Panametrics

User's Manual

XMO2pro

Thermoparamagnetic Oxygen Analyzer

Standard Industry (STN) & SIL 2 Model (SIL)

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Services

Panametrics provides customers with an experienced staff of customer support personnel ready to respond to technical inquiries, as well as other remote and on-site support needs. To complement our broad portfolio of industry-leading solutions, we offer several types of flexible and scalable support services including: Training, Product Repairs, Service Agreements and more.

Please visit https://panametrics.com/services for more details.

Typographical Conventions

Note: *These paragraphs provide information that provides a deeper understanding of the situation, but is not essential to the proper completion of the instructions.*

IMPORTANT: These paragraphs provide information that emphasizes instructions that are essential to proper setup of the equipment. Failure to follow these instructions carefully may cause unreliable performance.

CAUTION! This symbol indicates a risk of minor personal injury and/or damage to the equipment unless these instructions are followed carefully.

WARNING! This symbol indicates a risk of serious personal injury unless these instructions are followed carefully.

Safety Issues

WARNING! It is the responsibility of the user to follow all site rules and applicable regulatory requirements.

IMPORTANT Any instructions on grounding and cable termination in this manual are necessary for compliance with global EMC / RFI standards. Such compliance may be required by National EMC / RFI legislation.

Local Safety Standards

The user shall ensure that he operates the equipment in accordance with the applicable local codes, standards, regulations, or laws.

Qualification of Personnel

Ensure that all personnel have applicable training to use the equipment.

Personal Safety Equipment

Ensure that operators and maintenance personnel have all safety equipment applicable.

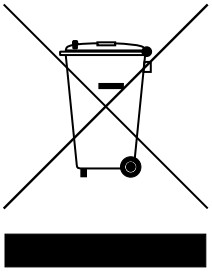
Unauthorized Operation

Ensure that unauthorized personnel cannot gain access to the operation of the equipment.

Environmental Compliance

Waste Electrical and Electronic Equipment

This apparatus required the extraction and use of natural resources for its production. It may contain hazardous substances that could impact health and the environment. To avoid the dispersal of these substances into our environment and to reduce the pressure on natural resources, we encourage you to use an appropriate “take-back” resource recovery scheme. These schemes will reuse or recycle most of the materials of your end-of-life equipment in an environmentally responsible way. The crossed-out wheeled bin symbol marked on the product invites you to use such a scheme.



If you need more information on the collection, reuse and recycling systems, please contact your local waste management administration.

As part of its commitment to the environment and the EU's WEEE Directive 2012/19/EU, Panametrics participates in a take-back scheme.

Please visit https://panametrics.com/health-safety-and-environment-hse for take-back instructions and more information about this initiative.

Chapter 1. Features and Capabilities

Chapter 2. Installation

Chapter 3. Startup and Operation

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Chapter 1. Features and Capabilities

1.1 Introduction

This chapter introduces you to the features and capabilities of the Panametrics XMO2pro Thermoparamagnetic Oxygen Analyzer. The following specific topics are discussed:

- Description and basic features of the XMO2pro
- Product overview
- Theory of operation
- System description
- Overview of typical XMO2pro applications

Note: *The XMO2pro technical specifications and ordering information can be found in Chapter 8, "Specifications"*

1.2 Basic Features

The XMO2pro analyzer measures the oxygen concentration in the range of 0-100% in various gas mixtures and provides a digital output and also two 4-20 mA analog output signals proportional to the oxygen concentration. The microprocessor-based XMO2pro provides automatic oxygen signal compensation for background gas composition and/or pressure variations. In addition, the XMO2pro is equipped with real-time error detection, field calibration via the integrated HMI (keypad), and optional fast-response software.

The XMO2pro analyzer offers several unique design features:

- Ultra-stable thermistors and a temperature-controlled and ambient-temperature-resistant measuring cell ensures excellent zero and span stability as well as high tolerance to fluctuations in the ambient temperature, up to 40°C. For special applications, a high temperature unit is available for operation at higher ambient temperatures, up to 55°C.
- The design of the measuring cell is resistant to visible (medium-sized) contamination and relatively tolerant of sample gas flow rate variations. As it has no moving parts, the XMO2pro performs reliably under the shock and vibration found in many industrial applications.
- The modular design of the XMO2pro allows for easy and quick replacement of the sensor and electronics with a replacement module (e.g. a module with different factory calibration) as well as field calibration in just a few minutes.
- The XMO2pro's unique "bridge-within-a-bridge" measurement circuit and microprocessor-based operation automatically compensate the oxygen signal for variations in the magnetic and thermal properties of the background gas that would otherwise cause measurement errors.
- At high oxygen concentrations, changes in atmospheric pressure have significant effects on the measured oxygen level. However, the XMO2pro provides automatic microprocessor-based atmospheric pressure compensation of the oxygen signal for these applications.
- The modular design of the XMO2pro allows the user to easily replace the measuring cell and the entire electronics with a precalibrated measuring cell in just a few minutes. After the short field calibration, the XMO2pro is ready for use again without having to remove the apparatus from the sample system.
- An integrated display with user accessible magnetic switch buttons.
- An additional 4-20 mA analog output is available, allowing the user to output a second, tighter range within the existing calibration range.
- The XMO2pro analyzer, which is available in weatherproof and explosion-proof packaging, is designed to be installed as close as possible to the process sample point. It can be located up to 450 ft (150 m) from the control system, display, or recorder using standard Panametrics cables.
- An RS485/RS232 serial communications interface and a multilevel, menu-driven user program provide a convenient means for calibrating and programming the XMO2pro.
- Internal software algorithms along with user-programmed calibration data provide compensation of the oxygen signal for background gas composition, atmospheric pressure, or both.
- Panametrics proprietary fast-response software provides enhanced response times to track rapidly changing processes.

- Sophisticated error-checking software with user-programmable defaults and error limits detects abnormal measurement conditions.
- Adjustment of the 4-20 mA analog output zero and span values can be made via the magnetic buttons on the HMI (stylus required).
- A drift calibration routine provides automatic drift compensation for minor changes in the sensor calibration setting.
- Programmable recalibration is accomplished in the field on the apparatus itself, with no potentiometers to adjust.

1.3 Product Overview

As shown in *Figure 1* below, the XMO2pro is equipped with several external features designed to facilitate its operation, maintenance and usability.

1. Configuration and certification information
2. Mounting holes
3. Cable entries (2 on each side)
4. Removable top cover
5. Removable front cover (secured with an adjustment screw)
6. Multi-parameter display
7. Magnetic keypad
8. Flame arrestors (gas inlet/outlet) and breather

Figure 1: External Components of the XMO2pro

1.4 Theory of Operation

The XMO2pro measures the concentration of oxygen in a gas mixture by utilizing the unique paramagnetic properties of oxygen.

As its magnetic susceptibility is approximately 100 times greater than that of most other common gases, oxygen can be easily differentiated from these gases based on its behavior in a magnetic field. Also, oxygen's magnetic susceptibility varies inversely with temperature. Therefore, by carefully combining a magnetic field gradient and a temperature gradient within the XMO2pro measuring cell, an oxygen-containing gas mixture can be made to flow along these gradients. This induced gas flow is known as a magnetic wind. The intensity of this magnetic wind depends on the concentration of oxygen in the gas mixture.

Figure 2 shows a flow schematic for the XMO2pro measuring cell. Permanent magnets within the cell create a magnetic field, while the cell temperature is controlled at an elevated temperature to maintain a stable, controlled, measurement environment. In addition, the cell contains two pairs of thermally-matched and highly stable, glass-coated thermistors. One thermistor of each pair located inside the magnetic field with the other thermistor of the pair located outside the field. The heated thermistors give rise to a temperature gradient within the magnetic field, part of the principle of operation of the apparatus.

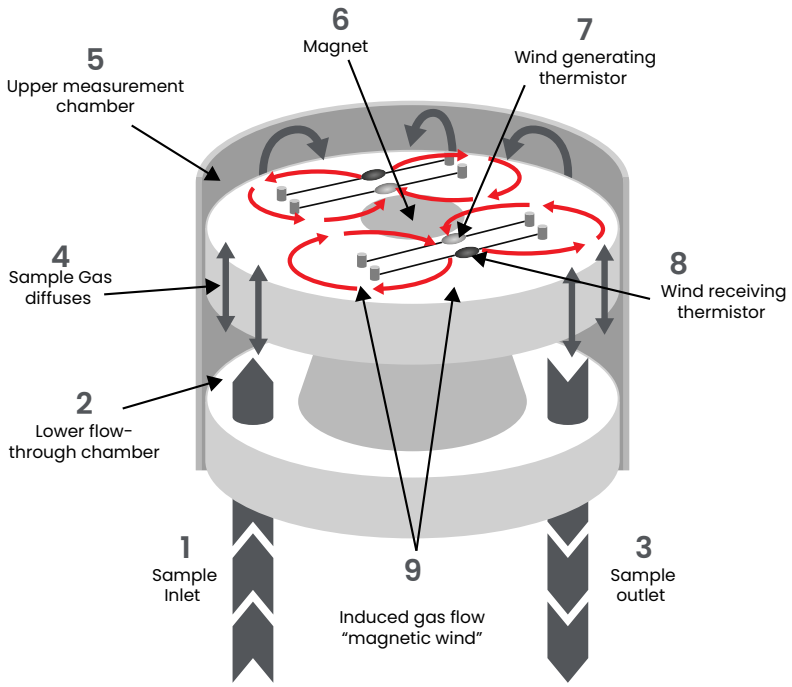


Figure 2: Flow Diagram of the XMO2pro Measuring Cell

Sample gas continually flows through the lower flow-through chamber (1)(2)(3). This chamber acts as a pass-through and protects the sensor from contamination. A portion of the sample gas diffuses (4) into the upper chamber (5). The oxygen molecules are drawn into the center by the magnet (6) and leave across the heated matched thermistor pairs (7)(8) creating a "magnetic wind" (9). These thermistor pairs form part of a Wheatstone bridge, which generates a signal proportional to the oxygen concentration in the sample gas.

1.5 System Description

As an extractive industrial process oxygen analyzer, the XMO2pro requires the use of a sample conditioning system. This sample conditioning system may vary in design (required components) depending on process conditions. Panametrics offers complete solutions based on standard packages, but also designs and manufactures customized sample conditioning systems. Please contact Panametrics to find out what is required for a specific application.

The sample system is mandatory and can either be provided by Panametrics or constructed according to Panametrics' recommendations.

1.5.1 Packaging and Temperature Rating

The XMO2pro analyzer is a self-contained apparatus, consisting of the oxygen sensor and associated electronics. It draws approximately 1.6-2.0A during warm-up, dropping to 300-500mA in normal operation. It provides a two self-powered 4-20mA analog outputs and a digital output signal that is proportional to the oxygen concentration of the sample gas and has fully programmable zero and span points. Also provided is an RS232/RS485 digital output for oxygen concentration, background gas, and atmospheric pressure signals. Programming, and calibration of the unit may also be performed via this interface. We recommend a power source capable of supplying up to 2.5A at 24+/-4 VDC.

The XMO2pro is designed to be installed in a sample system as close as possible to the process sample point. Thus, it is available in two environmental packages:

- Weatherproof
- Explosion-proof (with the addition of flame arrestors for the inlet and outlet)

The standard XMO2pro is configured for operation in an area with an ambient temperature up to 40°C. A high temperature XMO2pro is available for operation at higher ambient temperatures, up to 55°C (see *"Ambient Operating Temperature Range"* in *Chapter 8*).

Depending on the requirements of the installation site, the XMO2pro is available with an aluminum or stainless steel enclosure (see *Figure 3*). There is also a Blind or no-display option of the XMO2pro available. This has the same installation requirements however field calibration is completed over digital communications (See *Figure 4*).

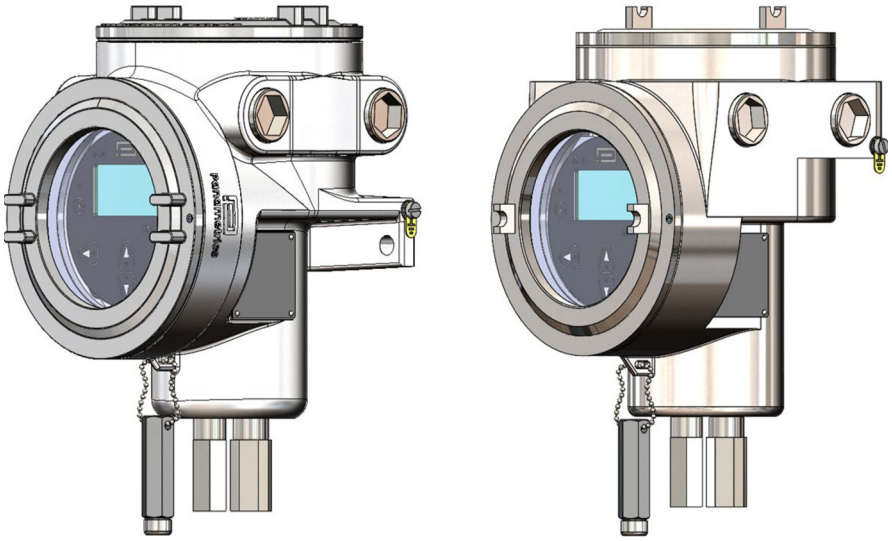


Figure 3: Aluminum (left) and Stainless Steel (right) XMO2pro

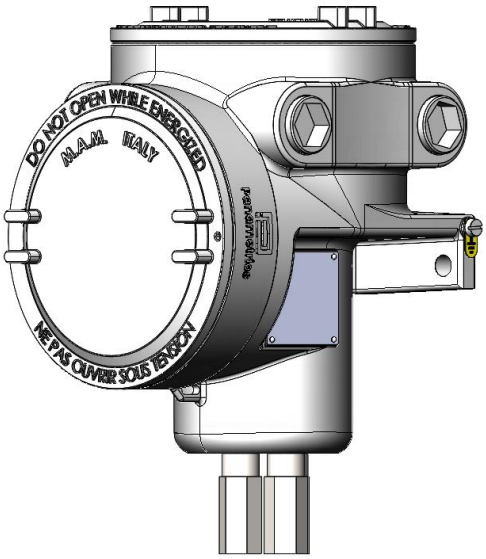


Figure 4: Blind Analyzer

As shown in *Figure 5*, the XMO2pro has three ports: two interchangeable sample inlet and outlet ports and (for hazardous area units) a breather / vent fitting. The breather serves as a vent to avoid any potential accumulation of flammable gases inside the apparatus, allowing any such gases to diffuse safely out of the apparatus to the

ambient before they can accumulate to a significant level (IEC 60079-1 requirement). It is permissible for the vented gas to disperse locally or to be piped to a dedicated vent in accordance with any site venting requirements.

WARNING! There shall be no restriction on the vent or any attached piping.

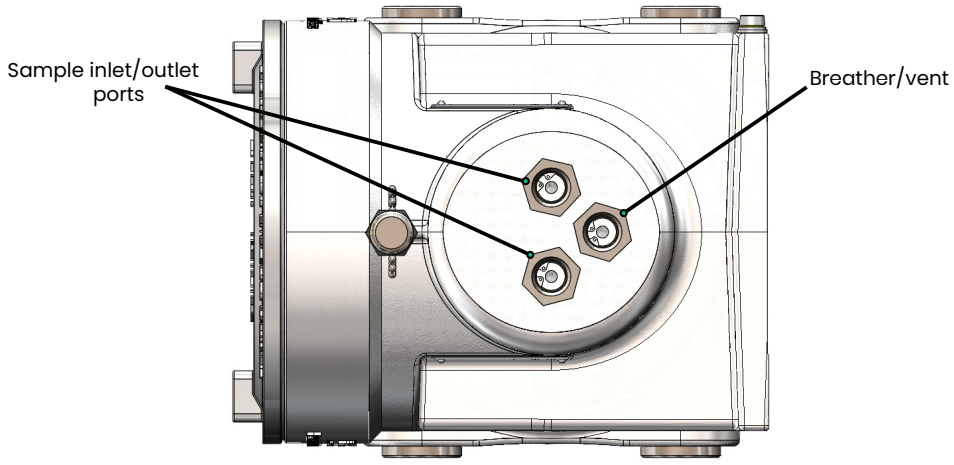


Figure 5: XMO2pro Ports

IMPORTANT: The XMO2pro analyzer can be configured for the following standard oxygen ranges:

0 to 1%	0 to 25%
0 to 2%	0 to 50%*
0 to 5%	0 to 100%*
0 to 10%	80 to 100%*
0 to 21%	90 to 100%*

*Pressure compensation is required

The standard XMO2pro is configured for operation in an area with an ambient temperature up to 40°C. A high temperature XMO2pro is available for operation at higher ambient temperatures, up to 55°C, for special applications.

Note: *The higher operating temperature cell should only be selected only when necessary, as this results in reduced sensitivity.*

Note: *On request, the XMO2pro can be calibrated for other concentration ranges.*

1.5.2 The Sample System

A sample system is mandatory for use with the XMO2pro analyzer. The specific design of the sample system depends on the conditions of the sample gas and the requirements of the application. At a minimum, the sample system shall include a sample gas flowmeter and a gas flow regulator valve/upstream flow limiting device.

In general, the sampling system must provide the XMO2pro analyzer with a clean (i.e. dust and moisture-free), representative sample of the sample gas at a temperature, pressure and flow rate that are within the limits listed in the technical specifications section of this manual (see *Chapter 8, "Specifications"*).

Panametrics offers sample systems for a wide variety of applications. A typical sample system for use with the XMO2pro analyzer is shown in *Chapter 2, "Installation"*. For assistance in designing your own sample system, please consult the factory.

Compliance to IEC 60079-1 requires:

- The maximum inlet pressure is 2 bar(g) / 0.2 MPa(g).
- The maximum inlet flow rate is 1.25 L/min (2.65 SCFH / 0.075m^3/hr). An up-stream flow limiting device is required.

CAUTION! If the XMO2pro is outside of a Panametrics sample conditioning system, the customer must ensure sample pressure is controlled, e. g. using a pressure regulator, if required in the system design.

CAUTION! If the XMO2pro has not been provided with a Panametrics sample conditioning system, it is recommended that the instrument is mounted to a metallic mounting plate of at least 1.5mm thickness, or a substrate of similar strength.

1.6 Applications

The stable and accurate thermoparamagnetic sensor, certified globally for use in hazardous area environments, make the XMO2pro the tool of choice for use in:

Refinery & Petrochemical

- Blanketing gases in hydrocarbon storage
- Oxidation reactors
- Fertilizer processing urea production
- Terephthalic acid (PTA) production

Metal Heat Treatment

- Monitoring of oxygen during various heat treatment processes of metals
- Aluminized steel

Biogas & Landfill

- O_2 during anaerobic digestion to produce biogas
- O_2 to ensure process safety
- O_2 as a contamination after biogas processing
- O_2 in aerobic digesters during wastewater treatment

Nitrogen Generators

- O_2 monitoring in Nitrogen generation

Pharmaceutical

- Safety measurement in centrifuge for solid-liquid separation

Transportation

- Maritime inert gas generators

Two typical application use cases are described in more detail in the *Appendix H on page 99.*

Chapter 2. Installation

2.1 Introduction

This chapter describes the installation of the XMO2pro analyzer and its sample conditioning system. It also contains information on connecting optional system components. Installing the XMO2pro sampling system consists of two basic steps:

1. Installing the XMO2pro analyzer in the sample system (if you purchased your sample system from Panametrics, this step has already been done for you).
2. Mounting, plumbing, and wiring the sample system.

WARNING! It is the responsibility of the end user to ensure that any site personnel who are performing installation, commissioning and maintenance have been trained in proper site procedures for working with and around Panametrics supplied equipment, per Safe Work Practices.

WARNING! Proper Lockout/Tagout of energy sources prior to maintenance, per Safe Site Work Practices, is the end user's responsibility.

WARNING! The XMO2pro is capable of measuring hazardous gases. These gases may be flammable, toxic, asphyxiants, corrosive, oxidizers etc. Users must take appropriate steps in reviewing the risks and safety measure associated with this installation.

2.2 Installing the XMO2pro Analyzer

Note: *This section applies only if the XMO2pro analyzer has not already been installed in the sample system by Panametrics.*

The sample system delivers a clean, representative gas sample to the XMO2pro at the proper temperature, pressure and flow rate. This usually means a clean, dry gas sample that is free of solid and liquid particulates and is delivered at atmospheric pressure, a temperature no greater than 40°C (104°F) or 55°C (131°F) for the optional cell, and a flow rate of approximately 500 cc/ min (1.0 SCFH). A typical sample system for the XMO2pro might include an inlet gas flow regulating needle valve, a sample gas flow meter, and a pressure gauge (see *Figure 6*).

Note: *Because factory calibration of the XMO2pro is done at atmospheric pressure and at a flow rate of 1.0 SCFH, operation of the XMO2pro at other pressures and/or flow rates requires a field recalibration to ensure optimum accuracy.*

WARNING! Customer to ensure correct safety practices and any applicable regional regulations are followed when handling pressurized gas and when connecting same to the XMO2pro instrument and/or any equipment provided by Panametrics.

To install the XMO2pro analyzer in the sample system, complete the following steps:

1. Select a location in the sample system that provides at least 230 mm (9 in) of clearance above the top cover of the XMO2pro for access to the interior of the analyzer.
2. Mount the XMO2pro analyzer in the sample system via its two mounting holes. Be sure that the analyzer is upright and is level to within ±15°.
3. Use 1/4" stainless steel tubing to connect the sample system Inlet and outlet fittings to the corresponding XMO2pro ports.

2.3 Installing the Sample System

You can order a complete sample system from Panametrics that is mounted on a steel panel and includes the XMO2pro analyzer and all necessary components and plumbing. Panametrics also offers standard (off-the-shelf) sampling systems and designs customized sampling systems build to your exact specifications.

2.3.1 A Basic System

Figure 6 shows a basic sample system that has been designed for use with the XMO2pro analyzer.

The sample system shown in *Figure 6 on page 8* consists of a painted steel plate with the following components mounted on it:

- Needle valves (1) for sample, zero, and span gas flow regulation
- Ball valves (2) for flow selection
- The process tubing (3)
- XMO2pro analyzer (4)
- Sample gas outlet pressure gauge (5)
- Sample gas flowmeter (6)

As it is recommended to operate the XMO2pro at atmospheric pressure and also because the sample pressure cannot exceed 2 barg per the specific conditions of use (refer *Section 2.5, "Specific Conditions of Use"*), it is recommended to include a pressure regulator (7) to prevent over-pressurization. Other components include a filter (8), coalescer, or a pump could be added if needed.

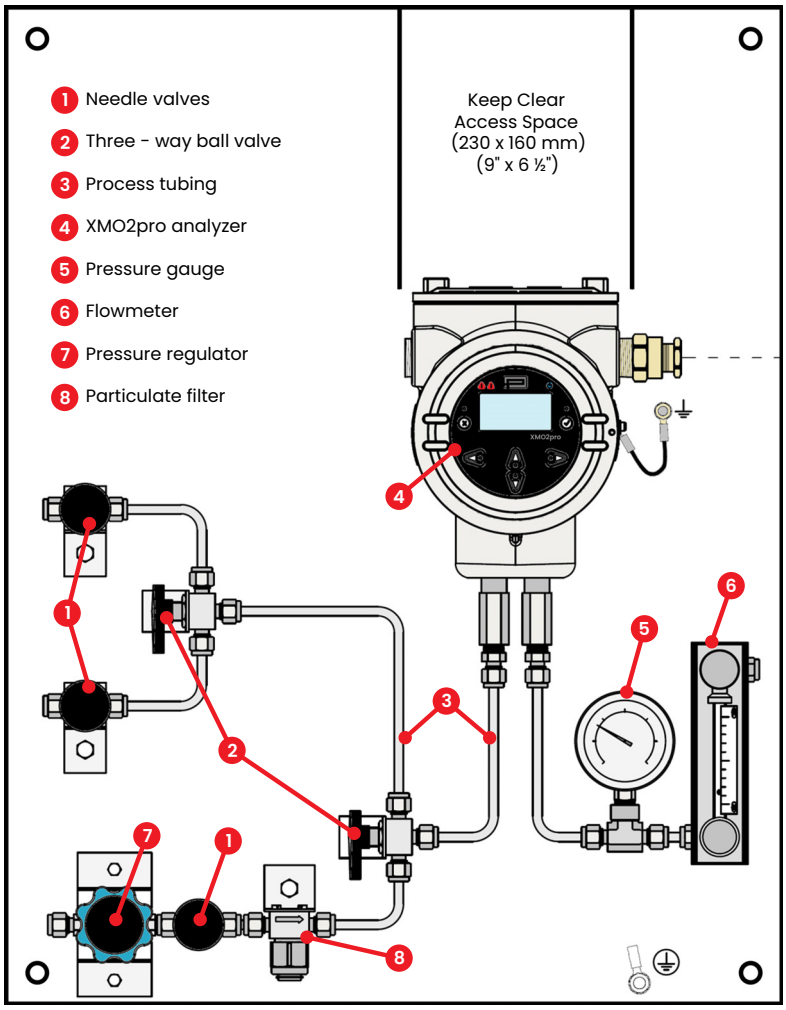


Figure 6: Basic Sample System for XMO2pro

2.3.2 Mounting the Sample System

To mount the sample system, complete the following steps:

1. Select a location that is as close as possible to the process sampling point. The ambient temperature at this location should be in the range of -20° to +40°C (-4° to +104°F), for the standard cell.

IMPORTANT: For locations where the ambient temperature falls below -20°C (-4°F), install the sample system in a heated enclosure.

2. Using the mounting holes provided, fasten the sample system to a convenient vertical surface. The system shall be installed in an orientation that keeps the XMO2pro analyzer upright and level to within ±15°.
3. After the sample system has been mounted, use 1/4" stainless steel tubing to connect all inlet and outlet lines to the 1/4" tube fittings on the sample system. The sample line leading from the process to the sample system should be as short as possible in order to decrease system lag time and to prevent condensation in the line.

2.4 Wiring the Analyzer

IMPORTANT: Installation in hazardous locations shall be in accordance with these installation instructions and the National Electrical Code® ANSI/NFPA 70, the Canadian Electrical Code C22.1, or IEC/EN 60079-14, as applicable.

IMPORTANT: Ensure that the cable entry devices and plugs are IP66 and/or NEMA Type 4X rated as applicable.

2.4.1 Grounding the Enclosure

WARNING! **The XMO2pro analyzer shall be properly grounded. Connect the external ground screw on the XMO2pro enclosure (see *Figure 7* below) to a suitable earth grounding point.**

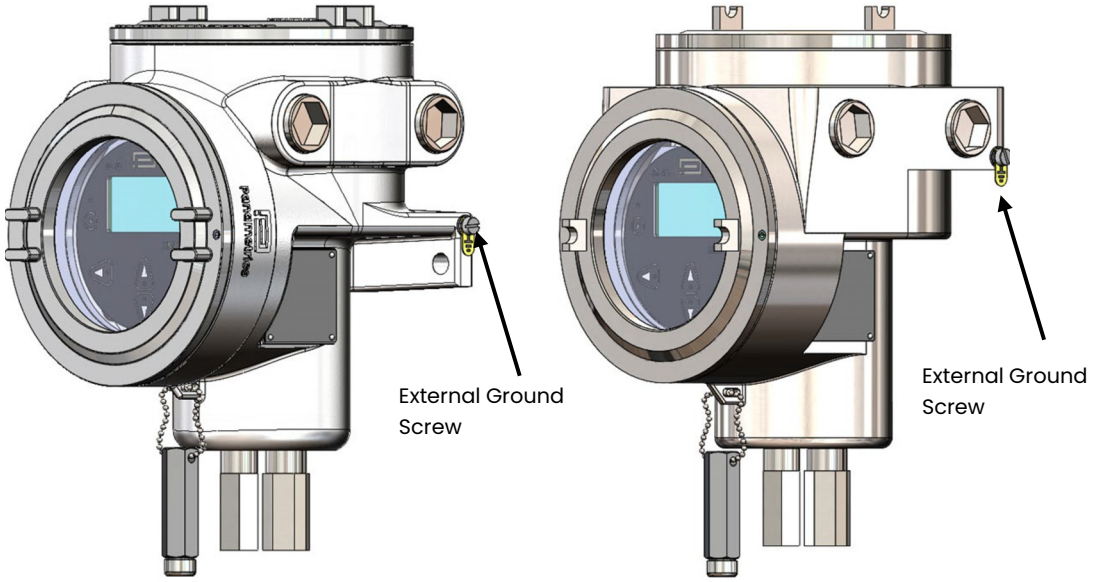


Figure 7: External Ground Screw Locations for Aluminum and Stainless Steel Versions of XMO2pro

2.4.2 Electromagnetic Compatibility (EMC) Performance Requirements

WARNING! To complete an EMC installation per IEC 61326-1 requirements, all electrical cables shall been installed as described in *Appendix G, "CE Mark Compliance" on page 97.*

WARNING! An EMC installation per IEC 61326-1 is required for apparatus installed in most countries around the world including, but not limited to, EU, EEA, EAC, Australia, New Zealand, Korea and India.

WARNING! Cable entries devices and/or plugs of an approved flameproof design are required. These must be installed according to the manufacturer's instructions the choice of cable entry device may limit the overall installation category achieved.

2.4.3 Cable Specifications

PSU cable: 2-core, shielded, twisted pair cable [TB1]{Port A}

4-20mA Outputs cable: 4-core, shielded, twisted pair cable [TB4]{Port B}

Digital comms cable: 3-core, shielded, RS-232/RS-485 cable [TB10]{Port C}

Relay cables: 12-core, shielded cable [TB2 & TB3] {Port D}

Refer to *Figure 8* for port location and *Table 1* for PSU cable length requirements:

Table 1: Cable Length Requirements

Maximum Cable Length		Wire Size	
ft	m	AWG	mm^2
450	137	22	0.3
700	213	20	0.50
1050	320	18	0.8
1700	518	16	1.3
2800	853	14	2.00
4000	1219	12	3.3

2.4.3.1 Accessing Terminal Blocks TB1, TB2, TB3, TB4, and TB10

The 24 VDC power input, 4-20 mA analog outputs, relay outputs and digital comms outputs wiring connections are made to terminal blocks TB1, TB2, TB3, TB4, and TB10 inside the XMO2pro (see *Figure 7*). To access this terminal block, loosen the locking screw and remove the cover. Then, refer to *Figure 8* for the location and pin designations of terminal blocks TB1, TB2, TB3, TB4, and TB10.

CAUTION! Do not make any connections to any unused pins on terminal blocks TB1, TB2, TB3, TB4, TB10, and TB11.

