METROTEC

Systems for Measuring and Controlling Oxygen

Operating Instructions

U16-DIGITAL

Oxygen Measuring and Control Device

U16 Series Measuring module

*** Version 1.0 ***

EC Declaration of Conformity

for

Oxygen measuring and control unit Type U16 Series

This device has been designed for industrial purposes in accordance with:

EN 61000-6-4:
EN 61000-6-2:

It is compliant with the directives:
EMC Directive: 2014/30/EU
Low Voltage Directive: 2014/35/EU
RoHs: 2011/65/EU
Radio Equipment Directive 2014/53/EU

This device complies with following standards:
EN 61010-1
EN 61000-6-4:
EN 61000-6-2:
EN 63000
EN 300220-2

Description of measures taken to assure compliance:
Quality management system DIN EN ISO 9001:2015, No. 12 100 27736 TMS

This declaration becomes invalid if changes are made without our consent.

Kirchheim/Teck, 08/10/2024

Place, Date Signature

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1 Safety Instructions

	Please read these operating instructions carefully before installing and using the device. Improper use of the product will invalidate the warranty!
	The ambient conditions described in the Specifications chapter must be complied with in order to ensure the device's proper functioning and operational safety.
	The device may only be started up and operated by qualified and trained personnel. The operator of the device must ensure that all applicable regulations and guidelines are complied with. These are, among others, the EU Directive on work safety, national work safety legislation, accident prevention regulations, etc.
	Please ensure that the supply corresponds with the information given on the type plate. All coverings necessary to provide touch protection must be installed. In case the device is interconnected with other devices and/or installations, the consequences must be considered and appropriate precautions taken before switching the device on.
	In some cases, hot parts or surfaces may be unprotected during or after installing or uninstalling the device. Appropriate precautions must be taken to avoid injuries and/or damage.
	In case the device shows defects which suggest that it will not be possible to operate it safely, it must not be put into operation. We recommend to have the device inspected at least once a year at the factory or by a customer service representative.
	Disposal of the device must be performed according to the applicable regulations.

2 Preface

The measuring device serves for recording oxygen partial pressures in gas atmospheres in connection with an oxygen sensor. Such sensors operate at high temperatures. Therefore, precautions must be taken to keep ignitable gas mixtures from reaching the sensor or the device. In case of the sensor ceramic breaking, sample gases may leak or air may enter the sample gas side. Should this occur, applicable measures must be provided for to save the environment and device parts from damage.

Wrong entries, leaks, corrosion, condensation, etc. may cause damage of the plant and erroneous measured values. It is vital to have all parts of the system maintained regularly.

The oxygen measuring devices and the attachments have been produced and controlled subject to complete quality assurance in accordance with DIN EN-ISO 9001.
Installation and operation must be performed subject to compliance with all local and special regulations. These particularly include VDE and DVGW requirements.
Depending on the application, a periodic inspection of the measuring device in terms of measuring accuracy and function may be required and must be performed in the course of calibration and inspection procedures after initial commissioning.

Illustration: Oxygen Measuring Module Type U16-Digital

This description is valid for the versions listed here				
Versions of U16-Digital				
Designation	**Field bus**	**Analog output**	**Alarm**	**Supply**
U16-Digital	--	2	2	230VAC
U16-DigitalB	X[1]	2	2	230VAC
U16-DigitalBL	X[1] with loop	2	2	230VAC
U16-Digital24	--	2	2	24VDC
U16-Digital24B	X[1]	2	2	24VDC
U16-Digital24BL	X[1] with loop	2	2	24VDC
X[1] : The integrated field bus, which is optionally available, is specified in the order and delivery documentation				

Example for Type Plate

Type designation	Device type with option. Index “B” additional field bus, “L” bus loop
Serial number[2]	Clear identification of measuring module including options and configuration. *Note: Serves for answering questions about specific characteristics.*
Set number[3]	Identification of sensor and measuring module combination. *Note: In case of deviating set number, device combination must be newly calibrated.*

