

## Small Footprint Low Power CO<sub>2</sub> Sensor

### DESCRIPTION

The ExplorIR®-W is a small footprint low power NDIR CO<sub>2</sub> sensors using state-of-the-art solid-state LED optical technology. The low power LEDs are manufactured in-house, giving GSS complete control of the CO<sub>2</sub> sensor signal chain.

The ExplorIR®-W is designed for applications that need to work reliably over a wide range of conditions and environments. The sensor is available in multiple versions with several user selectable options, including temperature and RH measurement capability. The sensor will measure CO<sub>2</sub> levels up to 100% concentration.

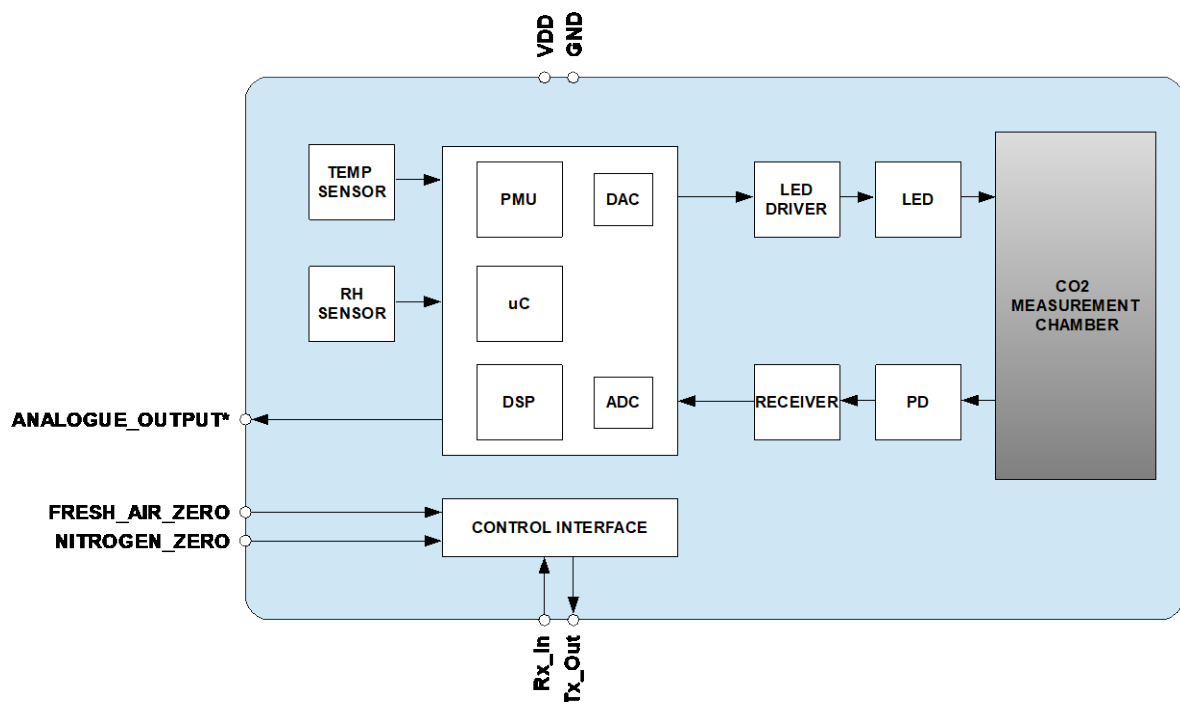
### FEATURES

- Low power CO<sub>2</sub> sensor
- 70ppm typical measurement accuracy
- Measurement range up to 100%
- Solid state NDIR LED optical technology
- UART control and data interface
- Built-in auto-calibration

### APPLICATIONS

- Agriculture
- Healthcare
- Safety
- Aerospace
- Food packaging
- Incubators
- Food storage and transportation

### BLOCK DIAGRAM



T, RH and \* Optional

## Small Footprint Low Power CO<sub>2</sub> Sensor

### TABLE OF CONTENTS

|   |    |
|---|----|
| DESCRIPTION.....  | 1  |
| FEATURES.....   | 1  |
| APPLICATIONS.....   | 1  |
| BLOCK DIAGRAM.....  | 1  |
| ORDERING INFORMATION.....   | 4  |
| PACKAGE DRAWING: ExplorIR®-W.....   | 5  |
| PIN-OUT DESCRIPTION: ExplorIR®-W.....   | 5  |
| FLOW ADAPTOR DRAWING: ExplorIR®-W.....  | 6  |
| ABSOLUTE MAXIMUM RATINGS.....   | 7  |
| RECOMMENDED OPERATING CONDITIONS.....   | 7  |
| MECHANICAL SEALING – FLOW ADAPTOR OPTION ONLY.....                                    | 7  |
| CO <sub>2</sub> PERFORMANCE CHARACTERISTICS.....                                      | 8  |
| HUMIDITY PERFORMANCE CHARACTERISTICS - ExplorIR®-W Option.....                        | 9  |
| TEMPERATURE PERFORMANCE CHARACTERISTICS - ExplorIR®-W Option.....                     | 9  |
| CO <sub>2</sub> ANALOGUE OUTPUT PERFORMANCE CHARACTERISTICS – ExplorIR®-W Option..... | 9  |
| ELECTRICAL CHARACTERISTICS.....   | 10 |
| POWER CONSUMPTION - ExplorIR®-W.....  | 10 |
| INTERFACE TIMING – NITROGEN_ZERO and FRESH_AIR_ZERO.....                              | 11 |
| METHOD OF OPERATION.....  | 12 |
| MODE 0 COMMAND MODE.....  | 12 |
| MODE 1 STREAMING MODE.....  | 12 |
| MODE 2 POLLING MODE.....  | 12 |
| DIGITAL FILTER.....   | 13 |
| ZERO POINT CALIBRATION.....   | 14 |
| ZERO IN A KNOWN GAS CONCENTRATION.....  | 14 |
| ZERO IN NITROGEN.....   | 14 |
| ZERO IN FRESH AIR.....  | 14 |
| ZERO POINT ADJUSTMENT.....  | 15 |
| AUTO-CALIBRATION.....   | 15 |
| AUTO-CALIBRATION INTERVALS.....   | 15 |
| AUTO-CALIBRATION SETTINGS.....  | 15 |
| PRESSURE AND CONCENTRATION LEVEL COMPENSATION.....                                    | 16 |
| ALTITUDE COMPENSATION TABLE.....  | 16 |
| CONTROL INTERFACE.....  | 18 |
| CONTROL INTERFACE TIMING - UART MODE.....   | 18 |
| UART COMMAND PROTOCOL.....  | 18 |
| UART OPERATION.....   | 18 |
| UART INTERFACE SUMMARY.....   | 19 |
| CO <sub>2</sub> LEVEL MEASUREMENT VALUE - Z INFORMATION (0x5A).....                   | 21 |
| CO <sub>2</sub> LEVEL MEASUREMENT VALUE - z INFORMATION (0x7A).....                   | 21 |
| ‘.’ COMMAND (0x2E).....   | 21 |
| TEMPERATURE MEASUREMENT VALUE - ExplorIR®-W Option.....                               | 22 |
| HUMIDITY MEASUREMENT VALUE - ExplorIR®-W Option.....                                  | 22 |

**Small Footprint Low Power CO<sub>2</sub> Sensor**

---

|  |    |
|--|----|
| CO <sub>2</sub> ANALOGUE OUTPUT COMMAND.....                       | 23 |
| K COMMAND.....   | 24 |
| K COMMAND (0x4B) .....   | 24 |
| DIGITAL FILTER COMMANDS .....                                      | 24 |
| A COMMAND (0x41) .....   | 24 |
| a COMMAND (0x61).....  | 24 |
| ZERO POINT CALIBRATION COMMANDS .....                              | 25 |
| F COMMAND (0x46).....  | 25 |
| G COMMAND (0x47) .....   | 26 |
| U COMMAND (0x55).....  | 26 |
| u COMMAND (0x75) .....   | 26 |
| X COMMAND (0x58) .....   | 26 |
| P COMMAND - CO <sub>2</sub> Level for Auto-calibration .....       | 26 |
| P COMMAND – CO <sub>2</sub> Level for Zero-Point Calibration ..... | 27 |
| AUTO-CALIBRATION INTERVALS .....                                   | 28 |
| @ COMMAND (0x2E).....  | 28 |
| PRESSURE AND CONCENTRATION COMPENSATION .....                      | 29 |
| S COMMAND (0x53).....  | 29 |
| s COMMAND (0x73).....  | 29 |
| MEASUREMENT DATA OUTPUTS .....                                     | 30 |
| M COMMAND .....  | 31 |
| Q COMMAND .....  | 31 |
| SERIAL NUMBER AND FIRMWARE VERSION .....                           | 31 |
| CONNECTION DIAGRAM FOR UART INTERFACE .....                        | 33 |
| IMPORTANT NOTICE .....   | 34 |
| ADDRESS .....  | 34 |

