

CO₂ Sensor for Aircraft In-Cabin Interior Air Quality Monitoring

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WHAT IS THE PROBLEM THAT NEEDS TO BE SOLVED?

Building management systems (BMS), Demand-Controlled Ventilation (DCV) systems and Indoor Air Quality (IAQ) equipment often require installation of wirelessly-connected, battery-powered CO₂ sensor devices in environments where mains power is not easily accessible or where its provision is not economically viable; such as with building technology upgrades and retrofitting.

The requirement to measure air quality is being driven by two key factors, legislation, and economics. Many countries have either set or are in the process of setting maximum allowable levels of CO₂ in School Classrooms, Hospitals, Public Buildings, Hotels and in the workplace. For example, the US Occupational Safety and Health Administration (OSHA)¹ has set a Permissible Exposure Limit (PEL) for CO₂ of 5,000 parts per million (ppm) (or 0.5 %) over an 8-hour workday. They report that exposure to levels of CO₂ above this can cause problems with concentration, an increased heart rate, breathing issues, headaches, and dizziness.

Changing the air in a building to regulate CO₂ levels has an energy cost - especially if the incoming air also has to be heated or cooled. This is particularly relevant at night-time and weekends when buildings may not be fully occupied. DCV or IAQ equipment are increasingly incorporating CO₂ monitors so that the air change is controlled by the need to reduce the CO₂ levels.

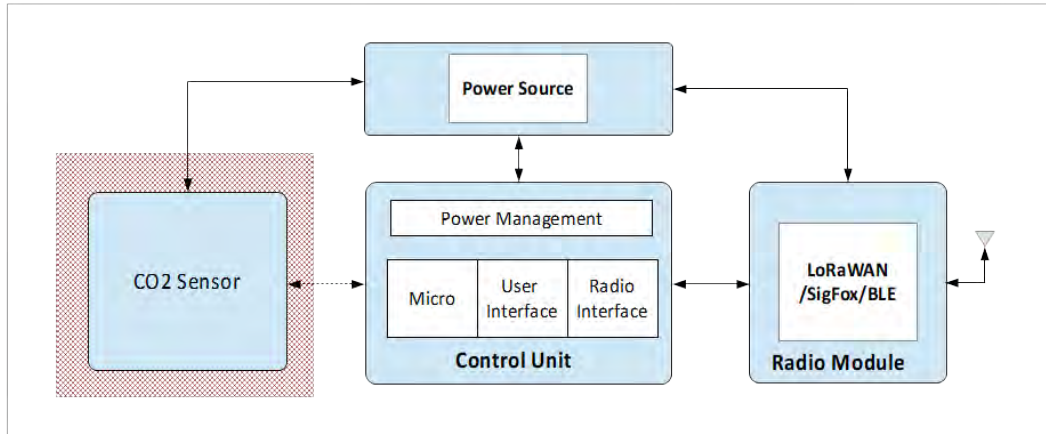
WHAT ARE THE REQUIREMENTS FOR THE CO₂ SENSOR?

CO₂ monitoring systems often need to be installed in locations where access to mains power is limited, or its provision is costly. The ability to be able to power the CO₂ sensor for long periods of time from a battery or from energy generated using harvesting techniques is highly desirable. To reduce maintenance costs, users want the ability for the CO₂ sensor to operate autonomously for up to 10 years without user intervention.

Energy harvesting is a technique used to collect very small amounts of ambient energy to power wireless devices. Assuming the power consumption of the CO₂ sensor and wireless network interface is low enough, ambient energy present in the environment can be sufficient to power remote monitoring equipment with an almost unlimited lifetime.

