

# C1 & C2 SENSOR MANUAL

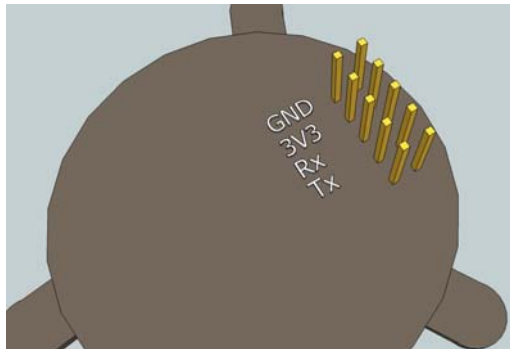
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# 1 Serial Format and Connection

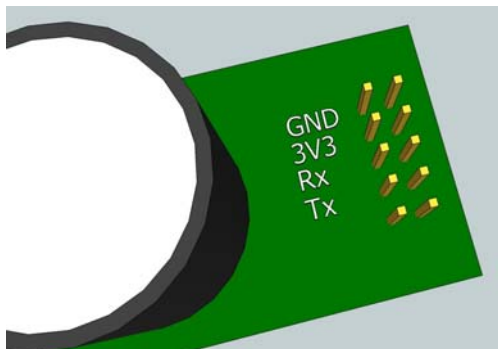
## 1.1 Connection

Communication to and from the C1 & C2 sensor is via a serial connection. Pins are shown looking at the connector of the sensor.



C1

|     |         |
|-----|---------|
| GND | N/C     |
| 3V3 | N/C     |
| Rx  | N/C     |
| Tx  | Zero    |
| N/C | Ambient |



C2

The Rx and Tx pins are normally high, suitable for direct connection to a UART. If the sensor is to be read by a true RS232 device (eg a PC) it is necessary to pass through a level converter to step up/down the voltage and invert the signal.

A starter kit is available to allow simple interfacing between the sensor and a PC. Contact Euro-Gas for details.

Connection to the sensor is via a 10 way, 0.1" pitch connector. In practice, only the first 4 pins are required (GND, 3V3, Rx and Tx) so a 4 way connector can be used.

When powered, the sensor will immediately start to transmit readings (see Mode 1 in "**Operating Modes**")

| Parameter             | Value                |
|-----------------------|----------------------|
| Baud Rate             | 9600                 |
| Data Bits             | 8                    |
| Parity                | None                 |
| Stop Bits             | 1                    |
| Format                | UART (normally high) |
| Hardware Flow Control | None                 |
| Voltage $V_h$         | 3V                   |

**NB** If you connect to the sensor using HyperTerminal®, you must select the box "Send line ends with line feeds" under ASCII setup.

## 1.2 Reading Format

The reported CO<sub>2</sub> output is presented as:

Z ##### z #####/r/n

Where

Z ##### shows the CO<sub>2</sub> concentration after digitally filtering

and

z ##### shows the instantaneous CO<sub>2</sub> concentration without any digital filtering.

The concentration is reported in the following units

| Type   | Range      | Units   | Example                   |
|--------|------------|---------|---------------------------|
| C1     | Up to 2%   | ppm     | Z 00631 = 631ppm          |
| C2     | Up to 65%  | ppm/10  | Z 01200 = 12000ppm = 1.2% |
| C2-100 | Up to 100% | ppm/100 | Z 01500 = 150000ppm = 15% |

Note that the same units must be used when sending concentration information to the sensor (X command, F command).

Note that all output from the sensor has a leading space.

## 2 Command Summary

For complete details of the commands and their correct usage, please refer to the **Command Reference**.

