Operating manual

Angst+Pfister Sensors and Power
oxygen sensor modules

FCX-MLD25 & FCX-MLD95
OEM module platform

This manual contains information on how to operate the standard Angst+Pfister Sensors and Power OEM FCX-MLD25-DIFF and FCX-MLD95-DIFF products. The FCX-MLDxx-DIFF configuration always have the oxygen sensor soldered onto the PCB. The oxygen sensor can be chosen from a selection of 2 sensors;

1) the FCX-UC 0…25% (xx = 25) and
2) the FCX-UWC 0…95% (xx = 95)

As an example, the FCX-MLD25-DIFF-CH Module is a 0…25% FCX oxygen sensor module with a serial, digital interface and is typically used in applications diffusion based gas exchange – for instance in gas alarm systems.

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

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-MLDxx 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.

Angst+Pfister Sensors and Power AG
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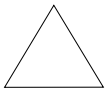
8424 Embrach/ZH
Switzerland

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:

Warning

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

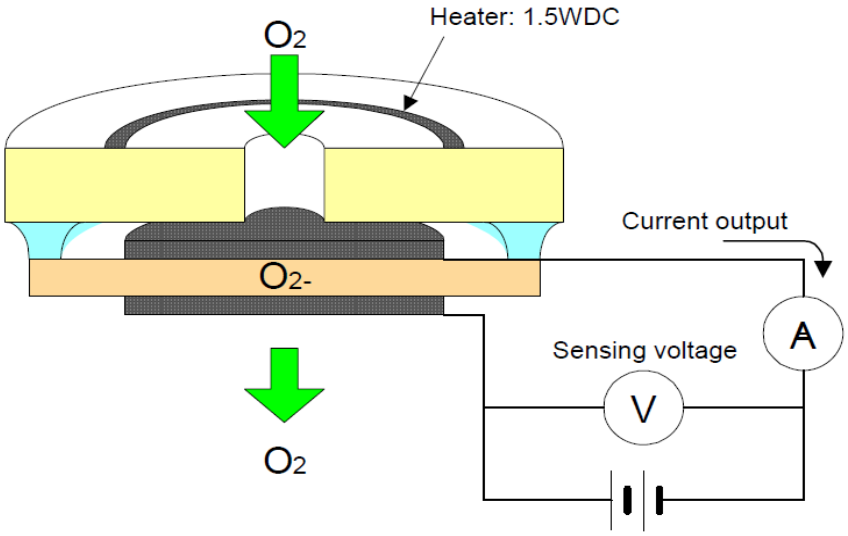


Caution

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

4 Measuring Principle

The sensor module is a complete solution for fast and accurate oxygen concentration measurements within the range 0...25% (ML25) or 0…95% (ML95). The sensor and the measurement electronics are one unit with the sensor soldered onto the electronics board. The signal communication is done via a 3.3 V TTL level, serial data interface



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 two tasks:

- Regulation of the heating power of the sensor
- Conversion of the analog sensor current signal into a digital sensor signal

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 electronics board with the sensor batch number and the module batch number.

5 Commissioning

5.1 Mechanical Installation

The electronics board has dimensions 48 x 38 x 25.6 mm (including the sensor) (Fig.1 and Fig. 2).
The oxygen sensor is soldered onto the electronics board. The connection to the board is done via the 4-pol xxxxx connector that xxxxxx (Fig. 2)

