

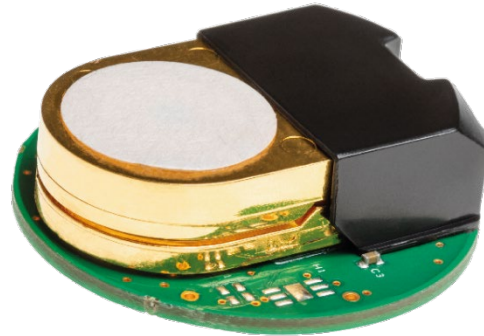
AN006: CO₂ Sensor Analogue Output Voltage

ABSTRACT

GSS sensors are designed to measure CO₂ levels in variety of applications.

Typically, measurement data is accessed through either a UART or I²C digital interface. In some circumstances, this interface mode may not be suitable.

In such cases, some GSS sensors come with a true analogue CO₂ level indicator output, where the analogue signal level voltage is directly proportional to the CO₂ gas level.



This application note describes how the GSS voltage level indicator functions and how to ensure the user maximises the performance of the sensor using this indication method.

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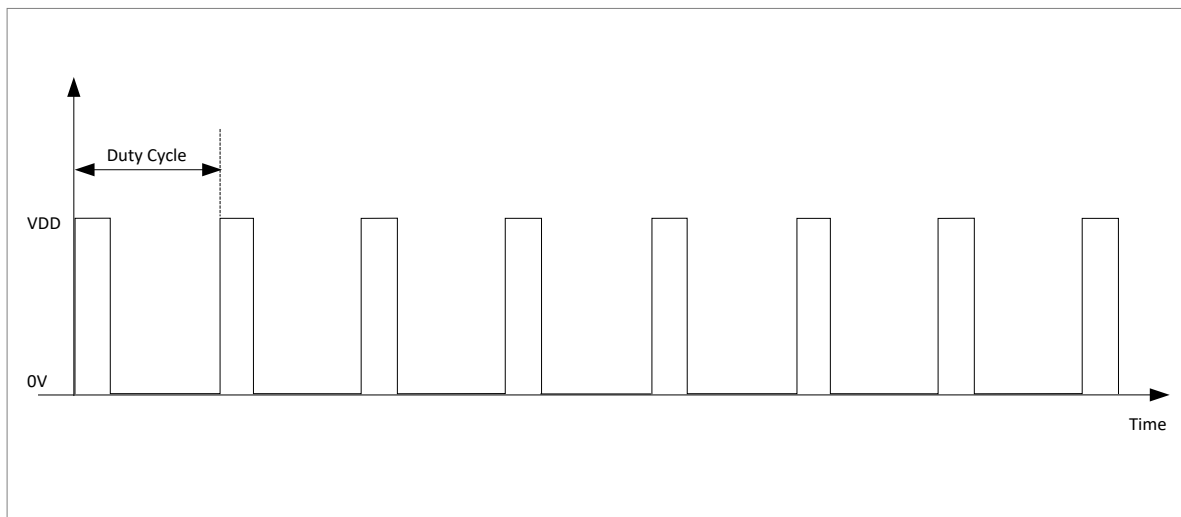
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METHOD OF OPERATION

The user can specify an analogue CO₂ level indication option on a number of GSS CO₂ sensors. If specified as an option on the sensor, the output voltage level will be directly proportional to the measured gas level.

The on-board sensor microprocessor generates a PWM output with a duty cycle proportional to the CO₂ signal level. There are a number of methods to use the PWM output. In some circumstances, the digital PWM signal can be used directly. This method is not supported by GSS sensors as it offers little advantage over and above the UART or I²C interface.