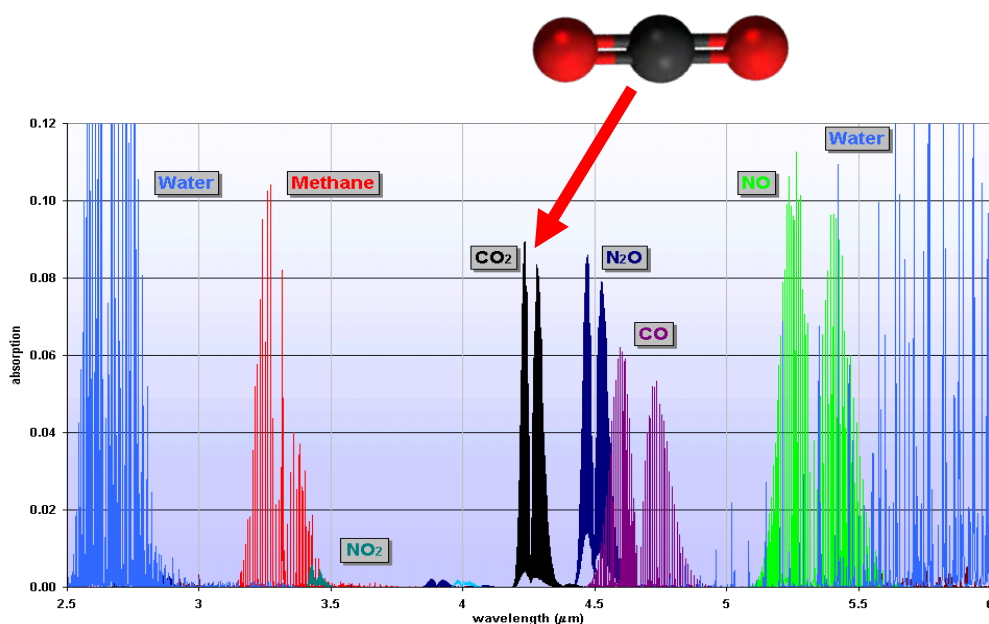
HOW IS THIS ENABLED?

A wireless CO₂ sensor suitable for use in IAQ systems consists of four major building blocks, a CO₂ sensor, microcontroller, low power radio module and a power source.



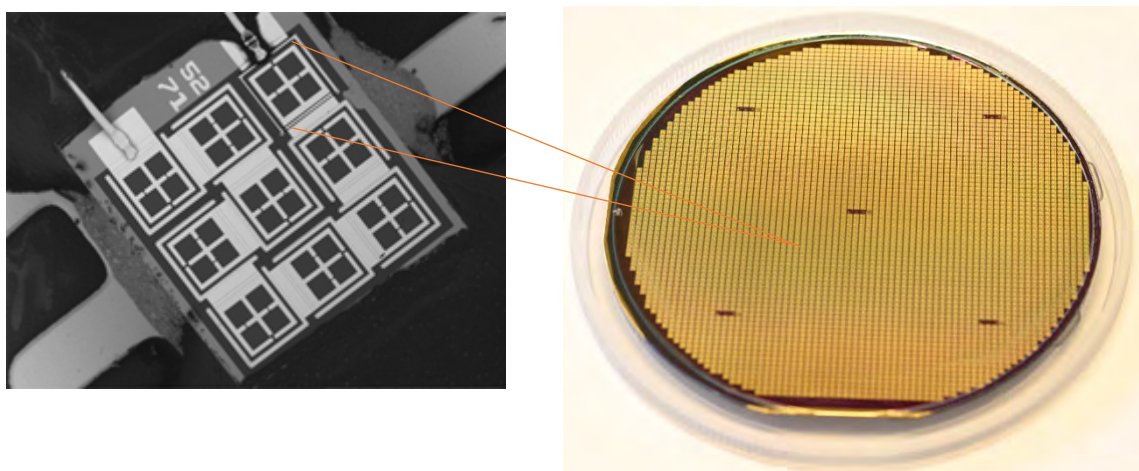
Conventional CO₂ sensors work by illuminating the gas using a filtered incandescent light source and measuring the absorption using a light detector. However, the power consumed using this type of CO₂ sensor is too high to make it usable in a portable, or low power application. The cost of facilities management required to frequently change batteries is impractical and too expensive.

Regardless of the source of illumination, measurement of the CO₂ level is determined using the Beer-Lambert law². Beer-Lambert's law states that the loss of light intensity when it propagates in a medium is directly proportional to intensity and path length. CO₂ molecules absorb infrared radiation at a wavelength of around 4.25 microns.



Gas Sensing Solutions' CO₂ sensor uses a solid state, ultra-low power LED light source. This type of light source has a number of advantages, particularly for low power applications. The CO₂ gas is strongly absorbed by mid-IR 4.25um light. GSS manufactures its own LEDs, which have been specifically designed to emit a narrowband of light centred at 4.25um. This means little or no energy is consumed generating light of wavelengths that are unused. This is very different from a typical incandescent light source, which is intrinsically inefficient as it generates broadband light, most of which is wasted.

