

COZIR™ Application Note: Power Consumption

1	Overview	2
2	Operating Modes – Power Levels	3
2.1	Streaming Mode (K 1)	3
2.2	Polling Mode (K 2).....	3
2.3	Command Mode (K 0)	3
3	Current Profile.....	4
4	Warm-up Time	5
5	Minimising the Power in Streaming and Polling Modes.....	8
5.1	Polling and Streaming Key Points.....	8
6	Minimising Power using Command Mode.....	9
6.1	Command Mode Power Reduction Key Points	10
7	Minimising Power by Power Cycling	11
7.1	Power Cycling Key Points	12
8	Implementing a User Auto-Calibration Routine	12

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1 Overview

The COZIR family of sensors offers low power CO₂ sensing using patented GSS sensor technology. COZIR sensors are available over the whole measurement range from 400ppm to 100%.

COZIR sensors have been optimized for use in battery power applications where the short startup time and low power consumption offer very significant advantages over standard NDIR sensing technology.

Because of the very rapid power-up time, COZIR sensors are also being used in energy scavenged applications, using power sources such as PV cells, where it is essential to minimize the energy used per measurement.

This document considers the best methods to use in applications where energy is limited.

There are three distinct ways to operate the sensor:

Continuous Power, Continuous Measurement (3mW-3.5mW)

COZIR sensors are designed for continuous power operation. The typical power consumption is 3mW in polling mode, and 3.5mW in streaming mode. In these modes, the sensor is constantly measuring, two fresh measurements per second. In streaming mode, all measurements are transmitted. In polling mode, measurements are only transmitted when requested.

Continuous Power, Interrupted Measurement (power depends on usage)

Switching to a low power command mode ($150\mu\text{W}^3$) between measurements greatly reduces the average power consumption, though with some loss of functionality.

Power Cycled Operations (power depends on usage)

Short startup allows power cycling which gives the lowest power consumption. There is some loss of functionality which must be addressed by the user.

Operation	Measurements	Power Consumption¹	Autocalibration Available
Streaming	2 per second	3.5mW	Yes
Polling	2 per second	3.0mW	Yes
Command Mode	on demand	$270\mu\text{W}^{*3}$	Yes, but with modification.
Power Cycling	on demand	$120\mu\text{W}^*$	User Routine

^{*} Power consumption based on 1 reading every 5 minutes, sensor powered for 10s per reading

2 Operating Modes – Power Levels

There are three operating modes available in the COZIR range of sensors. Users can switch between modes using the 'K' command (see *COZIR Software User's Guide* for details).

2.1 Streaming Mode (K 1)

This is the factory default. Measurements are made and transmitted twice per second.

To enter Streaming mode, send `K 1\r\n`

The power consumption is approximately 3.5mW¹

2.2 Polling Mode (K 2)

In this mode, data is not transmitted until requested, however the sensor continues to make measurements twice per second.

To enter Polling mode, send `K 2\r\n`

The typical power consumption in this mode is 3.0mW when data is not being polled, and 3.5mW when data is polled.

2.3 Command Mode (K 0)

In command mode, no measurements are made or reported. This mode is primarily intended to be used when interacting with the sensor, for example to read the serial number, to determine the status or to set output mask or filter values. It can be used to reduce the power consumption by reducing the power level when measurements are not required. Users looking for the lowest power applications should consider powering down the sensor rather than using command mode to save power.

