

Oxygen Transmitter

Microx ProSafe SIL2

O2-Safety-Device

User Manual



Revision History

Issue No.	Description	Date	Author Initials
00	New document	06/2025	PS, NF, IM
01	Update of certificate	07/2025	PS
02	DwyerOmega document layout	10/2025	MB, PS



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Microx ProSafe SIL2

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Before using your Microx ProSafe SIL2

Safety Information



Necessary safety precautions are described in the following chapters and also highlighted using pictographic warnings on yellow background (as above). Functional safety aspects are covered in the Microx ProSafe SIL2 Safety Manual (ES016e)

Integration into a larger safety instrumented system (SIS) also requires consideration of application-specific environmental conditions and risks. A final evaluation and validation of the safety function must be carried out by the system developer, who determines the O₂ threshold value for safety shutdown on this basis.

Installation, initial commissioning, inspection, maintenance, and servicing must be carried out by trained specialists.

Abbreviations

AC	Alternating Current
AM	Additive Manufacturing
Ar	Argon
CO ₂	Carbon Dioxide
DC	Direct Current
°C	Degrees Celcius
°F	Degrees Fahrenheit
EEPROM	Electrically Erasable Programmable Read-only Memory
ELV	Extra Low Voltage
ESD	Electrostatic Discharge
g	Grams
GND	Ground
kg	Kilogram
LED	Light Emitting Diode
LPM	Liters per Minute

mA	Milliamp
N ₂	Nitrogen
OEM	Original Equipment Manufacturer
PCB	Printed Circuit Board
PELV	Protective Extra Low Voltage
PLC	Programmable Logic Controller
PLd	Performance Level d
PPM	Parts per Million
SELV	Safety Extra Low Voltage
SIL	Safety Integrity Level
SIS	Safety-instrumented System
ZrO ₂	Zirconium Dioxide

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1 Introduction

The Microx ProSafe SIL2 oxygen transmitter measures oxygen (O₂) by means of amperometric zirconium dioxide (ZrO₂) sensors where the volumetric O₂ concentration in gas mixtures is determined. The oxygen measurement is used for inerting monitoring in a larger safety instrumented system. The safety function (via relay) evaluates that an oxygen concentration is safe when it is below a defined threshold value.

1.1 Scope of Use

Microx ProSafe SIL2 is ideal for use in the following applications:

- Additive Manufacturing (AM) – powder bed fusion machines, sieving systems for AM metal powder
- Filtration systems
- Glove box and containment solutions
- Inert gas blanketing applications.

NOTE: The sensors are calibrated and specified for nitrogen inerting. Argon can also be used as an inerting gas; this will slightly affect accuracy but not the safety integrity level.

Application limitations are listed below:

- The system is not ATEX-approved because its internal sensor achieves elevated temperatures during normal use (up to ca. 600 °C)
- The sensor is not recommended for use in flammable gases, as local combustion can cause inaccurate (reduced) O₂ concentration readings. If using in flammable gases, the concentration of combustible gases must be negligible to the O₂ concentration.
- The use in deviating inerting gases e.g. carbon dioxide (CO₂) has not yet been evaluated for use as part of a safety-integrated system (SIS).
- The sensor is not suitable for measuring O₂ concentrations in liquids.
- The sensor is not suitable for use with AM plastic powders or filaments.
- The sensor is not suitable for conditions with condensing humidity, and therefore not suitable for outdoor use.

1.2 Overview

With current-limiting zirconia sensors, Microx ProSafe SIL2 delivers a long-life, reliable solution capable of an extended measurement range.

This dual-channel transmitter features a SIL-capable alarm set-point for management of gas quality and personnel safety. Factory-calibration with data points stored in the smart oxygen sensors, streamline sensor replacement to save time and simplify your process.

Microx ProSafe SIL2 features:

- A high-resolution sensor for low oxygen concentration measurement, ensuring high accuracy.
- DIN rail mounting for installation inside a control cabinet.
- Supply via external 24 V DC SELV (safety extra-low voltage) supply.
- Maximum current consumption: 250 mA (channel 1) + 250 mA (channel 2).
- One potential-free contact pair per channel for safety
 - The contact pair is closed when the O₂ concentration is below the threshold value
 - To achieve SIL2/PLd, both contact pairs must be closed
 - If the O₂ threshold is exceeded, in the event of a fault or when the system is taken out of service, the contact pairs will open.
- Primary measuring range: 0.1...23.5 % O₂ (1st sensor, channel 1)
 - Analog (4...20 mA) or digital (RS485/Modbus) O₂ reading output
 - Periodic test is carried out in air, see Safety Manual (ES016e)
 - The primary measuring range has the advantage of direct functional testing in air.
- Secondary measuring range: standard 0.01...2.35 % (2nd sensor, channel 2)
 - Analog (4...20 mA) or digital (RS485/Modbus) O₂ reading output
 - Periodic test is carried out by comparing with channel 1, see Safety Manual (ES016e)
 - The secondary measuring range has the advantage of a more precise O₂ measurement below 2 % O₂.