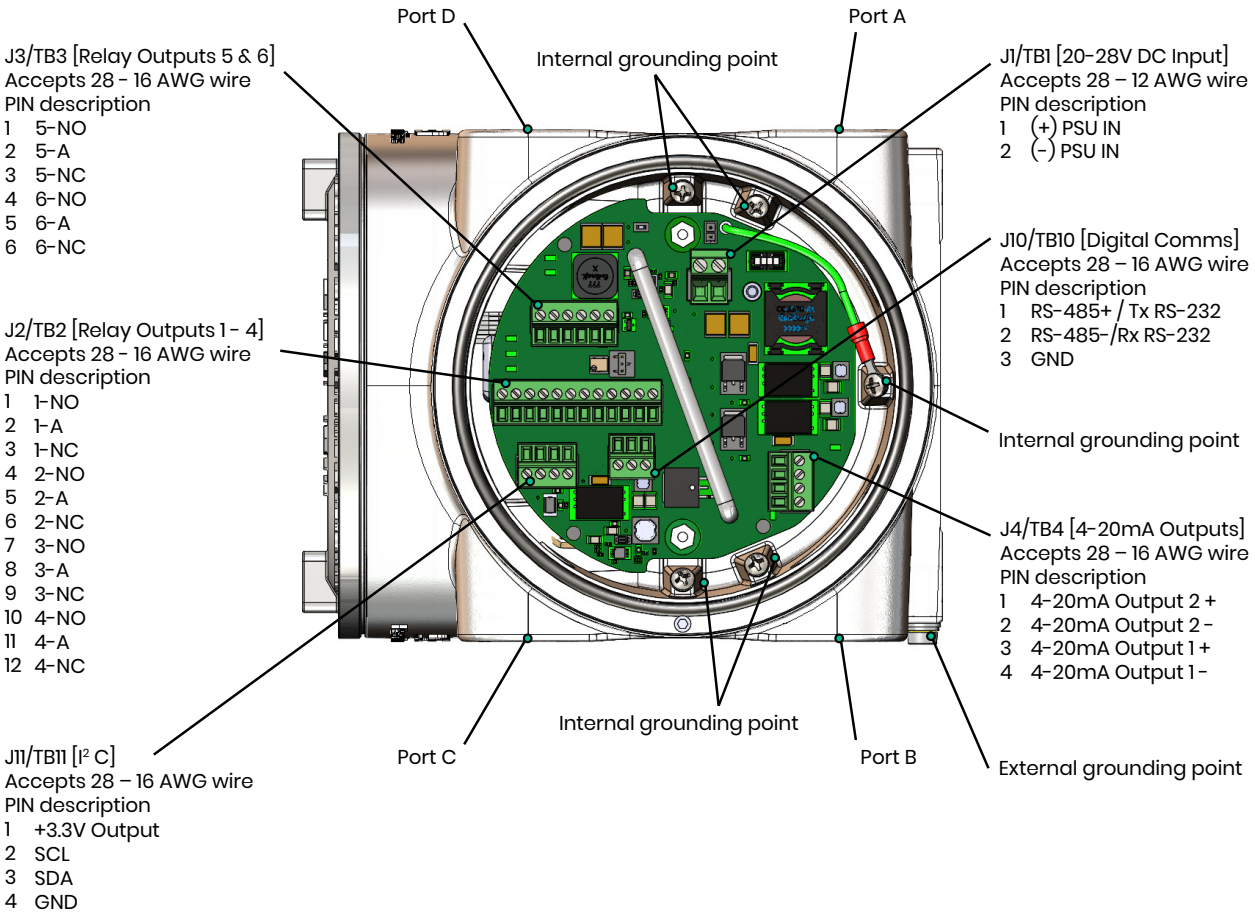


Figure 8: Wiring Diagram

2.4.4 Wiring the Power and Signal Connections

Complete the following steps to make the signal connections to the analyzer:

1. Install a cable clamp or gland in the 3/4" conduit hole.

CAUTION! All unused cable entries shall be sealed.

CAUTION! The 4-20mA outputs are internally-powered by the instrument. DO NOT apply any power supply source to any pin of J4/TB4

2. Route the associated cable through the cable clamp as described in *Section 2.4.3, "Cable Specifications"*. Then, tighten the clamp to secure the cable.
3. Unplug the associated connector to this cable as outlined in *Section 2.4.3, "Cable Specifications"* by pulling them straight off the printed circuit board and loosen the screws on the side of the connectors.
4. Connect the appropriate leads per the wiring diagram in *Figure 8*.

Complete the following steps to safely finalize the wiring of the apparatus.

CAUTION! **The positive supply shall only be connected via TB1-1. Connecting the +24 VDC supply to any other terminal will damage the XMO2pro. Such damage is not covered by our warranty.**

1. Carefully plug the TB1, TB2, TB3, TB10 connectors back onto the printed circuit board, and reinstall the cover on the XMO2pro. Tighten the lid-securing setscrew.
2. Connect the other ends of the cables to the 24 ± 4 VDC power supply, the 4-20 mA inputs of the display/control device, and the serial port of the computer or terminal (see the instruction manuals for those devices for details).

2.4.5 Wiring the Alarm Relays

Terminal block J2 contains connections for the alarm relays. To wire these alarms, complete the steps described below.

Note: *A failsafe alarm is wired to the normally-closed (NC) contacts, while a non-failsafe alarm is wired to the normally-open (NO) contacts. Alarms LL, L and H are factory-configured as non-failsafe. Alarm HH is factory-configured as failsafe. Alternative configuration by the user is not possible.*

1. **LL Alarm** (factory-configured as non-failsafe):
   a. Connect pin #1 (NO) to the alarm device input.
   b. Connect pin #2 (A) to the alarm device return.
2. **L Alarm** (factory-configured as non-failsafe):
   a. Connect pin #4 (NO) to the alarm device input.
   b. Connect pin #5 (A) to the alarm device return.
3. **H Alarm** (factory-configured as non-failsafe):
   a. Connect pin #7 (NO) to the alarm device input.
   b. Connect pin #8 (A) to the alarm device return.
4. **HH Alarm** (System Fault Alarm) (this alarm is factory-configured in failsafe mode)
   a. Connect pin #11 (A) to the alarm device return.
   b. Connect Pin #12 (NC) to the alarm device input.

2.4.6 Wiring the Serial Port

The XMO2pro is equipped with a Modbus communication port for either a connection to PanaView Plus (PC software) or to a separate control system. On blind analyzers (no display) the port is an RS485 interface however on display versions the port can be configured as RS232 or RS485 via the display.

IMPORTANT: The maximum cable length for an RS485 connection is 4000 ft (1200 m). To wire to the serial port, refer to *Figure 8* and complete the following steps:

1. Disconnect the main power to the unit and remove the rear cover.
2. Install the required cable gland in the chosen conduit hole on the side of the electronics enclosure.
3. Feed one end of the cable through the conduit hole, and wire it to the terminal block.
4. If wiring of the unit has been completed, reinstall the wiring cover on the enclosure and tighten the set screw.

Note: *Prior to use, the serial port must be programmed.*

2.4.7 Wiring the Serial Cable

The XMO2pro if supplied as a blind analyzer will be delivered with a communication cable. This cable will need to be connected to the terminal block in the device per the manufacturers instructions.

2.5 Specific Conditions of Use

The XMO2pro has hazardous area certifications for multiple regions. Special conditions are required for safe operation. These are as follows:

1. Do not open when an explosive environment is present.
2. Do not block or restrict the enclosure vent (3rd flame arrestor).
3. The maximum inlet pressure is 2 bar(g)/0.2 MPa(g).
4. The maximum inlet flow rate is 2.67 L/min (5.65 SCFH). An up-stream flow limiting device is required.
5. To avoid the risk of electrostatic-charging of the painted surface, the apparatus shall only be cleaned with a damp cloth. Guidance on protection against the risk of ignition due to electrostatic discharge can be found in documents such as IEC TS 60079-32-1, ANSI/UL 60079-32 & C22.2 No. 60079-32.
6. The internal CR1632 battery should not need to be replaced during the lifetime of the XMO2pro. Should replacement be necessary, this shall only be performed by authorized service personnel. Only RENATA or Panasonic batteries are permitted for apparatus installed in hazardous areas.
7. The apparatus cannot be repaired by the user. Specifically, the flameproof design was assessed with non-standard thread lengths and cemented joints; these cannot be repaired. Contact Panametrics service team for assistance.

2.5.1 Other Hazardous Area Installation Requirements

1. Connecting cables shall be mounted securely and protected from mechanical damage, pulling and twisting.
2. Cable entry devices of a suitably certified flameproof design are required. These shall be installed according to the manufacturer's instructions.
3. Unused entries shall be sealed using a suitably certified threaded plug.
4. All threaded entries shall be wrench-tight, suggested minimum torque is 54 N.m / 40 lbf-ft.
5. For Class I and Zone 1 installations under (US) NEC or (Canadian) CEC jurisdiction, seal all conduit entries within 18" of the apparatus.
6. Modifications to the flameproof enclosure are not permitted.
7. Only trained, competent personnel may install, operate, and maintain the apparatus.
8. The product is an electrical apparatus and shall be installed in the hazardous area in accordance with the requirements of the issued certificate. The installation shall be carried out in accordance with all the appropriate international, national and local standard codes of practices and site regulations for flameproof apparatus and in accordance with the instructions contained in the manual. Access to the circuitry is not permitted during operation.

[no content intended for this page]

Chapter 3. Startup and Operation

3.1 Introduction

This chapter provides instructions for starting up and operating the XMO2pro system. The following specific topics discussed:

- Powering up the XMO2pro
- Establishing Sample Flow
- Calibration of the analog output signal

If you have not already done so, read *Chapter 2, "Installation"* for details on mounting and wiring the XMO2pro analyzer, the sample system, and any other optional equipment.

3.2 Powering the Analyzer

The XMO2pro analyzer does not have a power switch. It begins its initialization process as soon as a connection to the 24 VDC power source is established. The output signals are inhibited until a stable internal operating temperature is established, typically under 30 minutes.

Because the standard XMO2pro measurement cell is controlled at an elevated temperature, allow at least 30 minutes for the unit to reach a stable operating temperature before relying on the measurement. During this time, you can establish a sample gas flow through the system, as described in the next section.

Note: *On SIL Models, Channel 1 is the primary 4-20 mA output and SIL-certified. Channel 2 is not covered by SIL.*

CAUTION! **It is the responsibility of the user to ensure that all cable entry devices and covers are properly installed and securely-fitted prior to applying power to the XMO2pro. The lid-securing setscrew shall always be tightened when the lid is reinstalled.**

3.3 Establishing a Sample Gas Flow

Usually, the XMO2pro analyzer is factory-calibrated at a sample gas flow rate of 500 cc/min (1.0 SCFH) and at atmospheric pressure. Unless otherwise specified on your XMO2pro calibration sheet *(see Appendix I, "Calibration Sheet")*, optional sample system tagging, or optional sample system instructions, your XMO2pro should be operated at atmospheric pressure and at the flow rate listed in *Table 2*.

Note: *For optimum performance, operating the XMO2pro at conditions other than those used for the factory calibration requires that the unit be recalibrated at the actual field conditions.*

To establish a flow of sample gas through the system, complete the following steps (see *Figure 6 on page 8* as an example):

1. Set the sample system ball valves to direct only the sample inlet stream to the inlet port of the XMO2pro analyzer.
2. Use the sample inlet needle valve to regulate the flow of sample gas until the flowmeter reads the same flow rate listed for your unit in *Table 2 on page 16*.
3. Read the resulting system pressure on the pressure gauge. Make sure that there are no unnecessary flow restrictions downstream of the sample system.

IMPORTANT: For atmospheric pressure-compensated units, the XMO2pro outlet port shall be vented directly to atmosphere with no downstream restrictions. All sample system components and other restrictions shall be upstream of the XMO2pro analyzer.

4. Take a reading of the XMO2pro 4-20 mA analog output.

In some applications, pressure changes due to flow rate changes can cause noticeable errors in the oxygen measurement. In such cases, consider the following corrective measures:

- Reduce the flow rate to the minimum recommended value minimizes flow rate sensitivity. A bypass flow (speed loop) allows minimum flow through the XMO2pro yet maintains a fast transport of the sample gas to the XMO2pro.
- For the fastest transport, minimize the sample line length from the process.
- If you cannot shorten the sample line length, reduce the sample line pressure to less than 5 psig. Proceed to the next section to complete the initial XMO2pro startup.

Table 2: Recommended Sample Gas Flow Rates

XMO2pro Type	Flow Rate in cc/min (SCFH)
Weatherproof	500 ± 250 (1.0 ± 0.5)
Explosion-proof	500 ± 100 (1.0 ± 0.2)
Pressure-compensated	250 ± 50 (0.5 ± 0.5)

3.4 Analog Output Calibration Options

The XMO2pro 4-20 mA analog output has been calibrated at the factory for the oxygen range indicated on the XMO2 Calibration Sheet shipped with the unit (see *Appendix I, "Calibration Sheet"*). Upon initial startup, field verification and/or calibration of the 4-20 mA analog output is required. To perform this task, either of the following procedures may be used:

- Field Calibration through HMI
- Digital communication calibration

After the XMO2pro is in operation, field calibration is recommended at intervals of about 1-3 months, depending on the application.

3.5 Factory Calibration Procedures

Prior to shipment, your XMO2pro was calibrated at the factory for the $\%O_2$ range specified at the time of purchase. The following standard $\%O_2$ ranges are available:

- 0 to 1%
- 0 to 2%
- 0 to 5%
- 0 to 10%
- 0 to 21%
- 0 to 25%
- 0 to 50%*
- 0 to 100%*
- 80 to 100%*
- 90 to 100%*

* Pressure compensation is required.

In addition, your XMO2pro was calibrated at the factory for the compensation signal specified at the time of purchase. The following standard compensation signals are provided:

- Background Gas Compensation - the standard factory calibration uses N_2 and CO_2 as the background gases.
- Pressure Compensation - the standard factory calibration is for atmospheric pressure (700-800 mm of Hg).

Note: *Compensation signals are available for special background gases and/or special pressure ranges. For availability, pricing, and delivery, please contact Panametrics.*

3.6 Required Calibration Materials

To perform a field calibration the following materials are required:

- Offset gas - for a one gas $\%O_2$ calibration.
- Zero gas - for a two gas $\%O_2$ and/or 4-20mA output calibration.
- Span gas - for a two gas $\%O_2$ and/or 4-20mA output calibration.

Note: *Suggestions for suitable calibration gases are listed on the XMO2pro Calibration Data Sheet provided with the unit (See Appendix I, "Calibration Sheet" for example). The accuracy of the calibration will only be as good as the accuracy of the calibration gas(es) used.*

- Panametrics XMO2pro Calibration Data Sheet.
- A sample system or individual components (e.g. flowmeter, needle valve, pressure gauge, etc.) for introducing the calibration gas(es) to the XMO2pro analyzer at the required pressure and flowrate. See *Chapter 2, "Installation"* for specific installation recommendations.
- A multi-meter or ammeter (for 4-20mA output calibration).

WARNING! Avoid using explosive gas mixtures as your XMO2pro Calibration gases.

WARNING! User to observe correct handling of pressurized cylinders and ensure physical connections comply with manufacturers recommendations.

[no content intended for this page]

Chapter 4. Programming with HMI

The XMO2pro is factory-programmed and ready for immediate use. However, you can access its programming using the HMI or a Modbus client software through your PC.

4.1 The XMO2pro Keypad

Along with the 128 x 64, monochrome LCD, the XMO2pro analyzer includes a 6-key magnetic keypad (see *Figure 9*). The magnetic wand used to activate a magnetic key is found attached to the meter chassis below the front panel. An operator activates the key by pressing the magnetic wand up to the glass lid over the desired key. The LED will light indicating a successful key press.

Note: *The magnetic switches also include mechanical switch contacts. This mechanical switch feature shall only be accessed when the area is known to be safe. The apparatus shall be fully sealed when operating in a potentially explosive atmosphere.*

Use the magnetic keypad to navigate through the user program. The menu map may be followed in sequence, or the four arrow keys may be used to scroll through the prompt screens.

Figure 9: Keypad Layout

IMPORTANT: The XMO2pro keypad enables programming of the instrument through the glass faceplate without removing the cover. Thus, all programming procedures may be performed while the unit is installed in a hazardous area.

Six keys on the keypad enable users to program the XMO2pro:

[✓] - **Enter**: confirms choice of a specific option and data entry within the option.

[✕] - **Cancel/Back**: allows users to cancel a selection and/or return to the previous option.

[▲] [▼] - **Up and Down**: enable users to navigate through the sub-menu after entering one of the main menu options (using the Enter key).

[◀] [▶] - **Left and Right**: enable users to scroll to a specific option, among choices in an option, or to a character in a text entry.

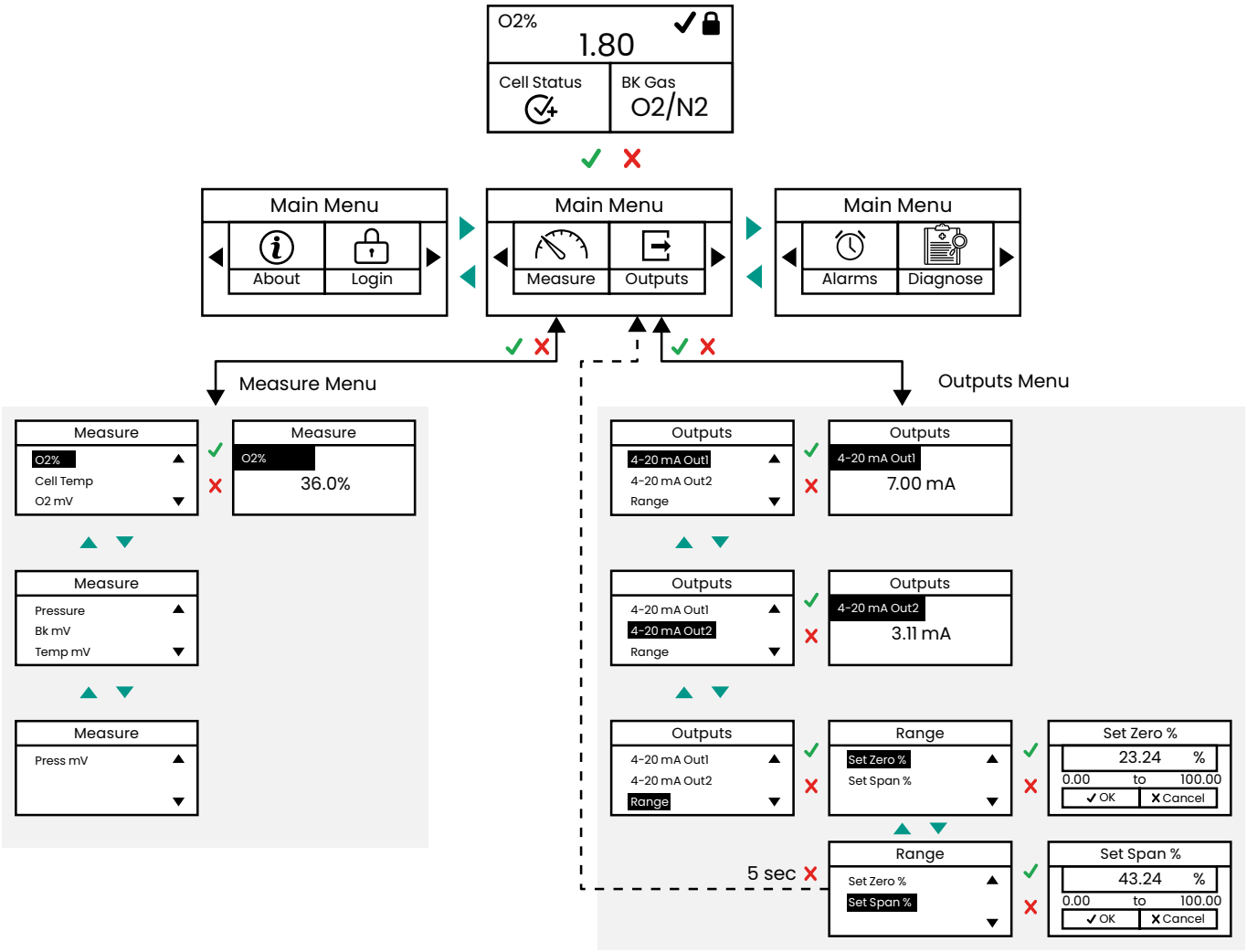


Figure 10: Snapshot of the XMO2pro User Menu

For a complete overview of the navigation options available for programming the XMO2pro, please refer to the full menu map located in *Appendix D, page 77*.

4.2 Indicator Lights

The **blue LED** on the top right above the display is the **Power Indicator**, that is under electronic control and lit when the instrument is powered.

The **red LED** on the top left above the display is the **Fault indicator**. The *Fault Indicator* light blinks out a three digit error code to indicate specific error messages. In addition, the error code will be displayed in the HMI.

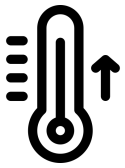
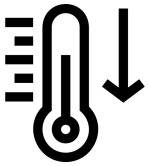
The **yellow LED** on the top left above the display is the **Heater Status**. This light blinks to indicate warming up of the product.

Figure 11: Indicator Lights

4.3 Dashboard

The XMO2pro dashboard screen provides real time monitoring of key parameters related to the gas analyzer performance. In addition to these parameters, the dashboard also displays important status indicators such as active alarms and user login information. As shown in *Figure 12*, the following readings and parameters are displayed:

1. O_2%: This shows the percentage of the signal gas in the gas mixture. It provides a direct measurement of the signal gas concentration
2. Cell Temp Status: Indicates the current status of the cell, which is critical for accurate measurements. The status may display as under temperature, over temperature and stable temperature using the following icons:

	Indicates the cell temperature is over the setpoint
	Indicates the cell temperature is under the setpoint
	Indicates the cell temperature is at the correct level

3. Background Gas Name: Displays the name of the background gas mixture.
4. Error Code: Indicates an active error by displaying the corresponding error code. Refer to Appendix C for the list of error codes. When an error is indicated, the fault indicator light (see *Figure 11*) blinks to alert the user.

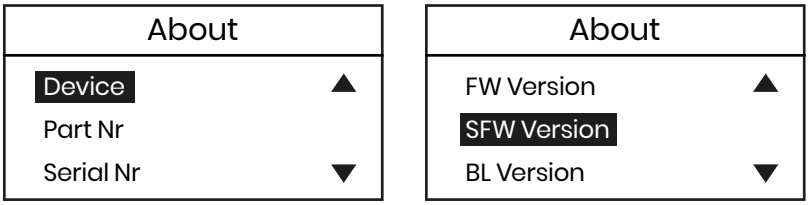
5. Login Indicator: Shows an open lock symbol to indicate a logged in user, and a closed lock symbol when the user is logged out.

Figure 12: Dashboard Screen

4.4 The About Menu

The “About” menu provides the user with the following information about the device:

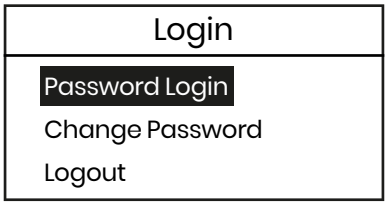
1. Device Name
2. Serial Number
3. Part Number (configuration string)
4. Firmware Version
5. Safety Firmware Version
6. Boot Loader Version



4.5 Login Menu

The “Login” menu provides the operator with three functionalities:

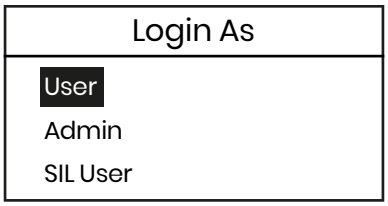
1. Log on to the unit
2. Change the password for a User profile
3. Logout



The unit comes configured with 3 different user access levels (see figure below). Each level defines the information the different users can access and edit, i. e., the different levels of read-only and read-write privileges. For instance, the User profile can only configure some device level parameters like the contrast but cannot configure a "Field Cal" whereas an Admin profile can configure a “Field Cal” but can also adjust the contrast level of the device. The following are the profile options available:

1. User

2. Admin
3. SIL User (only on SIL devices)



For every wrong password attempt a cooldown time is activated which starts at 3 seconds and doubles for every subsequent wrong password attempt. The cooldown time will reset after a successful password login.

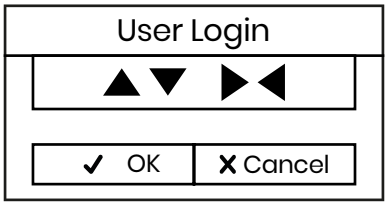
Symbol	Key on Unit
U	Up Key
D	Down Key
L	Left Key
R	Right Key

Note: *Logging in takes the meter offline and it enters configuration mode. When in configuration mode the meter will still send and receive digital signals and also output alarm relays but the primary 4-20mA output will read 3.8mA. You must log out to return to online mode and resume measurements.*

4.5.1 Login as User

To log in as a user to the device, go to the logins menu and select “Login As”. You will be provided with 3 options, select “User”. Now the unit will prompt the password for that profile. Enter the password and press OK. If login is successful, you will be redirected to the dashboard screen and you will see an open padlock icon with the number 1 in it, indicating “USER” profile login. In the case the password is incorrect you will be prompted with a “Login Error” screen and will be redirected to the login screen.

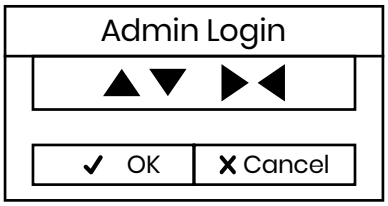
Note: *The default User profile password is “▲▲▲▲▲▲▲▲” (up key eight times). The customer can initially login in with this password and make use of the change password feature to set an alternate password. Customers are advised to change the default passwords upon initial commissioning. Refer to the local cyber security guidelines.*



4.5.2 Login as Admin

To log in as an admin to the device, go to the logins menu and select “Login As”. You will be provided with 3 options, select “Admin”. Now the unit will prompt the password for that profile. Enter the password and press OK. If login is successful, you will be redirected to the dashboard screen and you will see an open padlock icon with the number 2 in it, indicating “ADMIN” profile login.

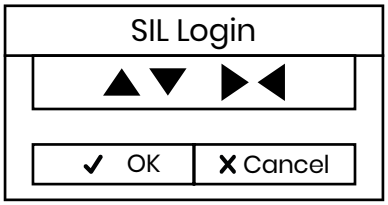
Note: *The default Admin profile password is "▲▼▲▼▲▼▲▼" (up and down keys four times). The user can initially login in with this password and make use of the change password feature to set an alternate password. Customers are advised to change the default passwords upon initial commissioning. Refer to the local cyber security guidelines.*



4.5.3 Login as SIL User (SIL Model)

The SIL User profile is a special access that enables proof tests on the unit. The SIL User login works differently than the other two profiles. To log in as SIL User refer to calibration sheet for password.

Enter the password and if password validation is successful, you will be redirected to the dashboard with an open padlock icon with the number 3 in it, indicating the "SIL USER" profile.



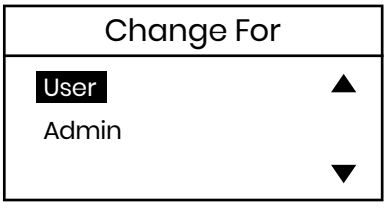
* Check the configuration string on the XMO2pro serial number label to confirm if the analyzer has the SIL option.

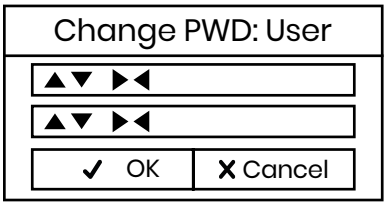
Note: *The password for the SIL User profile can be found in the calibration datasheet.*

4.5.4 Change Password

The “Change Password” menu lets you change the password for the “USER” or “ADMIN” profile for the unit. To change the password for a specific profile you need to be logged in first. In case, you are not logged in and try to change the password you will be presented with a “LOGIN FIRST” error screen.

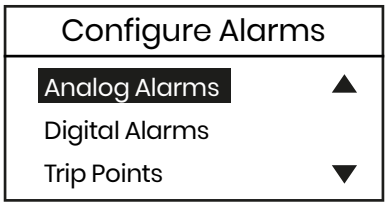
Once you are on the change password screen, you will be presented with two text boxes, where you enter the new password in the first text box and enter the new password again in the second text box to validate it. If both passwords match, then the password change is successful, and you will be redirected to the dashboard.





4.6 Error Handling/Alarms

The "Alarms" menu allows you to configure the manner in which the XMO2pro responds to various error conditions. When you click on the Alarms menu option from the Main Menu a window like the figure below appears. Clicking on any option opens the window for that option.



There is an options/button in the above window for each of the following error conditions:

1. Watch Dog Error
2. Heater Error
3. ADC Error
4. DAC Error
5. MCU Error
6. Data Error
7. Brownout Error
8. Temperature Over
9. Temperature Under
10. Early Warning Under
11. Early Warning Over
12. Gas Over
13. Gas Under
14. Calibration Error
15. System Error
16. Logged in (STN only)

To configure the XMO2pro's response to any of the above error conditions, click on the corresponding button and proceed to the appropriate section for instructions. See *Table 3* below for a description of the alarms and error conditions.

Table 3: Alarm Relays and Error Conditions

No.	Error	Default mA	Alarm Relays	Meaning
1	Watchdog Err	21 mA	HH Alarm	Firmware is unresponsive
2	Heat Err	21 mA	HH Alarm	Heater hardware fault detected
3	ADC Err	21 mA	HH Alarm	Input hardware fault detected
4	DAC Err	21 mA	HH Alarm	Output hardware fault detected
5	MCU Err	21 mA	HH Alarm	Firmware has hard faulted
6	Data Er	21 mA	HH Alarm	Unrecoverable data loss detected
7	Brownout Err	3.6 mA	HH Alarm	Power supplied is not sufficient
8	Temp Over	20.5 mA	H Alarm	Cell is too hot (normal during warmup)
9	Temp Under	3.8 mA	H Alarm	Cell is warming up (Normal during warmup)
10	Early Over	20.5 mA	L Alarm	Gas% is below early low trip point
11	Early Under	3.8 mA	L Alarm	Gas% is above early high trip point

Table 3: Alarm Relays and Error Conditions(Continued)

No.	Error	Default mA	Alarm Relays	Meaning
12	Gas Over	21 mA	LL Alarm	Gas% is above alarm high trip point
13	Gas Under	3.6 mA	LL Alarm	Gas% is below alarm low trip point
14	Cal Err	21 mA	HH Alarm	Calibration corrections cannot be applied
15	Sys Error	21 mA	HH Alarm	System fault detected
16	Logged in	3.8 mA	N/A	User logged in

The early under, early over, gas under and gas over alarms are associated with trip points and will trigger when the gas% exceeds the specified trip point. See *Figure 13* to determine how Early low/high alarms and trip points function.

