XZR200 Oxygen Analyzer User's Manual

97337 Issue 5
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XZR200

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Safety

The manufacturer has designed this equipment to be safe when operated using the procedures detailed in this manual. The user must not use this equipment for any other purpose than that stated. Do not apply values greater than the maximum value stated.

This manual contains operating and safety instructions, which must be followed to ensure the safe operation and to maintain the equipment in a safe condition. The safety instructions are either warnings or cautions issued to protect the user and the equipment from injury or damage. Use qualified personnel and good engineering practice for all procedures in this manual.

Electrical Safety

The instrument is designed to be completely safe when used with options and accessories supplied by the manufacturer for use with the instrument. The input power supply voltage limit is 24 V ±10%.

Pressure Safety

The XZR200 is designed to be operated at atmospheric pressures. However, it is possible to measure in the range 0 to 25% O_2 at pressures up to 3 barg (43.5 psig) without damage to the unit. The unit will require calibration at the operating pressure and a separate pressure transducer for active compensation feeding into your control system may also be required.

Toxic Materials

The use of hazardous materials in the construction of this instrument has been minimized. During normal operation it is not possible for the user to come into contact with any hazardous substance which might be employed in the construction of the instrument. Care should, however, be exercised during maintenance and the disposal of certain parts.

Repair and Maintenance

The instrument must be maintained either by the manufacturer or an accredited service agent. Refer to www.michell.com for details of Michell Instruments' worldwide offices contact information.

Calibration

The recommended calibration interval for the XZR200 is between one and three months. This duration may be shorter or longer dependent on installation, application and customer preferences.

Safety Conformity

This product meets the essential protection requirements of the relevant EU directives.

Abbreviations

The following abbreviations are used in this manual:

°C	degrees Celsius
°F	degrees Fahrenheit
DC	direct current
EU	European Union
kg	kilogram(s)
l/min	liters per minute
lb	pound
mA	milliampere
max	maximum
min	minute(s)
scfh	standard cubic feet per hour
Td	cycle time to evacuate and re-pressurize the sealed cell
Td averaging	counting x number of cycles and averaging the result
V	Volts
%	percentage
"	inches

Warnings

The following general warning listed below is applicable to this instrument. It is repeated in the text in the appropriate locations.

Where this hazard warning symbol appears in the following sections, it is used to indicate areas where potentially hazardous operations need to be carried out.

1 INTRODUCTION

The XZR200 measures the partial pressure of O_2 utilizing a Zirconium Dioxide (ZrO_2) sensor cell in Safe Area (general purpose) applications.

This user manual will show you how to measure oxygen using the XZR200 oxygen analyzer.

In the following sections you will learn about:

- Zirconium Dioxide technology
- Analyzer components
- Installation
- Operation
- Calibration

Please read the manual carefully and pay particular attention to any safety warnings and notifications.

Note: Warnings and items of importance will be marked with bold text.

1.1 Features

- Accurate linear configurable outputs: 4-20mA & 0-10 V DC or RS232
- Selectable output measurement ranges: Standard ranges of 0 to 25% O_2 and 0 to 100% O_2 or fully adjustable via RS232 when configured in 0 to 100% O_2 mode
- Externally triggered automatic or manual calibration
- Calibrated in ambient air (20.7% O_2) or in any other known O_2 concentration
- Cycling 3.3 V DC logic output allows direct monitoring of the O_2 sensor pump cycle for diagnostic purposes
- Selectable output filtering allows adaptive, fast and dynamic, or slow and stable output
- IP65 die-cast aluminum case with stainless steel probe 210mm (8.27") or 400mm (15.75")

1.2 Unpacking

It is recommended that all packaging is retained, in case products are returned for service or calibration. Alternatively, if you choose to dispose of the packaging materials, ensure they are recycled in accordance with local legislation.

1.3 Description

The XZR200 is designed to determine the oxygen concentration in air or inert gas mixtures within a temperature range of -100°C (-148°F) to +400°C (+752°F). The XZR200 is particularly suitable for measuring oxygen in areas that are not easily accessible, or in closed systems such as ventilation pipes, flues and containers.

The XZR200 can be user-configured to output measuring ranges of 0 to 25% O_2 or 0-100% O_2. The entire measurement range is linear in both cases. Factory default is 0 to 25% O_2. When configured for 0 to 100% O_2 the user can also modify the analog output ranges to suit their application. The oxygen concentrations are simultaneously output via 2 output channels (4-20mA and 0 to 10 V DC or RS232 Rx and Tx) - both channels are referenced to the system ground (GND).

The outputs can be configured to either 4-20mA and 0 to 10 V DC or RS232 interface. Prior to shipping, all XZR200's are preconfigured with a measuring range of 0.1% to 25% volume O_2 with linear 4-20mA and 0 to 10 V DC outputs. All settings can be changed by the customer, should the measurement or interface requirements change, by simply altering the position of jumper links on the PCB. The electronics are housed in an IP65 die-cast aluminum housing.

The oxygen sensor is mounted in the tip of the stainless steel probe and is protected by a stainless-steel sintered cap which acts as both a large particulate filter and also as a flame trap.

A digital 3.3 V DC logic output cycles at the same frequency as the electrochemical pumping action of the oxygen sensor during normal operation. This provides a real time sensor health check; if the output ceases to cycle the sensor has entered a start-up or fault state. The digital output is also used during the calibration process to indicate the interface status.

A green on-board LED mirrors the CYCLE output and can be used to visually determine the sensor status or during the calibration process. The red LED indicates the unit has power applied.

The sensor measures the partial pressure of oxygen within the measurement gas and not the oxygen concentration. In order to output an oxygen concentration (%) the XZR200 must be calibrated (more specifically re-referenced) in a known gas concentration, typically normal air. Calibration data is stored on power loss.

The automatic or manual calibration function is user-configurable. Regular calibration removes the effects of application and atmospheric pressure changes and also eliminates any sensor drift that may occur during the first few hundred hours of operation.

2 OPERATION

The XZR200 is designed as a fit and forget device. Once configured, installed and all electrical connections made, there are no further operating instructions required. Only routine inspection and calibration of the unit is required. The inspection is more a preventative measure to ensure the surrounding environment or any other factor is not damaging or interfering with the performance of the analyzer.

