Oxygen measurement and control unit
Type GSM

*** Version 2.1 ***
Declaration of Conformity

for
Oxygen measurement and control unit

GSM

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
Machinery Directive: 2006/42/EC

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

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, 05.02.2019

Place, Date

Signature

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1 Safety instructions

Please read through this operating manual very carefully before installing and commissioning the unit. Incorrect utilisation will invalidate the guarantee!

Correct functioning and the operating safety of the unit can only be guaranteed if the ambient conditions specified in the Specifications chapter are maintained.

Only qualified specialists are permitted to commission and operate the unit. The owner of the unit must ensure that the installation complies with the relevant laws and directives. These include, for example, the EU Directives covering safety in the workplace, national safety in the workplace regulations and the prevention of accidents regulations, etc.

You must ensure that the power supplies concur with the details listed on the nameplate. All of the covers needed to ensure that the unit cannot be touched when operating must always be fitted. You must consider the effects of the overall operation and take the necessary precautions if the unit will be linked up with other equipment and/or devices before you switch on.

Parts and surfaces will occasionally become and remain hot during the installation or de-installation. Suitable precautions must be taken in order to prevent injuries or damage to the unit from occurring.

If the unit shows signs of having been damaged and you are of the opinion that that safe operation is no longer possible then you must not run the unit. We recommend that periodical inspections are carried out at our factory or by our customer service department at least once a year.

Future disposal must always comply with the legal regulations.
2 Preface

With the aid of an oxygen sensor, the measurement unit serves to measure the oxygen partial pressure in gaseous atmospheres. Such sensors work at high temperatures and so it is necessary for measures to be taken to ensure that no flammable gas mixtures contact the sensor or the unit. In the event of the sensor ceramic suffering breakage the measurement gas could escape or air could enter the measurement gas side of the unit and so suitable measures have to be taken to avoid such an event leading to environmental pollution or damage being done to equipment.

In the event of incorrect parameters being set or the occurrence of leakage, corrosion, condensation, etc., damage could be done to the equipment and incorrect measurement results be indicated and so it is essential that all parts of equipment be regularly serviced.

The oxygen sensor and its accessories are subjected to thorough quality control in accordance with DIN ISO 9001 in the course of their manufacture and testing. They must only be installed and used in compliance with all applicable local and special regulations, particularly the VDE and DVGW standards that apply in Germany. The measurement accuracy and effective function of the measurement device will need to be checked at intervals whose frequency will depend on the application concerned. Such a check must be effected in the course of a calibration and examination check on the equipment being first put into operation.
3 Introduction

3.1 Measurement principle

Oxygen measurement units are designed to process signals transmitted from an oxygen sensor constructed of stabilised zirconium oxide. Zirconium oxide, a ceramic material that is also spoken of as a solid-state electrolyte, acts as an excellent oxygen-ion conductor when at a high temperature.

Within certain temperature limits, that 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 occur against an electrically conductive surface that is generally of platinum.

The concentration of oxygen in a measurement gas is thus decisive for the extent of oxygen activity, and thus for the number of oxygen ions.

An oxygen sensor consists essentially of a solid-state electrolyte with a contact surface on both sides.

One side of the electrolyte is in contact with a reference gas such as air, and the other with the gas whose oxygen content is to be measured. The mechanical construction of the sensor prevents contact between the two gases so that there is no risk of their being intermixed.

Depending on the application concerned, heated or unheated sensors are used. Unheated sensors are generally used in furnaces while heated sensors are used for applications where the gas to be measured is at a temperature of less than around 600 degrees Celsius (the measurement principle necessitates the sensor being maintained at a temperature of not less than 500 - 650 degrees Celsius).

Heated sensors are maintained at a set temperature by an electronic temperature regulator that forms part of the electronic control unit. The temperature of both heated and unheated sensors as measured by the electronic control is an important parameter for inclusion in the calculation of the oxygen content (oxygen partial pressure) in accordance with the following equation:

\[
EMF = \frac{R \cdot T}{4 \cdot F} \cdot \ln\left(\frac{P_1}{P_2}\right)
\]

whereby:

- \(R\) = 8.31 J/mol K
- \(T\) = Temperature in Kelvin
- \(F\) = 96493 As/mol
- \(P_1\) = Oxygen partial pressure on the reference side with 0.20946 bar
- \(P_2\) = Oxygen partial pressure on the measurement gas side
- \(EMF\) = Electromotive force in Volts
3.2 Measurement electronics
The electronic circuit of the measurement unit Type GSM provides the following functions:
Measurement of the oxygen partial pressure
Maintaining the oxygen content at a present level
Generating alarm signals
Option: Calculation of the dew point
Option: Calculation of the air factor lambda point
The device is operated with the aid of a keypad.
Menus assist the operator in the selection of inputs and outputs
and in the setting of parameters.