| Command     | Use  | Example       | Response          | Comments   |
|-------------|--|---------------|-------------------|--|
| A ###\r\n   | Set the digital Filter                           | A 16\r\n      | A 00016\r\n       | See " <b>User Settings</b> "                         |
| a\r\n       | Return the digital filter setting                | a\r\n         | a 00016\r\n       | See " <b>User Settings</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       | Return most recent humidity measurement          | H\r\n         | H 00552\r\n       | =55.2% in the example. Not available on all models.  |
| K #\r\n     | Selects the operating mode                       | K 1\r\n       | K 00001\r\n       | See " <b>Operating Modes</b> "                       |
| L\r\n       | Return the most recent light measurement         | L\r\n         | L 02900\r\n       | Not available on all models.                         |
| M #####\r\n | Sets the output fields                           | M 6\r\n       | M 00006\r\n       | See " <b>Output Fields</b> "                         |
| P ###\r\n   | Sets a user configurable field in EEPROM         | P 1 10\r\n    | P 00001 00010\r\n | See " <b>User Settings</b> "                         |
| p ###       | Reads a user-configurable field from EEPROM      | p 10\r\n      | p 00010 00001\r\n | See " <b>User Settings</b> "                         |
| Q\r\n       | Return most recent fields                        | Q\r\n         |                   | See " <b>Command Reference</b> "                     |
| S #####\r\n | Sets the span calibration value                  | S 8192\r\n    | S 08192\r\n       | See " <b>Span Calibration</b> "                      |
| s\r\n       | Return the span calibration value                | s\r\n         | s 08192\r\n       | See " <b>Span Calibration</b> "                      |
| T\r\n       | Return the most recent temperature measurement   | T\r\n         | T 01225\r\n       | 22.5 °C in the example. Not available on all models. |
| 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 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         |                   | See " <b>Command Reference</b> " for details         |
| Z\r\n       | Return the most recent CO2 measurement.          | Z\r\n         | Z 01521\r\n       | 1521ppm in the example                               |
| *\r\n       | Return configuration information.                | *\r\n         |                   | See the " <b>Command Reference</b> " for details     |

All communications are in ASCII, have a leading space(ASCII character 32), and are terminated by carriage return, line feed (ASCII characters 13 and 10). This document uses the protocol "\r\n" to indicate the carriage return line feed.

The character '#' represents an ASCII representation of a numeric character (0-9).

Note that there is a space between the first letter and any parameter. For example, the X command reads "X space 2000 carriage return line feed".

### 3 Operating Modes

The C1 & C2 sensor can be operated in three different modes. Users can switch between the modes using the "K" command.

#### 3.1 Mode 0 Command Mode

This is primarily intended for use when extracting larger chunks of information from the sensor (for example using the Y and \* commands).

In this mode, the sensor is stopped waiting for commands. No measurements are made, and the sensor will run through a warm-up cycle after exiting this command. There is no latency in command responses.

The power consumption is less than 3.5mW as no measurement activity takes place.

Commands which report measurements or alter the zero point setting are disabled in mode 0.

#### 3.2 Mode 1 Streaming Mode

This is the factory default. 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 100mS in responding to commands. The power consumption is 3.5mW (assuming one field of information is transmitted, and there is no temperature and humidity sensor).

#### 3.3 Mode 2 Polling Mode

In polling mode, the sensor only reports readings when requested. The measurement cycle continues in the background, but the output stream is suppressed. The power consumption depends on the frequency of polling, but is approximately the same as the streaming mode power consumption.

In Polling Mode, measurements can be accessed using the polling commands H, L, Q, T and Z (see "**Command Reference**").

## 4 Output Fields

The C1 & C2 sensor can be configured to output up to five fields of information. Typically, the only fields of interest are the CO2 concentration and Temperature/Humidity (if fitted). This allows users to customise the output string transmitted by the sensor. Up to five values can be transmitted in the string. The format is always the same: each field is identified by a single character, followed by a space, followed by the five digit number indicating the value of the parameter.

The output fields can be set by sending a command of the format "M 12345\r\n" where 12345 represents a mask value which defines the output fields.

