An approach to utilize a grid of EMF potentiometric CO_2 sensors in a ultra low power wireless sensor network

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Abstract: The demand for a wireless CO_2 solution is ever increasing. One of the biggest problems with the majority of commercial available CO_2 sensors is the high energy consumption which makes them unsuitable for battery operation. Possible candidates for CO_2 sensing in a low power wireless application are very limited and show a problematic calibration process. This study focuses on one of those EMF candidates, which is a Ag_4RbI_5 based sensor[1]. This EMF sensor is based on the potentiometric principle and consumes no energy. The EMF cell was studied in a chamber where humidity, temperature and CO_2 level could be controlled.

This study gives an detailed insight in the different drift properties of the potentiometric CO_2 sensor and a method to amplify the sensors signal. Furthermore, a method to minimize the several types of drift is given. With this method the temperature drift can be decreased by a factor 10, making the sensor a possible candidate for a wireless CO_2 sensor network.

1 Introduction: The demand for a wireless CO_2 solution is ever increasing. Within buildings or for instance in greenhouses the demand for a CO_2 monitoring system without having to wire the entire location with an intricate distribution network of power and data cables is desired. One of the biggest problems with the majority of commercial available CO_2 sensors is the high energy consumption which makes them unsuitable for battery operation. Powering these sensors implies large expensive battery packs or short maintenance intervals. Possible candidates for CO_2 sensing in a low power wireless application are very limited and show a problematic calibration process. This study focuses on one of those EMF candidates, which is a Ag_4RbI_5 based sensor[1].

This EMF sensor is based on the potentiometric principle and consumes no energy, but actually produces a very small potential difference as a function of the surrounding CO_2 level. One of the challenges of utilizing this sensor is a compensation method for the drift due to temperature changes, humidity drift and typical characteristic drift.

A well known aspect of a EMF based CO_2 sensor measuring at room temperature without artificial heating are reported [2-4] to drift on temperature changes and drift due to variations in humidity. These omissions can of course be compensated by measuring at a high temperature. This property makes the sensor undesired in ultra low power application such as a wireless network CO_2 sensing node. Another property is the long (2-24 hours) heating period before the sensor is within specifications which makes it unsuitable for short measuring intervals with power down. This study focuses on finding an alternate solution to improving the drift properties other than introducing a heating coil or another power consuming element.

2 Experimental: The EMF cell was studied in a chamber where humidity, temperature and CO_2 level could be controlled. Humidity and temperature are measured with a SHT15 humidity sensor and CO_2 levels are measured with a NDIR type sensor type EE89 with a accuracy of 50ppm. After a initial stabilizing period of 24 hours the humidity was set at 20%Rh and the CO_2 level was set at 400ppm starting with a 1000ppm peak. During a measurement period of 2 days the temperature was varied according to figure 1.

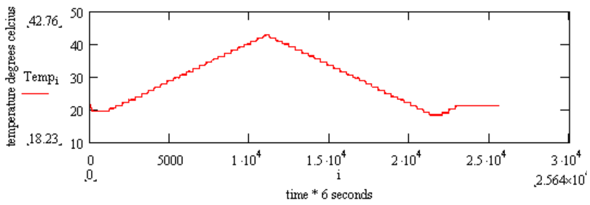

Fig. 1. Temperature variation applied to the sensor grid over 2 days.

The response of the sensor was measured both with an open sensor and with a closed sensor not being able to sense CO_2. The Ag_4RbI_5 EMF cell potentials were fed in a low drift and low power differential amplifier and was digitized by a 10 bit AD converter.

3 Results and discussion: Figure 2 shows a plot of the sensors output as a function of the time. Here we can see that the closed EMF sensor has a similar response to the change of temperature compared to the sensor that is exposed to CO_2.

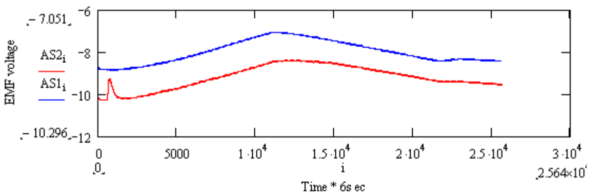

Fig. 2. Sensor response of closed and open sensor.

Note that the preferred response would be a flat line. The sensor data from the closed sensor was then used to correct the sensor data from the other sensor. The principle is based on long term average as shown in equation (1).

$$Acorrected_i = AS2_i - \left[\left[\frac{1}{i}\sum_i AS1_i\right]\frac{\min(AS2)-\max(AS2)}{\min(AS1)-\max(AS1)}\right] \qquad (1)$$

Were AS1-2 is the EMF sensor data

Min-max are embedded functions

Figure 3 shows the corrected signal data when equation (1) was used to correct the data.

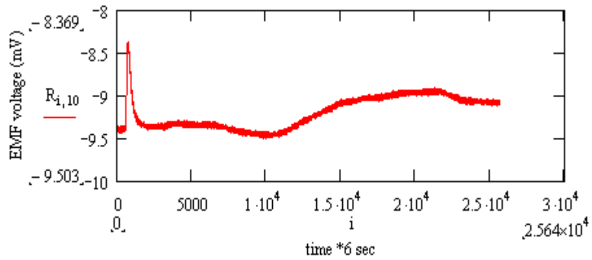

Fig. 3. Corrected response.

Conclusions: When a EMF sensor is used without a heating coil one has to compensate for the drift properties. This study shows that a grid of at least two EMF sensors of the same type can be used as a temperature drift compensation technique. Research data show that temperature drift can be reduced by at least a factor 10.

Acknowledgements

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