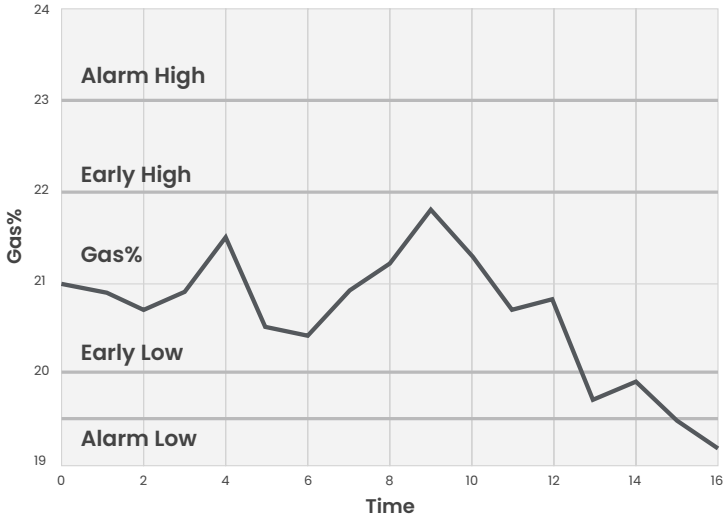
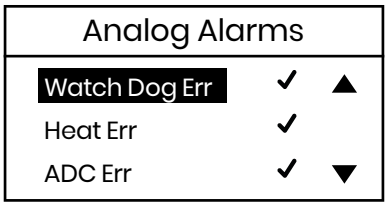


Figure 13: Early Low/High Alarms and Trip Points Function

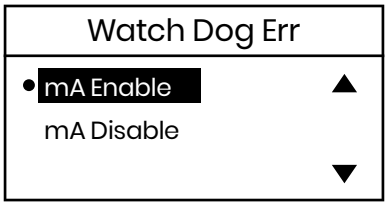
The “Analog Alarms” menu allows you to enable or disable error handling for the secondary 4-20 mA output for each specific error conditions for the XMO2pro. When you click on the alarms menu from the main menu a window as shown in the figure below opens. Clicking on any option opens the window for that option.



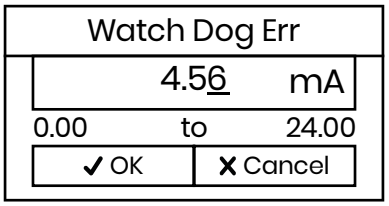
There is an options/button in the above window for each of the following error conditions listed in *Table 3*. To configure the XMO2pro's response to any of the listed error conditions, click on the corresponding button in the window above and proceed to the appropriate section for instructions.

4.6.1 Analog Alarms

The “Analog Alarms” menu lets you enable or disable error handling for the secondary 4-20 mA output (SIL model only). The window is similar to the figure below. If you disable the alarm, it will not be signaled via the secondary 4-20 mA output.



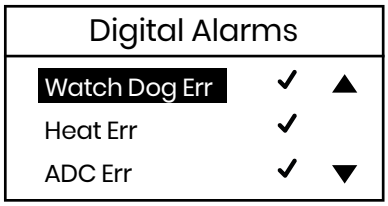
If you click on “mA Enable”, a window similar to the figure below opens.

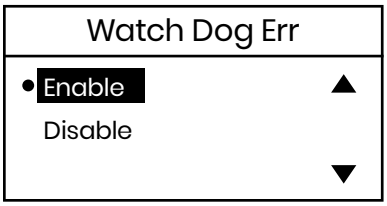


Enter the desired error mA output in the text box and click on enter to confirm the entry.

4.6.2 Digital Alarms

The “Digital Alarms” option lets you enable or disable error handling for alarm relays. The windows are similar to the figures below.

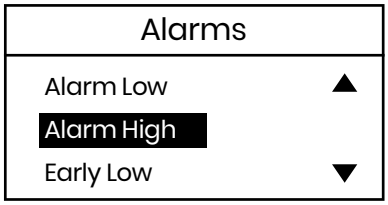


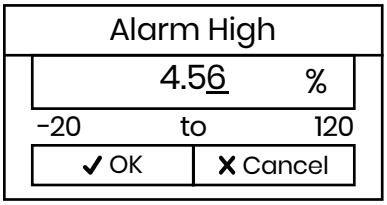


Once the error condition is selected, if you click on enable, the error condition will not be signaled via the alarm relays. You are then returned to the error handler window.

4.6.3 Trip Points

The “Trip Points” option lets you specify the gas% alarm trip points. The windows are similar to the figures below.





If you click the trip points, the window displays a text box similar to that in the figure above. Enter the desired gas % beyond which the alarm should trip. Output in the text box and click on the next item/enter to confirm the entry. The gas % set is a threshold and if the unit exceeds that the alarm will be triggered. You are then returned to the error handler window.

4.6.4 Disable Alarms on Channel 1 (STN Model)

Alarm functionality on *Table 3* users to disable the 4 to 20 mA response to alarms. For SIL models, this functionality is limited to Channel 2. The functionality has been extended for STN models to allow users to disable alarms on Channel 1. To perform this function the user should access the menu as detailed in *Appendix E.4*.

Note: *The factory default is all alarms are disabled on both 4 to 20 mA channels for H2G models, these can be enabled as required. All alarms are enabled for other XMO2pro models.*

4.6.5 Clamping the 4-20 mA output (STN Model)

Channel 1 and or Channel 2 can have clamping applied to the 4-20mA output. This feature can be accessed through the Alarms menu as shown in *Figure 14*. In the Configure Alarms screen there is an option to enable / disable the clamping feature. This option allows / disallows slightly out of range measurements to make use of the out-of-range bands. See *Table 4* for how these options affect the measurement ranges. The factory default is 3.8mA ... 20.5mA for all other XMO2pro models and 4.0 ... 20.0mA for H2G models.

Table 4: Clamping Analog Outputs

Output	Value	Measurement Range (mA)
Clamp CH1/CH2	Disabled	3.8...20.5
Clamp CH1/CH2	Enabled	4.0...20.0

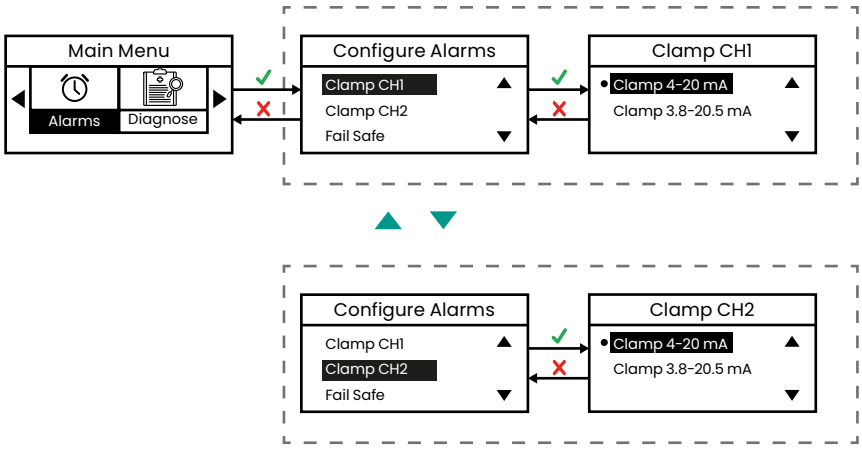


Figure 14: Clamping the 4-20 mA Output in the Alarms Menu

4.6.6 Configurable Fail Safe HH/Sys Error Alarm (STN Model)

HH Alarm from *Table 3* (Relay Output no. 4 in *Figure 8 "Wiring Diagram"*) can be configured to be fail safe or non-fail safe. This can be accessed through the Alarms menu on the Configure Alarms screen by selecting Fail Safe and then having the option to Enable or Disable. Selecting Enable makes the HH Alarm Fail Safe and Disable makes the HH Alarm non-fail safe. The factory default is fail safe.

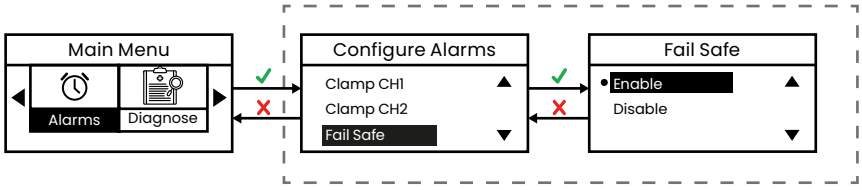


Figure 15: Fail Safe Alarm Configuration

4.6.7 Logged in Measurement Output (STN Model)

To prevent errors during navigation (incorrect settings), the 4 to 20 mA output on Channel 1 goes out of range when user logs in. The output is forced to 3.8 mA as per NAMUR standard NE43 This function can be disabled on H2G models. *Table 5* contains information on how this option affects the analog outputs. This setting can be accessed through the Alarms menu on the Configure Alarms screen by selecting Logged In and then having the option to Enable or Disable (See *Figure 16*). The factory standard for this Logged In Alarm is disabled meaning when a user logs in the 4 to 20 mA output will output the measurement. If the user enables this function once a user logs in the 4 to 20 mA output will output 3.8 mA until the user logs out or is timed out.

Table 5: Logged In Signal

Option	Value	Affect When Logged In
Logged In	Disabled	mA = measurement
Logged In	Enabled	mA = 3.8mA (or custom mA)

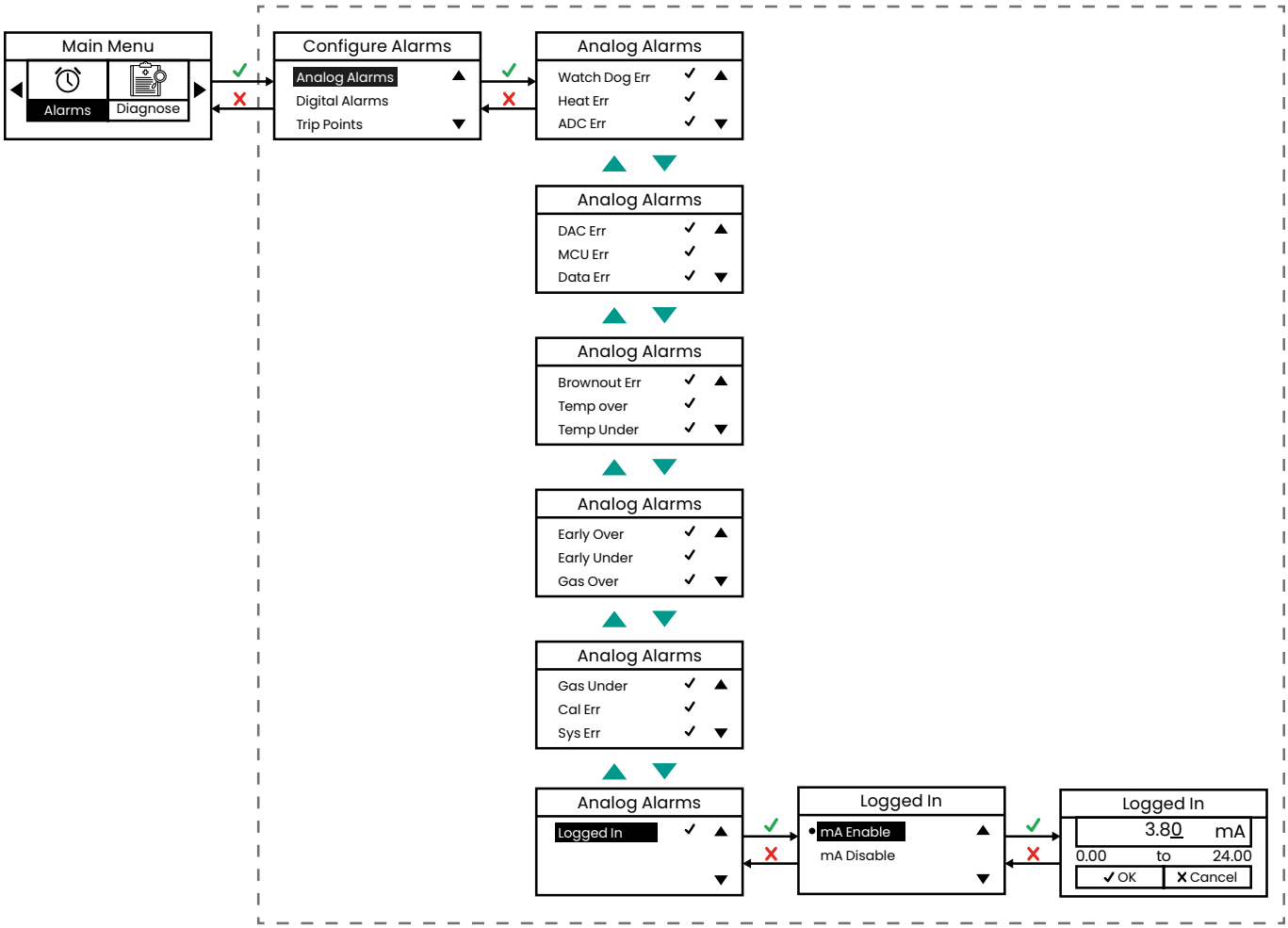
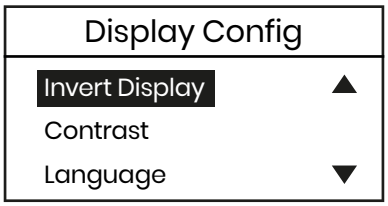


Figure 16: Logged in Alarm Configuration

4.7 Display Config

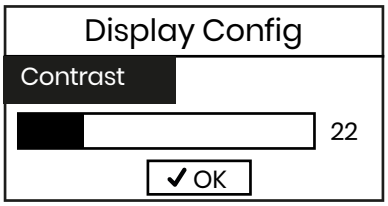
The “Display Config” menu gives the operator 4 options to customize the display. The menu can be found under the “Config” menu from the main menu.

1. Invert Display (invert the coloring scheme)
2. Contrast (adjust the contrast)
3. Language
4. Units (change unit system)



4.7.1 Contrast Settings

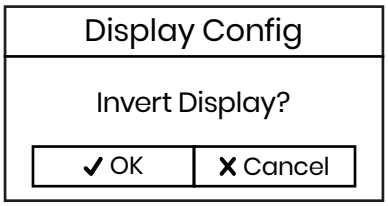
To adjust the contrast settings of the LCD display, navigate to the “Config” menu and select “Display Config”. Select “Contrast” and the below screen should appear:



Use the left/right arrow keys on the unit to decrement/increment the contrast of the LCD. When done press Enter.

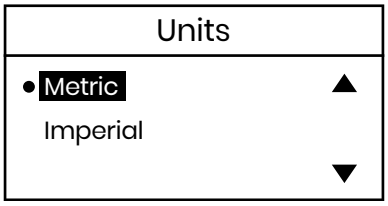
4.7.2 Invert Display

The LCD has the capability to invert its colors from black to white and vice versa. To toggle between the 2 modes, select the “Invert Display” option from the "Display Config" menu and click OK.



4.7.3 Units

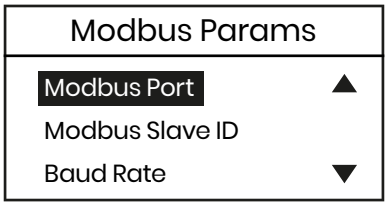
The feature enables customers to toggle between metric and imperial unit systems for parameter readings. For example: cell temperature in Celsius (metric) or Fahrenheit (imperial). By default, the unit system is metric, but the user has the flexibility to switch between the two-unit systems whenever desired.



4.8 Modbus Parameters

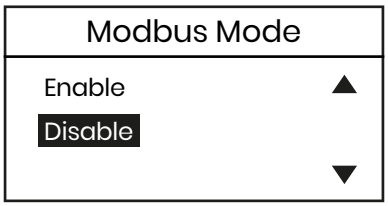
The “Modbus Parameters” provides the following configurable parameters to the operator:

1. Modbus Port
2. Modbus Slave ID
3. Baud Rate
4. Parity
5. # of bits
6. Stop Bits



4.8.1 Mode

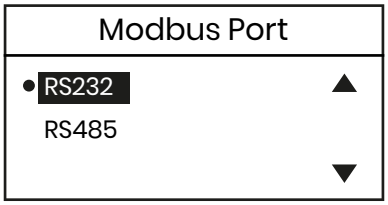
Enable or disable Modbus on the unit. When enabled Modbus parameters cannot be configured. To configure any of the following parameters, disable Modbus and change the desired parameter.



4.8.2 Port

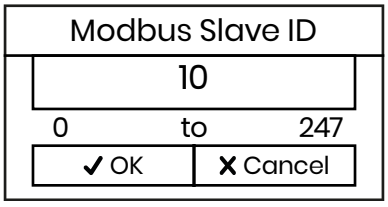
Modbus communications is available through 2 ports. You can select one of the following through the HMI:

1. RS232
2. RS485



4.8.3 Slave ID

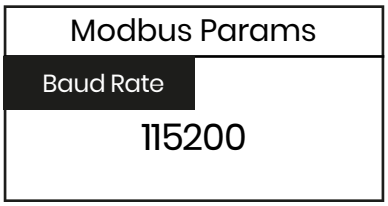
Modbus slave ID can be set using the Modbus parameters menu between 1 and 247.



4.8.4 Baud Rate

The unit supports different baud rates for Modbus communications. You can select from the options below:

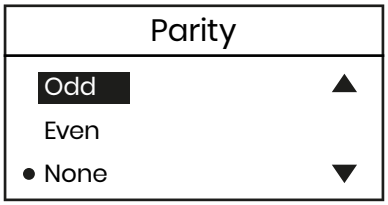
1. 9600
2. 14400
3. 19200
4. 68400
5. 57600
6. 115200



4.8.5 Parity

The unit supports three parity options for Modbus:

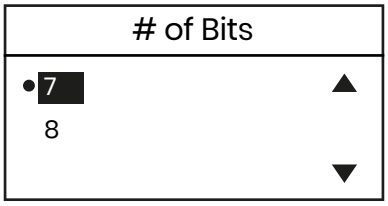
1. Odd
2. Even
3. None



4.8.6 Number of Bits

There are two options for stop bits:

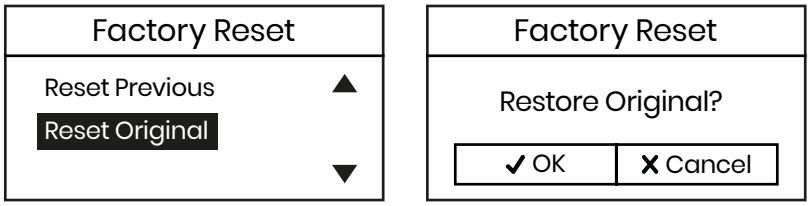
1. 7 Bits
2. 8 Bits



4.9 Factory Reset

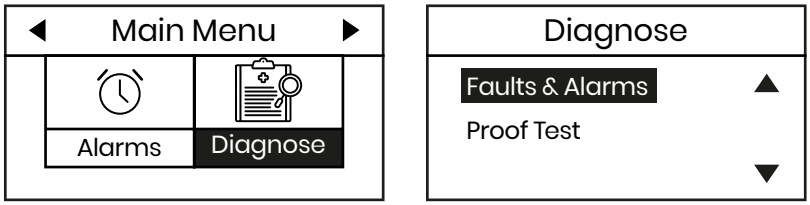
The factory reset menu is available under the “Config” menu and gives the operator two options:

1. Restore Previous – Restores the previous settings for the device.
2. Restore Factory – Restore factory settings for the device.



4.10 Faults and Alarms

The “Faults and Alarms” menu provides the operator with a summary of the alarms that are enabled, tripped, or disabled during device operation. The “Faults and Alarms” menu can be found under the “Diagnose” menu.



The following icons indicate the operation of alarms:

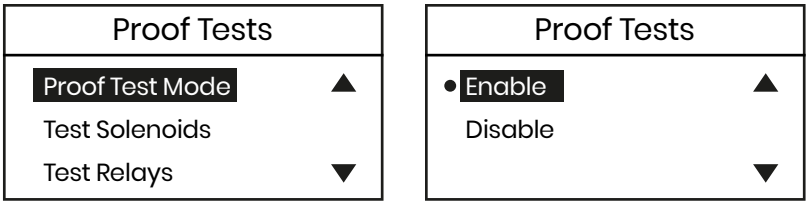
Icon	Operation
	Alarm Enabled
	Alarm Disabled
	Alarm Tripped

4.11 Proof Tests (SIL Model)

Proof tests allow you to stress test the device to maintain your SIL certification. The Proof tests menu can be found under the Diagnose Menu. The menu provides you with the following options:

1. Proof Test Mode
2. Test Solenoids
3. Test Relays
4. Test NAMUR
5. Test Alarms
6. Test CH1
7. Test CH2

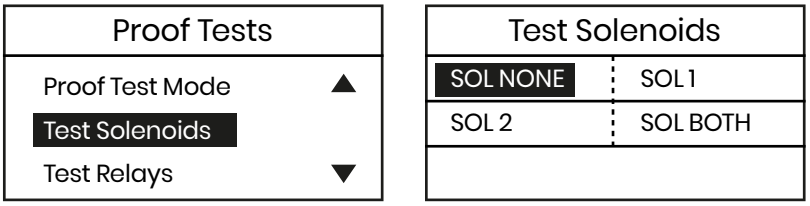
To enable proof tests select “Proof Test Mode” and click enable.



4.11.1 Test Solenoids

The menu provides you the option to test either both solenoids on the unit or test either one at a time. The menu provides four options to test solenoids:

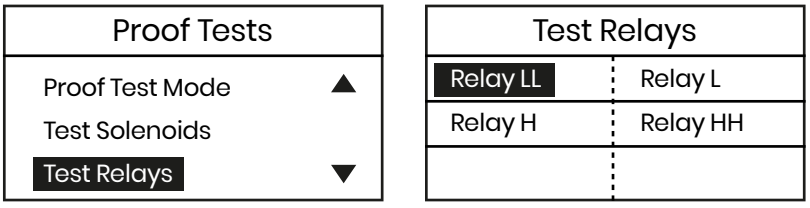
1. SOL_NONE
2. SOL 1
3. SOL 2
4. SOL BOTH



4.11.2 Test Relays

The menu provides you the option to test the relays on the unit. The menu provides four options to test the relays:

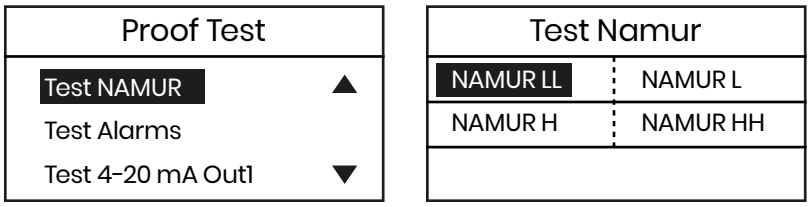
1. Relay LL (Low-Low)
2. Relay L (Low)
3. Relay H (High)
4. Relay HH (High-High)



4.11.3 Test NAMUR

The menu provides you the option to test the NAMUR on the unit. The menu provides four options:

1. NAMUR LL (Low-Low)
2. NAMUR L (Low)
3. NUMAR H (High)
4. NAMUR HH (High-High)

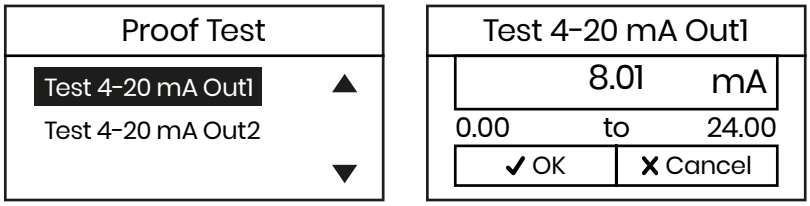


4.11.4 Test Alarms

The menu provides you with an option to test all 15 alarms as mentioned in *Section 4.6*. Simply select the alarm you want to test and click enable.

4.11.5 Test 4-20 mA Out1

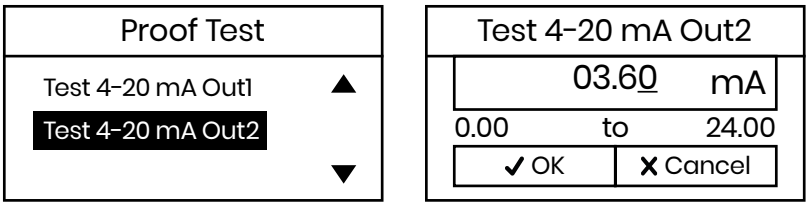
The option lets you test the 4-20 mA output 1 for Channel 1. Enter the mA value you want to test for after selecting the "Test CH1" option from the "Proof Test" menu.



Note: *Achieving the limits of this range, 0 and 24mA (limits of the DAC), requires a perfect circuit with no offsets in place in the device. It is recommended that the user adjust their test points away from these limits closer to the calibrated range which will cater for any offsets.*

4.11.6 Test 4-20 mA Out2

The option lets you test the 4-20 mA output 2 for Channel 1. Enter the mA value you want to test for after selecting the "Test CH1" option from the "Proof Test" menu.



Note: *Achieving the limits of this range, 0 and 24mA (limits of the DAC), requires a perfect circuit with no offsets in place in the device. It is recommended that the user adjust their test points away from these limits closer to the calibrated range which will cater for any offsets.*

Chapter 5. Programming with Modbus

5.1 Introduction

The Modbus communications protocol allows you to read/write data and log/view real-time and diagnostic data in numeric formats.

This chapter has instructions for programming various features of the XMO2pro analyzer using Modbus. In this chapter, we will list all available options. The user can then change the User Preferences and Inputs/Outputs, Programming for measurements to meet their needs.

Note: *Be sure you have properly installed Modbus Client Software on your PC before attempting to program the XMO2pro*

Note: *Only qualified and trained personnel are allowed to change and validate safety parameters. Please refer to the XMO2pro safety manual for details on these parameters. Not all users will have access to all of the menus. Some menus are restricted to only those users with the proper passcode. It is recommended for users to regularly check firmware upgrades and communication from Panametrics.*

5.1.1 Secure Usage Advisory

IMPORTANT: Only qualified and trained personnel are allowed to change and validate safety parameters. Please refer to the XMO2pro safety manual (document #PANA079C71) or details on these parameters. Not all users will have access to all of the menus. Some menus are restricted to only those users with the proper passcode. It is recommended for users to regularly check firmware upgrades and communication from Panametrics.

CAUTION! **XMO2pro should be connected to PC only with a hardwired connection. Connection through internal networks or internet is not recommended.**

IMPORTANT: It is the full responsibility of the end user to observe the cyber security precautions for this product. The authorized user must maintain and safeguard the user level passwords that are required to access program parameters in the instrument via the keypad, PanaView Plus software or Modbus. The user must connect to the instrument via a direct wired connection. Any connection to the Internet is not recommended.

IMPORTANT: It is required that the connected PC is always scanned with an updated anti-virus program.

Note: *Be sure you have properly installed Modbus Client Software on your PC before attempting to program the XMO2pro.*

Note: *XMO2pro devices which have been ordered with no HMI interface will ship pre-configured with RS-232 configuration. They are shipped with a cable which requires driver installation to operate the interface cable. Users should go to the manufacturers website to download the driver for the model of cable or alternatively wire the unit to their own system as instructed in the wiring diagram (See Figure 8).*

5.2 Connecting the PanaView Plus/Modbus

XMO2pro units with a display should have the communication settings programmed (*Section 4.8, "Modbus Parameters"*) to match the parameters selected on PanaView Plus or the Modbus client. Units without a display will have pre-configured settings per below, the Modbus client / PanaView Plus should be set to read these parameters. Custom parameters can be pre-configured, please contact the factory for information.

Table 6: No Display - Modbus Parameter

Parameter	Setting
Modbus Slave Address	10
Baud Rate	115200
Data Bits	8 bits
Parity	no parity
Stop Bits	1 stop bit

5.3 About Menu

The About Menu provides the following information about the device:

1. Device Serial Number
2. Device Part Number
3. Device Firmware Version
4. Device Safety Firmware Version
5. Device Boot Loader Version

You can find the registers corresponding to these in the Modbus Map. These are read-only registers that can only be modified by Service(s).

5.4 Login

The XMO2pro comes configured with 3 profiles (below) and each profile has different levels of Read-Only and Read-Write privileges. For instance, the User profile can only configure some device level parameters like the contrast but cannot configure a “Field Cal” whereas an Admin profile can configure a “Field Cal” but can also adjust the contrast level of the device. The following are the profile options available:

Profile	USER_ID
User	1
Admin	2
SIL User	3

5.4.1 Login as User

To log in as a user via Modbus write to the register USER_ID and set ID as 1. Refer table above. Write the password to the register “PWD_LOGIN”. If validation is successful, you will receive a status “OK” from the Modbus client.

Note: *The default User profile password is “7951”. The customer can initially login in with this password and make use of the change password feature to set an alternate password. Customers are advised to change the default passwords upon initial commissioning. Refer to the local cyber security guidelines.*

5.4.2 Login as Admin

To log in as an admin over Modbus write to the register USER_ID and set it to 2. Refer table above. Write the password to the register "PWD_LOGIN". If validation is successful, you will receive a status "OK" from the Modbus client.

Note: *The default Admin Profile password is "7852". The customer can initially login in with this password and make use of the change password feature to set an alternate password. Customers are advised to change the default passwords upon initial commissioning. Refer to the local cyber security guidelines.*

5.4.3 Login as SIL User (SIL ONLY)

The SIL User profile is a special access that enables proof tests on the unit. The SIL User login works differently than the other two profiles. To log in as an SIL User do the following:

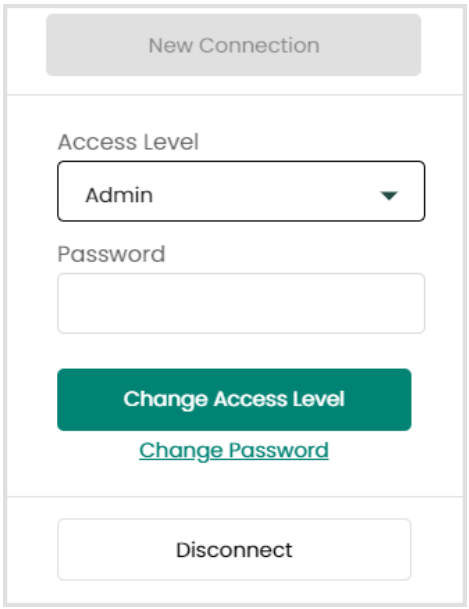
Once, you have the acquired password, write the password to register PWD_LOGIN. If validation is successful, you will receive a status "OK" from the Modbus client. (Refer to *Appendix A, "Modbus Map," on page 65* for register information).

