Rapidox 1100-OPT-MAX Dual Sensor Oxygen Analyser

Instruction Manual

D11-217-1

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Document Revision D11-217-1

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Declaration of Conformity

Manufacturer:	Cambridge Sensotec Ltd Unit 29 Stephenson Road St Ives CAMBS PE27 3WJ, ENGLAND	
Product Names:	Rapidox portable oxygen gas analyser	
Model Numbers:	RX1100-OPT-MAX	
Conform to the following specifications:	**EMC:** EN 61326-1:2021	Electrical equipment for measurement, control and laboratory use
	LVD: EN 61010-1:2010	Safety requirements for electrical equipment for measurement, control and laboratory use
Declaration:	I declare that the above product conforms to the applicable requirements of the LVD Directive 2006/95/EC, RoHS2 Directive 2011/65/EU and the EMC Directive 2004/108/EC and is UKCA & CE marked accordingly.	
Signature:		
Name:	Dr Mark Swetnam	
Title:	Managing Director	
Company:	Cambridge Sensotec Limited	
Date:	5th March 2024	

WEEE Regulations 2006

Cambridge Sensotec takes its responsibilities under the WEEE Regulations extremely seriously and has taken steps to be compliant in line with our corporate and social responsibilities. In the UK, Cambridge Sensotec has joined a registered compliance scheme “WeeeCare” (WeeeCare registration number WEE/MP3538PZ/SCH).

UK users only: If you have purchased any electronic or electrical product from Cambridge Sensotec since 2007 and would like to dispose of it correctly under the WEEE scheme, please contact us and we will be happy to either arrange the collection of the waste or have it returned to our offices for recycling. All our in-house manufactured products are scheme compliant and carry the WEEE label indicating that it is NOT allowed to be disposed of in a landfill site.

Warnings and Cautions

 A warning icon indicates a threat to personal safety.

 A caution icon indicates the possibility of damage to data or equipment.

	• Electrical Shock Hazard • Do NOT open • There are no user-serviceable parts in this unit • Do not attempt to repair the analyser yourself • Refer all servicing to qualified Cambridge Sensotec personnel
	• The unit must not be exposed to extreme temperatures below -5°C (23°F) or above 50°C (122°F) • Normal operating temperature is 5°C (41°F) to 35°C (95°F) • Avoid direct sunlight • Do not use liquid cleaners, aerosols or solvents to clean the case • Use a damp cloth for cleaning with the power cable disconnected • Do not use this equipment near water • Avoid touching the Display as this may cause permanent damage • Make sure the rear ventilation slots and the fan on the rear panel are free of obstruction
	• This unit is NOT designed for use in life support situations or any use that is not specified by the manufacturer • No responsibility can be held for injury or loss of life caused by inappropriate use of this equipment • Always use a tube connected to the gas outlet which is vented to atmosphere when working with gases that may be toxic or injurious
	• This unit is not suitable for enriched oxygen samples (O_2 > 30%) as the measurement is limited to ppm levels.

Contents

1 Introduction

The Rapidox 1100-OPT-MAX (OPT= Optical MAX= full range O_2 analysis) dual-sensor oxygen analyser gives accurate oxygen analysis over the full oxygen range 0.5ppm to 1,000,000ppm (0-100%) O_2 with a resolution of 0.1ppm. The analyser provides continuous on-line oxygen analysis, with a typical response time of less than 2 seconds for a t_{63} response to a step change in gas compositions. Note that below 100ppm O_2 response times may be considerably longer.

This special dual-sensor analyser uses two optical sensors to measure both high and low range oxygen measurements in a single instrument. This dual-sensor analyser is designed for applications where a traditional zirconia sensor is not suitable. This includes applications where the measurement gas contains VOCs, solvents, fuels, helium, or hydrogen.

The analyser is fitted with two optical oxygen sensors:

1) OPT% Sensor: a standard high range optical oxygen sensor capable of measuring from 100% down to 1000ppm oxygen.
2) OPTppm Sensor: a special low range optical sensor capable of measuring from 2500ppm down to 0.5ppm oxygen

The Rapidox 1100-OPT-MAX is a fully integrated unit complete with a powerful diaphragm pump to provide gas sampling at up to approximately 1.0 litres per minute.

Note: There is an overlap of the two sensor ranges to allow smooth transition from high to low measurement range, that is controlled by a user-configurable switching point . The analyser uses 200ppm of hysteresis to prevent measurement instability at the switch over point which is factory set to an initial value of 1000ppm.

Note: Only one O_2 sensor is powered at any one time to increase overall sensor life expectancy to over five years for the OPTppm sensor and up to ten years for the OPT% sensor.

Models covered by this manual

This manual describes the following product variants in the Rapidox 1100-OPT-MAX family:

- Rapidox 1100-OPT-MAX-F: Gas connections are on the front panel
- Rapidox 1100-OPT-MAX-R: Gas connections are on the rear panel
- Rapidox 1100-OPT-MAX-P: This model has a 4U panel mounting plate, suitable for installing the Rapidox analyser in a 19" rack

1.1 Sensor Description & Cross Sensitivity

The optical oxygen sensor technology is based on luminescence quenching of a sensor dye. The dye is excited with red light, and the properties of the resulting luminescence are measured in the near infrared. The presence of molecular oxygen quenches the luminescence, changing its intensity. This principle is very robust. It shows virtually no interferences to other gases, has a very low drift, and the sensor is fully solid-state. It does not deplete over time, unlike galvanic oxygen sensors with their limited shelf life. The optics and electronics are hermetically sealed from the measured gas. For typical indoor environmental conditions, a five year operating life is expected for the OPTppm sensor and up to ten years for the OPT% sensor.

Due to the optical measurement principle, the sensor has minimal cross sensitivity to other gases, unlike galvanic oxygen sensors. However, it is cross-sensitive to chlorine gas (Cl_2) and nitrogen dioxide (NO_2).

Exposure of the sensor to organic solvent vapours or other volatile organic compounds (e.g. acetone, outgassing from adhesives or paints), or elevated temperatures, should be avoided since it can result in erroneous oxygen readings and enhanced drift. Please contact Cambridge Sensotec for more information.

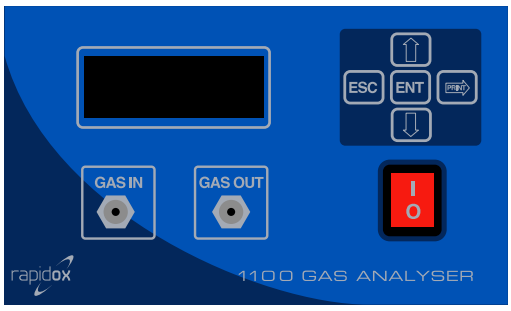
1.2 System Features

- Accurate oxygen analysis in hydrogen, helium and gases containing low levels of solvents / VOCs
- Special dual-sensor analyser measuring 0.5ppm - 1,000,000ppm (0-100%) O_2
- User-configurable switch over point to minimise disturbance of measurements in this range
- Fast measurement response (t_{63} < 2 seconds)
- Accuracy ±2ppm or ±5% whichever is the greater
- Ultra-low drift digital sensor
- Low maintenance, sensor life expectancy over 5 years for OPTppm sensor and 10 years for OPT% sensor
- Powerful variable speed diaphragm pump fitted for sampling the gas
- Clear OLED display (20 x 4 characters)
- 0–10V and 4–20mA analogue signal outputs (both fully configurable)
- Fully configurable alarm relay circuits
- Full data-logging software accessed via RS232 connection to a PC (RS485 available on request)
- Rapidox and Modbus RTU language protocols
- PIN code protection available
- Optional filters:
  - Particle filter: filters out 99.99% particles > 0.1µm
  - Water trap: traps liquid water in very wet environments
  - PTFE filter: for aggressive flux-type gases
  - Carbon trap: absorbs VOCs (volatile organic compounds)
  - Membrane filter: special filter that prevents water vapour from getting into the analyser
- Optional printer attachment
- Optional swing handle kit
- Optional sampling hose and needle probe

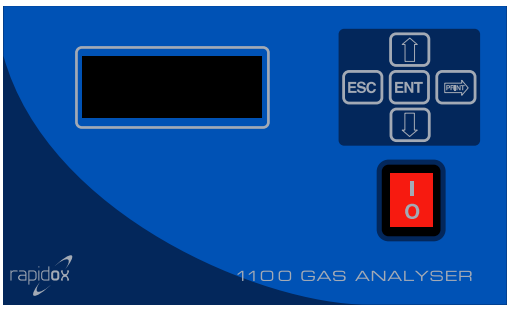
1.3 Front Panel Features

The image below shows the front panel features of the Rapidox Analyser.

The 1100-OPT-MAX-F and 1100-OPT-MAX-P both have the **GAS IN** and **GAS OUT** connectors on the front panel. On the 1100-OPT-MAX-R these are on the rear panel.



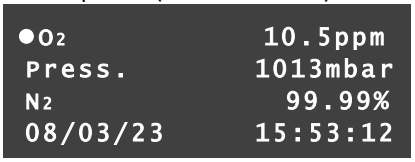
1100-OPT-MAX-F



1100-OPT-MAX-R

Figure 1: Front panel features

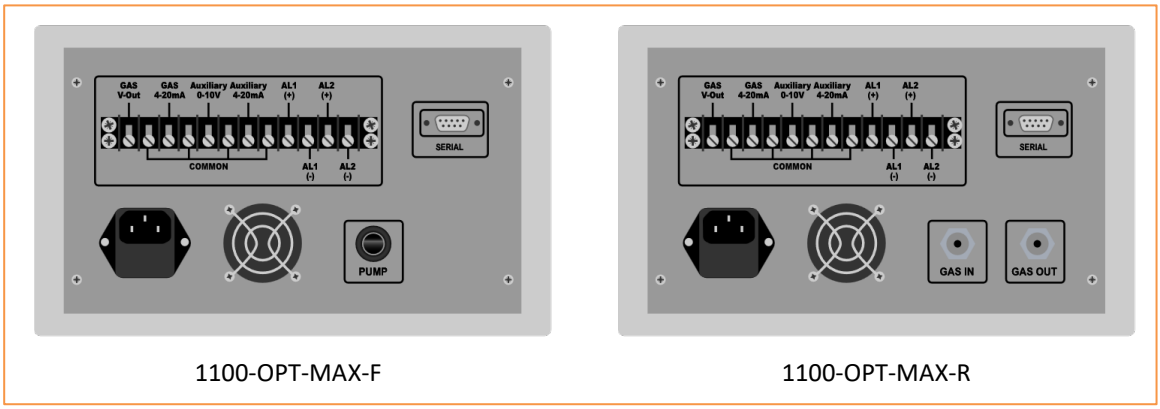
- Display: Four-line OLED panel (20 characters on each line) that displays gas readings, status messages and menu options (see section 1.6)



- **GAS IN** and **GAS OUT** ports (1100-OPT-MAX-F only): These are usually the push-on nipple connector type, but may optionally be one of the following:
  - Swagelok fittings (6mm metric or ¼" imperial)
  - Rectus fittings (closed coupled, i.e. the female has a pin that opens the male)
- Keypad: Soft-touch buttons (e.g. ENT) that allow you to configure and control the Rapidox Analyser via the built-in menu system
- **I/O**: On/Off switch

1.4 Rear Panel Features

The image below shows the rear panel features of the Rapidox 1100-OPT-MAX.



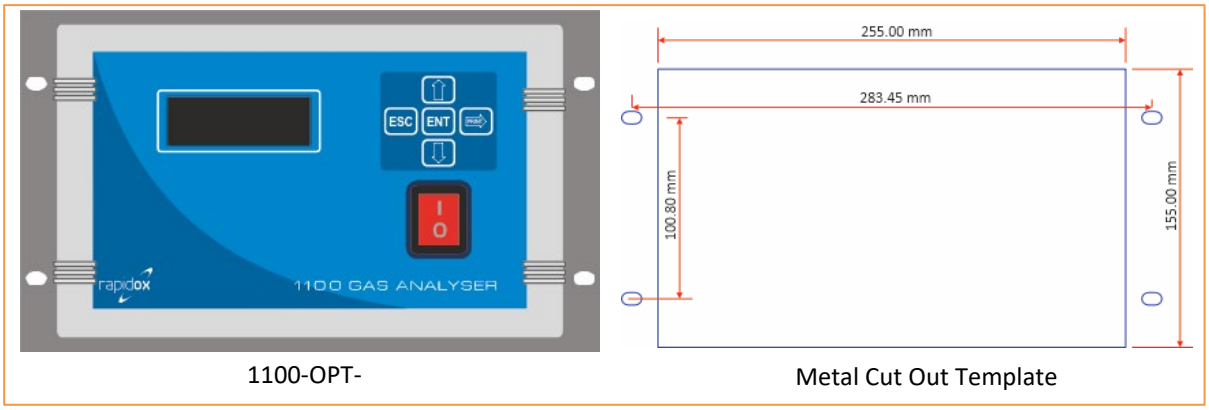
1100-OPT-MAX-F 1100-OPT-MAX-R

Figure 2: Rear panel features

- Analogue output terminal connection panel: Provides connections for industry-standard current and voltage analogue outputs (e.g. 4–20mA, 0–10V), as well as two fully-programmable alarm relays (**AL1** and **AL2** - see section 3.3)
- Fan: Cooling fan
- **GAS IN** and **GAS OUT** ports (1100-OPT-MAX-R or 1100-OPT-MAX-P): These are usually the push-on nipple connector type, but may optionally be one of the following:
  - Swagelok fittings (6mm metric or ¼" imperial)
  - Rectus fittings (closed coupled, i.e. the female has a pin that opens the male)
- IEC power connector: 90–260VAC worldwide voltage
- **SERIAL** communications port: See sections 3.7 and 0
- **PUMP** (1100-OPT-MAX-F): Manual pump override switch. Use this to switch the pump on or off, overriding the current menu setting (see section 3.9). Not fitted to 1100-OPT-MAX-R or 1100-OPT-MAX-P

1.5 Panel Mounting

The image below shows the 1100-OPT-MAX-P panel mount front panel with bezel in place and hole pattern template for cutting & mounting.



