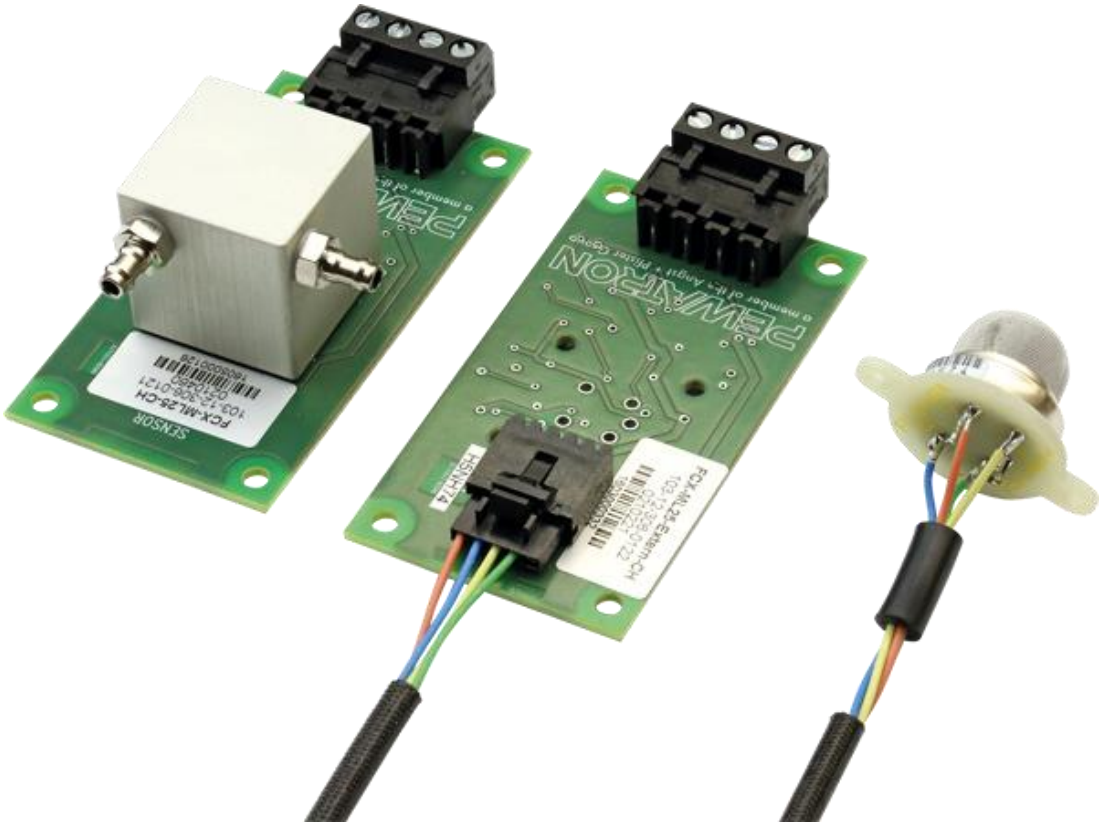
Operating manual

Oxygen sensor module

FCX-MLxx-CH &

FCX-MLxx-Extern-CH



This manual contain information on how to operate the standard Pewatron OEM FCX-MLxx-CH and FCX-MLxx-Extern-CH products. The standard FCX-MLxx-CH configuration always have the oxygen sensor soldered onto the PCB and covered with an aluminium flow housing. The standard FCX-MLxx-Extern-CH configuration have 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 0.1…95% (xx = 95)

As an example the FCX-ML95-CH Module is a 0.1-95% FCX-UWC oxygen sensor module 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

Issue	Month / Year	Valid for Software version
1.1	February 2012	NA
1.2	December 2015	NA
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1.4	May 2017	NA

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1 List of Contents

2 Customer Service

At PEWATRON AG, we want to offer you the best customer service possible. If you have any questions or comments about your FCX-MLxx-CH or FCX-MLxx-Extern-CH 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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Please send any returns to our Logistics Centre:
Before returning anything, please request an RMA number from us.

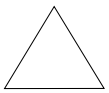
PEWATRON AG
Logistics Centre
Hardhofstrasse 31
8424 Embrach/ZH
Switzerland

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:

Means that failure to follow the instruction indicated can lead to personal injury.