Note: *SIL profile login password for both HMI and Modbus will be available in the calibration certificate.*

5.4.4 Login with PanaView Plus

Follow these steps to for programming with PanaView Plus:

1. Open Panametrics PanaView Plus. Click on [Connect].
2. Select instrument model and communication Port.
3. Click on [CONNECT TO INSTRUMENT].
4. Change [Access Level] to Operator and enter respective [Password]. Click on [Change Access Level].
5. Refer to *Section 5.5, "Change Password"* for passwords for profile login.



5.5 Change Password

To change the password of a certain User profile, ensure you are logged in using the respective profile. Post that, write the new desired password into the register PWD_CHANGE. If the Modbus responds with an OK, the password has been changed successfully.

5.6 Error Handler/Alarms

The “Alarms” menu allows you to configure the way the XMO2pro responds to various error conditions. Refer to the Modbus Map below to access XMO2pro alarms.

To enable/disable an alarm you need to write to the ANALOG_ALARMS_EN register which is a bitmask to enable alarms. Once the alarm is enabled you can set the mA value of the alarm for it to trip.

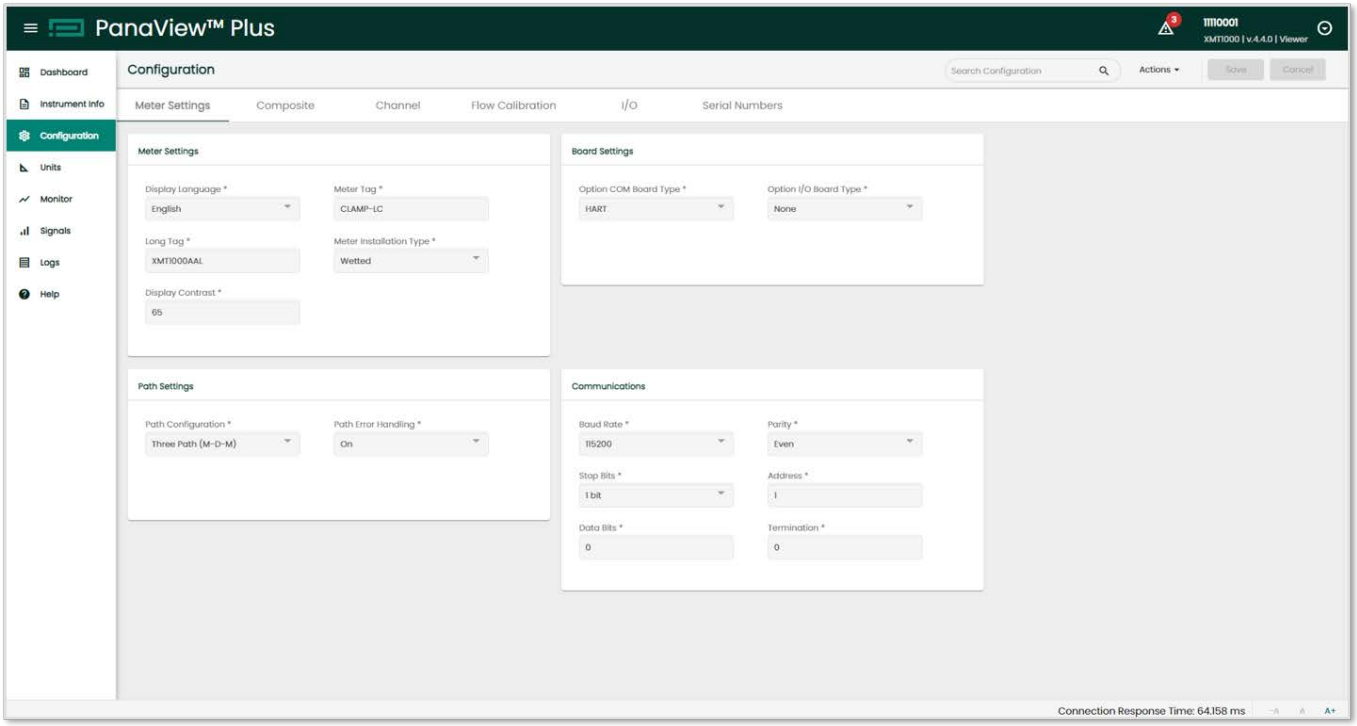
There is a register in the map for each of the following error conditions:

Register	Alarm
ALARM_01_MA	Watch Dog Error
ALARM_02_MA	Heater Error
ALARM_03_MA	ADC Error
ALARM_04_MA	O2 DAC Error
ALARM_05_MA	MCU Error
ALARM_06_MA	Data Error
ALARM_07_MA	Brownout Error
ALARM_08_MA	Temperature Over
ALARM_09_MA	Temperature Under
ALARM_10_MA	Early Warning Over
ALARM_11_MA	Early Warning Under
ALARM_12_MA	Gas Over
ALARM_13_MA	Gas Under
ALARM_14_MA	Calibration Error
ALARM_15_MA	System Error

To program for all the XMO2pro error conditions listed above, write to the register corresponding to the alarm you want to program. Enter the mA output within the range provided in the Modbus Map that you wish to have generated in the event of an error.

5.7 PanaView Plus Error Handler/Alarms

Alarms and trip points can also be configured using PanaView Plus. Use the configuration tab to set upper and lower limits along with enabling/disabling analog and digital alarms.



[no content intended for this page]

Chapter 6. Field Calibration with HMI

6.1 Preparing the XMO2pro for Calibration

1. Connect the zero gas to the zero gas inlet on the sample system or other gas control system to the XMO2pro.
2. Establish a flow rate of 500 cc/min (1.0 SCFH) of zero gas at 0.0 bar(g)/0.0 MPa(g) to the XMO2pro.
3. Allow for the reading to settle. This can take up to 15 minutes.
4. Proceed to *Section 6.2, "Test and Trim"* if 4-20mA channel requires test & trim, if not proceed to *Section 6.3, "Field Cal"*.
5. If conducting 2 point calibration repeat steps 1 to 4 above with Span Gas connected.

Note: *The calibration must be verified by testing zero and span gases. When verifying the analyzer, the expected value should be within the accuracy tolerance of 2% of span. If the calibration cannot be verified, then repeat the calibration.*

IMPORTANT: The calibration system can not verify that the calibration gas is connected to the correct inlet. It is the responsibility of the end user to verify the gas in connected to the correct inlet.

IMPORTANT: Field calibration should only be performed by trained / competent persons, for SIL applications refer to product Safety Manual.

6.2 Test and Trim

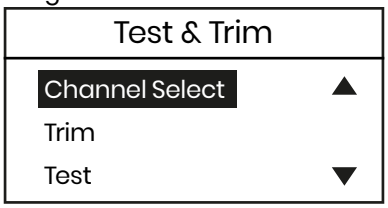
The 4-20 mA output command enables you to recalibrate the output that the XMO2pro sends to an external device such as a recorder or digital multimeter. Selecting the Test and Trim menu will provide you with the following options:

The Trim function calibrates the 4-20 mA output signals by defining the zero and span points to preferred values. The Test function enables validation of the configuration by driving arbitrary values to the 4-20 output and applying the updated Trim configuration before saving it.

Channel 1 is the primary output, this is factory configured to the calibrated range. Channel 2 is a secondary output which can be used to output a specific region of the calibrated range. This is configurable through the test and trim function.

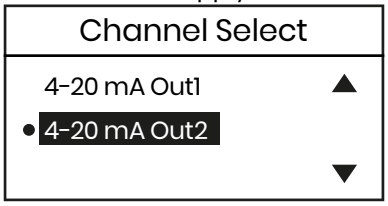
To execute a Trim, select the “Test and Trim” option under the “Cal” menu. It will show you the following options:

1. Channel Select – Determines which channel the Trim will be applied to.
2. Trim – Initiates the Trim function workflow.
3. Test – Assigns the value for testing the Trim setup.
4. Discard Trim – Discards the current Trim configuration.
5. Save Trim – Persists the current Trim configuration.



6.2.1 Channel Select

Customer can switch between Channel 1 or Channel 2 to apply the Trim configuration.

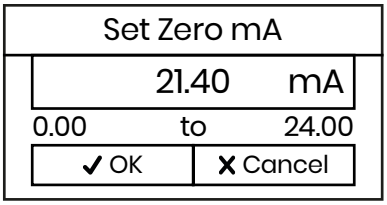


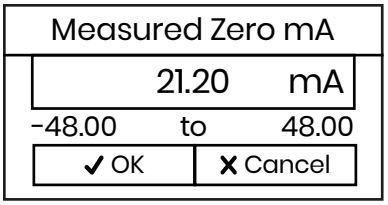
6.2.2 Trim

Initiates the Trim workflow by requesting numerical inputs in the designated sequence for the following parameters:

1. Set Zero mA – Desired Zero Point.
2. Set Measured Zero mA – Measured Zero Point.
3. Set Span mA – Desired Span Point.
4. Set Measured Span mA - Measured Span Point.

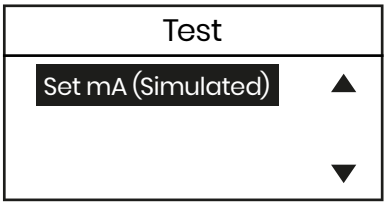
After completing the workflow above, you will be redirected to the “Test” menu.

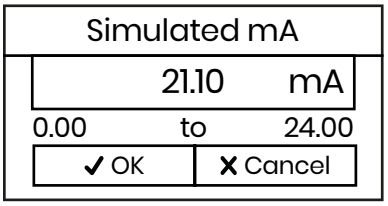




6.2.3 Test

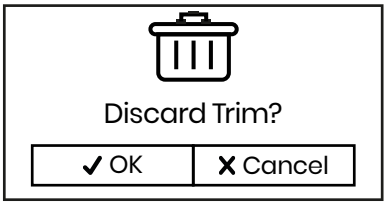
Enabling test mode, actives the newly configured trim setting temporarily. It will prompt you to the enter a mA value which will be trimmed according to the new trim setting. You can verify the operation of the new trim value using a multimeter or recorder in Test Mode. If the signal is not satisfactory, you can delete the configuration using discard trim or save it, if it is satisfactory.

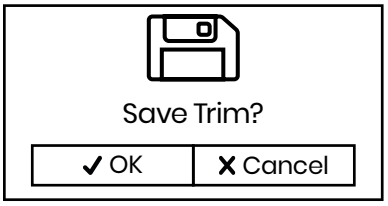




6.2.4 Discard Trim and Save Trim

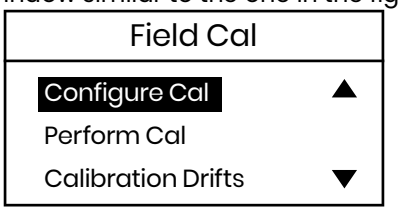
Discards/Saves the current Trim configuration.





6.3 Field Cal

When you select the “Field Cal” option, a window similar to the one in the figure below opens:



The “Field Cal” options offers the following 7 choices:

1. Configure Cal - Sets the calibration type and parameter.
2. Perform Cal – Calibrates the XMO2pro.
3. Calibration Drifts – Lists drift percentages for zero and span gases.
4. Hold Last Value - Holds 4-20 mA output to a fixed value (STN Model)
5. Abort Cal - Aborts the field calibration process.
6. Clear Cal - Clears the last calibration.
7. Save Cal - Saves current calibration to flash memory.

Note: *Clicking on the Next Item/Enter button selects the option listed on the status line above the option buttons (Perform Cal in figure above). The option listed on the status line in any window is the option that was chosen the last time that menu was used.*

Clicking on any of the “Field Cal” choices opens a new window that allows you to perform that function. Proceed to the appropriate section for a detailed description of each option.

6.3.1 Configure Cal

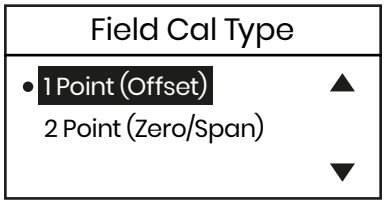
The “Configure Cal” option enables you to change the field calibration type and various calibration parameters. Clicking on the “Configure Cal” button opens a window like that shown in figure below:

Click on the desired option button and proceed to the appropriate section for a discussion of that option.

The field calibration feature allows you to calibrate the XMO2pro using either a 1-point or 2-point calibration method. The selected calibration determines the steps required and the gases used.

6.3.1.1 Field Cal Type

A typical “Field Cal Type” window is shown in figure below:



IMPORTANT: The factory setting is the 2-point (Zero/Span) calibration type.

Click on the appropriate button to select the desired calibration type. Then, click on any button on the right to return to the “Configure Cal” window.

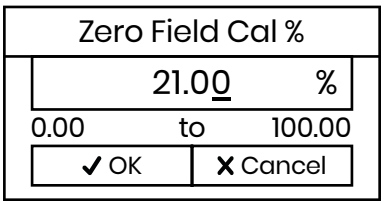
6.3.1.2 Field Cal Percent

There are two field percent options available under the “Config Cal” menu:

1. Zero Field Cal
2. Span Field Cal

The above options are used to specify the oxygen percentages of the zero and span calibration gases that will be used (values should match the gas cylinder). The recommended gases are listed on the XMO2pro calibration

datasheet. Click on the “Zero Field Cal” button to enter the percentage of oxygen in your zero gas. A window similar to the figure below opens.



Type the zero-gas oxygen percentage in the text box, and click the Enter button to confirm the entry (click the Previous Item or Exit Page button to leave the window without changing the existing percentage)

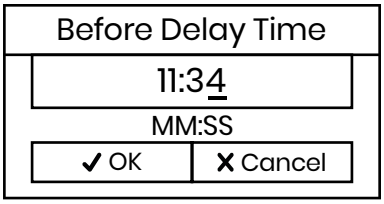
IMPORTANT: The factory setting is for a 0.00% zero gas and a 20.93% span gas (air).

Repeat the above procedure to enter your span calibration gas oxygen percentage. Then, click on any button on the right to return to the “Configure Cal” window.

6.3.1.3 Before Delay Time

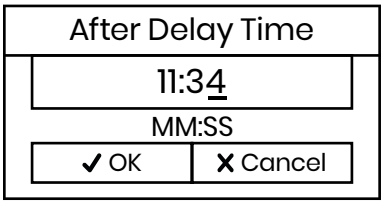
Clicking on the “Before Delay Time” button opens a window similar to the figure below. Entering a before delay time will set it for both zero and span calibration points.

Enter the desired zero/span point before delay time, in minutes and seconds, in the text box. Then, click on the Next Item/ Enter button to confirm the entry (click the Previous Item or Exit Page button to exit the window without changing the existing value).



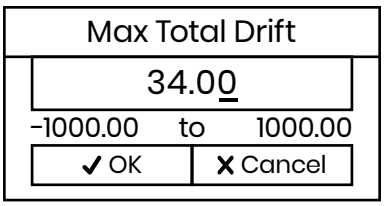
6.3.1.4 After Delay Time

Repeat the procedure in the above section to set the after-delay time for both the zero and span points.



6.3.1.5 Max Total Drift

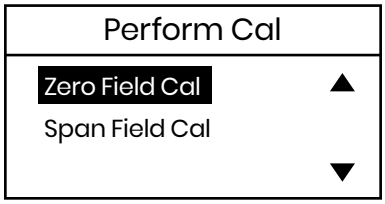
“Max Total Drift” is the maximum total calibration drift allowable, expressed as a percentage of the full-scale reading. Selecting this option opens a window similar to the figure below:



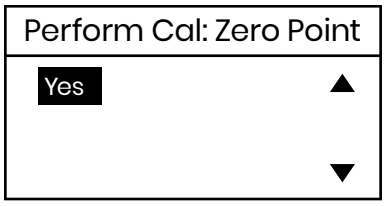
Enter the desired percentage of the full-scale reading in the text box, and click the Next Item/Enter button to confirm the entry (click the Previous Item or Exit Page button to leave the window without changing the existing percentage).

6.3.2 Perform Cal

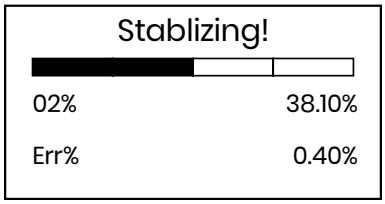
Clicking on the “Perform Cal” button opens a window similar to figure below. Click on the appropriate button to select the desired calibration type.



In case of a 2-point calibration, first connect your zero gas to the XMO2pro. Now click on the “Zero Field Cal” button. A window like the figure below opens.



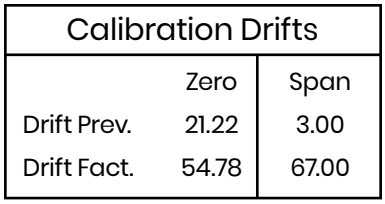
Click “Yes” to perform the calibration, or “Abort Field Cal” to stop the calibration and return to the previous menu. Once you click “Yes,” the system will enter a stabilization phase. During this period, the analyzer monitors the gas readings until they stabilize, which may take up to 10 minutes. This stabilization time is critical to ensure accurate calibration results. While the gas is stabilizing, you'll see a screen similar to the one below, which displays a progress indicator and current readings:



After the zero-point calibration is complete, the system will prompt you to start the span calibration manually. Before proceeding, ensure the span gas is properly connected to the XMO2pro. When you initiate span calibration, the system will monitor readings for approximately 10 minutes until stabilization. Once complete, a confirmation screen indicates your calibration process has finished successfully.

6.3.3 Calibration Drifts

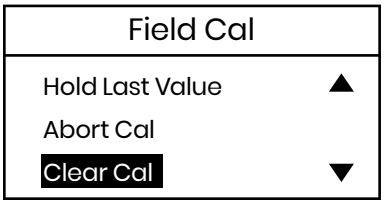
The “Calibration Drifts” option enables you to view the current calibration drift at both the zero and span points when the last calibration was performed. It will also show the drift at the time of factory calibration. Clicking on this button opens a window similar to the figure below.



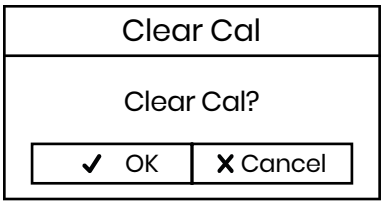
Click on any button to return to the main “Field Cal” window.

6.3.4 Clear Calibration

The window for the “Clear Calibration” option is similar to figure below.

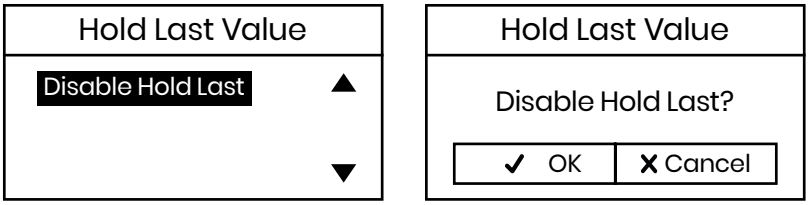


Click on the “Yes” button to clear the most recent calibration, or click on the “No”, “Previous Item” or “Exit Page” button to close the window without clearing the most recent calibration. If you click on the Yes button, a confirmation screen similar to the figure below opens.



6.3.5 Hold Last Value (SIL Model)

In addition to performing a field calibration or configuring the calibration parameters, you can program the XMO2pro to hold the last calibrated value. To perform this task, click on the “Hold Last Value” button. You will notice that the text on the button now reads “Disable Hold Last”. To cancel the Hold Last Value programming, just click on this new button. You can toggle between the two states for this parameter by clicking on this button (remember that the current state is the one NOT written on the button).



6.3.6 Hold Last Value (STN Model)

On STN models, this function enables the user to select either a predefined value or configure a custom hold value. It applies to Channel 1 and/or Channel 2 and affects the 4-20mA outputs during field calibration.

This feature can be accessed through the Cal menu, Field Cal screen. In this screen there is an option to Hold Last Value. In this screen the user can Enable or Disable, if enable is selected the user is prompted to confirm a mA value, either one suggested by the device or enter a custom value (See *Figure 17*). Note even if the user exits out of this screen hold last value takes effect, disabling while logged in during a filed calibration does not enable the output. If the user does not set a custom value, the default value set by the device is 12mA. To disable the user must disable and logout of the device.

Once field calibration is complete, the user must Disable and Logout for the output to return to measurement output. Note If power is maintained, the device will retain custom mA values for subsequent field calibrations, however if the unit is disconnected from power or power is lost, the device will revert to 12mA default.

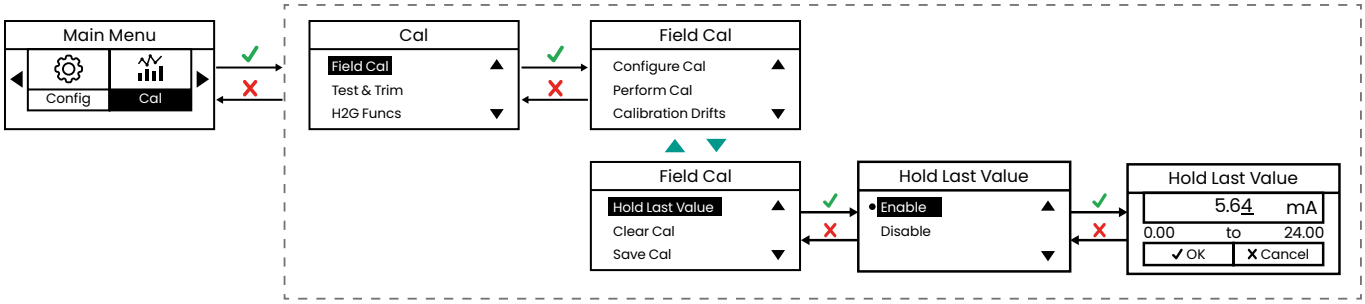
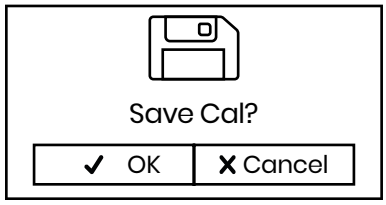


Figure 17: Hold Last Value Configuration

6.3.7 Save Calibration

The window for the “Save Calibration” option is similar to the figure below



Clicking OK, will save the current calibration and persist to flash memory. If the save operation is successful, you will see a notification screen as the figure below.

Else, if the operation fails, you would see a screen as the figure below.

Chapter 7. Calibration

7.1 Calibration with Modbus

7.1.1 Test and Trim

The Trim procedure can be configured over Modbus as follows:

1. TRIM_CH – Channel Select (Ch 1 or Ch 2) to apply the Trim configuration.
2. TRIM_MA – Enter the desired mA value.
3. TRIM_MEASURED – Enter the measured mA value.
4. TRIM_SAVE –
   a. Write 0 to discard Trim.
   b. Write 1 to persist Trim.
   c. Write 4 to save the Trim point for 4 mA.
   d. Write 20 to save the Trim point for 20 mA.
   e. Write 12 to activate Verify Mode.

The workflow will be as follows:

1. Select the desired Channel by writing to TRIM_CH.
2. Enter the desired 4 mA point in TRIM_MA.
3. Enter the measured mA for the 4-mA point in TRIM_MEASURED
4. Save the 4-mA point by writing 4 to TRIM_SAVE.
5. Enter the desired 20 mA point in TRIM_MA.
6. Enter the measured mA for the 20-mA point in TRIM_MEASURED.
7. Save the 20-mA point by writing 20 to TRIM_SAVE.
8. Enter verify mode by writing 12 to TRIM_SAVE.
9. Now, test the new Trim configuration by writing test values in TRIM_MA and validate them.
10. If you are satisfied with the Trim configuration enter 1 to TRIM_SAVE.
11. To discard it, write 0 to TRIM_SAVE.

7.1.2 Field Calibration

This section explains how to perform a field calibration of your unit over the Modbus interface.

First configure the calibration,

1. **Select Calibration Type:**

   Write to the register CAL_CONFIG to select either:

   a. 1-point calibration, Write 1 to CAL_CONFIG
   b. 2-point calibration, Write 2 to CAL_CONFIG

2. **Configure Solenoids Valves:**

   Write to the CAL_SOLENOIDS register to select the appropriate solenoid valve(s). Refer to *Appendix A. "Modbus Map"* for details on the registers and table below for the values to write to each register in order to activate / deactivate solenoids.

Operation	CAL_SOLENOIDS register value	SOL1	SOL2
Normal	0	0	0
Calibrate Zero	1	1	0
Normal	2	0	1
Calibrate Span	3	1	1

Note: *Solenoids refers to solenoid valves which are either user supplied or supplied as part of a sample system. These solenoid valves can be activated manually through Modbus to energize / de-energize to supply zero and span gases to the apparatus during a field calibration. This option is not currently available through the display.*

3. Define Gas Concentrations:

a. Write to CAL_ZERO to specify the oxygen percentage in the zero gas.

b. Write to CAL_SPAN to specify the oxygen percentage in the span gas.

Note: *In case you have selected a 1-point calibration, you do not need to specify the span gas reference percentage. In case of a 2-point calibration, both values (CAL_ZERO and CAL_SPAN) are essential.*

4. Perform the Calibration

In case of a 2-point calibration:

a. Connect your zero gas and wait for 10 minutes for the gas to stabilize.

b. Once, stabilized write to the register CAL_SAVE the value 1 to record the zero-point reference.

c. Now, connect the span gas. Wait for 10 minutes for it to stabilize.

d. Once, stabilized, write to the register CAL_SAVE the value 2 to record the span gas reference point.

e. Once both points are recorded successfully, write to the register value of 3 to enter verification mode.

f. Verification mode will temporarily load on the calibration to the unit for verification purposes. If verification is successful, you can save the calibration by writing the value 4 to the register CAL_SAVE.

g. Once verification mode is active, you should attach different gas mixes to verify it. If satisfied, write the value 4 to the register CAL_SAVE to persist the new calibration.

In case of a 1-point calibration:

a. Connect your zero gas and wait for 10 minutes for the gas to stabilize.

b. Once, stabilized write to the register CAL_SAVE the value 1 to record the zero-point reference.

c. Once the zero point is recorded successfully, write to the register value of 3 to enter verification mode.

d. Verification mode will temporarily load on the calibration to the unit for verification purposes. If verification is successful, you can save the calibration by writing the value 4 to the register CAL_SAVE.

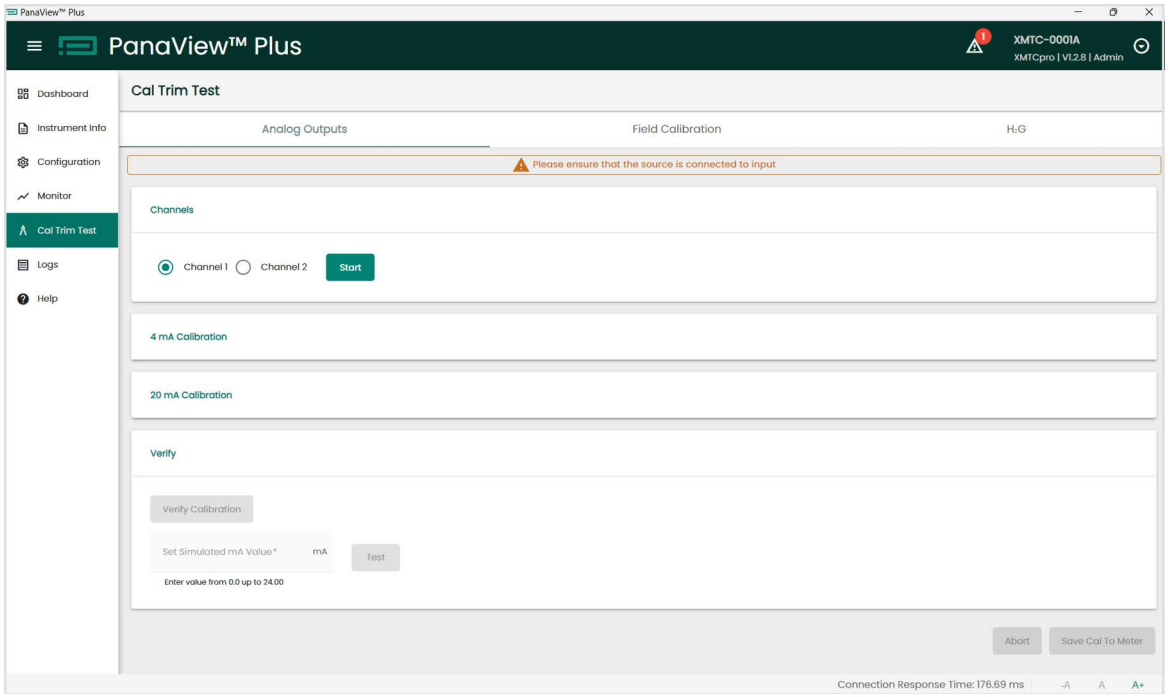
e. Once verification mode is active, you should attach different gas mixes to verify it. If satisfied, write the value 4 to the register CAL_SAVE to persist the new calibration.

