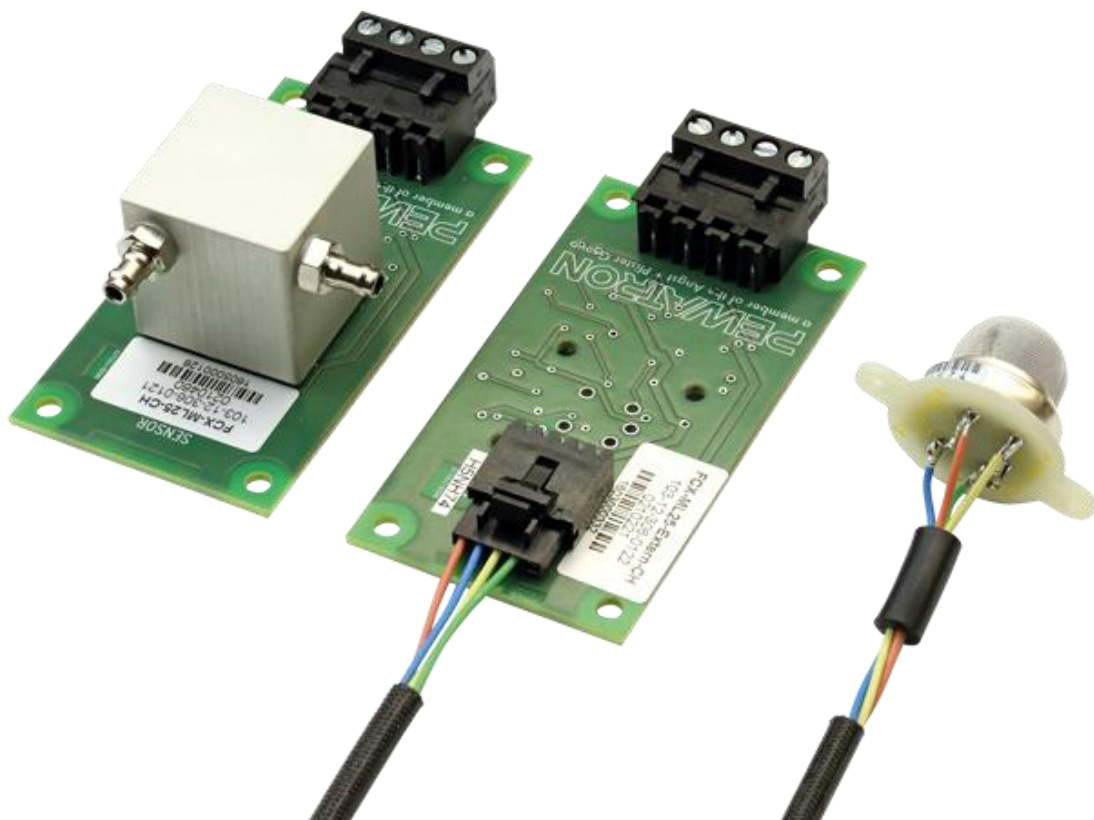


Operating manual

Angst+Pfister Sensors and Power oxygen sensor modules

FCX-ML05, FCX-ML25 & FCX-ML95 OEM module platform



This manual contains information on how to operate the standard Angst+Pfister Sensors and Power OEM FCX-MLxx-FLOW and FCX-MLxx-EXT products. The standard FCX-MLxx-FLOW configuration always has the oxygen sensor soldered onto the PCB and covered with an aluminium flow housing. The standard FCX-MLxx-EXT configuration has the oxygen sensor connected to the PCB via a 30 cm long cable. The oxygen sensor can be chosen from a selection of 3 sensors;

- 1) the FCX-UL 0...5% (xx = 05)
- 2) the FCX-UC 0...25% (xx = 25) and
- 3) the FCX-UWC 0...95% (xx = 95)

As an example the FCX-ML95-FLOW-A-CH Module is a 0...95% FCX oxygen sensor module with normalized current output and used in flow applications or in applications where a gas sample is extracted for analysis.

Other configurations of sensor, sensor termination and cable lengths are available upon request.