## Small Footprint Low Power CO<sub>2</sub> Sensor

### ORDERING INFORMATION

#### EXPLORIR-W-X-XXX-X

|       |                                      |
|-------|--------------------------------------|
| X     | <b>Measurement Range</b>             |
| 5     | 0-5%                                 |
| 20    | 0-20%                                |
| 60    | 0-60%                                |
| 100   | 0-100%                               |
| X     | <b>Temperature and RH</b>            |
| H     | Included                             |
| Blank | Not included                         |
| X     | <b>CO<sub>2</sub> Voltage Output</b> |
| V     | Included                             |
| Blank | Not included                         |
| X     | <b>Temperature Range</b>             |
| E     | Extended, -25 to 55°C                |
| Blank | Standard                             |
| X     | <b>Flow Adaptor</b>                  |
| F     | Included                             |
| X     | Not included                         |

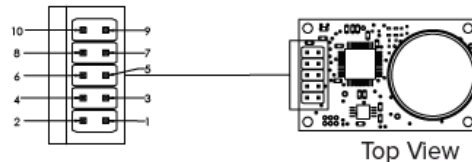
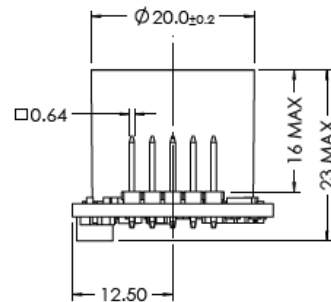
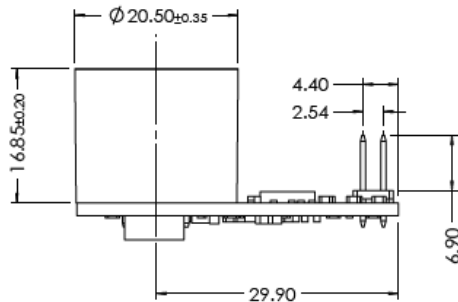
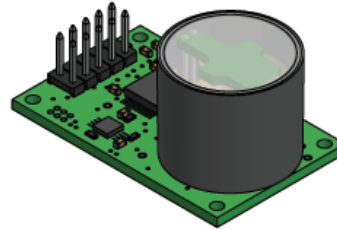
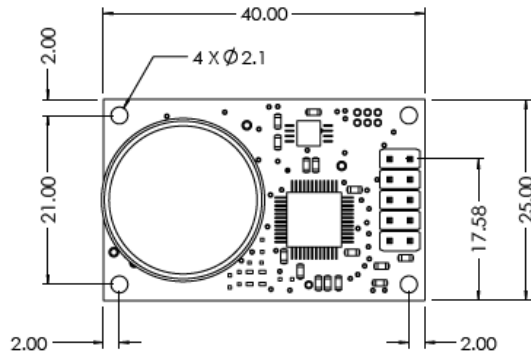
#### Notes:

1. Sensors are shipped individually

See separate data sheet for ExplorIR®-W evaluation kit options

## Small Footprint Low Power CO<sub>2</sub> Sensor

### PACKAGE DRAWING: ExplorIR®-W



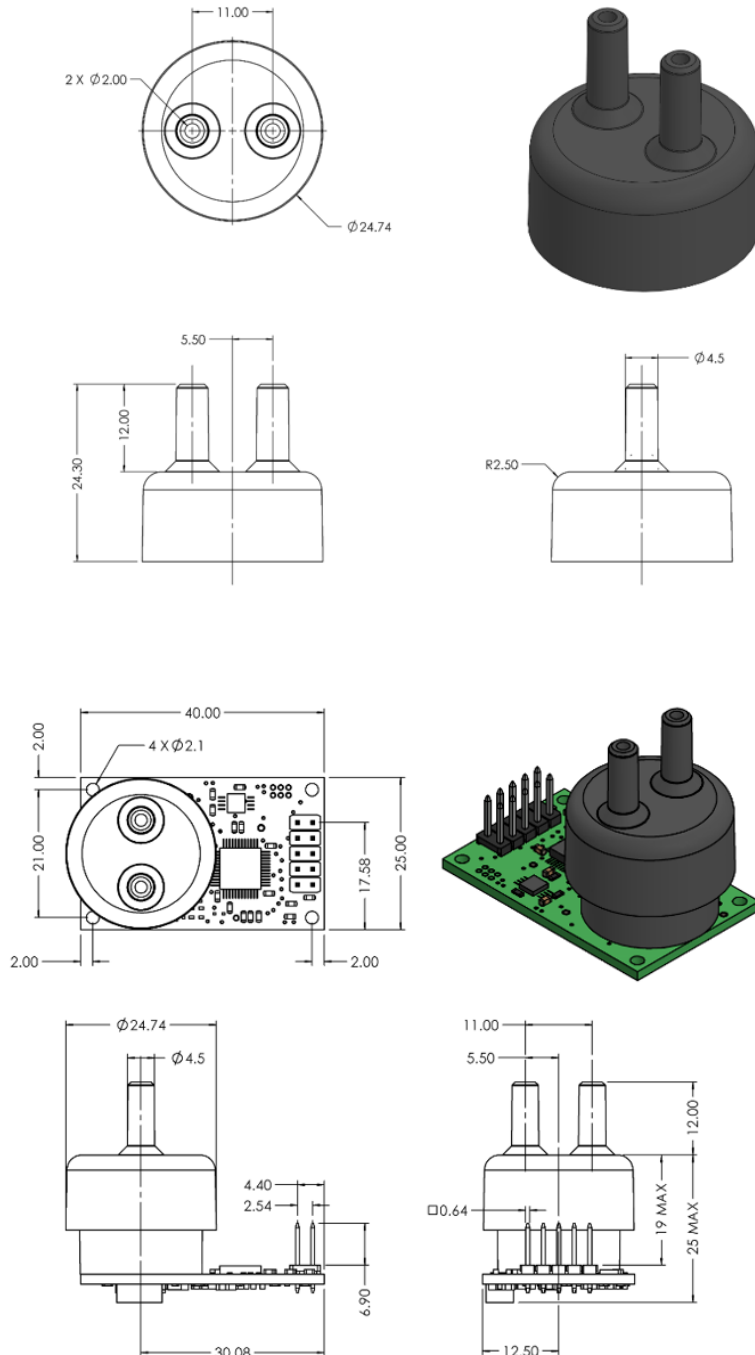
Weight = ~6g

### PIN-OUT DESCRIPTION: ExplorIR®-W

| PIN | NAME            | TYPE            | DESCRIPTION   |
|-----|-----------------|-----------------|---|
| 1   | GND             | Supply          | Sensor ground   |
| 2   | NC              | Unused          | Do Not Connect  |
| 3   | VDD             | Supply          | Sensor supply voltage                                     |
| 4   | GND             | Supply          | Sensor ground   |
| 5   | Rx_In           | Digital Input   | UART Receive Input  |
| 6   | GND             | Supply          | Sensor ground   |
| 7   | Tx_Out          | Digital Output  | UART Transmit Output                                      |
| 8   | NITROGEN_ZERO   | Digital Input   | Set low to initiate a Zero in Nitrogen Calibration Cycle  |
| 9   | ANALOGUE_OUTPUT | Analogue Output | CO <sub>2</sub> Level (Optional)                          |
| 10  | FRESH_AIR_ZERO  | Digital Input   | Set low to initiate a Zero in Fresh Air Calibration Cycle |

**Small Footprint Low Power CO<sub>2</sub> Sensor**

**FLOW ADAPTOR DRAWING: ExplorIR®-W**



**Notes**

1. The flow adaptor is sealed over the existing outer body of the sensor and replaces the membrane cover of the standard sensor

## Small Footprint Low Power CO<sub>2</sub> Sensor

### ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings are stress ratings only. Permanent damage to the ExplorIR® may be caused by continuously operating at or beyond these limits. The ExplorIR® functional operating limits and guaranteed performance specifications are given at the test conditions specified.



ESD Sensitive Device. This sensor uses ESD sensitive components. It is therefore generically susceptible to damage from excessive static voltages. Proper ESD precautions must be taken during handling and storage of this device.

| CONDITION                                     | MIN       | MAX   |
|---|-----------|-------|
| Supply Voltages                               | -0.3V     | +6.0V |
| Voltage Range Digital Inputs                  | GND -0.3V | 5V    |
| Operating Temperature Range (T <sub>a</sub> ) |           |       |
| - Standard                                    | 0°C       | +50°C |
| - Extended                                    | -25°C     | +55°C |
| Storage Temperature Range                     | -40°C     | +70°C |
| Humidity Range (RH), Non-Condensing           | 0         | 95%   |
| Operating Ambient Pressure Range              | 500mbar   | 2bar  |

### RECOMMENDED OPERATING CONDITIONS

| PARAMETER | SYMBOL | MIN  | TYP | MAX | UNIT |
|-----------|--------|------|-----|-----|------|
| Supply    | VDD    | 3.25 | 3.3 | 5.5 | V    |
| Ground    | GND    |      | 0   |     | V    |

### MECHANICAL SEALING – FLOW ADAPTOR OPTION ONLY

| CONDITION                         | MIN    | MAX |
|-----------------------------------|--------|-----|
| Test gauge pressure <sup>1</sup>  | 0.3bar |     |
| Burst gauge pressure <sup>2</sup> | 2bar   |     |

#### Test Conditions Unless Otherwise Specified

1. The mechanical sealing between the flow adaptor and sensor housing is tested by pressurising the gas chamber to 0.3bar. The pressure reading must not drop by more than 1mbar within 30 seconds
2. Guaranteed by design, not tested
3. Sensors with a membrane cover do not have an air-tight seal between the sensor casing and the main sensor body.