4 General arrangement
4.1 Description of the measurement electronics
The elements at the front of the unit are in three groups
Keypad:
The keypad has four keys by means of which all the necessary functions can be effected.
Display:
The graphic display provides for the display of measured values, data, time graphs and messages.
5 Putting the unit into operation

5.1 Mounting and connection of sensors
Read separate instructions.

5.2 Switching the unit on
Once all electrical connections have been made and checked, the power plug is plugged in. After waiting for about 15 minutes for the sensor to be heated up, the unit indicates the oxygen content of the gas concerned. but stable values are only indicated about fifteen minutes after the heating-up period has expired.

5.3 Switching off the measurement unit
It is preferable for the unit to be kept in continuous operation. As the sensor then remains heated there is less risk of it suffering the presence of condensation, that could lead to corrosion but if it is required to put the unit out of operation, the power plug should be withdrawn and attention be paid to the following points:

Heated sensors:

Inline sensors:
Remove carefully while still hot and allow to cool, taking care to avoid mechanical or thermal stress!

Compact sensors:
Flush with air before switching off

Unheated sensors:
These are generally left in place

Putting the measurement unit briefly out of operation:
When the unit is switched on again after being switched off for a short time, the instructions given above under "Switching the unit on" should be followed.
6 Operation

A few seconds after switching on, the first page is displayed as follows:

Each page has a headline that is separated by a line from the rest of the display. This headline indicates the page number and the title or an outstanding fault message. Beneath the line there is either a graph or a 6-line text.

The keypad has five components.

⇒ On the extreme left there is a rubber cap that is only removed to allow access to the socket beneath to which the communication cable is connected when it is required to install a new program.
⇒ The adjacent key provides for switching between manual and automatic operation.
⇒ The two arrow keys provide for moving the cursor line upwards or downwards or for increasing or decreasing values when alterations to entry fields are enabled.
⇒ The key on the right provides for
   a) Opening a display page
   b) Opening an entry field to enable an entry to be made
   c) Closing an entry field and storing an entry.
⇒ The “Esc” key is for closing the display page or return to overview

Pressing the right-hand key causes the display to jump to the page selection list and then the cursor bar can be moved to the line bearing the required page title. When this no longer illuminated page title is confirmed by pressing the right-hand key, the page concerned is displayed.

An opened page can be closed again by pressing the right-hand key.

A window opens for any inputs. Like below example values can stored by pressing the buttons. „Min“ and „max“ shows the limit values. „Cu“ shows the current value. Store by pressing „OK“.

The various pages that can be selected in normal operation are detailed below.
### 107 P-Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMF</td>
<td>250 mV</td>
</tr>
<tr>
<td>Temp</td>
<td>700 Grad C</td>
</tr>
<tr>
<td>logO2</td>
<td>-5.47 bar</td>
</tr>
<tr>
<td>Dewp.</td>
<td>100 Grad C</td>
</tr>
<tr>
<td>Lambda</td>
<td>1.00</td>
</tr>
<tr>
<td>O2 red</td>
<td>9999 ppm</td>
</tr>
</tbody>
</table>

### 112 Trend Lambda

![Graph of Trend Lambda](image1)

- Minimum: 0.73
- Maximum: 1.50

### 113 Trend Log O2

![Graph of Trend Log O2](image2)

- Minimum: -19.20 bar
- Maximum: -40.00 bar

### 114 Trend DewP.

![Graph of Trend DewP.](image3)

- Minimum: -26
- Maximum: 100
7 Configuration

7.1 Enablement of Configuration

Before parameters can be altered it is first necessary to overcome the disablement code. Only then is access to additional pages possible. Enablement is effected as follows:

1. Select the page entitled CODE in the page selection table.
2. Press the key on the extreme right.
3. Keep pressing an arrow key until the NUMBER line is no longer backlit.
4. Press the right-hand key. A input mask will open.

5. Press the right-hand key until your specific code (which was "1" on delivers) is displayed.
6. Once the required code is displayed, press the right-hand key once more to confirm the entry. The message "Parameters free" appears in the next line.
You then have access to the page selection list once more.

Note:
Access to parameters and configurations is enabled for only a limited period. (90 seconds) If more time is needed, then it will be necessary to repeat the steps needed to overcome the disablement code.

