Zeroing a CO_2 Sensor

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ABSTRACT

GSS sensors are fully calibrated and characterised over their full operating temperature range, their gas concentration range and tested for CO_2 output measurement accuracy.

All GSS sensors use a technique called non-dispersive infra-red (NDIR) sensing where light from a LED is injected into the optical measurement chamber, which contains the gas which has been allowed to enter it. 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 CO_2 in the optical measurement chamber.

The performance of an NDIR sensor can be compromised by the build-up of contaminants in the measurement chamber of the sensor, as well as other degradations in the optical components.

The effect of these degradations can be fully eliminated by using one or more of the GSS zeroing routines. Zero-point setting is the process of modifying the CO_2 measurement value read by the sensor and align it with an external reference set point. The set point can be any value within the concentration range of the sensor, but is typically 0ppm, or some other easily accessed reference gas level. In a typical ambient application, fresh air with a CO_2 level of 400ppm is often used as a reference set point.

The requirement to re-zero the sensor will depend on the application and the environment in which the sensor is used.

There is no requirement GSS sensors to be re-set for the CO_2 concentration span. A simple zero reset is sufficient to maintain accuracy over the full lifetime of the sensor.

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OVERVIEW OF ZERO SETTING

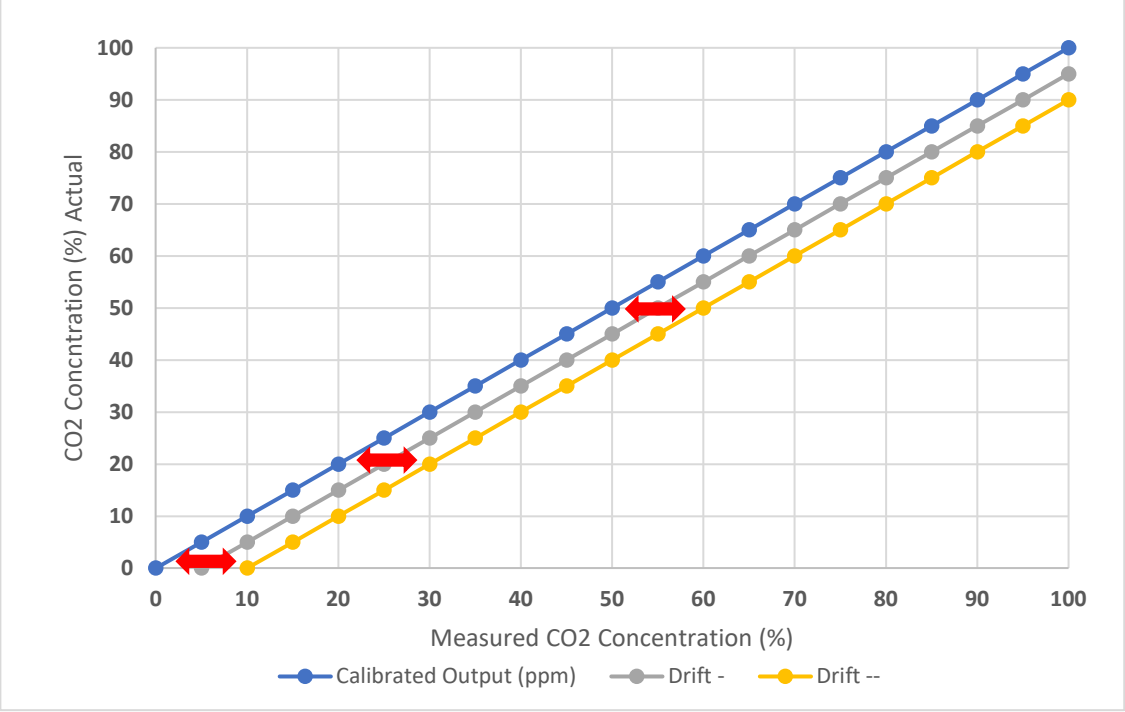
All GSS sensors are 100% tested for measurement accuracy at multiple, different gas concentrations before leaving the factory. In use, and dependent on the conditions, the CO_2 concentration value measured by the sensor may vary from the reference value.

The GSS sensor has two methods to reset the reference value or 'zero-point. Setting the zero-point can be done manually in either software or hardware on some models, or it can be done automatically using the sensor's auto-zeroing settings.

Regardless of which method is chosen, the best zero-point setting method is obtained when the gas concentration and sensor temperature is stable. The sensor only stores the latest zero-point setting.

BACKGROUND TO ZERO-POINT SETTING

All GSS sensors are calibrated for accuracy at the factory at multiple concentration levels. In use, the sensor reference level will change, due to changes in the optical surfaces, accumulation of dirt in the sensor and other degradations. The relationship between CO_2 concentration and measured CO_2 remains linear, however the reference levels may change compared to the those when the sensor shipped from the factory.