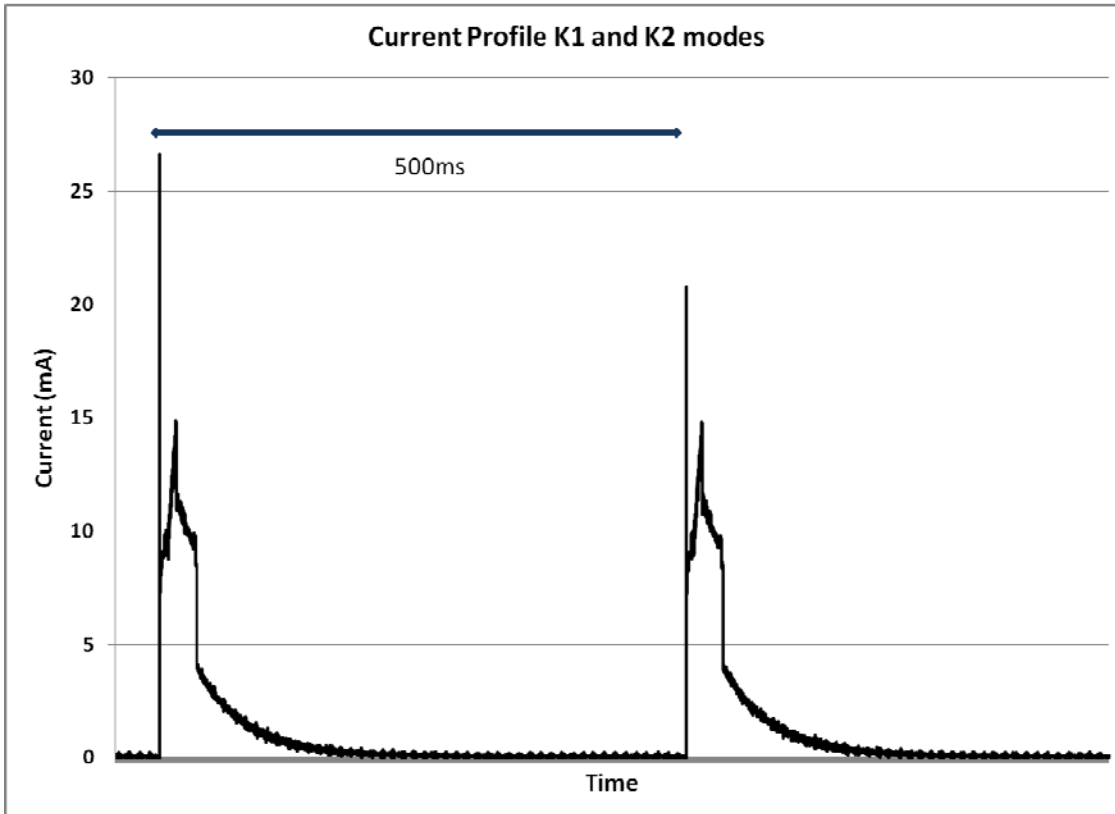
To enter command mode, send `K 0\r\n`

The typical power consumption in command mode is 150μW³.

3 Current Profile

Streaming mode and Polling mode are very similar. There is a very short initial inrush current at the start of each measurement cycle. The peak is typically 33mA, and is present for less than 1mS. GSS recommends that the sensor supply circuit is capable of supplying a peak of 100mA.

Each measurement cycle lasts 30ms-40ms depending on the number of output fields being transmitted. Between measurements cycles, the power consumption reduces to 150 μ W³.



4 Warm-up Time

When the sensor is powered up initially, or when it is switched from command mode, it must run through a short warm-up period.

The COZIR warm-up time comprises two parts; start-up cycle, and signal processing delay.

The start-up cycle takes 1.2s, during which time the sensor will use approximately 6mJ of energy. The first readings are transmitted by the sensor in streaming mode immediately following the start-up cycle.

The signal processing delay depends on user settings. The sensor has a low pass digital filter which smoothes the CO₂ reading (reported in the filtered CO₂ output -Z). It takes some time for the digital filter to reach a final value. This time depends on the digital filter setting, which is user configurable. To set the digital filter, use the A command:

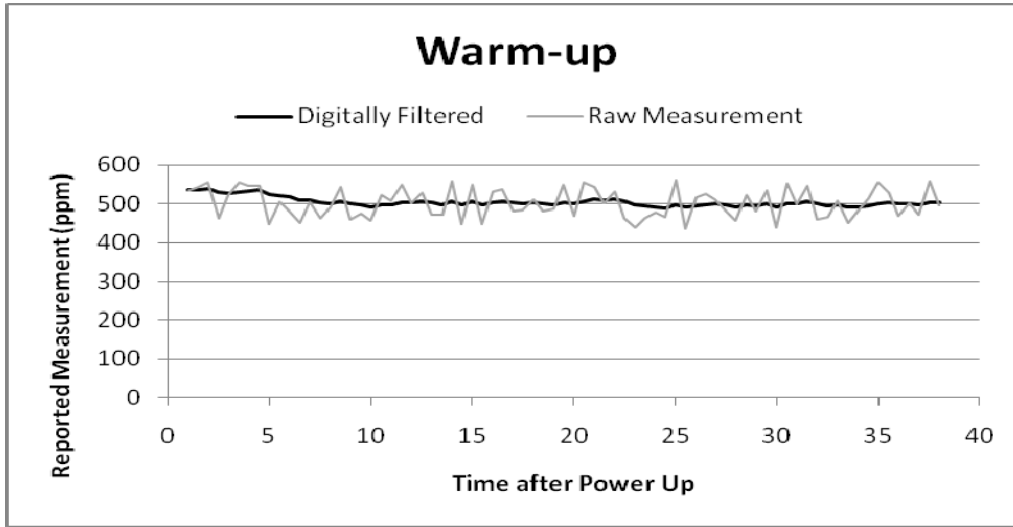
```
A #\r\n
```

where # is the digital filter setting (see *COZIR Software Users Guide* for more information).

The warm-up time must be long enough to allow the filter response to reach a final value. The required warm-up time in seconds is approximately equal to the filter value.

Filter Setting	Warm-up Time
1	1.2s
2	3s
4	5s
8	9s
16	16s
32	32s

The graph shows a typical start-up from command mode or from power up (there is no difference). In this case, the

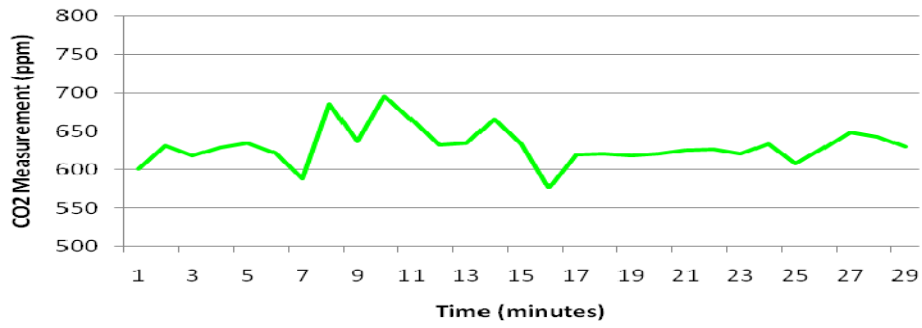


digital filter value was 8. In this case, the digital filter setting was 8.

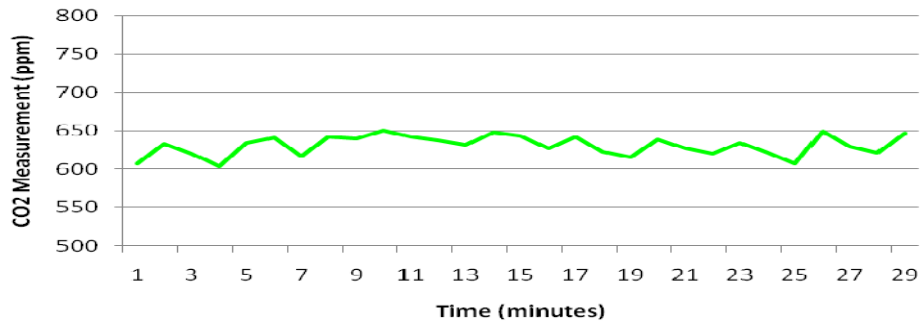
The choice of filter setting is a trade-off between reducing noise and reducing power (higher filter = lower noise, lower filter = shorter warm-up).

These shows the same sensor data, but with filter settings of 1, 4 and 8, and the corresponding warm-up period. The figure graphed is the CO₂ reading reported by the sensor at the end of the warm-up period.

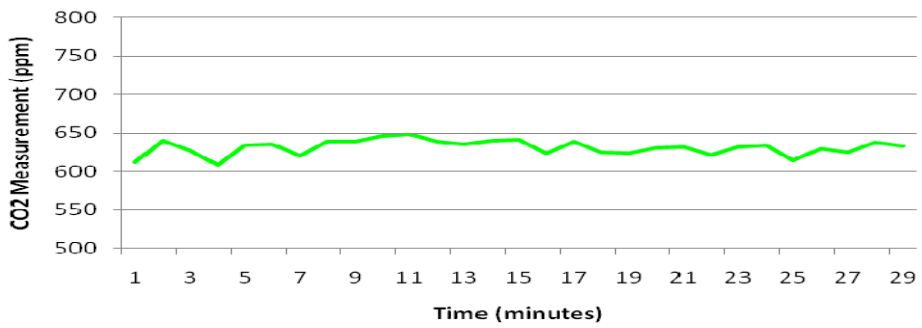
Power Cycle 1.2s on, 60s off



Power Cycle 5s on, 60s off



Power Cycle 10s on, 60s off



5 Minimizing the Power in Streaming and Polling Modes

Both polling and streaming are continuous power modes, using 3mW-3.5mW. The power consumption and measurement cycle cannot be varied in these modes, so the user must simply focus on minimizing any options on the sensor. The lowest power is achieved by reporting one value only, the CO₂ measurement.