The mask value is created by adding the mask values for the parameters required (see table below). The sensor will output a maximum of five fields. If the mask setting represents more than five fields, only the first five (those with the highest mask values) will be output.

| Parameter                       | Field Identifier | Mask Value | Comments   |
|---------------------------------|------------------|------------|--|
| Unused                          |                  | 65535      |  |
| Unused                          |                  | 32768      |  |
| Unused                          |                  | 16384      |  |
| Light                           | L                | 8192       | Reports the output of the Light Sensor (if Fitted).                                |
| Humidity                        | H                | 4096       | Reports the humidity output of the Temperature and Humidity Sensor (if Fitted).    |
| 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                      |
| D recent maximum                |                  | 512        | Reports the recent highest normalized LED signal strength                          |
| Zero Set Point                  |                  | 256        | Reports a value related to the normalized LED signal strength                      |
| Sensor Temperature (unfiltered) | V                | 128        | Reports a value which varies inversely with the sensor temperature.                |
| Temperature                     | T                | 64         | Reports the temperature output of the Temperature and Humidity Sensor (if Fitted). |
| LED Signal (digitally filtered) | o                | 32         | Reports a value which gives an indication of the LED signal strength (smoothed)    |
| LED Signal (unfiltered)         | O                | 16         | Reports a value which gives an indication of the LED signal strength.              |
| Sensor Temperature (filtered)   | v                | 8          | Reports a value which varies inversely with the sensor temperature. (smoothed)     |
| CO2 Output (Digitally Filtered) | Z                | 4          | Digitally filtered CO2 reading   |
| CO2 Output (not filtered)       | z                | 2          | Instantaneous CO2 reading  |
| None                            |                  | 1          | Reserved   |

Note that most fields are for advanced use only and require specific guidance from Euro-Gas for their correct interpretation and use.

For example, to output the temperature, humidity and CO2 measurements, send:  
M 4164\r\n

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

## 5 Zero Point Calibration

There are a several methods to calibrate the zero point of the sensor. The recommended method is zero point calibration in a known gas (see X command) which will give the most accurate zero setting.

In all cases, the best zero is obtained when the gas concentration is stable and the sensor is at a stabilized temperature.

### 5.1 Zero in a known gas concentration (recommended)

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

Send the command "X ###\r\n"

The concentration must be in the same units as the sensor output (see "**Reading Format**").

The sensor will respond with an echo of the command and the new zero point.

For example, to set the zero point in a C1 when the sensor is in a known gas concentration of 2000ppm

```
send:      X 2000\r\nresponse:  X 32950\r\n
```

### 5.2 Zero in Nitrogen

Place the sensor in a gas containing no CO2 (typically Nitrogen) and allow time for the sensor temperature to stabilize, and for the gas to be fully diffused into the sensor.

Send the command "U\r\n"

The sensor will respond with an echo of the command and the new zero point.

For example,

```
send:      U\r\nresponse:  U 32950\r\n
```

### 5.3 Zero in Fresh Air (assumed to be 450ppm)

If there is no calibration gas and no nitrogen available, the sensor zero point can be set in fresh air. The sensor is programmed to assume that fresh air is 450ppm (this value is user configurable – see "*User Settings*").

Place the sensor in a fresh air environment and allow time for the sensor temperature to stabilize, and for the fresh air to be fully diffused into the sensor.

Send the command "G\r\n"

The sensor will respond with an echo of the command and the new zero point.

For example,

```
send:      G\r\nresponse:  G 32950\r\n
```

## 5.4 Fine Tune the Zero Point

If the CO2 concentration and the sensor reported concentration are known, the zero point can be adjusted using the known concentration to fine tune the zero point. This is similar in operation to the “X” command (see above) but can operate on historic data. For example, if the sensor has been in an environment in which it is known to have 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 command takes two parameters, separated by a space. The first parameter is the reading reported by the sensor. The second is the corrected reading. Both parameters must be in the same units as the sensor output (see “**Reading Format**”)

The sensor will respond with an echo of the command and the new zero point.

For example,

```
send:      F 400 380\r\n
response:  32950\r\n
```

In this example, the sensor zero point would be corrected so that a reading of 400ppm, would now be reported as 380ppm.

## 5.5 Zero Point Adjustment

The precise zero point can be fine-tuned by sending a zero point to the sensor. This is not recommended for general use.

Send the command “u #####\r\n” where ##### is the new zero point.

## 5.6 Auto Zero Point Calibration

The sensor can be configured to zero automatically using fresh air as the calibration source. Contact Euro-Gas for details.

## 6 Span Calibration

NB Span calibration must only be performed AFTER the unit has been correctly zeroed.