2.1 Configuration

The XZR200 may be reconfigured at any time by adjusting the position of the header pin jumper links on the interface PCB.

Prior to re-configuration the unit MUST be powered down. The jumper links MUST also be re-positioned correctly and in the correct orientation.

Failure to adhere to the above could result in product damage. Products damaged due to incorrect configurations will not be covered under warranty.

1. Power down the analyzer
2. Remove the lid using a Phillips (cross head) screwdriver.
3. Adjust the position of the jumper links to the desired configuration.

Thin-nosed pliers should be used to remove and replace the jumper links. Ensure the jumper links are correctly seated before reapplying the power.

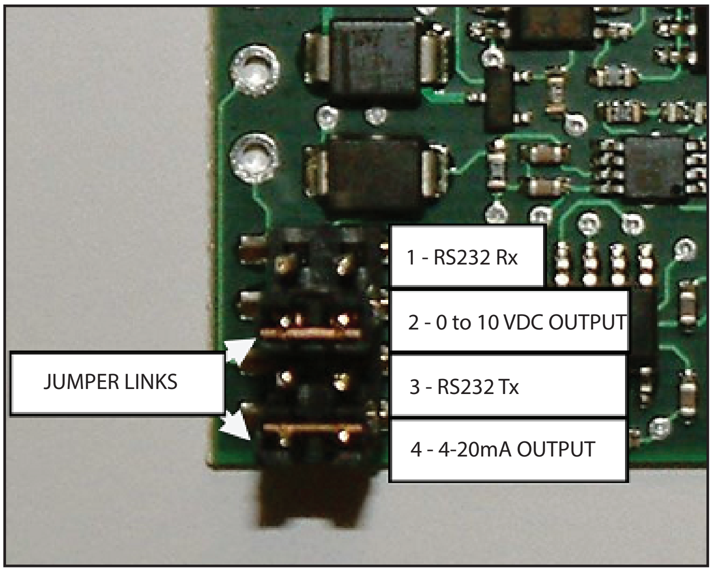


Figure 1 *Jumper Configuration for Output Selection*

When selecting the output, you must choose either 4-20mA and 0 to 10 V DC or RS232 Tx and Rx. Ensure the jumper links are always inserted horizontally between 2 adjacent pins. Place the jumper link(s) into the relevant position(s). Two jumper links are required for RS232 (positions 1 & 3) and only one jumper link is required for either 0-10 VDC (position 2) or 4-20 (position 4). **NOTE: If only using one jumper link make sure the other jumper link is stored safely for future use.**

Using the jumper settings shown below, both the measurement range and the calibration option can be set. The following options are available:

Measuring range: 0-25% or 0-100%
Calibration: Auto cal or manual calibration

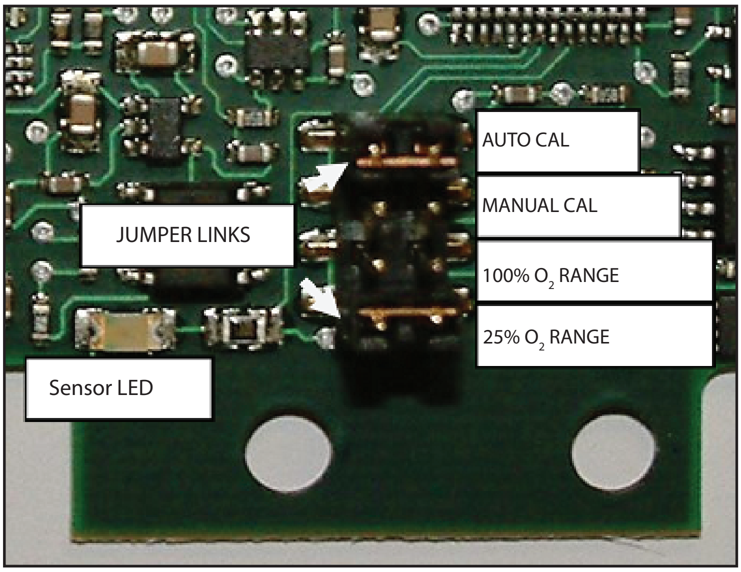


Figure 2 *Jumper Configuration for Calibration Type & Range Selection*

2.2 Initial Sensor Drift and Active Burn-In

NOTE: In the first 200 hours the sensor output can drift by up to ±3%.

This is due to a number of factors including:

- impurities in the Zirconium Dioxide migrating to the surface of the platinum electrode bond which alters the catalytic properties.
- heater coil ageing.
- the internal stainless steel surface of the cap becoming less reflective due to thermal oxidation.

Regular calibration removes the effect of initial sensor drift as the sensor output is constantly re-referenced against the known calibration gas. However, if regular calibration is not possible and the output is required to have stabilized prior to use in the application then it may be necessary to actively burn-in the sensor.

Active burn-in involves operating the sensor normally in a controlled atmosphere where the exact PPO_2 is known. If this is normal air then all weather data must be recorded and the PPO_2 calculated.

The level of stability required will be dependent on the application specifications. However, in general the output can be considered stable when the value has varied by less than ±0.2% of reading in the previous 48 hours.

When performing an active burn-in, measurements should be taken at regular intervals and the environmental temperature should also be kept constant to negate any temperature dependence the sensor output may exhibit.

2.3 XZR200 Variations

The XZR200 can be ordered with either probe length:

XZR200-B2-C1	XZR200, temperature up to +400ºC (+752ºF) 210mm (8.27") probe
XZR200-B2-C2	XZR200, temperature up to +400ºC (+752ºF) 400mm (15.74") probe

2.4 Life Span of the Analyzer

Dependent on the application, the XZR200 sensor will have a variable lifespan. In ambient temperatures with inert gases, the sensor should last approximately 7 years.

For combustion processes the following guide should be used:

Natural gas	Approximately 5 to 7 years
Biogas	Approximately 3 to 4 years
Biomass	Approximately 2 years
Coal and Oil	Approximately 1 to 2 years

If there is zero oxygen in the sample, the sensor will still try to pump O_2 and this will, in time, damage the ZrO_2 and degrade its performance. It is, therefore, imperative that the sensor is not used for prolonged periods in very low oxygen environments (0.1% O_2), especially in reducing atmospheres (an atmosphere in which there is little free oxygen and oxygen is consumed).