Warning

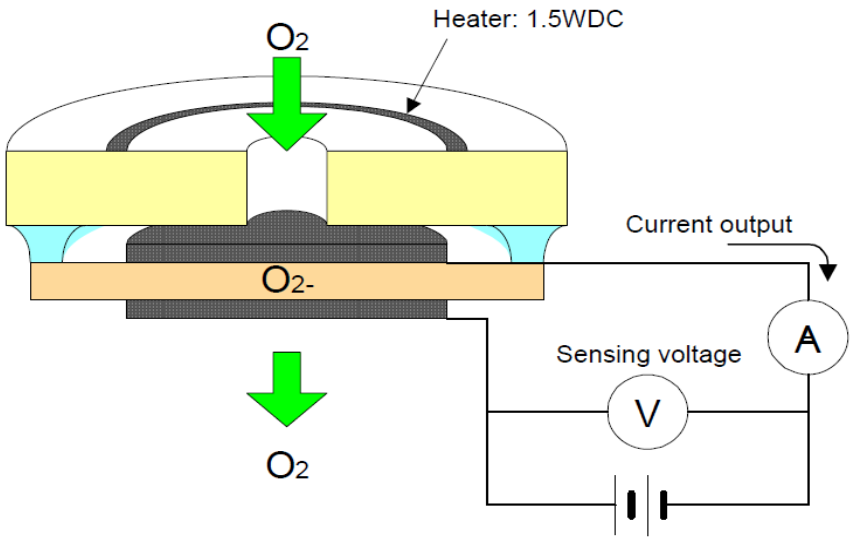


Means that the instruction indicated must be followed exactly to prevent damage to the machine.

Caution

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 it proportional to the quantity of oxygen molecules pumped away. The relationship between the oxygen partial pressure and sensor current is governed by the formula

$$I_s = c \ln (1 - p_{O2} / p_t)$$

where:

I_s : Sensor current
c : Constant (sensor-specific)
p_{O2} : 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.

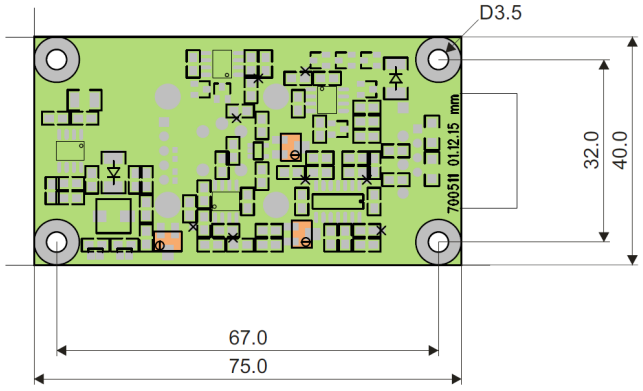


Fig. 1 PCB electronic layout for FCX-MLxx-CH/FCX-MLxx-Extern-CH

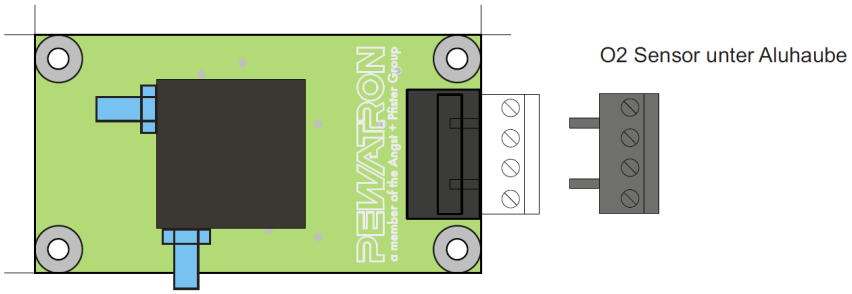


Fig. 2 PCB side with flow housing; FCX-MCxx-CH

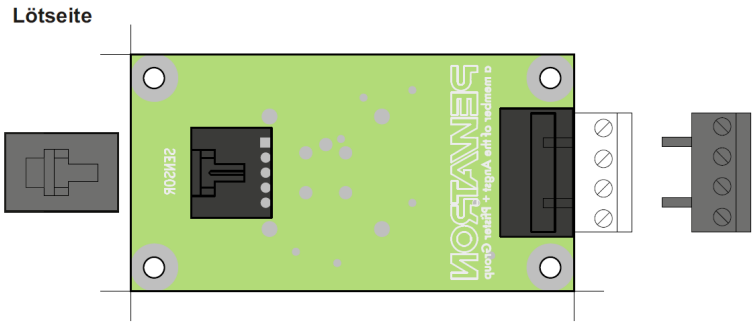


Fig. 3 PCB side with plug cable connector; FCX-MLxx-Extern-CH

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.