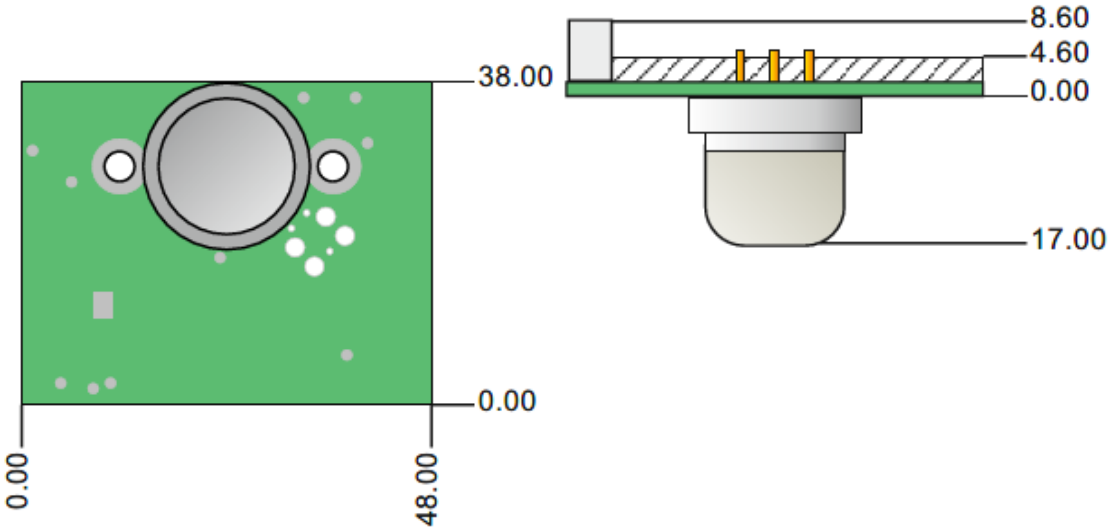


Fig. 1 Electronic board (sensor side) for FCX-MLDxx product

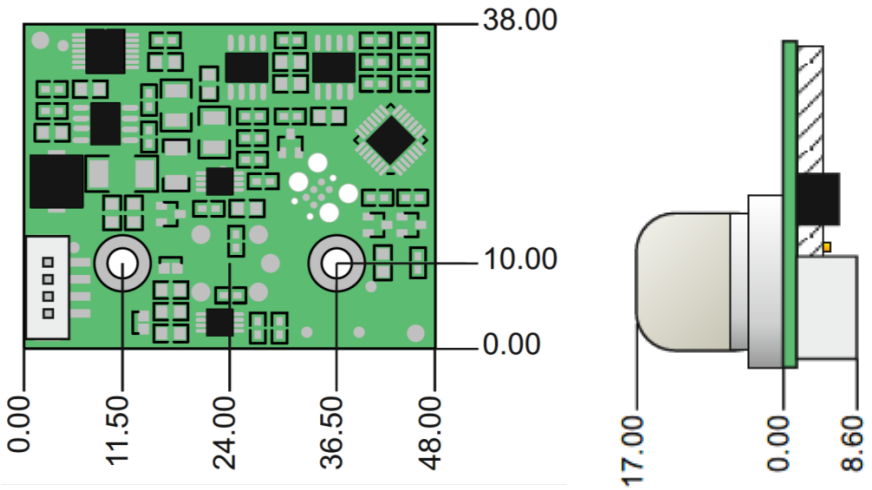


Fig. 2 Electronic board (electronics side) with cable connector; FCX-MLDxx

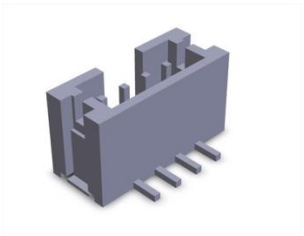
There are two mounting holes with a diameter of 3.5 mm, positioned close to oxygen sensor (Fig. 2).
The distance between the centre of mounting holes is 25 mm.

Caution

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

5.2 Electrical connections

For power supply and general communication with the FCX-MLD module a standard male JST connector of the type B4B-PH-SM4-TB is used and is located on the electronics side of the electronics board (see picture below).



5.2.1 Supply voltage

The 24VDC power for the module is supplied through terminals 1 (+) and 2 (GND), at about 250 mA.

5.2.2 Signal Output and command structure

For the output signal and communication between module and the customer signal conditioner the clamps 3 (Tx) and 4 (Rx) are to be used.

Communication interface parameters:

Baud rate 9600 kbps
8 data bits
1 stop bit
No parity

Command structure (overview):

- **Read status**
  The operating status of the module is queried with this command.
- **O2 concentration value**
  This command requests the current oxygen concentration.
- **Define time interval between measurements**
  This command defines a time interval of 100 ms steps. The module then sends the measured O2 values in this interval without being asked. The function is switched off with a time interval setting of 0 ms.

- **Sensor on/off function)**
  This command switches the heating of the oxygen sensor on and off (standby with 20% heating output).

- **Reset (reset)**
  This command executes a hardware reset on the module. The module then behaves as if it had been switched on.