3 INSTALLATION

When installing the sensor do not use any lubricants or grease which may contain silicone.

The sensor is located in the tip of the probe and is heated to 700°C (1292°F).

Do NOT touch the probe tip with bare hands as this will cause damage to skin.

3.1 Mounting and Orientation

The XZR200 should be grounded (earthed) via the probe as well as through the cable.

When using the XZR200 in a combustion process the diagram below shows the correct mounting and orientation. The downward angle of the probe tip will protect the sensor from dust settling or moisture sitting in the tip and damaging the sensor.

A 12mm fitting with a retaining nut that can be welded to the process and fix the probe in position. A suitable O-ring should be used to ensure a good seal.

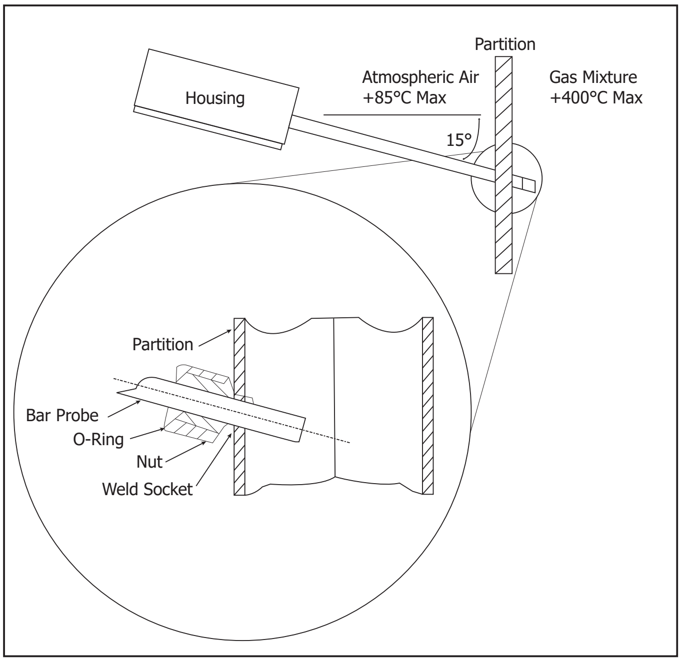
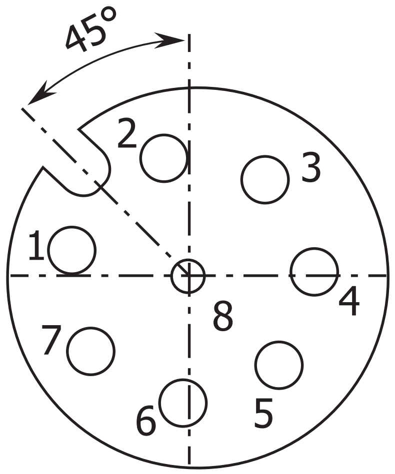


Figure 3 *Mounting and Orientation*

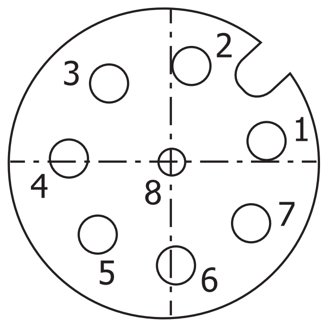
3.1.1 Ambient Monitoring

When used for ambient monitoring or confined spaces, there are two holes on the rear of the electronics case that can be utilized for mounting (see Dimensions in Appendix A). If placed tight against a wall or surface, a heat shield may be required to protect the surface from being damaged.

3.2 Electrical Connections



Pin Number	Description
1	24 V DC ± 10%
2	NC
3	0 to 10 V DC / RS232 Rx
4	4-20mA / RS232 Tx
5	Cycle
6	Calibrate
7	GND (0 V DC)
8	NC
Connector Body	Housing/Probe Earth



NOTE: The above view of the electrical connections is shown from the mating side.

Here are the connections as viewed from the back of the connector and this should be used for wiring purposes.

Figure 4 *Electrical Connections*

Housing connector: 99 3481 578 08

Mating connector: 713 99 1486 812 08
(mating connector supplied loose with each product)

Output pins 3 and 4 are both referenced to the supply GND (pin 7). Due to high current flow in the supply GND - when monitoring the 0 to 10 V DC output (pin 3) it is recommended that a separate GND wire for the measurement system is taken from pin 7. This removes errors due to voltage drops in the power supply connections.

3.3 System Block Diagram

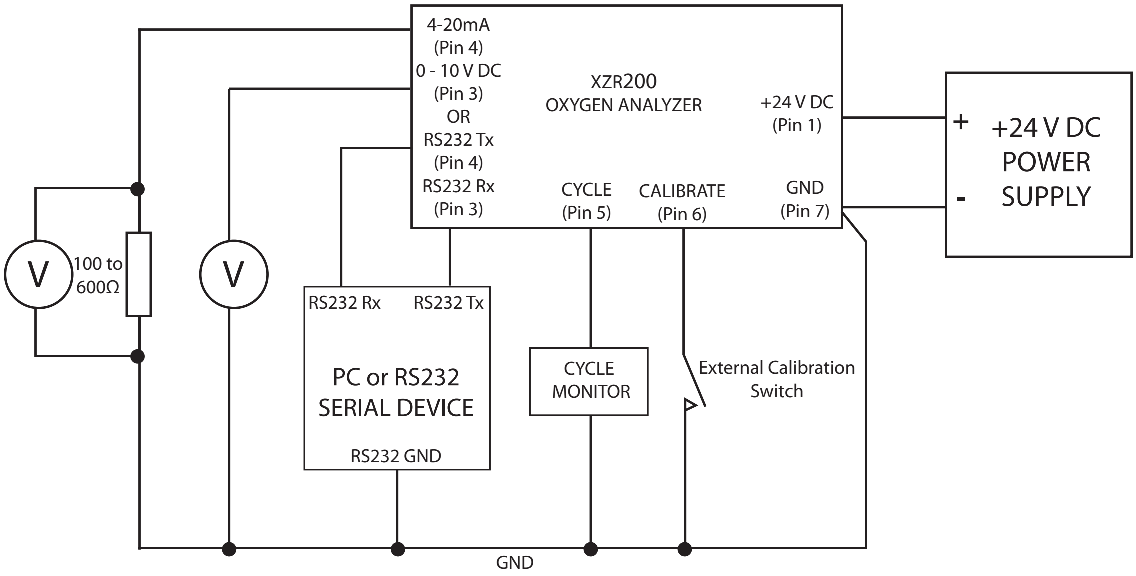


Figure 5 *System Block Diagram*

3.4 RS232 Communication Settings

When connecting the XZR200 via the RS232 connections, ensure Tx goes to Rx of the PC and Rx goes to Tx of the PC.