1.3 System Overview

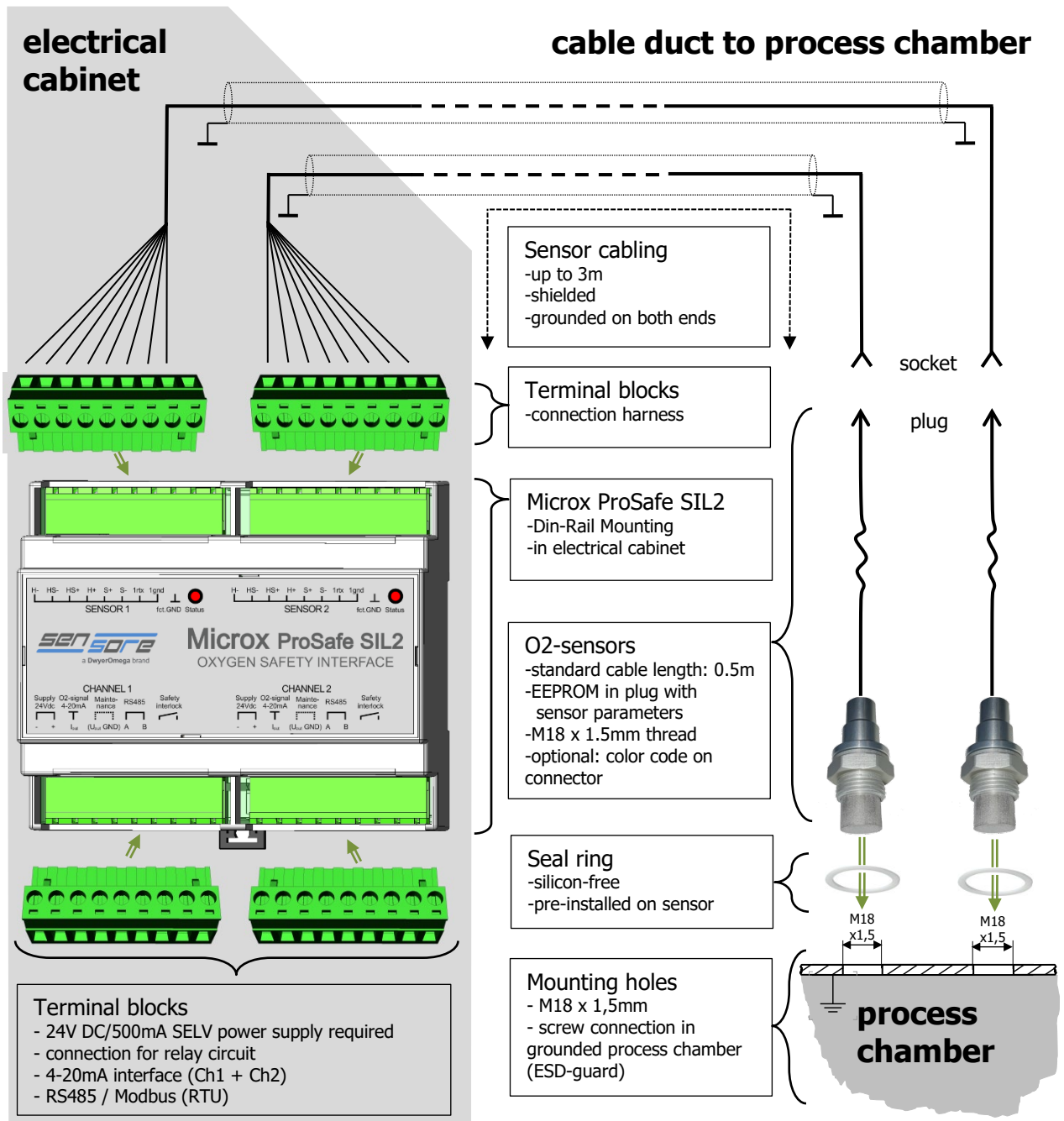


Figure 1. Larger Safety System schematic

The specification for the O₂ measurement is determined by the sensor.

- The design of the sensor chip defines the O₂ measuring range.
- The calibration information is stored in the sensor connector (EEPROM).
- The main parameters are:
 - Specified total measuring range: standard 0.01...23.5 % O₂
 - Display channel 1: standard 0...23.5 % O₂
 - Display channel 2: standard 0...2.35 % O₂
- O₂ safety threshold: as defined by order code, 2 %, 1.5 % or 1 % O₂.

2 Microx ProSafe SIL2 Functions

The essential operating parameters for the sensors are in a non-volatile memory (EEPROM) on the sensor connector, i.e. there is no need to calibrate the sensors with or match them to a specific monitor.

2.1 O₂ Threshold Detection - Safety Function

Both channels have a potential-free contact pair (relay). The Microx ProSafe SIL2 detects a safe condition only when both pairs of contacts are closed.

Details of the safety function:

- The safety critical O₂ threshold value and hysteresis is stored in the EEPROM on the sensor connector.
- The relays open when the threshold value is exceeded.
- They close when it falls below (O₂ threshold hysteresis).



To implement SIL 2/PLd, the contact pairs must be connected in series, or in the case of a single tap, they must be linked to an AND function by the larger safety instrumented system.

2.2 Analog Output (4...20 mA)

$$\text{Channel 1: } \text{Measured } O_2 = \frac{I_{out} [mA] - 4mA}{16mA} \times 25 \% O_2$$

$$\text{Channel 2: } \text{Measured } O_2 = \frac{I_{out} [mA] - 4mA}{16mA} \times 2.5 \% O_2$$

- I_{out} is the measuring current of the 4...20 mA current loop at the respective channel
- The value range is cut off at 19 mA (23.5 % O₂ or 2.35 % O₂)
- Current values between 19 and 20 mA are used to indicate special states and faults
- Special Channel 2 Special Conditions:
 - 19.05mA >2.35 % O₂ - slight exceedance of measuring range (sensor heated)
 - 19.10mA >>2.35 % O₂ - strong measuring range exceedance (sensor unheated, standby).
- General special states of channels 1 and 2:
 - 19.15 mA Heat
 - ≥19.2 mA Error
 - ~0.5 mA Over-temperature shutdown (special fault mode).

2.3 Digital Output (RS485/Modbus)

$$\text{Channel 1: } \text{Measured } O_2 = \frac{O_2\text{norm}}{1000} \times 25 \% O_2$$

$$\text{Channel 2: } \text{Measured } O_2 = \frac{O_2\text{norm}}{1000} \times 2.5 \% O_2$$

- The digital value "O2norm" is read out via register 0x0002
- The digital value range is only cut off at 1,250, i.e. an O₂ measurement value is transmitted digitally even if the measuring range is slightly exceeded
- Special states can be read via registers 0x0000
- Further details on RS485/Modbus communication can be found in "9 RS485 Modbus Interface" on page 21.

2.4 Status LEDs/System States

Stable (Measurement) States	
LED permanently on	Channel 1/2 and O ₂ measurement mode
LED On, flicker every 5s	Channel 2 in standby mode because O ₂ concentration is too high for O ₂ measurement mode
Temporary States (during start-up)	
LED 0.5s on, 0.5s off	Contact check of the sensors (usually imperceptible 1...2s)
LED 0.2s on, 0.8s off	Heating phase of the sensors (typically 60s per channel)
Error States that may resolve without intervention	
LED flashing (10 Hz)	Error mode (restart the sensor after 60s)
LED off	Temporary complete extinction of the LED, followed by failure mode, occurs when overtemperature protection mode is activated. => installation situation/check ambient temperature
Error States that require intervention	
LED 0.5s on, 0.5s off	System gets stuck in contact test => check the connection of the sensors
LED flashing (10 Hz) longer than 60s	No reboot from error mode, after repeated error => see 8.2

3 Installation

Only assemble and install the transmitter when it is powered off and disconnected from the electricity supply.

3.1 Sensor Installation in a Process Chamber

- The sensor has an M18 x 1.5 mm screw thread for mounting in the wall of the process chamber.
- A silicone-free sealing ring must be provided for sealing, an appropriate sealing ring is pre-installed.
- The sensor has been evaluated for oxygen safety monitoring applications within gas temperatures ranging from 10...100 °C (50...212 °F). Monitoring oxygen at higher gas temperatures is possible but will require separate approval.

 Positioning the sensors incorrectly in the process chamber can negatively impact measurement. To avoid this:

- Do not mount sensors in the immediate vicinity of gas inlets or outlets
- Do not place them near heaters/fans or in direct airflow
- Mount on surfaces that will not vibrate.

For oxygen measurement, the gas must pass the sensor's porous sinter cap. To facilitate this:

- The sinter cap should protrude into the process chamber as much as possible
- Contamination/encrustation of the sinter cap must be avoided
- Mounting the sensor upside down should reduce contamination risks.