3 Introduction

3.1 Measuring Principle

Oxygen measuring devices are designed to process signals of an oxygen sensor made of stabilised zirconium dioxide. Zirconium dioxide, a ceramic also referred to as solid state electrolyte, is perfectly suited to serve as an oxygen-ion conductor at high temperatures.
Within certain temperature limits, which depend on the doping of the material concerned, such ion conductors are able to fill empty spaces in their crystal lattice with oxygen ions. The oxygen ions form itself on a conductive contact layer, whích usually consists of platinum.
Thus, the oxygen concentration in a sample gas is essential for the extent of oxygen activity and accordingly the number of oxygen ions.
The basic structure of a sensor revolves around a solid state electrolyte which is contacted on both sides. One side of the electrolyte is operated by a reference gas, such as air, the other one with sample gas. The mechanical design of the sensor separates both gas sides from each other, thus preventing the gases to mix.
Depending on the application, either heated or unheated sensors will be used. Unheated sensors are predominantly used in ovens, while heated sensors come into play in applications, where gases below 600 degrees Celsius are to be measured. (The measuring principle requires a minimum temperature of 500 – 650 degrees Celsius.)
Heated sensors are adjusted to a specific target temperature by means of a temperature controller integrated in the processing electronics. The temperature of heated and unheated sensors is measured by the electronic unit and is an essential element in the calculation of the oxygen oxygen level (oxygen partial pressure).
The value is calculated by means of the following formula:

$$EMK = \frac{R \cdot T}{4 \cdot F} \cdot \ln\left(\frac{P_1}{P_2}\right)$$

whereby

R = 8.31J/mol K
T = Temperature in Kelvin
F = 96493 As/mol
P1 = Oxygen partial pressure on the reference side with 0.20946 bar
P2 = Oxygen partial pressure on the sample gas side
EMF = Electromotive force in Volt

3.2 Measuring Module

The U16 series measuring module includes the following functions:

- Measurement of oxygen partial pressure in connection with a separate A19-PC/NC type sensor
- Output of measured value 0-20 mA, 4-20 mA or 0-24mA, configurable
- Image of measured value parameterizable
- Generation of alarms
- Communication via Bluetooth
- Communication via field bus (optional)

The module is parameterised after the installation, if necessary, and will operate permanently with these settings.

Note:
For changes/parameterization and displaying measured values, either the "METROTEC App for Android" or the "METROTEC App for Windows" are required.

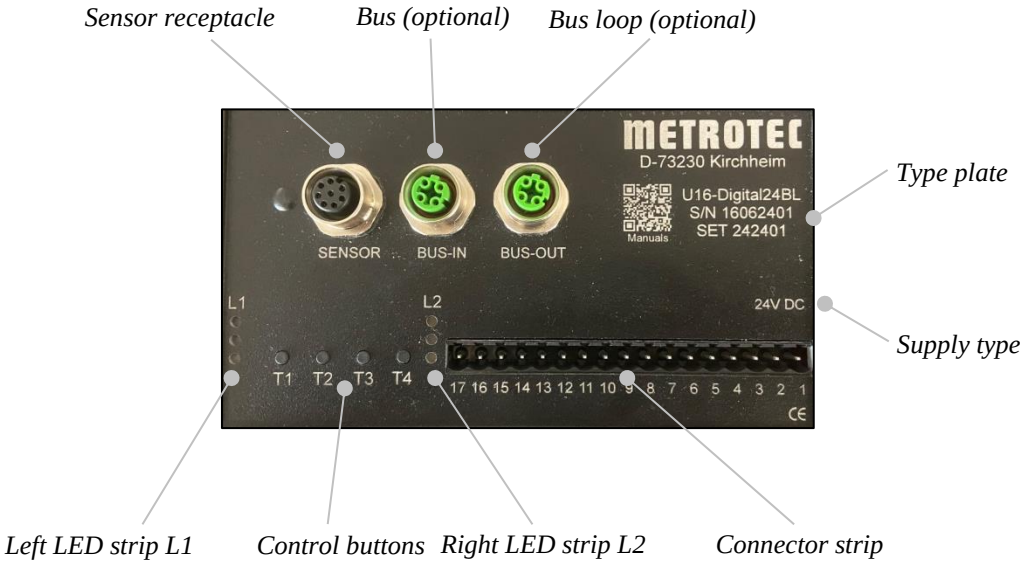
3.3 Sensor

The measuring module requires a separate extractive oxygen sensor to enable its functioning.
Connecting the sensor: See section "Connection Diagram" as well as separate operating instructions of the sensor.