Additional features will increase the power consumption, for example, temperature and humidity measurement, voltage output, or additional output fields. These should be avoided in low power applications.

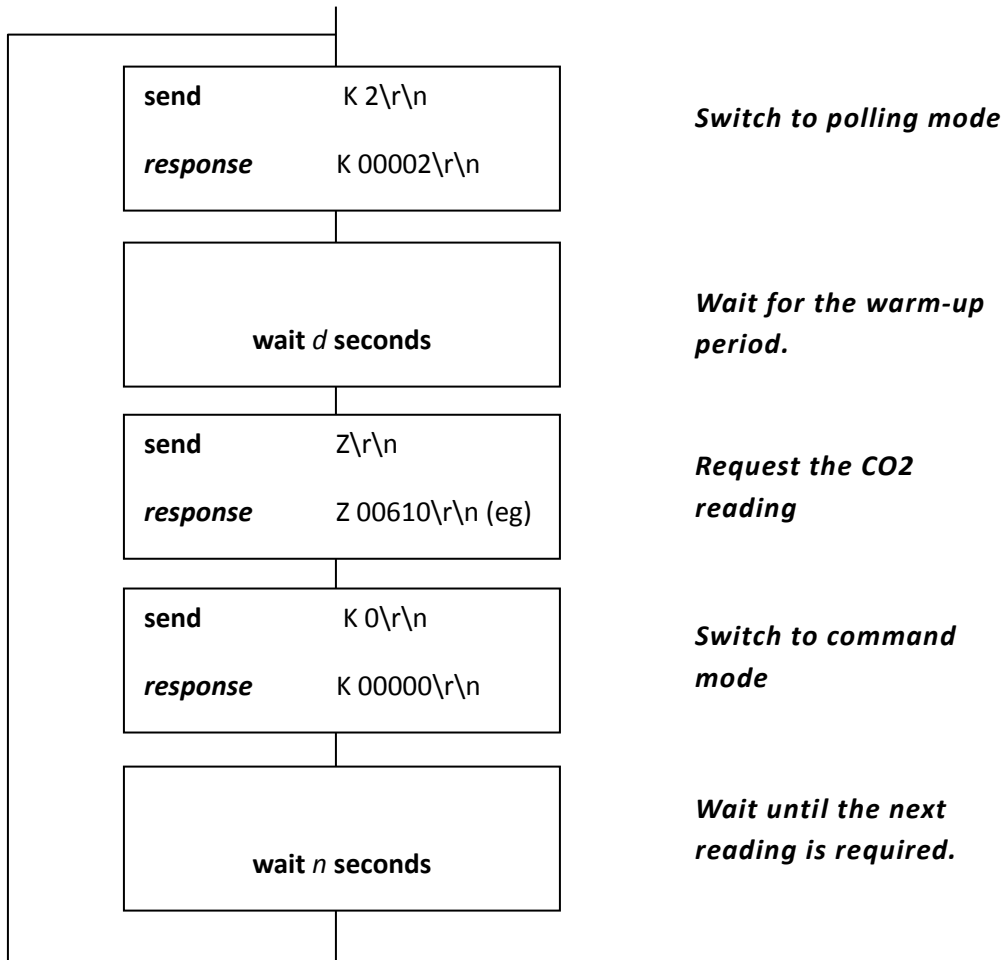
5.1 Polling and Streaming Key Points

- Use polling mode to minimize transmission time. This will reduce the average power consumption by approximately 0.5mW, depending on the polling frequency.
- Ensure that only necessary output fields are turned on to minimize the measurement Tx time. Use the M command to configure the output fields. To return the filtered CO₂ value only (recommended) send M 4\r\n to the sensor. Each additional output field will add approximately 0.25mW to the total power consumption.
- Use the digital output from the sensor only. The voltage output (optional fit) increases the power consumption.
- The temperature and Humidity sensor (optional fit) increases the power consumption by approximately 1mW.
- The lowest achievable power using continuous measurements is approximately 3mW.
- All functionality is preserved and the sensor will be fully responsive to commands at all times.