The XZR200 communicates via standard COM port settings that are default on most PC's and many other RS232 compatible devices. If, however, communication problems are occurring, the settings below can be used to configure the PC or device COM Port.

Figure 6 *COM Port Settings*

3.5 RS232 Operation

With the RS232 outputs connected to a PC or any other RS232 compatible device the user has the ability to access two modes of operation, continuous data streaming and the menu screens.

Programs for communicating via PC serial RS232 are readily available.

3.6 RS232 User-Configurable Options

3.6.1 Menu Screens

If the XZR200 receives an **ENTER** command from the connected PC or device, it automatically enters the password screen and stops outputting O_2 % and Td values. After the correct password is input followed by the **ENTER** key, the menu screens are accessed. The menu screens are primarily for diagnostics and information, although there are user-configurable options that may be changed. These are: the amount of output filtering (averaging), the automatic O_2 calibration %, and the analog output ranges. All three processes are further described below. The menu access password may also be changed by the user, as shown below.

3.6.2 Changing the Menu Access Password

The password is factory set to 'default'. However this may be changed to a user specific password.

1. Connect the XZR200 via the RS232 interface to the PC.
2. Press **ENTER** then enter your current security password.
3. Press **ENTER** to access the menu screen.
4. In the Configuration Menu (menu 2) enter '**3**' to access the password menu screen.
5. Enter the new password then press **ENTER** to save.

The new password is now stored in memory and is retained on power loss.

Pressing **ESC** returns the screen to the previous menu.

3.6.3 Variable Output Filtering (Td Averaging)

The XZR200 is factory set to use adaptive output filtering to give an optimum balance between output stability and response to oxygen changes. However, this balance may be altered by the customer to suit the needs of the application.

1. Connect the analyzer via the RS232 interface to the PC. See Section 2.1 on Configuration.
2. Press **ENTER** then enter your security password. Press **ENTER** to access the menu screen.
3. In the Configuration Menu (menu 2) enter the Td average screen (Option 2 - Enter Td Averaging).
4. The number entered should be between 0 and 200. 0 for adaptive filtering (recommended), 1 for very fast and dynamic output response but relatively unstable, to 200 for an extremely stable output but very slow response to oxygen changes.
5. Press **ENTER** to save.

The new averaging value is now stored in memory. This value is retained on power loss.

Td output by the XZR200 is proportional to the partial pressure of oxygen (PPO2) and the typical value of Td per mbar of PPO2 is 1.05ms ±15%.

For example if we have 20.7% oxygen in 1000mbar barometric pressure the PPO2 value would be 207mbar. This equates to a typical Td of 207*1.05=217.5ms.

To convert the XZR200 Td output back to ms the number must be multiplied by 0.000048 which is the clock period of the microprocessor in seconds.

So for the example above a Td value of 217.5ms would be output from the XZR200 as, 0.2175/0.000048 = 4531.

3.6.4 Changing the Automatic Calibration Value

The system is factory set to automatically calibrate to 20.7% O_2 to allow simple calibration in normal air. The auto calibration value is factory set to 20.7% to take into account average humidity in the atmosphere. If a calibration with a gas of a different known oxygen concentration is required, then the factory set value may be changed via the RS232 interface.

1. Connect the XZR200 via the RS232 interface to the PC. See Section 2.1 on Configuration.
2. Press **ENTER** then enter your security password. Press **ENTER** to access the menu screen.
3. In the Configuration Menu (menu 2) enter the auto calibration value screen (Option 1 - Enter Auto Calib).
4. The number entered should be the oxygen concentration (%) of the calibration gas to 2 decimal places. Press **ENTER** to save.

The new Automatic Calibration value is now stored in memory. This value is retained on power loss.

If calibration is required with a different gas of known O_2 concentration, and access to the RS232 menus with a PC is not available in order to change the calibration percentage, a manual calibration must be performed.

3.6.5 Adjusting the Minimum and Maximum Ranges of the Analog Outputs (4-20mA and 0 to 10 V DC)

The XZR200 is factory default to output a range of 0-25% O_2 via its two analog outputs.

This range can be expanded to 0 to 100% O_2 as described in Section 2.1. When the unit is reconfigured to output 0 to 100% O_2 the user also has the option to fully customize the output ranges via RS232. This is extremely useful in applications where the O_2 variation is within a narrow band as it allows the analog outputs to be tailored to this limited range.

1. Ensure the XZR200 is configured for 0 to 100% and RS232 operation. See Section 2.1 on Configuration.
2. Connect the XZR200 via the RS232 interface to the PC.
3. Press **ENTER** then enter your security password. Press **ENTER** to access the menu screen.
4. In the Configuration Menu (menu 2) enter the maximum range screen (Option 3 - Enter O_2 Max Range).
5. The number entered should be between 1.00 and 100.00 to represent the maximum output range. The number must also be greater than the saved minimum range.
6. Press **ENTER** to save and **ESC** to return to the Configuration Menu.
7. Enter the minimum range screen (Option 4 - Enter O_2 Min Range).
8. The number entered should be between 0.00 and 99.00 to represent the minimum output range. The number must also be less than the saved maximum range.
9. Press **ENTER** to save.

The new ranges are now stored in memory and are retained on power loss.

An example of changing the min and max output ranges would be in a normal air atmosphere where the O_2 range is between 20 to 21%. The user could set the minimum output range to 19% and the maximum output range to 22% and the outputs would vary linearly in between. The min and max ranges lock out the outputs at the set limits - so 19% O_2 or lower would set the analog outputs to 0 V DC / 4mA and 22% O_2 or higher would set the analog outputs to 10 V DC / 20mA.