4 General Layout

4.1 Description of the Measuring Electronics

The front is divided into several areas representing interfaces, key panel and display.



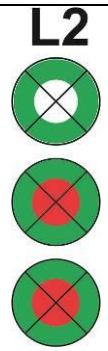
5 Device Start-up

5.1 Switching the Measuring Module on

The measuring module is wired up in accordance with the wiring diagram. The module is ready to start when the supply voltage is applied.

The status LED in strip L2 flashes green. See Table 1
After the heating-up phase of the sensor, the status LED in strip L2 flashing green indicates readiness. See Table 1
When ready, the measuring module delivers the current measured value at the mA output.

Table 1: Status display of LED strip L2

LED	Status	Description
	Off	Bluetooth switched off
	Flashing green	Bluetooth switched on
	Green	Bluetooth connected
	Flashing green	Status Heating-up phase
	Green	Status Readiness
	Flashing red	Status Malfunction Cable break/Excess temperature/Insufficient temperature
	Off	Alarm Limit value switched off
	Green	Alarm Limit value OK
	Red	Alarm Limit value too high

5.2 Measurement

After the starting routine the device is ready for use and can determine the oxygen content in gases. This requires supplying the sample gas according to the sensor type. Alternatively the sample gas contains the sensor. See the operating instructions of the respective sensor.

5.3 Switching the Measuring Device off

It is advisable to keep the device continuously in operation. This will avoid the condensation of steam in heated sensors which may cause corrosion.
Should the unit need to be switched off, the energy supply of the measuring module will be interrupted. See the operating instructions of the respective sensor.

6 Measured Value Output

The measuring module can output the measured value in linear or logarithmic mode. The standard setting is "linear". The settings may be changed by means of the *"METROTEC App for Android"* or the *"METROTEC App for Windows"*. See Section "Parameter Groups".

6.1 LIN Measured Value Output

The linear output of measured values implicates the assignment of the measured values to either the 0 to 20 mA or 4 to 20 mA output, or the 0 bis 24 mA output in linear mode. The assignment is fixed and can only be changed by means of the *"METROTEC App for Android"* or *the "METROTEC App for Windows"*.

6.2 LOG Measured Value Output

The logarithmic output of measured values implicates the assignment of the measured values to either the 0 to 20 mA or 4 to 20 mA output, or the 0 bis 24 mA output in logarithmic mode. The assignment is fixed and can only be changed by means of the *"METROTEC App for Android"* or *the "METROTEC App for Windows"*.
The output can take on values between 10^{0} and 10^{-35} . The values represent the logarithm of the oxygen partial pressure. This presentation helps to output values stretching over many powers of ten.

Conversion table				
%	**bar**	**ppm**	**log (x)**	**10^{x}**
100	1	1000000	0.00	10^{0}
10	0.1	100000	-1.00	10^{-1}
1	0.01	10000	-2.00	10^{-2}
0.1	0.001	1000	-3.00	10^{-3}
0.01	0.0001	100	-4.00	10^{-4}
0.001	0.00001	10	-5.00	10^{-5}
0.0001	0.000001	1	-6.00	10^{-6}
0.00001	0.0000001	0.1	-7.00	10^{-7}
0.000001	0.00000001	0.01	-8.00	10^{-8}

The measurement module can process values between 10^{0} and 10^{-35} .

7 Configuration

The configuration and parameterization can only be changed by means of the *"METROTEC App for Android"* or *the "METROTEC App for Windows"*.

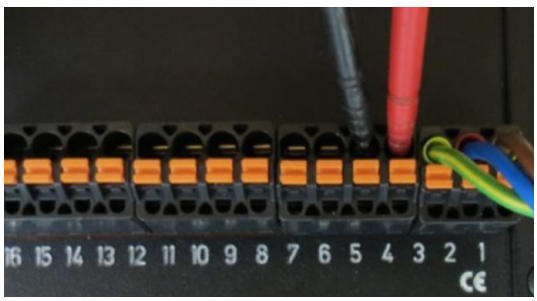
Attention!
Important settings can be changed in the "Configuration" mode which may result in initial functions being no longer available!
Therefore it needs to be defined for what reason this mode is selected. The following actions are available:

1. *Check/adjustment of measured value at 20.94% oxygen. (Reference Point)*
2. *Check/adjustment of measured value with test gas. (Operating Point)*
3. *Check/setting of switch point for limit value relay*
4. *Check/parameterization and configuration of mA outputs*
5. *Check/parameterization of field bus connection*

Specifically the check/adjustment of the measured value at 20.94% oxygen must be executed with the greatest possible care. The adjustment affects the displayed measured value when the sensor is being flushed through with sample gas.