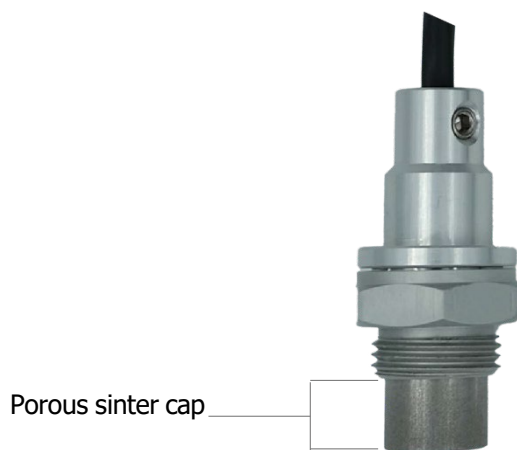


Figure 2. Sensor's porous sinter cap

 If the sensor is located so that its housing is easily accessible to end-users, please note the following:

- During operation, the sensor housing's temperature can reach up to 60 °C (140 °F)
 - Sensor housing temperature depends heavily on the thermal connection to the process chamber.
- Use appropriate warning labels, when necessary, e.g. "hot surface"





- When the sensor's metal housing is screwed directly into the grounded metal wall of the process chamber, it provides adequate protection against electrostatic discharge (ESD). Refer to Figure 1 on page 3 for guidance.

3.2 Connection in a Control Cabinet

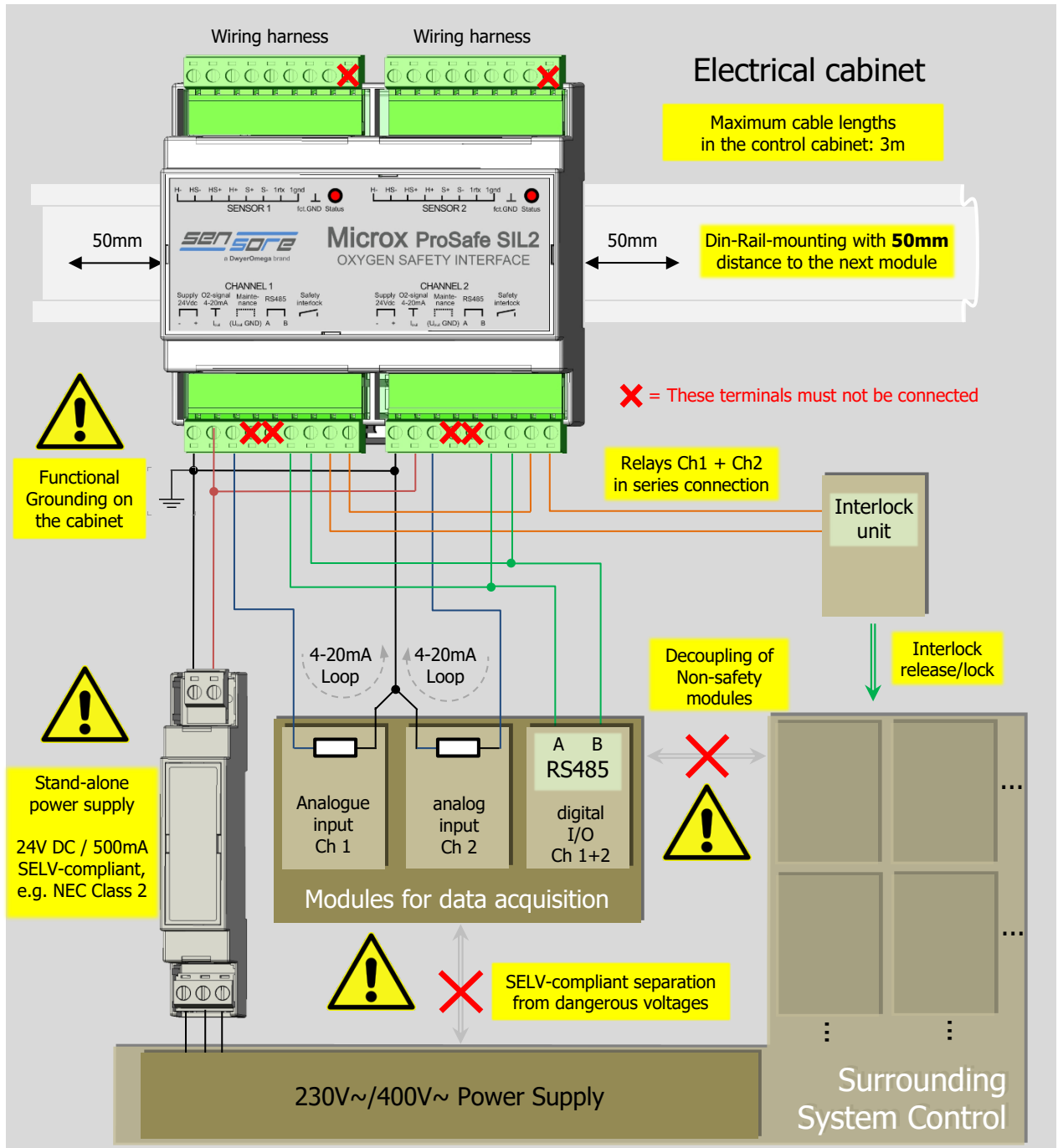


Figure 3. Control Cabinet Connections

NOTE: Installation must be carried out by trained specialists.

- Microx ProSafe SIL2 can be mounted on a DIN rail in a control cabinet.
 - Functional grounding must take place at one point, in the immediate vicinity of the transmitter.

⚠ A SELV power supply unit (24 V DC, min. 500 mA) must be provided for the power supply, which is used exclusively to supply the transmitter.

The entire O₂ safety monitoring is to be implemented as a SELV / PELV circuit. Due to the functional GND connection the resulting circuit will be PELV

⚠ The O₂ safety monitoring system must be decoupled from the rest of the installation's facilities.

Interfaces for data acquisition must be checked for suitability; for RS485, galvanic decoupling must be provided if necessary.