NOTE: The min and max range adjustment does not apply to the RS232 output and is overruled if the unit is reconfigured for 0 to 25% operation.

3.7 Continuous Data Streaming

On power up, after the initial 60 seconds warm up period, the XZR200 will automatically begin to output the measured O_2 concentration and sensor Td as both an averaged and raw value. The sensor Td value is the measure of the partial pressure of oxygen in the measurement gas. The O_2 concentration (%) is the Td value scaled by the stored calibration value.

The averaged values give a stable (smooth) output while the raw un-averaged values allow the user to detect sudden oxygen changes. The averaged value is the measurement output on both the 4-20mA and 0 to 10 V DC outputs. The user can alter the averaging setting to suit the application requirements.

NOTE: To stop or restart the data streaming - the command 's' (lower or upper case) should be sent to the unit. Data streaming automatically ceases during calibration.

4 CALIBRATION

The XZR200 will require routine calibration determined by the application, installation and user preferences. The analyzer can be configured for manual or automatic calibration by changing the jumper on the board. Calibration is achieved by connecting the calibration input to GND and monitoring the status of the digital cycle output or by visually monitoring the on-board green LED. During the calibration process the output will either automatically calibrate to a fixed reference or can be manually calibrated to any output by way of a PCB mounted potentiometer.

The fixed reference is factory set to 20.7% O_2 for calibration in normal air though this value may be altered via the RS232 interface for calibration with a reference gas of any known oxygen concentration.

4.1 Automatic Calibration

Ensure the XZR200 is configured for automatic calibration. See Section 2.1 on Configuration.

1. Place the sensor probe in the calibration gas, typically normal air.
2. Allow the output to stabilize for at least 5 minutes. Allow 10 minutes if powering from cold.
3. Apply GND to the CALIBRATE input (PIN 6) for a minimum of 12 seconds. During the 12 seconds, the CYCLE output (PIN 7) and the green LED will go high/on, blink rapidly, go high/on, go low/off then return to cycling normally to indicate normal operation has resumed. At this point remove GND from PIN 6.
4. The output will now track to the correct value for the calibration gas.

Calibration is complete. Calibration values are retained on power loss.

4.2 Manual Calibration

Ensure the XZR200 is configured for manual calibration. See Section 2.1 on Configuration.

1. Place the sensor probe in the calibration gas, typically normal air.
2. Allow the output to stabilize for at least 5 minutes. Allow 10 minutes if powering from cold.
3. Apply GND to the CALIBRATE input (PIN 6) for a minimum of 5 seconds or until the CYCLE output and green LED blink at a steady 1Hz. Remove GND from PIN 6. Manual calibration is now initialized.
4. Adjust the MANUAL CAL POT until the output equals the correct value of the calibration gas concentration.
5. Re-apply GND to PIN 6 for a minimum of 5 seconds. During the 5 seconds the CYCLE output/LED will blink rapidly, go high/on, go low/off then return to cycling normally to indicate normal operation has resumed. At this point remove GND from PIN 6.
6. The output will now track to the correct value for the calibration gas.

Calibration is complete. Calibration values are retained on power loss.

5 GOOD MEASUREMENT PRACTICE

There are no user-serviceable parts in the XZR200. In the event of a repair or warranty case, please return the unit, suitably packaged with a decontamination certificate, to Michell's Service Department.

5.1 Error Conditions

If the oxygen sensor is damaged, the XZR200 will highlight this by blinking the CYCLE output (pin 4) and green LED in 3 short blinks, 1 long blink pattern or continuously OFF. An error code is also displayed on the RS232 output and the analog outputs will go to 4mA and 0 V.

5.2 Sensor Operating Tips

To get the best performance from the XZR200 analyzer it is important that the oxygen probe is installed and maintained in the correct manner. The following are useful sensor operating tips and list of gases & materials that must be avoided to ensure a long sensor life.

5.2.1 Operating the Sensor in Aggressive Humid Environments

When operating the sensor in warm, humid environments it is important the sensor remains at a higher temperature than its surroundings, especially if there are corrosive components in the measurement gas. During operation this is not a problem due to the 700°C (1292°F) generated by the heater. However, when the sensor or application is being powered down, the sensor heater must be the last thing to be turned off after the temperature of the surroundings have suitably cooled. Ideally the sensor should be left powered at all times in very humid environments.

Failure to adhere to the above will result in condensation forming on the heater and sensing cell (as these will be the first components to cool due to their connections to the outside world). When the sensor is re-powered the condensation will evaporate, leaving behind corrosive salts which very quickly destroy the heater and cell as illustrated below. Note how the sensor’s external metalwork looks completely normal.

Figure 7 *Sensor Damage*

5.2.2 Protecting from Water Droplets

In environments where falling water droplets are likely, the sensor should be protected from water falling directly onto the very hot sensor cap as this can cause massive temperature shocks to the cell and heater. Popular methods include a hood over the sensor cap or for the sensor to be mounted in a larger diameter cylinder.

At a very minimum the sensor cap should be angled downwards in the application as this will deflect any falling moisture and prevent the sensor cap from filling with water (see Section 3, Installation).

5.2.3 Cross Sensitivity With Other Gases

Gases or chemicals that will have an influence on the life of the sensor or on the measuring results are:

1. **Combustible Gases**

   Small amounts of combustible gases will be burned at the hot Platinum electrode surfaces or Al2O3 filters of the sensor. In general, combustion will be stoichiometric as long as enough oxygen is available. The sensor will measure the residual oxygen pressure which leads to a measurement error (low oxygen reading). The sensor is not recommended for use in applications where there are large amounts of combustible gases present and an accurate O_2 measurement is required.

   Gases tested:

   - H2 (Hydrogen) up to 2%; stoichiometric combustion
   - CO (Carbon Monoxide) up to 2%; stoichiometric combustion
   - CH4 (Methane) up to 2.5%; stoichiometric combustion
   - NH3 (Ammonia) up to 1500 ppm; stoichiometric combustion

2. **Heavy Metals**

   Vapors of metals like Zn (Zinc), Cd (Cadmium), Pb (Lead) and Bi (Bismuth) will have an effect on the catalytic properties of the Pt– electrodes. Exposure to these metal vapors must be avoided.