7.1 Practical approach

In many cases the visual display of the mA signal is not within sight distance of the measuring module. Thus our recommendation is to disconnect the mA connection from terminals 4 and 5 and replace it by a commercially available portable mA measuring device.



The adjustments and settings described can be executed by means of the *"METROTEC App for Android"* or *the "METROTEC App for Windows"*. After finishing these settings the previously disconnected connections are restored.

7.2 Correcting the Measured Value

The current measured value can be corrected, if required. In this case it is advisable to make the adjustment after a stable measurement has been achieved and possible errors in measurement can be ruled out.

7.2.1 Reference Point

An adjustment should be made only, if the following conditions are met:

1. The sensor must have reached operating temperature
2. The sensor must have been flushed with clean air containing 20,94% oxygen

The exact procedure can be found in the chapter *Adjustment* in the respective *METROTEC App*.

7.2.2 Operating Point

An adjustment should be made only, if the following conditions are met:

1. The sensor must have reached operating temperature
2. The sensor must have been flushed with test gas

The exact procedure can be found in the chapter *Adjustment* in the respective *METROTEC App*.

7.2.3 Limit Value

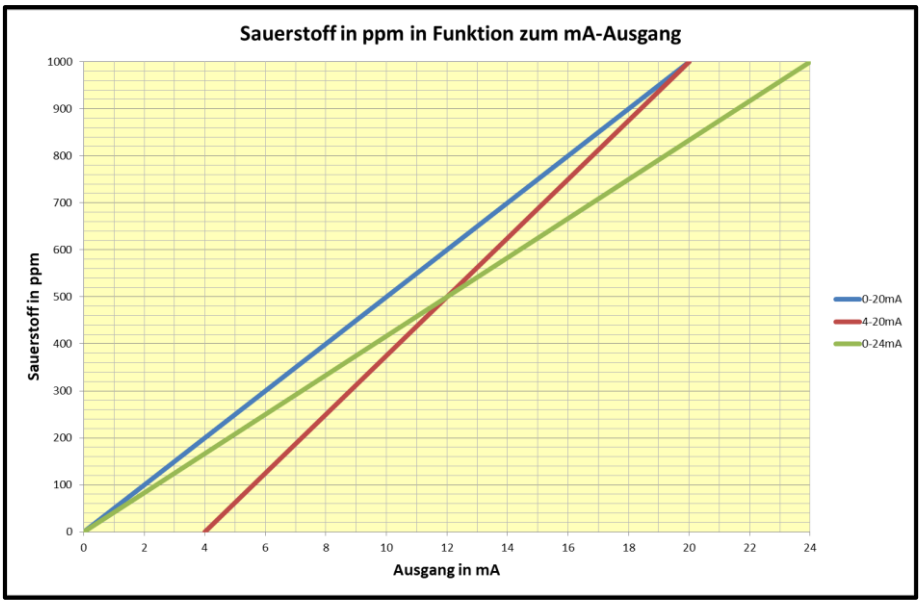
The limit value is switched when the current measured value exceeds the current limit value. The limit value is independent of the programmed measuring range. An alarm status is signalled by LED strip L2. See Table 1. At the same time the semiconductor relay switches.

The exact procedure can be found in the chapter *Configuration* in the respective *METROTEC App*.