**NB The C1 & C2 Sensor should not require span calibration. Euro-Gas does not recommend using the span calibration procedure.**

Span calibration allows users to fine tune readings to ensure that the sensor gives exactly the correct reading when presented with a gas of known concentration. Typically, span calibration should not be required, however it may become necessary if the unit has suffered shock (mechanical or thermal) sufficient to cause a local distortion of the optical elements. It can also be used to fine tune the unit to give the most accurate readings around a specific concentration of interest.

### **Procedure:**

- Switch on the unit and allow to warm up for at least two minutes.
- Present the sensor with a known gas for calibration. The gas should be in the general range which the sensor is to be used to measure.
- Allow the sensor reading (filtered output) to settle.
- Work out the span calibration factor by using the formula
- Span Calibration Factor = (Known Gas Concentration x 8192)/Sensor Reading
- Now programme the span calibration factor into the unit by sending the following command

**S ####\r\n**

where

**####** is Span Calibration Factor  
**\r\n** is Line Feed, Carriage Return

### **Example**

If the known gas is 2000ppm and the sensor reading is 1950ppm then:

$$\text{Span Calibration Factor} = (2000 \times 8192) / 1950 = 8402$$

The command line is:

## 7 User Settings

### 7.1 Digital Filter

The CO<sub>2</sub> measurement is passed through a digital filter to condition the signal. The characteristics of the filter can be altered by the user to tune the sensor performance to specific applications.

The filter can be set to a value between 1 and 256 (see below for smart filter). A low value will result in the fastest response to changes in gas concentration, a high value will result in a slower response. Note that the response is also determined by the diffusion rate into the sensor. The default setting is 32.

To change the setting, type "A ###\r\n" where ### is the required filter setting.

For most applications, a filter setting of 32 is recommended.

Eg

```
A 32 \r\n
```

The filter works as a low pass filter - increasing the parameter reduces measurement noise, but slows the response.

If the filter is set to zero, a smart filter mode will be used in which the filter response is altered to suit the prevailing conditions. This is useful if there is a combination of steady state conditions, with some periods of rapidly changing concentrations.

### 7.2 User Options – EEPROM Settings

Some user settings can be altered in the internal EEPROM.

These settings can be set by using the parameter setting command "P", and read using a lower case "p".

#### 7.2.1 Setting EEPROM

To set an EEPROM location, send "P ### #\r\n" where the first parameter is the address, and the second is the value.

Note that two byte values must be set one byte at a time.

For example, to change the default value of the ambient gas concentration used for ambient calibration (ie the assumed CO<sub>2</sub> concentration in fresh air) to 380ppm, send

```
send:      P 10 1\r\nresponse:  P 00010 00001\r\nsend:      P 11 124\r\nresponse:  P 00011 00124\r\n
```

## 7.2.2 Reading EEPROM

To read a parameter value from an EEPROM location, send “p #####\r\n” where ##### is the address of the parameter.

Note that two byte values must be read one byte at a time.

For example, to read the value of the ambient gas concentration used for ambient calibration (ie the assumed CO<sub>2</sub> concentration in fresh air) send:

```
send:      p 10\r\nresponse:  p 00010 00001\r\nsend:      p 11\r\nresponse:  p 00011 00124\r\n
```

## 7.2.3 EEPROM Settings

Most of the EEPROM settings are two byte values, indicated by HI and LO in the variable name in the following table. We recommend contacting Euro-Gas before altering the default values.

| Location | Name     | Purpose  | Default Value |
|----------|----------|--|---------------|
| 0        | AHHI     | Reserved   | 0             |
| 1        | ANLO_    | Reserved   | 0             |
| 2        | ANSOURCE | Reserved   | 0             |
| 3        | ACINITHI | Autocalibration Preload. This preloads the autocalibration timer so that the first autocalibration occurs after a shorter time.                              | 87            |
| 4        | ACINITLO | Low byte of above.   | 192           |
| 5        | ACHI     | Autocalibration Interval. Sets the time interval between autocalibrations.   | 94            |
| 6        | ACLO     | Low byte of above.   | 128           |
| 7        | ACONOFF  | Switches Autocalibration ON/OFF  | 0             |
| 8        | ACPPMHI  | Autocalibration Background Concentration. This determines what background CO <sub>2</sub> level is assumed for autocalibration.                              | 1             |
| 9        | ACPPMLO  | Low byte of above.   | 194           |
| 10       | AMBHI    | Ambient Concentration (for G command). This determines what background CO <sub>2</sub> level is assumed for ambient calibration using the “G” command.       | 1             |
| 11       | AMBLO    | Low byte of above.   | 194           |
| 12       | BCHI     | Buffer clear time. This will clear any incomplete commands from the serial buffer after a fixed period of inactivity. The time is in half second increments. | 0             |
| 13       | BCLO     | Low byte of above.   | 8             |