Products mentioned in this manual may possibly be trademarks used only for the purposes of identification.

Output protocol

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1 List of Contents

	Page
1. List of Contents	3
2. Customer Service	4
3. Safety instructions	5
4. Measuring Principle	6
5. Commissioning	7
5.1 Mechanical Installation	7
5.2 Pneumatic Connections	8
5.3 Electrical Connections	8
5.3.1 Supply voltage	8
5.3.2 Analog Output	8
6. Environmental conditions	9
7. Warm-up time	9
8. Gas flow	9
9. Calibration	9
9.1 Calibration Adjustment	10
9.2 Adjustment Span and Zero	10
9.3 Adjustment if the sensor need to be replaced	11
10. Important notes	12
10.1 Restrictions	12
11. Specifications	13

2 Customer Service

At Angst+Pfister Sensors and Power AG, we want to offer you the best customer service possible. If you have any questions or comments about your FCX-MLxx modules, we would be happy to hear from you. Should you have any problems with the modules, please contact us for advice and support. We recommend that all service and repair work on the unit be done exclusively by our customer service or specially trained personnel.

You can reach us at the following addresses:

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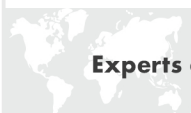
sensorsandpower.de@angst-pfister.com

<https://sensorsandpower.angst-pfister.com>

**Please send any returns to our Logistics Centre:
Before returning anything, please request an RMA number from us.**

Angst+Pfister Sensors and Power AG

Logistics Centre
Hardhofstrasse 31
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Switzerland

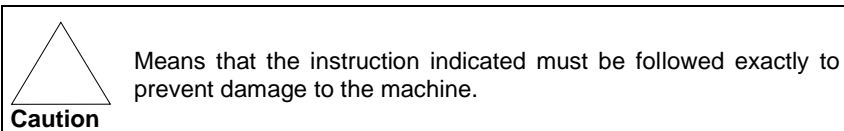
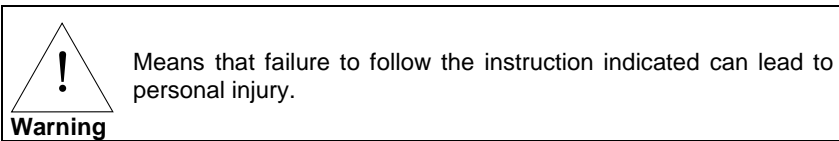


3 Safety instructions

Danger sources that could result in personal injury or damage to machinery are explicitly indicated in the appropriate places in the user documentation.

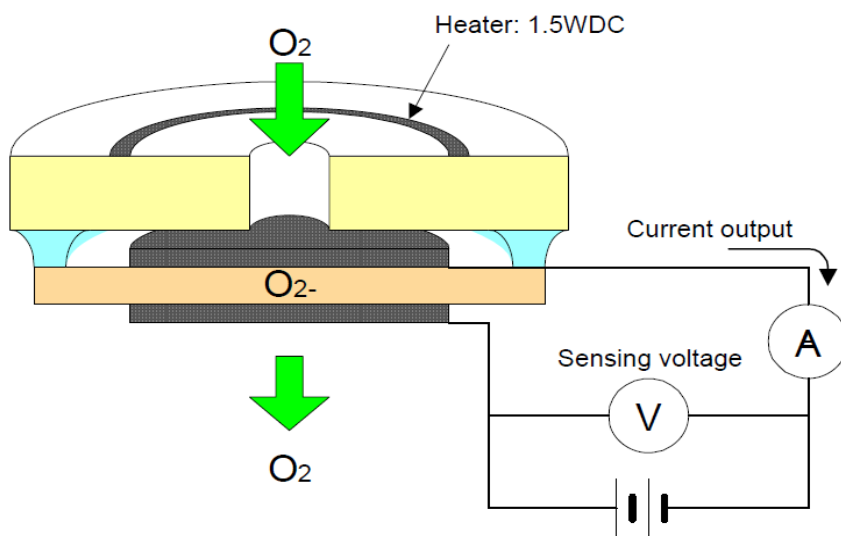
Before installing the machine, please read this operating manual carefully. Pay particular attention to the sections explaining possible hazards.

