Performance evaluation methodology

for XENSIV™ PAS CO2 gas sensors

About this document

Scope and purpose

This application note presents a possible gas measurement setup for customers who would like to evaluate the performance of Infineon's XENSIV™ PAS CO2 gas sensors.

There is a wide range of gas sensor products available on the market, but very few offer high-performance solutions like XENSIV™ PAS CO2 gas sensors (PASCO2V01, PASCO2V15). Therefore, extra care is necessary to ensure that the measurement data reproduces the datasheet performance.

Intended audience

The intended audiences for this document are design engineers, technicians, and developers of electronic systems.

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1 Introduction

The XENSIV™ PAS CO2 is a real CO2 sensor that overcomes the size, performance, and assembly challenges of existing CO2 sensor solutions. The sensor has been designed based on the unique photoacoustic spectroscopy (PAS) principle. XENSIV™ PAS CO2 comes in an exceptionally miniaturized module that is four times smaller and three times lighter than the existing commercial real CO2 sensors that operate based on the non-dispersive infrared (NDIR) principle. In addition to the unprecedented compact design, XENSIV™ PAS CO2 delivers superior-quality data thanks to its high-accuracy performance beating other state-of-the-art CO2 gas sensors. The sensor's high accuracy level makes it the right choice for indoor air-quality monitoring stations, HVAC systems, and IoT applications.

All major components of XENSIV™ PAS CO2 are developed and designed in-house according to Infineon's high-quality standards (e.g., component traceability, internal and external audits, state-of-the-art qualification standards, and tools). As shown in Figure 1, outside of the cavity, there is an XMC™ microcontroller to support data processing and a MOSFET to drive the light source. Within the cavity, there is a high-SNR silicon microphone as the detector and an in-house built MEMS-based infrared emitter as the light source.

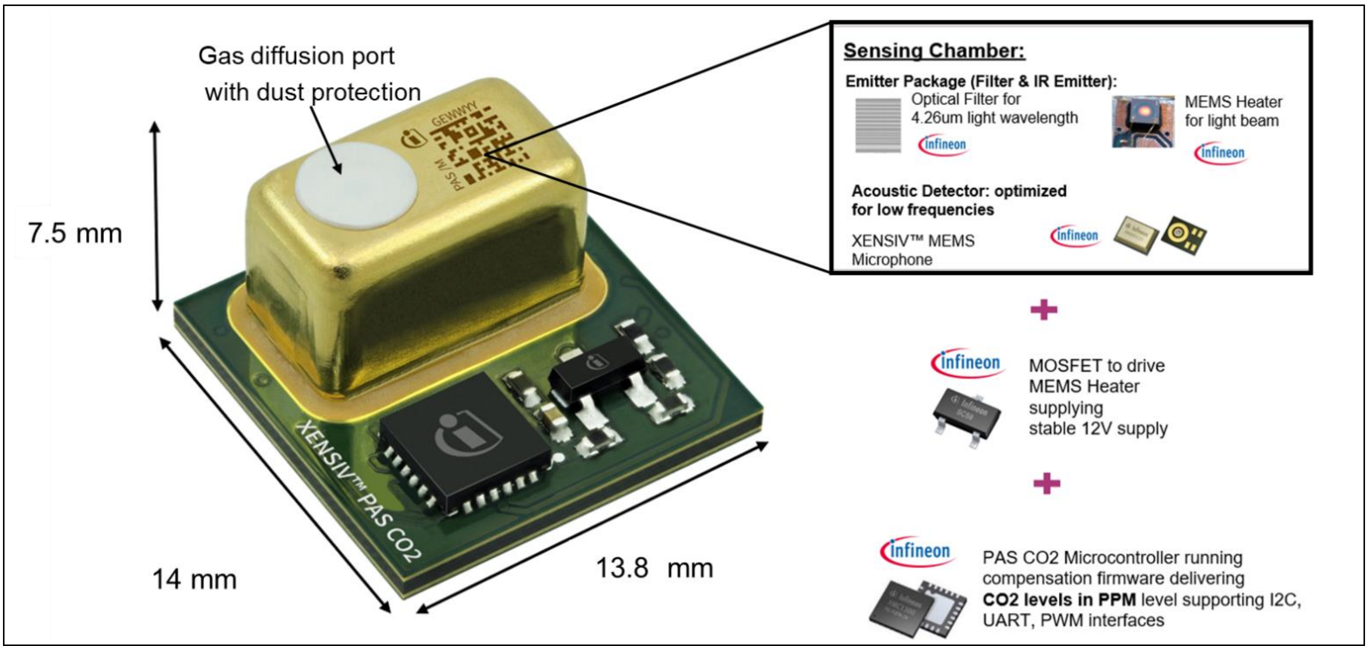

Figure 1 All the key components of XENSIV™ PAS CO2 are developed in-house to ensure best-in-class quality of the sensor