1100-OPT-

Metal Cut Out Template

Figure 3: Panel mount version features

- Bezel is 3mm thick clear anodised aluminium
- Bezel size is 300mm wide by 4U tall
- Four fixing holes 10mm x 7mm ovals
- Mounting hole 255mm x 155mm allows 5mm clearance around the housing
- Unit is supplied without feet or carry handle fitted (can be re-fitted at a later date)

1.6 OLED: Display Modes

The OLED (Organic Light Emitting Diode) Display operates in the following modes:

1.6.1 Display: Run mode

When the Rapidox Analyser has reached its operating temperature, the Display shows the oxygen reading and pressure. For example:

```
O2              98.50%
Press.        1025mbar

08/03/23   15:53:12
```

When the analyser is operating in High mode >1000ppm O_2 the reading is coming from the OPT% Sensor.

```
●O2             3.50ppm
Press.        1025mbar

08/03/23   15:53:12
```

When the analyser is operating in Low mode a "●" circle appears next to O_2 to indicate the reading is coming from the Low Range OPTppm Sensor

- Line 1: The oxygen reading (in percent or ppm). A "●" symbol next to O_2 indicates the unit is operating in Low-Range mode.
- Line 2: The pressure (in mbar, bar, kPa, Torr or psi). Note that pressure is absolute on this analyser
- Line 3: Blank, Temperature (in °C or °F) or Balance gas displayed (in % or ppm)
- Line 4: Time and date (default)

The Display can also alert you when alarm conditions have been reached:

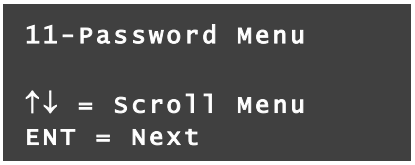
```
O2             ALARM 1L
Press.        1013mbar

08/03/17   15:53:12
```

- If the alarm system is enabled (see section 3.11) and an alarm condition applies, the text **ALARM 1** or **ALARM 2** may appear over the oxygen or pressure reading

- If both alarms are active the text **ALARMS 1&2** will appear
- The additional character **L** indicates that the alarm is latching. If latching is applied to any of the alarms, then the character persists until the appropriate alarm has been removed

1.6.2 Display: Menu mode

Press ENT to access the menu system. The menu screens on the Display are laid out as follows:

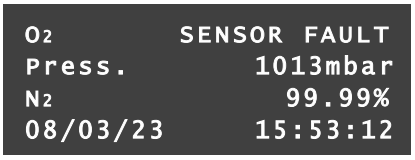


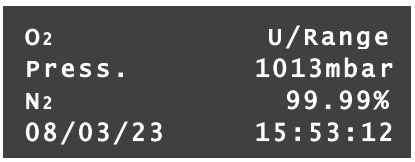
- Line 1: Displays the current menu title or the current action
- Line 2: Displays values that are changing (either numbers such as cal, alarm or analogue values) or the current option in a scrolling list (press ⇧ or ⇩ to cycle through the options)
- Lines 3 & 4: Display instructions explaining how to proceed to the next menu, save the current options or exit the menu system. Line 4 always alternates (every two seconds) between **ESC** and the current instruction. For example, **ENT = Next** means press ENT to move to the next menu screen

There is an example of using the menu system in section 0.

1.6.3 Display: Fault mode

The Display can let you know when faults are detected. Here are two examples:





The oxygen sensor reading may flash, show **U/Range** or **O/Range** when its limits are reached, as shown in Table 1 below, and error messages will be displayed if there is a fault with the sensor

Display messages: Oxygen Sensor	
O_2 Reading > 200%	Display shows **O/Range**
O_2 Reading > 0% and < 200%	Display shows the normal oxygen reading in % or ppm
O_2 Reading <0%	Display shows **U/Range**
O_2 Sensor is OK the pressure sensor is out of range and automatic pressure correction is on.	O_2 Reading is flashing
O_2 Sensor has failed completely or become disconnected	Display shows **Fault** flashing.
O_2 Sensor is OK but the pressure sensor is faulty and the auto pressure correction mode is selected	Display shows **Fault** flashing.
O_2 Reading > 200%	Display shows **O/Range**
O_2 Reading > 0% and < 200%	Display shows the normal oxygen reading in % or ppm
Unit is switching between High and Low Ranges and then sensor is warming up	Display shows **Please Wait** flashing until the Low Range Optical sensor readings are on range.
L-cell sensor has <5% life remaining	Display shows **Replace Sensor Soon** during boot up
L-cell sensor has 0% life remaining	Display shows **Replace Sensor Now** during boot up
Display messages: Pressure Sensor	
Pressure Reading > 1750 mbar abs	Display shows **O/Range Press.**
Pressure Reading > 1700 and <1750 mbar abs	Display flashes
Pressure Reading > 650 and <1700 mbar abs	Display shows the normal pressure reading in mbar, bar, kPa, torr or psi
Pressure Reading > 600 and <650 mbar abs	Display flashes
Pressure Reading < 600 mbar abs	Display shows **U/Range Press.**
Pressure sensor has failed completely or become disconnected or the reading is outside the limits of the ADC.	Display shows **Fault Press.** with the word **Fault** flashing

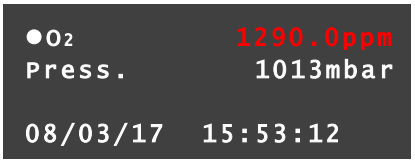
Table 1: Display messages in Fault mode

1.6.4 Display: Switching Mode

At the switching point where the oxygen level is low enough for the OPTppm sensor to take over and begin measuring, the Rapidox switches off the OPT% sensor and the OPTppm sensor is powered on. The analyser then displays the readings on the OPTppm sensor until such time that the oxygen rises to a point where the OPT% sensor takes over again. This transition point is adjustable from 0.05% (500ppm) to 0.2% (2000ppm) with the default setting being 1000ppm. There is a 200ppm hysteresis switching up compared with switching down to prevent reading instability.

During the transition there is a settling period of up to thirty seconds while the OPTppm sensor comes on-line and during this time the display will say "**Please Wait**" flashing. Once the readings are on-scale they will continue to flash for a moment until they have fallen below the switching point, i.e. 1000ppm. All analogue outputs and alarms are frozen temporarily during this wait period.

When the analyser is switching from High range to Low range operation the message "Please Wait" appears for a few seconds.



When the Low Range sensor is on-line and falling the reading flash until the switch point is reached.

1.7 Using the Keypad to Access the Menu System

There are two methods by which you can control and configure the Rapidox 1100-OPT-MAX:

- Using the built-in configuration menu, via the front panel Keypad and the Display
- Using the Rapidox Software application. In this case, you need to connect the unit (via the **SERIAL** port) to a PC running MS-Windows, then install and run the Rapidox Software

This manual describes how to use the built-in configuration menu. Please see the Rapidox Software Manual for instructions on how to use the Rapidox Software to configure the unit, run the Data Logger, and perform other tasks.

You can access the user-configurable functions via a menu system, using the Keypad. Menus and options are shown on the Display.

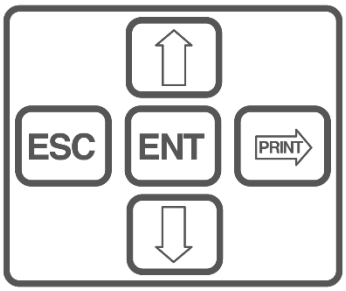


Figure 4: Front Panel Keypad

The table below describes the results of pressing the different keys on the Keypad.

Key press	Action	Result
ENT	Press once	(Run mode) Access the menu system (Menu) Confirm settings, proceed and finally return to menu item start
ENT	Press and hold for 2 seconds	(Menu) reserved for Calibration Save, clean mode & System restore. Confirm settings and return to menu item start or Run mode
⇧ or ⇩	Press once	Scroll through menu options and parameters
PRINT	Press once	(Menu) Select the next character or digit on the line for editing
PRINT	Press repeatedly	(Menu) Scroll through characters/digits on a line (wraps at end)
PRINT	Press once	(Run mode) Print out system information if a printer is connected
ESC	Press once	Go back a level in the menu structure without saving any changes
ESC	Press twice	Return to Run mode without saving any changes

Table 2: Keypad Actions

1.7.1 Example of using the Keypad

Here's an example of how to use the Keypad to change the password. We will assume:

- The current password is the default value of **0000**
- The new password you want to set is **2021**
- You don't want to change the password status (see section 3.11 for full details)
- Pressing ESC at any time returns you to the previous menu screen

To change the password:

1. Press ENT to access the menu system.
2. Press ⇧ or ⇩ to scroll to a menu (e.g. **11-Password Menu**).

```
11-Password Menu

↑↓ = Scroll Menu
ENT = Next
```

3. Press ENT. Notice that the cursor flashes under first character of the password.

```
Enter Password
Password: ****
↑↓→ = Edit
ENT = Next
```

4. Press ⇧ or ⇩ until the correct first character (**0**) is displayed.
5. Press PRINT to move the cursor under the second character.
6. Press ⇧ or ⇩ until the correct second character (**0**) is displayed.
7. Repeat to enter the third and fourth characters.

Note: To edit a character to the left of the cursor, press PRINT repeatedly and the cursor will wrap around back to the beginning of the line.

8. Press ENT to enter the password and move to the next menu screen.

```
Password Status:
Fully Enabled
↑↓  = Change
ENT = Next
```

9. In this case, we don't want to change the password status, so press ENT again to move to the next menu screen.

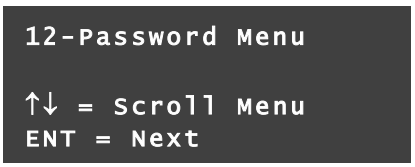
```
Change Password
Password: 0000
↑↓→ = Edit
ENT = Save
```

10. Use PRINT ⇧ and ⇩ to move the cursor between characters and edit the values, as described above.

```
Change Password
Password: 2021
↑↓→ = Edit
ENT = Save
```

11. Press ENT to save the new password.

This screen will be displayed for 2 seconds, then the Display will return to the top-level Password menu.



12. Press ESC to return to Run mode.

For more details on the Menu options see section 3 below.

2 Getting Started

This section explains how to connect the Rapidox Analyser, switch on, and begin taking measurements.

2.1 Before you Start

Before you start:

- Ensure that the Rapidox analyser is located away from extreme heat and dirty environments
- Ensure that there is access to a suitable extractor fan or window
- Make sure that the cooling fan is not obstructed during operation
- Be sure to use an approved gas tubing type (FEP or stainless steel, 6mm OD/4mm ID) for any gas connections

2.2 Make the Gas and Power Connections

This section explains how to connect the Rapidox Analyser before switching on. It includes instructions for connecting any optional filters you may have purchased.

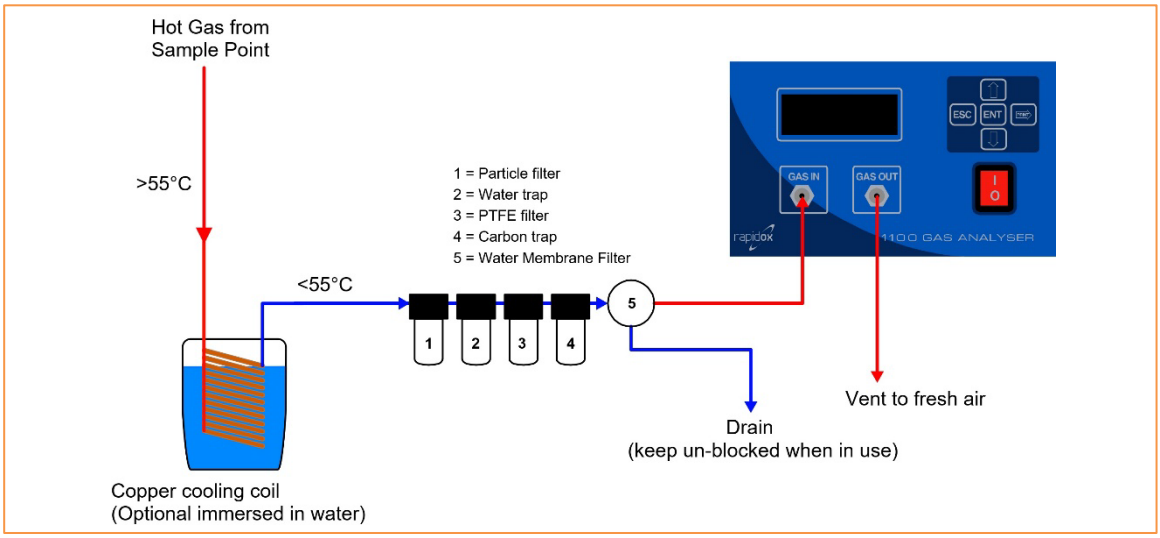


Figure 5: Making the gas connections to filters & dealing with cooling down hot gas