Warnings and instructions are shown as follows:



4 Measuring Principle

The sensor module is a complete solution for fast and accurate oxygen concentration measurements within the range 0...5% (ML05), 0...25% (ML25) or 0.1...95% (ML95). The sensor and the measurement electronics are located on a PCB (FCX-MLxx-CH). Alternatively, the oxygen sensor can be connected to the PCB via a cable (FCX-MLxx-extern-CH). The electronic amplifies the raw sensor signal and the output is a logarithmic current output signal 4...20mA (according to IEC 60381) as a function of oxygen partial pressure (see Appendix)



Zirconium oxide, heated to about 450 °C, is penetrable for oxygen ions. A voltage applied to the sensor therefore pumps the oxygen out of the inner chamber. At a constant gas pressure, the quantity of oxygen pumped out is equal to the quantity of oxygen molecules diffusing in through the capillary, and within a certain range it is independent of the voltage applied between the electrodes. The measurement current is proportional to the quantity of oxygen molecules pumped away. The relationship between the oxygen partial pressure and sensor current is governed by the formula

$$I_s = c \ln(1 - p_{O_2} / p_t)$$

where:

- I_s : Sensor current
- c : Constant (sensor-specific)
- p_{O_2} : Oxygen partial pressure
- p_t : Gas pressure (total)

The sensor module performs three tasks:

- Regulation of the heating power of the sensor
- Amplification of the microampere signal from the sensor
- Conversion of the amplified signal into standardised voltage/current output signals

The sensor and module are calibrated together as one unit at the factory. The heating voltage must be correctly adjusted for each sensor to bring the temperature to exactly 450 °C. The sensor is not directly replaceable, and cannot be used with other modules. All modules have a label on the PCB with the sensor batch number and the module batch number.

5 Commissioning

5.1 Mechanical Installation

The PCB has dimensions 75 x 40 x 28 mm (including the flow housing) (Fig.1.). There are two different variants for how the sensor can be connected to the module: Soldered directly onto the PCB or using a plug cable connector. In Fig. 2 below is shown the PCB with a sensor soldered directly onto the PCB and covered with an aluminium flow housing. In Fig.3 below is shown the PCB without a sensor, but with a plug cable connector.