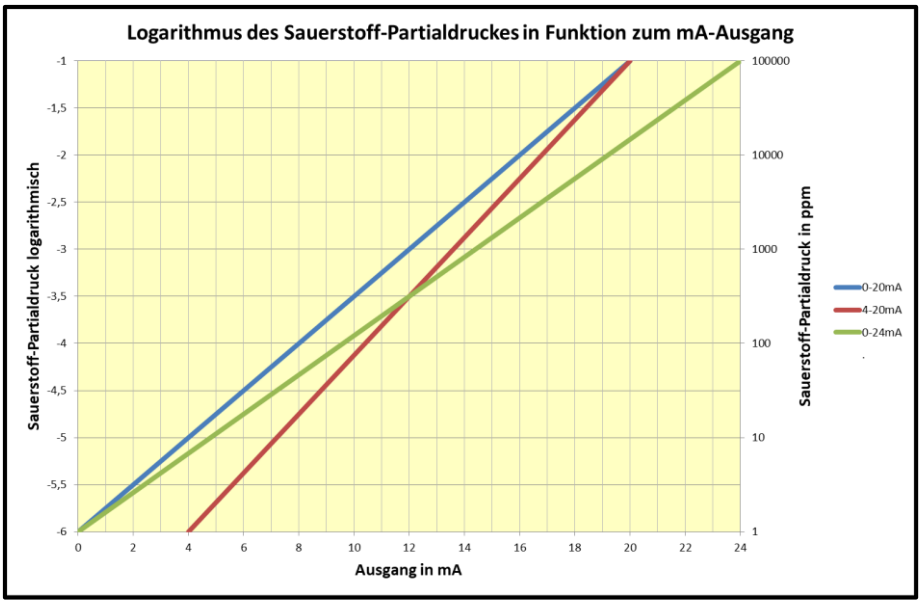
7.3 Definition of Analog Outputs

The switch 4-20 mA, 0-20 mA, 0-24 mA and the analog output definitions take place by means of the *"METROTEC App for Android"* or *the "METROTEC App for Windows.*

Example for 0-20 mA, 4-20 mA and 0-24 mA if the output has been parameterized for 0 to 1000 ppm oxygen.



Example for 0-20 mA, 4-20 mA and 0-24 mA if the output has been logarithmically parameterized for 10^{-1} (=10.000 ppm = 10 %) bis 10^{-6} (= 1 ppm) oxygen. In the diagram, the left y-axis -1 to -6 has been scaled to correspond with 10^{-1} bis 10^{-6}, the right y-axis shows the value converted into ppm.



8 Interfaces

8.1 Analog Interfaces

- 2 x mA interface configurable

8.2 Digital Interfaces

- Semiconductor relay for oxygen limit value
- Semiconductor relay for readiness
- Bluetooth
- Field bus (see separate operating instructions)

9 METROTEC App for Windows

The *"METROTEC App for Windows*" enables you to look at measuring values, execute adjustments and change configuration settings. This requires the activation of the Bluetooth interface at the measuring module.
This is done by pressing "T2". The Bluetooth LED in the LED strip L2 flashing green signals readiness for connecting via Bluetooth. See Table 1.
Now a connection can be established. As soon as the connection is active, the Bluetooth LED in the LED strip L2 lights up permanently. Pressing "T2" again will switch the Bluetooth connection off.
An exact description is available in the *"METROTEC App for Windows*" operating instructions.

10 METROTEC App for Android

The *"METROTEC App for Android*" enables you to look at measuring values, execute adjustments and change configuration settings. This requires the activation of the Bluetooth interface at the measuring module.
This is done by pressing "T2". The Bluetooth LED in the LED strip L2 flashing green signals readiness for connecting via Bluetooth. See Table 1.
Now a connection can be established. As soon as the connection is active, the Bluetooth LED in the LED strip L2 lights up permanently. Pressing "T2" again will switch the Bluetooth connection off.
An exact description is available in the *"METROTEC App for Android*" operating instructions.

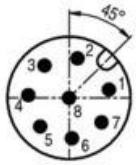
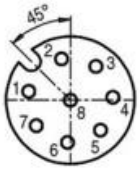
11 Specifications

Measuring range	100 % to 10^{-35} bar O_2
Ambient temperature	0 to 45 degrees Celsius
Measuring accuracy	+/- 0.3 mV of the sensor e.m.f. +/- 2 degrees Celsius +/- 2% of the mA output +/- 2% of the log oxygen partial pressure
Dimensions	ca. 130 x 180 x 90 mm (HxWxD)
Weight	ca. 1.5 kg
Supply voltage	230 VAC, 24 VDC Observe type plate!
Power	Acc. to sensor type, ca. 100 VA max.
2 Analog outputs	0/4 – 20/24 mA configurable, floating
2 Relay outputs	configurable for alarms, 60 VAC-DC, 1A ohmic, floating