3.2.1 Connection Assignment - Control Cabinet Side

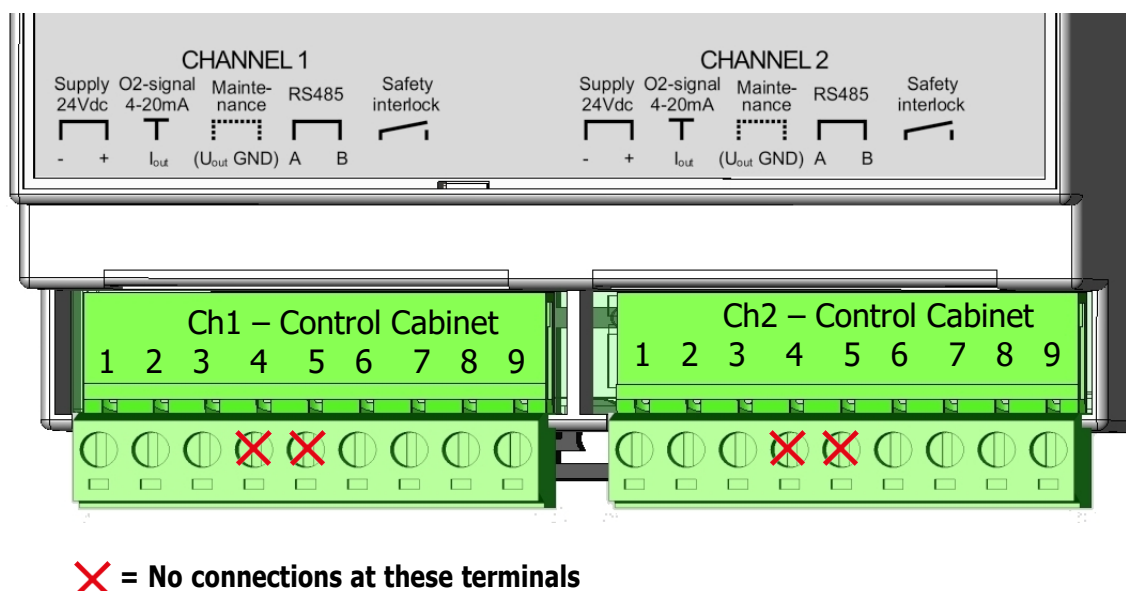


Figure 4. Cabinet side connections

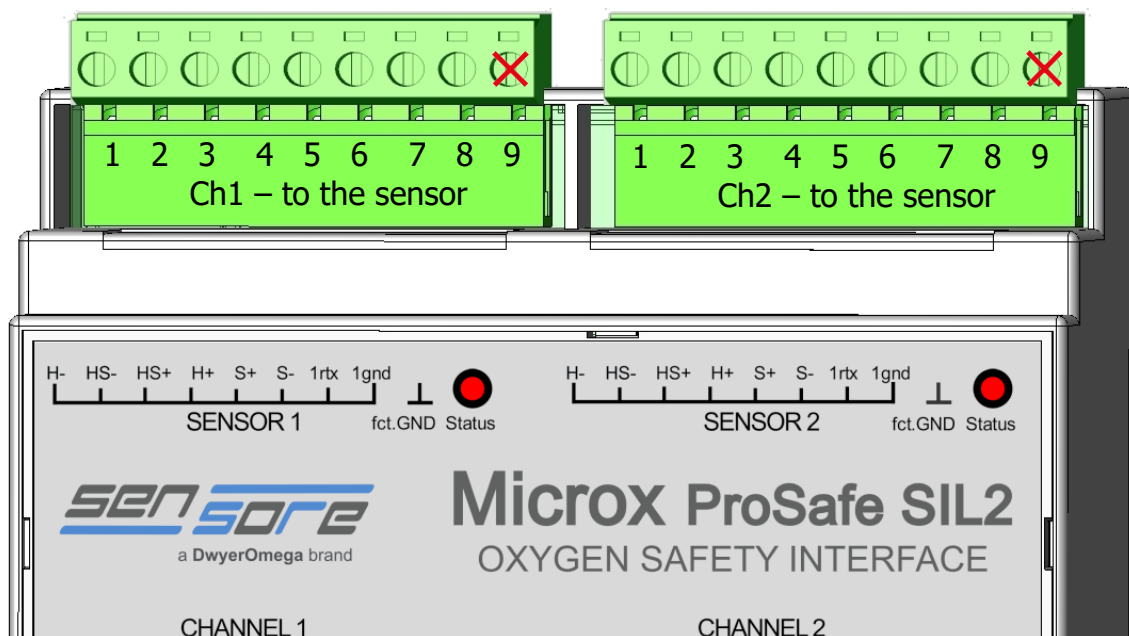
POs	Function	Information
1	Power supply 24 V - (Earth)	To be connected to SELV power supply
2	Power supply 24 V +	
3	Iout (4...20 mA)	Current loop output for the O2 reading, must be traced back to pin 1 (see 3.2 on page 7)
4	Uout	To be connected for maintenance, see next page
5	GND	
6	RS485 A	Connection to RS485 only with external protection measures
7	RS485 B	
8	Relay contact/Potential free Contact pair	Closed only when safe O2 concentration is detected
9		

- Optional voltage output 0...5 V, Uout and GND (pins 4 and 5)
 - The analog voltage output does not allow active fault detection (e.g. cable breakage, transmitter out of operation) and may therefore only be tapped for maintenance.
 - During maintenance, a voltage proportional to the O₂ concentration can be monitored during measurement operation, this will test the basic function of the Microx ProSafe SIL2.
- RS485
 - Ground reference for the RS485 signals is pin 1. This means that a possible RS485 ground connection must be made to pin 1 (not pin 5).

3.2.2 Wire the Sensors

The electronics and sensors are connected to each other via cable harnesses, permanently installed in the system. These along with short sensor cables (50 cm), facilitate easy sensor installation.

3.2.3 Connection Assignment - Sensor Side



✗ = No connections in these terminals

Figure 5. Sensor Side Connections

POs	Function	Information
1	Sensor H-	To be connected to sensor cabling
2	Sensor HS-	To be connected to sensor cabling
3	Sensor HS+	To be connected to sensor cabling
4	Sensor H+	To be connected to sensor cabling
5	Sensor S-	To be connected to sensor cabling
6	Sensor S-	To be connected to sensor cabling
7	1rtx (1-Wire-EEPROM)	To be connected to sensor cabling
8	1gnd (1-Wire-GND)	To be connected to sensor cabling
9	Fct. GND	Not to be connected

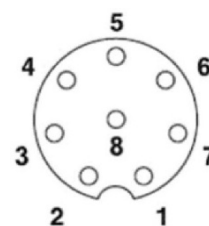
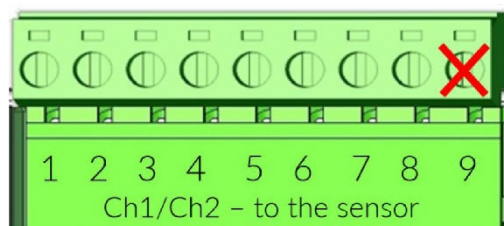
3.3 Sensor Connector Design

3.3.1 Connection via M12 cable assembly (maximum 3 m)

Sensors with M12 connector design require two connector cables with the following parameters:

- Sensor direction: M12 female, female, 8-pin, A-coding
- Cable: AWG24/0.25 mm², shielded, maximum length 3 m
- Direction electronics: open end of cable.

Variant A requires the following connections for both channels:



Sensor Side		DIN 47100 Color Code	M12 Pin No.
POs	Function		
6	Sensor S-	White	1
5	Sensor S-	Brown	2
8	1gnd	Green	3
7	1rtx	Yellow	4
2	Sensor HS-	Grey	5
3	Sensor HS+	Pink	6
1	Sensor H-	Blue	7
4	Sensor H+	Red	8

NOTE: The Color code may differ from DIN 47100.