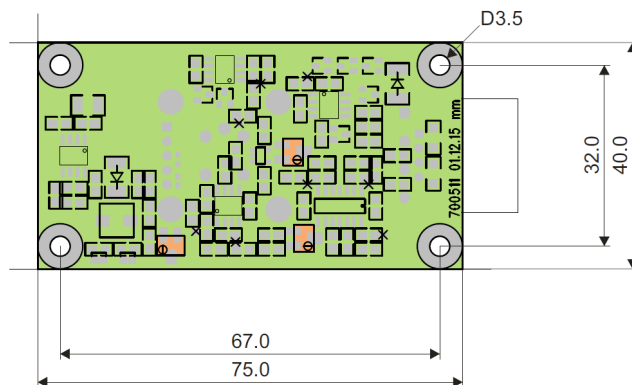


Fig. 1 PCB electronic layout for FCX-MLxx product

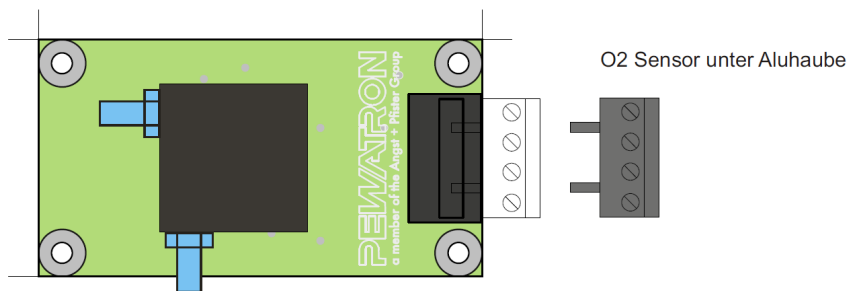


Fig. 2 PCB side with flow housing; FCX-MCxx-FLOW-A-CH

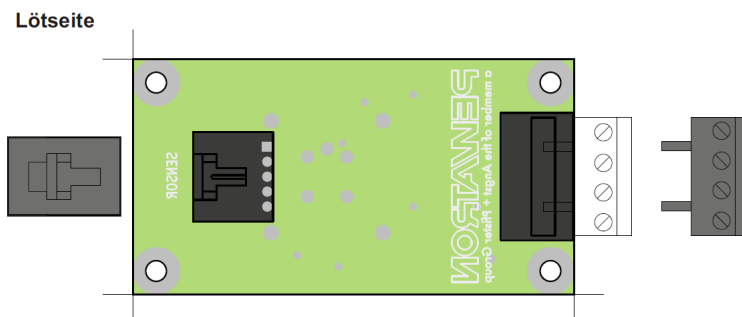
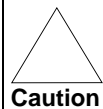


Fig. 3 PCB side with plug cable connector; FCX-MLxx-EXT-STD-030-A-CH

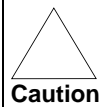
In each corner of the PCB, there are mounting holes with a diameter of 3.5 mm. The distance between the centre of mounting holes are 67 and 32 mm, respectively.



The PCB has highly sensitive circuitry. During installation, be careful that none of the components are damaged mechanically.

5.2 Pneumatic connections

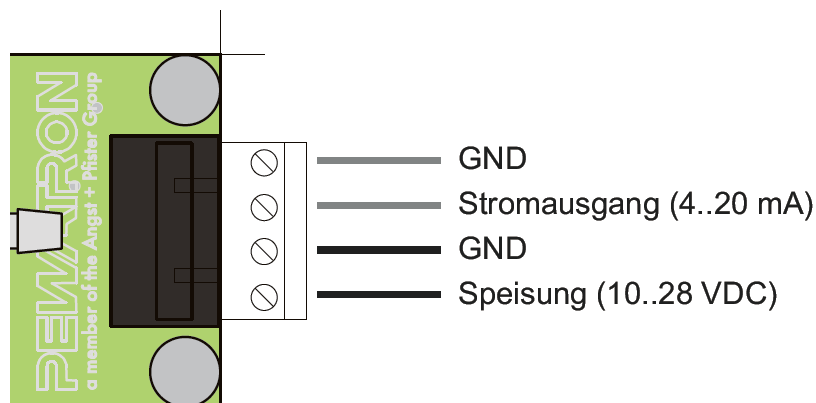
The flow housing has two hose connectors with a diameter of 5 mm. The direction of flow can be chosen arbitrarily.



Hoses containing silicone should not be used. Gases containing silicon destroy the sensor

5.3 Electrical connections

5.3.1 Supply voltage



The 10–28 VDC power for the module is supplied through terminals 1 (+) and 2 (GND), at about 250 mA (24 VDC). For the lower limit of the power supply voltage, please take into account the resistance between the current output terminals. As an example; using a 500 Ohm resistance between the output terminals will cause of 10 V voltage drop at an output current of 20 mA. If the supply voltage is only slightly above this voltage drop, the required current for operating the module may be too low, which will then cause erroneous measurement output values.

5.3.2 Analog Output (4-20 mA)


For the output signal the clamps 3 (+) and 4 (-) is to be used.

6 Environment Condition

See also under 11. Specifications, in particular for the temperature and humidity ranges (not condensing).

- Operation outdoors not permitted.
- Protect from moisture

The sensor temperature is about 450 °C. Please note in any case the resulting hazards for applications with reactive gas mixtures.

 Warning	<p>Potentially explosive atmospheres The unit may under no circumstances be operated in or with potentially explosive atmospheres.</p>
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7 Warm Up Time

The module need a warm up time of approx. 3 minutes. After 3 minutes the sensor delivers an output signal which is within the accuracy limits of the sensor module.

8 Gas Flow

The following points should be noted:

- The flow should not be less than 0.1 l/min and no greater than 3.0 l/min; ideally, it should be 0.5 l/min.
- We recommend placing an appropriate filter upstream of the module, since contaminants brought in by the flow can significantly shorten the service life of the sensor.
- Avoid condensation (H₂O) in the sensor housing.