- **Read/write adjustment values**
  With this command the adjustment values zero and span of the module are read / written

- **Reset adjustment values**
  With this command, the adjustment values are reset to the delivery state

Protocol frame definition

The protocol uses the following format:

STX	Command (2 Byte)	Data (n Byte)	Checksum (2 Byte)	ETX

- STX Start identification "Start of Text", Hex 0x02.
- Command A command consists of two representable ASCII characters.
- Data The data is a variable number of ASCII characters that can be displayed.
- Checksum The checksum also consists of two representable ASCII characters and is formed by the EXOR combination of all characters (bytes) sent between STX and the checksum.
- ETX End identification "End of Text", Hex 0x03.

Except for STX and ETX, only readable ASCII characters are sent for the start and end recognition.

Command description

The answers to read commands in the following command descriptions are examples. The responses during operation depend on the operating status of the module and the measured oxygen concentration in the vicinity of the sensor.

Read status: Command "01"

This command queries the operating state of the O2 module.

Byte	1	2	3	4	5	6
Anfrage	STX	Command		Checksum		ETX
ASCII		0	1	0	1	
Hex	0x02	0x30	0x31	0x30	0x31	0x03

Byte	1	2	3	4	5	6	7	8
Antwort	STX	Command		Data (Status)		Checksum		ETX
ASCII		0	1	0	4	0	5	
Hex	0x02	0x30	0x31	0x30	0x34	0x30	0x35	0x03

The O2 module responds with the command sent and the status. It knows the following status values:

- "02" Standby The heating of the O2 sensor is on standby, no O2 measurement is possible.
- "03" ramp-up The O2 sensor is in the heating phase, no O2 measurement is possible.
- "04" Run The O2 module is in normal operation.
- "05" Error The O2 module has detected a system error, no O2 measurement is possible.

Read O2 value: Command "02"

This command queries the measured oxygen concentration in%.

Byte	1	2	3	4	5	6
Anfrage	STX	Command		Checksum		ETX
ASCII		0	2	0	2	
Hex	0x02	0x30	0x32	0x30	0x31	0x03

Byte	1	2	3	4	5	6	7	8	9	10	11
Antwort	STX	Command		Data (O2-Wert)					Checksum		ETX
ASCII		0	2	2	0	.	9	5	2	2	
Hex	0x02	0x30	0x32	0x32	0x30	0x2E	0x39	0x35	0x32	0x32	0x03

The O2 module responds with the command sent and the O2 value. If no O2 measurement is possible, the O2 module answers with the corresponding status.

- "02" oxygen concentration in the range from 00.05% to 25.00%.
- "01" status value if no O2 measurement is possible (see Read status: Commend “01”).

Set time interval: Command "03"

This command sets a time interval for the automatic transmission of the oxygen concentration. The answer is analogous to the settings in “Read O2 value: Command “02”"
The value of the interval is defined in 100 millisecond units, so intervals between 0.1 to 9.9 seconds can be defined.
The function is switched off with an interval of 0 seconds.

Byte	1	2	3	4	5	6	7	8
Anfrage	STX	Command		Data (Intervall)		Checksum		ETX
ASCII		0	3	1	0	0	2	
Hex	0x02	0x30	0x33	0x31	0x30	0x30	0x32	0x03

Byte	1	2	3	4	5	6	7	8
Antwort	STX	Command		Data (Intervall)		Checksum		ETX
ASCII		0	3	1	0	0	2	
Hex	0x02	0x30	0x33	0x31	0x30	0x30	0x32	0x03

The O2 module responds with the command sent.

Switch sensor on / off: Command "04"

This command switches the heating of the O2 sensor on and off (standby with 20% heating output).
· Data = "0" heating is switched to standby.
· Data = "1" heating is switched on.

 The oxygen concentration can only be measured when the heating is switched on.

Byte	1	2	3	4	5	6	7
Anfrage	STX	Command		Data	Checksum		ETX
ASCII		0	4	1	3	5	
Hex	0x02	0x30	0x34	0x31	0x33	0x35	0x03

Byte	1	2	3	4	5	6	7
Antwort	STX	Command		Data	Checksum		ETX
ASCII		0	4	1	3	5	
Hex	0x02	0x30	0x34	0x31	0x33	0x35	0x03

The O2 module responds with the command sent.

Reset: Command "11"

This command executes a hardware reset on the module. The module then behaves as if it had been switched on.