## Small Footprint Low Power CO<sub>2</sub> Sensor

### CO<sub>2</sub> PERFORMANCE CHARACTERISTICS

Test Conditions Unless Otherwise Specified

VDD = 3.3V, GND = 0V. CO<sub>2</sub> = 450ppm, RH = 0% non-condensing, T= 25°C, Pressure = 1013mbar

| PARAMETER                                | SYMBOL | TEST CONDITIONS  | MIN | TYP                      | MAX       | UNIT |
|--|--------|--|-----|--------------------------|-----------|------|
| CO <sub>2</sub> measurement range        |        |  | 0   |                          | 5         | %    |
|  |        |  | 0   |                          | 20        | %    |
|  |        |  | 0   |                          | 60        | %    |
|  |        |  | 0   |                          | 100       | %    |
| Accuracy (Peak-Peak) 0-60%               |        | @25°C  |     | ±70, +5%                 | ±100, +5% | ppm  |
|  |        | 0°C to +55°C, after auto-zero @25°C                            |     | ±70, +5%, +0.1% per °C   |           | ppm  |
|  |        | -25°C to +55°C, after auto-zero @25°C                          |     | ±70, +5%, +0.1% per °C   |           | ppm  |
| Accuracy (Peak-Peak) 0-100%              |        | @25°C  |     | ±300, +5%                | ±300, +5% | ppm  |
|  |        | 0°C to +55°C, after auto-zero @25°C                            |     | ±300, +5%, +0.1% per °C  |           | ppm  |
|  |        | -25°C to +55°C, after auto-zero @25°C                          |     | ±1000, +5%, +0.1% per °C |           | ppm  |
| CO <sub>2</sub> RMS Noise                |        | Digital filter setting 16                                      |     | 6                        |           | ppm  |
| Time to Valid Measurement After Power-On |        | Digital filter setting 16, dependent on digital filter setting | 0.8 | 8.3                      |           | secs |
| Response Time                            |        | T <sub>90</sub> , no filter, diffusion                         |     | 8                        |           | secs |
|  |        | T <sub>90</sub> , filter = 16, diffusion                       |     | 22                       |           |      |
|  |        | T <sub>90</sub> , no filter @ 0.1l/min, flow port              |     | 5.0                      |           |      |
|  |        | T <sub>90</sub> , filter = 16 @ 0.1l/min. flow port            |     | 18                       |           |      |
| Repeatability                            |        | @25°C, 0-60%   |     | ±70, +5%                 |           | ppm  |
|  |        | @25°C, 0-100%  |     | ±300, +5%                |           | ppm  |
| Current Consumption                      |        | Peak current when sampling                                     |     | 35                       |           | mA   |
|  |        | Peak at turn-on  |     | 40                       |           | mA   |
|  |        | SLEEP Mode (K2 polling)  |     | 0.01                     |           | mA   |



## Small Footprint Low Power CO<sub>2</sub> Sensor

### HUMIDITY PERFORMANCE CHARACTERISTICS - ExplorIR®-W Option

| PARAMETER                  | SYMBOL | TEST CONDITIONS | MIN | TYP  | MAX | UNIT    |
|----------------------------|--------|-----------------|-----|------|-----|---------|
| Humidity measurement range |        |                 | 0   |      | 100 | %       |
| Accuracy                   |        | @25°C           |     | ±3   |     | % RH    |
| Repeatability              |        | @25°C           |     | ±1   |     | %       |
| Response time              |        | 0-50%           |     | <8   |     | secs    |
| Accuracy drift             |        |                 |     | 0.25 |     | % RH/Yr |

### TEMPERATURE PERFORMANCE CHARACTERISTICS - ExplorIR®-W Option

| PARAMETER                     | SYMBOL | TEST CONDITIONS | MIN | TYP  | MAX | UNIT |
|-------------------------------|--------|-----------------|-----|------|-----|------|
| Temperature measurement range |        |                 | -25 |      | 55  | °C   |
| Accuracy                      |        | 0-50°C          |     | ±0.5 |     | °C   |
| Repeatability                 |        | @25°C           |     | ±0.1 |     | %    |
| Response time                 |        | 0-50%, @25°C    |     | >10  |     | secs |
| Accuracy drift                |        |                 |     | 0.03 |     | %/Yr |

### CO<sub>2</sub> ANALOGUE OUTPUT PERFORMANCE CHARACTERISTICS – ExplorIR®-W Option

| PARAMETER                           | SYMBOL          | TEST CONDITIONS                               | MIN | TYP  | MAX | UNIT   |
|-------------------------------------|-----------------|---|-----|------|-----|--------|
| Output voltage range <sup>1,2</sup> | ANALOGUE_OUTPUT |   | 0   |      | VDD | V      |
| CO <sub>2</sub> level               |                 | 0-10%   |     | 33   |     | uV/ppm |
|                                     |                 | 0-20%   |     | 16.5 |     | uV/ppm |
|                                     |                 | 0-60%   |     | 5.5  |     | uV/ppm |
|                                     |                 | 0-100%  |     | 3.3  |     | uV/ppm |
| Repeatability                       |                 | @25°C, 0-60%                                  |     | ±0.1 |     | %      |
|                                     |                 | @25°C, 0-100%                                 |     | ±0.1 |     | %      |
| Response time                       |                 | From 0ppm to T <sub>50</sub> default settings |     | 0.5  |     | secs   |

#### Notes

1. The output CO<sub>2</sub> accuracy is degraded where ANALOGUE\_OUTPUT <50mV, or >VDD-50mV
2. ANALOGUE\_OUTPUT accuracy specified with a resistive loading @ >100Kohm

## Small Footprint Low Power CO<sub>2</sub> Sensor

**ELECTRICAL CHARACTERISTICS**

| PARAMETER                   | SYMBOL | TEST CONDITIONS        | MIN | TYP | MAX | UNIT |
|-----------------------------|--------|------------------------|-----|-----|-----|------|
| <b>Digital Input/Output</b> |        |                        |     |     |     |      |
| Input HIGH Level            |        |                        | 1.8 |     |     | V    |
| Input LOW Level             |        |                        |     |     | 1.0 | V    |
| Output HIGH Level           |        | I <sub>OH</sub> = +1mA | 2.6 |     | 3.0 | V    |
| Output LOW Level            |        | I <sub>OL</sub> = -1mA |     |     | 0.4 | V    |

**POWER CONSUMPTION - ExplorIR®-W**

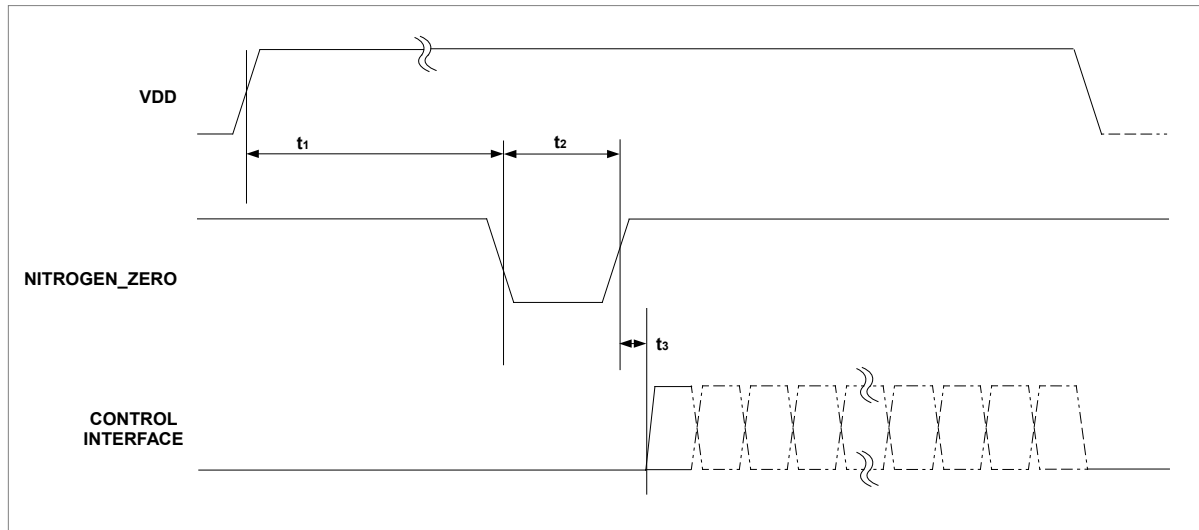
Test Conditions Unless Otherwise Specified

