AN005: CO_2 Sensor Response Time

ABSTRACT

GSS offer CO_2 sensors with different gas sampling methods. The gas is either diffused into the measurement chamber typically through a PTFE membrane, or pumped into the chamber using a flow through adaptor.

Apart from some gas flow around the sensor, the response time of diffusion sensors is dominated by the digital filter setting and the pore size of the membrane filter. Diffusion sensors are used for applications that do not require a fast response, or where a slow response is beneficial such as environmental control systems.

However, there are many applications that require faster real-time gas measurements. GSS have designed a family of sensors with gas flow through adaptors optimised for responsiveness and CO_2 measurement accuracy at flow rates from 50ml/minute to >6l/minute.

This application note explores flow through gas sampling and the effects of flow rate on response time.

AN005: CO_2 Sensor Response Time

CONTENTS

ABSTRACT ... 1
INTRODUCTION ... 3
TERMINOLOGY ... 3
DIFFUSION ... 3
FLOW PORT ... 3
MEASUREMENT SPEED ... 4
SAMPLE VOLUME ... 4
DIGITAL FILTER SETTING ... 5
FLOW RATE ... 7
CONCLUSION ... 9
IMPORTANT NOTICE ... 10
ADDRESS ... 11
REVISION HISTORY ... 12

AN005: CO_2 Sensor Response Time

INTRODUCTION

GSS manufacture Carbon Dioxide sensors with two different types of gas sampling methods, diffusion and flow through. Different sampling methods are needed to optimise the gas measurement method to meet the varying application requirements.

TERMINOLOGY

The response time of a sensor is usually quoted as the time to reach a proportion of the target value. For example, T_{90} 30s indicates the sensor will reach at least 90% of the final value within 30s of the measured property being changed.

DIFFUSION

Diffusion of the gas into the measurement chamber is the most common method for sensors used in Indoor Air Quality applications, either as part of a control system for the HVAC or just monitoring conditions within a building. For low-power sensing, diffusion is the obvious choice as it requires no artificial air circulation (e.g., from a pump). The ambient range of CO_2 sensors from GSS have small openings on the outer surface of the optic. These are typically protected from view under a PTFE membrane dust filter. Natural gas diffusion allows the outside sample to fill the volume of the optic, typically with a T_{90} response time of 30s. The sensor response time is largely defined by the pore size of the PTFE membrane and therefore cannot be changed without modifying the membrane.

FLOW PORT

A flow port is typically used where either high speed of response is required, or the sensor is used to sample a process environment, where the sample is side streamed through the sensor and returned to the process. In these cases, the response time is influenced by the flow rate and the measurement rate of the sensor. This application note will primarily address these variables.

AN005: CO_2 Sensor Response Time

MEASUREMENT SPEED

GSS sensors use a technique called Non-Dispersive Infra-Red (NDIR) where the gas concentration is determined by the amount of light absorption by the target gas in measurement chamber.

There are three factors that affect sensor response time; the gas flow into the measurement chamber, the amount of digital filtering done by the sensor, and the measurement rate.

For GSS diffusion sensors with a measurement rate of 2Hz, the limiting factor is the diffusion rate through the membrane. For sensors with a gas flow port, the response time can be reduced by increasing the measurement frequency.

Sensor family	Measurement speed	Sample method / option
CozIR-Blink	On demand*	Diffusion
CozIR-A/LP/LP2/LP3	2Hz	Diffusion
ExplorIR-M/W	2Hz	Diffusion / Flow
SprintIR-W/6S	20Hz	Diffusion / Flow
SprintIR-R	50Hz	Flow

*The measurement time of the CozIR-Blink sensor is adjustable between 1 and 7 seconds. The sensor must be switched on to initiate a measurement and must be switched off between measurements.

SAMPLE VOLUME

For diffusion sensors, the volume of the gas sample has negligible influence on response time. However, where the sample is flowing through the sensor, the lower the volume of the gas sample, the faster the response for a fixed gas flow rate.