6 Minimizing Power using Command Mode

It is possible to reduce the power consumption by switching the sensor into command mode between measurements. The power consumption in command mode is only $150\mu W^3$, much lower than either polling or streaming data.

This is simple to implement using the COZIR commands:



where:

d is the warm-up delay

and

$n+d$ is the gap between measurements

This method offers much lower average power than conventional power up modes, though with some loss of functionality.

6.1 Command Mode Power Reduction Key Points

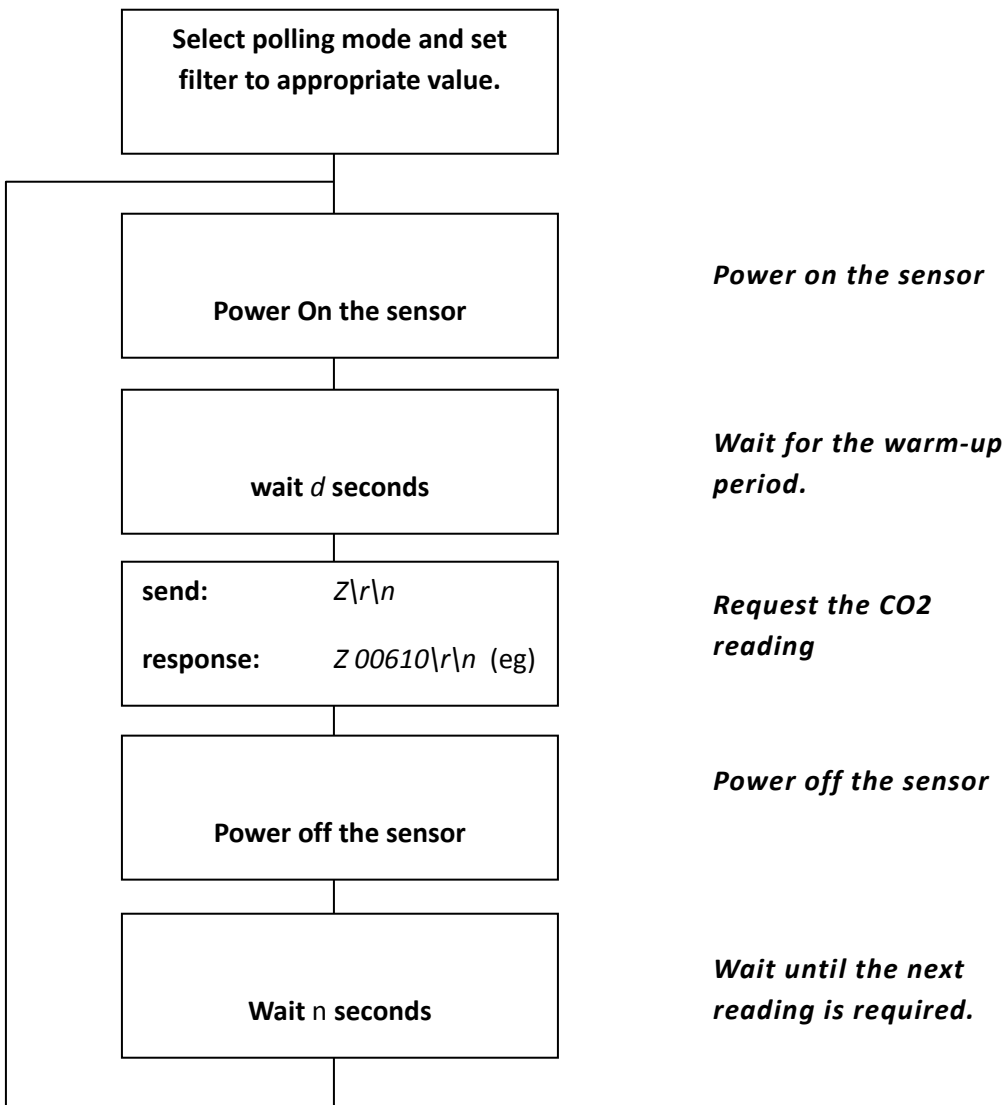
- When exiting from command mode, the sensor must run through the same warm-up period as a newly powered sensor. See the warm-up section for details and recommended times.
- None of the zeroing functions are operational in command mode.
- The autocalibration process is timed by measurement cycles. As measurement cycles are suspended in command mode, the autocalibration period must be adjusted to take account of the decreased number of measurements. For example, if the sensor is used in command mode, and powered up for only 10s every 5 minutes, the autocalibration counter will run 30x slower than in streaming or polling mode, so the autocalibration period should be adjusted to reflect that. See *COZIR Application Note Auto-Calibration* for details of the autocalibration set-up.
- The power level will depend on the duty cycle of the sensor. It will typically be possible to achieve levels of less than 300 μ W.
- The digital filter will retain the last reading when switching into command mode, and use this as its initial value when the sensor measurement is switched on again (filtered output only). If there is a very large step change between readings, the filter may not reach a final stable value in one warm-up cycle. User's can avoid this potential issue by implementing their own signal conditioning using the unfiltered (z) output from the sensor.
- The sensor will always power up in Streaming or Polling mode (whichever was the last selected). It will not power up in command mode – this has to be selected by the user.