VDD = 3.3V, GND = 0V. CO<sub>2</sub> = 450ppm, RH = 0% non-condensing, T= 25°C, Pressure = 1013mbar

| SETTING  | SYMBOL | TEST CONDITIONS                      | VDD |        | Total Power |
|--|--------|--------------------------------------|-----|--------|-------------|
|  |        |                                      | V   | I (mA) | mW          |
| OFF  |        | No power applied                     |     | 0      | 0           |
| Active, K0 SLEEP mode, no measurement                      |        |                                      | 3.3 | 0.01   | 0.03        |
| Active, K1 mode whilst taking CO <sub>2</sub> measurements |        | Default settings                     | 3.3 | 1      | 3.5         |
| With RH active   |        | RH measurement on                    |     | +0.05  | +0.2        |
| With T active  |        | Temperature measurement on           |     | +0.05  | +0.2        |
| With CO <sub>2</sub> active                                |        | With analogue CO <sub>2</sub> output |     | +0.02  | +0.1        |

## Small Footprint Low Power CO<sub>2</sub> Sensor

### INTERFACE TIMING – NITROGEN\_ZERO and FRESH\_AIR\_ZERO



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

#### Notes

1. The timing for FRESH\_AIR\_ZERO is identical to NITROGEN\_ZERO
2. Ensure gas concentration is stable ( $t_1$ ) before beginning zeroing process

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### METHOD OF OPERATION

After power is applied to the ExplorIR®-W, the sensor will automatically start to take CO<sub>2</sub> measurements using the Mode 1 default settings, where the sensor is pre-programmed to send CO<sub>2</sub> measurement data at 2 readings per second. The measurement rate is fixed at 2 readings per second at 9600 baud rate. The sensor will return the previous CO<sub>2</sub> measurement results if the user requests more frequent measurements. The ExplorIR®-W has 3 potential modes of operation.

### MODE 0 COMMAND MODE

In this mode, the sensor is in a SLEEP mode, waiting for commands. No measurements are made. There is no latency in command responses. All commands that report measurements or alter the zero-point settings are disabled in Mode 0. Mode 0 is NOT retained after power cycling.

### MODE 1 STREAMING MODE

This is the factory default setting. Measurements are reported twice per second. Commands are processed when received, except during measurement activity, so there may be a time delay of up to 10ms in responding to commands.

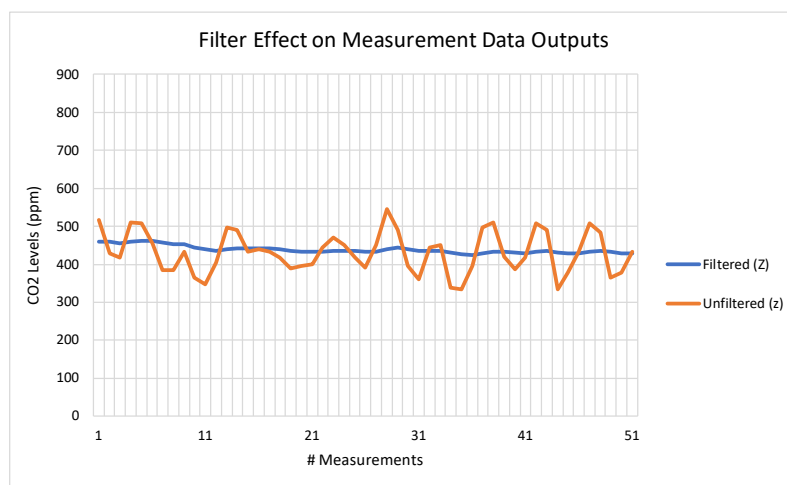
### MODE 2 POLLING MODE

In polling mode, the sensor only reports readings when requested. The sensor will continue to take measurements in the background, but the output stream is suppressed until data is requested. The sensor will always power up in streaming or polling mode, whichever mode was used before the power cycle.

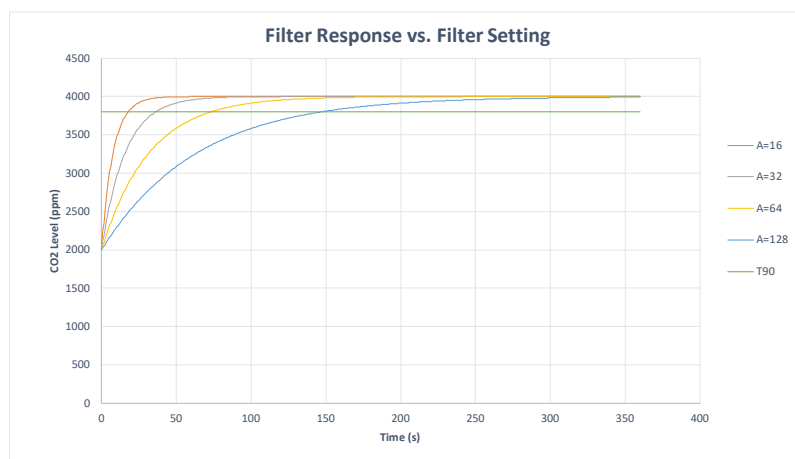
## Small Footprint Low Power CO<sub>2</sub> Sensor

### DIGITAL FILTER

The CO<sub>2</sub> gas chamber is illuminated with a nominal 4.25um wavelength LED and the signal received using a photo-diode. The signal from the photo-diode is processed and filtered by the sensor to remove noise and provide an accurate CO<sub>2</sub> reading. High frequency noise coming from the sampling process is removed using a proprietary lowpass filter. The digital filter setting can be varied, allowing the user to reduce measurement noise at the expense of the measurement response time. The ideal digital filter setting is application specific and is normally a balance between CO<sub>2</sub> reading accuracy and response time. The ExplorIR®-W sensor will also output the raw unfiltered CO<sub>2</sub> measurement data. This data can be post processed using alternative filter algorithms.



The graph above shows the effects of the filter on the CO<sub>2</sub> measurement data (Z or z). The unfiltered output is shown in orange and the filtered output shown in blue.



The graph above shows the effect of the filter on response times. Increasing the filter setting increases the measurement output response time. T<sub>90</sub> is the time to 90% of reading. The ExplorIR®-W takes 2 readings per second.

## **Small Footprint Low Power CO<sub>2</sub> Sensor**

---

### **ZERO POINT CALIBRATION**

There are a several methods available to the user to calibrate the zero point of the sensor. The recommended method is zero-point calibration in a known gas concentration. In all cases, the best zero is obtained when the gas concentration is stable, and the sensor is at a stabilised temperature.

Note that zero-point calibrations are not cumulative and only the latest zero-point calibration is effective. For example, there is no benefit in calibrating in nitrogen, and then calibrating in a calibration gas. The sensor will store only the latest zero point.

To improve calibration accuracy, the recommended digital filter setting is 32. See the 'A' command.

### **ZERO IN A KNOWN GAS CONCENTRATION**

Place the sensor in a known gas concentration, power up the sensor and allow time for the sensor temperature to stabilise, and for the gas to be fully diffused into the sensor.

Send the **ZERO IN A KNOWN GAS CONCENTRATION** command X to the sensor. The sensor will be zeroed using the known gas concentration level sent by the user. The concentration value written to the sensor must be scaled dependent on the sensor CO<sub>2</sub> measurement range. The multiplier for the scaling factor is set according to the range of the sensor, see the '.' command.

### **ZERO IN NITROGEN**

Place the sensor in nitrogen gas and allow time for the sensor temperature to stabilise and the gas to be fully diffused into the sensor. Send the **ZERO IN NITROGEN** command U to the sensor. The sensor is calibrated assuming a 0ppm CO<sub>2</sub> environment.

This function can also be enabled in hardware by pulling the NITROGEN\_ZERO pin low for greater than 3 seconds (ExplorIR®-W Only).

### **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<sub>2</sub> concentrations in fresh air are typically 400ppm. The CO<sub>2</sub> concentration fresh air calibration level is programmable over a range from 0ppm to the full scale of the sensor.

Place the sensor in a fresh air environment and allow time for the sensor temperature to stabilise, and for the fresh air to be fully diffused into the sensor. Power up the sensor, write the G command to the sensor. The concentration value written to the sensor must be scaled dependent on the sensor CO<sub>2</sub> measurement range. The sensor can use the default fresh air CO<sub>2</sub> concentration value (400ppm), or the user can write a different fresh air value to the sensor if desired.