3. **Halogen and Sulphur Compounds**

   Small amounts (< 100ppm) of Halogens and/or Sulphur compounds have no effect on the performance of the oxygen sensor. Higher amounts of these gases will, in time, cause readout problems or, especially in condensing atmospheres, corrosion of sensor parts. These gases often outgas from plastic housings and tubes when hot.

   Investigated gases were:

   - Halogens, F_2 (Flourine), Cl_2 (Chlorine)
   - HCL (Hydrogen Chloride), HF (Hydrogen Fluoride)
   - SO_2 (Sulphur Dioxide)
   - H_2S (Hydrogen Sulphide)
   - Freons
   - CS_2 (Carbon Disulfide)

4. Reducing Atmospheres

Long time exposure to reducing atmospheres may, in time, impair the catalytic effect of the Pt-electrodes and has to be avoided. Reducing atmospheres are defined as an atmosphere with very little free oxygen and where combustible gases are present. In this type of atmosphere oxygen is consumed as the combustible gases are burned.

5. Other

Fine dust (Carbon parts/soot) might cause clogging of the porous stainless steel filter and may have an effect on the response of the sensor to oxygen changes. Heavy shocks or vibrations may alter sensor properties resulting in the need for a recalibration.

5.2.4 Using the Sensor with Silicones

The XZR200 oxygen sensor, like all other Zirconium Dioxide sensors, will be damaged by silicon presence in the measurement gas. Vapors (organic silicone compounds) of RTV rubbers and sealants are widely used in many applications. These materials, which are often applied as a liquid or gel, still release silicone vapors into the surrounding atmosphere even after they have cured. When these vapors reach the sensor the organic part of the compound will be burned at hot sensor parts, leaving behind a very fine silicon-dioxide (SiO_2). This SiO_2 completely blocks the pores and active parts of the electrodes.

If silicon cannot be avoided in the application we advise using high quality, high temperature cured materials which do not release silicone vapor when subsequently heated.

When installing the sensor do not use any lubricants or grease which may contain silicon.