## 8 Command Set

This gives the complete command set for the C1 & C2 sensor and illustrates use of some of the more commonly used options.

Key points to note are:

- In all cases, commands are terminated with a carriage return, line feed (“\r\n”).
- Commands are case sensitive.
- The commands use all use ASCII characters. Each command lists the ASCII letter and includes the hex code for avoidance of doubt.
- Always check for a correct response before sending another command.
- If a command is unrecognized, the sensor will respond with a “?”

### **WARNING**

This document is provided to give a complete reference of the command set and outputs from the C1 & C2 sensor. It is intended for advanced users only. If in doubt, please contact Euro-Gas prior to use.

## 8.1 Customisation

### **A COMMAND (0x41)**

### **USER CONFIGURATION**

Eg: "A 128\r\n"

Description: Set the value for the digital filter.  
Syntax: ASCII character 'A', SPACE, decimal, terminated by 0x0d 0x0a (CR & LF)  
Response: "A 00032\r\n"

### **a COMMAND (0x61)**

### **INFORMATION**

Eg: "a\r\n"

Description: Return the value for the digital filter.  
Syntax: ASCII Character 'a' terminated by 0x0d 0x0a (CR & LF)  
Response: Eg: "a 00032\r\n"

### **M COMMAND (0x4D)**

### **USER CONFIGURATION**

Eg: "M 212\r\n"

Description: Determines which values are going to be returned by the unit.  
Syntax: "M", SPACE, followed by an up-to 5 digit number, each bit of which dictates which item will be returned by the sensor, terminated by 0x0d 0x0a (CR & LF).  
Response: Eg "M 212\r\n" (see “Output Fields” for details)

## **P COMMAND (0x50)**

## **USER CONFIGURATION**

Eg: "P 10 1\r\n"

Description: Sets a user configurable parameter..

Syntax: "P", SPACE, followed by an up to 2 digit number, SPACE followed by an up to 3 digit number, terminated by 0x0d 0x0a (CR & LF).

Response: Eg "P 00001 00010\r\n" (see "User Settings" for details)

## **p COMMAND (0x70)**

## **USER CONFIGURATION**

Eg: "p 10\r\n"

Description: Returns a user configurable parameter.

Syntax: "P", SPACE, followed by an up-to 2 digit number, terminated by 0x0d 0x0a (CR & LF).

Response: Eg "P 10 1\r\n" (see "User Settings" for details)

## **8.2 Information**

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

### **INFORMATION**

Eg: "Y\r\n"

Description: the present version string for the firmware

Syntax: ASCII character 'Y', terminated by 0x0d 0x0a ( CR & LF )

Response: Y May 30 2008 10:45:03 CA08 B 00233

NB This command requires that the sensor has been stopped (see 'K' command).

### **\* COMMAND (0x59)**

### **INFORMATION**

Eg: "\*" \r\n"

Description: Returns a number of fields of information giving information about the sensor configuration and behavior.

Syntax: ASCII character '\*', terminated by 0x0d 0x0a ( CR & LF )

Response: Contact Euro-Gas for details.

## **8.3 Switching between Modes**

For discussion of different modes of operation, see the section "Operating Modes".

### **K COMMAND (0x4B)**

### **USER CONFIGURATION**

Eg: "K 1"

Description: Switches the sensor between the operating modes..

Syntax: ASCII character "K", SPACE, followed by the mode number, terminated by 0x0d 0x0a (CR & LF).

Response: "K #\r\n" where # is the mode number.