This function can also be enabled in hardware by pulling the FRESH\_AIR\_ZERO pin low for greater than 3 seconds (ExplorIR®-W Only).

## **Small Footprint Low Power CO<sub>2</sub> Sensor**

---

### **ZERO POINT ADJUSTMENT**

If the CO<sub>2</sub> 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 calibration routines.

The known CO<sub>2</sub> concentration value and the reported CO<sub>2</sub> value from the sensor can be sent to the sensor using the **ZERO POINT ADJUSTMENT** command F.

### **AUTO-CALIBRATION**

The sensor has a built-in auto-calibration function. In order to function correctly, the sensor must be exposed to typical background levels (400-450ppm) at least once during the auto-calibration period. For example, many buildings will drop quickly to background CO<sub>2</sub> levels when unoccupied overnight or at weekends. The auto-calibration function uses the information gathered during these periods to re-calibrate. The sensor will reset the 'zero' level every time it does an auto-calibration. Auto-calibration is enabled by default. If the sensor is powered down, the auto-calibration is reset to default values.

The auto-calibration function works in the same way as the **ZERO IN FRESH AIR** command. Auto-calibration is disabled by default, but can be enabled to operate automatically, or calibration can be forced. The user can also independently adjust the CO<sub>2</sub> level used for auto-calibration. Typically, it is set to the same value as the **ZERO IN FRESH AIR** value, but it can also be set at a different level if desired.

### **AUTO-CALIBRATION INTERVALS**

The auto-calibration period can be programmed by the user. The sensor can be programmed to undertake an initial auto-calibration after power-on. Thereafter, the auto-calibrate period can be set independently of the start-up calibration time. Note, the calibration settings are reset if the sensor is powered down.

### **AUTO-CALIBRATION SETTINGS**

By default, the sensor will automatically 'zero' using the measured CO<sub>2</sub> level sampled during the auto-calibration period. The user can alter the behaviour of the sensor as a result of the auto-calibration process.

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### 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 450ppm CO<sub>2</sub>. The reading will vary due to pressure and CO<sub>2</sub> concentration. It is possible to correct for the effects of pressure and concentration by setting a compensation value. This will apply a permanent correction to the output of the sensor, depending on the compensation value. The compensation value needs to be written to the sensor and will overwrite the default 1013mbar and 450ppm CO<sub>2</sub> value. The new compensation value will be used for all subsequent measurements and will be retained after a power cycle.

### ALTITUDE COMPENSATION TABLE

| Altitude (ft.) | Altitude (m) | Pressure (mbar) | Sea Level Difference | % Change per | CO <sub>2</sub> Measurement Change (%) | Compensation Value |
|----------------|--------------|-----------------|----------------------|--------------|--|--------------------|
| 0              | 0            | 1,013           | 0                    | 0.14         | 0                                      | 8,192              |
| 500            | 153          | 995             | 18                   | 0.14         | 3                                      | 8,398              |
| 1,000          | 305          | 977             | 36                   | 0.14         | 5                                      | 8,605              |
| 1,500          | 458          | 960             | 53                   | 0.14         | 7                                      | 8,800              |
| 2,000          | 610          | 942             | 71                   | 0.14         | 10                                     | 9,006              |
| 2,500          | 763          | 925             | 88                   | 0.14         | 12                                     | 9,201              |
| 3,000          | 915          | 908             | 105                  | 0.14         | 15                                     | 9,396              |
| 3,500          | 1,068        | 891             | 122                  | 0.14         | 17                                     | 9,591              |
| 4,000          | 1,220        | 875             | 138                  | 0.14         | 19                                     | 9,775              |
| 4,500          | 1,373        | 859             | 154                  | 0.14         | 22                                     | 9,958              |
| 5,000          | 1,525        | 843             | 170                  | 0.14         | 24                                     | 10,142             |
| 6,000          | 1,830        | 812             | 201                  | 0.14         | 28                                     | 10,497             |
| 7,000          | 2,135        | 782             | 231                  | 0.14         | 32                                     | 10,841             |
| 8,000          | 2,440        | 753             | 260                  | 0.14         | 36                                     | 11,174             |
| 9,000          | 2,745        | 724             | 289                  | 0.14         | 40                                     | 11,506             |
| 10,000         | 3,050        | 697             | 316                  | 0.14         | 44                                     | 11,816             |

Other compensation values can be calculated using the following formula.

$$\text{Compensation Value} = 8192 + \left( \frac{\text{Sea Level Difference} * 0.14}{100} \right) * 8192$$



---

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

The pressure compensation values calculated above are only approximate and only valid for concentrations below 1%. For higher accuracy compensation, the sensor output must be adjusted for both pressure and concentration as the CO<sub>2</sub> level measured by the sensor is affected by both ambient pressure and gas concentration levels. To calculate the adjusted CO<sub>2</sub> level, use the following calculation.

$$\text{Corrected CO}_2 \text{ Value} = \frac{\text{CO}_2 \text{ Measurement Value from Sensor (C1)}}{1 + Y(1013 - P)}$$

where,

C1 = Concentration reading from sensor

P = Pressure in mbar

Where concentration is < 1500ppm.

$$Y = 2.6661 \times 10^{-16} x C1^4 - 1.1146 \times 10^{-12} x C1^3 + 1.7397 \times 10^{-9} x C1^2 - 1.2556 \times 10^{-6} x C1 - 9.8754 \times 10^{-4}$$

Where concentration is >1500ppm.

$$Y = 2.811 \times 10^{-38} x C1^6 - 9.817 \times 10^{-32} x C1^5 + 1.304 \times 10^{-25} x C1^4 - 8.126 \times 10^{-20} x C1^3 + 2.311 \times 10^{-14} x C1^2 - 2.195 \times 10^{-9} x C1 - 1.471 \times 10^{-3}$$

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### CONTROL INTERFACE

The ExplorIR® family of sensors are controlled by writing and reading from the sensor via its UART interface. The Rx\_In and Tx\_Out pins are normally high, suitable for direct connection to a UART. If the sensor is to be read by a true RS232 device (e.g. a PC), it is necessary to pass through a level converter to step up/down the voltage and invert the signal.

### CONTROL INTERFACE TIMING - UART MODE

| PARAMETER             | SYMBOL | MIN | TYP  | MAX | UNIT   |
|-----------------------|--------|-----|------|-----|--------|
| Baud Rate             |        |     | 9600 |     | Bits/s |
| Data Bits             |        |     | 8    |     |        |
| Parity                |        |     | None |     |        |
| Stop Bits             |        |     | 1    |     |        |
| Hardware Flow Control |        |     | None |     |        |

### UART COMMAND PROTOCOL

All UART commands must be terminated with a carriage return and line feed <CR><LF>, hex 0x0D 0x0A. In this document, this is shown as '\r\n'. UART commands that take a parameter always have a space between the letter and the parameter. The sensor will respond with a '?' if a command is not recognised. The two most common causes are missing spaces or missing <CR><LF> terminators.

All command communications are in ASCII and are terminated by carriage return, line feed (0x0D 0x0A). This document uses the protocol "\r\n" to indicate the carriage return line feed. All responses from the sensor, including measurements, have a leading space (ASCII character 32).

The character '#' represents an ASCII representation of a numeric character (0-9). Note there is a space between the first letter and any parameter. For example, the X command reads "X space 2000 carriage return line feed".

### UART OPERATION

When initially powered, the sensor will immediately start to transmit a CO<sub>2</sub> reading on receiving any character.

The CO<sub>2</sub> measurement is reported as:

```
Z #####\r\n
```

where Z ##### shows the CO<sub>2</sub> concentration.

Note that all outputs from the sensor have a leading space.