Sensor family	Sample volume	Sample method
CozIR-A	5.0ml	Diffusion
CozIR LP, LP2, LP3 and Blink	4.0ml	Diffusion
ExplorIR-M	3.0ml	Diffusion
SprintIR-WF	3.0ml	Flow
SprintIR-6S, R	2.8ml	Flow

AN005: CO_2 Sensor Response Time

DIGITAL FILTER SETTING

GSS sensors (excluding CozIR-Blink) implement a digital filter that allows the user to select whether to read raw CO_2 data or filtered CO_2 readings from the sensor. This allows the user to trade the response time with reading noise, depending on application requirements. The graph below in figure 1 shows the effect of the filter when exposed to a step change. The raw reading (Z) changes from 400 to 1500ppm on the next measurement sample. With a digital filter setting of 16, T_{90} is a period of 18 readings. For a CozIR®-LP3, this equates to 9 seconds (2 readings per second), or 360 milliseconds (50 readings per second) for a SprintIR®-R.

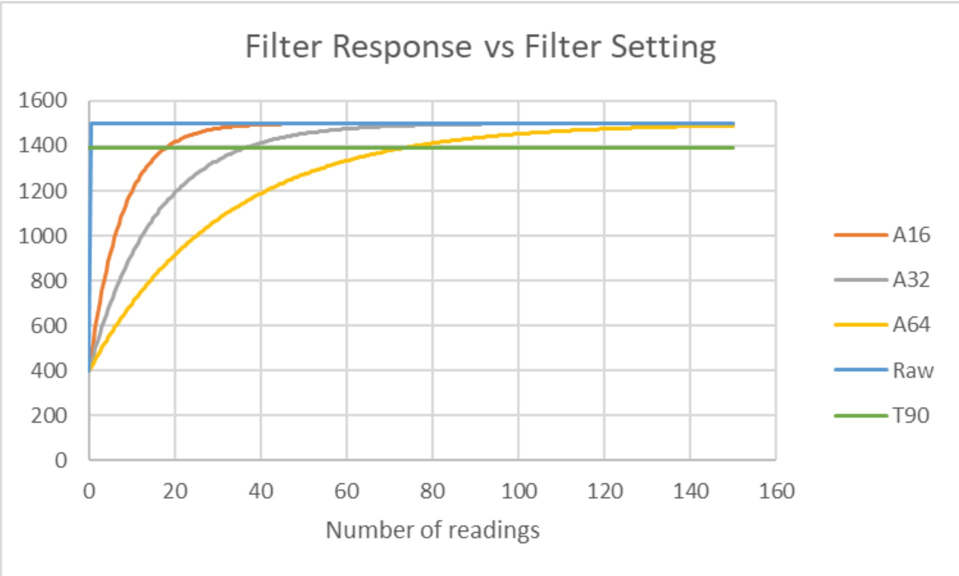

Figure 1: Filter Response vs Filter Setting

It is important to recognise that the response time is also limited by the ability of the sensor to change the gas in the measurement chamber. The gas must be flushed out of the chamber, in the above case from gas at 400ppm to gas at 1,500ppm. The rate at which this can be done is defined by the volume of gas in the measurement chamber and the gas flow rate through the sensor.

Figure 2 and 3 below show the combined effect of gas exchange and filter setting in a real-life example.