3.4 Route Cables and Shielding Grounding

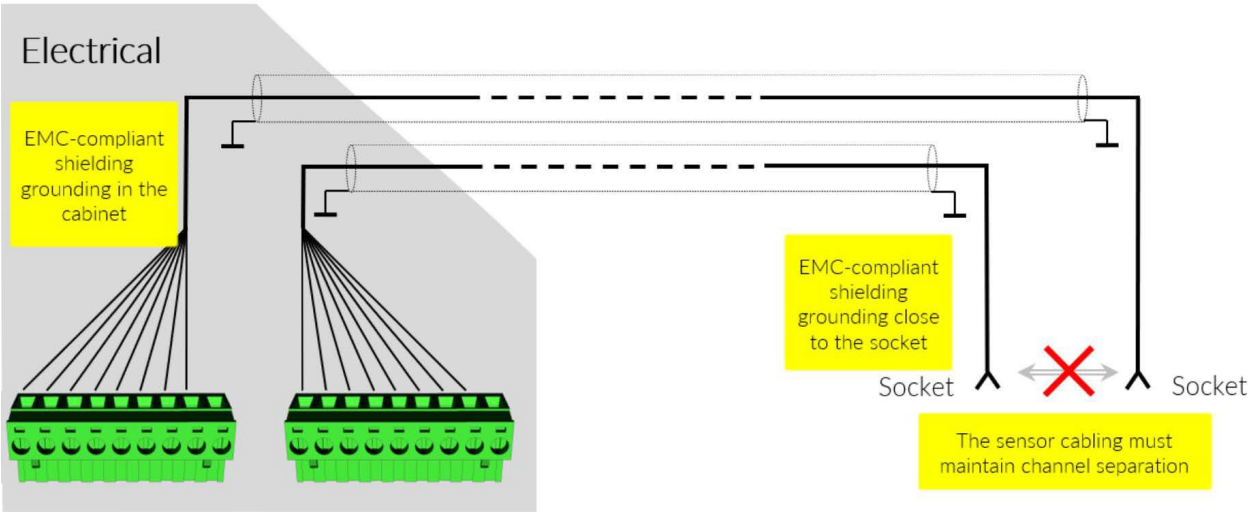


Figure 6. Shielding Grounding

4 Commissioning

A periodic test is must be carried out before using the Microx ProSafe SIL2. It should be implemented into a larger SIS to determine an automated periodic test of sensor performance. The periodic test monitors drift, so that preventive sensor replacement can be carried out, when required, to maintain optimal performance.

Periodic tests are covered in the Safety Manual (ES016e).

4.1 Initial Power-up

- The system will power-up as soon as the supply voltage is connected.
- After initial power-up, a periodic test must be carried out as described in Section 3 of the Safety Manual (ES016e).

4.2 Power-up after Maintenance

- After power-up following maintenance, a periodic test must be carried out as described in Section 3 of the Safety Manual (ES016e).

4.3 Decommissioning

- The system can be safely powered-down by disconnecting the supply voltage.

4.4 Recommissioning

- The system will restart as soon as the supply voltage is connected.
- For recommissioning after a malfunction, please refer to "8.2 Recovering from (Permanent) Fault Conditions" on page 19.

4.5 System Behavior During Commissioning

Commissioning In Air					
Channel States	Duration (secs)	Channel 1		Channel 2	
		4... 20 mA	LED	4 .. 20 mA	LED
Contact Check	<1		-		-
Ch1: Heating up Ch2: Standby	~30	~19.15 mA	Flashing	~19.10 mA	On with Standby flickering*
Ch1: Stabilizing Ch2: Standby	~30	~19.15 mA	Flashing	~19.10 mA	
Ch1: Measuring O ₂ Ch2: Standby	Continuous	~17.38 mA (~20.9 %)	On	~19.10 mA	

* In standby mode, the LED is always on but flickers every 5 seconds.

Commissioning at 1 % O ₂					
Channel States	Duration (secs)	Channel 1		Channel 2	
		4... 20 mA	LED	4 .. 20 mA	LED
Contact Check	<1		-		-
Ch1: Heating up Ch2: Standby	~30	~19.15 mA	Flashing	~19.10 mA	On with Standby flickering*
Ch1: Stabilizing Ch2: Standby	~30	~19.15 mA	Flashing	~19.10 mA	
Ch1: Measuring O ₂ Ch2: Heating up	~30	~4.64 mA (~1.0 %)	On	~19.15 mA	Flashing
Ch1: Measuring O ₂ Ch2: Stabilizing	~30	~4.64 mA (~1.0 %)	On	~19.15 mA	Flashing
Ch1: Measuring O ₂ Ch2: Measuring O ₂	Continuous	~4.64 mA (~1.0 %)	On	~10.4 mA (~1.0 %)	On

* In standby mode, the LED is always on but flickers every 5 seconds.

5 Maintenance

5.1 Inspect Your Sensors/Sensor Cleaning

The sinter caps of the sensor must be checked for visible contamination.

The sensors may only be cleaned mechanically (brushing), no chemical cleaning agents or water may be used for cleaning.

5.2 Inspect Your Microx ProSafe SIL2

Verification of the safety function in the Safety Manual (ES016e), also covers the required safety-related measurement accuracy of the Microx ProSafe SIL2.

5.3 Process Measurement Accuracy

Hardware self-monitoring and periodic tests are only used to ensure O₂ threshold monitoring. Further measures may be required to monitor process accuracy, e.g. tighter limits on periodic inspections.

6 Repairs and Replacements

6.1 Replace the Sensor

Sensors should be replaced either at the end of the maximum service life or if they are defective.

The maximum service life is 5 years after initial commissioning of a sensor in the system. The prerequisite for this is a logging of the initial commissioning by the customer.

NOTE: If the customer fails to log this information, the date of manufacture of the sensor is considered the time of the initial commissioning.



Only previously unused O₂ sensors may be used as a replacement. In the case of the replacement sensor, the article number/parameter configuration must match the old sensor.

Procedure for sensor replacement:

- Before replacing the sensor, Microx ProSafe SIL2 must be powered down.
- If the sensor is replaced during operation, the transmitter switches to fault mode for approximately 60 seconds; if the fault is triggered repeatedly, it will switch to permanent fault mode. This can only be resolved by powering-down.
- Ensure general practice ESD precautions are adhered to while changing the sensor.
- During sensor replacement ensure that the new sensor is:
 - Assigned to the correct channel
 - Sealed to the process chamber
 - Relocked at its connector.
- After the sensor has been replaced, the transmitter can be powered up.
- Once replaced, carry out a periodic test of the system, see safety manual (ES016e).
- If the 25 % sensor for channel 1 has been replaced, tighter limits apply for periodic testing in air:
 - When operating in air with low humidity (0 %rh), an O₂ value between 20.4 % and 21.4 % can be achieved
 - For this measurement, it is essential that the O₂ measurement is not influenced by a nitrogen/argon supply. High humidity can also affect the measurement.

6.2 Replace the Microx ProSafe SIL2

Microx ProSafe SIL2 has a maximum service life of 20 years. If the transmitter is replaced, the sensor's do not need to be replaced if they are less than 5 years old and performing well.

After replacing the transmitter, a periodic test must be carried out. This is covered in the Safety Manual (ES016e).

