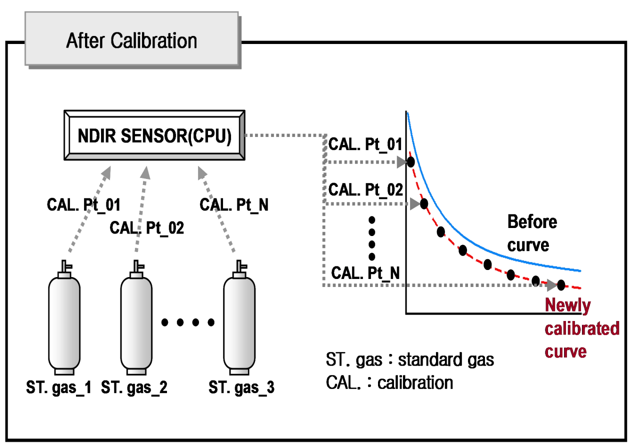
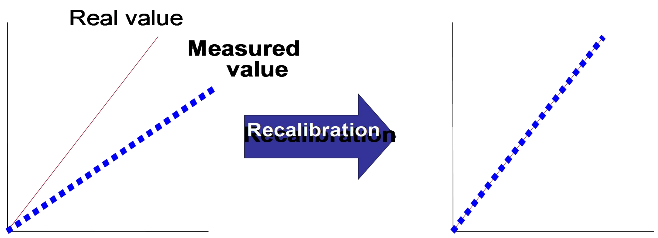


Fig. 5 Function type of CO2 concentration and temperature calibration

As time goes by, all kind of sensors make errors. It may be caused by the change of operating conditions like humid and temperature. When the errors become out of permission range, sensors must be recalibrated to recover the perfor mance and we need to recalibrate them into permission range.



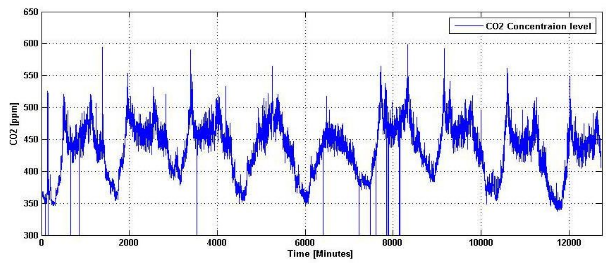
(a) Recalibration procedure with a function based method



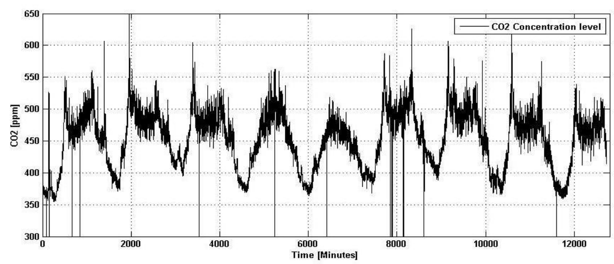
(b) Results of recalibration

Fig. 6 Recalibration procedure

Fig. 6(a) explains how the recalibration procedures are going on and if we use this function based recalibration method, it is easy to recalibrate NDIR sensors by using only one point to be recalibrated and Fig. 6(b) shows the result of recalibration representing a good fitting after calibration. NDIR CO_2 sensors used for the measurement test for CO_2 concentration were a model of B-530 which was manufactured by ELT Co. Ltd. We compared the test results in CO_2 concentration with two sensor nodes and analyzed received two data by using the linear regression analysis that gave the correlation coefficient to figure out if the two data were similar to each other or not as time varied. Consequently, the experimental results in Fig. 7 were satisfied with the error range approximately about 20[ppm] which was within permission error range provided by the manufacturer. Fig. 8 shows the CO_2 concentrations measured in a subway station for 3 days.

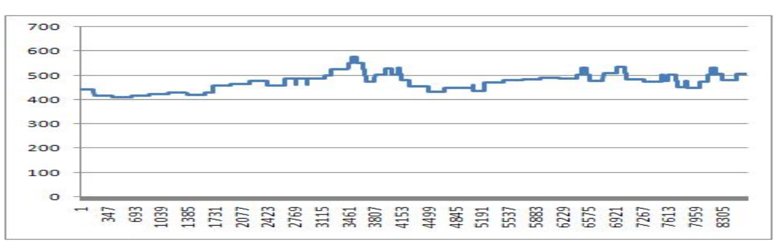


(a) Sensor Node.1

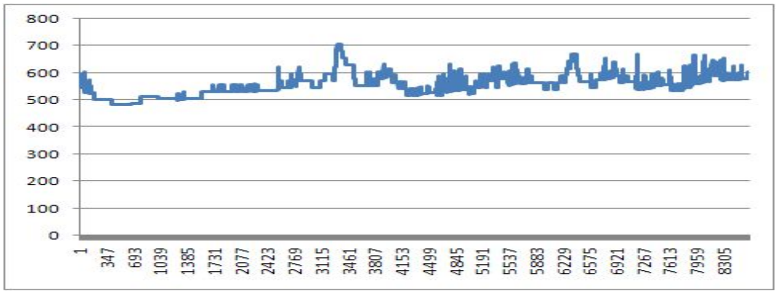


(b) Sensor Node. 2

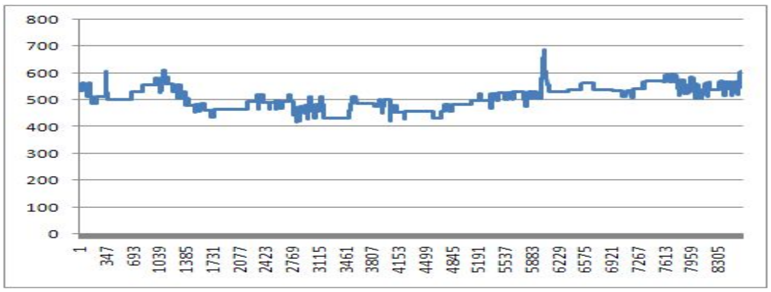
Fig. 7 Experimental results of measuring CO2 with NDIR sensors.



(a) waiting room



(b) platform



(c) tunnel

Fig. 8 Measured CO2 concentration in a subway station (y-axis : ppm)

III. CONCLUSIONS

In this paper, we discussed about the basic principle of non-dispersive infrared-based CO2 sensor and its calibration methods. We explained several design considerations and the importance of recalibration in NDIR-based sensor. We confirmed that NDIR sensor modules could be improved to have superior characteristics in measuring CO2 concentration by calibration method. We implemented the application of measuring CO2 concentration with NDIR-based CO2 sensors and confirmed NDIR-based CO2 sensor to be suitable for measuring CO2 concentration with precision in subway station. Through this study, it is shown that the air quality in subway can be monitored using this type of CO2 sensor modules.

IV. ACKNOWLEDGEMENT

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