Operating Instructions

for the

PLUGSYS®-Module

Oxygen Partial Pressure Module OPPM Typ 697

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1. Introduction, manufacturer's details

These Operating Instructions describe the operation and use of the **OPPM** Module Type 697. It is part of the equipment and should be kept close to it.

All the information in these Instructions has been drawn up after careful examination but does not represent a warranty of product properties. Alterations in line with technical progress are reserved.

This PLUGSYS module is manufactured by:

Hugo Sachs Elektronik
Gruenstr. 1,
79232 March-Hugstetten
Germany

Phone (Germany):	07665 / 92 00-0
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Internet:	http:/www.hugo-sachs.de

Copyright

Trademark

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2. Safety note

Important: This equipment is not suitable for operation in hazardous areas and/or in a flammable atmosphere.

The equipment is not approved for measurement on humans!

3. General description, applications

The **OPPM** Module Type 697 is a module for the HSE PLUGSYS measuring system and serves to measure oxgen partial pressure using clark electrodes. The main application is the continuous recording of the pO_2 in biological solutions such as e.g. the perfusate from isolated organs as heart, lung, liver, kidney and tissues. Using a special pO_2 electrode mounted in a flow-through chamber it is possible to make continuous measurements over hours or days. Changes or fluctuations in pO_2 can be recorded continuously. In order to avoid interaction where several electrochemical parameters (such as pO_2, pCO_2, Na^+, K^+ or Ca^{++}) are being measured continuously, this module incorporates an input with isolating amplifier (floating input). This also avoid possible hum interference. The input circuit is isolated from the output circuit and the housing through an isolating amplifier.

The pO_2 value is indicated on a 3 ½ digit LED display. It is possible to indicate either the signal current, the O_2 value in Vol% or the pO_2 in mmHg.

The pO_2 signal im mmHg or the volume % signal is available as analog voltage at a BNC socket on the front panel and also internally on the PLUGSYS system bus for recording.

A simulating device which can simulate two fixed pO_2 values is provided for calibrating a recorder or a computer data acquisition system.

For using the OPPM module it has to be installed in a PLUGSYS housing Series 600.

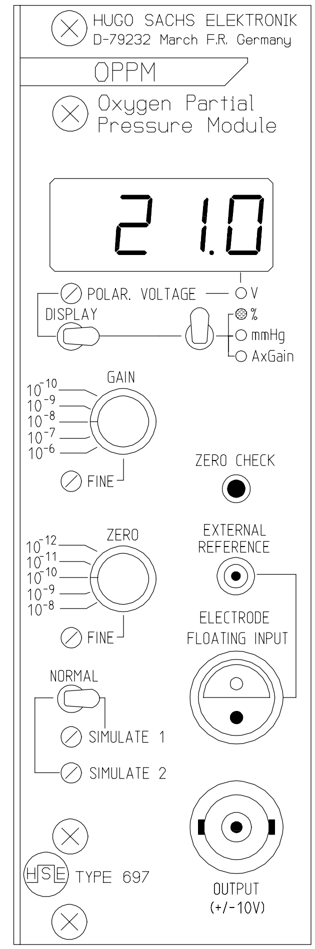


Fig. 1: Front panel

4. Description of the controls

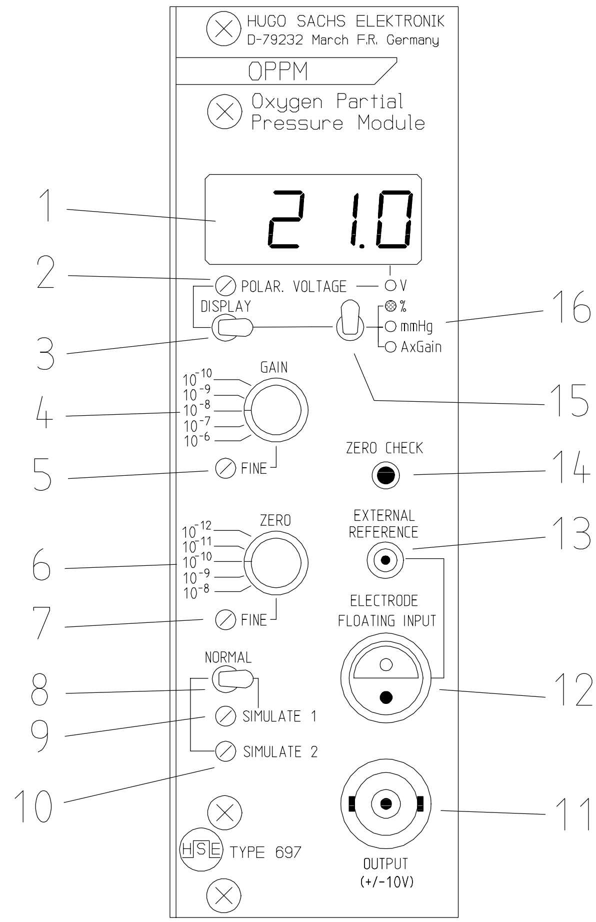


Fig. 2: Controls on the front panel

(1) Digital display to indicate pO_2 value in **Vol%** or **mmHg**, electrode current or polarisation voltage. The display is switched over to show the polarisation voltage by setting the **DISPLAY** switch into left position. In right position the second switch (15) on the right side is used to display the pO_2 value either in **vol%**, in **mmHg** or the electrode current in **AxGain**.
(e.g. the gain button is in position 10^{-9} and the display shows 150 this means the electrode current is 150 x 10^{-9} or 150 nA (nanoAmpere).