6.3 Installation Changes

- If the transmitter's wiring is altered during a repair, a periodic test must be carried out afterwards.
- If transmitter components (e.g. power supply) are replaced, a periodic test must be carried out afterwards. Periodic tests are covered in the Safety Manual (ES016e).

7 Disposing of

Dismantling the Microx ProSafe SIL2 must be carried out when it is powered off.

The system must be disposed of appropriately, and sensors must be disposed of as electronic waste.

8 Troubleshooting

If the system detects a fault condition, it will initiate the following:

- Interrupt the external interlock circuit (open safety relay contacts)
- Switch into a failure mode, indicated with flashing LEDs and 19 mA analog output via RS485 (see Section 9.5 on page 24)
- After 1 minute in failure mode, the system will initiate an automatic restart
- Following repeated automatic restarts, the system will enter a permanent error state (see Section 9.5 on page 24)

To recover from a permanent error state, see Section "8.2 Recovering from (Permanent) Fault Conditions" on page 19.

8.1 Error Codes

No.	Error State	Description	Troubleshooting/Cause
0	No error		
1	Channel	Fault detected on the other channel	Troubleshooting on the opposite channel, check power supply and sensor connection
2	Heating	Failure during the heat-up phase	Occasional errors are automatically resolved by restarting the heating process For persistent heat-up errors, the sensor must be replaced, or the sensor wiring checked
3	Heater open circuit	Fault with sensor heater	Check sensor wiring or replace sensor
4	Heater short circuit	Fault with sensor heater	Check sensor wiring or replace sensor
5	Heater control	Incorrect sensor temperature	Check sensor wiring or replace sensor
6	Sensor cell	Implausible sensor current/voltage	Check sensor wiring or replace sensor
7	24V	Incorrect or faulty supply voltage	Check external supply voltage
8	3V3	Internal voltage fault	Check the external supply voltage. In case of continuous or repeated occurrence, it is necessary to replace the transmitter
9	1V1		
10	Over-temperature	Over-temperature of electronics	Check ambient temperature in electrical cabinet and of the transmitter. If persistent, replace the transmitter
11	Watchdog	Internal electronics monitoring errors	If error is permanent or repetitive, replace the transmitter
12	Relay		
13	Reserved		
14	Error on Uout	Faulty connection of Uout	Check Uout terminal and connection
15	External EE	Fault with the EEPROM of the sensor	Check sensor replacement or sensor wiring
16	EE Error Internal	Fault at the sensor EEPROM	Invalid EEPROM data. If parameter data is corrupted, contact SENSORE.

No.	Error State	Description	Troubleshooting/Cause
17	Flash	Self-monitoring error detection	If persistent or repetitive, replace the transmitter.
18	RAM		
19	System		
20	Parameter	Invalid sensor parameters	Sensor parameter set incompatible with SIL2 system => sensor replacement required
21	Watchdog	Critical error in the SW sequence	If persistent or repetitive, replace the transmitter.

8.2 Recovering from (Permanent) Fault Conditions

8.2.1 Via RS232/Modbus

To restart switch to programming mode then initiate measurement mode.

8.2.2 Disconnect (and reconnect) Power Supply

- Disconnect the power supply for at least 5 seconds.
- Reconnecting the power supply.

8.2.3 Disconnect (and reconnect) Sensors

Disconnecting/ and reconnecting the sensors will restart the system without requiring a power cycle. This is not recommended because reconnecting sensors when the system is powered-up may trigger a fault condition.

8.3 Interference with O₂ Measurement

The Microx ProSafe SIL2 is designed for measurement in O₂/N₂ or O₂/Ar atmospheres, i.e. it is assumed that other gases only occur in trace amounts (<1000 ppm).

8.3.1 Temporary Impairment of O₂ Measurement

- Rapid pressure fluctuations can lead to a short-term disturbance of the O₂ measurement, such influences can be reduced by averaging the output measured analog signal over time
- Operating below the specified measuring range increases the cross-sensitivity to oxygen containing gases such as H₂O (water vapor) or CO₂, which leads to an increase in the O₂ measurement signal.
- Traces of flammable gases can lead to a reduction in the O₂ measurement signal if present in a high enough concentration.

8.3.2 Permanent Impairment of O₂ Measurement

- When the Pt-ZrO₂ electrode is damaged by chemical substances, the sensor aging may accelerate, leading to permanent reduction in the O₂ measurement signal.
 - Volatile silicone compounds (silanes), e.g. generated by the out-gassing of silicone seals, are particularly harmful to the sensors' measurement performance

- When used in chemically aggressive environments, the glass seal of the sensor cell can leak, leading to a permanent increase in the O₂ measurement signal.
 - e.g. environments that try to reduce O₂ by chemical means.
- Condensing or wet environments can lead to destruction of the sensor cell.
- The periodic test, which is covered in the Safety Manual (ES016e), is used to detect a permanent impairment.

9 RS485 Modbus Interface

The RS485 Modbus interface is designed to be used either for maintenance purposes only, when external protection against overload must be provided, e.g. optical isolation.

NOTE: Under no circumstances should RS485 be used to connect directly to areas of the system that are not part of the safety concept.

9.1 RS485 Parameters

Baud Rate	19200
Start Bits	1
Data Bits	8
Stop Bits	1
Parity	None

9.2 Modbus Functions

During O₂ measurement operation, access via Modbus is restricted, Write access is ignored, Read access is limited to a maximum of 4 registers.

	Read Only Register	Read/write Registers		
	fct 0x04 (Read)	fct 0x03 (Read)	fct 0x06 (Write)	fct 0x16 (Write)
O₂ Measurement	Max. 4 registers	Max. 4 registers	Error	Error
PRG Mode	Multiple registers	Multiple registers	1 register	Multiple registers

General remarks regarding programming mode (PRG mode):

- Changes to stored EEPROM parameters are only permitted by the manufacturer. The parameters are protected by a checksum, i.e. in the event of inadmissible changes, the system will switch to error mode.
- The only exception is the register for the Modbus address, which can be changed by the customer, as it is not part of the checksum.

9.3 Modbus Communication Examples

9.3.1 Readout of the status register via Modbus function code 0x04

Hexadecimal data packet sent:

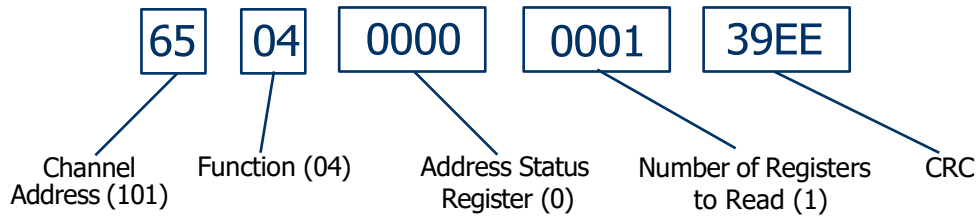


Figure 7. Hexadecimal data packet sent

CRC Calculation:

- For the above hexadecimal data sequence 0x650400000001
 - Seed value 0xFFFF
 - Polynomial 0x8005
- Provides 0xEE39 => Modbus protocol LSB/MSB => 0x39EE