7.2 Displayed values

For the calculation of lambda and dew point it is necessary to enter characteristic values as also detailed under "Options".
Here you can adjust the measured value with an set point value of a test gas by varying “EMF+” or “EMF*”. The result is displayed under “LOG” and “O2”. The value 0.00 for the additive correction and of 1.0 for the multiplicative correction means that no correction is to be applied to the determined EMF value.

7.3 Process parameters

This page is selected from the page list as described above. The unlighted cursor beam can be positioned against the required value by means of the arrow keys. The cursor beam is then positioned against the value concerned and the entry is confirmed by pressing the right-hand key. The displayed value can be increased or decreased to cause the new required value to be displayed. Once this is achieved, it is confirmed by pressing the right-hand key and the new value is thus stored in the memory.

Filter = 0.0 means that no filter is active. Fluctuations in the sensor signal can be attenuated with the aid of a filter factor.

7.4 mA outputs

The device has three analogue outputs. Output 1 is for the logarithmic oxygen value, Output 2 for the linear oxygen value and Output 3 for various optional values such as dew point or lambda: values for outputs 1 and 2 are thus displayed on one page and those for Output 3 on a separate page.
The significance of LINmax values:

<table>
<thead>
<tr>
<th>LINmax</th>
<th>LOGmax</th>
<th>LOGmin</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^{-3}</td>
<td>10^{-6}</td>
<td>10^{-9}</td>
</tr>
</tbody>
</table>

It should be borne in mind that linear values always extend from 0 to LINmax and that with logarithmic values the LOGmax value must always be greater than LOGmin.

A choice has to be made between four possibilities. The figure "W" has to be set accordingly. End values have also to be set for 0 and for 20 mA. This is done by defining an end point within the total physical range for 0 – 100 parts indicated in the table below, within which a window for UPPER and LOWER limits can be established.

<table>
<thead>
<tr>
<th>Lambda</th>
<th>0 to 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>0 to 10%</td>
</tr>
<tr>
<td>Dew point</td>
<td>-100 to 100 degrees</td>
</tr>
<tr>
<td>O2B</td>
<td>0 to 1000 ppm</td>
</tr>
</tbody>
</table>
7.5 Alarm output

<table>
<thead>
<tr>
<th>128 Alarm Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit Temp</td>
</tr>
<tr>
<td>Max = 800 Grad C</td>
</tr>
<tr>
<td>Min = 500 Grad C</td>
</tr>
<tr>
<td>Limit logPO2</td>
</tr>
<tr>
<td>Max = 0.00 bar</td>
</tr>
<tr>
<td>Min = -30.00 bar</td>
</tr>
</tbody>
</table>

The definition of Alarm is self evident.
It has also to be defined whether the physical output is to be a relay or a semiconductor.

7.6 Control output

It has also to be defined whether the physical control output is to be a relay or a semiconductor.
If the alarm output is a relay then the control output is a semiconductor and if the alarm output is a semiconductor, then the control output is a relay.
7.7 Scaling of the trend graphs

The scaling of the graphs cannot be altered. Alterations to the axes can only be effected by the supplier.

**Exception:** The Y-axis will be enlarged 4 times if “+“ will be pressed. Pressing “-“, the original scale is active again.

8 Options

8.1 Dew point

For some applications it is required that the dew point in degrees Celsius be calculated. This is frequently the case where nitrogen/hydrogen mixtures are concerned. The dew point is determined by comparing the measured O₂-value with that of a standard hydrogen percentage who's value has to be entered under "Parameters".

**Note:**

*Calculation of dew point is a mathematical function. If there is a change in the hydrogen percentage or if no hydrogen is present, then the dew point cannot be calculated correctly*
8.2 Lambda
For some applications it is of importance to know the lambda value of a combustion gas or of a gas/air mixture. In this case, lambda is defined as follows:

\[ \text{Lambda} = \frac{\text{combustion air supplied}}{\text{combustion air theoretically required}} \]

If this feature is required, it is necessary for a characteristic value to be entered in the "Parameter" menu.

Note:

*Calculation of dew point is a mathematical function. If the C/H value changes or is not present, then the lambda value can no longer be calculated correctly.*

8.3 CO
The CO value is derived from the lambda function. (see note under lambda)

8.4 Calculated oxygen value
The calculated oxygen value "O2B" of a nitrogen/hydrogen mixture is determined from the hydrogen percentage (see under "Dew point" option)
9 Interfaces

9.1 Analogue interfaces
The device has three 0 – 20 mA analogue interfaces all of which can be active at the same time. A change to 4 – 20 mA can be effected by the user.