Appendix A

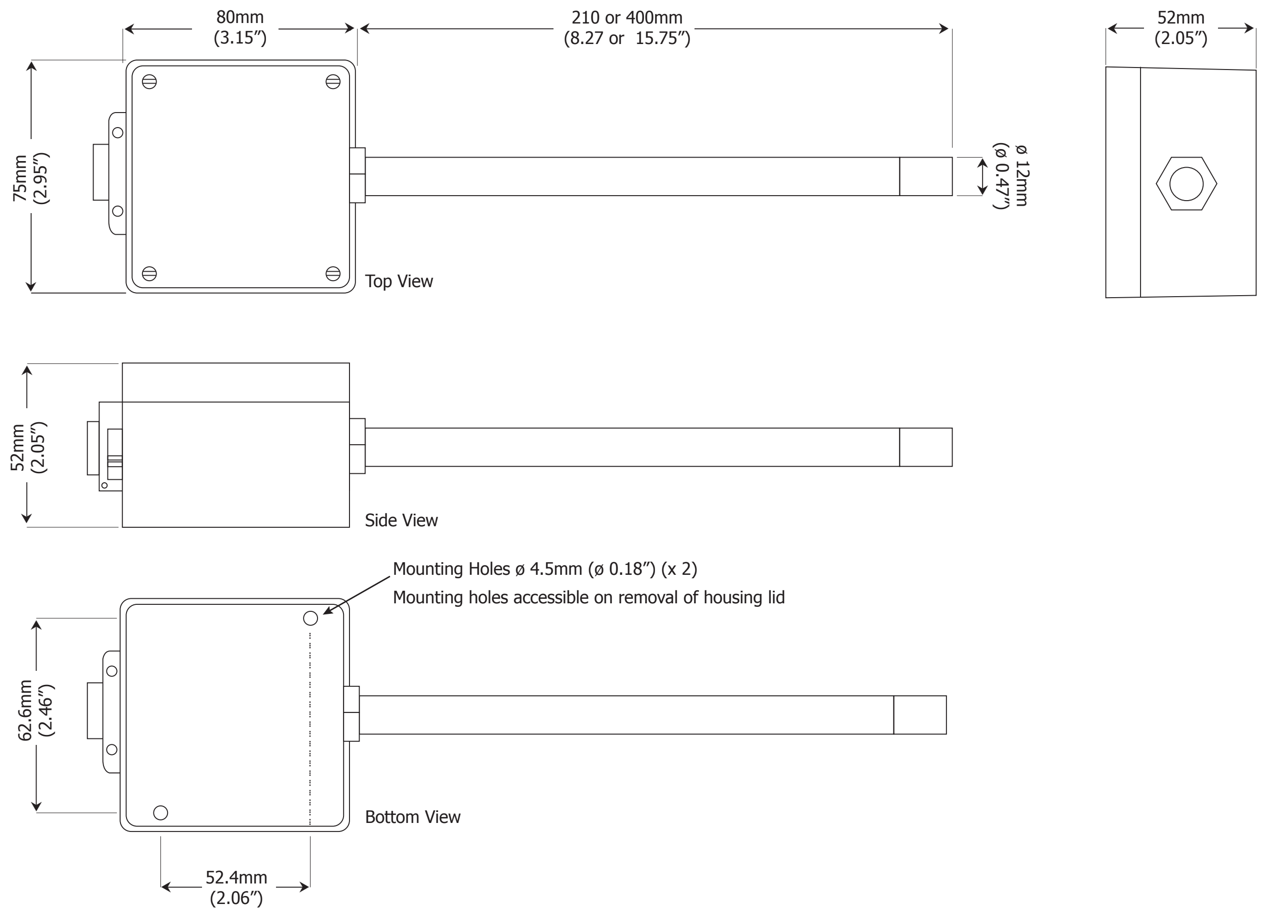
Technical Specifications

Appendix A Technical Specifications

Performance	
Measurement Technology	Zirconium Dioxide
Gas	Oxygen
Measurement Range	0 to 25% or 0 to 100%
Output Resolution	0.01 V, 0.01 mA or 0.01% O_2
Accuracy (0 to 25%)	< 0.5% O_2
Accuracy (0 to 100%)	< 1% O_2
Response Time (T90)	< 5 seconds
Repeatability	< 0.5%
Sample Flow Rate	0-10 m/sec
Sample Flow Effect (calibrated @ 0.5 l/min)	±0.1% O_2 (0 to 1 l/min)
Sample Pressure	Atmospheric*
Sample Temperature	Up to +400°C (+752°F)
Background Gas	Air, N_2, CO_2, Ar or Combustion Gas
Electrical Specifications	
Power Supply	24 V DC, ±10%
Power consumption	500 mA maximum @ 24 V DC
Analog Outputs	4-20 mA and 0 to 10 V DC
Output Ranges	0 to 25% or 0 to 100%
Digital Communications	RS232 (not available if 4-20 mA output selected)
Operating Conditions	
Ambient Temperature	-10 to +85°C (14 to +185°F)
Mechanical Specifications	
Warm Up Time	Approximately 10 minutes
Stabilization Time	Included in the above
Dimensions	52 x 75 x 80mm (2.05 x 2.95 x 3.15") (h x w x d) excluding probe
Probe Dimensions	210 or 400mm (length) ø 12mm (8.27 or 15.75" (length) ø 0.47")
Weight	< 0.5kg (< 1.1lb)
Wetted Materials	Stainless steel
Process Connection	12mm Swagelok® compression fitting or equivalent required
Ingress Protection	IP65
Housing Material	Waterproof die-cast aluminum housing

* The XZR200 is designed to be operated at atmospheric pressures. However, it is possible to measure in the range 0 to 25% O_2 at pressures up to 3 barg (43.5 psig) without damage to the unit. The unit will require calibration at the operating pressure and a separate pressure transducer feeding into the control system may be required.

Dimensions


80mm
(3.15")
210 or 400mm
(8.27 or 15.75")
52mm
(2.05")
75mm
(2.95")
ø 12mm
(ø 0.47")
Top View
52mm
(2.05")
Side View
Mounting Holes ø 4.5mm (ø 0.18") (x 2)
Mounting holes accessible on removal of housing lid
62.6mm
(2.46")
Bottom View
52.4mm
(2.06")

Appendix B

Theory of Operation

Appendix B Theory of Operation

The sensor employs a well proven, small Zirconium Dioxide based element at its heart that does not require a reference gas. This removes limitations in the environments in which the sensor can be operated with high temperatures, humidity and oxygen pressures all possible.

Background Physics:

The partial pressure is defined as the pressure of a single gas component in a mixture of gases. It corresponds to the total pressure which the single gas component would exert if it alone occupied the whole volume.

Dalton's Law:

The total pressure (*ptotal*) of a mixture of ideal gases is equal to the sum of the partial pressures (*pi*) of the individual gases in that mixture.

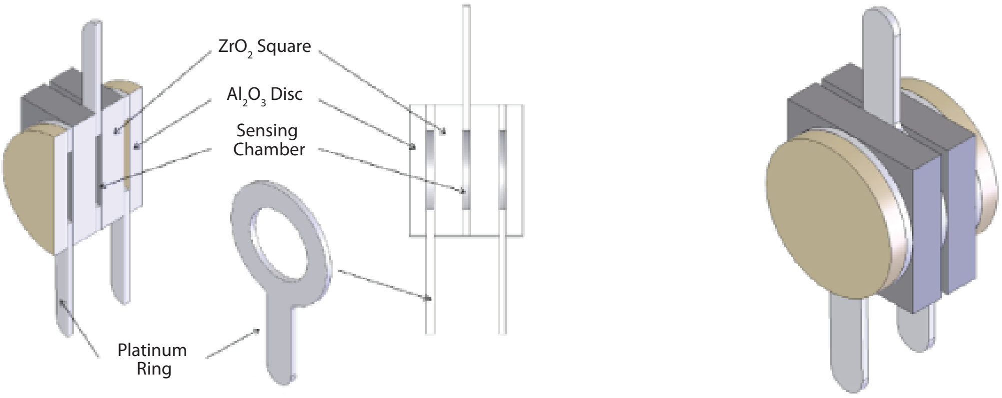
$$P_{total} = \sum_{i=1}^{k} P_i$$

From the equation above it can be derived that the ratio of the number of particles (*ni*) of an individual gas component to the total number of particles (*ntotal*) of the gas mixture equals the ratio of the partial pressure (*pi*) of the individual gas component to the total pressure (*ptotal*) of the gas mixture.

$$\frac{n_i}{n_{total}} = \frac{P_i}{P_{total}}$$

ni	Number of particles in gas i
ntotal	Total number of particles
pi	Partial pressure of gas i
ptotal	Total pressure

Sensor Function:



At the core of the XZR200 oxygen analyzer is a cell consisting of two Zirconium Dioxide (ZrO_2) squares coated with a thin porous layer of platinum which serve as electrodes. The platinum electrodes provide the catalyst necessary for the measured oxygen to dissociate, allowing the oxygen ions to be transported through the ZrO_2.