Received hexadecimal data packet:

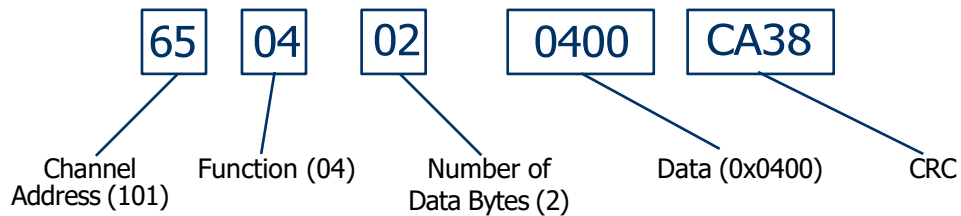


Figure 8. Received hexadecimal data packet via Modbus function 0x04

Modbus data is based on the "big endian" representation i.e. 0400 corresponds to 0x0400:

- MSB 0x04 => b 0000 0100 => measurement mode active; Channel 2 not enabled; relay contact off
- LSB 0x00 => no error

9.3.2 Readout of status, O₂-standardized and O₂ in ppm via Modbus function code 0x04

Hexadecimal data packet sent:

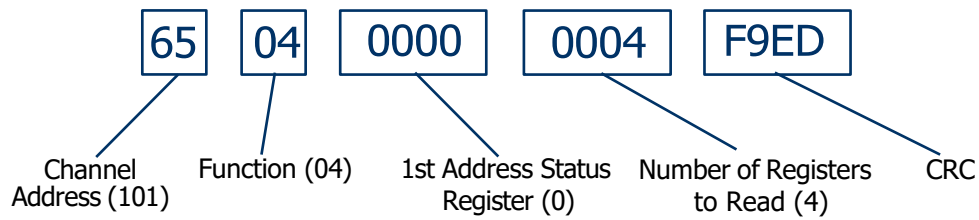


Figure 9. Hexadecimal data packet sent via Modbus function 0x04 (ppm)

Received hexadecimal data packet:

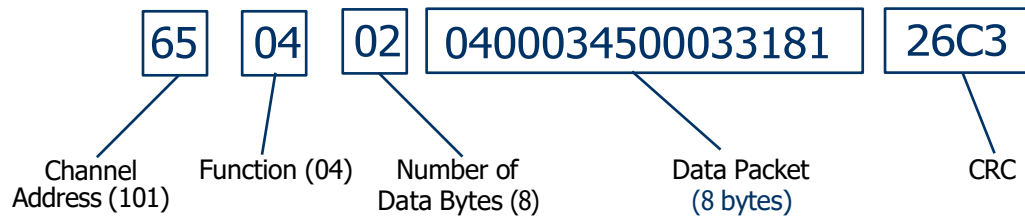


Figure 10. Received hexadecimal data packet

Breakdown of the data package:

- 2-byte status register: 0x0400 see
- 2-byte O₂ normalized: 0x0345 => 837 Dec.
 - In this example, normalized to 25 % O₂, i.e. $837/1000 \cdot 25\% \text{ O}_2 \Rightarrow 20.925 \% \text{ O}_2$
- 4-byte O₂ and ppm: 0x00033181 => 209.281 ppm O₂

9.4 Modbus Register Overview

The following tables provide an overview of the most important registers

9.4.1 Modbus function code 0x04 (useful in measurement mode) "Read" register

Modbus Address	Data Type	Description
0x0000	unsigned int16	LSB 0... no error, >0... Error code when the error state is active (9.2 on page 21)
		MSB... Status Flags (9.5 on page 24)
0x0002	unsigned int16	O ₂ value (digital) normalized
0x0004-6	unsigned int32	O ₂ value absolute (in ppm O ₂)

Modbus Address	Data Type	Description
0x0008	unsigned int16	Current sensor current (in 0.1uA)
0x000A	unsigned int16	Current sensor temperature (in °C)
0x000C	unsigned int16	Current sensor voltage (in mV)
0x000E	unsigned int16	Current heater voltage (in mV)
0x0010	unsigned int16	Current heater current (in 0.1 mA)
0x0012	unsigned int16	Adjusted cold resistance
0x0014	unsigned int16	Current Warm Resistance
0x0016	unsigned int16	Digital system states (0-8) (9.6 on page 25)
0x0022	unsigned int16	Last error code encountered since powering on
0x003E	unsigned int16	Internal PCB temperature of the monitor (near hot spot)
0x007C	unsigned in16	FW Rev (111 => v1.11)
0x007E	unsigned in16	Reading this address will switch to Programming Mode (PRG) from Measuring Mode

9.4.2 Modbus function code 0x03/0x06 (usable in PRG mode) "Write"/"Read" tabs

Modbus Address	Data Type	Description
0x1012	unsigned int16	Registry contains Modbus address

9.4.3 Modbus function code 0x06 "Write" register to execute commands

Modbus Address	Data Type	Description
0x0102	unsigned int16	Switch to programming mode
0x0104	unsigned int16	Initiation of measurement mode (from programming mode)

To quit a permanent error mode, apply the following command sequence:

- Switch to programming mode (0x0102)
- Switching to measurement mode (0x0104)

9.5 Digital Status Register 16Bit (Modbus Register 0x0000)

- Bit 0-7: 0 ... no error, or error code in case of error ("8.1 Error Codes" on page 18).
- Bit 8-15: set flag (1) if state/phase is active.

Bit 16	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9
Permanent error state	Above temperature	Contact check	Standby mode	Heat-up mode	Measuring mode	Relay status flag	Channel 2 active

- Channel 2 active can only be viewed by channel 1.
- Standby mode can only be viewed by channel 2.
- The relay status flag will be 1 if the relay is closed, or 0 if it is open.