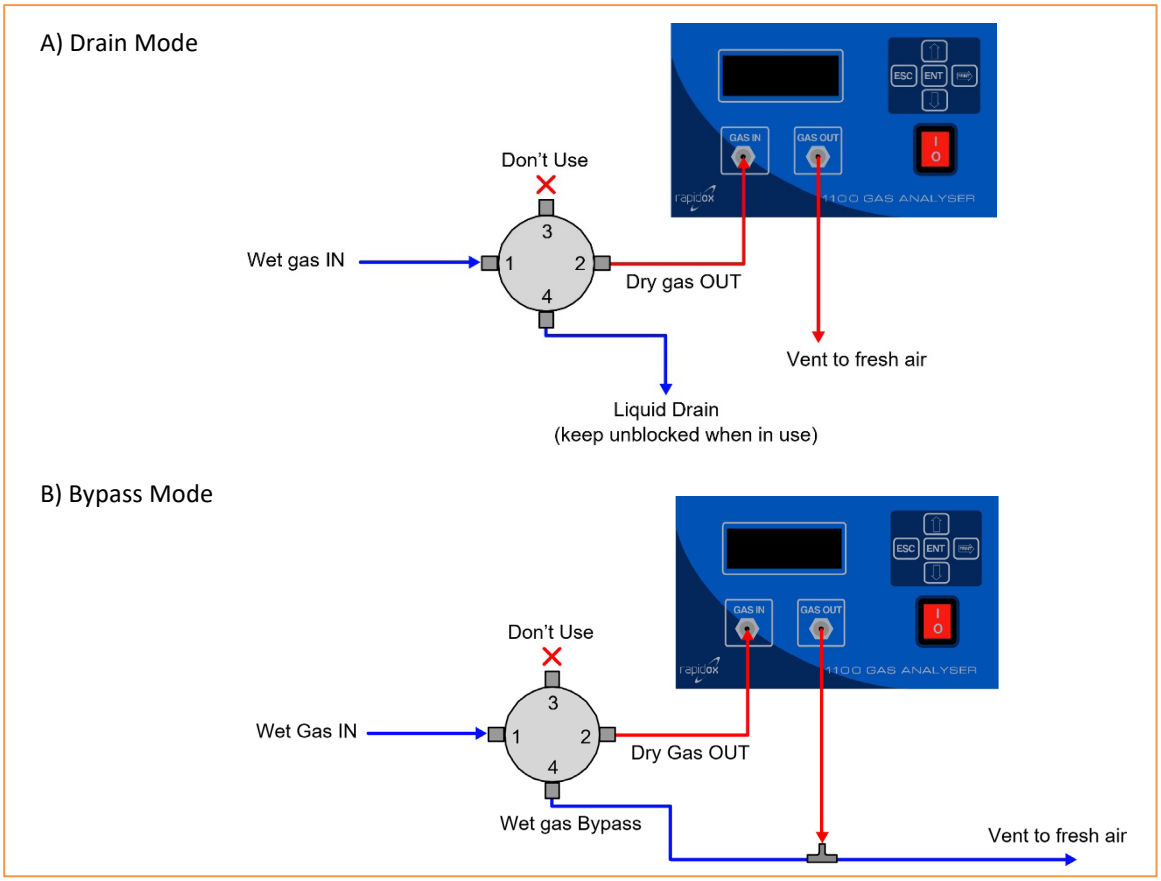


Figure 6: Examples of how to set up and use a water membrane filter on gas lines that have a lot of liquid water present

To make the connections:

1. Connect a gas sample tube from the process you are measuring to any optional cooling coils or filters you have purchased.

   Note: Coils and Filters should normally be connected in the order shown in Figure 5. However, any combination of the filters may be used depending on the application.

2. If you are working with wet gas, use a water membrane filter connected as shown in the examples given in Figure 6 above.

   Note: this type of membrane filter only removes liquid water droplets and not gaseous water vapour.

3. Fit a gas sample tube from the filters onto the **GAS IN** connector and fit the retaining collar so that it is hand tight.
4. If an outlet tube is required, connect a tube to the **GAS OUT** connector and run it to an extractor fan or window.
   The pump will draw gas at a flow rate depending on the value set from the Keypad menu (see section 3.9) or in the Rapidox Software (see the Rapidox Software Manual).
   The default setting is **70%**.
5. Connect the unit into a suitable power supply (noting the information on the serial sticker and using the power cable supplied) via the IEC power socket on the rear panel.

   Note: The machine can operate on any worldwide voltage from 90Vac to 260Vac.

2.3 Make the Analogue Output Connections

Requirements are different for the GAS/Auxiliary and the AL1/AL2 connections.

2.3.1 GAS and Auxiliary Connections

Cabling for **GAS** and **Auxiliary** outputs can be one of the following:

- Twin conductor cable for each signal
- Twisted pair for each signal

For this application, any wire capable of withstanding 0.5A/24V will be suitable.

Connect to a voltmeter, ammeter or PLC as appropriate.

2.3.2 Alarm Connections

The diagram below shows how to connect to the **AL1**/**AL2** terminals (using **AL1** as an example).

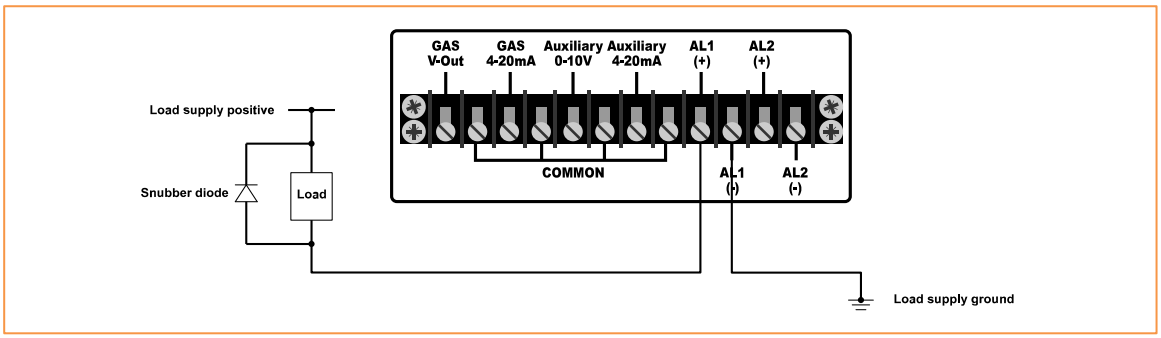


Figure 7: Analogue Output Connections: AL1 & AL2

Note: The load current must not exceed the 0.5A rating of the Rapidox Alarm contact

Note: The load supply voltage must not exceed the 24Vdc rating of the Rapidox Alarm contact

Note: The total load power must not exceed the 10W rating of the Rapidox Alarm contact

Note: For inductive loads such as solenoid valves and secondary electromechanical relays, always fit a snubber diode (UF4001 or similar will be suitable for most loads)

2.4 Connect the Sample Gas Tube

Connect the sample gas tube from the **GAS IN** connector to the process you want to measure. This might be:

- Pure nitrogen (if, for example, you just want to check the Rapidox is working)
- A known calibration gas
- A gas sample point in your industrial process

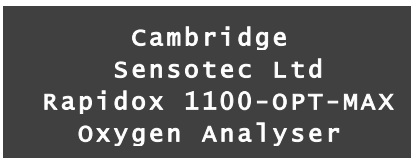
The following gases are **not suitable** for analysis with the Rapidox 1100-OPT-MAX

- Chlorine (Cl_2) containing gases – due to the optical measurement cross sensitivity.
- Nitrogen dioxide (NO_2) – due to the optical measurement cross sensitivity.
- Gases containing large amounts of VOCs & solvent vapours – these can result in erroneous readings and enhanced drift.

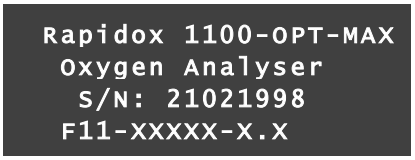
2.5 Switch on the Rapidox and Take Readings

To start the Rapidox Analyser:

1. Switch the unit on using the red power **I/O** switch on the front panel.
2. The Display shows an initial start-up screen for 2 seconds:



3. The Display shows some system information and the serial number (for another 2 seconds):



   The Rapidox will now begin to take measurements.

4. Allow thirty minutes for the analyser to reach a stable working temperature.

   During this warm-up period, it is common for the baseline oxygen to drift by a small amount. If necessary, you can correct this by recalibrating (see section 3.1).

3 Configuring the Rapidox using the Keypad & Menu

This section explains how to use the Keypad and Display to configure the Rapidox Analyser.

You can also perform these and other operations using the Rapidox Software application (see the Rapidox Software Manual).

3.1 Calibrating the Rapidox

This section explains how to calibrate the Rapidox Analyser using a single point calibration gas.

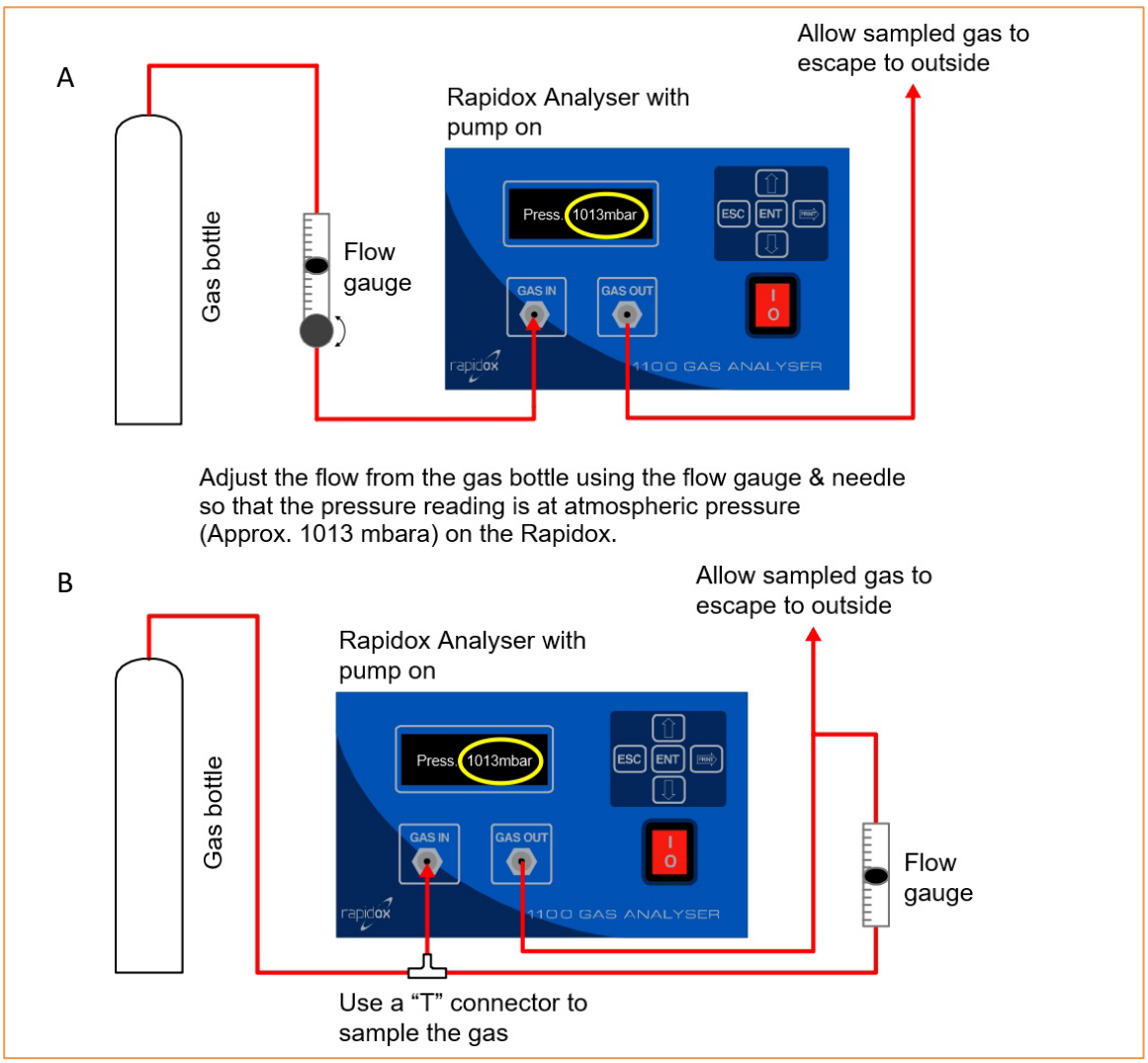


Figure 8: Examples of a typical calibration setup

Note: Make sure that the external flow gauge shows a positive flow with the Rapidox pump switched on. The pressure display of the Rapidox should read atmospheric pressure (approx. 1013mbara) in this configuration.

3.1.1 About calibration

The two optical sensors are extremely stable and virtually drift free meaning that the factory calibration should be fine for most users. However periodic calibration is still highly recommended every twelve months to achieve full accuracy.

You can re-calibrate the Rapidox 1100-OPT-MAX analyser using any three calibration gases (LOW, MIDDLE & HIGH) as long as HIGH > MIDDLE > LOW and the MIDDLE gas falls within the sensor switching point range (500 - 2500ppm O_2). The cal gas values are factory set as LOW = 10ppm, MIDDLE = 1000ppm & HIGH = 209,500ppm, and we recommend that you don't change these unless you have a good reason. During each calibration, the two sensors are exposed to the correct calibration gas from a cylinder until the display reading is stable.

The OPT% sensor is calibrated using the HIGH and MIDDLE cal points and the OPTppm sensor is calibrated using the MIDDLE and LOW cal points. This means that the two sensors are locked together by the MIDDLE cal point and both sensors are calibrated at the same time in the same gas at the switchover point which guarantees a smooth transition from high to low during use.

You can calibrate the analyser HIGH using any calibration gas including air (20.95%) as long as it is >0.1% oxygen. For the MIDDLE calibration the oxygen value is restricted to between 500ppm (0.05%) and 2,000ppm (0.25%) since both sensors must be calibrated at the same time, in gas that is compatible with their scale. The LOW calibration can be completed on any gas <1000ppm including 6.0 N_2 for a zero point (0.00%).