Byte	1	2	3	4	5	6	7
Anfrage	STX	Command		Data	Checksum		ETX
ASCII		0	4	1	3	5	
Hex	0x02	0x30	0x34	0x31	0x33	0x35	0x03

Byte	1	2	3	4	5	6	7
Antwort	STX	Command		Data	Checksum		ETX
ASCII		0	4	1	3	5	
Hex	0x02	0x30	0x34	0x31	0x33	0x35	0x03

The O2 module responds with the command sent.

Read / write adjustment value Zero: Command "21"

This command reads or writes the adjustment value for the zero point correction of the O2 sensor. The zero point correction is to be carried out with a gas mixture of 1% oxygen and 99% nitrogen.

If no data follows the command, the current value is read from the O2 module, otherwise the transferred value is written to the O2 module.

Valid zero values range from 1 to 254.

Depending on the sensor, the usual values are between 80 and 130. A value of 100 represents the neutral value, i.e. Values below 100 lead to a lowering, values above 100 lead to an increase in the zero point.


Changes in the zero value affect the full scale (FS) value.


The adjusted O2 sensor characteristic is changed by setting the zero value. This can lead to incorrect measured values.

Byte	1	2	3	4	5	6
Anfrage	STX	Command		Checksum		ETX
ASCII		2	1	0	3	
Hex	0x02	0x32	0x31	0x30	0x33	0x03

Byte	1	2	3	4	5	6	7	8	9
Antwort	STX	Command		Data (Zero-Wert)			Checksum		ETX
ASCII		2	1	1	3	7	3	6	
Hex	0x02	0x32	0x31	0x31	0x33	0x37	0x33	0x36	0x03

The O2 module responds with the current zero value.

Read / write full span adjustment value: Command "22"

This command reads or writes the adjustment value for the full span (FS) correction of the O2 sensor.

The full span correction is to be carried out in ambient air (FCX-MLD25-DIFF-CH).
The full span correction is to be carried out with a gas mixture of 90% oxygen and 10% nitrogen (FCX-MLD95-DIFF-CH).

If no data follows the command, the current value is read from the O2 module, otherwise the transferred value is written to the O2 module.

Valid span values range from 1 to 254.

Depending on the sensor, the usual values are between 80 and 130. A value of 100 represents the neutral value, i.e. Values below 100 lead to a lowering, values above 100 lead to a full deflection.

 Changes in the full span value affect the zero value.

 The adjusted O2 sensor characteristic is changed by setting the full span value. This can lead to incorrect measured values.

Byte	1	2	3	4	5	6
Anfrage	STX	Command		Checksum		ETX
ASCII		2	2	0	0	
Hex	0x02	0x32	0x32	0x30	0x30	0x03

Byte	1	2	3	4	5	6	7	8
Antwort	STX	Command		Data (Span-Wert)		Checksum		ETX
ASCII		2	2	9	7	0	E	
Hex	0x02	0x32	0x32	0x39	0x37	0x30	0x45	0x03

The O2 module responds with the current full span value.

Reset adjustment values: Command "2F"

With this command, the adjustment values are reset to the first delivery state, i.e. the O2 module is then operated again with the values adjusted at Angst+Pfister Sensors and Power.

Byte	1	2	3	4	5	6
Anfrage	STX	Command		Checksum		ETX
ASCII		2	F	7	4	
Hex	0x02	0x32	0x46	0x37	0x34	0x03

Byte	1	2	3	4	5	6
Antwort	STX	Command		Checksum		ETX
ASCII		2	F	7	4	
Hex	0x02	0x32	0x46	0x37	0x34	0x03

The O2 module responds with the command sent.

6 Environment Condition

See also under 9. 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 Important notes

8.1 Restrictions

1 Do not remove the sensor from the circuit board.

2 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.

3 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.

4 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.

5 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.

9 Specifications

Measurement range	:	0…25 % or 5…95 % O_2
Supply voltage	:	24 VDC nominal (22…29 VDC)
Power current	:	type 250 mA (24 VDC). Power-on peak about 0.7 A
Power consumption	:	< 2 W
Output signal	:	digital, serial output (3.3 V TTL level)
Accuracy	:	±0.5 % FCX-MLD95 ±2 % FS FCX-MLD25 (> 10% O_2) +/-0.2% FCX-MLD25 (< 10% 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}
Gas temperature	:	-10...+50 °C
Environmental temperature	:	-20...+70 °C
Rel. humidity	:	98% RH, not condensing
Dimensions L x W x H	:	48.0 x 38.0 x 25.6 mm (including flow housing)
Weight	:	50 g

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Sensors and Power

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