(2) Trimmer POLAR. VOLTAGE
This trimmer is used to set the necessary polarisation voltage for the pO_2 electrode. The standard polarisation voltage for all clark type electodes is normally **-0.75 V**. This value is factory set. In case of using a different polarisation voltage this value can be changed with a small screw driver. For this procedure the DISPLAY switch must be in the left position, so that the changes directly can be seen on the display.

(3) **DISPLAY** switch
switch in left position --> Display shows the polarisation voltage

switch in right position --> Display shows either O_2 concentration in **vol%**, pO_2 in **mmHg** or the electrode current in **AxGain.**

(4) **GAIN** Coarse rotary switch
This rotary switch is used to select the coarse gain. The setting depend on the connected electrode sensitivity. If a clark electrode is connected first time start in the middle position 10^{-8}. During the calibration with a solution containing 95 vol% O_2 the gain has to be set this way that the display does not overflow. Search the position where a value around +95.0% (or 677 mmHg) can be set on the display. The fine adjustment has to be done with trimmer gain FINE.

(5) Gain **FINE** trimmer
This trimmer is used to adjust the gain so that the high calibation value (95 vol%) can be set accurately.

(6) **ZERO** Coarse rotary switch
This rotary switch is used to select the coarse ZERO adjustment range. The setting depends on the connected electrodes zero current. If a clark electrode is connected first time, start in the middle position 10^{-10}. During the calibration with a solution containing 20.9 vol% O_2 (or 0% O_2) the zero has to

be set this way that the display can be adjusted to 20.9 (or to 0 vol%)
Search the position where 20.9 (or 0) can be set on the display. The fine adjustment has to be done with trimmer zero FINE.

(7) Zero **FINE** trimmer
This trimmer is used to adjust the gain, so that the low calibration value (e.g. 20.9 vol% or 0 vol%) value can be set accurately.

(8) Switch **SIMULATE 2 / MEASURE / SIMULATE 1**
This switch is automatically in the measure position. If you move the switch into the left position the simulation value set on trimmer **SIMULATE 2** is displayed and the corresponding output voltage appeares on the OUTPUT BNC connector and on the internal bus line.
The switch automatically jumps back to the **MEASURE** position. The value and the corresponding output voltage remain for 10 seconds on the display and on the output.
If you move the switch into the right position the simulation value set on trimmer **SIMULATE 1** is displayed and the corresponding output voltage appeares on the OUTPUT BNC connector and on a internal bus line.

(9) Trimmer **SIMULATE 1**: This trimmer is used to set the first pO_2 simulation value. To do this, push the switch **SIMULATE 1 / MEAS / SIMULATE 2** to the **right** position, hold it there and, using a screwdriver, set the required value with trimmer SIMULATE 1 as shown on the display. See also Section 0.

(10) Trimmer **SIMULATE 2**: This trimmer is used to set the second pO_2 simulation value. To do this, push the switch **SIMULATE 1 / MEAS / SIMULATE 2** to the **left** position, hold it there and, using a screwdriver, set the required value as shown on the display. See also Section 0.

(11) BNC socket **OUTPUT**. This output socket carries, either the output voltage for the **vol%** value or the output voltage for **mmHg** value. With a slide switch on the circuit board the output can be selected.

Slide switch in position %	-->	0	%	-	0	V
		100	%	-	10.0	V
Slide switch in position mmHg	-->	0	mmHg	-	0	V
		1000	mmHg	-	10.0	V

(12) Input socket **ELETRODE FLOATING INPUT.** This socket is used to connect the clark electrode.
In order to avoid interaction when several electrochemical parameters (such as pO_2, pCO_2, Na^+, K^+ or Ca^{++}) are being measured continuously, this module incorporates an input with isolating amplifier (floating input). This avoid possible hum interference. The input circuit is isolated from the output circuit and the housing through an isolating amplifier.

(13) 2 mm socket **EXTERNAL REFERENCE**. This socket is used to connect an external reference electrode when using a pO_2 electrode with separate reference electrode.

(14) Push button **ZERO CHECK**. This button is used to display the electrodes zero offset. If the button is pressed the electrode is switched off and the displayed value represents the zero offset of the connected electrode in the selected unit (%, mmHg, AxGain)

(15) Unit switch for digital display

The green lights on the right side of the switch show the selected unit for the displayed value.
In the upper position the measured O_2 concentration is indicated in vol**%**, in the middle position the measured pO_2 value is indicated in **mmHg**. In the lowest position the electrode current is displayed in the unit **AxGain**. This means e.g. if the gain rotary switch is in position 10^{-9} and the display shows 150 this means the electrode current is 150 x 10^{-9} or 150 nA (nano Amperes).