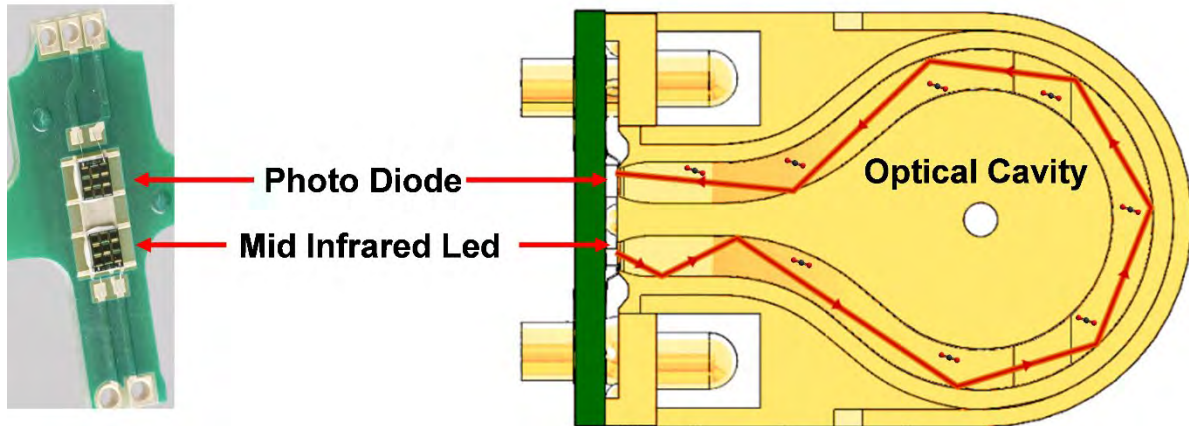
Solid state sensors such as those from GSS also have a much longer lifetime, typically measured in years, which along with the long run time dramatically reduce lifetime maintenance costs.



GSS's ultra-efficient LED light source can also be switched on and off rapidly, much faster than conventional incandescent sources. The GSS LEDs can switch on and become usable for CO₂ measurement within seconds. This enables the user to take readings quickly before shutting down the module, thus minimising overall power consumption.

INTRODUCING THE COZIR®-BLINK

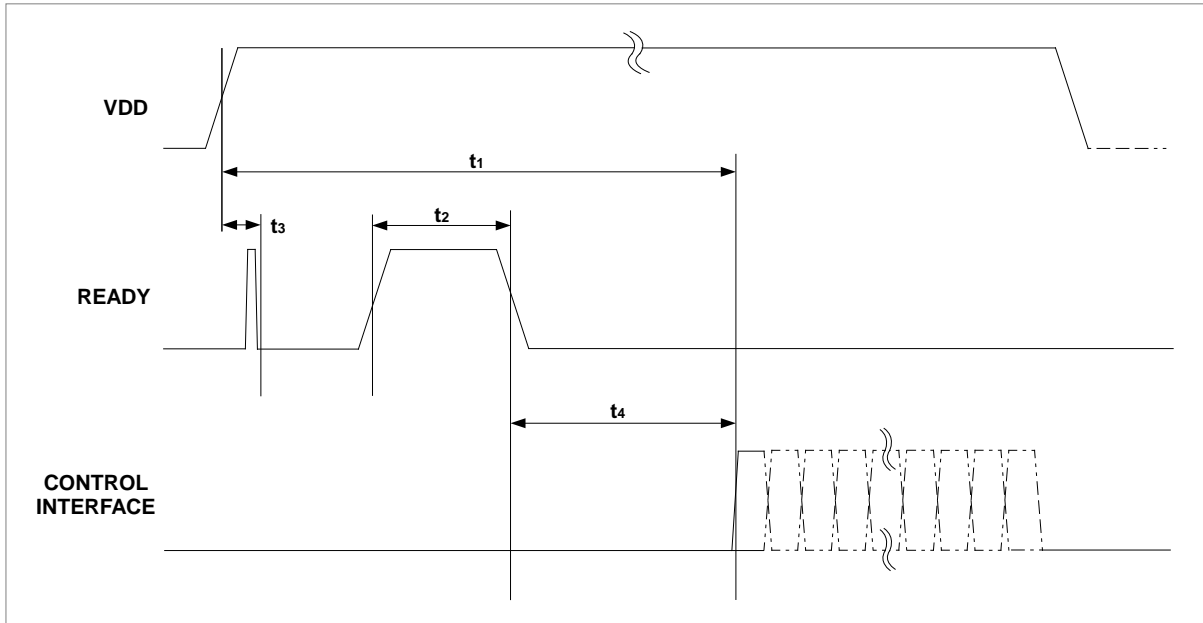
GSS has recently designed a new ultra-low power CO₂ sensor module specifically for low power applications. The module consists of four major functions, a mid-IR LED, a photo-diode, an optical light path and a microcontroller.