9 Calibration

All compensations and calibrations needed for operation have been carried out at the factory. The output signal should be interpreted as follows:

FCX-ML05, 0...5%:

$$I_{out} (mA) = 16 [mA] * (pO_2 [\%] / 5 [\%]) + 4 [mA]$$

FCX-ML25, 0...25%:

$$I_{out} (mA) = -57 [mA] * \ln(1 - (pO_2 [\%] / 100 [\%])) + 4 [mA]$$

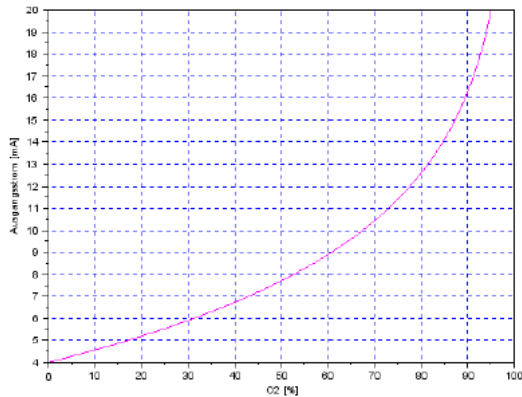
FCX-ML95, 0...95%:

$$I_{out} (mA) = -5.34 [mA] * \ln(1 - (pO_2 [\%] / 100 [\%])) + 4 [mA]$$

pO₂: oxygen partial pressure in % of the total pressure

I_{out}: output current in mA

In the figure below is shown the relationship between output current and partial oxygen concentration for a 95% oxygen sensor module. The output from a 25% oxygen sensor module can be considered quasi-linear.



9.1 Calibration Adjustments

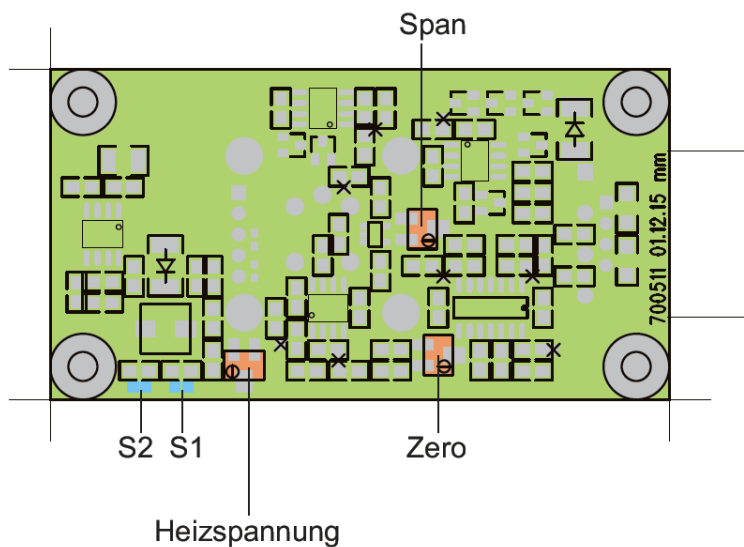
It is recommended to check the device periodically by running it under regular lab conditions and flush the sensor with regular air (20.95% O₂).

9.2 Adjustment Span and Zero

Initial calibration of the ML module needed for operation has been carried out at the factory. The result of a measurement in air and at a temperature of 25°C should be 20.95 %O₂ +0.2/-0.5% O₂. Should there be a higher difference the module output can be adjusted according to the following procedure:

- 1 Attach the module to the supply
- 2 Use the sensor in regular air (20.95% O₂). For the 0...5% sensor please use a N₂-O₂ gas with an oxygen concentration of 5 %O₂ +/-2% rel.
- 3 After 10 minutes adjust the output signal using the potentiometer (Span). In a dry and clean environment the amplifier should have an output signal of 17.44 mA (±0.05 mA) for the 25% sensor and 5.26 mA (±0.05 mA) for the 95% sensor. The module with the 5% sensor should be adjusted to 20 mA using a full-scale gas (i.e. N₂-O₂; 5 %O₂ +/-2% rel.)
- 4 Flow pure N₂.
- 5 After approx. ca. 10min. adjust the output signal to 4.050 ± 0.005 mA using the potentiometer (Zero).