The change in reference level of the sensor can be cancelled out using a process known as zero-setting. This resets the sensor to a defined concentration level.

ZERO SET POINT METHODS

All GSS sensors have three manual zero-point setting methods.

SET POINT METHOD	DESCRIPTION	CO_2 SET POINT LEVEL
Know Gas Concentration	Sensor is placed in CO_2 gas with a known gas concentration level.	Variable from 0ppm to full scale of the sensor
Nitrogen	Sensor is placed in 100% nitrogen gas.	0ppm
Fresh Air	Sensor is placed in 'fresh air'.	Variable, typically 400ppm

ZERO IN A KNOWN GAS CONCENTRATION

The sensor must be placed in CO_2 gas with a known gas concentration level. The sensor needs to be instructed to run a zero-point setting cycle in a known gas concentration. The value of the known gas concentration level must be written to the sensor. Once the sensor has completed the measurement cycle, it will internally compare the measured result with the input gas concentration level and calculate an offset value. This offset value is stored in memory and used for all subsequent measurements at all concentration levels.

ZERO IN NITROGEN

The sensor must be placed in Nitrogen gas. The sensor needs to be instructed to run a zero-point setting cycle in Nitrogen. Once the sensor has completed the measurement cycle, it will internally compare the measured result with the expected gas concentration level of 0ppm and calculate an offset value. This offset value is stored in memory and used for all subsequent measurements at all concentration levels.

ZERO IN FRESH AIR

If there is no calibration gas or nitrogen available, the sensor zero point can be set in fresh air. Ambient CO_2 concentrations in fresh air are typically 400ppm. The CO_2 concentration fresh air zero level is programmable over a range from 0ppm to the full scale of the sensor.

The sensor needs to be instructed to run a zero-point setting cycle in 'Fresh Air'. Once the sensor has completed the measurement cycle, it will internally compare the measured result with the expected gas concentration level and calculate an offset value. This offset value is stored in memory and used for all subsequent measurements at all concentration levels.

The sensor can use the default fresh air CO_2 concentration value (400ppm), or the user can write a different fresh air value to the sensor if desired.

ZERO POINT ADJUSTMENT

If the CO_2 concentration and the sensor reported concentration are known, the zero point can be adjusted using the known concentration to fine tune the zero point. For example, if the sensor has been in an environment that has been exposed to outside air, and the sensor reading is known at that time, the zero point can be fine-tuned to correct the reading. This is typically used to implement automated zeroing routines.

PRESSURE AND CONCENTRATION LEVEL COMPENSATION

NDIR gas sensors detect the concentration of gas by measuring the degree of light absorption by the gas analyte. The degree of light absorption is converted into a concentration reported by the sensor.

The absorption process is pressure and gas concentration dependent. In general, as the pressure increases, the reported gas concentration also increases. As the pressure decreases, the reported concentration decreases. This effect takes place at a molecular level and is common to all NDIR gas sensors.

GSS sensors are calibrated at 1013mbar and at different CO_2 concentrations. The reading will vary due to pressure and CO_2 concentration. Before resetting the zero-point, it is important to adjust for the effects of pressure and concentration by setting a compensation value. This applies a permanent correction to the output of the sensor, depending on the compensation value.

AUTO-ZERO FUNCTION

All the above methods are instructed by the user either in software or in hardware on some models. However, the sensor can be programmed to reset the zero-point in fresh air.

In order to function correctly, the sensor must be exposed to typical background levels (400-450ppm) at least once during the auto-zero period and it must be powered-up. For example, many buildings will drop quickly to background CO_2 levels when unoccupied overnight or at weekends. The auto-zero function uses the information gathered during these periods to reset the zero-point. The sensor will reset the ‘zero’ level every time it does an auto-zero.

AUTO-ZEROING INTERVALS

The auto-zero period can be programmed by the user. Depending on the model type, the sensor can be programmed to undertake an initial auto-zero after power-on. Thereafter, the auto-zero period can be set independently of the start-up auto-zero time and can be programmed based on a fixed time period, or in the case of the CozIR®-Blink, based on the number of power cycles. With the exception of the CozIR®-Blink, the zero settings are reset if the sensor is powered down.

AUTO-ZERO SETTINGS

By default, the sensor will automatically 'zero' using the measured CO_2 level sampled during the auto-zeroing period. The user can alter the behaviour of the sensor as a result of the auto-zeroing process.