<table>
<thead>
<tr>
<th>118 Out LIN/LOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINmax = -3.00</td>
</tr>
<tr>
<td>LOGmax = 0.00</td>
</tr>
<tr>
<td>LOGmin = -6.00</td>
</tr>
<tr>
<td>....Output mA...</td>
</tr>
<tr>
<td>= 4-20mA</td>
</tr>
</tbody>
</table>

9.2 Digital interfaces

9.2.1 Standard interfaces
There are two relays, either of which can be defined as either a control output or as an alarm output. There are also two semiconductor outputs which can be defined as an alarm or as a control output.

<table>
<thead>
<tr>
<th>180 Lockout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code = 1 New</td>
</tr>
<tr>
<td>Code = 0 I/O</td>
</tr>
<tr>
<td>Code = 0 Konf.</td>
</tr>
<tr>
<td>Code = 0 Comm.</td>
</tr>
<tr>
<td>Alarm is a Relay</td>
</tr>
</tbody>
</table>

9.2.2 Optional interface: RS 485
The interface plug is at rear site between the connector block
To define the interface it first must be entered at “Lockout” the code 5 in line “Comm”. Then skip to the definition-page with 2 times pressing the “Esc” button. Following the interface-parameters like type, address and baurate can be defined.

### Main menu
- Operating pages
- Parameter
- Signals
- Configuration
- Device settings

### Device settings
- Date, time
- Device data
- Online/Offline
- Calibration
- Info
- Status I/O
- Status CAN-Bus
Data request at protocol ISO 1745, 7bit, 1 Stopbit, Even, for the example address 1 is:
Whereat: Ad r = address, C3 ...C6 and C1 are invariable,

<table>
<thead>
<tr>
<th>Value for C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 = % O₂</td>
</tr>
<tr>
<td>4 = Log O₂</td>
</tr>
<tr>
<td>5 = ppm O₂</td>
</tr>
<tr>
<td>6 = Tp</td>
</tr>
<tr>
<td>7 = O₂ red</td>
</tr>
<tr>
<td>8 = Temperature</td>
</tr>
<tr>
<td>9 = Alarm</td>
</tr>
</tbody>
</table>

Whereat alert 1 = faultless, 2 = collective message, 3 = range overstepping 4 = collective message and range overstepping

<table>
<thead>
<tr>
<th>EOT</th>
<th>Adr</th>
<th>Adr</th>
<th>C1</th>
<th>C2</th>
<th>.</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>.</th>
<th>C6</th>
<th>ENQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOT</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>.</td>
<td>0</td>
<td>ENQ</td>
</tr>
<tr>
<td>04</td>
<td>30</td>
<td>31</td>
<td>30</td>
<td>33</td>
<td>2C</td>
<td>30</td>
<td>30</td>
<td>31</td>
<td>2C</td>
<td>30</td>
<td>05</td>
</tr>
</tbody>
</table>

Response

<table>
<thead>
<tr>
<th>STX</th>
<th>C1</th>
<th>C2+1</th>
<th>=</th>
<th>Wert</th>
<th>EOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>STX</td>
<td>0</td>
<td>1</td>
<td>=</td>
<td>Wert</td>
<td>EOT</td>
</tr>
<tr>
<td>04</td>
<td>30</td>
<td>34</td>
<td>3D</td>
<td>HEX-Wert</td>
<td>05</td>
</tr>
</tbody>
</table>

Data request at protocol Modbus RTU, 8bit, 1 Stopbit, Even
Adress | Function | Storage adress | Registers | CRC 1 | CRC 2
--- | --- | --- | --- | --- | ---
03 | Byte1 | Byte2 | Byte1 | Byte2 | Byte

Example for a request at address 1 in HEX-display

**Measurement value**

<table>
<thead>
<tr>
<th>% O₂</th>
<th>log O₂</th>
<th>ppm O₂</th>
<th>TP</th>
<th>O₂-red</th>
<th>Temperature</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>03</td>
<td>80</td>
<td>A4</td>
<td>00</td>
<td>02</td>
<td>AC</td>
</tr>
<tr>
<td>01</td>
<td>03</td>
<td>80</td>
<td>A6</td>
<td>00</td>
<td>02</td>
<td>0D</td>
</tr>
<tr>
<td>01</td>
<td>03</td>
<td>80</td>
<td>A8</td>
<td>00</td>
<td>02</td>
<td>6C</td>
</tr>
<tr>
<td>01</td>
<td>03</td>
<td>80</td>
<td>AA</td>
<td>00</td>
<td>02</td>
<td>CD</td>
</tr>
<tr>
<td>01</td>
<td>03</td>
<td>80</td>
<td>AC</td>
<td>00</td>
<td>02</td>
<td>2D</td>
</tr>
<tr>
<td>01</td>
<td>03</td>
<td>80</td>
<td>AE</td>
<td>00</td>
<td>02</td>
<td>8C</td>
</tr>
<tr>
<td>01</td>
<td>03</td>
<td>80</td>
<td>B0</td>
<td>00</td>
<td>02</td>
<td>EC</td>
</tr>
</tbody>
</table>

**Example for the request:**

| Temperature | 01 | 03 | 80 | AE | 00 | 02 | 8C | 2A |

**Example-answer** = 1760,00
9.2.3 Optionale interface: Ethernet

The interface plug is at rear site between the connector block. Connection to network is done by standard cables.