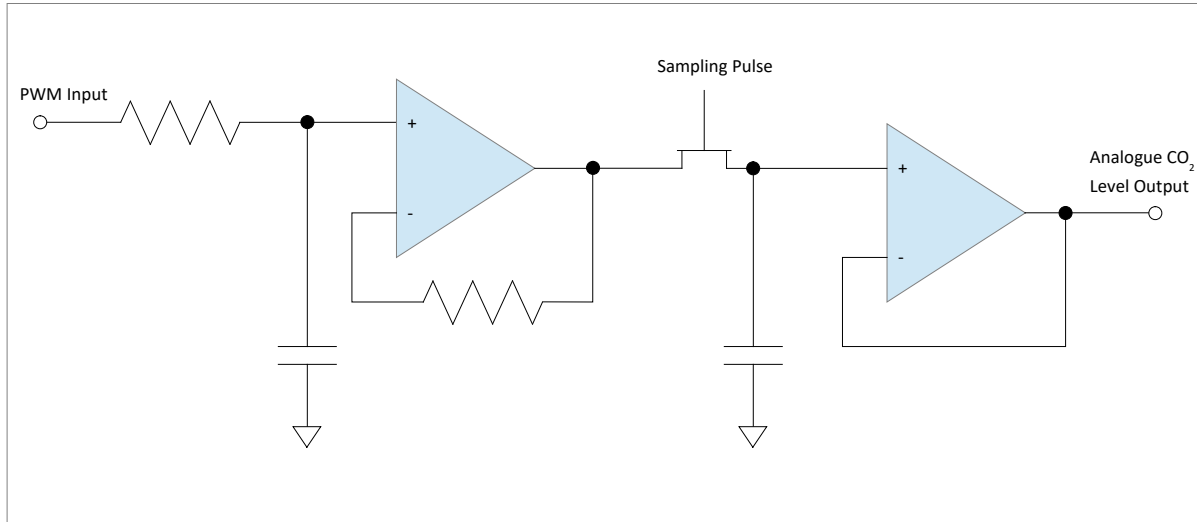
All GSS sensors provide a genuine analogue signal level output. The PWM signal could be filtered using a simple RC network, or filtered and buffered before being made available to the user. In normal circumstances, in order to maintain a constant output signal, the PWM signal must be run continuously, consuming unnecessary power.



However, in all GSS sensors where there is an analogue output CO₂ signal level option, GSS has chosen to implement a more sophisticated analogue output option, that saves power and does not need any external components.

The on-board PWM output is switched on in synchronisation with the sampling period. The digital PWM signal is filtered to create an analogue output, and the signal sampled by the sample and hold circuit. Once the signal is sampled by the sample and hold circuit, the PWM output from the microprocessor is stopped. This reduces noise in the sensor increasing measurement accuracy, and dramatically reduces sensor power consumption. Power consumption can be reduced by as much as 50% compared to a continuously running PWM output.

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ANALOGUE CO₂ SIGNAL LEVEL

The voltage range of the CO₂ level output from the sensor is determined by the sensor supply voltage. The sensor supply voltage defines the PWM signal levels. All voltage outputs are relative to the sensor input supply voltage. For example, if the supply voltage is 3.4V, then the full-scale output from the voltage pin will also be 3.4V, the half scale voltage will be 1.7V etc.

To convert a voltage into a CO₂ concentration, use the following formula.

$$\text{Concentration (ppm)} = \frac{V_{out}}{V_{supply}} * \text{Full Scale Range of Sensor (ppm)}$$

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CO₂ ANALOGUE OUTPUT PERFORMANCE CHARACTERISTICS

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage range ^{1,2}	ANALOGUE_OUTPUT		0		VDD	V
Repeatability		@25°C		±0.1		%
Response time		From 0ppm to T ₉₀ default settings		0.5		secs

Notes

The output CO₂ accuracy is degraded where ANALOGUE_OUTPUT <50mV, or >VDD-50mV
ANALOGUE_OUTPUT accuracy specified with a resistive loading @ >100Kohm

The CO₂ sensor voltage output pin has an internal resistance of approximately 150Ω. The internal capacitance between the voltage output pin and ground is 220nF. This gives the output a single order high frequency roll-off at about 4.8kHz.

To avoid loading issues affecting the measurement, it is essential to ensure the load connected to the voltage output pin is greater than 10kΩ and preferably greater than 100kΩ. A low value external load resistance will introduce reading errors as illustrated in the table below.

EXTERNAL LOAD RESISTANCE (OHMS)	CO ₂ MEASUREMENT ERROR
4k7	3%
10k	1.5%
100k	0.1%
500k	0.03%

The CO₂ analogue signal level accuracy is also affected by op-amp DC offsets and op-amp signal headroom. At low CO₂ concentrations, the DC offset of approximately 14mV will increasingly affect the signal level accuracy. At high CO₂ concentrations, the CO₂ analogue signal level is unable to generate a voltage of more than VDD-50mV. The user is advised to take care when interpreting CO₂ analogue signals below 50mV and or where the signal level is >VDD-50mV.