Note: Before performing the evaluation, it is recommended to perform Forced Compensation Scheme (FCS) or enable Automatic Baseline Offset Correction (ABOC) for long-term test.

2 Recommended gas measurement setup

A gas measurement setup should have three main components:

- Gas mixing system
- Test chamber
- Reference sensors

In the following section, a brief description of each component is provided.

2.1 Gas mixing system

To deliver the target CO2 concentration to the gas chamber, a gas mixing system should be used. The schematic of a typical setup is presented in Figure 2. To control the gas and humidity concentration, at least three mass flow controllers (MFCs) are needed. For the example setup, MFC 1 is being used for the CO2 bottle. A synthetic air gas bottle is connected to MFCs 2 and 3, which are used to dilute the gas concentration within the gas bottle to achieve an ideal target gas concentration. MFC 2 is maintaining the dry airflow, whereas MFC 3 is maintaining the wet airflow via a water column. By varying the flow ratio between dry air and wet air, the relative humidity can be controlled. Alternatively, a humidity generator can also be used to maintain a stable relative humidity point.

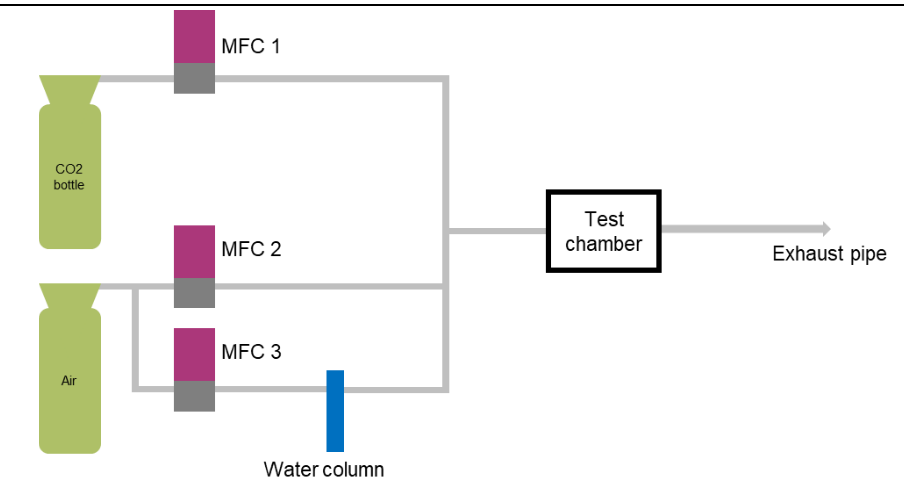

Figure 2 Gas mixing system to transfer exact CO2 concentration to the gas chamber

To achieve a target gas concentration at specific relative humidity, the following equation needs to be used:

$$T_c = \frac{B_c \times G_f}{D_f + W_f + G_f}$$

Equation 1

Where,

T_C = Target gas concentration (ppm)

B_C = Bottle concentration (ppm)

G_f = CO2 gas flow (SCCM)

D_f = Dry air flow (SCCM)

W_f = Wet air flow (SCCM)

The target relative humidity can be achieved by varying the ratio between Df and Wf.