Typically, the factory settings are:

- **HIGH** = 209,500ppm (20.95%) O_2 (fresh air can be used 20.954%)
- **MIDDLE** = 1000ppm (0.1%) O_2
- **LOW** = 10ppm (0.001%) O_2 (pure N_2 6.0 can be used for a zero point)

Note: the calibration points are independent of each other so you can calibrate the analyser in any order you desire. However, you must ensure that **HIGH > MIDDLE > LOW**.

3.1.2 Before you start

1. Decide which gases you are going to use for calibration. If you constantly work at a specific range of compositions, it would be wise to obtain small cylinders of calibration gas with analysis certificates. Cambridge Sensotec can supply these.
2. Check the Display in Run mode to see which units are currently in use. If you want to work in different units, see section 0.

Note: You should always perform a **full** calibration to achieve good accuracy.

Note: Under normal operation an annual calibration will prove sufficient. All Rapidox analysers can be returned to Cambridge Sensotec for a range of service and calibration options. Please contact us for further information.

3. If at any time, you want to restore the unit to a default calibration state, you can:

- Reset the Rapidox Analyser to 'generic' factory defaults directly from the Keypad (see section 3.10)
- Use the Rapidox Software to load the machine-specific factory default settings (see the Rapidox Software Manual). Each machine is provided with a unique file that contains the factory settings. This is located on the USB memory stick provided and is copied onto your PC during the installation process.

3.1.3 Calibrating the HIGH Gas Point

In the example below, we show how to calibrate the analyser High point to air (20.95%). The same principles apply to calibrating for any Cal Gas value. To perform the calibration:

1. Make the gas connections as shown in Figure 8 (page 17).
2. Press ENT on the Keypad to access the menu system.

3. Scroll (press ⇧ or ⇩) to the **1-Calibrate** menu and press ENT.
4. If prompted (because a partial password has been set, as described in section 3.11), enter your password and press ENT.
5. Scroll to **O_2 Cal Gas: HIGH** and press ENT.

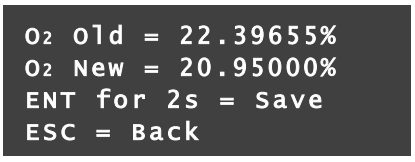
6. You are asked if you are using fresh air. This will speed up the process. Scroll to **Y** and press ENT.

7. The analyser asks if you have fitted a new OPT% sensor. Scroll to **N** and press ENT.

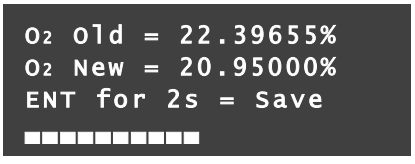
The display will set itself to show air 20.95000%. If you want to change this to something else then use the ⇧ or ⇩ or PRINT keys to make changes to the characters to form a new gas value. To edit a digit to the left of the cursor, press PRINT repeatedly and the cursor will wrap around back to the beginning of the line.

8. Press ENT when you are ready to proceed.

   The old and new values will be displayed:



9. Make sure to switch on the pump and allow fresh air to flow through the analyser.
10. Wait several minutes for the sensor to flush properly, after which the reading on the top line of the Display will become stable.
11. Press and hold ENT for two seconds to complete the calibration. During this time, the Display will show a progress bar.



The analyser will then recalibrate and display **O_2 High Calibrated** for 2 seconds before returning to Run mode:

```
O2 Old = 22.39655%
O2 New = 20.95000%

O2 High Calibrated
```

The Display will now correctly read the value of the selected calibration gas.

Note: If you release ENT before two seconds have elapsed, the recalibration will be aborted; when the analyser returns to Run mode, it will use the old (unchanged) calibration

3.1.4 Calibrating the MIDDLE point

Calibrating the MIDDLE calibration point sets both the OPT% Sensor LOW point and at the same time sets the OPTppm Sensor HIGH point. Since both sensors are calibrated at the same time in the same gas, the gas needs to be compatible with both sensor scales, and because of this the range of cal gas permitted is restricted from 500ppm (0.05%) to 2,500ppm (0.25%) with the default setting at 1000ppm (0.1%) It is strongly recommended that 1000ppm is the gas always used.

1. Make the gas connections as shown in Figure 8 (page 17).
2. Press ENT on the Keypad to access the menu system.
3. Scroll (press ⇧ or ⇩) to the **1-Calibrate** menu and press ENT.
4. If prompted (because a partial password has been set, as described in section 3.11), enter your password and press ENT.
5. Scroll to **O_2 Cal Gas: MIDDLE** and press ENT.

```
1-Calibrate
O2 Cal Gas: Mid
↑↓ = Change
ENT = Next
```

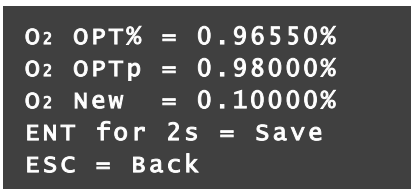
6. You are asked if the OPTppm sensor has been replaced. The default is N. If it is a new sensor scroll to **Y** and press ENT. The lifetime calculator will then be reset to 100%

```
Calibrate
New OPTppm Fitted? N
↑↓ = Change
ENT = Next
```

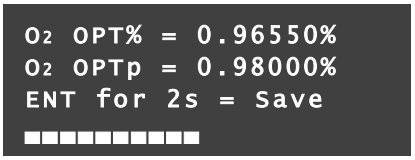
7. The display will set itself to show 1000ppm (0.1%). If you want to change this to something else then use the ⇧ or ⇩ or PRINT keys to make changes to the characters to form a new gas value. To edit a digit to the left of the cursor, press PRINT repeatedly and the cursor will wrap around back to the beginning of the line. Note the limits are set between 500ppm (0.05%) and 2,500ppm (0.25%) for this cal point.

```
Set O2 Gas Mid
O2: 0.1000%
↑↓→ = Edit
ENT = Next
```

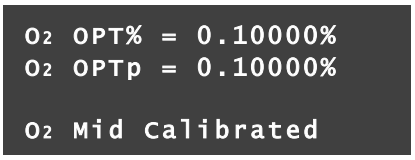
8. Press ENT when you are ready to proceed. The cal gas needs to be applied to the gas inlet and the analyser will then display both live values for The High and Low range sensors together. The units of percent or ppm are determined by the Display Settings used:



9. Wait several minutes for both sensors to flush properly, after which both readings the top two lines of the display will become stable.
10. Press and hold ENT for two seconds to complete the calibration. During this time, the display will show a progress bar.



The analyser will then recalibrate and display **O2 Low Calibrated** for 2 seconds before returning to Run mode:



The Display will now correctly read the value of the selected calibration gas.

Note: If you release ENT before two seconds have elapsed, the recalibration will be aborted; when the analyser returns to Run mode, it will use the old (unchanged) calibration

3.1.5 Calibrating the LOW point

To set the LOW point of the sensor use pure 6.0ppm nitrogen gas from a cylinder or a certified cal gas e.g. 10ppm to set the Cal Gas LOW

1. Repeat the above procedure, but this time select the next calibration gas (e.g. **O2 Cal Gas: Low**).
2. Flush the analyser with the ultra-pure nitrogen gas or certified cal. gas following the guide in Figure 1 above, allowing several minutes for the new gas to flush through.
3. Wait for the display to become stable then press ENT for two seconds.

   The analyser will recalibrate and display **O2 Gas Low Calibrated** for 2 seconds and then return to Run mode. The Display will now correctly read zero in pure nitrogen gas.

The analyser is now correctly calibrated and will read accurately.

3.2 Setting Alarms

The Rapidox is fitted with two independent and fully configurable alarm relay outputs, which can be configured to be either normally open (N/O: closes on alarm) or normally closed (N/C: opens on alarm).

The alarm circuit relays are accessed via the terminal block on the rear panel and are clearly labelled (see Figure 7). Alarm 1 is assigned to the terminals labelled **AL1** and Alarm 2 is assigned to the terminals labelled **AL2**. The relay circuit is rated at 24V, 0.5A maximum, for non-inductive loads. Contact Cambridge Sensotec for advice on driving inductive loads such as solenoid valves.

You can:

- Assign each alarm to the internal oxygen, pressure or balance gas readings.
- Enable the alarm relay circuits
- Enable an audible buzzer
- Enable a visual warning on the Display
- Configure the alarms to latch, so that once triggered they must be turned off manually
- Set alarm delays to prevent false or repeated triggering on noise spikes in the readings

The full list of possible settings is given in Table 3 below.

Parameter	Options	Description
Outputs	**ON** **OFF**	Enables or disables the rear panel relay outputs
Audible	**ON** **OFF**	Enables or disables the audible buzzer inside the unit which will sound in an alarm condition
Visible	**ON** **OFF**	Enables or disables warning messages on the Display. During an alarm condition, either **ALARM 1** or **ALARM 2** (or a combination of both) will flash alternating with the gas or pressure reading
Polarity	↑ ↓	Determines whether you are setting a rising or falling alarm. A rising alarm means that the alarm will be silent at values below the set-point but as soon as the value rises above the set-point the alarm will be triggered
Delay	**0 to 60s**	You can choose a value of between 0 and 60 seconds to delay the triggering of the alarm. If the alarm is still active after the delay period, it will energise. Otherwise, it will do nothing. This is to allow for noise spikes and to prevent alarm "chattering"
Latching	**ON** **OFF**	When a latching alarm is triggered, press ESC to cancel it. If a second alarm state is active, then after 1 second the alarm will re-trigger ad infinitum. If latching is off, the alarm will automatically engage and disengage with alarm events. When a latching alarm is triggered, the Display shows the character **L** after the alarm number to indicate that an alarm is latched
Contacts	**N/O** **N/C**	The factory default is **N/O**, meaning the contacts will close when an alarm condition occurs. Note this menu option is only available if **Outputs** has been set to **ON**
Setpoint		The current alarm set-point is displayed in the units of choice with a flashing cursor under the first digit. The limits are set to match the scale of the sensor.

Table 3: Alarm Settings Menu Options

Note: You must program all the parameters for each alarm for the settings to be saved. Line 4 of the Display will show **Alarm x Set** (where 'x' is the selected alarm channel) to confirm that the settings have been saved.

3.2.1 Example: Setting an alarm

The example below shows how to set Alarm 1 to trigger when the oxygen level rises above 200ppm. We will work through all the options (for example, enabling the audible and visible alarms, setting an alarm delay) as you must always set all the options in the Alarms menu for the settings to be saved.

Note: This example assumes the Display Units option is set to **%** (see section 0).

The options are listed in full in Table 3 above.

To change the alarm settings, proceed as follows (in some cases you can just press ENT to accept the default setting and move to the next menu screen, rather than scrolling to select a particular option):

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **2-Alarms** menu and press ENT.
3. Scroll to **Set: Alarm 1** and press ENT.
4. Scroll to **Assign To: Oxygen** and press ENT.
5. Scroll to **Alarm Outputs: ON** and press ENT. This enables the rear panel relay outputs.
6. Scroll to **Audible Alarm: ON** and press ENT.
7. Scroll to **Visible Alarm: ON** and press ENT.
8. Scroll to **Alarm Polarity: ↑** and press ENT. This sets a rising alarm.
9. Scroll to **Alarm Delay: 0.5sec** and press ENT.
10. Scroll to **Alarm Latching: OFF** and press ENT.
11. Scroll to **Alarm Contacts: N/C** and press ENT. This sets the relay outputs to Normally Closed.
12. Set the alarm trigger point **O_2: 200.00ppm**.

    Press PRINT to move the cursor between characters, and press ⇧ or ⇩ to alter the values.
13. Press ENT when finished.
14. Press ENT to save the settings.

    The Display will show a confirmation message for two seconds, before returning to the **2-Alarms** menu:

15. Press ESC to return to Run mode

3.2.2 Alarm Behaviour in Abnormal Operational Conditions

Under certain abnormal conditions (such as when the analyser is being powered up and in user-menu mode) the Rapidox will disable the alarms, and the relay contacts for the affected channel will go to the programmed N/O or N/C setting if alarm outputs are configured ON. If they are configured OFF, then the relay contacts will remain OPEN under all conditions. For detailed information please refer to Table 4 below.

Alarm settings: Alarm outputs = On, Contacts = Normally Open, Others = Don't care

	Alarm status	
Analyser Status	**Alarm assigned to Oxygen**	**Alarm assigned to Pressure**
Power up greeting	Open	Open
Run mode	Active according to settings	Active according to settings
User setup menu	No change – latched in current state	No change – latched in current state
Power loss	Open	Open
Sensor fault – disconnected	Open	Open
Pressure sensor fault – auto pressure compensation enabled	Open	Open
Pressure sensor fault – no pressure compensation	Active according to settings	Open

Alarm settings: Alarm outputs = On, Contacts = Normally Closed, Others = Don't care

	Alarm Status	
Analyser Status	**Alarm assigned to Oxygen**	**Alarm assigned to Pressure**
Power up greeting	Open	Open
Run mode	Active according to settings	Active according to settings
User setup menu	No change – latched in current state	No change – latched in current state
Power loss	Open	Open
Sensor fault – disconnected	Closed	Closed
Pressure sensor fault – auto pressure compensation enabled	Closed	Closed
Pressure sensor fault – no pressure compensation	Active according to settings	Closed

Table 4: Alarm behaviour in abnormal operational conditions

3.3 Configuring the Analogue Outputs

The Rapidox analyser provides various analogue outputs on a linear output scale.

The standard industrial analogue outputs (0–10V and 4–20mA) for both oxygen and internal pressure are accessible via the terminal block on the rear panel. The selected balance gas reading can also be assigned to the rear outputs if desired. These outputs have a 12-bit resolution (approximately 1 in 4000) and the lower and upper values are fully user-configurable using the Keypad or the Rapidox Software (see the Rapidox Software Manual).