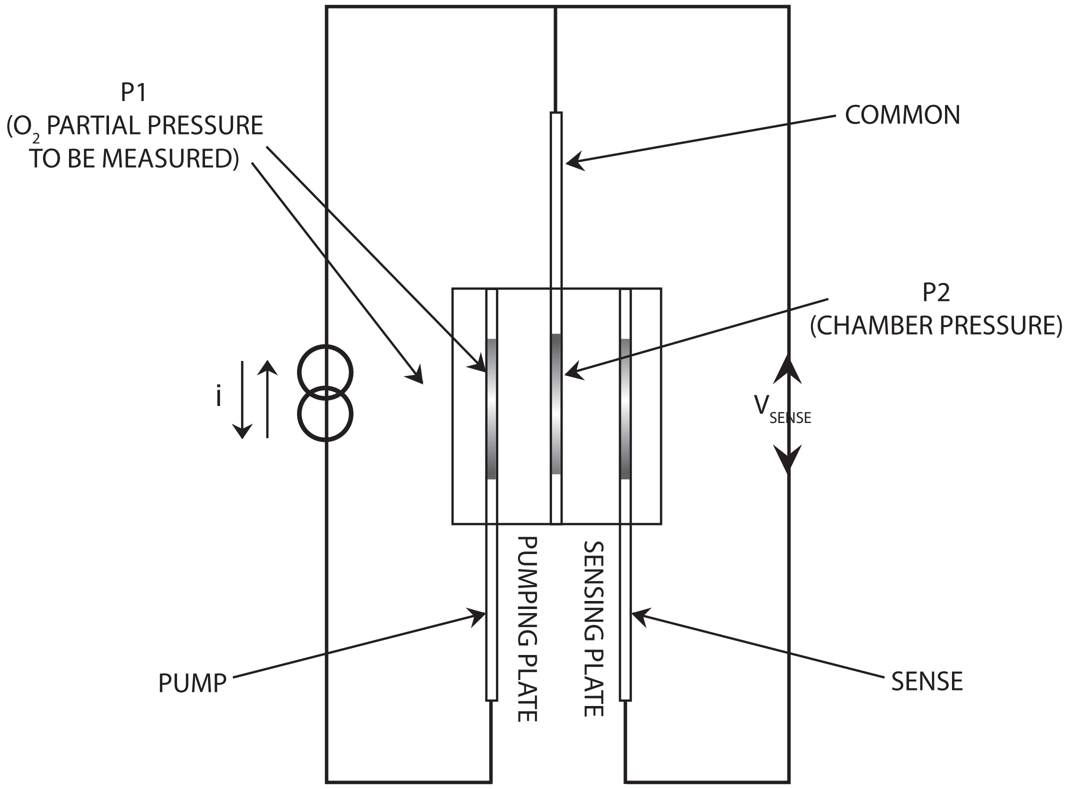
The two ZrO_2 squares are separated by a platinum ring which forms a hermetically sealed sensing chamber. At the outer surfaces there are two further platinum rings which, along with a center platinum ring, provide the electrical connections to the cell.

Two outer alumina (Al_2O_3) discs filter and prevent any particulate matter from entering the sensor and also remove any unburnt gases. This prevents contamination of the cell which may lead to unstable measurement readings. The above figure shows a cross-section of the sensing cell with all the major components highlighted.

A heater coil which produces the necessary 700°C (1292°F) required for operation, surrounds the sample cell. Both are housed within a porous stainless steel cap to filter larger particles and dust. The filter cap also protects the sensor from mechanical damage.

Pumping Plate:

The first ZrO_2 square works as an electrochemical oxygen pump, evacuating or re-pressurising the hermetically sealed chamber. Depending on the direction of the reversible DC constant current source the oxygen ions move through the plate from one electrode to the other. This in turn changes the oxygen concentration and therefore the pressure (P_2) inside the chamber. As we only evacuate then re-pressurize the chamber using the gas around the sensor, the pressure inside the chamber is always less than the ambient pressure outside the chamber. The electrical connections to the cell are shown in the figure below.



Sensing Plate:

A difference in oxygen pressure across the second ZrO_2 square generates a Nernst voltage which is logarithmically proportional to the ratio of the oxygen ion concentrations (see Nernst Voltage). As the pressure inside the chamber (P2) is always kept less than the pressure outside of the chamber (P1), the voltage at SENSE with respect to the common is always positive.

This voltage is sensed and compared with two reference voltages and every time either of these two references is reached, the direction of the constant current source is reversed. When the PPO_2 is high, it takes longer to reach the pump reversal voltages than it does in a low PPO_2 atmosphere. This is because a greater number of oxygen ions are required to be pumped in order to create the same ratio-metric pressure difference across the sensing disc.

Nernst Voltage:

Two different ion concentrations on either side of an electrolyte generate an electrical potential known as the Nernst Voltage. This voltage is proportional to the natural logarithm of the ratio of the two different ion concentrations.

$$\Delta V = -\frac{k_B T}{e_O} \cdot \ln\left(\frac{c_1}{c_2}\right)$$

kB	Boltzmann constant (kB = 1.3x10-23J/K)
T	Temperature in K
e_0	Elementary charge (e_0 = 1.602x10-19C)
ci	Ion concentration in mol/kg

Appendix C

Quality, Recycling & Warranty Information

Appendix C Quality, Recycling & Warranty Information

Michell Instruments is dedicated to complying to all relevant legislation and directives. Full information can be found on our website at:

www.michell.com/compliance

This page contains information on the following directives:

- ATEX Directive
- Calibration Facilities
- Confl ict Mi nerals
- FCC Statement
- Manufacturing Quality
- Modern Slavery Statement
- Pressure Equipment Directive
- REACH
- RoHS2
- WEEE2
- Recycling Policy
- Warranty and Returns

Appendix D

Analyzer Return Document & Decontamination Declaration

Appendix D Analyzer Return Document & Decontamination Declaration

Decontamination Certificate

IMPORTANT NOTE: Please complete this form prior to this instrument, or any components, leaving your site and being returned to us, or, where applicable, prior to any work being carried out by a Michell engineer at your site.

Instrument			Serial Number	
Warranty Repair?	YES	NO	Original PO #	
Company Name			Contact Name	
Address				
Telephone #			E-mail address	
Reason for Return /Description of Fault:				

Has this equipment been exposed (internally or externally) to any of the following? Please circle (YES/NO) as applicable and provide details below		
Biohazards	YES	NO
Biological agents	YES	NO
Hazardous chemicals	YES	NO
Radioactive substances	YES	NO
Other hazards	YES	NO
Please provide details of any hazardous materials used with this equipment as indicated above (use continuation sheet if necessary)		
Your method of cleaning/decontamination		
Has the equipment been cleaned and decontaminated?	YES	NOT NECESSARY

Michell Instruments will not accept instruments that have been exposed to toxins, radio-activity or bio-hazardous materials. For most applications involving solvents, acidic, basic, flammable or toxic gases a simple purge with dry gas (dew point <-30°C) over 24 hours should be sufficient to decontaminate the unit prior to return.
Work will not be carried out on any unit that does not have a completed decontamination declaration.

Decontamination Declaration

I declare that the information above is true and complete to the best of my knowledge, and it is safe for Michell personnel to service or repair the returned instrument.

Name (Print)		Position	
Signature		Date	

MICHELL Instruments F0121, Issue 2, December 2011

MICHELL Instruments

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