This completes the recalibration.



9.3 Adjustment if the sensor need to be replaced

1. Attach the module to the supply
2. After approx. 10 minutes adjust the sensor heating (U Heat) using the potentiometer (Heizspannung) and jumpers S1 and S2 for fine adjusting (see jumper configuration below). Please note that the VH differs from sensor to sensor and has to be adjusted at an accuracy of $\pm 0.005V$. The corresponding values can be found on the attached calibration sheet.

S1 S2 U HEAT+

open	open	2.07 .. 2.30V
close	open	2.25 .. 2.58V
open	close	2.46 .. 2.89V
close	close	2.80 .. 3.47V

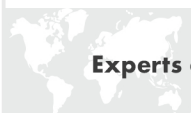
3. Use the sensor in regular air (20.9% O₂). For the 0...5% sensor please use a N₂-O₂ gas with an oxygen concentration of 5 %O₂ +/-2% rel.
4. After 10 minutes adjust the output signal using the potentiometer (Span). In a dry and clean environment the amplifier should have an output signal of 17.44 mA (± 0.05 mA) for the 25% sensor and 5.26 mA (± 0.05 mA) for the 95% sensor. The module with the 5% sensor should be adjusted to 20 mA using a full-scale gas (i.e. N₂-O₂; 5 %O₂ +/-2% rel.)
5. Flow pure N₂.
6. After approx. ca. 10min. adjust the output signal to 4.050 ± 0.005 mA using the potentiometer (Zero).

This completes the recalibration.

10 Important notes

10.1 Restrictions

- 1 Do not remove the sensor from the circuit board.
- 2 Do not change the length of the lead wires.
- 3 Please use regulated DC power source with current capacity over 1 ampere/pc. If current capacity is not sufficient, the sensor module will not operate correctly.
- 4 This sensor module was adjusted for O₂-N₂ system. Output characteristics may change if there are other gases present in the gas mixture to be measured.
- 5 Don't use in a gas that contains the halogen atoms (F, Cl, Br). The sensor can be damaged by decomposition of a gas containing halogen atoms.
- 6 SO_x, NO_x und H₂S will damage the performance of the sensor. Therefore, please do not use sensor module in the atmosphere that contains these gases.



11 Specifications

Measurement range	: 0...5 %, 0...25 % or 0...95 % O ₂
Supply voltage	: 24 VDC nominal (10...28 VDC)
Power current	: type 250 mA (24 VDC). Power-on peak about 0.7 A
Power consumption	: < 3 W
Output signal	: 4...20 mA logarithmic
Accuracy	: ±0.5 % FCX-ML95 ±2 % FS FCX-ML25 (> 10% O ₂) +/-0.2% FCX-ML25 (< 10% O ₂) ±2 % FS FCX-ML05 (< 5% O ₂)
Stability	: ±0.5 % FS/Year
Repeatability	: ±1% of the value displayed
Temperature influence	: Measurement error [in % pO ₂] ~ pO ₂ [%] x (T _e [°C] – 25 °C) / 500 T _e = Environmental temperature of the sensor
Response time (diffusion)	: < 30 s T ₉₀
Response time (flow)	: < 8 s T ₉₀
Gas temperature	: -10...+50 °C
Environmental temperature	: -20...+70 °C
Rel. humidity	: 98% RH, not condensing
Pressure influence	: The oxygen sensor itself has no static pressure influence between 200 mbar and 50 bar absolute. The minimum/maximum pressure that can be applied to the sensor module is very dependent of the sensor integration. Please consult us for advice and appropriate sensor integration for high and low pressure applications Sudden pressure changes causes the signal to strongly oscillate. The oscillations are damped over time, but the relaxation time is long
Dimensions L x W x H	: 75.0 x 40.0 x 28.0 mm (including flow housing)
Weight	: 100 g

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