## Small Footprint Low Power CO<sub>2</sub> Sensor

### UART INTERFACE SUMMARY

| Syntax                     | Use  | Example                    | Response                       | Comments   |
|----------------------------|--|----------------------------|--------------------------------|--|
| A ###\r\n                  | Set value of the digital filter  | A 128\r\n                  | A 00128\r\n                    | See <b>"Digital Filter"</b>  |
| a\r\n                      | Return the value of the digital filter   | a\r\n                      | a 00128\r\n                    | See <b>"Digital Filter"</b>  |
| F #####\r\n                | Fine Tune the zero point   | F 410 400\r\n              | F 33000\r\n                    | See <b>"Zero Point Calibration"</b>                                      |
| G\r\n                      | Zero-point calibration using fresh air   | G\r\n                      | G 33000\r\n                    | See <b>"Zero Point Calibration"</b>                                      |
| H\r\n                      | Returns the relative humidity value  |                            | H 00551\r\n                    |  |
| K #\r\n                    | Switches the sensor between different modes  | K 1\r\n                    | K 1\r\n                        |  |
| M #####\r\n                | Sets the number of measurement data types output by the sensor   | M 212\r\n                  | M 212\r\n                      | See <b>"Measurement Data Outputs"</b>                                    |
| P 0 ###\r\n<br>P 1 #\r\n   | Sets the CO <sub>2</sub> reading for maximum voltage output level  | P 0 19\r\n<br>P 1 136\r\n  |                                | Two byte value,<br>P 0 = MSB<br>P 1 = LSB<br><br>5000ppm in the example  |
| P 8 ###\r\n<br>P 9 #\r\n   | Sets value of CO <sub>2</sub> background concentration in ppm for auto-calibration                           | P 8 1\r\n<br>P 9 144\r\n   |                                | Two byte value,<br>P 8 = MSB<br>P 9 = LSB<br><br>400ppm in the example   |
| P 10 ###\r\n<br>P 11 #\r\n | Sets value of CO <sub>2</sub> background concentration in ppm used for zero- point calibration in fresh air. | P 10 1\r\n<br>P 11 144\r\n |                                | Two byte value,<br>P 10 = MSB<br>P 11 = LSB<br><br>400ppm in the example |
| Q\r\n                      | Reports the latest measurement data types, as defined by 'M'   | Q\r\n                      | H 12345 T 12345 Z<br>00010\r\n |  |
| S #####\r\n                | Sets the pressure and concentration compensation value   | S 8192\r\n                 | S 08192\r\n                    | See <b>"Pressure and Concentration Compensation"</b>                     |
| s\r\n                      | Returns the pressure and concentration compensation value  | s\r\n                      | s 08192\r\n                    | See <b>"Pressure and Concentration Compensation"</b>                     |
| T\r\n                      | Returns the temperature value  |                            | T 01224\r\n                    |  |
| U\r\n                      | Zero-point calibration using nitrogen  | U\r\n                      | U 33000\r\n                    | See <b>"Zero Point Calibration"</b>                                      |

## Small Footprint Low Power CO<sub>2</sub> Sensor

| Syntax      | Use  | Example       | Response                 | Comments                                  |
|-------------|--|---------------|--------------------------|---|
| u #####\r\n | Manual setting of the zero point.  | u 32997\r\n   | u 32997\r\n              | See <b>“Zero Point Calibration”</b>       |
| X #####\r\n | Zero-point setting using a known gas calibration                                   | X 2000\r\n    | X 32997\r\n              | See <b>“Zero Point Calibration”</b>       |
| Y\r\n       | Return firmware version and sensor serial number                                   | Y\r\n         | Returns <u>two</u> lines |   |
| Z\r\n       | Return the most recent filtered CO <sub>2</sub> measurement in ppm                 | Z\r\n         | Z 01521\r\n              |   |
| z\r\n       | Return the most recent unfiltered CO <sub>2</sub> measurement in ppm               | z\r\n         | Z 01521\r\n              |   |
| @ #.#.#\r\n | Sets the timing for initial and interval auto-calibration periods                  | @ 1.0 8.0\r\n | @ 1.0 8.0\r\n            | See <b>“Auto-calibration”</b> for details |
| @ r\r\n     | Returns the Autocalibration configuration  | @ 1.0 8.0\r\n | @ 1.0 8.0\r\n            | See <b>“Auto-calibration”</b> for details |
| @ #r\r\n    | Switch Auto-calibration on or off  | @ 0\r\n       | @ 0\r\n                  | See <b>“Auto-calibration”</b> for details |
| .\r\n       | Returns the scaling factor multiplier required to convert the Z or z output to ppm | .\r\n         | . 00010\r\n              | Multiply by 10 in the example             |

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### CO<sub>2</sub> LEVEL MEASUREMENT VALUE - Z INFORMATION (0x5A)

|                    |   |
|--------------------|---|
| <b>Description</b> | Reports the latest filtered CO <sub>2</sub> measurement |
| <b>Syntax</b>      | ASCII Character 'Z', terminated by 0x0D 0x0A (CR & LF)  |
| <b>Example</b>     | Z\r\n   |
| <b>Response</b>    | Z 00521\r\n   |

This value needs to be multiplied by the appropriate scaling factor to derive the ppm value. See the '.' command.

### CO<sub>2</sub> LEVEL MEASUREMENT VALUE - z INFORMATION (0x7A)

The sensor is also capable of reporting the real time unfiltered CO<sub>2</sub> measurement value.

|                    |  |
|--------------------|--|
| <b>Description</b> | Reports the unfiltered CO <sub>2</sub> measurement     |
| <b>Syntax</b>      | ASCII Character 'z', terminated by 0x0D 0x0A (CR & LF) |
| <b>Example</b>     | z\r\n  |
| <b>Response</b>    | z 00521\r\n  |

### '.' COMMAND (0x2E)

To calculate the measurement value in ppm, the 'Z' or 'z' value, they must be converted into ppm by using the '.' multiplier factor. This multiplier will depend on the full-scale measurement range of the sensor. The multiplier is related to the full-scale range of the sensor.

The multiplier must also be used when sending CO<sub>2</sub> concentration levels to the sensor, for example when setting the fresh air CO<sub>2</sub> concentration value. The '.' Command can also be used to read back the scaling factor.

For example, if the user wants to zero the sensor in a known concentration of gas (e.g. 450ppm), the value written to the sensor must be 450/scaling factor.

|                    |   |
|--------------------|---|
| <b>Description</b> | Returns a number indicating what multiplier must be applied to the Z CO <sub>2</sub> measurement output to convert it into ppm. |
| <b>Syntax</b>      | ASCII character '.', terminated by 0x0D 0x0A ( CR & LF )  |
| <b>Example</b>     | .\r\n   |
| <b>Response</b>    | . 00010\r\n (this number is variable, usually 10)   |

| Measurement Range of Sensor | CO <sub>2</sub> Measurement Scaling Factor (Z) | CO <sub>2</sub> Measurement Output Units | Example                    |
|-----------------------------|--|--|----------------------------|
| 0 – 60%                     | 10   | ppm/10                                   | Z 01200 = 12,000ppm = 1.2% |
| 0 – 100%                    | 100  | ppm/100                                  | Z 01500 = 150,000ppm = 15% |

## Small Footprint Low Power CO<sub>2</sub> Sensor

### TEMPERATURE MEASUREMENT VALUE - ExplorIR®-W Option

| Command | Use  | Example     | Response    | Comments   |
|---------|--|-------------|-------------|--|
| T\r\n   | Returns the most recent temperature measurement. | T #####\r\n | T 01224\r\n | Where ##### is a 5-digit number.<br><br>Temperature (°C) = (##### - 1000)/10.<br><br>22.4°C in the example |

|                    |  |
|--------------------|--|
| <b>Description</b> | Returns the most recent temperature measurement.                         |
| <b>Syntax</b>      | ASCII character 'T', SPACE, decimal, terminated by 0x0D 0x0A ( CR & LF ) |
| <b>Example</b>     | T\r\n  |
| <b>Response</b>    | T 01224\r\n (this number is variable)                                    |

### HUMIDITY MEASUREMENT VALUE - ExplorIR®-W Option

| Command | Use  | Example     | Response    | Comments   |
|---------|--|-------------|-------------|--|
| H\r\n   | Return the most recent humidity measurement. | H #####\r\n | H 00551\r\n | Where ##### is a 5-digit number.<br><br>Humidity (%RH)C = #####/10.<br><br>55.1% RH in the example |

|                    |  |
|--------------------|--|
| <b>Description</b> | Returns the most recent the humidity measurement.                        |
| <b>Syntax</b>      | ASCII character 'H', SPACE, decimal, terminated by 0x0D 0x0A ( CR & LF ) |
| <b>Example</b>     | H\r\n  |
| <b>Response</b>    | H 00551\r\n (this number is variable)                                    |

Note both temperature and humidity outputs are a factory fit option on the ExplorIR®-W only. If not fitted, sensor will return either T 00000 or H 00000.

The sensor default data output is filtered CO<sub>2</sub> only. To output temperature, humidity, and filtered CO<sub>2</sub>, send "M 4164\r\n" (see "**Measurement Data Outputs**").

The output format will have the form: *H 00345 T 01195 Z 00065\r\n*

This example indicates 34.5% RH, 19.5°C and 650ppm CO<sub>2</sub>.

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### CO<sub>2</sub> ANALOGUE OUTPUT COMMAND

|                    |   |
|--------------------|---|
| <b>Description</b> | Sets the CO <sub>2</sub> reading for maximum voltage output level.<br>Typically set to sensor full scale value.<br>Value is scaled by CO <sub>2</sub> value multiplier, see '.' command.        |
| <b>Syntax</b>      | ASCII character 'P', SPACE, then 0, SPACE, then MSB terminated by 0x0D 0x0A (CR & LF)<br><br>ASCII character 'P' then a space, then 1, then a space, then LSB terminated by 0x0D 0x0A (CR & LF) |
| <b>Example</b>     | P 0 19\r\n<br>P 1 136\r\n   |
| <b>Response</b>    | P 00000 00019\r\n<br>P 00001 00136\r\n  |

The value is entered as a two-byte word, MSB first.