Note: the voltage outputs (0 to 10V) and current outputs (4 to 20mA) are locked together, so that these outputs cannot be set independently of each other. In normal operation, therefore, 0V output always corresponds to 4mA and 10V always corresponds to 20mA output.

During initial warm up of the Rapidox (when the Display shows the serial number) the output sent to the rear terminal for oxygen will stay at 2mA (1.25V) which is the standby signal. If at any stage a sensor becomes disconnected internally, or the signal exceeds the measurable range for that sensor, then the Display will indicate there is a fault and the outputs will change to 1mA (0.625V) which is the sensor fault signal. This will recover as soon as the sensor is reconnected, and the fault cleared. Additional current and voltage signals are provided by the analyser to give an indication of various conditions and these are described in Table 5 overleaf, together with the status of the alarms during the condition:

O_2 Analogue Outputs				
Current (4–20mA)	**Voltage (0–10V)**	**Description**	**Explanation**	**Alarms**
1mA	0.625V	Fault	There is a sensor fault on the oxygen sensor, and/or the temperature sensor has a fault condition, and/or the pressure mode is set to automatic (pressure compensation active) and the pressure sensor has a fault condition	Deactivated
2mA	1.25V	Start-up	The analyser is still initialising	Deactivated
2.5mA	1.5625V	Sensor under range	The sensor reading is under range	Active
3mA	1.875V	Sensor over range	The sensor reading is over range	Active
3.5mA	2.1875V	Sensor operating out of specification	The sensor reading is in range, but the temperature sensor reading is out of range, and/or the pressure mode is set to automatic (pressure compensation active) and the pressure sensor is out of range	Active
4 to 20mA	0 to 10V	Normal operating output	The O_2 sensor and associated sensor(s) are operating normally and readings are in range	Active
Pressure Analogue Outputs				
Current (4–20mA)	**Voltage (0–10V)**	**Description**	**Explanation**	**Alarms**
1mA	0.625V	Fault	The pressure sensor has a fault	Deactivated
2mA	1.25V	Start-up	The analyser is still initialising	Deactivated
2.5mA	1.5625V	Sensor under range	The pressure sensor / Balance Gas reading is under range	Active
3mA	1.875V	Sensor over range	The pressure sensor / Balance Gas reading is over range	Active
4 to 20mA	0 to 10V	Normal operating output	The pressure sensor / Balance Gas reading is operating normally and readings are in range	Active

Table 5: Analogue output settings and alarm status for certain conditions

Note: The current outputs are *active* self-powered outputs; they are *not* loop powered

Note: The voltage (0 to10V) outputs produce non-zero voltages during start-up, fault, and over/under range conditions; if 1V to 5V outputs are required, with these conditions indicated by corresponding voltages between 0V and 1V, the current outputs can be used, with a 250Ω load resistor

Note: Alarms are deactivated during start-up initialisation, and when a fault condition occurs on the assigned sensor

3.3.1 Example: Setting the oxygen analogue output range

The example below explains how to configure the oxygen analogue output range with the following settings:

- 0V/4mA: 10.000ppm
- 10V/20mA: 200.00ppm

Note: This example assumes the Display Units option is set to **ppm** (see section 0).

To modify the oxygen analogue output range:

1. Press ENT on the Keypad to access the menu system.

2. Scroll (press ⇧ or ⇩) to the **3-Analogue Outputs** menu and press ENT..
3. Scroll to **Set: Oxygen** and press ENT.
4. Set the 0V/4mA Value **O_2: 10.00ppm**

   Press PRINT to move the cursor between characters, and press ⇧ or ⇩ to alter the values.

5. Press ENT when finished.
6. Set the 10V/20mA Value **O_2: 200.0ppm**
7. Press ENT to save the settings.

   The Display will show a confirmation message for two seconds, before returning to the **3-Analogue Outputs** menu:

```
Oxygen Output
0V/4mA:   10.000ppm
10V/20mA: 200.00ppm
Analogue Output Set
```

8. Press ESC to return to Run mode.

3.3.2 Example: Modifying the pressure outputs

The example below explains how to set the pressure output range with the following settings:

- 0V/4mA: 900mbar (absolute)
- 10V/20mA: 1100mbar (absolute)

The permissible range is 0mbar to +2000mbar (absolute)

> **Note**: This example assumes the Display Units option for Pressure is set to **mbar (absolute)** (see section 0).

To select and modify the pressure outputs:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **3-Analogue Outputs** menu and press ENT.
3. Scroll to **Set: Auxiliary Out** and press ENT.
4. Scroll to **Set: Pressure** and press ENT.
5. Set the 0V/4mA Value **Pressure: 900.0 mbar**.
6. Press PRINT to move the cursor between characters, and press ⇧ or ⇩ to alter the values.
7. Press ENT when finished.
8. Set the 10V/20mA Value **Pressure: 1100 mbar**.
9. Press ENT to save the settings.

The Display will show a confirmation message for two seconds, before returning to the **3-Analogue Outputs** menu:

```
Auxiliary Output
0V/4mA:   900mbar
10V/20mA: 1100mbar
Analogue Output Set
```

10. Press ESC to return to Run mode

3.3.3 Oxygen Output Linear Scale

The linear oxygen output mode setting produces an output that is scaled linearly between 0 and 10V (or 4 and 20mA). For example, if the scale is set 0V = 0ppm O_2 and 10V = 2500ppm O_2 (the full scale of the OPT-MAX sensor) then 5V would indicate an oxygen reading of 1250ppm O_2. The scaling of this example is shown in the following plot, from which other intermediate values can also be read.

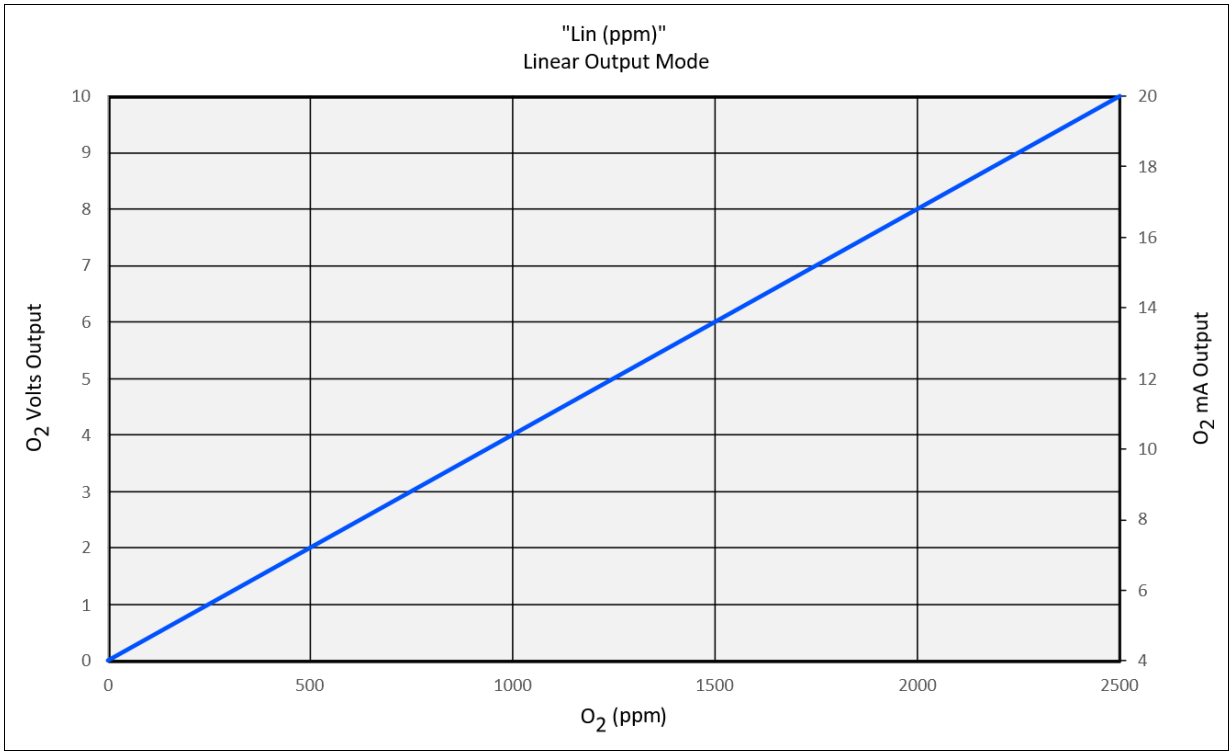


Figure 9: Graph showing the linear output mode option for oxygen

The following general formulae can be used to calculate the oxygen from the voltage or current outputs when set to the linear output mode:

Output type	Formula for calculating oxygen from analogue output signal
0–10V	$O_2 = V_{out} / 10 * (O_{2H} - O_{2L}) + O_{2L}$
4–20mA	$O_2 = (mA_{out} - 4) / 16 * (O_{2H} - O_{2L}) + O_{2L}$

Where:

O_{2L} = user setting of oxygen for 0V or 4mA output
O_{2H} = user setting of oxygen for 10V or 20mA output
V_{out} = the measured voltage output in volts
mA_{out} = the measured current output in mA

Note: O_2, O_2L and O_2H must all be in the same units.

3.4 Setting the Display Units

You can use the Keypad or the Rapidox Software (see the Rapidox Software Manual) to set the Display units.

The following options are available:

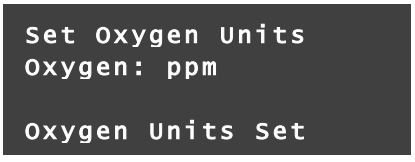
Menu screen	Options	Description
Set Oxygen Units	**%**	The oxygen reading can be displayed in percent (e.g. 0.250%)
	ppm	The oxygen reading is displayed in ppm (e.g. 2500ppm) – the default on this model.
	EXP	The oxygen reading is displayed in scientific notation (e.g. 2.500E+02ppm)
	Auto	The oxygen reading is displayed as a percentage from 100% down to 0.1% and as ppm below this value
Set Pressure Units	**mbar** **bar** **psi** **torr** **kPa**	Sets the display units when you select **Pressure** in the menu described above

Table 6: Display Units

To set the Oxygen Units:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **4-Display Units** menu and press ENT.
3. Scroll to select **Oxygen** and press ENT.
4. Scroll through the available units and press ENT to select an option (e.g. **ppm**; see Table 6 for a full list of options).

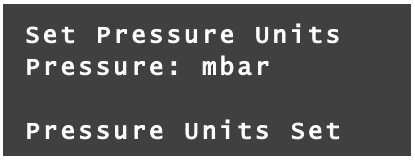
   The Display will confirm your selection for 2 seconds then return to the **4-Display Units** menu.



To set the Pressure Units:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **5-Display Units** menu and press ENT.
3. Scroll to select **Pressure** and press ENT.
4. Scroll through the available units and press ENT to select an option (e.g. **mbar**; see Table 6).

   The Display will confirm your selection for 2 seconds before returning to the **4-Display Units** menu.



5. Press ESC to return to Run mode.

Note: The units you select here will be used in all other configuration menus on the Rapidox

3.5 Setting the Display Options

You can select the Display refresh rate and the text shown on line 3 & 4 of the Display in Run mode using the Keypad or the Rapidox Software (see the Rapidox Software Manual).

```
5-Display Setup

↑↓ = Scroll Menu
ENT = Next
```

The following options are available:

Menu screen	Options	Description
Refresh Rate	**Seconds**	The refresh rate of the OLED can be changed from 0.1 to 1.5 seconds
Line 3 options	**N_2 Balance**	This displays the balance of the O_2 reading as nitrogen (100-O_2=N_2)
	Ar Balance	This displays the balance of the O_2 reading as argon (100-O_2=Ar)
	CO_2 Balance	This displays the balance of the O_2 reading as carbon dioxide (100-O_2=CO_2)
	H_2 Balance	This displays the balance of the O_2 reading as hydrogen (100-O_2=H_2)
	He Balance	This displays the balance of the O_2 reading as helium (100-O_2=He)
	Balance	This displays the balance of the O_2 reading as a balance (100-O_2=Balance)
	None	Line 3 is left blank
Line 4 options	**Date & Time**	Displays the Date & Time on line 4. The format of the display can be changed through Menu Option 9
	None	Line 4 is left blank

Table 8: Display Units

To change the refresh interval:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **5-Display Setup** menu and press ENT.
3. Scroll to select **Refresh Interval** and press ENT.
4. Scroll to select a refresh interval and press ENT.

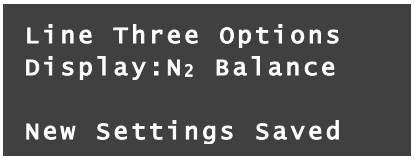
   You can select a value between 0.1 and 1.5 seconds. The default is 0.3 seconds.
5. The Display confirms your choice for 2 seconds before returning to the **5-Display Setup** menu. For example:

```
Refresh Interval
Interval: 0.3secs

OLED Refresh Set
```

To change the Line Three Display:

1. Press ENT, scroll to select **Line Three Options** and press ENT.
2. Scroll to select an option (**N_2, Ar, CO_2, H_2, He, Balance or None**) and press ENT.

The Display confirms your choice for 2 seconds before returning to the **5-Display Setup** menu. For example:

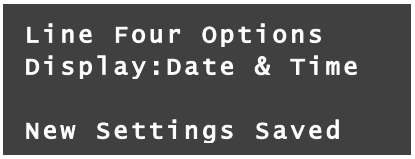


3. Press ESC to return to Run mode.

To change the Line Four Display:

4. Press ENT, scroll to select **Line Four Options** and press ENT.
5. Scroll to select an option (**None** or **Date & Time**) and press ENT.