AN005: CO_2 Sensor Response Time

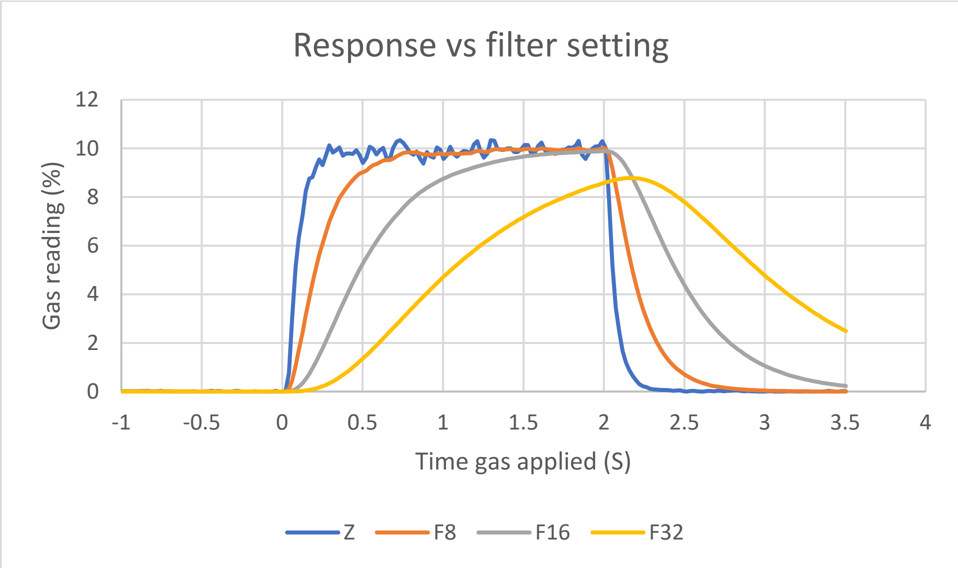

Figure 2: Filter Response vs Filter Setting Graph (2s gas pulse)

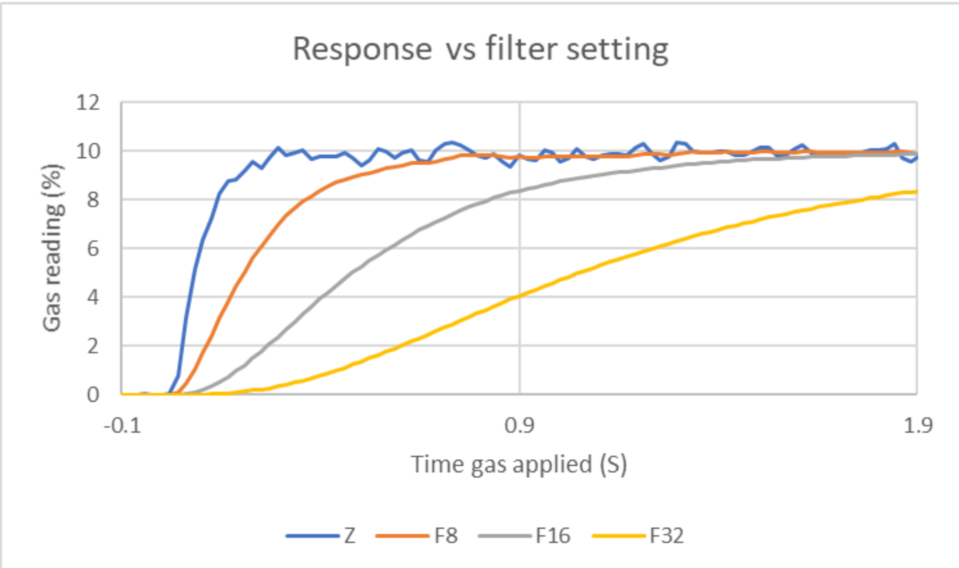

Figure 3: Filter Response vs Filter Setting Graph (step change)

AN005: CO_2 Sensor Response Time

FLOW RATE

For a sensor where the sample is being passed through the sensor, the flow rate is critical to the response time. As a rule of thumb, to fully exchange a gas volume in a chamber, 5 times the volume of gas needs to pass through the chamber. However, much like the filter settings above, this is not a linear function. If the gas volume is only exchanged once, the sensor will only be able to respond with ~80% of the final reading. These figures are only an estimate, and much depends on the type of flow system used.