7.2 Calibration with PanaView Plus

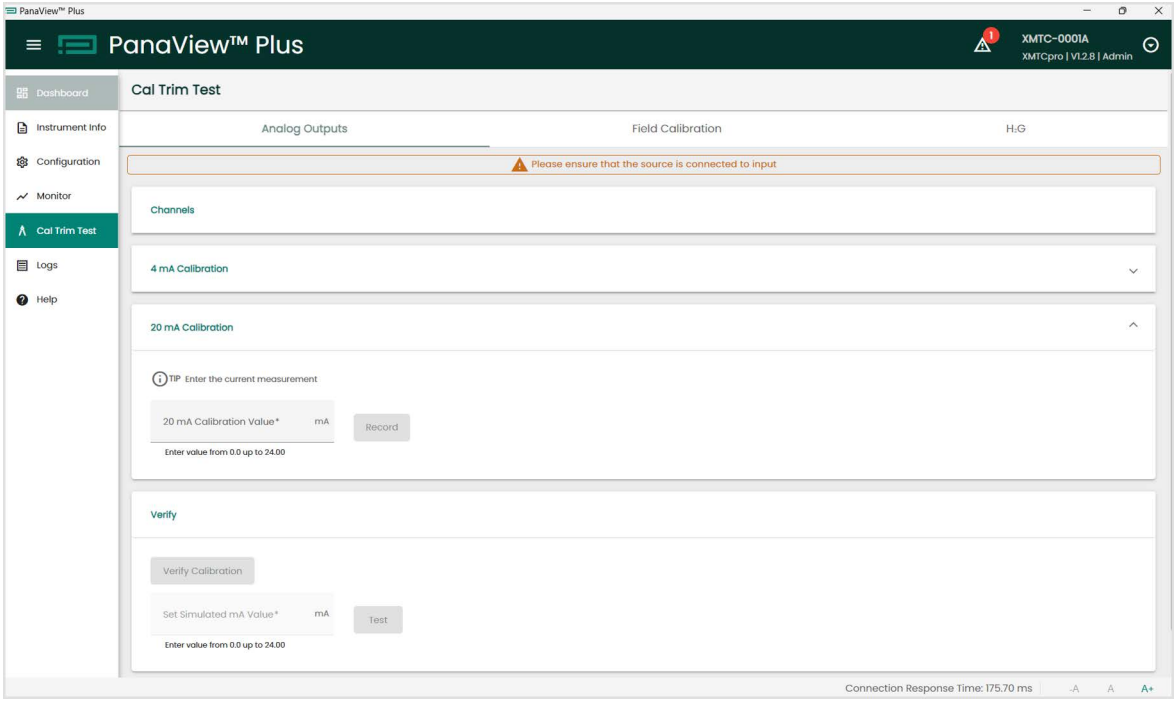
7.2.1 Test and Trim

The Trim procedure can be configured over PanaView Plus as follows:

1. Open “Cal Trim Test” window, in Analog Outputs calibration tab, select Channel to trim
2. Click on 4 mA Calibration and enter the measured value, click “Record”
3. Click on 20 mA Calibration and enter the measured value, click “Record”



4. Click on Verify and enter a value to test, click “Test”. Verify that the measured value is same as entered value.
5. Click “Save Cal To Meter”



7.2.2 Field Calibration

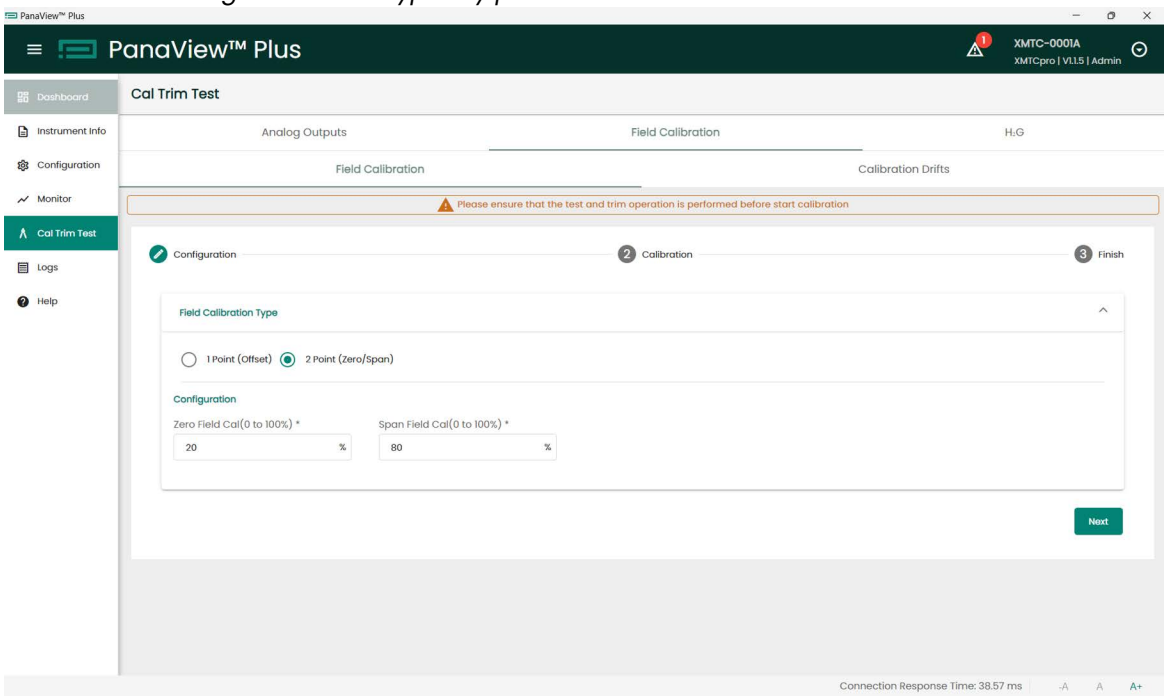
The “Field Cal” for the unit can be done using PanaView Plus as follows.

1. Continue the workflow after performing “Cal Trim Test”.
2. Choose calibration type (1 point/zero cal or 2 point/zero-span cal).

Note: *A 1 point cal creates an offset to the entire calibration based on 1 point, a 2 point calibration adjusts the calibration bases on a zero and span value.*

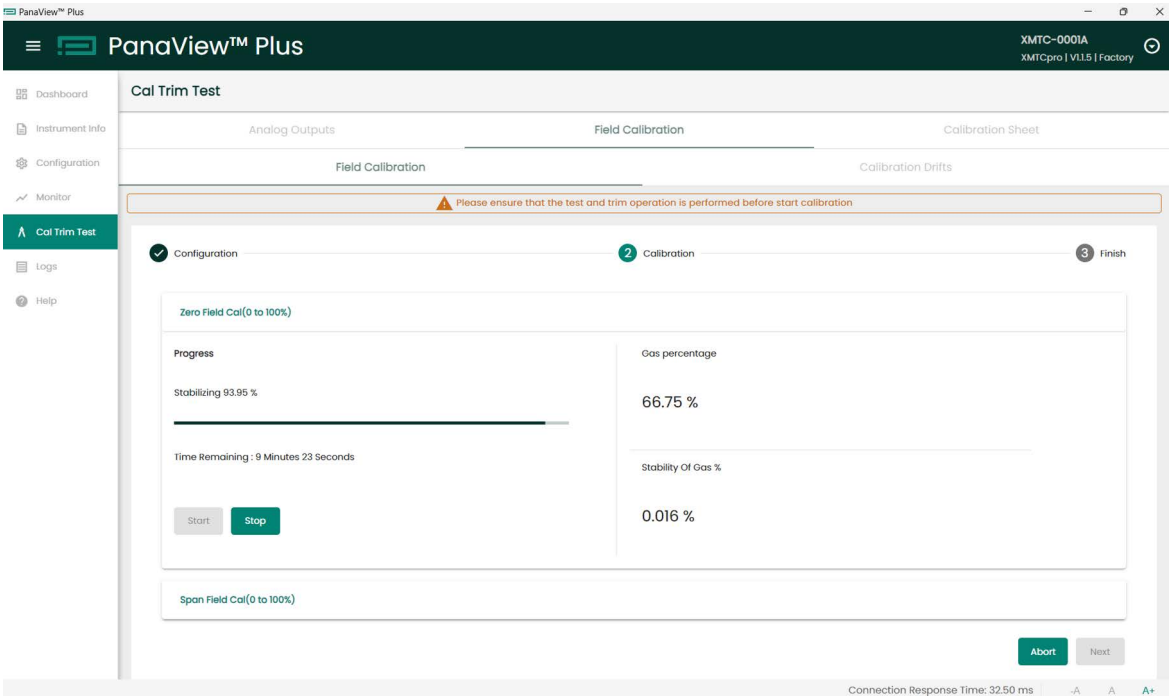
3. Enter the value expected Zero gas%. For a 2 point calibration enter the % of the span gas.

Note: *The recommended gas% value is typically provided in the calibration data sheet.*



4. Press “Next” for calibration, adjust the gas composition to achieve the zero point and Start the calibration. PanaView Plus will wait for 10 minutes so that the gas mixture can settle down.

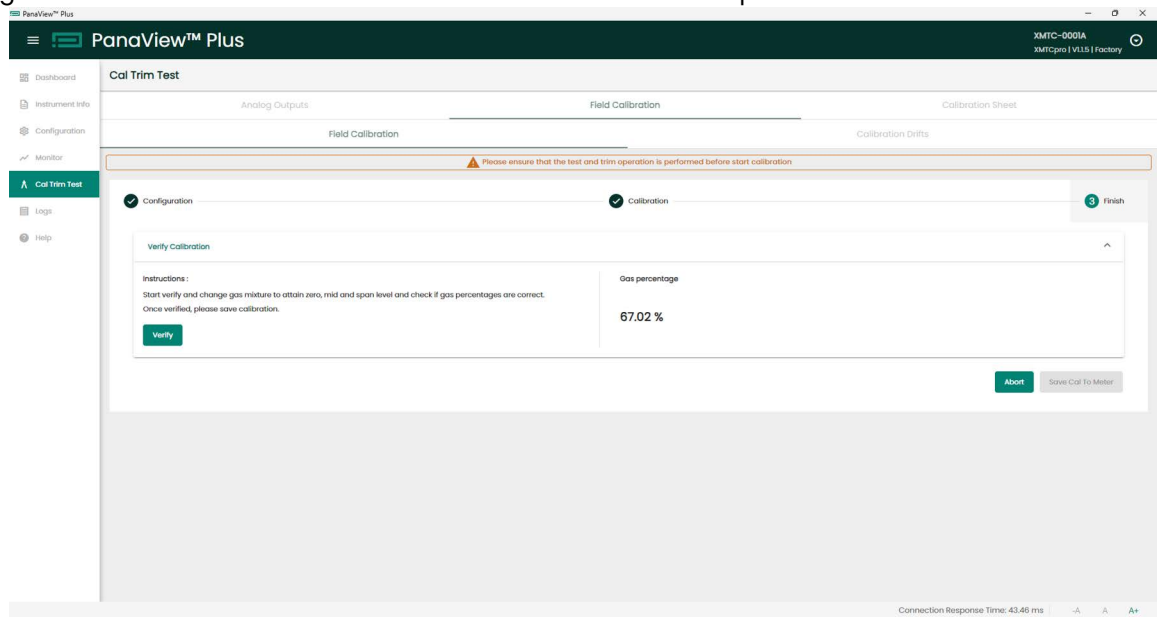
5. Once the wait time is over, PanaView Plus will calibrate the zero-calibration point. With the Zero gas flowing click "Start" to begin the Zero Field Calibration point. A progress bar will appear. Once this has reached 100% the gas has stabilized.



6. If performing a 2-point calibration, repeat step 5—this time by flowing the "Span" gas and waiting for the reading to stabilize. Once complete, click "Save."

Note: *The calibration can be verified by flowing the Zero or Span gas and verifying the read correctly on the device.*

7. Press "Next" for verifying the newly calibrated range of the device.
8. Press "Verify" to start the verification process. Change the gas mixture to attain zero, mid and span level and check if gas percentages are correct. Once verified, please Save Calibration.
9. During the field calibration "Abort" will cancel the whole calibration process.



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Chapter 8. Specifications

8.1 Functional

Functional Safety	IEC61508 SIL 2 (optional)
Analog Output	Two 4 to 20 mA isolated, 550Ω maximum load, field-programmable
Digital I/O	Display version - RS232/RS485, 3-conductor No display version - RS485, 3-conductor (consult factory for RS232 configuration before ordering)
Power	2.0 A at 24.0 VDC ±4 VDC
Power Requirement (Typical)	1.6-2.0 A during warm-up, dropping to 300-400 mA in stable operation with no alarms tripped, subject to ambient conditions and process gases
Storage Temperature	-20°C to +65°C (-4°F to 149°F)
Ambient Operating Temperature	Standard: -20°C to +40°C (-4°F to +104°F) High: -5 to 55°C (23 to 131°F)
Sample Gas Pressure Range	Max 2 barg (29 psig)
Sample Gas Flow Range	Max 1.25 L/min (2.65 SCFH)
Keypad	Magnetic, through the glass, keypad
Display	Backlit liquid crystal display
Relay outputs	• Contact ratings: 2 A, 28 VDC • SPDT, Non-latching, fail-safe

8.2 Performance

Accuracy	±1% of span ±2% of span for 0 to 1% range ±0.2% O_2 range for 90 to 100% and 80 to 100%
Linearity	±0.5% of span
Repeatability	±0.2% of span
Measurement Resolution	0.01 mA
Zero Stability	±1.0% of span per month (±2% of 0-1% O_2 range)
Span Stability	±0.4% of span per month (±0.8% for 0-1% O_2 range)
Response Time, 90% Step Change	Fast 15 seconds EN50104 45 seconds Standard 70 seconds
Measurement Ranges (typical)	0-1% 0-2% 0-5% 0-10% 0-21% 0-25% 0-50%* 0-100%* 80-100%* 90-100%* *Pressure compensation required Consult factory for other optional ranges
Atmospheric Pressure Effect	Standard: ±0.2% of span per mm of Hg Optional: Pressure compensation
Required Sample Gas Flow Rate	Range: 0.1 to 2.0 SCFH (50 to 1,000 cc/min) Nominal: 1.0 SCFH (500 cc/min) nominal
Sample Gas Flow Rate Effect	<1% of span, with weatherproof apparatus with background gas compensation, and 0.1-2.0 SCFH (50-1,000 cc/min) flow rate
Warmup Time	30 minutes

8.3 Physical

Sensor Wetted Materials	Standard: 316 SS process-wetted fittings, glass, and Viton™ internal O-ring seals Optional: Hastelloy processed-wetted fittings or Chemraz™ internal O-ring seals
Dimensions	Weatherproof unit: (H x D x W) 228 x 178 x 142 mm (9 x 7 x 6 in.) Explosion-proof unit: (H x D x W) 252 x 178 x 142 mm (10 x 7 x 6 in.)
Weight	Aluminum version: 4.5 kg (9.9 lb) Stainless Steel version: 11.0 kg (24.2 lb)
Connections	Electrical: 4 x ¾ in. NPTF conduit entries Process: 2 x 1/4 in. NPTF inlet and outlet

Environmental

Ingress Protection / Weatherproof rating

- IP66
- NEMA Type 4X

Hazardous Area classification

IECEx, ATEX

- Ex db IIC T6 Gb
  Ex tb IIIC T78°C Db
  -20°C to +55°C

NEC/CEC

- XP Class I Division 1 Groups ABCD T6
  -20°C to +55°C
- DIP Class II Division 1 Groups EFG, Class III T6
  -20°C to +55°C
- Class I Zone 1 AEx/Ex db IIC T6 Gb
  -20°C to +55°C
- Class I Zone 21 AEx/Ex tb IIIC T78°C Db
  -20°C to +55°C
- NI Division 2 Class I, II, III Division 2 Groups ABCDEFG T6
  -20°C to +55°C
- NI Division 2 Class I, II, III Division 2 Groups ABCDEFG T6
  -20°C to +55°C

Ordinary locations, NEC/CEC

- UL 61010-1
  -20°C to +55°C

European Union Compliance

- EMC Directive 2014/30/EU
  Group 1, Class A, Industrial Electromagnetic Environments
  (IEC EN 61326-1 / CISPR 11)
- ATEX 2014/34/EU
  II 2 G & II 2D

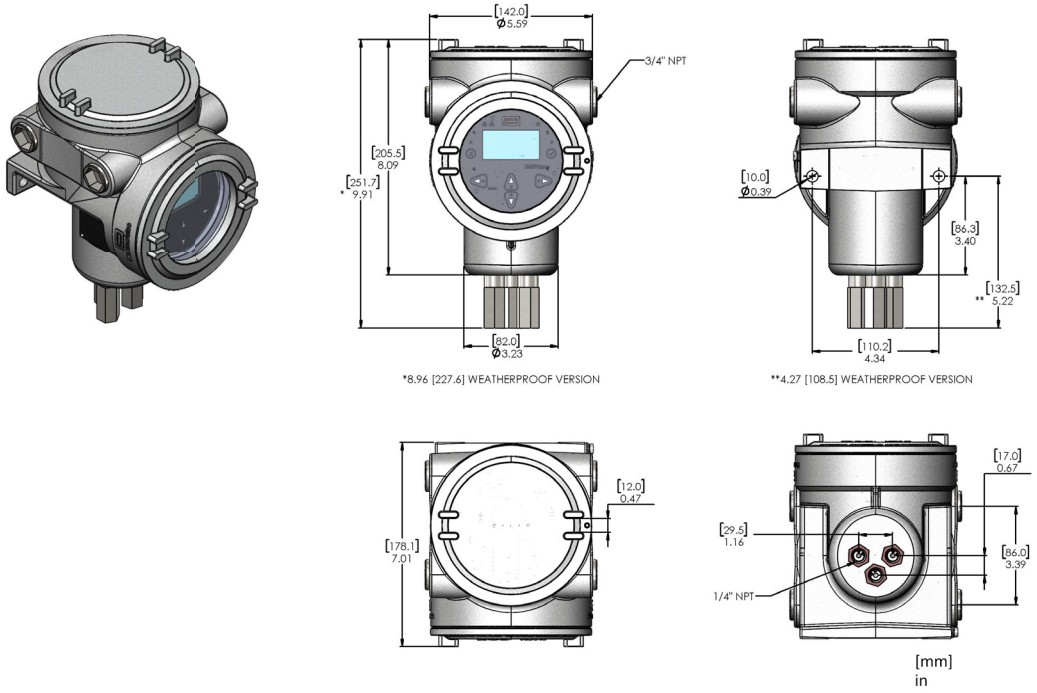


Figure 18: Aluminum Version Dimensions

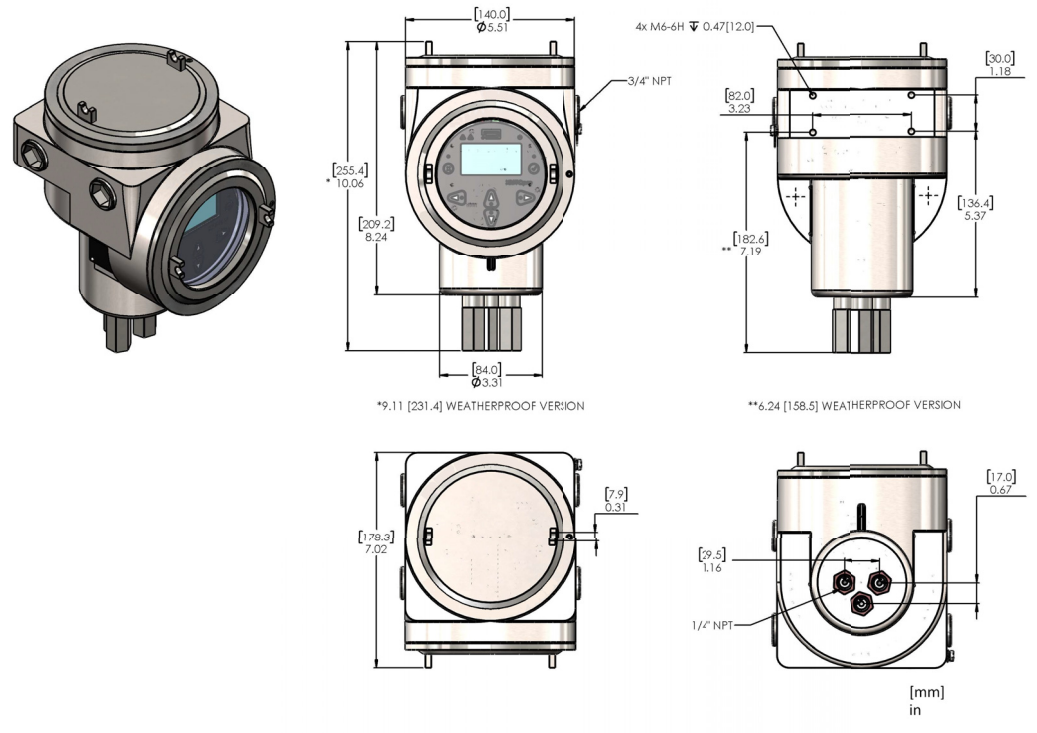


Figure 19: Stainless Steel Version Dimensions

[no content intended for this page]

Chapter 9. Decommissioning

Upon completion of service, the analyzer shall be decommissioned (removed from service) by an authorized user.

9.1 Objective

Before decommissioning any safety system from active service, be sure a proper review is conducted and obtain any required authorization. Also, maintain appropriate safety functions during decommissioning activities.

Management of change procedures shall be implemented for all decommissioning activities.

9.2 Hazard and Risk Analysis to be Performed by the Customer

The impact of decommissioning on adjacent operating units and facilities or other field services shall be evaluated prior to decommissioning.

9.3 Disposal

Disposal shall comply with the Waste Electrical and Electronic Equipment Directive (WEEE Directive) at the following link: http://ec.europa.eu/environment/waste/weee/index_en.htm

Please contact our Customer Service using the following link https://panametrics.com/support or use the QR code present on the back cover to report a decommissioned product.

[no content intended for this page]

Appendix A. Modbus Map

ADDRESS	NAME	TYPE	ACCESS	COMMENT
40000(DEC) 9C40(HEX)	RUNNING_TIME	U32	RO (Admin) RO (User)	Seconds since power on / reset
40002(DEC) 9C42(HEX)	MODBUS_ID	U16	RW (Admin) RW (User)	Modbus device identifier
40003(DEC) 9C43(HEX)	STATUS	U16	RO (Admin) RO (User)	3 digit codes
40004(DEC) 9C44(HEX)	PRODUCT	U16	RO (Admin) RO (User)	Identifies the product model
40005(DEC) 9C45(HEX)	ALARM_STATES	U16	RO (Admin) RO (User)	Flags which indicate alarm is active
40006(DEC) 9C46(HEX)	UNITS	U16	RW (Admin) RW (User)	Unit systems
40007(DEC) 9C47(HEX)	CH1_GAS_PC	F32	RO (Admin) RO (User)	Primary gas %
40009(DEC) 9C49(HEX)	CH2_GAS_PC	F32	RO (Admin) RO (User)	User customized gas %
40011(DEC) 9C4B(HEX)	BK_GAS_PC	F32	RO (Admin) RO (User)	Background binary gas mixture %
40013(DEC) 9C4D(HEX)	GAS_PC_STABILITY	F32	RO (Admin) RO (User)	Stability of the gas % reading
40015(DEC) 9C4F(HEX)	CELL_TEMP_SETPOINT	F32	RO (Admin) RO (User)	Target cell temperature
40017(DEC) 9C51(HEX)	CELL_TEMP	F32	RO (Admin) RO (User)	Cell temp reading
40019(DEC) 9C53(HEX)	CELL_TEMP_STABILITY	F32	RO (Admin) RO (User)	Stability of the cell temperature
40021(DEC) 9C55(HEX)	AMBIENT_TEMP	F32	RO (Admin) RO (User)	Ambient temp reading
40023(DEC) 9C57(HEX)	AMBIENT_PRESS	F32	RO (Admin) RO (User)	Atmospheric pressure
40025(DEC) 9C59(HEX)	PROCESS_PRESS	F32	RO (Admin) RO (User)	Process pressure
40027(DEC) 9C5B(HEX)	CELL_O2MV	F32	RO (Admin) RO (User)	Bridge voltage
40029(DEC) 9C5D(HEX)	CELL_BKMV	F32	RO (Admin) RO (User)	Bridge voltage
40031(DEC) 9C5F(HEX)	CELL_PRMV	F32	RO (Admin) RO (User)	Pressure voltage
40033(DEC) 9C61(HEX)	CELL_PWRMV	F32	RO (Admin) RO (User)	Power supply
40035(DEC) 9C63(HEX)	CELL_TEMPMV	F32	RO (Admin) RO (User)	Cell temp sensor
40037(DEC) 9C65(HEX)	AMBIENT_TEMPMV	F32	RO (Admin) RO (User)	Ambient temp sensor
40039(DEC) 9C67(HEX)	POWER_VDC	F32	RW (Admin) RO (User)	20-28VDC Power supply (24VDC Nominal)
40041(DEC) 9C69(HEX)	DATE_YY	U16	RW (Admin) RO (User)	Year

ADDRESS	NAME	TYPE	ACCESS	COMMENT
40042(DEC) 9C6A(HEX)	DATE_MM	U16	RW (Admin) RO (User)	Month
40043(DEC) 9C6B(HEX)	DATE_DD	U16	RW (Admin) RO (User)	Day of month
40044(DEC) 9C6C(HEX)	DATE_WK	U16	RW (Admin) RO (User)	Weekday
40045(DEC) 9C6D(HEX)	TIME_HH	U16	RW (Admin) RO (User)	Hours
40046(DEC) 9C6E(HEX)	TIME_MM	U16	RW (Admin) RO (User)	Minutes
40047(DEC) 9C6F(HEX)	TIME_SS	U16	RW (Admin) RO (User)	Seconds
40048(DEC) 9C70(HEX)	CH1_RANGE_ZERO	F32	RO (Admin) RO (User)	Primary Channel gas % lower limit
40050(DEC) 9C72(HEX)	CH1_RANGE_SPAN	F32	RO (Admin) RO (User)	Primary Channel gas % upper limit
40052(DEC) 9C74(HEX)	CH2_RANGE_ZERO	F32	RW (Admin) RO (User)	Secondary Channel gas % lower limit
40054(DEC) 9C76(HEX)	CH2_RANGE_SPAN	F32	RW (Admin) RO (User)	Secondary Channel gas % upper limit
40056(DEC) 9C78(HEX)	TRIM_CH	U16	RW (Admin) RO (User)	Set channel for test and trim
40057(DEC) 9C79(HEX)	TRIM_MA	F32	RW (Admin) RO (User)	Set mA output to a known value
40059(DEC) 9C7B(HEX)	TRIM_MEASURED	F32	RW (Admin) RO (User)	Enter the value measured with a multi-meter
40061(DEC) 9C7D(HEX)	TRIM_SAVE	U16	RW (Admin) RO (User)	Discard/Record/Persist test trim readings
40062(DEC) 9C7E(HEX)	CAL_CONFIG	U16	RW (Admin) RO (User)	Select a calibration type
40063(DEC) 9C7F(HEX)	CAL_SOLENOIDS	U16	RW (Admin) RO (User)	Remote operation of the calibration relays
40064(DEC) 9C80(HEX)	CAL_ZERO	F32	RW (Admin) RO (User)	Enter % from zero calibration gas
40066(DEC) 9C82(HEX)	CAL_SPAN	F32	RW (Admin) RO (User)	Enter % from span calibration gas
40068(DEC) 9C84(HEX)	CAL_SAVE	U16	RW (Admin) RO (User)	Save Field Cal data
40069(DEC) 9C85(HEX)	DRIFT_INDEX	U16	RW (Admin) RO (User)	Index into drift history
40070(DEC) 9C86(HEX)	DRIFT_TIMESTAMP	U32	RO (Admin) RO (User)	Time at which drift data was captured
40072(DEC) 9C88(HEX)	DRIFT_ZERO	F32	RO (Admin) RO (User)	Total drift from factory at zero point
40074(DEC) 9C8A(HEX)	DRIFT_SPAN	F32	RO (Admin) RO (User)	Total drift from factory at span point
40089(DEC) 9C99(HEX)	GAS_CONFIG	U16	RO (User) RO (Admin)	Configure gas
40090(DEC) 9C99(HEX)	GAS_IDX_BK	U16	RO (User) RO (Admin)	Gas background mixture index

ADDRESS	NAME	TYPE	ACCESS	COMMENT
40092(DEC) 9C9C(HEX)	GAS_IDX_PT	U16	RO (User) RO (Admin)	Gas point on curve
40093(DEC) 9C9D(HEX)	GAS_O2_PC	F32	RO (User) RO (Admin)	Specifies the signal gas%
40097(DEC) 9CA1(HEX)	GAS_O2_MV	F32	RO (User) RO (Admin)	-
40099 (DEC) 9CA3 (HEX)	GAS_BK_MV	F32	RO (User) RO (Admin)	-
40103 (DEC) 9CA7 (HEX)	GAS_TEMP_MV	F32	RO (User) RO (Admin)	-
40105(DEC) 9CA9(HEX)	DIGITAL_ALARMS_EN	U16	RW (Admin) RO (User)	Bitmask to enable digital alarms
40106(DEC) 9CAA(HEX)	ANALOG_ALARMS_EN	U16	RW (Admin) RO (User)	Bitmask to enable analog alarms
40107(DEC) 9CAB(HEX)	ALARM_LOW_PC	F32	RW (Admin) RO (User)	Lower limit of the signal gas %
40109(DEC) 9CAD(HEX)	ALARM_HIGH_PC	F32	RW (Admin) RO (User)	Upper limit of the signal gas %
40111(DEC) 9CAF(HEX)	ALARM_01_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 01
40113(DEC) 9CB1(HEX)	ALARM_02_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 02
40115(DEC) 9CB3(HEX)	ALARM_03_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 03
40117(DEC) 9CB5(HEX)	ALARM_04_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 04
40119(DEC) 9CB7(HEX)	ALARM_05_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 05
40121(DEC) 9CB9(HEX)	ALARM_06_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 06
40123(DEC) 9CBB(HEX)	ALARM_07_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 07
40125(DEC) 9CBD(HEX)	ALARM_08_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 08
40127(DEC) 9CBF(HEX)	ALARM_09_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 09
40129(DEC) 9CC1(HEX)	ALARM_10_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 10
40131(DEC) 9CC3(HEX)	ALARM_11_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 11
40133(DEC) 9CC5(HEX)	ALARM_12_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 12
40135(DEC) 9CC7(HEX)	ALARM_13_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 13
40137(DEC) 9CC9(HEX)	ALARM_14_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 14
40139(DEC) 9CCB(HEX)	ALARM_15_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 15
40141(DEC) 9CCD(HEX)	ALARM_16_MA	F32	RW (Admin) RO (User)	NAMUR mA level for alarm 16

ADDRESS	NAME	TYPE	ACCESS	COMMENT
40143(DEC) 9CCF(HEX)	ALARM_SAVE	U16	RW (Admin) RO (User)	Save alarm config
40170(DEC) 9CEA(HEX)	GAS_NAME	S16	RO(User) RO(Admin)	Name of gas
40178(DEC) 9CF2(HEX)	SAVE_CONFIG	U16	RO(User) RO(Admin)	Saves all config changes
40179(DEC) 9CF3(HEX)	SERIAL_NO	S16	RO(User) RO(Admin)	Serial number
40197(DEC) 9CFB(HEX)	PART_NO	S16	RO(User) RO(Admin)	Part number
40195(DEC) 9D03(HEX)	FIRMWARE_VERSION	F32	RO(User) RO(Admin)	Application software version
40197(DEC) 9D05(HEX)	SAFETY_FW_VERSION	F32	RO(User) RO(Admin)	Safety critical software version
40199(DEC) 9D07(HEX)	BOOTLOADER_VERSION	F32	RO(User) RO(Admin)	Bootloader software version
40201(DEC) 9D09(HEX)	USER_ID	U16	RW (User) RW (Admin)	User profile
40202(DEC) 9D0A(HEX)	PWD_LOGIN	U64	WO (User) WO (Admin)	Password entry for login
40206(DEC) 9D0E(HEX)	PWD_CHANGE	U64	WO (User) WO (Admin)	Change password for logged-in profile
40210(DEC) 9D12(HEX)	PWD_RESET	U16	RO (User) RW (Admin)	Admin can reset any User profile password
40211(DEC) 9D13(HEX)	REBOOT	U16	RO (User) RW (Admin)	Reboot the system
40212(DEC) 9D14(HEX)	FACTORY_RESET	U16	RO (User) RW (Admin)	Restore factory or restore previous
40201(DEC) 9D09(HEX)	USER_ID	U16	RW (User) RW (Admin)	User profile
40202(DEC) 9D0A(HEX)	PWD_LOGIN	U64	WO (User) WO (Admin)	Password entry for login
40206(DEC) 9D0E(HEX)	PWD_CHANGE	U64	WO (User) WO (Admin)	Change password for logged-in profile
40210(DEC) 9D12(HEX)	PWD_RESET	U16	RO (User) RW (Admin)	Admin can reset any User profile password
40211(DEC) 9D13(HEX)	REBOOT	U16	RO (User) RW (Admin)	Reboot the system
40212(DEC) 9D14(HEX)	FACTORY_RESET	U16	RO (User) RW (Admin)	Restore Factory or Restore Previous
40153(DEC) 9CD9(HEX)	SOLENOIDS	U16	RW (Admin) RO (User)	Remote operation of the calibration relays
57020 (DEC) DEBC (HEX)	FLAG_OFFLINE	U16	RO (Admin) RO (User)	Indicates if the customer is logged in
57021 (DEC) DEBD (HEX)	FLAG_BROWNOUT	U16	RO (Admin) RO (User)	Brownout fault is detected
57022 (DEC) DEBE (HEX)	FLAG_SYS_FAULT	U16	RO (Admin) RO (User)	Fault is detected