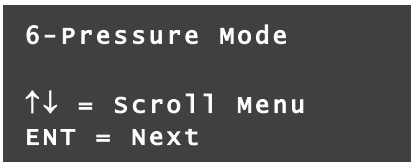
   The Display confirms your choice for 2 seconds before returning to the **6-Display Setup** menu. For example:



6. Press ESC to return to Run mode.

3.6 Setting the Pressure Mode

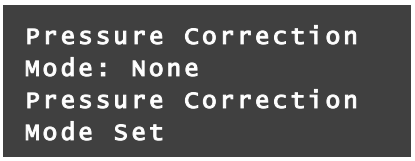
You can use the reading from the internal pressure sensor to automatically correct for changes in gas pressure and hence oxygen pressure.



To set the Pressure Mode:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **6-Pressure Mode** menu and press ENT.
3. If prompted (because a partial password has been set, as described in section 3.11) enter your password and press ENT.
4. Scroll to select a mode (**None** or **Auto**) and press ENT. See Table for a description of the two modes.

   The Display confirms your choice for 2 seconds before returning to the **6-Pressure Mode** menu. For example:



5. Press ESC to return to Run mode.

Mode	Description
None	No pressure correction is performed on the oxygen reading. The pressure and oxygen sensor act independently. If the sensor is working in 200ppm oxygen and the pressure is doubled to 2000 mbara, then the reading will also double to 400ppm. This is the correct oxygen partial pressure in air at 1 bar gauge since there is a simple linear relationship between pressure and concentration.
Auto	This is the factory default setting. The reading from the internal pressure sensor is used to correct the oxygen partial pressure and maintain a concentration reading. If the sensor is working in 200ppm oxygen and the pressure suddenly jumped to, for example, 500 mbar above atmospheric, the oxygen reading would remain at 200ppm because the sensor has been corrected for the pressure change. This allows users who are working with fluctuating input pressures to maintain a meaningful reading of oxygen concentration that will only be affected by changes in gas composition and not gas pressure.

Table 9: Pressure Modes

3.7 Setting the Communications Protocol

The Rapidox has two communications options: Rapidox protocol (used with our software) and Modbus RTU (used with PLCs).

Please refer to Appendix 1: Modbus Communications for detailed instructions on how to configure Modbus communications.

3.7.1 Setting up the Rapidox Communications Protocol

If you are using the Rapidox Software for data logging, you can set the communications speed (Baud Rate) as follows:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **7-Configure Comms** menu and press ENT.
3. Select the Protocol (**Rapidox**) and press ENT.
4. Select the baud rate (**115200, 57600** or **9600**) and press ENT.

   The default factory setting is 115200. However, if you are using an older PC you can decrease this to 9600 to improve the reliability of the software and data communications.

   The Display confirms your choice for 2 seconds before returning to the **7-Configure Comms** menu. For example:

```
Rapidox Protocol
Baud Rate: 57600

Comms Configured
```

5. Press ESC to return to Run mode.

Refer to the Rapidox Software Manual for further information.

3.7.2 Setting up the Modbus Communications Protocol

Please note that Modbus communications are described in detail in Appendix 1 below. To set Modbus RTU as the communication protocol:

```
7-Configure Comms

↑↓ = Scroll Menu
ENT = Next
```

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **7-Configure Comms** menu and press ENT.
3. Select the Protocol: **Modbus RTU** and press ENT.
   Follow the instructions on the Display to set the other Comms options. See Table 10 below for a detailed description of all the options
4. Press and hold ENT for 2 seconds to complete the setup and return to Run mode.

Parameter	Options	Description
Baud Rate	**2400** **4800** **9600** **19200** **38400** **57600**	This needs to match the baud rate of the PLC. The factory default is 9600
Data Bits	**8**	This is factory set to 8 and cannot be changed. The screen is displayed just for information purposes
Parity	**None** **Odd** **Even**	This is a check feature. The factory default is **Even**
Stop Bits	**1** **2**	This is the number of bits used to signify the end of the data. The factory default is 1
Float	**ABCD** **CDAB** **BADC** **DCBA**	This defines the sequence in which floating point data packets are sent and is shown in Figure 10 below. The factory default is **ABCD**
Address	**1–247**	The Rapidox needs to be assigned a unique address to communicate on the Modbus. Choose an address from 1 to 247 which is not assigned to any other equipment. If you select a number outside this range, then it will be set to the max. or min. value instead

Table 10: Modbus communication parameters

These four bytes shown in Figure 10 represent the floating-point ppm value of oxygen OR pressure depending on which resister has been requested. The sequence of bytes ABCD is defined by the **Float** menu setting described above.

Most Significant Bytes		Least Significant Bytes	
48 A	44 B	93 C	C0 D

Figure 10: Floating-point ppm value of oxygen OR pressure

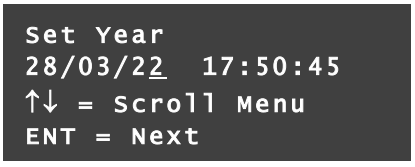
3.8 Setting the Date and Time

To set the date and time:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **8-Set Date & Time** menu and press ENT.
3. Select the Date Format (e.g. **DD/MM/YY**) and press ENT.

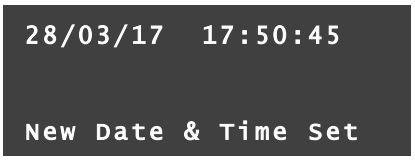
   You can choose from DD/MM/YY, MM/DD/YY, YY/MM/DD, DD-MM-YY, YY-MM-DD, DD.MM.YY YY.MM.DD or YYYY-MM-DD (ISO standard format).

   Whichever format you select, on the next screen the cursor flashes under the year value, as this will dictate how the months behave e.g., during a leap year. For example:



4. Press ⇧ or ⇩ to change the year, then press ENT..
5. Follow the instructions on the following screens to set the month, day, hours, minutes and seconds, using ⇧ or ⇩ to change the values and pressing ENT. To set and move to the next menu screen.
6. At the final screen, press ENT to save.

   The Display confirms your choice for 2 seconds before returning to the **8-Set Date & Time** menu. For example:



7. Press ESC to return to Run mode.

If you make a mistake at any time, press ESC to return to the main menu and then press ENT again.

Note: The Rapidox will permanently store the time and date entered. If you re-programme the date and time using the Rapidox Software (see Rapidox Software Manual), this will overwrite any changes you make using the Keypad. The analyser will use the current date and time of the PC as well as the local date format.

Note: The exact date format will depend on the country you are in and the language and local settings of the PC which you have used to connect to the analyser. To set the local date format, use the **Utility > Set date and time** drop-down menu in the Rapidox data logging software. For example, in the USA you would now see the date as mm/dd/yy. The local date format will be stored in the Rapidox, along with the date and time.

3.9 Setting the Pump Flow Rate

You can control the flow rate of gas drawn into the analyser using the menu option **9-Set Pump Flow**. The unit is supplied with the flow rate set to 70% which equates to approximately 1.0 Litres per minute.

Alternatively, you can switch the pump on or off using the **PUMP** switch on the rear panel (1100-OPT-MAX-F only)**.**

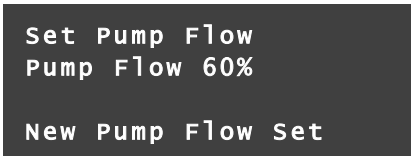
- Normally you should ensure that this is switched on and the pump is running
- When using the unit with a pressurised (flowing) gas source the pump can be left switched off

To change the flow rate:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **9-Set Pump Flow** menu and press ENT..
3. Select the Pump Flow (e.g. **60%**) and press ENT.

   The default factory setting is **70%**. You can choose from: OFF, 10,20,30,40 50,60,70,80,90,100%.

   The Display confirms your choice for 2 seconds before returning to the **9-Set Pump Flow** menu. For example:



4. Press ESC to return to Run mode.

3.10 Loading Default Configuration Settings

If you make a mistake programming the Rapidox, you can reset the machine to 'generic' defaults directly from the Keypad.

> **Note**: After this procedure, you will need to re-calibrate the Rapidox and check all the settings are suitable. See section 3.1.

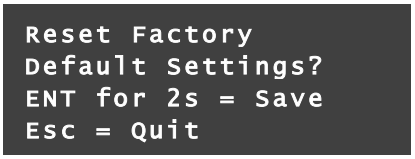
Alternatively, you can restore the machine back to its factory settings by loading the unique default configuration that is supplied on your software USB memory stick. You can only access the default factory setup using the Rapidox Software. Please see the section on Disaster Recovery in the Rapidox Software Manual for details.

To restore factory defaults:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **10-Load Defaults** menu and press ENT.

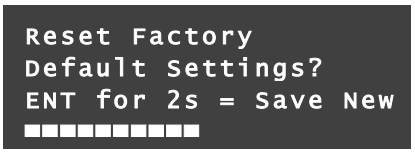
3. If prompted (because a partial password has been set, as described in section 3.11) enter your password and press ENT.

   The following screen will be displayed:

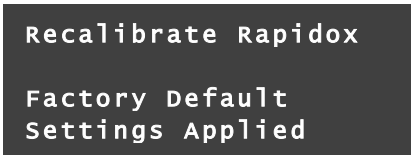


4. Press and hold ENT for 2 seconds.

   A progress bar appears while the default settings are applied:



   The Display confirms your choice for 2 seconds before returning to the **10-Load Defaults** menu. For example:

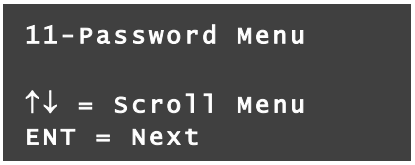


5. Press ESC to return to Run mode.

You will now need to recalibrate the Rapidox and check all the settings are suitable (see section 3.1.).

3.11 Controlling Menu Access (Passwords)

You can restrict access to certain menu options by enabling a password.



- Password protection is set to **Disabled** by default
- The default password is **0000**. We recommend that you change it as described below. The password must be 4 digits long and can be any combination of numbers from 0-9. Be sure to make a note of the new password

Note: If you have forgotten the password, please contact Cambridge Sensotec who will advise you on how to recover it.

You can set the following password states:

- **Fully Enabled**: Users must enter the password to gain access to *any* menu
- **Part Enabled**: Users must enter the password to gain access to critical menu options (Calibrate, Pressure Mode and Load Defaults)
- **Disabled**: Users have full access to all menu options without the need to enter the password

If password protection is enabled, once you have entered the password the protected menu will be accessible. You can make as many changes as you want to the options and only press ESC once you have

finished. Pressing ESC takes you out of the password protected area and you must re-enter the password to go back in again.

3.11.1 Changing the password

Here's an example of how to use the Keypad to change the password. We will assume:

- The current password is the default value of **0000**
- The new password you want to set is **2021**
- You *don't* want to change the current password status (see section 3.11 for full details).

To change the password:

1. Press ENT to access the menu system.
2. Press ⇧ or ⇩ to scroll to a menu (e.g. **11-Password Menu**).

```
11-Password Menu

↑↓ = Scroll Menu
ENT = Next
```

3. Press ENT. Notice that the cursor flashes under first character of the password.

```
Enter Password
Password: ****
↑↓→ = Edit
ENT = Next
```

4. Press ⇧ or ⇩ until the correct first character (**0**) is displayed.
5. Press PRINT to move the cursor under the second character.
6. Press ⇧ or ⇩ until the correct second character (**0**) is displayed.
7. Repeat to enter the third and fourth characters.

Note: To edit a character to the left of the cursor, press PRINT repeatedly and the cursor will wrap around back to the beginning of the line.

8. Press ENT to enter the password and move to the next menu screen.

```
Password Status:
Fully Enabled
↑↓  = Change
ENT = Next
```

9. In this case, we don't want to change the password status, so press ENT again to move to the next menu screen.

```
Change Password
Password: 0000
↑↓→ = Edit
ENT = Save
```

10. Use PRINT ⇧ and ⇩ to move the cursor between characters and edit the values.

```
Change Password
Password: 2021
↑↓→ = Edit
ENT = Save
```

11. Press ENT to save the new password.

```
Change Password
Password: 2021

Password Changed
```

This screen will be displayed for 2 seconds, then the Display will return to the top-level Password menu.

```
11-Password Menu

↑↓ = Scroll Menu
ENT = Next
```

12. Press ESC to return to Run mode.

3.11.2 Changing the password protection status

To change the password protection status:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **11-Password Menu** screen and press ENT.
3. When prompted, enter your password and press ENT.

   Press PRINT to move the cursor between characters. Use ⇧ or ⇩ to change the value.

```
Enter Password
Password: ****
↑↓→ = Edit
ENT = Next
```

If you enter an incorrect password, the following screen will be displayed for 2 seconds and then return to the **11-Password Menu** screen:

```
Enter Password
Password: 1966

Wrong Password!
```

When you enter the correct password, the following screen will be displayed. This example shows the current password status as **Fully Enabled** (it may be different on your machine):

```
Password Status
Fully Enabled
↑↓  = Change
ENT = Next
```

4. Press ⇧ or ⇩ to change the status.

Choose from **Fully Enabled**, **Part Enabled** and **Disabled**) and press ENT.

The Display confirms your choice for 2 seconds before returning to the **11-Password Menu** screen. For example:

```
Password Status

Changed to:
Part Enabled
```

5. Press ESC to return to Run mode.

3.12 Displaying System Info

The System Info screen allows you to scroll through details of the current calibration and alarm settings. These are all for information purposes only.

```
12-System Info

↑↓ = Scroll Menu
ENT = Next
```

To view system information:

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **12-System Info** screen and press ENT.
3. Scroll through the various information screens using ⇧ or ⇩. The screens repeat on a circular loop.