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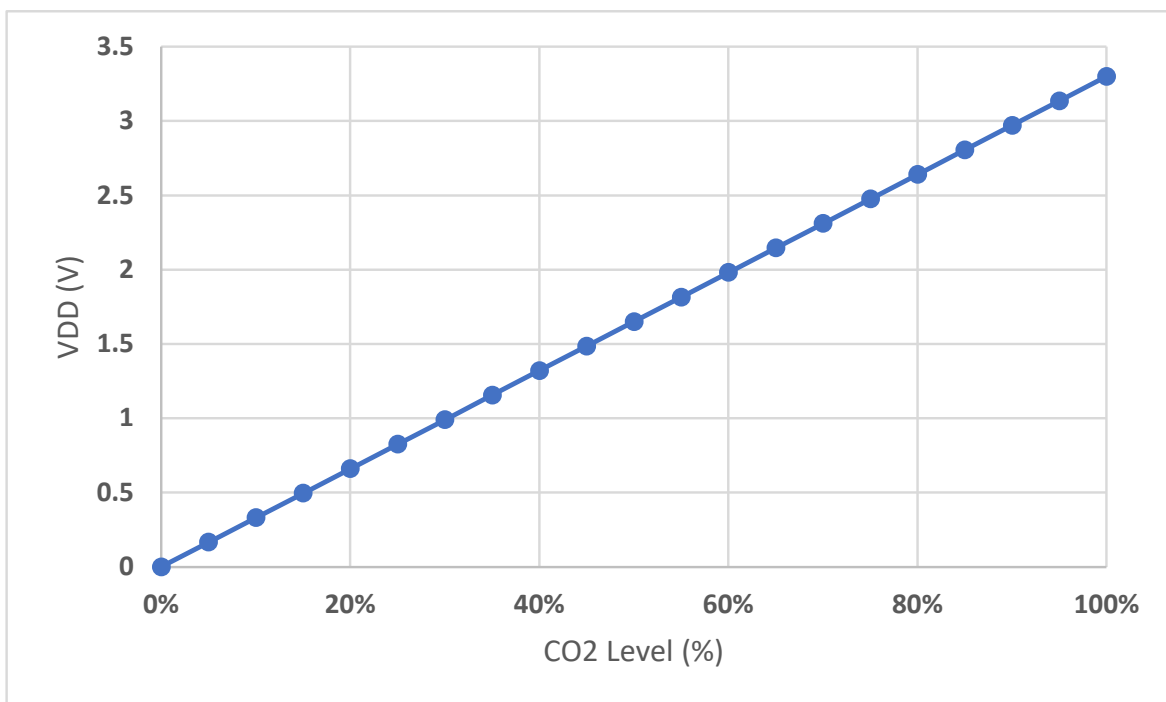
Although great care has been taken to minimise sensor noise, there may be some high frequency noise present on the analogue voltage output. The typical noise present on the voltage output is as follows with the voltage output at half full scale:

140 μ Vrms measured in a 20kHz bandwidth.
450 μ Vrms measured in a 10MHz bandwidth.

In a 10MHz bandwidth, the highest noise voltage amplitude is at least 70dB below the desired DC output voltage.

OUTPUT LINEARITY

The output voltage is linearly dependent on the CO₂ concentration measured by the sensor. However, as noted in the CO₂ analogue output performance characteristics, the accuracy of the reading will be compromised close to zero and near to full scale.



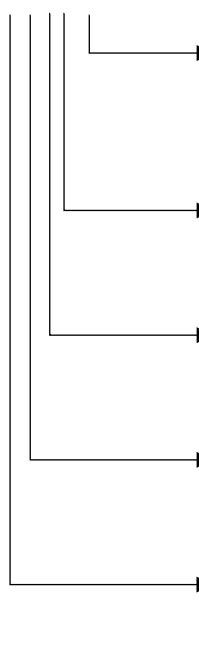
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SPECIFYING A VOLTAGE OUTPUT OPTION

The ordering guide for the CozIR[®]-A is shown below, but an analogue CO₂ signal output is available on several other GSS sensors. Refer to the specific sensor data sheet ordering information to determine if the option is available.

The full-scale analogue output signal range always matches the selected measurement range of the sensor. This means when the output signal level is full scale, the CO₂ level will be at full scale.

COZIR-A-X-XXX-X



X	Measurement Range
2000	2,000ppm
5000	5,000ppm
1	10,000ppm (1%)
X	Temperature and RH
H	Included
Blank	Not included
X	CO₂ Voltage Output
V	Included
Blank	Not included
X	Temperature Range
E	Extended, -25 to 55°C
Blank	Standard
X	Casing
U	Uncased
X	Cased

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ADDRESS

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REVISION HISTORY

DATE	RELEASE	DESCRIPTION OF CHANGES	PAGES
13/05/2020	1.0	First revision	All
18/05/2020	1.1	Re-write	All