ADDRESS	NAME	TYPE	ACCESS	COMMENT
57023 (DEC) DEBF (HEX)	FLAG_DAC_OUTPUT	U16	RO (Admin) RO (User)	Fault is detected
57024 (DEC) DEC0 (HEX)	FLAG_SIL_LOOP	U16	RO (Admin) RO (User)	Fault is detected
57025 (DEC) DEC1 (HEX)	FLAG_ADC_BKMV	U16	RO (Admin) RO (User)	Fault is detected
57026 (DEC) DEC2 (HEX)	FLAG_ADC_BOARD_OHM	U16	RO (Admin) RO (User)	Fault is detected
57027 (DEC) DEC3 (HEX)	FLAG_ADC_BRGMV	U16	RO (Admin) RO (User)	Fault is detected
57028 (DEC) DEC4 (HEX)	FLAG_CELL_OHM	U16	RO (Admin) RO (User)	Fault is detected
57029 (DEC) DEC5 (HEX)	FLAG_ADC_O2MV	U16	RO (Admin) RO (User)	Fault is detected
57030 (DEC) DEC6 (HEX)	FLAG_ADC_PRMV	U16	RO (Admin) RO (User)	Fault is detected
57031 (DEC) DEC7 (HEX)	FLAG_RTD_ADC1	U16	RO (Admin) RO (User)	Fault is detected
57032 (DEC) DEC8 (HEX)	FLAG_RTD_ADC2	U16	RO (Admin) RO (User)	Fault is detected
57033 (DEC) DEC9 (HEX)	FLAG_RTD_ADC3	U16	RO (Admin) RO (User)	Fault is detected
57034(DEC) DECA (HEX)	FLAG_RTD_ADC4	U16	RO (Admin) RO (User)	Fault is detected
57035(DEC) DECB (HEX)	FLAG_RTD_ADC5	U16	RO (Admin) RO (User)	Fault is detected
57036(DEC) DECC (HEX)	FLAG_RTD_ADC6	U16	RO (Admin) RO (User)	Fault is detected
57037(DEC) DECD (HEX)	FLAG_VER_ADC1	U16	RO (Admin) RO (User)	Fault is detected
57038(DEC) DECE (HEX)	FLAG_VER_ADC2	U16	RO (Admin) RO (User)	Fault is detected
57039(DEC) DECF (HEX)	FLAG_VER_ADC3	U16	RO (Admin) RO (User)	Fault is detected
57040(DEC) DED0 (HEX)	FLAG_VER_ADC4	U16	RO (Admin) RO (User)	Fault is detected
57041(DEC) DED1 (HEX)	FLAG_VER_ADC5	U16	RO (Admin) RO (User)	Fault is detected
57042(DEC) DED2 (HEX)	FLAG_VER_ADC6	U16	RO (Admin) RO (User)	Fault is detected
57043(DEC) DED3 (HEX)	FLAG_HAM_DECODER	U16	RO (Admin) RO (User)	Fault is detected

ADDRESS	NAME	TYPE	ACCESS	COMMENT
57044(DEC) DED4 (HEX)	FLAG_TEMP_C_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57045(DEC) DED5 (HEX)	FLAG_TEMP_C_OVER	U16	RO (Admin) RO (User)	Fault is detected
57046(DEC) DED6(HEX)	FLAG_BOARD_PSI_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57047(DEC) DED7 (HEX)	FLAG_BOARD_PSI_OVER	U16	RO (Admin) RO (User)	Fault is detected
57048(DEC) DED8 (HEX)	FLAG_O2PC_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57049(DEC) DED9 (HEX)	FLAG_O2PC_OVER	U16	RO (Admin) RO (User)	Fault is detected
57050(DEC) DEDA (HEX)	FLAG_O2MV_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57051(DEC) DEDB (HEX)	FLAG_O2MV_OVER	U16	RO (Admin) RO (User)	Fault is detected
57052(DEC) DEDC (HEX)	FLAG_O2LCL_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57053(DEC) DEDD (HEX)	FLAG_O2UCL_OVER	U16	RO (Admin) RO (User)	Fault is detected
57054(DEC) DEDE (HEX)	FLAG_BKMV_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57055(DEC) DEEF (HEX)	FLAG_BKMV_OVER	U16	RO (Admin) RO (User)	Fault is detected
57056(DEC) DEE0 (HEX)	FLAG_PRMV_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57057(DEC) DEE1 (HEX)	FLAG_PRMV_OVER	U16	RO (Admin) RO (User)	Fault is detected
57058(DEC) DEE2 (HEX)	FLAG_CELLOHM_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57059(DEC) DEE3 (HEX)	FLAG_CELLOHM_OVER	U16	RO (Admin) RO (User)	Fault is detected
57060(DEC) DEE4 (HEX)	FLAG_BOARDOHM_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57061(DEC) DEE5 (HEX)	FLAG_BOARDOHM_OVER	U16	RO (Admin) RO (User)	Fault is detected
57062(DEC) DEE6(HEX)	FLAG_BOARD_C_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57063(DEC) DEE7(HEX)	FLAG_BOARD_C_OVER	U16	RO (Admin) RO (User)	Fault is detected
57064(DEC) DEE8(HEX)	FLAG_SET_ALARMS	U16	RO (Admin) RO (User)	Fault is detected

ADDRESS	NAME	TYPE	ACCESS	COMMENT
57065(DEC) DEE9(HEX)	FLAG_PID_SETP	U16	RO (Admin) RO (User)	Fault is detected
57066(DEC) DEEA(HEX)	FLAG_VER_BOARD_C	U16	RO (Admin) RO (User)	Fault is detected
57067(DEC) DEEB(HEX)	FLAG_VER_CELL_C	U16	RO (Admin) RO (User)	Fault is detected
57068(DEC) DEEC(HEX)	FLAG_BRGMV_OVER	U16	RO (Admin) RO (User)	Fault is detected
57069(DEC) DEED(HEX)	FLAG_BRGMV_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57070(DEC) DEEE(HEX)	FLAG_VER_O2PC	U16	RO (Admin) RO (User)	Fault is detected
57071(DEC) DEEF(HEX)	FLAG_FAST_RESP	U16	RO (Admin) RO (User)	Fault is detected
57072(DEC) DEF0(HEX)	FLAG_FASTRESP_OVER	U16	RO (Admin) RO (User)	Fault is detected
57073(DEC) DEF1(HEX)	FLAG_FASTRESPUNDER	U16	RO (Admin) RO (User)	Fault is detected
57074(DEC) DEF2(HEX)	FLAG_DRIFTCOMP	U16	RO (Admin) RO (User)	Fault is detected
57075(DEC) DEF3(HEX)	FLAG_DRIFTCOMP_UNDER	U16	RO (Admin) RO (User)	Fault is detected
57076(DEC) DEF4(HEX)	FLAG_DRIFTCOMP_OVER	U16	RO (Admin) RO (User)	Fault is detected
57077(DEC) DEF5(HEX)	FLAG_TEST_TRIM	U16	RO (Admin) RO (User)	Fault is detected
57078(DEC) DEF6(HEX)	FLAG_H2G_PHASE	U16	RO (Admin) RO (User)	Fault is detected
57079(DEC) DEF7(HEX)	FLAG_VER_BOARD_PSI	U16	RO (Admin) RO (User)	Fault is detected
57080(DEC) DEF8(HEX)	FLAG_COMP_CALC	U16	RO (Admin) RO (User)	Fault is detected
57081(DEC) DEF9(HEX)	FLAG_CPMP_VERIFY	U16	RO (Admin) RO (User)	Fault is detected
57082(DEC) DEFA(HEX)	FLAG_MCU_FAULT	U16	RO (Admin) RO (User)	Fault is detected
57083(DEC) DEFB(HEX)	FLAG_EARLY_UNDER	U16	RW (Admin) RO (User)	Fault is detected
57084(DEC) DEFC(HEX)	FLAG_EARLY_OVER	U16	RW (Admin) RO (User)	Fault is detected
57085(DEC) DEFD(HEX)	FLAG_HAM_RECOVER	U16	RW (Admin) RO (User)	Fault is detected

ADDRESS	NAME	TYPE	ACCESS	COMMENT
57086(DEC) DEFE(HEX)	FLAG_MEASURE	U16	RW (Admin) RO (User)	Fault is detected
57087(DEC) DEFF(HEX)	FLAG_CHECKIN	U16	RW (Admin) RO (User)	Fault is detected
57088(DEC) DF00(HEX)	FLAG_SENSORTASK	U16	RW (Admin) RO (User)	Fault is detected
57089(DEC) DF01(HEX)	FLAG_PROOFTEST	U16	RW (Admin) RO (User)	Fault is detected
57090(DEC) DF02(HEX	FLAG_FSM_STATE	U16	RW (Admin) RO (User)	Fault is detected
57091(DEC) DF03(HEX	REBOOT_REASON	U16	RW (Admin) RO (User)	Fault is detected
57092(DEC) DF04(HEX)	REBOOT_COOLDOWN	U16	RW (Admin) RO (User)	Fault is detected

Appendix B. SIL Modbus Map

ADDRESS	NAME	TYPE	ACCESS	COMMENT
40144(DEC) 9CD0(HEX)	PROOF_TEST	U16	RW (SIL) RO (Admin) RO (User)	Perform a proof test
40145(DEC) 9CD1(HEX)	TEST_SOLENOIDS	U16	RW (SIL) RO (Admin) RO (User)	Remote operation of the calibration relays
40146(DEC) 9CD2(HEX)	TEST_RELAYS	U16	RW (SIL) RO (Admin) RO (User)	Test alarm relays
40147(DEC) 9CD3(HEX)	TEST_NAMUR	U16	RW (SIL) RO (Admin) RO (User)	Test analog NAMUR levels
40148(DEC) 9CD4(HEX)	TEST_ALARMS	U16	RW (SIL) RO (Admin) RO (User)	Test a specified alarm
40149(DEC) 9CD5(HEX)	TEST_MV	U16	RW (SIL) RO (Admin) RO (User)	Simulates input mVs
40150(DEC) 9CD6(HEX)	TEST_CH1	F32	RW (SIL) RO (Admin) RO (User)	Test analog output 1
40152(DEC) 9CD8(HEX)	TEST_CH2	F32	RW (SIL) RO (Admin) RO (User)	Test analog output 2
40154(DEC) 9CDA(HEX)	TEST_O2MV	F32	RW (SIL) RO (Admin) RO (User)	Inject a simulated GasMV reading
40156(DEC) 9CDC(HEX)	TEST_BKMV	F32	RW (SIL) RO (Admin) RO (User)	Inject a simulated BKMV reading
40160(DEC) 9CE0(HEX)	TOLERANCE	F3	RW (SIL) RO (Admin) RO (User)	

[no content intended for this page]

Appendix C. Error Codes

S.No	Code	Error/Warning	Faults
1	112	ERR: NMI Fault	
2	211	ERR: MEM Fault	
3	113	ERR: BUS Fault	
4	122	ERR: USAGE FAULT	
5	131	ERR: SVC Fault	
6	212	ERR: DBGMON Fault	
7	221	ERR: OS Fault	
8	311	ERR: No Init	
9	114	ERR: SIF Timeout	
10	123	ERR: No Watchdog	ALARM_WDG_ERROR
11	132	ERR: SIF Lost	ALARM_MCU_FAULT, ALARM_DATA_FAULT
12	141	ERR: No Temp. Control	ALARM_HEAT_FAULT, ALARM_WDG_ERROR
13	213	ERR: No Comp	ALARM_SYS_ERROR, ALARM_GAS_UNDER, ALARM_GAS_OVER, ALARM_WDG_ERROR
14	222	ERR: No BK Comp	
15	231	ERR: No PR Comp	
16	312	ERR: No PRBK Comp	
17	321	ERR: No Fast Response	ALARM_SYS_ERROR, ALARM_GAS_UNDER, ALARM_GAS_OVER
18	411	ERR: No Drift Comp	ALARM_CAL_ERROR,
19	115	ERR: No Trim CH1	ALARM_CAL_ERROR
20	124	ERR: No Trim CH2	
22	142	ERR: Brownout	ALARM_BROWNOUT
23	232	ERR: UART Lost	
24	241	ERR: RAM Lost	
25	313	ERR: ROM Lost	
26	322	ERR: MPU Lost	
27	331	ERR: DAC Lost	ALARM_DAC_FAULT
28	412	ERR: ADC Lost	ALARM_ADC_FAULT
29	421	ERR: PWM Lost	
30	511	ERR: Flash Lost	
31	116	ERR: IOX Lost	
32	125	ERR: LCD Lost	
33	134	ERR: ECC Error	
34	143	ERR: ADC CRC Error	

S.No	Code	Error/Warning	Faults
35	332	ERR: Not Found	
36	341	ERR: Invalid Argument	
37	413	ERR: CRC Error	
38	422	ERR: Access Denied	
39	431	ERR: Type Mismatch	
40	512	ERR: Under Range	
41	521	ERR: Over Range	
42	611	ERR: Out of Memory	
43	117	ERR: Incomplete	
44	126	ERR: No Connection	
45	234	WRN: Not yet Saved	
46	243	WRN: Warmup	
47	333	WRN: Cal Reminder	
48	414	ERR: Password Generation	
49	343	WRN: Offline	
50	146	WRN: No Clock	
51	245	ERR: Busy	
52	237	ERR: LCD Main Menu Cursor	
53	246	ERR: LCD Cursor Generation	
54	149	WRN: CRC Error	
55	158	WRN: No Modbus	
56	167	WRN: Modbus No Register	
57	176	WRN: Modbus No Command	
58	185	WRN: Modbus Idle	
59	194	WRN: Modbus Type Error	

Appendix D. Troubleshooting

Code	Error/Warning	Possible cause	Possible solution
112	NMI_FAULT	MCU has hard faulted	Reboot system via power cycle
113	BUS_FAULT	MCU has hard faulted	Reboot system via power cycle
114	SIF_TIMEOUT	Safety function did not respond in the required time	Reboot system via power cycle
115	NO_TRIM_CH1	No valid trim data available	Perform a test & trim
116	IOX_LOST	Hardware fault	Contact factory
117	TEMPMV_UNDER_RANGE	Heater has not reached temperature	Should only be active during power up, if not contact factory
118	NOT_FOUND	Missing data	Contact factory
121	HARD_FAULT	MCU has hard faulted	Reboot system via power cycle
122	USAGE_FAULT	MCU has hard faulted	Reboot system via power cycle
123	NO_WDG	Safety function did not respond in the required time	Reboot system via power cycle
124	NO_TRIM_CH2	No valid trim data available	Perform a test & trim
125	LCD_LOST	Hardware fault	Contact factory
126	TEMPMV_OVER_RANGE	Heater is over the target temperature	Verify ambient temp. is within limits
127	INVALID_ARG	Configuration is invalid	Contact factory
131	SVC_FAULT	MCU has hard faulted	Reboot system via power cycle
132	SIF_LOST	Safety function did not respond in the required time	Reboot system via power cycle
134	ECC_ERROR	Data corrupted	Contact factory
135	BOARDMV_UNDER_RANGE	Heater has not reached temperature	Should only be active during power up, if not contact factory
136	CRC_ERROR	Data corrupted	Contact factory
141	NO_TEMP_CONTROL	Heater has not reached temperature	Contact factory
142	BROWNOUT	Power supply not providing enough power	Verify power supply meets requirements
143	ADC_CRC_ERROR	ADC readout is corrupted	Contact factory
144	BOARDMV_OVER_RANGE	Ambient Temperature too high	Verify ambient temp. is within limits
145	ACCESS_DENIED	Attempt to configure without first logging in	Log in
146	NO_CLOCK	Time date not set	Set time and date
149	CRC_ERROR	Data corrupted - Not safety related	Repeat action or Contact factory
151	PRESSURE	Pressure sensor not calibrated	Contact factory
152	ALARM_LOST	Error occurred while raising an alarm	Contact factory
153	TEMPC_UNDER_RANGE	Heater has not reached temperature	Should only be active during power up, if not contact factory
154	TYPE_MISMATCH	Invalid configuration	Contact factory
155	PIN_RESET	System has rebooted	Should only be active during power up, if not contact factory
158	NO_MODBUS	Modbus connection cannot be established	Contact factory
162	TEMPC_OVER_RANGE	Heater has not reached temperature	Verify ambient temp. is within limits

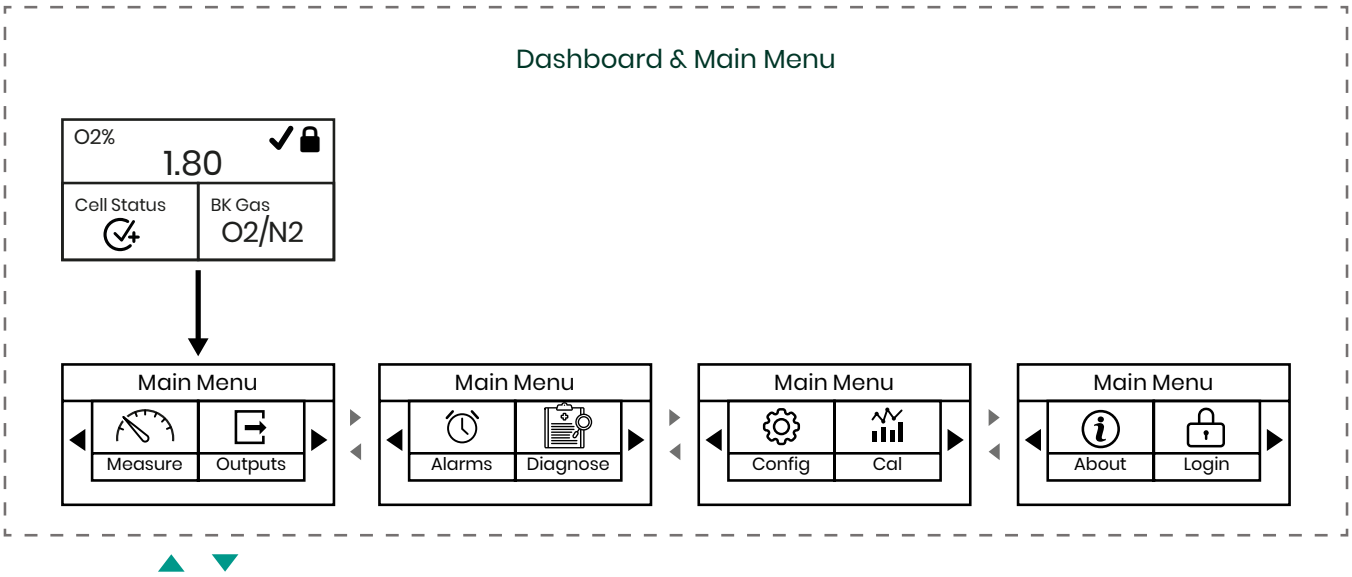
Code	Error/Warning	Possible cause	Possible solution
163	UNDER_RANGE	Attempt to write configuration to an invalid value	Repeat action
164	SW_RESET	System has rebooted	Should only be active during power up, if not contact factory
167	MODBUS_NOREG	Attempted to read non-existing modbus register	Try different parameters
171	BRDC_UNDER_RANGE	Heater has not reached temperature	Should only be active during power up, if not contact factory
172	OVER_RANGE	Attempt to write configuration to an invalid value	Repeat action
173	LPWR_RESET	System has rebooted	Should only be active during power up, if not contact factory
176	MODBUS_NOCMD	Modbus request cannot be satisfied	Try different parameters
182	CPU_RESET1	System has rebooted	Should only be active during power up, if not contact factory
185	MODBUS_IDLE	Modbus timed out due to no activity	Try different parameters
191	CPU_RESET2	System has rebooted	Should only be active during power up, if not contact factory
194	MODBUS_TYPE_ERR	Modbus request cannot be satisfied	Try different parameters
211	MEM_FAULT	MCU has hard faulted	Reboot system via power cycle
212	DBGMON_FAULT	MCU has hard faulted	Reboot system via power cycle
213	NO_COMP	Configuration is invalid or the sensor is damaged	Contact factory
216	BRDC_OVER_RANGE	Heater has not reached temperature	Contact factory
217	INCOMPLETE	Configuration is invalid	Contact factory
221	OS_FAULT	MCU has hard faulted	Reboot system via power cycle
222	NO_BKCOMP	Configuration is invalid or the sensor is damaged	Contact factory
223	MCU_LOST	MCU has hard faulted	Contact factory
225	PRESS_UNDER_RANGE	Pressure too low	Contact factory
231	NO_PRCOMP	Configuration is invalid or the sensor is damaged	Contact factory
232	UART_LOST	Modbus connection cannot be established	Contact factory
234	PRESS_OVER_RANGE	Pressure too high	Contact factory
241	RAM_LOST	Hardware fault	Contact factory
243	TIMEOUT	Required action has not completed within required time frame	Repeat action
245	BUSY	Busy processing earlier requests	Repeat action
261	NOCOMP_BAD_GAS_CAL	Configuration is invalid or the sensor is damaged	Contact factory
311	NO_INIT	Configuration is invalid	Contact factory
312	NO_PRBKCOMP	Configuration is invalid or the sensor is damaged	Contact factory
313	ROM_LOST	Hardware fault	Contact factory
315	NOT_YET_SAVED	Configuration is invalid	Contact factory

Code	Error/Warning	Possible cause	Possible solution
321	NO_FASTRESP	Configuration is invalid or the sensor is damaged	Contact factory
322	MPU_LOST	Hardware fault	Contact factory
324	WARMUP	Heater has not reached temperature	Should only be active during power up, if not contact factory
331	DAC_LOST	Hardware fault	Try placing a load on the CH1 output
332	GASMV_UNDER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
333	CAL_REMINDER	Calibration is due	Perform field calibration
341	GASMV_OVER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
342	ERR_EARLY_UNDER	Gas is beyond user configurable trip point	1. Verify configurable trip points 2. Verify Process 3. Contact factory if process is correct
343	OFFLINE	User has logged in	Log out to resume measurements
351	ERR_EARLY_OVER	Gas is beyond user configurable trip point	1. Verify configurable trip points 2. Verify Process 3. Contact factory if process is correct
411	NO_DRIFTCOMP	Calibration data is missing	Perform a Field calibration
412	ADC_LOST	Hardware fault	Contact factory
413	GAS_UNDER_RANGE	Gas provided is outside of calibrated range	Perform a Field calibration
421	PWM_LOST	Hardware fault	Contact factory
422	GAS_OVER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
431	BKMV_UNDER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
511	FLASH_LOST	Hardware fault	Contact factory
512	BKMV_OVER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
521	PMV_UNDER_RANGE	Pressure too high	Contact Factory
611	PMV_OVER_RANGE	Pressure too low	Contact Factory

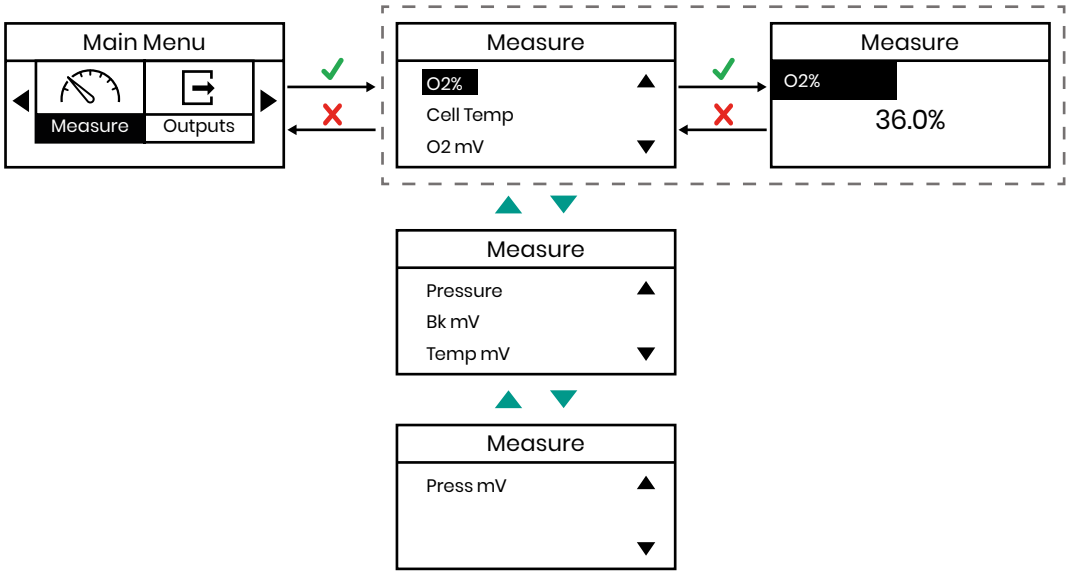
[no content intended for this page]