## 8.4 Zeroing and Calibration

See examples of each of the zero and calibration commands in the following section.

### **U COMMAND (0x55)**

**CALIBRATION – USE WITH CARE**

Eg: "U\r\n"

Description: Calibrates the zero point assuming the sensor is in 0ppm CO<sub>2</sub>.

Syntax: ASCII Character 'U' terminated by 0x0d 0x0a ( CR & LF )

Response: "U 32767\r\n" (the number is variable)

### **G COMMAND (0x47)**

**CALIBRATION – USE WITH CARE**

Eg: "G\r\n"

Description : Calibrates the zero point assuming the sensor is in 450ppm CO<sub>2</sub>.

Syntax: ASCII character 'G'

Response: "G 33000\r\n" (the number is variable).

### **F COMMAND (0x46)**

**CALIBRATION – USE WITH CARE**

Eg: "F 410 390\r\n"

Description : Calibrates the zero point using a known reading and known CO<sub>2</sub> concentration.

Syntax: ASCII character 'F' then a space, then the reported gas concentration then a space then the actual gas concentration.

Response: "F 33000\r\n" (the numbers are variable).

### **X COMMAND (0x58)**

**CALIBRATION – USE WITH CARE**

Eg: "X 1000\r\n"

Description : Calibrates the zero point with the sensor in a known concentration of CO<sub>2</sub>.

Syntax: ASCII character 'X' then a space, then the gas concentration.

Response: "X 33000\r\n" (the number is variable).

### **S COMMAND (0x53)**

**CALIBRATION – USE WITH CARE**

Eg: "S 8193\r\n"

Description: Set the 'Span' value in EEPROM

Syntax: ASCII character 'S', SPACE, decimal, terminated by 0x0d 0x0a (CR & LF)

Response: "S 8193\r\n" (the number mirrors the input value).

### **s COMMAND (0x73)**

**INFORMATION**

Eg: "s\r\n"

Description: Reports the set 'Span' value in EEPROM Nominally 8192 = a multiplier of 1.

Syntax: ASCII Character 's', terminated by 0x0d 0x0a (CR & LF)

Response: "S 8193\r\n"

### ***u* COMMAND (0x75)**

**USE ONLY WITH GUIDANCE**

Eg: "u 32767\r\n"

Description: Send a zero set point.

Syntax: ASCII character 'u', SPACE, decimal, terminated by 0x0d 0x0a (CR & LF)

Response: "u 32767\r\n"

NB For advanced use only. Contact Euro-Gas before using this command.

## **8.5 Polling Commands**

### ***H* COMMAND (0x48)**

**INFORMATION**

Eg: "H\r\n"

Description: Reports the humidity measurement from the temperature and humidity sensor (if fitted). Divide by 10 to get the %RH

Syntax: ASCII Character 'H', terminated by 0x0d 0x0a (CR & LF)

Response: "H 00551\r\n"

### ***L* COMMAND (0x4C)**

**INFORMATION**

Eg: "L\r\n"

Description: Reports the light measurement from the light sensor (if fitted).

Syntax: ASCII Character 'L', terminated by 0x0d 0x0a (CR & LF)

Response: "L 02221\r\n"

### ***T* COMMAND (0x54)**

**INFORMATION**

Eg: "T\r\n"

Description: Reports the humidity measurement from the temperature and humidity sensor (if fitted). Subtract 1000 and divide by 10 to get the temperature in °C.

Syntax: ASCII Character 'T', terminated by 0x0d 0x0a (CR & LF)

Response: "T 01224\r\n"

### ***Z* COMMAND (0x5A)**

**INFORMATION**

Eg: "Z\r\n"

Description: Reports the latest CO2 measurement in ppm.

Syntax: ASCII Character 'Z', terminated by 0x0d 0x0a (CR & LF)

Response: "Z 00512\r\n"

### ***Q* COMMAND (0x51)**

**INFORMATION**

Eg: "Q\r\n"

Description: Reports the latest measurement fields as defined by the most recent 'M' command.

Syntax: ASCII Character 'Q', terminated by 0x0d 0x0a (CR & LF)

Response: "H 12345 T 12345 Z 00010\r\n"