   For example:

```
Cal H = 20.950%
Cal M = 0.1000%
Cal L = 0.0010%
↑↓ = Scroll
```

   Another example:

```
OPT% Sensor
Raw H = 210784
Raw L = 2205.0
↑↓ = Scroll
```

   Another example:

```
RunTime:  14816Hrs
Atm.Temp:    23°C

↑↓ = Scroll
```

4. You can press PRINT to print the live values on the currently displayed screen (if you have a printer connected and configured; see section 4.3).
5. Press ESC to return to Run mode.

The following table gives a description of the information available:

Display	Description
CAL H M & L	The display shows the three current calibration gas values for High Middle and Low cal points
Raw H & L	For both OPT% and OPTppm sensors the raw calibration values are shown as numbers
OPT% Phase & temp	For the OPT% sensor the internal setting of phase and temp are displayed for technical information purposes only and can be ignored. These should normally be reading -1000 each
Latch Alarm	The display shows the date and time of the last latched alarm and the value that was exceeded to cause it. Both Alarm 1 and 2 are shown in sequence. The display will be blank if there has never been an alarm event.
Run Time	The total run time of the analyser is displayed in hours
Max Temp.	The maximum temperature internally recorded by the analyser
Max Press.	The maximum absolute pressure recorded by the internal pressure sensor on the gas sample line.

Table 11: System Information Menu Pages

3.12.1 Sensor Life Expectancy

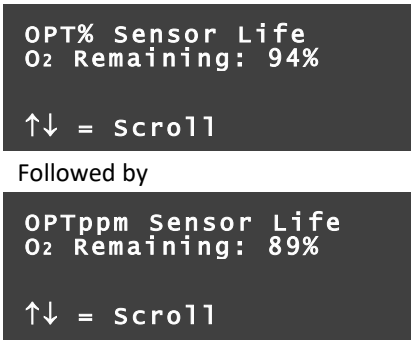
Included in the System Info menu is a feature to allow the user to check how much life is remaining in both Optical sensors.

For the OPT% sensor this is a percentage of the number of measurements allowed in the life of the sensor which is set at 300 million. At one measurement every second this gives a life of approximately ten years.

For the OPTppm sensor this is a percentage of the number of measurements allowed in the life of the sensor which is set at 32 million. At one measurement every five seconds this gives a life of approximately five years.

To check the lifetime remaining.

1. Press ENT on the Keypad to access the menu system.
2. Scroll (press ⇧ or ⇩) to the **12-System Info** screen and press ENT.
3. Scroll through the various information screens using ⇧ or ⇩ to the Sensor Health check menu.



Followed by

In both cases a brand-new sensor will read 100%. For the OPT% sensor a reserve of 1% (about 35 days) will display "**Replace OPT% Soon"** and when at 0% the cell is exhausted and the messages "**Replace OPT% Now".** For the OPTppm sensor a reserve of 2% (about one month) will display "**Replace OPTppm Soon"** and when at 0% the cell is exhausted and the messages "**Replace OPTppm Now".** These messages, or a combination of two messages, will repeat on the boot up of the machine until the user replaces the cell and recalibrates the new sensor.

3.12.2 Sensor Switch Point

The value of gas at which the OPT% hands over to the OPTppm sensor can be adjusted a little. The factory setting is 1000ppm (0.1%) oxygen, and this should not be changed unless it in a place where it is conflicting with important measurements. A setting of 1000ppm means that the OPTppm sensor will take over readings

once the OPT% sensor has got down to a 1000ppm reading. If the readings begin to rise, then the switching point upwards is offset by 200ppm (to 1200ppm) to prevent instability around the switch point.

The switch point can be changed to 500ppm (0.05%), 1000ppm (0.1%), 1500ppm (0.15%) or 2000ppm (0.2%).

To change the switch point:

4. Press ENT on the Keypad to access the menu system.
5. Scroll (press ⇧ or ⇩) to the **12-System Info** screen and press ENT.
6. Scroll through the various information screens using ⇧ or ⇩ to the Sensor Switch Point menu.
7. Use the ENT button to change the setting to 500ppm (0.05%), 1000ppm (0.1%), 1500ppm (0.15%) or 2000ppm (0.2%).
8. Once selected press ⇧ , ⇩ or ENT to continue through the menu or escape.

4 Using the SERIAL RS232/RS485 Port

Note: The **SERIAL** data communications port is factory-configured to use either RS232 or RS485 protocol. If you want to change the factory-configured setting, you will need to return the unit to Cambridge Sensotec Ltd.

Data from the Rapidox is sent on demand to the **SERIAL** port (a 9-way D-type socket) on the rear panel and can be read using a simple terminal program or with your own custom software. Alternatively, a simple and convenient Data Logger program is included with the Rapidox Software. Please refer to the Rapidox Software Manual for instructions.

4.1 RS232 Protocol

Oxygen data can be read from the RS232 port at the back of the Rapidox. The default RS232 configuration is 57600-8-N-1, as shown in this example for COM1:

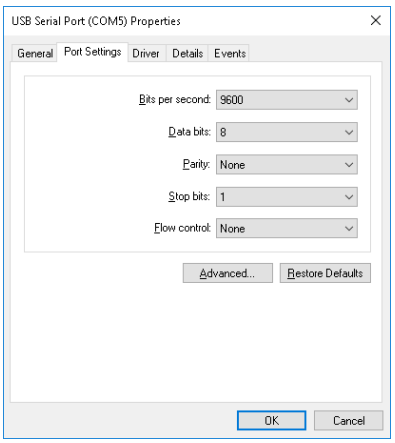


Figure 11: Rapidox default COM properties box

Alternatively, you can reduce the baud rate to 9600 using the Keypad (see section 3.7). This setting is stored in EEPROM.

1. Connect to RS232 socket at the back of the Rapidox using a 9-way D-type plug. Signals are as follows:

Rapidox D-type Socket			**PC/PLC:**
Pin#	**Signal**	**Direction**	**Signal**
2	Data Out	→	Data In (RX)
3	Data In	←	Data Out (TX)
5	Common/Gnd		Common/Gnd

Table 12: Rapidox RS232 pin configuration

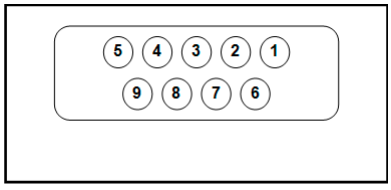


Figure 12: Rapidox RS232 pin configuration

All other pins (1,4,6,7,8,9) = Don't care

Reading Data: Data is read using command “D”. Send the single character “D” to the Rapidox. The Rapidox replies with one of the following responses. All valid responses end with [CR] & [LF] (where [CR] = ASCII 13 and [LF] = ASCII 10). An example is shown and described below:

	Response/Meaning
d2.086E+05,2.117E+05,1.004E+04,9.031E+03,2.086E+05,2.11719E+05,1.022E+03,0,,7.914E+05,12:30:32,07/10/25,,,,13100	
Response:	!Initialising[CR][LF]
Meaning:	Rapidox is still initialising
Response:	!User setup active[CR][LF]
Meaning:	The configuration menu has been activated via the Keypad. The menu will automatically time out 60 seconds after the last key was pressed, or press the Keypad’s ESC button to return immediately to normal run mode
Response:	!No sensor or sensor fault[CR][LF]
Meaning:	Sensor is not connected, or there is a fault in the sensor
Response:	d2.086E+02,2.117E+05,1.004E+04,9.031E+03,2.086E+02,2.117E+05,1.022EE+03,
Meaning:	0,,7.914E+05,12:30:32,07/10/25,,,,ALM1&2,13100[CR][LF] (note this example is in fresh air) “d” means data is being sent “2.086E+02” is OPT% sensor corrected reading fixed in ppm “,” = data separator “2.117E+05” is OPT% sensor raw signal data “,” = data separator “1.004E+04” is OPTppm sensor corrected reading fixed in ppm (note that 1.004E+04 is the standby reading as this sensor is not currently performing the measurement) “,” = data separator “9.031E+03” is OPTppm sensor raw signal data reading fixed in ppm (note that 9.031E+03 is the standby reading as this sensor is not currently performing the measurement) 2.086E+02” is the live measurement reading shown on the Rapidox display (in this case from the OPT% sensor) “,” = data separator “2.117E+05” is the live raw signal reading of the active sensor (in this case from the OPT% sensor) “,” = data separator “1.022E+03” is the absolute pressure reading fixed in mbara “0” = Temperature sensor (not fitted - used on other models) “,,” = data separators (reserved for other models) “7.914E+05 = The balance gas reading fixed in ppm (in this case nitrogen balance) “12:30:32” is Rapidox time in HH:MM:SS “,” = data separator “07/10/25” is Rapidox date in DD/MM/YY format “,,,,” = data separators (reserved for other models) “ALM1&2” means both alarm conditions 1 and 2 exist [1] “,” = data separator “13100” = sensor state code (0=not fitted, 1=O_2 OK, 2= O_2 U/Range, 3=O_2 O/Range, 4=O_2 Fault, 5=Fault, 6,7,8= Not Used)[2] [CR] = ASCII 13 (Carriage Return character) [LF] = ASCII 10 (Line Feed character)
Response:	?
Meaning:	“D” command was not recognised. Try to send it again

Table 7: Rapidox data responses

[1] If no alarm conditions exist, this data is empty, so the response would look like this instead:
d2.086E+02,2.117E+05,1.004E+04,9.031E+03,2.086E+02,2.117E+05,1.022EE+03,
0,,7.914E+05,12:30:32,07/10/25,,,,,13100[CR][LF]

[2] These are binary codes so fault combinations produce other numbers

4.2 RS485 Protocol

Please contact Cambridge Sensotec for further information on this feature.

4.3 Printing

If you have purchased the optional printer, you can print out various data from the analyser straight on to thermal paper.

Figure 13: Optional thermal printer

1. Connect the printer to the unit via the serial socket on the rear of the machine.
2. Make sure the printer is switched on (battery and mains versions are available).

To print the live values on the Display at any time during normal Run mode:

1. If the Rapidox is not currently in Run mode (i.e. if one of the menu screens is shown on the Display) press and hold ESC to return to Run mode.
2. Press PRINT to print the live values.

Each push of the button will print out the serial number followed by the data in a tabbed format followed by a blank line. If you hold the button down, the printer will keep printing data (but not the serial number).

When the printer is first connected or turned on, a start-up message like the one shown on the Display when the Rapidox is switched on will be printed, and will look like this:

```
Cambridge
Sensotec Ltd
Rapidox 1100-OPT-MAX
Oxygen Analyser
S/N: 21015942
FW v 01.03.03.01
```

5 Q & A

In this section, we provide answers to some common questions and issues that you might have.

Q: Why is the oxygen reading flashing?

A: During the transition from OPT% sensor to OPTppm sensor the display takes a moment to settle down and read correctly while the sensor is warming up. During this time the display will say “Please Wait” before showing new readings. If the new readings are still higher than the switch point (1000ppm) then they flash to warn you they are not fully on line yet. Please wait a little longer and once the readings fall below 1000ppm the flashing will stop.

Q: How long does the sensor last?

A: The sensor life is calculated around the number of measurements taken as each measurement uses up a bit of the life of the sensor lamp. The life expectancy is averaged around ten years for the OPT% base don readings every second, and five years for the OPTppm based on readings being taken every five seconds, but this may involve some maintenance to the sensor including replacing the sensor cap & filter every twelve months. Other factors such contamination affect the life of the sensor so a precise answer is not straight forward.

Q: The pump isn’t working.

A: Please check that on 1100-OPT-MAX-F models the rear panel pump switch is on. This is not present on 1100-OPT-MAX-R & -P versions. Please go to the pump menu and check that the pump speed is set to a value and not set to “off”

Q: The oxygen sensor readings seem affected by the pressure.

A: Please check that the pressure correction option is set to “Auto” in the pressure menu. With this option switched off the sensor readings are greatly affected by variations in line pressure for the simple reason that the optical sensors are partial pressure sensors. It is not advisable to run the machine with excessive pressure or vacuum on the inlet, although the auto correction will try to account for this up to a point.

Q: I can’t understand the readings taken from the analogue output terminals.

A: The signals that are sent to the rear terminals are fully configurable so it is important to check and know what they are set to so you can make sense of the readings. Note that the scale for 0-10V and 4-20mA are locked together so changing one changes the other at the same time

Q: Is this equipment suitable for ATEX environments?

A: NO – although the optical sensor installed is electrically safe and produces only digital signals using very low voltages, the Rapidox unit is not ATEX approved and must not be used in hazardous areas. It is certified for sale area use only.

Q: When I calibrate, the Rapidox gives strange readings that are way off the expected values.

A: Check to make sure which calibration gas is selected. Is it the same as the actual gas you used to perform the calibration? If not, you must recalibrate the analyser or reload the factory defaults to get you going again. Go to the System Info menu (12) and write down the calibration values displayed. E-mail these to Cambridge Sensotec support for advice.

Q: I messed up the calibration procedure and now the analyser is not working properly.

A: Return the box to the factory defaults using the keypad (see section 3.10). Now try recalibrating the Rapidox (see section 3.1).

Q: How do I get back to the factory calibration for my instrument.

A: Follow the instructions in section 3.10.

Q: The Rapidox won’t power up at all.

A: Please check the two fuses that are in the power socket housing on the rear. Have these blown? If so replace with new ones using T2A H250V 5 x 20mm glass types making sure the spec is the same.

Q: I replaced the fuses but the Rapidox still won't power up.

A: Is the power switch on the front panel illuminated? If it is then electricity is getting to the power supply but if the display is blank and there are no signs of life then it is most likely that the power supply has failed. Please contact Cambridge Sensotec about getting it replaced.