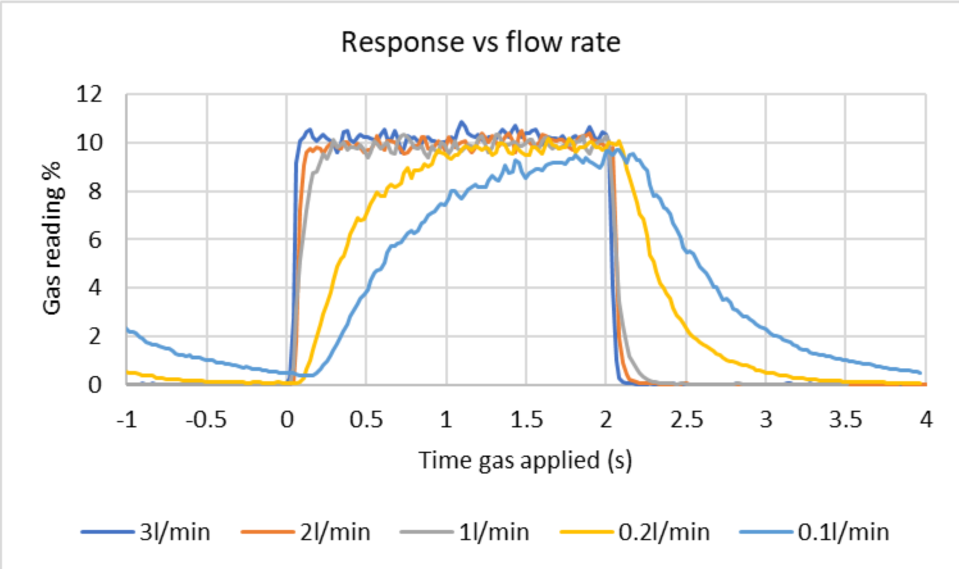

Figure 4: Response Time Graph (2 second gas pulse)

Figure 4 shows at low flow rates, the response time to T_{90} is approx. 1.5s at 0.1l/min. This equates to approximately 3ml of actual gas flow to reach T_{90}. As expected, a higher flow rate of 3l/min will improve the T_{90} time to of 60ms as shown in figure 5.

AN005: CO_2 Sensor Response Time

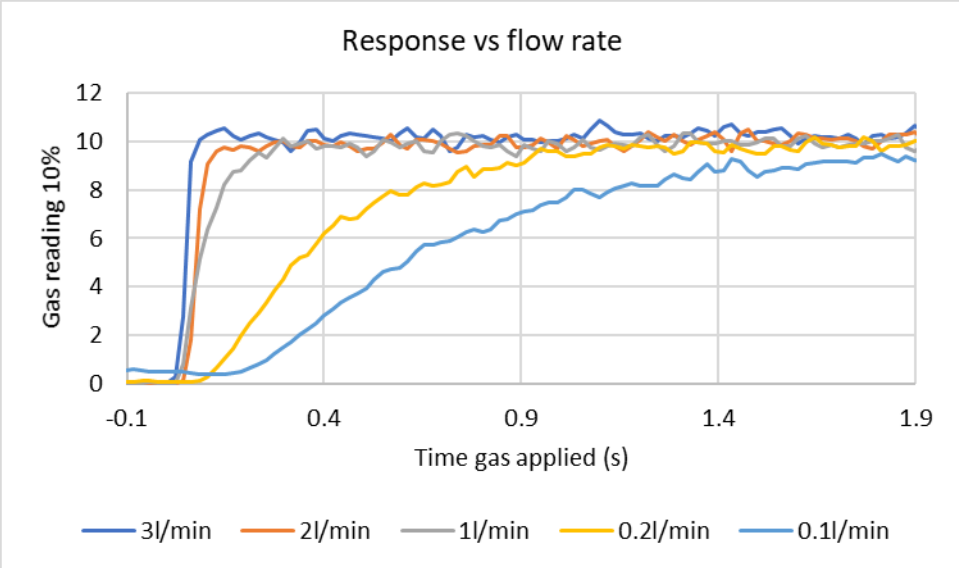

Figure 5: Response Time Graph (step change)