Appendix E. Menu Maps

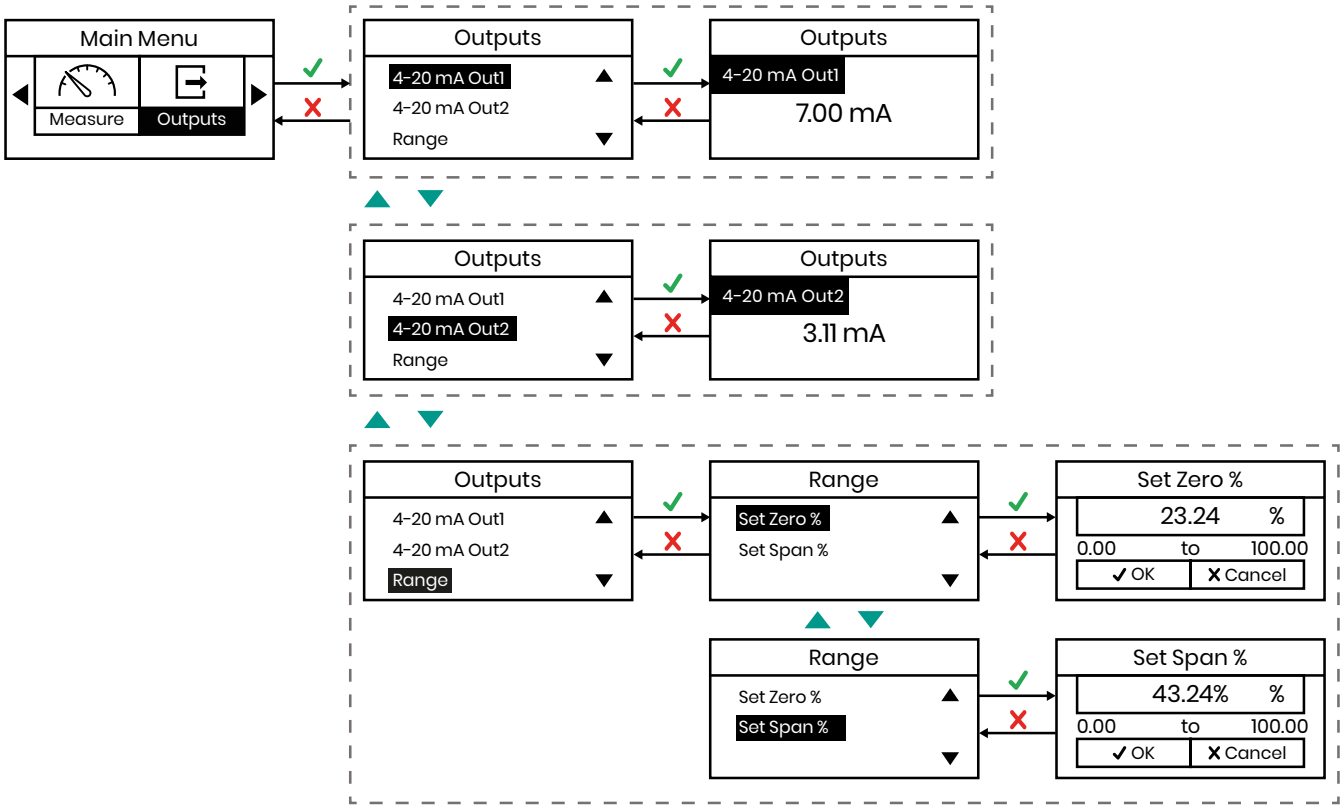
E.1 Dashboard & Main Menu



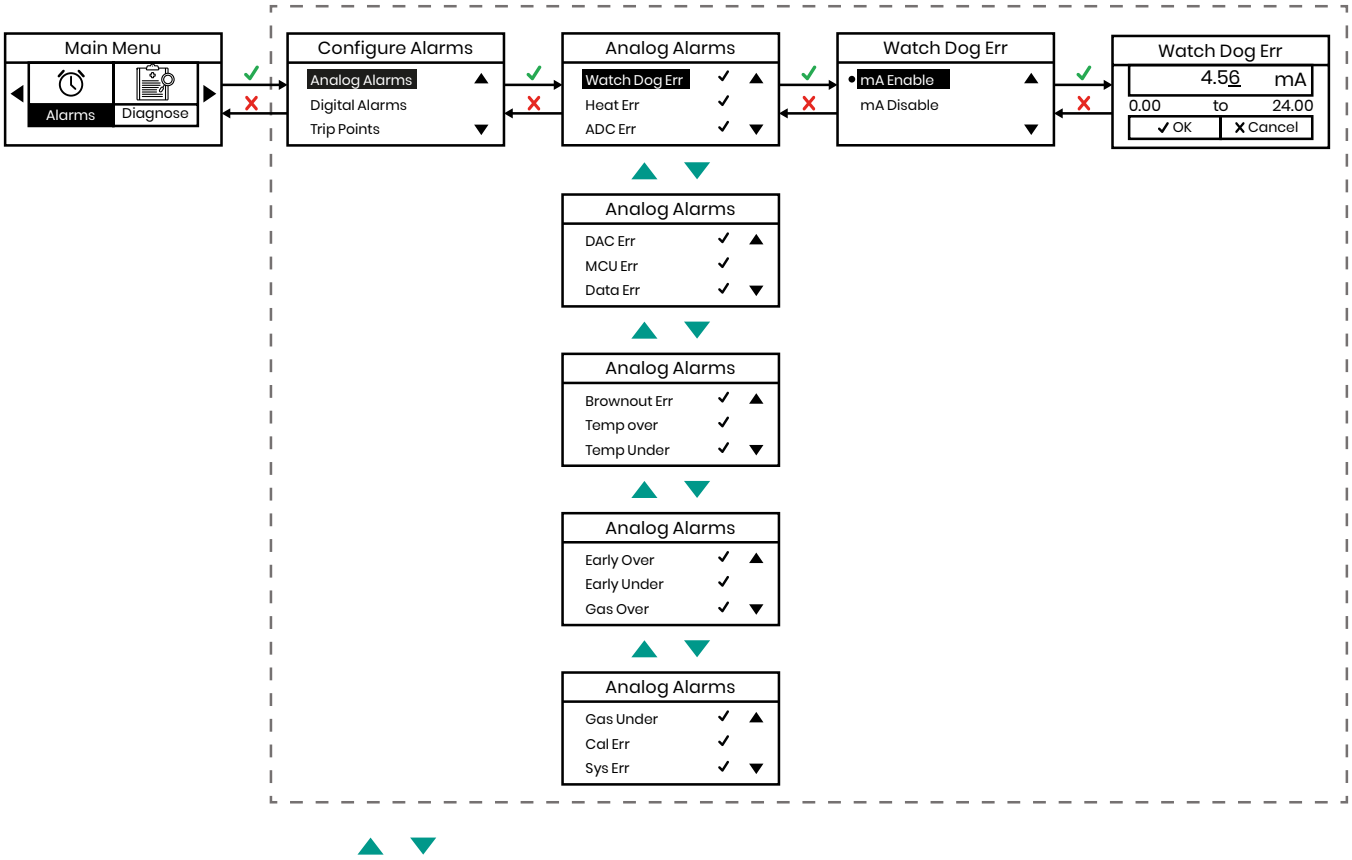
E.2 Measure Menu

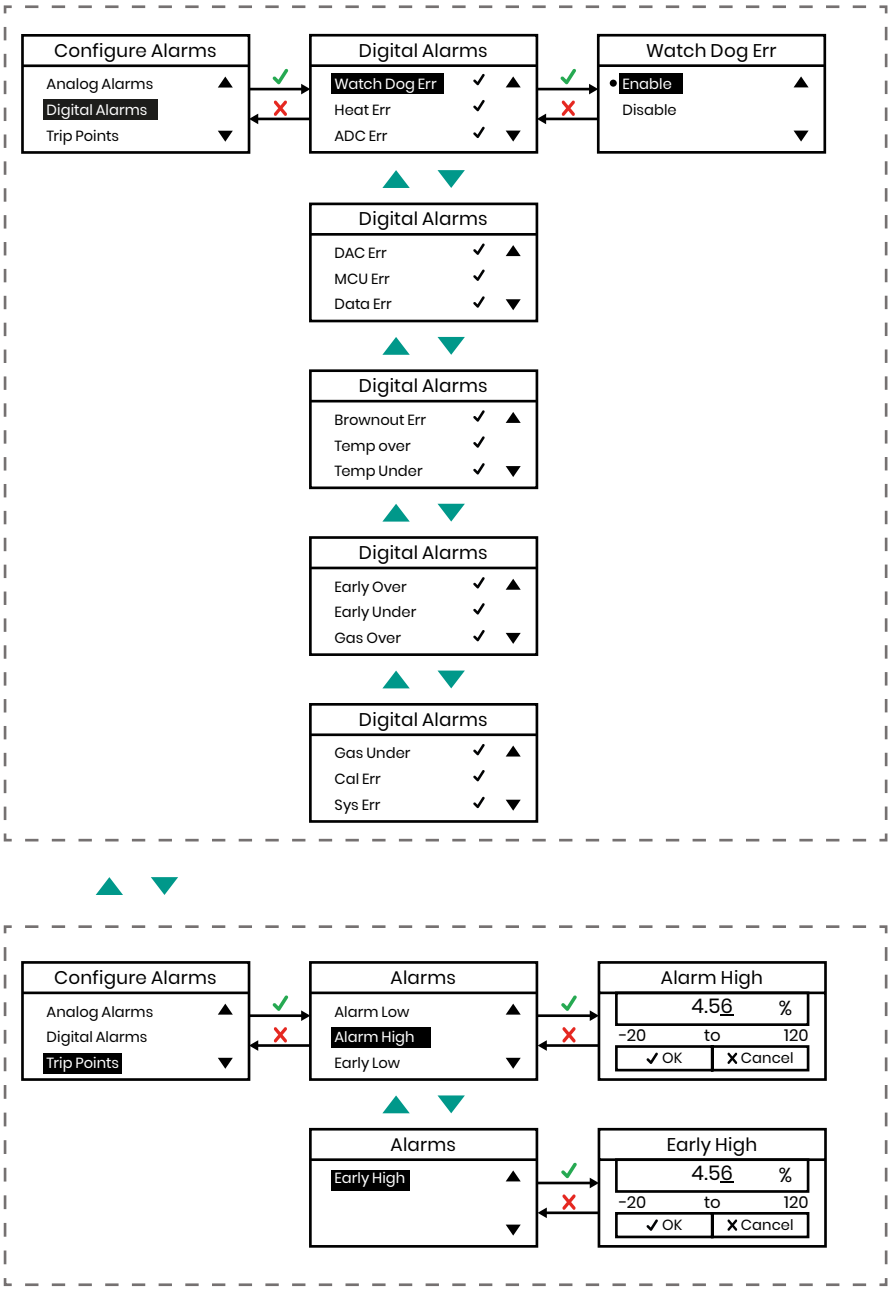


E.3 Outputs Menu

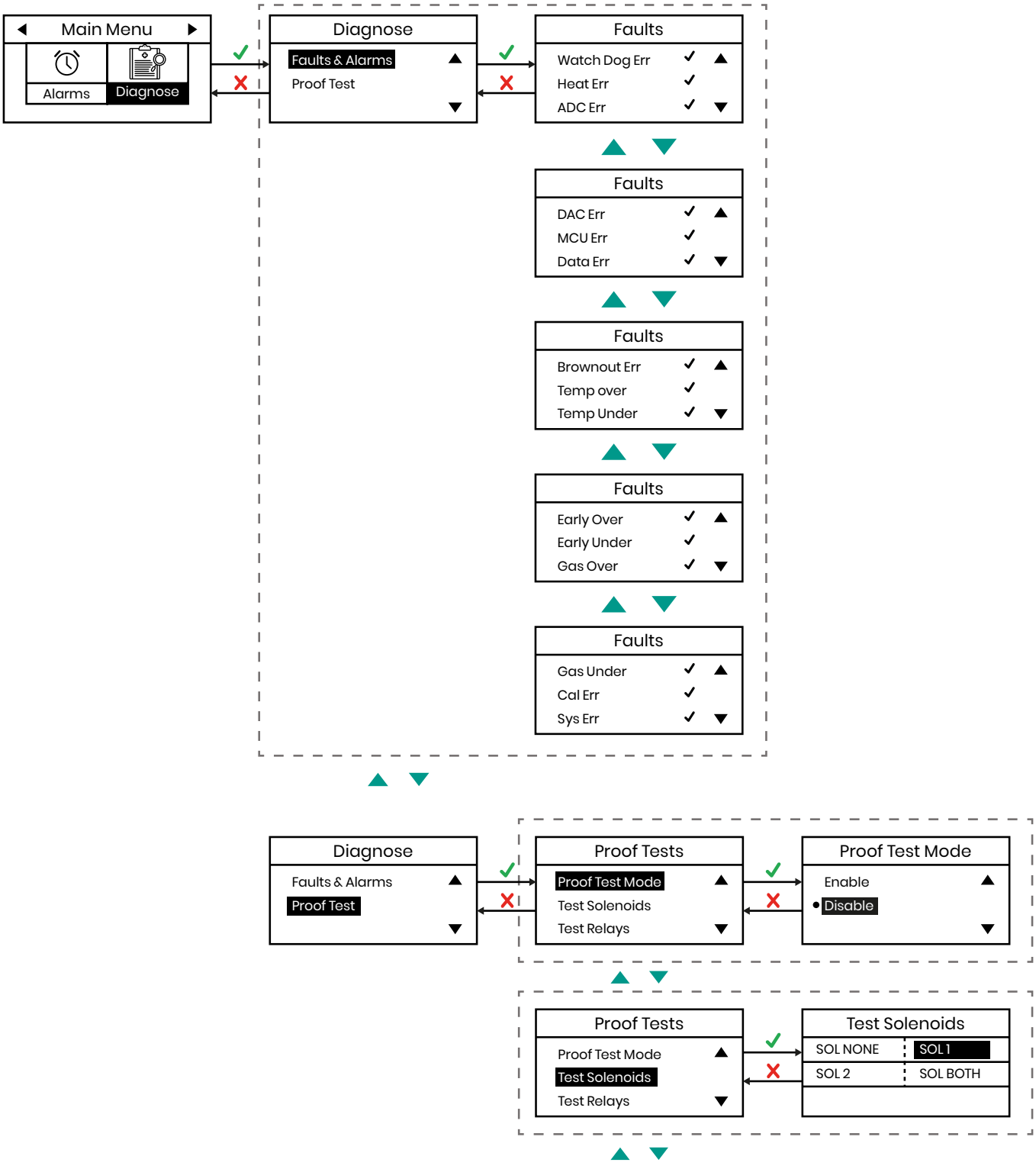


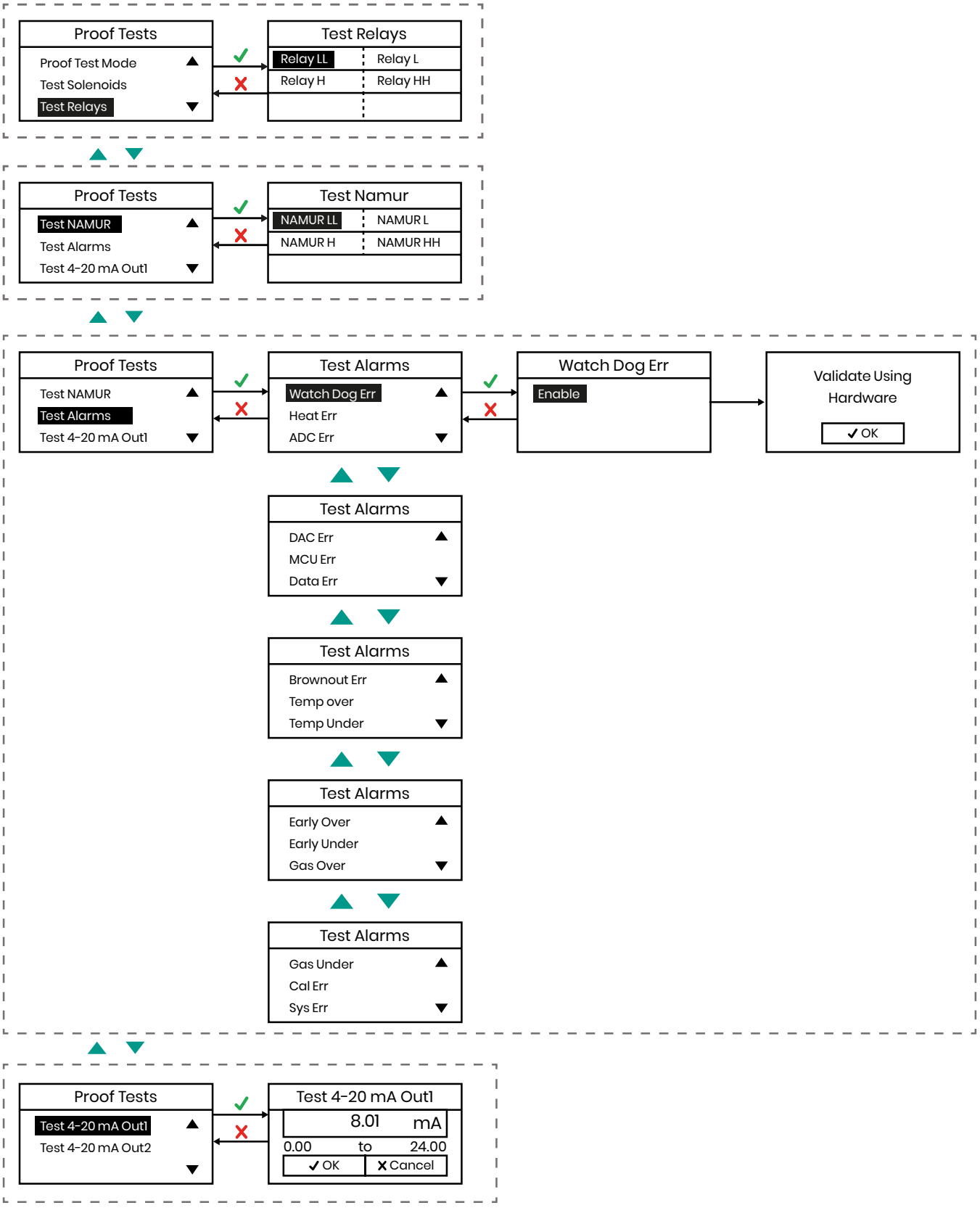
E.4 Alarms Menu



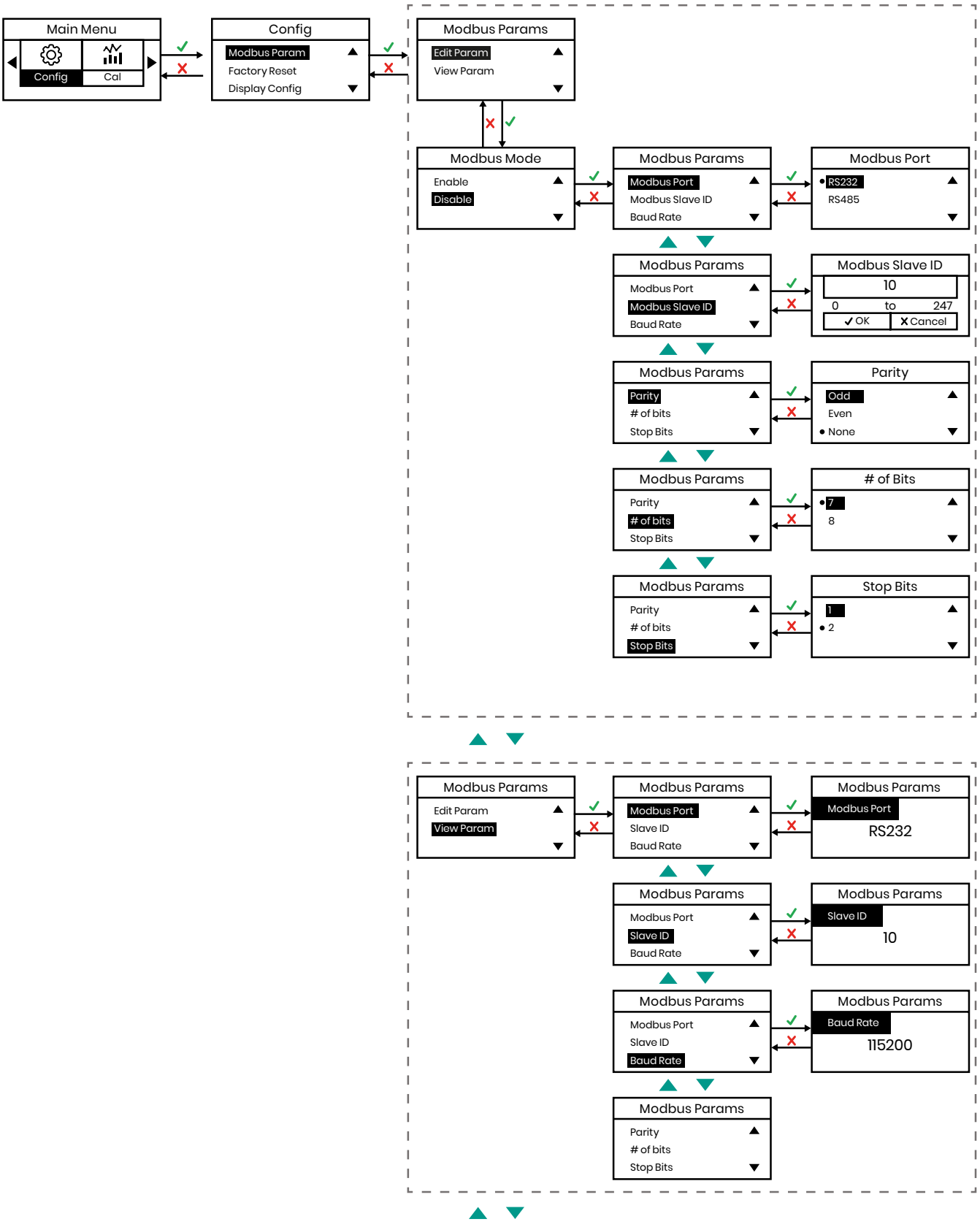

Configure Alarms
Analog Alarms
Digital Alarms
Trip Points
Digital Alarms
Watch Dog Err
Heat Err
ADC Err
Watch Dog Err
Enable
Disable
Digital Alarms
DAC Err
MCU Err
Data Err
Digital Alarms
Brownout Err
Temp over
Temp Under
Digital Alarms
Early Over
Early Under
Gas Over
Digital Alarms
Gas Under
Cal Err
Sys Err
Configure Alarms
Analog Alarms
Digital Alarms
Trip Points
Alarms
Alarm Low
Alarm High
Early Low
Alarm High
4.56 %
-20 to 120
OK
Cancel
Alarms
Early High
Early High
4.56 %
-20 to 120
OK
Cancel

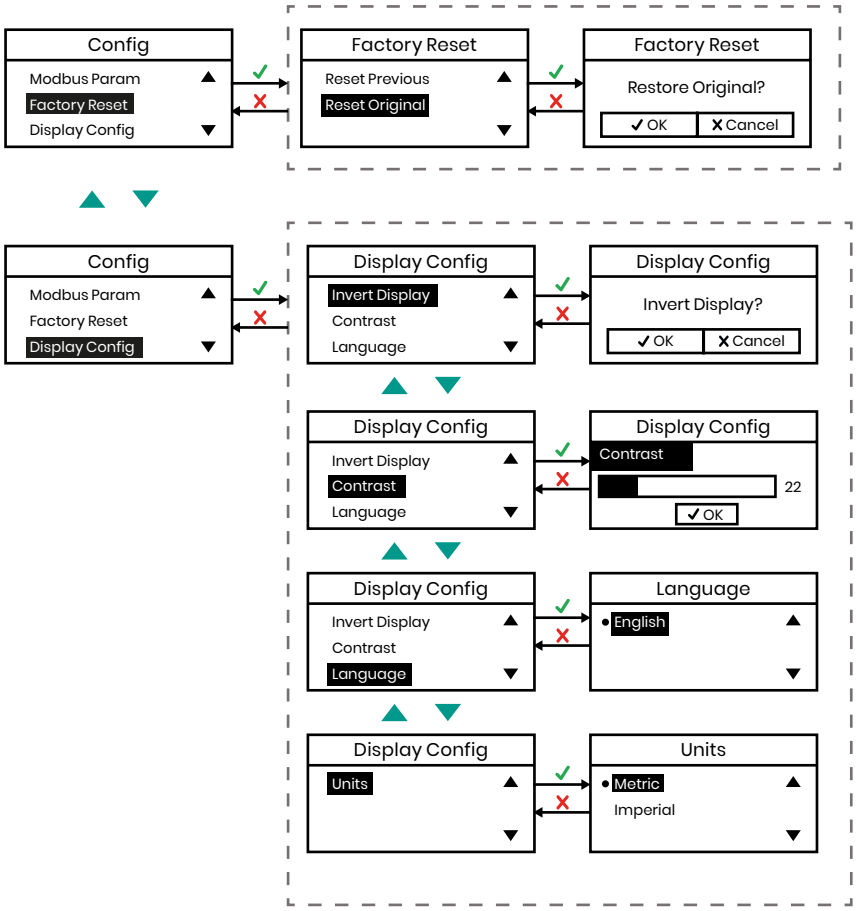
E.5 Diagnose Menu



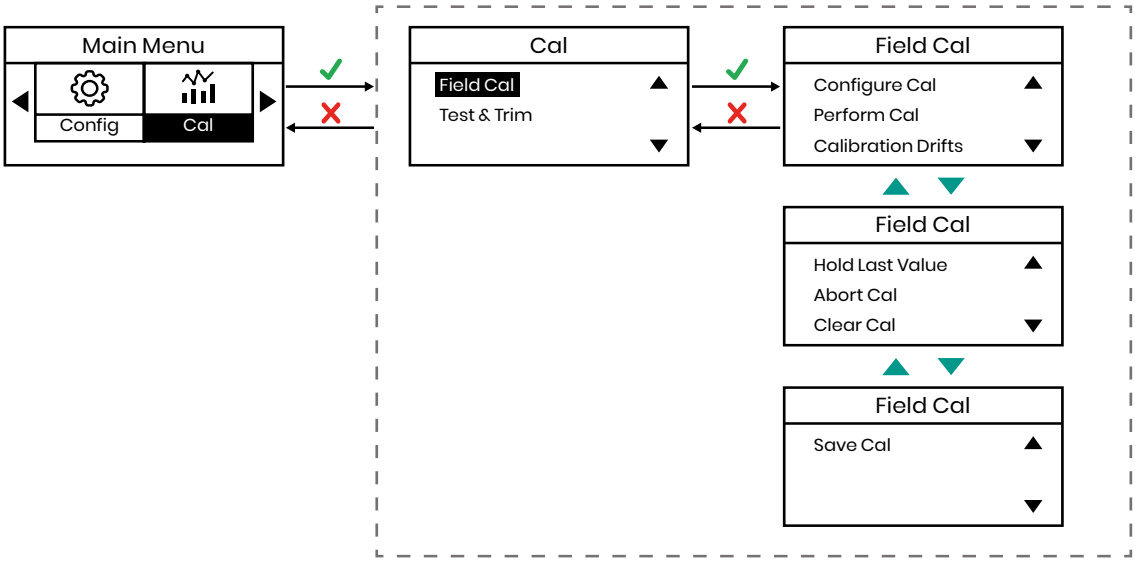

Proof Tests
Proof Test Mode
Test Solenoids
Test Relays
Test Relays
Relay LL
Relay L
Relay H
Relay HH
Proof Tests
Test NAMUR
Test Alarms
Test 4-20 mA Out1
Test Namur
NAMUR LL
NAMUR L
NAMUR H
NAMUR HH
Proof Tests
Test NAMUR
Test Alarms
Test 4-20 mA Out1
Test Alarms
Watch Dog Err
Heat Err
ADC Err
Watch Dog Err
Enable
Validate Using Hardware
OK
Test Alarms
DAC Err
MCU Err
Data Err
Test Alarms
Brownout Err
Temp over
Temp Under
Test Alarms
Early Over
Early Under
Gas Over
Test Alarms
Gas Under
Cal Err
Sys Err
Proof Tests
Test 4-20 mA Out1
Test 4-20 mA Out2
Test 4-20 mA Out1
8.01 mA
0.00 to 24.00
OK
Cancel