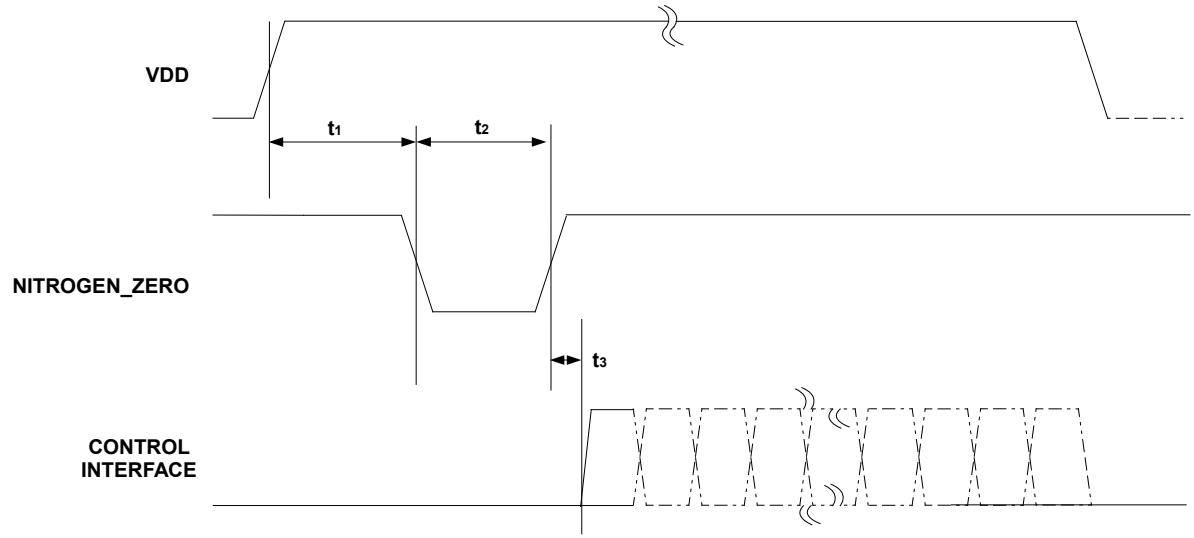
SOFTWARE INSTRUCTION SEQUENCE

To manually instruct a zero-point reset, follow the recommended sequence. This sequence is common to all GSS sensors.

Operation	Instruction	Comments
1	Power-up the sensor	
2	Adjust the sensor CO_2 filter setting.	Increasing the filter value reduces CO_2 measurement noise and results in a better zero-setting results. Typically set to 32.
3	Set the correct pressure and altitude compensation value	Automatically adjusts the measurement output for the effects of pressure and altitude for CO_2 concentrations up to 5%. For CO_2 concentrations above 5%, the user must manually correct the measured CO_2 value. (See GSS data sheets for compensation formula).
3	Allow the sensor to settle	Allow enough time for the gas to diffuse or flow into the gas measurement chamber.
4	Send the zero-point setting instruction	Choose one. • Zero in a known gas concentration • Zero in nitrogen • Zero in fresh air
5	Read back the CO_2 measured value	The sensor output should reflect the reference level chosen for the zero-pint setting.

HARDWARE INSTRUCTION SEQUENCE

Some GSS sensors have a pin on the sensor that can be used to force a zero reset. There are two options, either to initiate a Zero in Nitrogen, or a Zero in Fresh Air. The functions are identical to the those initiated in software. The zero reset is initiated by forcing the pin low for a minimum of 3 seconds.



PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Power On to NITROGEN_ZERO Ready	t_1	300			ms
NITROGEN_ZERO Low Pulse-Width	t_2	3			s
Control Interface Setup Time	t_3	600			ns

The timing for FRESH_AIR_ZERO is identical to NITROGEN_ZERO.

To manually instruct a zero-point reset using the hardware pins, follow the recommended sequence. This sequence is common to GSS sensors with hardware zero reset pins.

Operation	Instruction	Comments
1	Power-up the sensor	
2	Adjust the sensor CO_2 filter setting.	Increasing the filter value reduces CO_2 measurement noise and results in a better zero-setting results. Typically set to 32.
3	Set the correct pressure and altitude compensation value	Automatically adjusts the measurement output for the effects of pressure and altitude for CO_2 concentrations up to 5%. For CO_2 concentrations above 5%, the user must manually correct the measured CO_2 value. (See GSS data sheets for compensation formula).
3	Allow the sensor to settle	Allow enough time for the gas to diffuse or flow into the gas measurement chamber.
4	Set appropriate pin low for minimum of 3 seconds to initiate a Zero reset	Choose one. • Zero in nitrogen • Zero in fresh air
5	Read back the CO_2 measured value	The sensor output should reflect the reference level chosen for the zero-pint setting.

SUMMARY

Resetting the 'zero' reference level is a simple process that will maintain sensor accuracy for the lifetime of the product. The reset can be done manually, or depending on the environmental conditions, set to be done fully automatically with no user intervention. If done correctly, the sensor will continue to maintain the original factory test accuracy.

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