9.6 Digital System States (Modbus Register 0x0016)

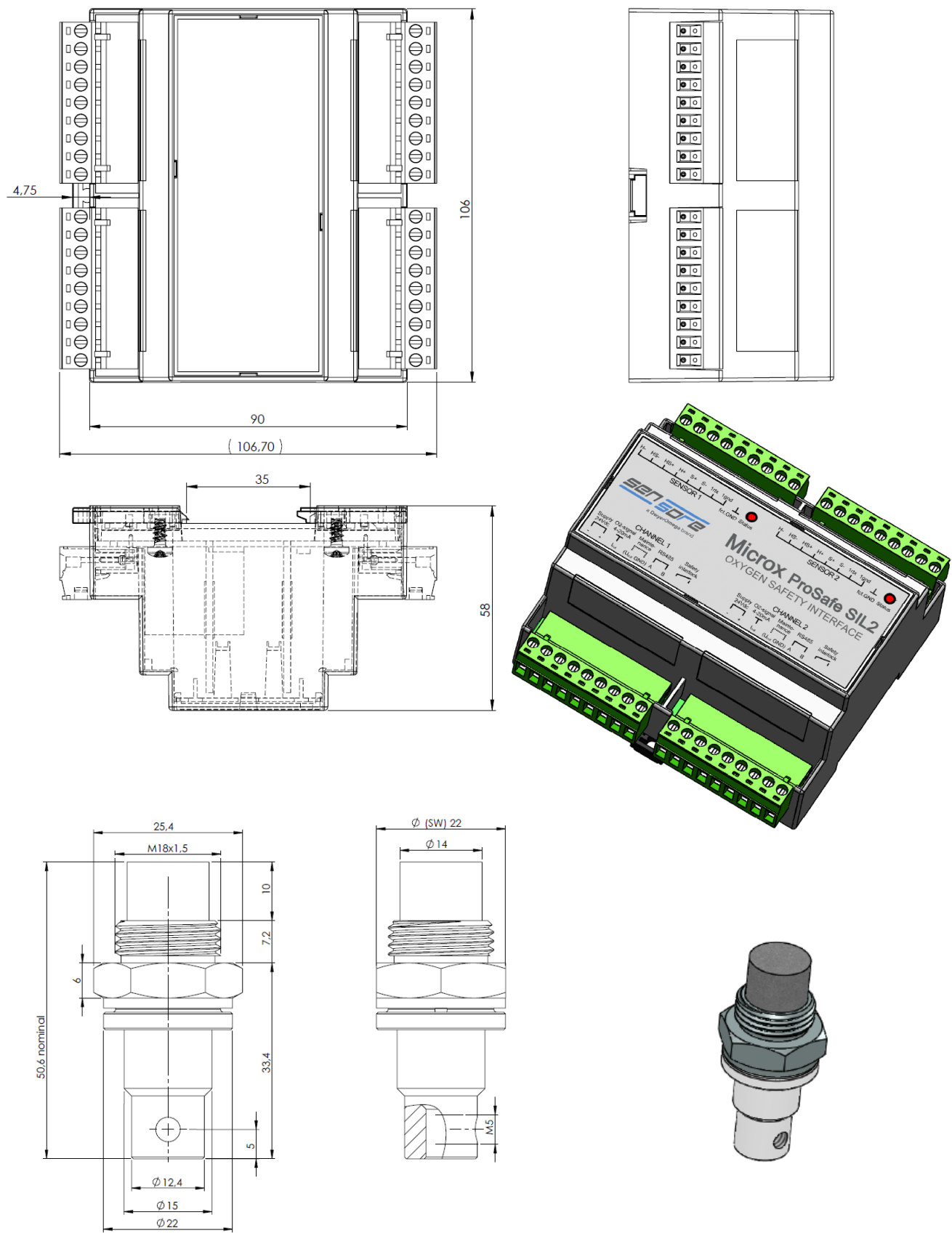
Number	Description of System State
0	Initializing
1	Not in use (custom option)
2	Contact check (and import of sensor EEPROM data)
3	Not in use (custom option)
4	Heating mode (and stabilization of the sensor signal)
5	Measuring mode
6	Programming mode
7	Failure mode (temporary or permanent)
8	Standby mode for channel 2 (due to high oxygen concentration)

10 Appendices

Appendix A - Technical Specifications

Sensor		Zirconia (ZR)	
	Channel 1		Channel 2
Measurement Range	0...23.5 %		0...2.35 %
Accuracy (at constant conditions)	1 % FS		1 % FS
Output Resolution (4...20 mA)	0.025 %		25 ppm _V
Lower Detection Limit	1000 ppm _V		100 ppm _V
Maximum flow velocity	6 m/s (19.7 ft/s)		
Pressure Range	700...1300 mBar _{abs} (10...19 psi)		
Maximum Safe Pressure	1.5 barg (21 psig)		
Response Time (T90)	< 10 seconds		
Operating Temperature Range (Sensor head)	+10...+100 °C (+50...+212 °F)		
Operating Temperature Range (Sensor plug)	+10...+75 °C (+50...+165 °F)		
Operating Temperature Range (Monitor)	+10...+50 °C (+50...+122 °F)		
Life Expectancy (application dependent)	Up to 5 years		
Humidity (with normal use)	0...90 %rh @ 40 °C (104 °F) non-condensing		
Process Connections	M18 x 1.5 male		
Shelf Life	Unlimited		
Calibration Interval	No calibration required. Calibration data stored in smart sensor.		
Analyzer			
Electrical			
Output Signal	4...20 mA (19/20 mA Error State) 19 mA = 23.5 %		4...20 mA (19/20 mA Error State) 19 mA = 2.35 %
Digital Communications	RS485 per channel		
O ₂ Safety Threshold	1, 1.5 or 2 %		
Relay Contact Output	Controlled by factory-configured O ₂ safety threshold stored in smart sensor		
Electrical Interface	8-pin M12 on sensor, extension cable from sensor plug to screw terminal on monitor		
Power Supply	24 V DC ±2		
Maximum Power Consumption	12 W or 0.5 A		
Mechanical			
Ingress Protection	IP40 (Monitor), IP66 (Sensor plug)		
Housing Material	PC (UL 94 V-0)		
Mounting	DIN rail		
Sensor Cable Length	50 cm (19.6 ")		
Extension Cable Length	Standard: 1 m (3.28 ft) Optional: 3 m (9.8 ft)		
Compliance			
CE: According to EU directives 2006/42/EC (machinery), 2014/30/EC (EMC) and 2011/65/EU (RoHS)			
SIL2: According to EN IEC 62061:2021			
PLd: According to EN ISO 13849-1:2015			
EMC: According to EN 50270:2015 + Cor.:2016			
For declaration of conformity see also document "Microx ProSafe SIL2 DOC"			

Appendix B - Technical Drawings (mm)



Appendix C - Quality, Recycling, and Warranty Information

SENSORE Electronic GmbH. is part of the DwyerOmega Group. and complies with applicable national and international standards and directives.

The following regulations have been considered:

- CE
- REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals)
- Recycling policy
- RoHS (Restriction of Hazardous Substances in electrical and electronic equipment)
- WEEE (Waste Electrical and Electronic Equipment recycling)

For declaration of conformity see document "Microx ProSafe SIL2 DOC"

Appendix D – Order Codes for systems, spare parts and accessories

Order Codes

Description

MPS – X X Complete Systems (monitor, ext. cable and 2 sensors)

Ext Cable Length
A (1 m)
B (3 m)

O ₂ Safety Threshold
A (1.0% O ₂)
B (1.5% O ₂)
C (2.0% O ₂)

MPS – CAL System Calibration certificate - single point + 2pt validation

MPS – S – X X Spare / Replacement sensors

O ₂ -Sensor Range
A (2.35% Sensor)
B (23.5% Sensor)

O ₂ Safety Threshold
A (1.0% O ₂)
B (1.5% O ₂)
C (2.0% O ₂)

MPS – S – CAL Sensor Calibration certificate - single point + 2pt validation

MPS – TML9 Spare / Replacement 9-pin screw terminals (Qty 4)

MPS – SIC1 Spare / Replacement Sensor Interconnect Cable - 1m (Qty 1)

MPS – SIC3 Spare / Replacement Sensor Interconnect Cable - 3m (Qty 1)

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