Light from the LED is injected into the optical cavity, which contains the CO₂ gas that has been allowed to enter it through a hole on the top surface. The light that passes through the optical cavity is detected by the photo diode. The signal from the photo diode is digitised by the microcontroller and compared with a reference level stored in memory. The microcontroller can then calculate the level of CO₂ in the optical cavity.

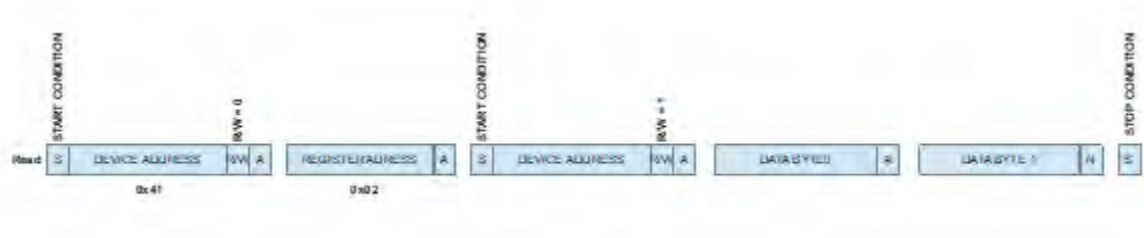
The introduction of the CozIR®-Blink allows users to reduce power consumption of the CO₂ measurement to unprecedented levels. The CozIR®-Blink is designed for ultra-low power applications where power is often at a premium. CozIR®-Blink is designed to be power cycled.

When the sensor is switched on, a measurement is automatically initiated. Data can be read out once the READY pin is pulsed high, approximately 3.3s after application of power. The sensor can then be subsequently switched off, saving power.



PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
READY Data Valid from Power On	t ₁	0.3	3.3		s
READY High Pulse-Width	t ₂		16.5		ms
READY Low from Power On	t ₃			100	ms
Control Interface Setup Time	t ₄	600			ns

The sensor interfaces to the host controller using a UART or I²C interface. In its simplest form, the sensor is accessed by the I²C Master requesting data from the sensor once the READY pin is pulsed high. The Master selects the CozIR[®]-Blink and reads out data in 2 bytes from the appropriate register. The data is in binary format.



Switching the CozIR[®]-Blink sensor off allows the user to reduce power consumption to close to zero when not taking measurements. The user can optimise the active power consumption of the CO₂ module by varying the power-on time, the measurement duration and measurement cycle time.

Power consumption of the CozIR®-Blink module is defined by the following equation.

$$\text{Power } (\mu\text{W}) = \frac{1.5625 * \text{number of pulses per reading}}{\text{Measurement period in Seconds}} * 1000$$

In a typical application such as HVAC where the user might want to take a reading every minute, the power requirement can be as low as 417uW per reading for the CozIR®-Blink. Power consumption can be reduced even further by setting the unit to reduce measurement accuracy, or by increasing the measurement interval.

The CozIR®-Blink has been designed to run autonomously and requires no in-use adjustment over the lifetime of the sensor. The sensor is calibrated before shipping with a 400ppm zero point. During use, the sensor can be programmed to automatically re-zero with a duty cycle defined by the user. This ensures the sensor can operate optimally over the lifetime of the product. Accuracy is further improved by allowing the user to configure the sensor for the effects of altitude.

The CozIR®-Blink automatically starts a measurement sequence when power is applied to the module. The sensor module flags that a CO₂ measurement is available and is designed to be powered down after the measurement is read out.

CONCLUSION

GSS's new CozIR®-Blink has been designed specifically to address applications that require measurement of CO₂ combining very low power consumption with high accuracy. This ultra-low power CO₂ sensor can be powered from a small battery, solar panel or other energy harvesting device, with enough power left over for a wireless data and control connection. This makes it ideal to address the emerging requirements for low cost distributed building management systems (BMS), Demand-Controlled Ventilation (DCV) and Indoor Air Quality (IAQ) systems.

To learn more about how the CozIR®-Blink can save your application on power consumption, visit our website today. <https://www.gassensing.co.uk/product/cozir-blink/>

REFERENCES

1. United States Department of Labour. (n.d.). *Permissible Exposure Limits / OSHA Annotated Table Z-1*. Retrieved from Occupational Safety and Health Administration: <https://www.osha.gov/dsg/annotated-pels/tablez-1.html>
2. chemguide. (n.d.). *THE BEER-LAMBERT LAW*. Retrieved from chemguid: <https://www.chemguide.co.uk/analysis/uvvisible/beerlambert.html>

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