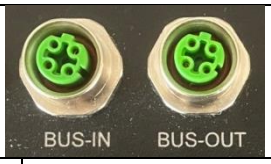
12 Connection Diagrams

Cable	Pin	Function	Definition
Sensor module M12-8P,CodeA (m)	1	Sensor -	Sensor signal EMF -
	2	Sensor +	Sensor signal EMF +
	3	Heating +	Sensor heating +
	4		
	5	Sense +	Sense line +
	6	Heating -	Sensor heating -
	7		
	8	Sense -	Sense line -

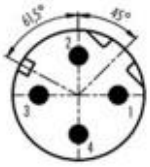
Pin Numbering

Type	Plug	Socket
M12-8P,CodeA		

Terminal	Function	Definition
1	Supply	Supply 24 VDC / 230VAC see type plate
2	Supply	Supply 24 VDC / 230VAC see type plate
3	PE (Protective Earth)	Protective Earth
4	mA+	Measured value output 1 +
5	mA-	Measured value output 1 -
6	mA+	Measured value output 2 +
7	mA-	Measured value output 2 -
8	Semiconductor relay	Readiness 60 VAC, 1 A
9	Semiconductor relay	Readiness 60 VAC-DC, 1 A
10	Semiconductor relay	Limit value 60 VAC-DC, 1 A
11	Semiconductor relay	Limit value 60 VAC-DC, 1 A
12	n.c.	
13	n.c.	
14	Test	Test output for factory settings
15	Test	Test output for factory settings
16	n.c.	
17	n.c.	



Cable	Pin	Function	Definition
M12-4P,CodeD (m)	1	TX +	Transmit Data + (BUS-IN)
	2	RX +	Receive Data + (BUS-IN)
	3	TX -	Transmit Data - (BUS-IN)
	4	RX -	Receive Data - (BUS-IN)
	SH	PE	Shield
M12-4P,CodeD (m)	1	TX +	Transmit Data + (BUS-OUT)
	2	RX +	Receive Data + (BUS-OUT)
	3	TX -	Transmit Data - (BUS-OUT)
	4	RX -	Receive Data - (BUS-OUT)
	SH	PE	Shield

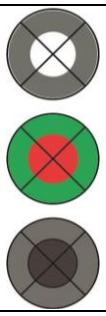
Pin images		
Type	**Plug**	**Socket**
M12-4P,CodeD		

13 Appendix

13.1 System flags

Bit	Value	Meaning
1	0	No function
2	0	No function
3	0	Display Measured value logarithmic
	1	Display Measured value (ppm)
4	0	Measurement Wide / LED L2/2 green
	1	Measurement Error / LED L2/2 red flashing (alternating cyclically between 1 and 0)
5	0	Limit value OK / LED L2/3 green
	1	Limit value Alarm / LED L2/3 is red
6	0	Limit value OK / Alarm relay closed
	1	Limit value Alarm / Alarm relay open
7	0	EMF display in application switched off
	1	EMF display in application switched on
8	0	Limit value monitoring deactivated / Alarm LED L2/3 off / Alarm relay closed
	1	Limit value monitoring activated / State Bit 5 and Bit 6
9	0	No function
10	0	No function
11	0	No function
12	0	No function
13	0	No function
14	0	No function
15	0	No function
16	0	No function

13.2 LED and Relay Status

Status of LED and Relay				
Event	**Ready**		**Alarm**	
	LED	**Relay**	**LED**	**Relay**
		Terminal 8 - 9		Terminal 10 - 11
Limit value monitoring deactivated	green	closed	off	closed
Limit value OK	green	closed	green	closed
Limit value alarm	green	closed	red	open
System error alarm	green	closed	flashing red-green	open
Heating-up phase	flashing green	open	off	open
Short circuit	flashing red	open	off	open
Cable break	flashing red	open	off	open
Excess temperature	flashing red	open	off	open
Insufficient temperature	flashing red	open	off	open
System error control	flashing red-green	open	off	open