MSB = Integer (Scale/256)

LSB = Scale – (256\*MSB)

In the above example, the scale is being set to 5000ppm

MSB = Integer (5000/256) = 19

LSB = 5000 – (256\*19) = 136

The analogue output is turned ON when a valid output value is set. To turn off the analogue output, set P0 and P1 to zero.

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### K COMMAND

| Command | Use   | Default | Range | Example | Response | Comments                |
|---------|---|---------|-------|---------|----------|-------------------------|
| K #\r\n | Switches the sensor between different control modes | 1       |       | K 1\r\n | K 1\r\n  | <i>See 'K' Commands</i> |

### K COMMAND (0x4B)

|                    |  |  |  |  |  |  |
|--------------------|--|--|--|--|--|--|
| <b>Description</b> | Sets the control interface mode  |  |  |  |  |  |
| <b>Syntax</b>      | ASCII character 'K', SPACE, mode number, terminated by 0x0D 0x0A (CR & LF) |  |  |  |  |  |
| <b>Example</b>     | K 1\r\n  |  |  |  |  |  |
| <b>Response</b>    | K 00001\r\n (this number is variable)                                      |  |  |  |  |  |

### DIGITAL FILTER COMMANDS

| Command   | Use                             | Default | Range     | Example  | Response    | Comments |
|-----------|---------------------------------|---------|-----------|----------|-------------|----------|
| A ###\r\n | Set value of the digital filter | 16      | 0 - 65535 | A 16\r\n | A 00016\r\n |          |
| a\r\n     | Return value of digital filter  |         | 0 - 65535 | a\r\n    | a 00016\r\n |          |

### A COMMAND (0x41)

|                    |  |  |  |  |  |  |
|--------------------|--|--|--|--|--|--|
| <b>Description</b> | Set the value for the digital filter                                   |  |  |  |  |  |
| <b>Syntax</b>      | ASCII character 'A', SPACE, decimal, terminated by 0x0D 0x0A (CR & LF) |  |  |  |  |  |
| <b>Example</b>     | A 16\r\n   |  |  |  |  |  |
| <b>Response</b>    | A 00016\r\n (this number is variable)                                  |  |  |  |  |  |

### a COMMAND (0x61)

|                    |  |  |  |  |  |  |
|--------------------|--|--|--|--|--|--|
| <b>Description</b> | Set the value for the digital filter                                   |  |  |  |  |  |
| <b>Syntax</b>      | ASCII character 'A', SPACE, decimal, terminated by 0x0D 0x0A (CR & LF) |  |  |  |  |  |
| <b>Example</b>     | A 16\r\n   |  |  |  |  |  |
| <b>Response</b>    | A 00016\r\n (this number is variable)                                  |  |  |  |  |  |



## Small Footprint Low Power CO<sub>2</sub> Sensor

### ZERO POINT CALIBRATION COMMANDS

| Command                    | Use  | Default                    | Range           | Example          | Response    | Comments   |
|----------------------------|--|----------------------------|-----------------|------------------|-------------|--|
| F #####<br>#####\r\n       | Fine Tune the zero point   |                            | Range of sensor | F 410<br>400\r\n | F 33000\r\n | See <b>"Zero Point Calibration"</b>                                      |
| G\r\n                      | Zero-point calibration using fresh air   |                            |                 | G\r\n            | G 33000\r\n | See <b>"Zero Point Calibration"</b>                                      |
| U\r\n                      | Zero-point calibration using nitrogen  |                            |                 | U\r\n            | U 33000\r\n | See <b>"Zero Point Calibration"</b>                                      |
| u #####\r\n                | Manual setting of the zero point   |                            |                 | u<br>32997\r\n   | u 32997\r\n | See <b>"Zero Point Calibration"</b>                                      |
| X #####\r\n                | Zero-point calibration using a known gas concentration   |                            | Range of sensor | X 2000\r\n       | X 32997\r\n | See <b>"Zero Point Calibration"</b>                                      |
| P 8 ###\r\n<br>P 9 #\r\n   | Sets value of CO <sub>2</sub> background concentration in ppm for auto-calibration                           | P 8 1\r\n<br>P 9 144\r\n   |                 |                  |             | Two byte value,<br>P 8 = MSB<br>P 9 = LSB<br><br>400ppm in the example   |
| P 10 ###\r\n<br>P 11 #\r\n | Sets value of CO <sub>2</sub> background concentration in ppm used for zero- point calibration in fresh air. | P 10 1\r\n<br>P 11 144\r\n |                 |                  |             | Two byte value,<br>P 10 = MSB<br>P 11 = LSB<br><br>400ppm in the example |

### F COMMAND (0x46)

|                    |  |
|--------------------|--|
| <b>Description</b> | Calibrates the zero-point using a known reading and a known CO <sub>2</sub> concentration terminated by 0x0D 0x0A (CR & LF)                  |
| <b>Syntax</b>      | ASCII character 'F', SPACE, then the reported gas concentration, SPACE, then the actual gas concentration, terminated by 0x0D 0x0A (CR & LF) |
| <b>Example</b>     | F 41 39\r\n  |
| <b>Response</b>    | F 33000\r\n (the numbers are variable)   |

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### G COMMAND (0x47)

|                    |   |
|--------------------|---|
| <b>Description</b> | Calibrates the zero point assuming the sensor is in fresh air (typically 400ppm CO <sub>2</sub> , but level can be set by user – see P commands.) |
| <b>Syntax</b>      | ASCII character 'G' terminated by 0x0D 0x0A (CR & LF)   |
| <b>Example</b>     | G\r\n   |
| <b>Response</b>    | G 33000\r\n (the number is variable)  |

### U COMMAND (0x55)

|                    |  |
|--------------------|--|
| <b>Description</b> | Calibrates the zero point assuming the sensor is in 0ppm CO <sub>2</sub> such as nitrogen. |
| <b>Syntax</b>      | ASCII Character 'U' terminated by 0x0D 0x0A (CR & LF)                                      |
| <b>Example</b>     | U\r\n  |
| <b>Response</b>    | U 32767\r\n(the number is variable)  |

### u COMMAND (0x75)

|                    |  |
|--------------------|--|
| <b>Description</b> | Forces a specific zero set point value.<br>Input value is scaled by CO <sub>2</sub> value multiplier, see '.' command. |
| <b>Syntax</b>      | ASCII character 'u', SPACE, then the gas concentration, terminated by 0x0D 0x0A (CR & LF)                              |
| <b>Example</b>     | u 32767\r\n  |
| <b>Response</b>    | u 32767\r\n  |

### X COMMAND (0x58)

|                    |  |
|--------------------|--|
| <b>Description</b> | Calibrates the zero point with the sensor in a known concentration of CO <sub>2</sub> .<br>Input value is scaled by CO <sub>2</sub> value multiplier, see '.' command. |
| <b>Syntax</b>      | ASCII character 'X', SPACE, then the gas concentration, terminated by 0x0D (CR & LF)   |
| <b>Example</b>     | X 1000\r\n   |
| <b>Response</b>    | X 33000\r\n (the number is variable).  |

### P COMMAND - CO<sub>2</sub> Level for Auto-calibration

|                    |   |
|--------------------|---|
| <b>Description</b> | Sets the value of CO <sub>2</sub> in ppm used for auto-calibration.<br>Input value is scaled by CO <sub>2</sub> value multiplier, see '.' command.  |
| <b>Syntax</b>      | ASCII character 'P', SPACE, then 8, SPACE, then MSB terminated by 0x0D 0x0A (CR & LF)<br><br>ASCII character 'P' then a space, then 9, then a space, then LSB terminated by 0x0D 0x0A (CR & LF) |
| <b>Example</b>     | P 8 0\r\n<br>P 9 40\r\n   |
| <b>Response</b>    | p 8 0\r\n<br>p 9 40\r\n   |

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

The value is entered as a two-byte word, MSB first.

MSB = Integer (Concentration/256)

LSB = Concentration – (256\*MSB)

In the above example, target CO<sub>2</sub> background concentration is 400ppm.

MSB = Integer (400/256) = 1

LSB = 400 – 256 = 144

### P COMMAND – CO<sub>2</sub> Level for Zero-Point Calibration

|                    |  |
|--------------------|--|
| <b>Description</b> | Sets value of CO <sub>2</sub> in ppm for zero-point calibration in fresh air.<br>Input value is scaled by CO <sub>2</sub> value multiplier, see '.' command.                               |
| <b>Syntax</b>      | ASCII character 'P', SPACE, then 10, SPACE, then MSB terminated by 0x0D<br>0x0A (CR & LF)<br><br>ASCII character 'P', SPACE, then 11, SPACE, then LSB terminated by 0x0D<br>0x0A (CR & LF) |
| <b>Example</b>     | P 10 7\r\n<br>P 11 208\r\n   |
| <b>Response</b>    | p 10 7\r\n<br>p 11 208\r\n   |

MSB = Integer (Concentration/256)

LSB = Concentration – (256\*MSB)

In the above example, target zero-point CO<sub>2</sub> concentration is 2000ppm.

