# Guidelines for CO$_2$ Sensor Selection

Overview

With an increase regarding awareness in Indoor Air Quality (IAQ), many manufacturers of ventilation equipment, air purifiers, air quality monitors and thermostats are incorporating IAQ sensors into their products. This provides homeowners and building owners information about environmental parameters, such as temperature, Relative Humidity (RH), Carbon Dioxide (CO$_2$), and Total Volatile Organic Compounds (TVOC's) in the indoor environment. In this application note, we will focus on measuring the amount of CO$_2$ in the air.
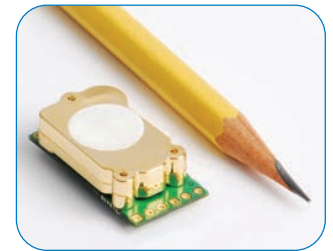
It is also important to note that during the present COVID-19 pandemic, the Center for Disease Control and Prevention (CDC) has suggested that CO$_2$ be used as an indicator to determine if a room is being properly ventilated. Every time you exhale, you are releasing CO$_2$ into the air. Since the Coronavirus is most often spread by breathing, coughing, or talking, you can use CO$_2$ levels to see if the room is filled with potentially infectious exhalations. The CO$_2$ level lets you estimate if enough fresh outside air is being introduced. As the Coronavirus is most often transmitted through the air, higher CO$_2$ levels in a room will most likely mean that there is a higher chance of transmission of the virus if an infected person is inside the space.

In 1989, Telaire started a project to develop a low cost Non-Dispersive Infrared (NDIR) Sensor to measure CO$_2$ concentration in air. Then, in 1992, Telaire introduced the first maintenance-free CO$_2$ sensor, and has since obtained over 35 patents centered around CO$_2$ sensing technologies. We are the only manufacturer that offers single and dual wavelength sensors, which pertain to the method that sensor drift is controlled.

Single Wavelength NDIR

In its simplest configuration, a Single Wavelength NDIR Sensor consists of an infrared light source, a chamber, light filter, and infrared detector. Virtually all gas sensors are subject to some drift over time. The degree of drift is partially dependent on the use of quality components and good design. Even with good components and excellent design, however, a small amount of drift can still occur over time, which may ultimately result in the need for sensor replacement or recalibration.

Telaire's Single Wavelength NDIR Sensors feature the patented Automatic Background Calibration (ABC) Logic that continuously maintains calibration for the lifetime of the sensor (typically 15 years). ABC Logic continuously monitors the environment and logs the lowest concentrations of CO$_2$ in the air taking place over a 24 hour period. The sensor assumes this low point is the same as outside levels of CO$_2$. Outdoor levels of CO$_2$ are approximately 400 ppm worldwide. The sensor collects approximately 2 weeks of data and performs a statistical analysis to determine if there have been any slight changes in the sensor reading over background that can be attributed to sensor drift. If the analysis concludes there is sensor drift, a small correction factor is made to the sensor calibration to adjust for this change.

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Single Wavelength NDIR (cont.)

Since the Single Wavelength NDIR Sensor uses outside air CO$_2$ levels as a reference point, these sensors should only be used in applications where a home or building will be unoccupied for periods of time, in order for indoor CO$_2$ levels to equalize with outdoor levels. This will occur in most home and commercial building applications where there is not 24-hour occupancy. Typical applications include commercial office buildings, movie theaters, restaurants, and residential homes.

Dual Wavelength NDIR

A Dual Wavelength NDIR Sensor has a similar construction to a single wavelength sensor; however, it has an additional infrared detector that measures light intensity of a reference wavelength within the chamber. As stated above, virtually all gas sensors are subject to drift over time. In applications where outdoor air CO$_2$ cannot be used for reference, an alternate method is required to ensure calibration over time.

A second wavelength is used as a reference point for this sensor as it continuously measures slight changes associated with potential drift of electronic components over time. The sensor monitors these changes, analyzes the data, and corrects the CO$_2$ output due to drift.

While not as accurate as the ABC Logic found in single wavelength sensor, over time, the Dual Wavelength NDIR Sensor is ideal for applications where the indoor environment will not be exposed to outside CO$_2$ levels on a periodic basis. Typical applications include hospitals, food monitoring and storage, and agricultural applications.

Metal Oxide (Equivalent CO$_2$)

Metal oxide-based sensors are a well-known method for VOC detection, typically consisting of a heater element on a Si-based MEMS structure and a metal oxide (MOx) chemiresistor. The signal conditioner controls the sensor temperature and measures the MOx conductivity, which is a function of the gas concentration.

Since there are thousands of volatile organic compounds, it is not possible to manufacture a cost-effective sensor to detect all possible VOC's in the indoor environment. Most sensor manufacturers focus on targeting certain VOC's, such as formaldehyde, toluene, xylenes, acetone and alcohols, just to name a few, and then use algorithms to provide an estimated Total Volatile Organic Compound (TVOC) Output in parts per billion (ppb). This type of sensor provides valuable information about the presence of contaminates in indoor air. However, it is typically used to provide trend data and is not recommended for exact measurements of VOC's.

In addition to TVOC Output, some manufacturers have chosen to provide a CO$_2$ equivalent output in parts per million (ppm). While CO$_2$ is not a VOC and cannot be directly measured with a MOx type of sensor, humans are a source of VOC's through the process of breathing; therefore, algorithms are used to analyze the data to determine TVOC attributed to the presence of humans, and then estimates CO$_2$ in parts per million (ppm).

This type of sensor should be used in applications where there is a desire to monitor common indoor air quality contaminants, where one can take appropriate action to reduce the levels of TVOC via increased ventilation or removal of the VOC source. It should not be used in applications that require specific measurements of CO$_2$; an example of such is ASHRAE Standard 62.1.

If CO$_2$ measurement is required, one should choose a sensing technology that measures the concentration of CO$_2$ directly, instead of an inferred value; therefore, we would not recommend CO$_2$ equivalent for these types of applications.