13.3 Example Data Record

Rec.Nr.	O2 Lin ppm5 U16/5 [P0]	*PG Custom Main U16 [P95]	Temperature [P1]	*Reference Point [P2]	*Operating Point [P3]	System flags [P7]	EMF (mV) [P9]	Out1=log (4-20mA) [P10]	Out2=ppm (4-20mA) [P11]	*mA1 log (1-4) [P25]	*mA2 ppm (1-4) [P26]	*Display at error [P30]	*Measurem. 1ppm 0log [P56]	O2 log actual [P155]	O2 ppm actual [P156]	Status :1 [P80]	UMODUL V1.0.BAS [P47]	Time
1	209400	0	505	0	1	11110100	0,603	20	20	1	2	15	1	-0,679	209400,031	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:43
2	209400	0	505	0	1	11110100	0,601	20	20	1	2	15	1	-0,679	209400,031	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:43
3	209400	0	505	0	1	11110100	0,761	20	20	1	2	15	1	-0,679	209400,031	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:43
4	145400	0	505	0	1	11110100	6,192	20	20	1	2	15	1	-0,835	146075,703	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:43
5	140055	0	505	0	1	11110100	6,748	20	20	1	2	15	1	-0,854	140052,266	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:44
6	141145	0	505	0	1	11110100	6,609	20	20	1	2	15	1	-0,85	141122,609	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:44
7	142673	0	505	0	1	11110100	6,447	20	20	1	2	15	1	-0,846	142656,766	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:44
8	143857	0	505	0	1	11110100	6,292	20	20	1	2	15	1	-0,842	143964,766	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:44
9	144853	0	505	0	1	11110100	6,176	20	20	1	2	15	1	-0,839	144826,531	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:44
10	146697	0	505	0	1	11110100	5,983	20	20	1	2	15	1	-0,834	146670,641	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:45
11	148368	0	505	0	1	11110100	5,776	20	20	1	2	15	1	-0,828	148513,563	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:45
12	149952	0	505	0	1	11110100	5,595	20	20	1	2	15	1	-0,824	149929,375	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:45
13	151565	0	505	0	1	11110100	5,437	20	20	1	2	15	1	-0,82	151521,063	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:45
14	152884	0	505	0	1	11110100	5,272	20	20	1	2	15	1	-0,815	153004,141	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:45
15	154268	0	505	0	1	11110100	5,124	20	20	1	2	15	1	-0,812	154229,188	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:45
16	155663	0	505	0	1	11110100	4,985	20	20	1	2	15	1	-0,808	155643,313	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:46
17	156931	0	505	0	1	11110100	4,835	20	20	1	2	15	1	-0,804	157055,938	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:46
18	158444	0	505	0	1	11110100	4,675	20	20	1	2	15	1	-0,8	158422,375	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:46
19	159955	0	505	0	1	11110100	4,53	20	20	1	2	15	1	-0,796	159935,438	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:46
20	161185	0	505	0	1	11110100	4,389	20	20	1	2	15	1	-0,792	161147,563	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:46
21	162477	0	505	0	1	11110100	4,254	20	20	1	2	15	1	-0,789	162461,109	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:47
22	163724	0	505	0	1	11110100	4,138	20	20	1	2	15	1	-0,786	163706,5	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:47
23	164862	0	505	0	1	11110100	4,012	20	20	1	2	15	1	-0,783	164843,219	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:47
24	166059	0	505	0	1	11110100	3,889	20	20	1	2	15	1	-0,78	166041,141	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:47
25	167361	0	505	0	1	11110100	3,772	20	20	1	2	15	1	-0,776	167327,344	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:47
26	168589	0	505	0	1	11110100	3,635	20	20	1	2	15	1	-0,773	168569,453	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:48
27	170008	0	505	0	1	11110100	3,509	20	20	1	2	15	1	-0,77	169971,703	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:48
28	171164	0	505	0	1	11110100	3,381	20	20	1	2	15	1	-0,766	171268,766	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:48
29	172320	0	505	0	1	11110100	3,269	20	20	1	2	15	1	-0,764	172304,844	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:48
30	173411	0	505	0	1	11110100	3,175	20	20	1	2	15	1	-0,761	173396,875	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:48
31	174314	0	505	0	1	11110100	3,077	20	20	1	2	15	1	-0,758	174396,813	Sensor ready	18-09-2024 10:08:17	30.09.2024 08:48