Caution

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

5.2 Pneumatic connections

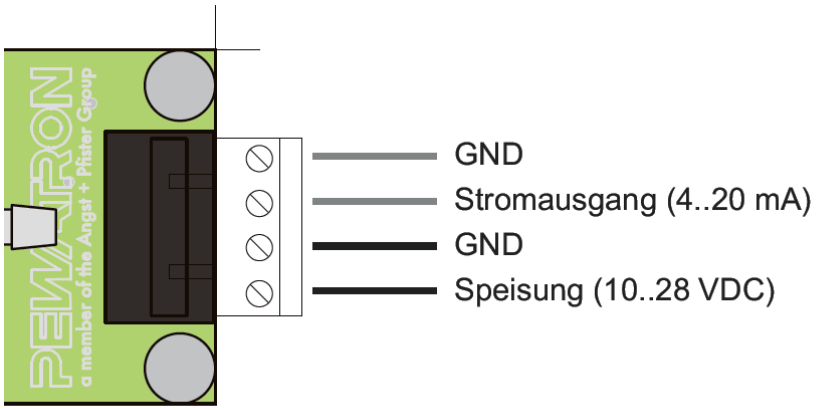
The flow housing has two hose connectors with a diameter of 5 mm. The direction of flow can be chosen arbitrarily.

Caution

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

Potentially explosive atmospheres
The unit may under no circumstances be operated in or with potentially explosive atmospheres.

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 (H_2O) 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:

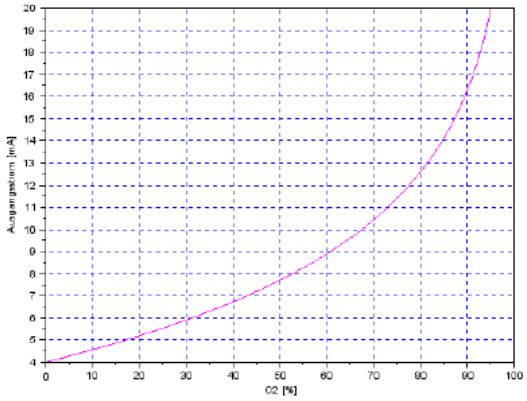
FCX-ML05, 0…5%:
$I_{out}\,(mA)$ = 16 [mA]*(pO_2 [%]/5 [%]) + 4 [mA]

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]

pO_2 : 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% O_2).

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 %O_2 +0.2/-0.5% O_2. Should there be a higher difference the module output can be adjusted according to the following procedure:

1 Attach the module to the supply

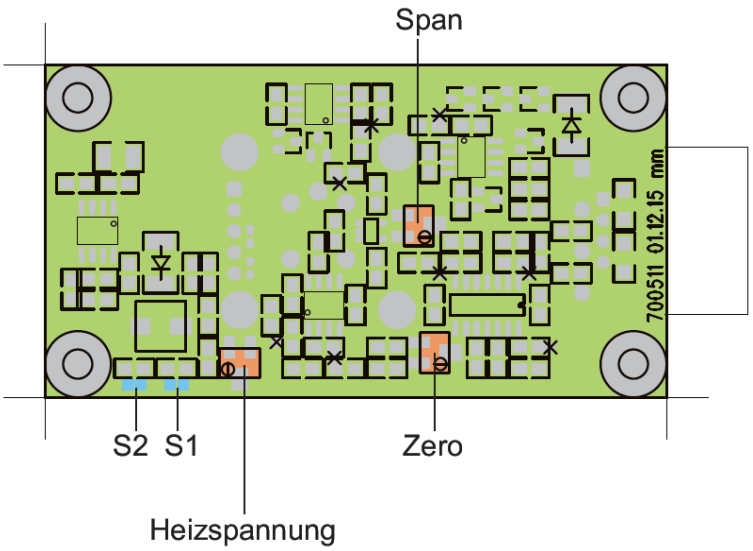
2 Use the sensor in regular air (20.95% O_2). For the 0…5% sensor please use a N_2-O_2 gas with an oxygen concentration of 5 %O_2 +/-2% rel.

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. N_2-O_2; 5 %O_2 +/-2% rel.)

4 Flow pure N_2.

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 ±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% O_2). For the 0…5% sensor please use a N_2-O_2 gas with an oxygen concentration of 5 %O_2 +/-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. N_2-O_2; 5 %O_2 +/-2% rel.)

5. Flow pure N_2.

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 O_2-N_2 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 H_2S 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 0.1…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
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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Sensors and Power

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