For example, if a sensor needs to be characterized at a room temperature and atmospheric pressure with a 50000 ppm (5 percent) gas bottle concentration at 500 SCCM flow, then a typical gas measurement protocol can be as follows:

Table 1 Experimental conditions

Target CO2 concentration [ppm]	Time [min]	MFC 1 [SCCM]	MFC 2 [SCCM]	MFC 3 [SCCM]
Air 50 percent RH	30	0	250	250
Air 50 percent RH + 400 ppm CO2	15	4	246	250
Air 50 percent RH	30	0	250	250
Air 50 percent RH + 1000 ppm CO2	15	10	240	250
Air 50 percent RH	30	0	250	250
Air 50 percent RH + 5000 ppm CO2	15	50	200	250
Air 50 percent RH	30	0	250	250

2.2 Typical test chamber

A test chamber needs to be designed in such a way that there is no leakage, and it can maintain laminar flow while exposing the sensor to the target gas concentration. Inside the test chamber, it is recommended to accommodate a reference CO2 sensor. Additionally, to get an overview of the complete test conditions, pressure sensor, humidity sensor, and temperature sensor should also be considered.

2.3 Recommended reference sensors

2.3.1 CO2 reference sensor

Vaisala CARBOCAP GMP343 CO2 probe is recommended as the reference CO2 sensor [1].

2.3.2 Pressure and temperature reference sensor

Infineon's XENSIV™ DPS368 [2] is recommended as the reference pressure and temperature sensor. The pressure sensor's pressure output comes with excellent precision of ± 0.002 hPa and relative accuracy of ± 0.06 hPa. The built-in temperature sensor offers an accuracy of ±0.5°C with 0.01°C data resolution.

2.3.3 Reference relative humidity sensor

A highly accurate low-powered relative humidity sensor should be considered as the reference relative humidity sensor.

3 Typical performance evaluation of XENSIV™ PAS CO2 sensors

Example test condition:

- Relative humidity 0%, 23%, 50%, and 85%
- Ambient pressure 960 hPa
- CO2 concentration steps: 1000 ppm, 1800 ppm, 3100 ppm, 4000 ppm, and 5000 ppm