To define the interface it first must be entered at “Lockout” the code 5 in line “Comm”. Then skip to the definition-page with 2 times pressing the “Esc” button. Following the interface-parameters like type, address can be defined.
Input for IP-address und Subnet.

The data protocol is similar Modbus protocol which is explained above

<table>
<thead>
<tr>
<th>Modbus RTU Message</th>
<th>Slave ID</th>
<th>FCode</th>
<th>Data</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modbus TCP/IP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Header</td>
<td>Modbus TCP/IP Message</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transaction ID</td>
<td>Protocol ID</td>
<td>Length</td>
<td>Unit ID</td>
<td>FCode</td>
</tr>
<tr>
<td>0005</td>
<td>0000</td>
<td>0006</td>
<td>01</td>
<td>010380A4</td>
</tr>
</tbody>
</table>

10 Special features

10.1 Correction factors

There is one additive and one multiplicative correction factor. These can be applied as a correction to the EMF value determined by the sensor and thus to the measured value that is displayed. It may be necessary to amend these factors in the course of calibration. The necessary entry is detailed under "Configuration".
10.2 Filter factor
If there is excessive fluctuation in the measured values, it is possible to apply an attenuation factor of between 0 and 200. This attenuation factor has an integration effect on the oxygen value. The necessary entry is detailed under "Configuration  Process parameters".

10.3 Oxygen controller
The required value is entered as the logarithmic oxygen partial pressure
The necessary entry is detailed under "Configuration  Process parameters".
10.4 Coding
To prevent unauthorised amendment of important entries, the pages concerned are only displayed once an access code has been entered (see under "Enablement of configuration"). On this page there is provision for programming a new access code.

Caution:
*Not even the supplier can decipher an access code that has been forgotten.*
*THE PROBLEM CAN ONLY BE SOLVED BY ENTERING COMPLETELY NEW SOFTWARE:*

![180 Lockout Table]

10.5 Function of the clock

First line displays the time. The time hasn’t any function inside of the program. If the time should be adjusted it should be done like described for the interface

![Device settings Interface]
10.6 Connection plan
## 11 Technical data

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement range</td>
<td>100 % to $10^{-3}$ bar O₂</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>0 to 45 degrees Celsius</td>
</tr>
<tr>
<td>Measurement accuracy</td>
<td>+/- 0.3 mV of the sensor EMF</td>
</tr>
<tr>
<td></td>
<td>+/- 2 degrees Celsius</td>
</tr>
<tr>
<td></td>
<td>+/- 2% of the mA output</td>
</tr>
<tr>
<td></td>
<td>+/- 2% of the log oxygen partial pressure</td>
</tr>
<tr>
<td>Temperature input</td>
<td>Thermocouple Type S</td>
</tr>
<tr>
<td>Heating-up time for sensors</td>
<td>10 to 15 minutes</td>
</tr>
<tr>
<td>Response time</td>
<td>approx 2 seconds</td>
</tr>
<tr>
<td>Contact load capacity</td>
<td>2A, 24 V (ohmic)</td>
</tr>
<tr>
<td>Dimensions</td>
<td>96 x 96 x 160 mm (HxWxD)</td>
</tr>
<tr>
<td>Cutout</td>
<td>92 x 92 mm</td>
</tr>
<tr>
<td>Electromagnetic compatibility</td>
<td>The equipment meets the requirements of European directive 89/336EWG and complies with the following standards:</td>
</tr>
<tr>
<td></td>
<td>Interference transmission EN 50081-1</td>
</tr>
<tr>
<td></td>
<td>Immunity from interference EN 50082-2</td>
</tr>
<tr>
<td></td>
<td>The device can be used without restriction in residential and industrial surroundings.</td>
</tr>
<tr>
<td>Power supply</td>
<td>100-240 Volt AC</td>
</tr>
<tr>
<td>Front protection (mounted)</td>
<td>IP 65</td>
</tr>
</tbody>
</table>