7 Minimizing Power by Power Cycling

When there are very low levels of power available, for example using a PV cell, the best option is to power down the sensor between measurements. Because of the short warm-up times, this approach can be used to run sensors indefinitely from a solar cell, or for many years from a small primary cell.

The user must address zero point calibration (autocalibration) see below.

The typical implementation is:



7.1 Power Cycling Key Points

- Ensure that the sensor is configured for polling mode.
- Ensure that the filter setting matches the planned power on period.
- COZIR sensors will store configuration information in non volatile memory, so this does not need to be refreshed when the sensor is powered up.
- On each power up, the sensor must run through the same warm-up period. See the warm-up section for details and recommended times.
- The autocalibration is disabled when the sensor is powered down, and the autocalibration timers are reset on power up. Users must implement their own autocalibration routine when power cycling. See *Implementing a User Autocalibration Routine*.
- The power level will depend on the duty cycle of the sensor.
- The power switch to the sensor must ensure that the sensor power supply requirements can be met, in particular, the peak current requirement (33mA) and minimum voltage (3.2V).

8 Implementing a User Auto-Calibration Routine

COZIR sensors have an autocalibration feature which uses background tracking to provide long term stability for the sensor. Please see *COZIR Application Note Auto-calibration* for further details.

This feature is disabled when the sensor is power cycled, or switched to command mode, and the responsibility for this routine switches to the user.

It is possible to calibrate the sensor using the standard zeroing commands (see *COZIR Software User's Guide*).

In many cases, it is preferable to implement a version of autocalibration which recalibrates the sensor zero point using the CO₂ background of approximately 400ppm to recalibrate the sensor zero point. This relies on the sensor being exposed to fresh air at least once during the calibration interval. For many applications, this condition is met overnight or during weekends when buildings are little occupied.

The COZIR sensor has a zero calibration option designed to allow users to implement an autocalibration routine when the sensor is not continuously powered.

First, select a calibration period. The choice of period should be long enough to ensure exposure to fresh air, so should usually be no less than one week.

Next, select the value of background CO₂ expected. COZIR sensors have a default of 400ppm, but users can select any value.

Now review the sensor output during the calibration period and note the lowest CO₂ value recorded. This is assumed to be ambient levels.

Finally, send a correction to the sensor to instruct it that this level should be corrected to read the background CO₂ level. This uses the COZIR "F" command (see *COZIR Software User's Guide*).

This command has the format `F ##### *****\r\n`

Where `#####` is the reading displayed by the sensor, and `*****` is the corrected reading.

For example, if the lowest reading measured over 3 weeks was 415ppm, and the user wants to correct that to read 400ppm, the command would be `F 415 400\r\n`.

Note that the this command can only be used once on a set of historic readings. To repeat the F command, a new set of readings must be generated.

Notes

¹ Power measurements are typical values for sensors measured at GSS at room temperature. Unless otherwise stated, power levels assume that each measurement comprises a CO₂ measurement only. The optional humidity sensor and voltage output will increase the power consumption. The power consumption will increase with temperature.

² Throughout this document, `\r\n` is used to signify the ASCII characters Carriage Return and Line feed, 0x0d, 0x0a.

³ Power levels in command mode vary with temperature. This is due to increased current in some of the individual components. The power level at 50°C can be 2x the power level at 20°C.