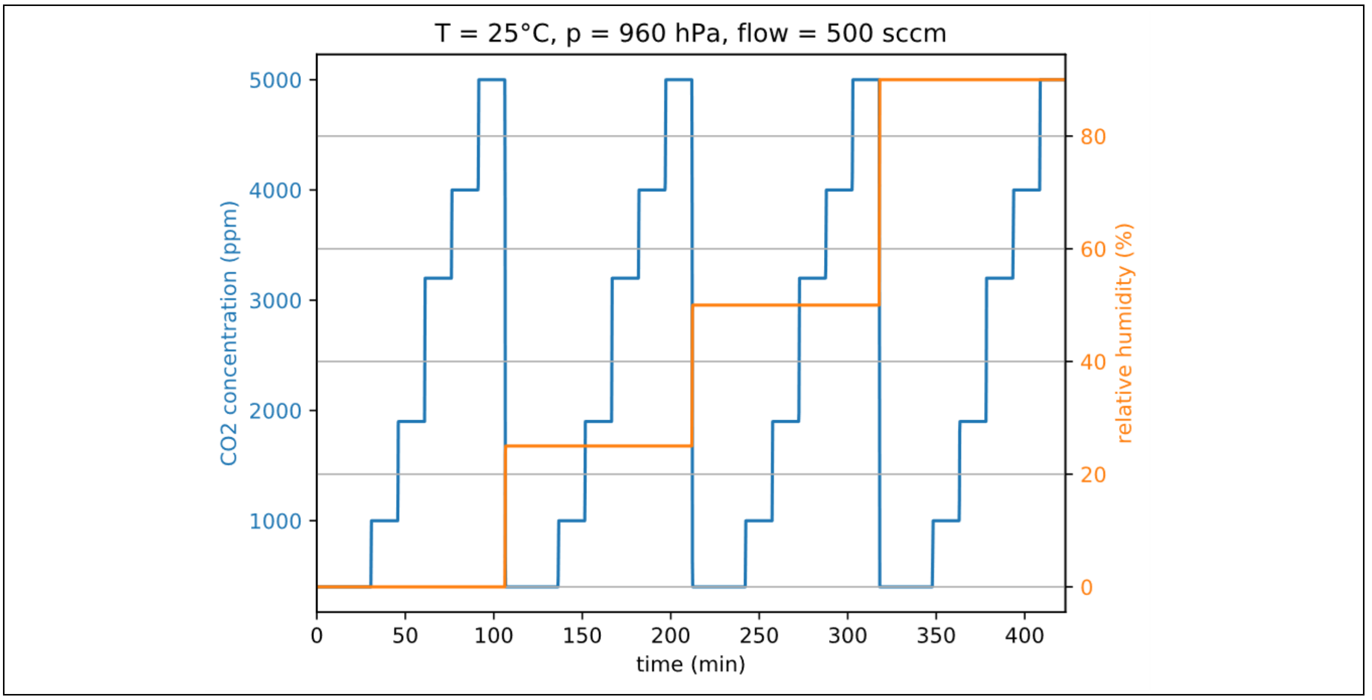

Figure 3 Gas ramp for sensor accuracy evaluation

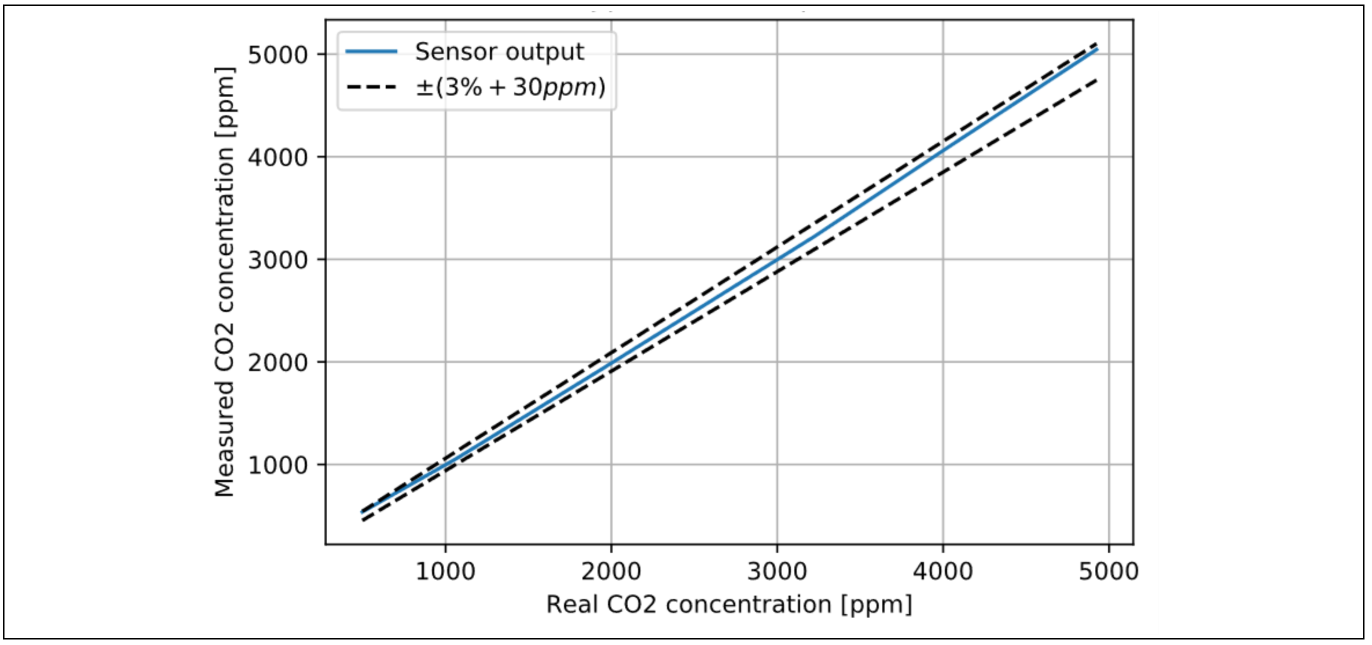

Figure 4 Typical CO2 response

References

[1] Vaisala: CO_2 Probe GMP343; https://www.vaisala.com/en/products/instruments-sensors-and-other-measurement-devices/instruments-industrial-measurements/gmp343

[2] Infineon Technologies AG: XENSIV™ DPS368 pressure sensor; Available online

[3] Infineon Technologies AG: *XENSIV™ PASCO2V01 gas sensor datasheet*; Available online

[4] Infineon Technologies AG: *XENSIV™ PASCO2V15 gas sensor datasheet*; Available online

Revision history

Document revision	Date	Description of changes
1.00	2021-06-02	Initial release
1.20	2022-07-01	Added Section 3
1.30	2025-04-02	Changed document ID Miscellaneous document cleanup updates

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