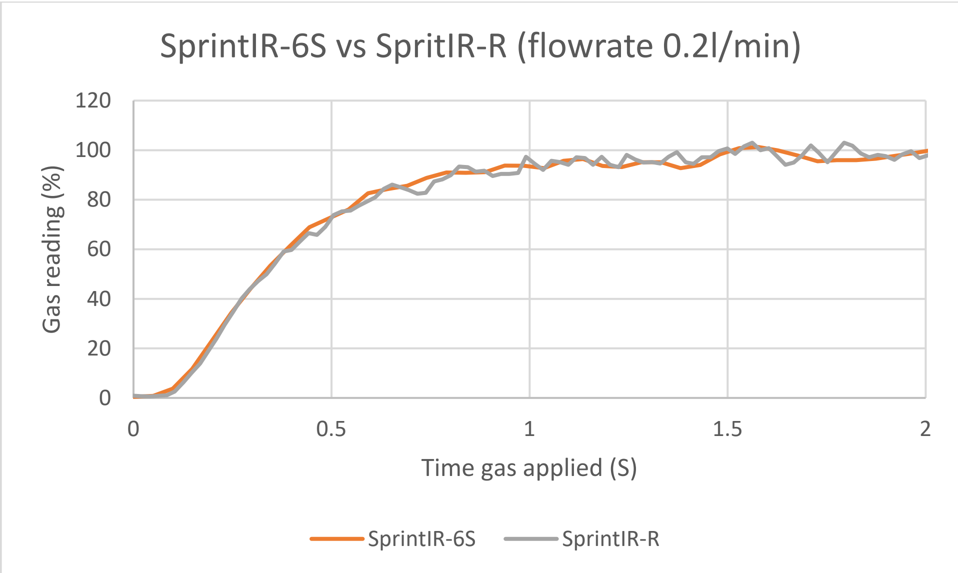

Figure 6: Response Time 20Hz vs 50Hz

At lower flow rates, the flow rate dictates the response time. Figure 6 shows the response time for SprintIR-6S (20Hz sample rate) and SprintIR-R (50Hz sample rate).

AN005: CO_2 Sensor Response Time

CONCLUSION

GSS has designed a range of CO_2 sensors specifically for applications that require fast response times. The response time of the sensor depends on several factors including the magnitude of the gas change to be measured, the measurement rate, sensor gas volume and digital filter settings.

The SprintIR® range of sensors are optimised to support measuring CO_2 in near real-time at flow rates from 50ml/minute to greater than 6ml/minute with better than ±70ppm +5% of reading accuracy. This makes them well suited for medical monitoring and diagnostic equipment, or applications where measurement speed is required such as food inspection.

AN005: CO_2 Sensor Response Time

IMPORTANT NOTICE

Gas Sensing Solutions Ltd. (GSS) products and services are sold subject to GSS's terms and conditions of sale, delivery and payment supplied at the time of order acknowledgement. GSS warrants performance of its products to the specifications in effect at the date of shipment. GSS reserves the right to make changes to its products and specifications or to discontinue any product or service without notice.

Customers should therefore obtain the latest version of relevant information from GSS to verify that the information is current. Testing and other quality control techniques are utilised to the extent GSS deems necessary to support its warranty. Specific testing of all parameters of each device is not necessarily performed unless required by law or regulation. To minimise risks associated with customer applications, the customer must use adequate design and operating safeguards to minimise inherent or procedural hazards. GSS is not liable for applications assistance or customer product design. The customer is solely responsible for its selection and use of GSS products. GSS is not liable for such selection or use nor for use of any circuitry other than circuitry entirely embodied in a GSS product.

GSS products are not intended for use in life support systems, appliances, nuclear systems, or systems where malfunction can reasonably be expected to result in personal injury, death or severe property or environmental damage. Any use of products by the customer for such purposes is at the customer's own risk.

GSS does not grant any licence (express or implied) under any patent right, copyright, mask work right or other intellectual property right of GSS covering or relating to any combination, machine, or process in which its products or services might be or are used. Any provision or publication of any third party's products or services does not constitute GSS's approval, licence, warranty, or endorsement thereof. Any third party trade-marks contained in this document belong to the respective third-party owner.

Reproduction of information from GSS datasheets is permissible only if reproduction is without alteration and is accompanied by all associated copyright, proprietary and other notices (including this notice) and conditions. GSS is not liable for any unauthorised alteration of such information or for any reliance placed thereon.

Any representations made, warranties given, and/or liabilities accepted by any person which differ from those contained in this datasheet or in GSS's standard terms and conditions of sale, delivery and payment are made, given and/or accepted at that person's own risk. GSS is not liable for any such representations, warranties, or liabilities or for any reliance placed thereon by any person.

AN005: CO_2 Sensor Response Time

ADDRESS

Gas Sensing Solutions Ltd.
Grayshill Road
Cumbernauld
G68 9HQ
United Kingdom

AN005: CO_2 Sensor Response Time

REVISION HISTORY

DATE	RELEASE	DESCRIPTION OF CHANGES	PAGES
09/03/2021	1.0	First revision	All