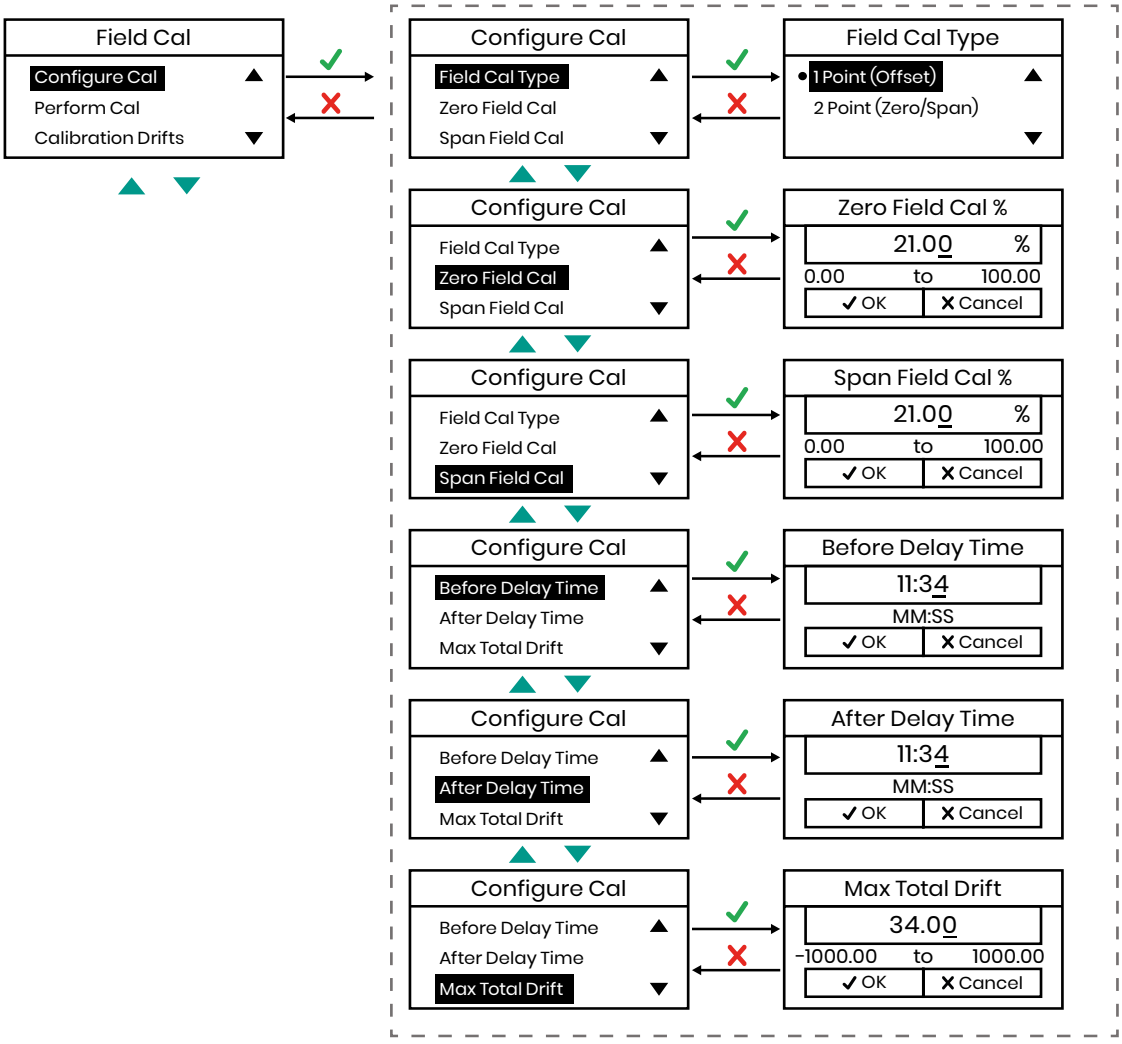
E.6 Config Menu

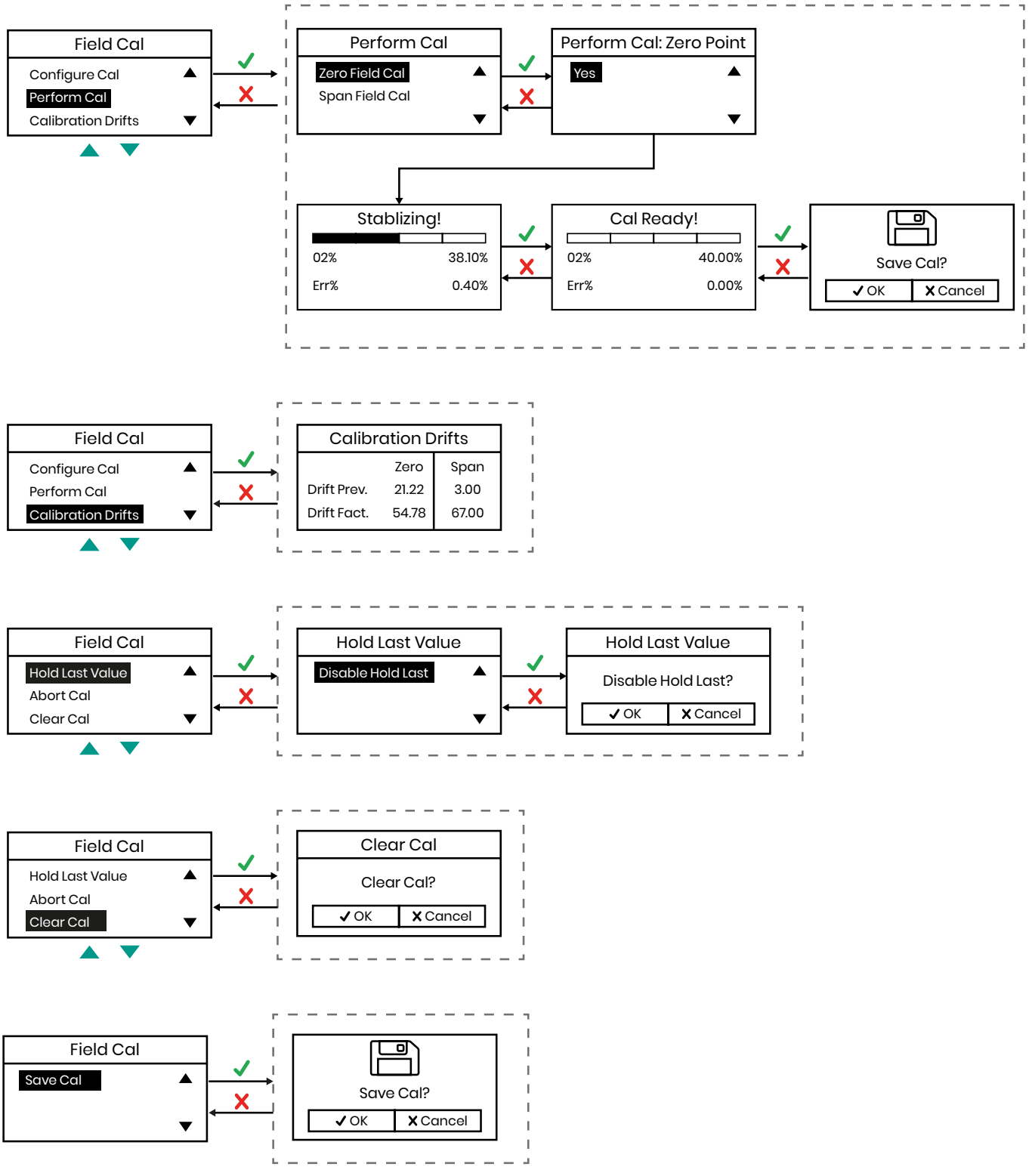


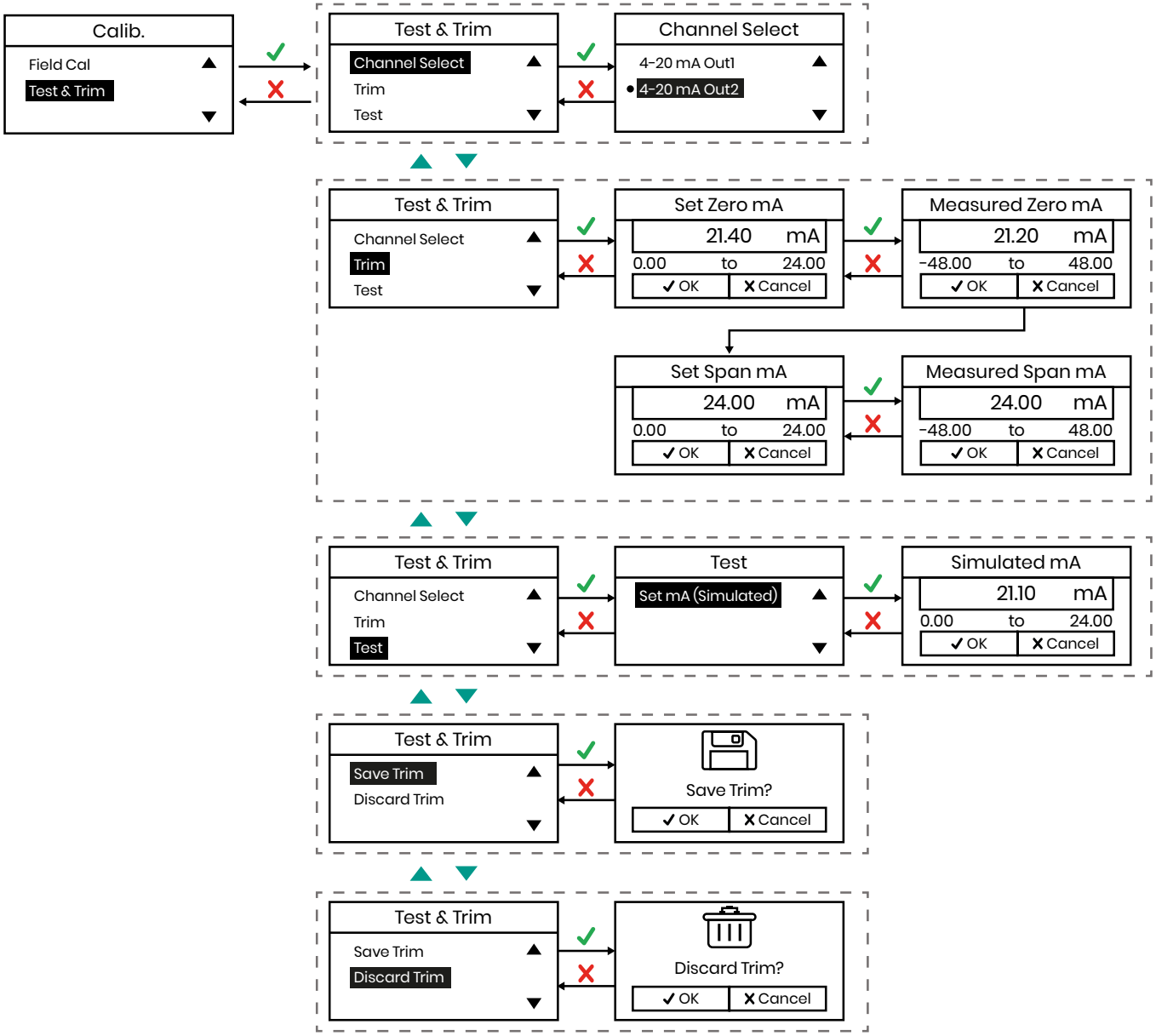

Config
Modbus Param
Factory Reset
Display Config
Factory Reset
Reset Previous
Reset Original
Factory Reset
Restore Original?
✓OK
✗Cancel
Config
Modbus Param
Factory Reset
Display Config
Display Config
Invert Display
Contrast
Language
Display Config
Invert Display?
✓OK
✗Cancel
Display Config
Invert Display
Contrast
Language
Display Config
Contrast
22
✓OK
Display Config
Invert Display
Contrast
Language
Language
•English
Display Config
Units
Units
•Metric
Imperial

E.7 Cal Menu

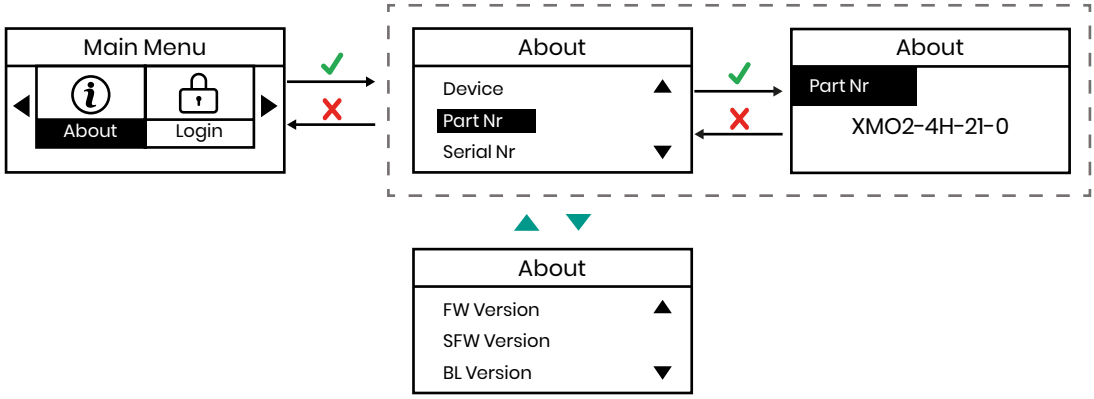

Main Menu
Config
Cal
Cal
Field Cal
Test & Trim
Field Cal
Configure Cal
Perform Cal
Calibration Drifts
Field Cal
Hold Last Value
Abort Cal
Clear Cal
Field Cal
Save Cal


Field Cal
Configure Cal
Perform Cal
Calibration Drifts
Configure Cal
Field Cal Type
Zero Field Cal
Span Field Cal
Field Cal Type
1 Point (Offset)
2 Point (Zero/Span)
Configure Cal
Field Cal Type
Zero Field Cal
Span Field Cal
Zero Field Cal %
21.00 %
0.00 to 100.00
OK
Cancel
Configure Cal
Field Cal Type
Zero Field Cal
Span Field Cal
Span Field Cal %
21.00 %
0.00 to 100.00
OK
Cancel
Configure Cal
Before Delay Time
After Delay Time
Max Total Drift
Before Delay Time
11:34
MM:SS
OK
Cancel
Configure Cal
Before Delay Time
After Delay Time
Max Total Drift
After Delay Time
11:34
MM:SS
OK
Cancel
Configure Cal
Before Delay Time
After Delay Time
Max Total Drift
Max Total Drift
34.00
-1000.00 to 1000.00
OK
Cancel

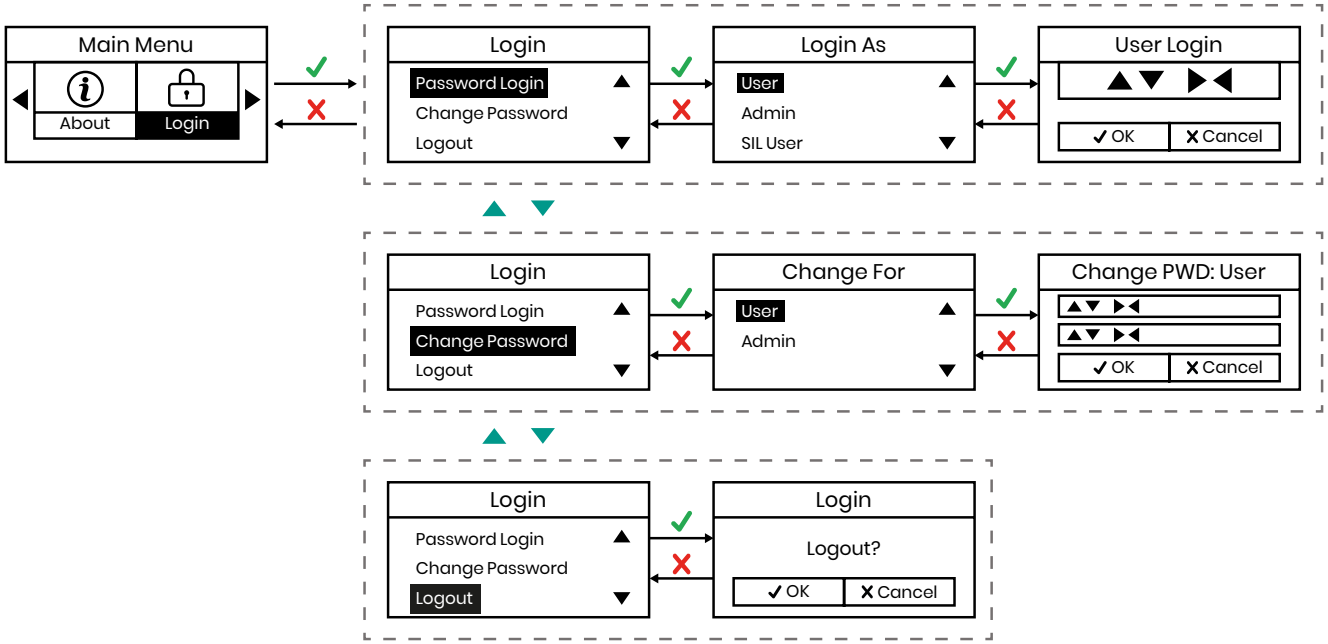

Field Cal
Configure Cal
Perform Cal
Calibration Drifts
Perform Cal
Zero Field Cal
Span Field Cal
Perform Cal: Zero Point
Yes
Stablizing!
02%
38.10%
Err%
0.40%
Cal Ready!
02%
40.00%
Err%
0.00%
Save Cal?
OK
Cancel
Field Cal
Configure Cal
Perform Cal
Calibration Drifts
Calibration Drifts
Zero
Span
Drift Prev.
21.22
3.00
Drift Fact.
54.78
67.00
Field Cal
Hold Last Value
Abort Cal
Clear Cal
Hold Last Value
Disable Hold Last
Hold Last Value
Disable Hold Last?
OK
Cancel
Field Cal
Hold Last Value
Abort Cal
Clear Cal
Clear Cal
Clear Cal?
OK
Cancel
Field Cal
Save Cal
Save Cal?
OK
Cancel


Calib.
Field Cal
Test & Trim
Test & Trim
Channel Select
Trim
Test
Channel Select
4-20 mA Out1
4-20 mA Out2
Test & Trim
Channel Select
Trim
Test
Set Zero mA
21.40 mA
0.00 to 24.00
OK
Cancel
Measured Zero mA
21.20 mA
-48.00 to 48.00
OK
Cancel
Set Span mA
24.00 mA
0.00 to 24.00
OK
Cancel
Measured Span mA
24.00 mA
-48.00 to 48.00
OK
Cancel
Test & Trim
Channel Select
Trim
Test
Test
Set mA (Simulated)
Simulated mA
21.10 mA
0.00 to 24.00
OK
Cancel
Test & Trim
Save Trim
Discard Trim
Save Trim?
OK
Cancel
Test & Trim
Save Trim
Discard Trim
Discard Trim?
OK
Cancel

E.8 About Menu



E.9 Login Menu



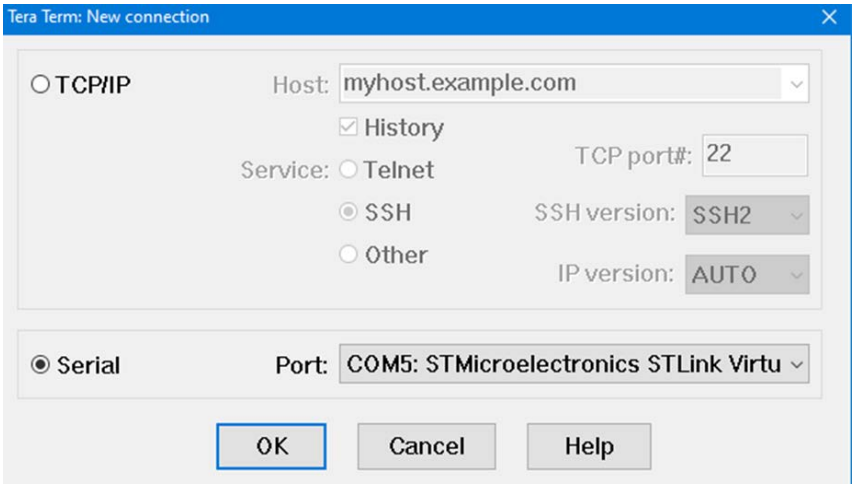
Appendix F. Bootloader

F.1 Setup

1. Power Supply
2. RS485 cable with USB adapter
3. Windows PC
4. TeraTerm Software (open-source terminal emulator)

F.2 Software Setup

1. Ensure the drivers for your RS485 ti USB adapter are installed
2. Start Tera Term application
3. The new connection menu will open:
   a. Select "Serial"
   b. Select the USB to RS485 adapter from the drop-down menu



4. Set the correct settings for the serial terminal
   a. From the menu at the top of the window, select "Setup" -> "Serial Port"
   b. Set the settings as shown below:
      i. Port: This does not need to be changed
      ii. Baud Rate: 11520
      iii. Data Bit: 8 bit
      iv. Parity: None
      v. Stop: 1 bit
      vi. Flow Control: None
      vii. Transmit Delay: 0.0
   c. Click “OK”
5. Set the correct font and text size (optional for readability)
   a. From the menu at the top of the window, select "Setup" -> "Font"
   b. Set the font to Arial

c. Set the font style to "Regular"

Note: *These are recommended settings, you may choose whichever font you are comfortable with.*

d. Click OK

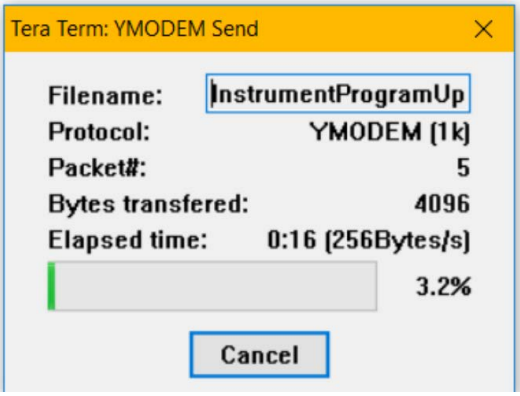
F.3 Accessing the Bootloader

When the device is powered up, the XMO2pro starts to autoboot the application skipping the bootloader. To disable autoboot and enter the bootloader, press any key.

F.4 Firmware Upgrade

To activate the bootloader, we can skip the autoboot procedure and access the bootloader.

1. On power up, you should see the autoboot screen
2. Press any key to skip autoboot
3. A login screen will appear. You need to login to activate the bootloader.
4. Enter the password and press Enter on the HMI
5. You will be presented with 4 options. Select “Upgrade”
6. Now, using Tera Term, select “File” -> “Transfer” -> “YModem” > “Send”
7. A file browse window will open
8. File your firmware binary file and select it
9. Click “Open”
10. A pop-up window shown below will open



11. Wait for the firmware binary fie to be downloaded (This may take a few minutes)
12. Once the file has been downloaded the bootloader will attempt to verify the downloaded binary:
13. The device will confirm the firmware has been installed correctly

IMPORTANT: It is important that the device does not lose power from this point until the firmware installation is confirmed. If the device loses power during the installation procedure it may cause a permanent software failure of the device.

F.5 Bootloader Config Menu

The config menu of the bootloader lets you setup display and serial port configurations. The display option. Gives you the following options:

1. Contrast
2. Backlight
3. Invert

The Serial menu gives you the following options for the serial port:

1. Mode
2. Baud Raute
3. Num Bits
4. Parity
5. Stop Bits

F.6 Bootloader Test Mode Menu

The Test Mode menu lets you toggle tests for the following:

1. Alarm Relays
2. Cal Relays
3. Loop 1 Relay

[no content intended for this page]

Appendix G. CE Mark Compliance

WARNING! To meet CE Mark requirements, you must shield and ground all electrical cables as described in this section (see *Table 7* below).

WARNING! CE Mark compliance is required for all units installed in EU countries.

WARNING! Cable entries of an approved flameproof design are required. These must be installed according to the manufacturer's instructions the choice of cable entry device may limit the overall installation category achieved.

WARNING! It is the responsibility of the user to ensure that all cable entry devices and covers are properly installed and secure prior to applying power to the XMO2pro.

Table 7: Wiring Requirements for CE Mark Compliance

Connection	Termination Modification
Power, Analog Outputs and Relay Outputs	1. When connecting the line power, analog outputs, and relay output cables, select the cable entry closest to the terminal blocks as shown in the wiring diagram in *Section 2.4.3* 2. Use shielded cable*. 3. Terminate the shield to the cable gland.
RS232/RS485 Output	1. Use shielded cable* to interconnect the XMO2pro enclosure with any external I/O devices. 2. Terminate the shield to the cable gland.

*Wires enclosed in a properly grounded metal conduit do not require additional shielding

[no content intended for this page]

Appendix H. Typical Application Examples

H.1 Blanketing Gases in Hydrocarbon Liquid Storage Tanks

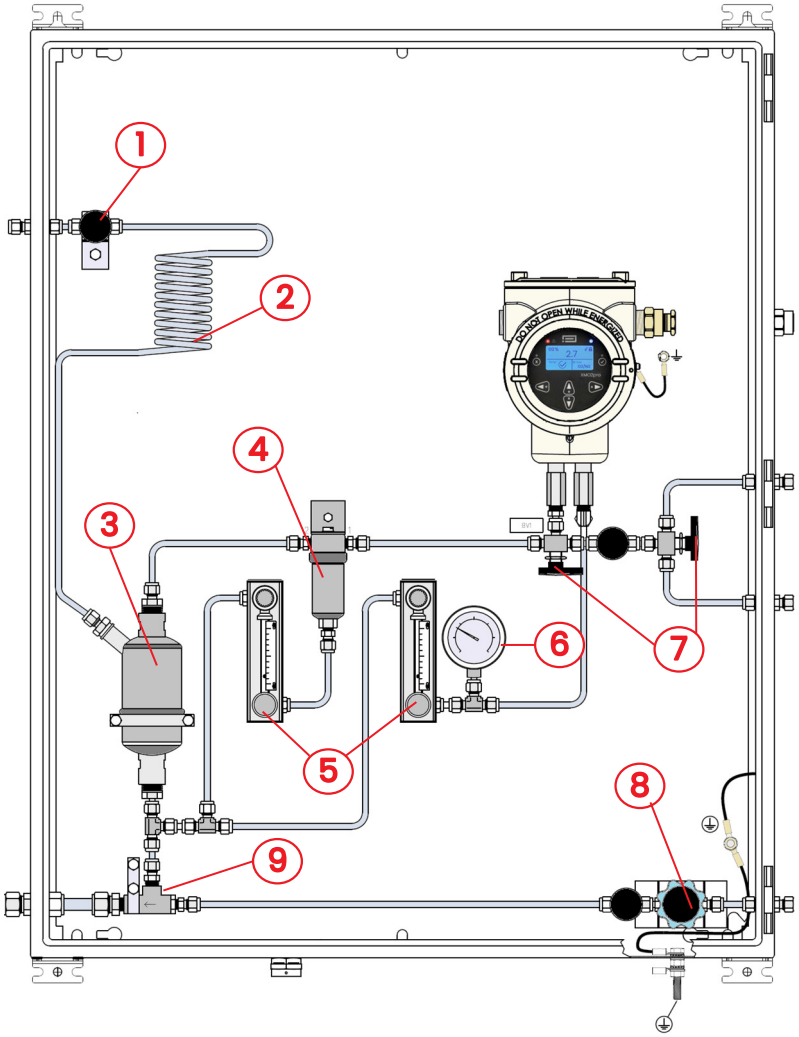
The XMO2pro analyzer and its associated sample system is often used to measure the concentration of oxygen (O_2) in the nitrogen (N_2) or carbon dioxide (CO_2) gases used to blanket hydrocarbon liquids during storage.

H.1.1 The Problem

Air can leak into the vapor space above hydrocarbon liquids stored in tanks or process vessels, forming a potentially explosive gas mixture. To solve this problem, inert gases such as N_2 or CO_2 are often used to purge the vapor space above the stored liquid and dispel any O_2 that may have leaked into that space. In such a system, one must constantly monitor the level of O_2 in the vapor space to make sure that an explosive gas mixture does not form.

H.1.2 Equipment Used

A typical instrumentation package for this application includes an XMO2pro analyzer configured for a range of 0-21% O_2 in N_2 or CO_2 and operating conditions of ambient temperature and atmospheric pressure. The XMO2pro is mounted in a sample system similar to the one shown in *Figure 20* below.



1. Needle valve
2. Condensing coil
3. Liquid dump
4. Coalescing Filter
5. Flowmeter
6. Pressure gauge
7. Three-way ball valves
8. Pressure regulator
9. Eductor

Figure 20: Blanketing gas sample system

A typical sample system in *Figure 20 on page 99* consists of:

- An eductor to draw the sample from and return it to the vapor space above the liquid in the storage tank.
- A liquid separator/dump to remove condensible liquids.
- A filter/coalescer for the removal of solid and liquid particulates.
- Flowmeters.
- Pressure gauges.

All components are mounted on a painted steel plate that may be housed in a heated enclosure.

H.1.3 Basic Operating Procedure

The sample system should be located at or near the top of the storage tank so that condensate can drip back into the tank. The gas used to purge the tank provides the motive force in the eductor to pull a gas sample from the vapor space above the hydrocarbon liquid into the sample system. The sample gas, condensed liquids, and the inert gas are all returned to the tank, making this is a closed-loop system. The XMO2pro is recalibrated periodically using the purge gas to zero the instrument and ambient air (20.93% O_2) to span the instrument. The span gas can optionally be vented to atmosphere, so that air is not introduced into the storage tank.

For this application the required calibration gases are:

- Zero Gas: N_2 or CO_2 (at least 99.95% pure)
- Span Gas: air (20.93% O_2)

H.1.4 Previous Systems

Electrolytic cells were once commonly used for this application. However, such systems required extensive maintenance and frequent manual calibration. In addition, the cells were easily damaged by condensible liquids, requiring frequent cell replacement. As the XMO2pro provides continuous monitoring of the O_2 content with maintenance free operation, it is now the system of choice.

H.2 Reactor Feed Gases in Formaldehyde Production

The XMO2pro analyzer and its associated sample system is often used to measure the concentration of oxygen (O_2) in an air/ methanol (CH_3OH) vapor mixture that is commonly used as a reactor feed gas in the production of formaldehyde.

H.2.1 The Problem

In order to maximize the yield of the reaction, while maintaining the O_2 concentration at a safe level, the air/CH_3 OH vapor mixture must be continuously monitored and accurately controlled.

H.2.2 Equipment Used

A typical instrumentation package for this application includes an XMO2pro analyzer configured for a range of 0-21% O_2 in N_2 or CO_2 and operating conditions of a controlled temperature and atmospheric pressure. The XMO2pro is mounted in a sample system similar to the one shown in *Figure 21* below (ref. dwg. #SS35D).

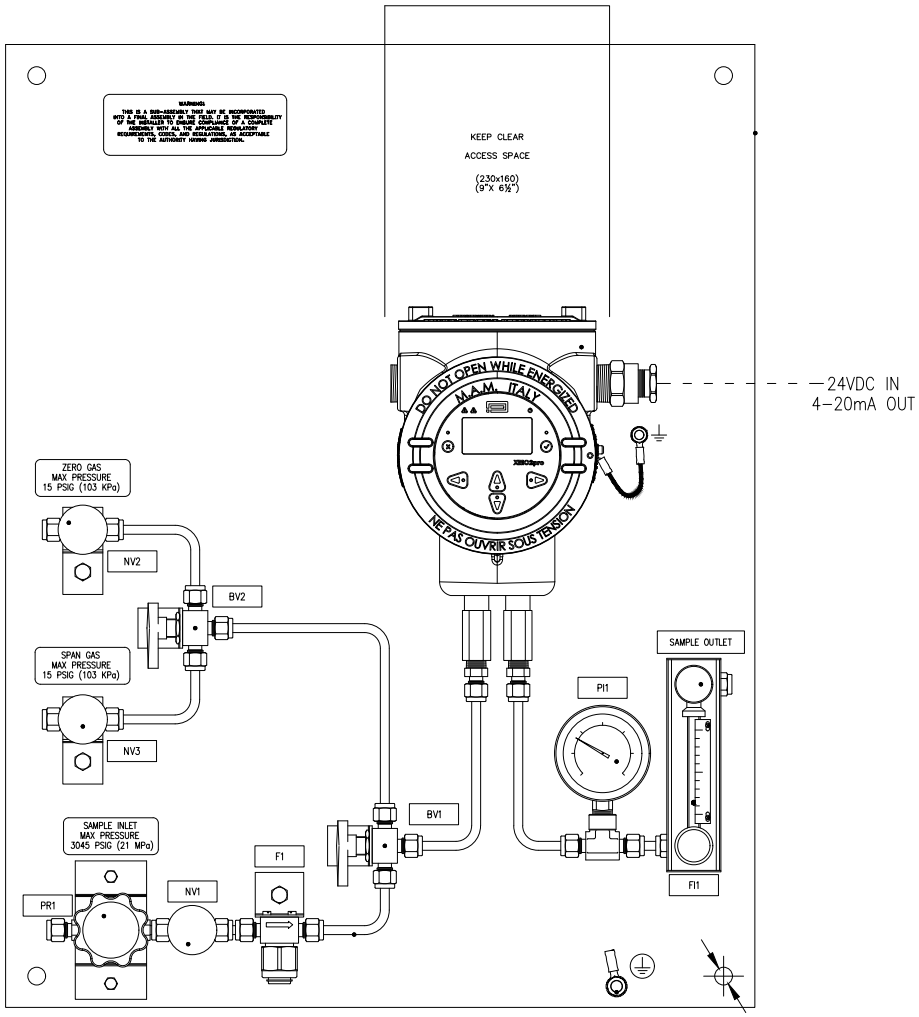


Figure 21: Formaldehyde feed gas sample system

The sample system in *Figure 21* consists of:

- Inlet, outlet, and calibration needle valves
- A filter/coalescer assembly
- Pressure gauges

- Flowmeters

All components are mounted on a painted steel plate in an enclosure that is heated to 75 ±10°F.

H.2.3 Basic Operating Procedure

The sample system should be mounted as close as possible to the reactor inlet in order to minimize lag time. Air (20.93% O_2) is used as the source of O_2, and the air/CH_3 OH vapor mixture is sampled at the reactor inlet. The XMO2pro continuously verifies that the optimal amount of O_2 (typically 9.8%) is present for the reaction to proceed safely to a maximized yield. Too low an O_2 level will decrease the yield, while too high an O_2 level will create a safety hazard.

For this application the required calibration gases are:

- Zero Gas: N_2 (at least 99.95% pure - 0.0% O_2)
- Span Gas: air (20.93% O_2)

H.2.4 Previous Systems

Dumbbell-type paramagnetic O_2 sensors were once commonly used for this application. However, such systems required extensive maintenance and frequent manual calibration. In addition, the sensors were easily damaged by condensible liquids, requiring frequent sensor replacement. As the XMO2pro provides continuous, accurate monitoring of the reactor feed gas O_2 content with maintenance-free operation and excellent calibration stability, it is now the system of choice.

Appendix I. Calibration Sheet

Panametrics

XMO2pro CALIBRATION SHEET

Tag #	NA
XMO2Pro Ser # :	84F73KD9
XMO2Pro P/No. :	XMO2PRO-4-1-4-1-0-2-0-NON-SIL-S
Software Revision:	VER 0.9.90
Calibration Gases :	N2 / CO2
Calibration Range:	0-2% O2
Work Order Number:	9305043
Temperature:	High Operating Temperature
Calibration Date:	29/02/2025
Technician:	J Hutton

Default Passwords:	Decimal	HMI
User:	7951	▲▲▲▲▲▲▲▲▲
Admin:	7852	▲▼▲▼▲▼▲▼
SIL:	NA	NA

The default user profile password is "▲▲▲▲▲▲▲▲" (eight times **up key)**

XMO2 Enable Compensation	Background	XMO2 Oxygen Grid	XMO2 Recorder
Yes	**N2/CO2**	**2 PTS, 2 CURVES**	**4-20mA 0-2% O2**

Curve 1 - Nitrogen (N2)				
PT	**%O2**	**O2 (mV)**	**Comp (mV)**	**O2 Output (mA)**
1	0.00	-39.40	363.70	4.00
2	2.00	88.30	363.90	20.00

Curve 2 - Carbon Dioxide (CO2)				
PT	**%O2**	**O2 (mV)**	**Comp (mV)**	**O2 Output (mA)**
1	0.00	-9.40	333.80	4.00
2	2.00	206.40	335.50	20.00

Field Calibration: Recommended values
ZERO:- Apply 100%N2
SPAN:- Apply 2% O2/N2

(EN) We hereby certify this Product has been manufactured and calibrated to product specification
(JP) この製品が製品仕様に合わせて製造され、校正されていることをここに証明します
(CN) 我们特此证明本产品已按照产品规格制造和校准
(DE) Wir bestätigen hiermit, dass dieses Produkt gemäß den Produktspezifikationen hergestellt und kalibriert wurde
(FR) Nous certifions par la présente que ce produit a été fabriqué et calibré selon les spécifications du produit
(ES) Por la presente certificamos que este Producto ha sido fabricado y calibrado según las especificaciones del producto.
(PT) Certificamos que este produto foi fabricado e calibrado de acordo com as especificações do produto

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Appendix J. Abbreviations

Abbreviation	Meaning
HMI	Human Machine Interface
LCD	Liquid-Crystal Display
Cal	Calibration
SIL	Safety Integrity Level
PC	Personal Computer
ERR	Error
CH1	Channel 1
CH2	Channel 2
LED	Light Emitting Diode
4-20 mA Out 1	Analog Output 1
4-20 mA Out 2	Analog Output 2
Config	Configuration

[no content intended for this page]

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