Q: How often do I need to calibrate the analyser?

A: As a bare minimum the Rapidox should be recalibrated every twelve months and this is normally all that is needed for most people. If you are working in a more intense application or using the analyser continuously then a six-month calibration may be recommended. Cambridge Sensotec has approved recalibration specialists around the World – please contact us for advice.

Q: My application does not allow us to use electric sample pumps

A: We have an ejector option for customers who want to use compressed air to create a vacuum instead of an electric pump. Please contact Cambridge Sensotec for details.

Q: I bought a Rapidox but want to panel mount it

A: We have a panel mount version of the Rapidox 1100-OPT-MAX available to order or if you have already got an existing unit it may be possible to supply an upgrade kit to add a panel adapter plate. Please contact Cambridge Sensotec for more information.

6 Warranty

We are immensely proud of the way we handle our after sales support. We always work with the customer to ensure that they are satisfied with the outcome and take a pragmatic view on most warranty claims.

The Rapidox analyser has been carefully tested and inspected before shipment and are guaranteed to be free from defective materials and workmanship for a period of twenty-four (24) months from date of purchase and delivery. Please note that damage caused by misuse of the equipment or operating the equipment outside its specification, damage to the sensors by contamination, chemical attack or water ingress will not be covered by this warranty.

6.1 Conditions of Warranty

1) This warranty is in addition to and does not affect any statutory rights of consumer purchasers.

2) This warranty is valid worldwide on a “back to base basis”. This means that the customer (The Purchaser) needs to pay for the shipping of the goods to an authorised repair centre and Cambridge Sensotec (The Seller) will pay for the return of the goods to the customer using DAP Incoterms.

3) Any Customs duties or taxes due outside the UK because of the shipment, are entirely the responsibility of the customer.

4) This warranty covers breakdowns due to design or manufacturing faults; it does not apply to damage, however caused, wear and tear, neglect, unauthorised adjustment or repair, or any items of limited natural life such as sensor and filters.

5) The warranty period applicable shall be 24 months from the date of delivery provided that:

   a) Notice in writing of the defects complained of shall be given to the Seller upon their appearance, and

   b) such defects shall be found to have arisen from the Seller's faulty design, workmanship or materials, and

   c) The defective goods shall be returned to the Seller's premises at the Purchaser's expense if so requested by the Seller.

   d) Any repaired or replaced goods shall be redelivered by the Seller free of charge to the original point of delivery but otherwise in accordance with and subject to these Conditions of Sale.

   e) Alternatively the Seller shall be entitled at its absolute discretion to refund the price of the defective goods in the event that such price shall already have been paid by the Purchaser to the Seller, or, if such price has not been so paid, to relieve the Purchaser of all obligation to pay the same by the issue of a credit note in favour of the Purchaser in the amount of such price.

6) In the event of failure, please take the following action:

   a) Refer to the “Troubleshooting” section of your instruction manual to identify and possibly correct the problem.

   b) If the fault cannot be resolved, please contact the Cambridge Sensotec service and repair centre at the address given on the cover of the manual so we can assist you.

7 Technical Specification

Property	Specification
Supply Voltage	90–260VAC, 50/60Hz
Power consumption	10W (max)
Analyser dimensions	250mm X 263mm X 150mm (without optional handle kit fitted)
Panel mount bezel size	300mm wide X 4U high
Weight	3.5kg
Display	20 × 4 character OLED
Warm up time	5 minutes at 20°C
Normal operating temperature	5–35°C
Normal operating pressure	800–1100 mbar absolute
Overall Sensor Range	0.5ppm to 100% O_2 using two separate Optical sensors
OPT% Sensor Accuracy	±0.02% @1% O_2 ±0.5% @20% O_2 ±2% @100% O_2
OPT% Sensor Resolution	0.01% O_2
OPT% Sensor Life Expectancy	Up to 300 million measurements @21% O_2 20°C (ten years at 1 sec. sample rate)
OPTppm Sensor Accuracy	±2ppm or ±5% @20°C
OPTppm Sensor Resolution	±0.15ppm @1ppm O_2 ±0.8ppm @100ppm O_2 ±1.5ppm @200ppm O_2
OPTppm Sensor Life Expectancy	Up to 32 million measurements @10ppm O2 20°C (five years at 5 sec. sample rate)
Switching Point	1000ppm down (OPT% to OPTppm) 1200ppm up (OPTppm to OPT%)
Outputs: O_2 & pressure	0–10V (user-configurable) into minimum 5kΩ
O_2 & pressure	4–20mA current loop (user-configurable) into maximum 500Ω
O_2 high and low alarms	Relay circuits, fully user-configurable
All data and parameters	RS232 or RS485, data streamed on demand Rapidox and Modbus RTU protocols
Sample Pump	Mains type diaphragm vacuum pump (variable flow) with power switch on rear panel.
Flow Rate	0–1.2 $L.min^{-1}$
Max. gas temperature on input	50°C
Max pressure on the inlet with the pump off	1100mbar absolute (assuming an unrestricted outlet to room air)
Calibration	Three-point calibration user configurable. Factory set to HIGH = 209,500ppm (20.9%), MIDDLE = 1000ppm (0.1%) & LOW = 10.0ppm (0.001%) O_2
Fuse	T2A H250V 5 x 20mm glass

Table 8: Rapidox 1100-OPT-MAX technical specification.

8 Appendix 1: Modbus Communications

This Rapidox has full Modbus RTU data communications written to Modicon Modbus standard PI-MBUS-300-Rev-J. The communication is one direction only, meaning that the PLC can request information from the Rapidox but it cannot configure the Rapidox.

This section gives detailed information on the Modbus communications protocol, but not how to configure the analyser to use it. For details on configuring the Rapidox analyser communications protocol, see section 3.7.

> **Note:** If you are using the Rapidox software for data logging, you can set the communications protocol to **Rapidox** and the speed (Baud Rate) to either **9600** or **57600**. The default factory setting is 57600. However, if you are using an older PC you can decrease this to 9600 to improve the reliability of the software and data communications.

8.1 Modbus Communication Protocol

The transmission command sequence sent from the Master is described below, followed by the receive command sent from the Slave (Rapidox). CRC error checking is used to ensure valid data transmission.

In this Modbus protocol, only Function 3 and Function 4 are used. Function 3 is used to interrogate the status of any Rapidox alarms, faults or whether or not the pump flow is off. Function 4 is used to interrogate the readings of oxygen and pressure from the Rapidox.

8.2 Function 3

Function 3 is reserved for requesting alarm values, fault codes and pump and application status from the Rapidox. An example of transmission and receive is shown below:

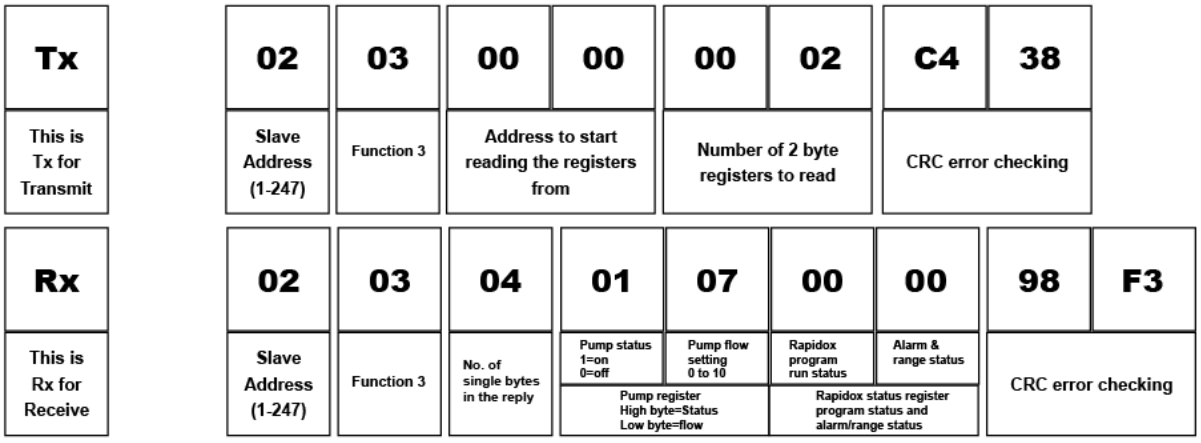


Figure 14: Example of a typical function 3 transmission and receive

In the above example:

- The first register indicates the pump status and flow and the second indicates the application and alarm status, and over/under range conditions. All values are in hexadecimal
- The Rapidox "Slave" has been assigned an address of 2 using the menu, and the Float setting is ABCD. The transmission sends to address 2 command function 3 which is a request for pump status and flow settings, and machine and alarm status readings

The pump status byte (byte 4) in the reply can have the following (hex) values:

Hex value	Meaning
00	Pump off
01	Pump on

The pump flow setting byte (byte 5) in the reply can have the following (hex) values:

Hex value	Meaning
00	0% flow setting (pump off)
01	10% flow setting
02	20% flow setting
03	30% flow setting
04	40% flow setting
05	50% flow setting
06	60% flow setting
07	70% flow setting
08	80% flow setting
09	90% flow setting
0A	100% flow setting

The Rapidox application run status byte (byte 6) in the reply can have the following (hex) values:

Hex value	Meaning
01	No sensor detected – “No sensor or sensor fault” message on Display
02	Sensor heating timeout – “Possible sensor fault” message on Display
03	“Heating sensor” message on Display
04	“Cleaning sensor” message on Display
05	User setup menu is active
06	“Cooling sensor” message on Display
07	Normal run mode – sensor readings are valid

The alarm and sensor range status byte (byte 7) in the reply can have the following (hex) values or combinations of them. Each of these is represented by a single bit in the byte, so the corresponding status can be tested by checking the corresponding bit. The binary value and bit number are also shown in the list.

Hex value	Binary value	Bit number (0–7)	Meaning
01	00000001	0	Alarm 1 activated
02	00000010	1	Alarm 2 activated
04	00000100	2	Oxygen value is Over Range
08	00001000	3	Oxygen value is Under Range
10	00010000	4	Pressure value is Over Range
20	00100000	5	Pressure value is Under Range

As these are represented by single bits, combinations are possible. For example:

Hex value	Binary value	Bit numbers (0–7)	Meaning
03	00000011	0 & 1	Alarms 1 and 2 activated
14	00010100	2 & 4	Oxygen and Pressure are Over Range
24	00101000	3 & 5	Oxygen is Over Range and Pressure is Under Range

8.3 Function 4

Function 4 can be used to request oxygen and/or pressure values from the Rapidox. An example of a transmission and receive is shown below:

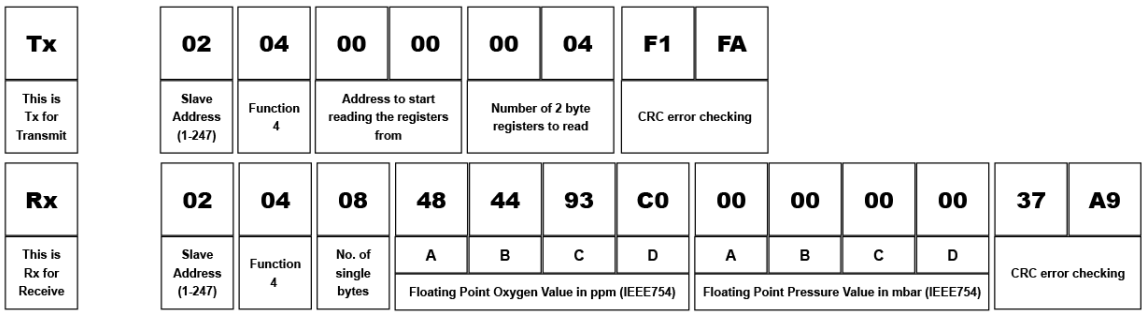


Figure 15: Example of a typical function 4 transmission and receive

In the above example:

- *Both* oxygen and pressure are requested by setting the address and number of registers to be sent. All values are hexadecimal.
- The Rapidox "Slave" has been assigned an address of 002 using the menu, and the Float setting is ABCD. The transmission sends to address 002 a command function 4 which is a request for oxygen and/or pressure readings. There are three possibilities:
  - 00 00 00 02 (hex) = oxygen only
  - 00 02 00 02 (hex) = pressure only
  - 00 00 00 04 (hex) = oxygen and pressure together

The command is completed with a CRC error checksum.

The Master then receives a response resembling the example above. In this case, the reply states the Slave address (e.g. 002), the function requested (in this case 4) followed by the number of single bytes in the data response. In the case of oxygen and pressure together this will be 08 hex otherwise it will be 04 hex.

The order of the following bytes is dependent on the float settings. Normally this would be ABCD as shown above but CDAB BADC and DCBA may also be specified.

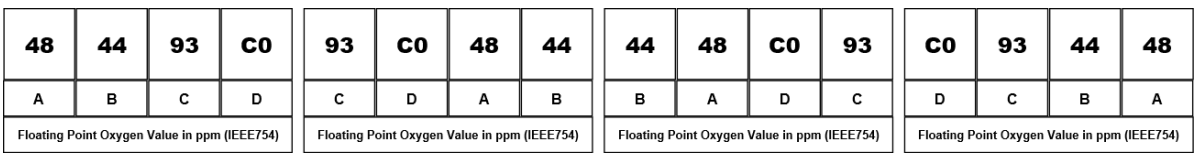


Figure 16: The four different float options shown with the same data. All values are hexadecimal.

The 4-byte response for both oxygen and pressure gives the floating-point value for oxygen in ppm and floating-point value for pressure in mbar. This uses the IEEE754 format for Modbus.

The response is completed with a CRC error checksum.

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