MSB = Integer (2000/256) = 7

LSB = 2000 – (256\*MSB) = 208

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

**AUTO-CALIBRATION INTERVALS**

| UART Command  | Use                                | Default | Range | Example       | Response      | Comments                           |
|---------------|------------------------------------|---------|-------|---------------|---------------|------------------------------------|
| @ #.# #.#\r\n | Auto-calibration interval settings |         |       | @ 1.0 8.0\r\n | @ 1.0 8.0\r\n | See "Auto-calibration" for details |

**@ COMMAND (0x2E)**

|                    |   |
|--------------------|---|
| <b>Description</b> | Set the 'Initial Interval' and 'Regular Interval' for auto-calibration events.        |
| <b>Syntax</b>      | ASCII character '@', SPACE, decimal, SPACE, decimal terminated by 0x0D 0x0A (CR & LF) |
| <b>Example</b>     | @ 1.0 8.0\r\n   |
| <b>Response</b>    | @ 1.0 8.0\r\n (the number mirrors the input value)                                    |

Both the initial interval and regular interval are given in days. Both must be entered with a decimal point and one figure after the decimal point. In the above example, the auto-calibration interval is set to 8 days, and the initial interval set to 1 day.

To disable auto-calibration, send @ 0\r\n

To determine the auto-calibration configuration, send @\r\n.

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### PRESSURE AND CONCENTRATION COMPENSATION

| UART Command | Use   | Default | Range   | Example    | Response    | Comments   |
|--------------|---|---------|---------|------------|-------------|--|
| S #####\r\n  | Sets the pressure and concentration compensation value    | 8192    | 0-65536 | S 8192\r\n | S 08192\r\n | See <i>“Pressure and Concentration Compensation”</i> |
| s\r\n        | Returns the pressure and concentration compensation value |         |         | s\r\n      | s 08192\r\n | See <i>“Pressure and Concentration Compensation”</i> |

### S COMMAND (0x53)

|                    |  |
|--------------------|--|
| <b>Description</b> | Set the 'Pressure and Concentration Compensation' value                |
| <b>Syntax</b>      | ASCII character 'S', SPACE, decimal, terminated by 0x0D 0x0A (CR & LF) |
| <b>Example</b>     | S 8192\r\n   |
| <b>Response</b>    | S 8192\r\n (the number mirrors the input value)                        |

### s COMMAND (0x73)

|                    |  |
|--------------------|--|
| <b>Description</b> | Reports the 'Pressure and Concentration Compensation' value. |
| <b>Syntax</b>      | ASCII Character 's', terminated by 0x0D 0x0A (CR & LF)       |
| <b>Example</b>     | s\r\n  |
| <b>Response</b>    | s 8192\r\n   |

## Small Footprint Low Power CO<sub>2</sub> Sensor

### MEASUREMENT DATA OUTPUTS

The sensor can send multiple fields of data as a single string. Up to five data fields can be transmitted, programmable by the user. The number of fields and the type of data to be transmitted is defined by the “Mask Value” setting.

The output data format is as follows. Each field is identified by the Data Field Identifier character, followed by a space, followed by the five-digit number indicating the value of the parameter.

| Data Parameter                      | Data Field Identifier | Mask Value | Description  |
|-------------------------------------|-----------------------|------------|--|
| Humidity                            | H                     | 4096       | Humidity value of the environment around the sensor                            |
| D digitally filtered                | d                     | 2048       | Reports a value related to the normalized LED signal strength (smoothed)       |
| D unfiltered                        | D                     | 1024       | Reports a value related to the normalized LED signal strength                  |
| Zero Set Point                      | h                     | 256        | Reports a value related to the normalized LED signal strength                  |
| Sensor Temperature (unfiltered)     | V                     | 128        | Reports a value that varies inversely with the sensor temperature.             |
| Temperature                         | T                     | 64         | Reports a true temperature value of the environment around the sensor          |
| LED Signal (digitally filtered)     | o                     | 32         | Reports a value that gives an indication of the LED signal strength (smoothed) |
| LED Signal (unfiltered)             | O                     | 16         | Reports a value that gives an indication of the LED signal strength.           |
| Sensor Temperature (filtered)       | v                     | 8          | Reports a value that varies inversely with the sensor temperature. (smoothed)  |
| CO <sub>2</sub> Output (Filtered)   | Z                     | 4          | Filtered CO <sub>2</sub> reading   |
| CO <sub>2</sub> Output (Unfiltered) | z                     | 2          | Raw CO <sub>2</sub> reading, unfiltered  |

| UART Command | Use   | Default     | Range | Example                        | Response    | Comments   |
|--------------|---|-------------|-------|--------------------------------|-------------|--|
| M #####\r\n  | Sets the number of measurement data types output by the sensor. ##### is the mask value | M 04164\r\n |       | See “Measurement Data Outputs” | M #####\r\n | Sets the number of measurement data types output by the sensor |

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

The required mask value is the sum of the 'Mask Value' for each field required. To output filtered and unfiltered CO<sub>2</sub> data, set M=6.

To output the temperature, humidity and CO<sub>2</sub> measurements, send: M 4164\r\n

The output string will then be: H 12345 T 12345 Z 00010\r\n

### M COMMAND

|                    |   |
|--------------------|---|
| <b>Description</b> | Sets the type and number of data outputs  |
| <b>Syntax</b>      | ASCII character 'M', SPACE, up to 5 digit number, terminated by 0x0D 0x0A ( CR & LF ) |
| <b>Example</b>     | M 04164\r\n   |
| <b>Response</b>    | M 04164\r\n   |

### Q COMMAND

|                    |  |
|--------------------|--|
| <b>Description</b> | Reports the latest output data fields defined by 'M'     |
| <b>Syntax</b>      | ASCII character 'Q', terminated by 0x0D 0x0A ( CR & LF ) |
| <b>Example</b>     | Q\r\n  |
| <b>Response</b>    | H 12345 T 12345 Z 00010\r\n                              |

### SERIAL NUMBER AND FIRMWARE VERSION

| UART Command | Use  | Default | Range | Example | Response                 | Comments |
|--------------|--|---------|-------|---------|--------------------------|----------|
| Y\r\n        | Return firmware version and sensor serial number |         |       | Y\r\n   | Returns <u>two</u> lines |          |

## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### **Y COMMAND (0x59)**

|                    |   |
|--------------------|---|
| <b>Description</b> | The present version string for the firmware and serial number of the sensor.  |
| <b>Syntax</b>      | ASCII character 'Y', terminated by 0x0d 0x0a (CR & LF)  |
| <b>Example</b>     | Y\r\n   |
| <b>Response</b>    | Y, Aug 25 2021, 14:19:56, LP15132<br>B 528148 00000<br><br>Where;<br><br>Aug 25 2021, 14:19:56 is the firmware compile date and time<br>LP15132 is the firmware revision<br>528148 is the sensor ID |

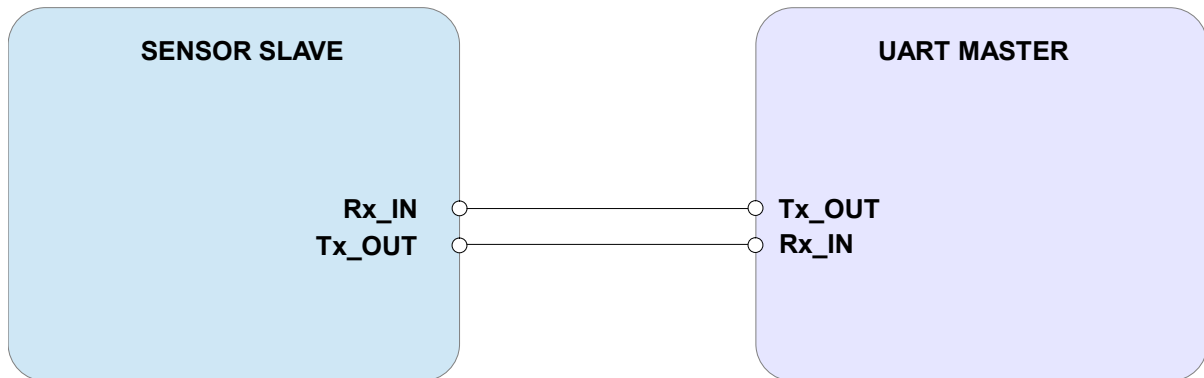
N.B. This command returns two lines split by a carriage return line feed and terminated by a carriage return line feed. This command requires that the sensor has been stopped (see 'K' command).



## Small Footprint Low Power CO<sub>2</sub> Sensor

---

### CONNECTION DIAGRAM FOR UART INTERFACE



## **Small Footprint Low Power CO<sub>2</sub> Sensor**

---

### **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. In order 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 trademarks 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.

### **ADDRESS**

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