(16) Selected **unit** of the value indicated on the digital display.
Four green light lights indicate:

V	=	Polarisation voltage in volt
%	=	O_2 concentration in vol%
mmHg	=	pO_2 in mmHg
AxGain	=	electrode current in Ampere multipled with the selected GAIN factor

5. Starting up

After the pO_2 electrode has been prepared and the pO_2 electrode cable has been connected to the floating input, the housing can be switched on and calibration measurement can begin.

5.1 Calibrating the connected pO_2 electrode in vol%

The description below assumes that a pO_2 electrode Type 733 or the ZABS pO_2 electrode Type ZABS **xxxxxx** is used.

Basic principle of calibrating pO_2 electrodes:
In order to avoid measurement errors it is important that calibration takes place at the same temperature as the subsequent measurements. The entire measurement in the flow through electrode chamber depends on flow rate and it is therefore important that the pumping speed of the roller pump is the same during calibration and during measurement. The recommended flow rate through the chamber should be between 0.5 and 2 ml/min (check pump output volumetrically). In principle the calibration should be repeated daily.

Procedure:
In order to ensure chemical stability the Diamond electrode should already have been stored in electrolyte solution for at least 24 hours. Using the ZABS pO_2 electrode the flow through channel should be filled with electrolyte solution.

(1) Connect the pO_2 electrode to the OPPM, socket **"ELECTRODE FLOATING INPUT"**.

(2) Set Display switch into the left position and adjust the polarisation voltage to -0.750 V

(3) Set Display switch into the right position and select **%** with the unit switch.

(4) Place approx. 100 ml of the used solution into a small vessel and bubble this solution with room air (20.9% O_2).
Another possibility is to use a special pO_2 zero solution. This avoids a longer calibration procedure.

Calibration solution for pO_2 zero available from:

Radiometer Deutschland GmbH
P.O.Box 3

D-47862 Willich, Germany

Phone: (int. + 49) 2154 / 818-0
Fax: (int. + 49) 2154 / 818-184

Local representatives of Radiometer should also be able to supply these zero solution.

It is also possible to prepare this zero solution: It is a **2% sodium sulfite solution**

(5) Place approx. 100 ml buffer solution into a small vessel and bubble that solution with carbogen (95% O_2, 5% CO_2).

(6) After the solutions have been bubbled for about 5 minutes start with the calibration.
The Diamond pO_2 electrode requires a coarse gain of 10^{-8} or 10^{-9}.
The ZABS pO_2 electrode which has a higher sensitivity requires a coarse gain of 10^{-7} or 10^{-6}.
If you use a different electrode from another manufacturer, set the rotary switch **GAIN** into middle position 10^{-8}. Set rotary switch **ZERO** to 10^{-10}.
Now start the roller pump and hold the input tubing of the electrode chamber into the vessel with 95% O_2. Where precision measurements are required, the solution should also be warmed to the temperature which is used later in the experiment. Wait until the solution is in the electrode chamber. Some seconds later a new value is indicated on the display.
Now search the GAIN with the rotary switch, where a value around +90% appeares on the display. Adjust Gain with a screwdriver with trimmer **Gain FINE** below the rotary switch to **+95%** If you don't reach +95% change coarse **GAIN** with the rotary switch and adjust again with trimmer Gain **FINE** to +95%.

(7) Now hold the input tubing into air and produce an air segment with approx. 4 cm length in the tube to avoid mixtures of solution with different oxygen concentration. Then hold the input tubing into the vessel bubbled with room air (+20.9%). Wait until the new solution is in the electrode flow through channel. Some seconds later a new value is indicated on the display.
Now adjust Zero with a screwdriver on trimmer **Zero FINE** below the ZERO rotary switch to **+20.9%** .
If you don't reach +20.9% change coarse Zero with the rotary switch and adjust again with trimmer Zero **FINE** to +20.9%.

If you use the special O_2 zero solution the calibration procedure is much more easy. In this case after you have produced an air segment in the tube you have to hold the input tubing into the vessel with the zero solution. Wait some seconds until the zero solution is in the electrode flow through channel. Some seconds later a value around zero is indicated on the display.
Now adjust display to zero with a screwdriver on trimmer **Zero FINE** below the ZERO rotary switch. If you have no success to reach 0% change coarse Zero with the rotary switch and adjust again with trimmer Zero **FINE** to 0%

(8) Now the 95% value must be repeated. Hold the input tubing again into air and produce an air segment with approx. 5 cm length in the tube. Then hold the input tubing into the vessel bubbled with carbogen (96% O_2). Wait until the new solution is in the electrode flow through channel. Some seconds later a new +95% value is indicated on the display.
Adjust again to +95.0 with a screwdriver on trimmer **Gain FINE** below the Gain rotary switch.

(9) If the calibration with room air bubbled solution is performed the 20.9% value must be repeated checked. With the Zero solution this is not necessary. To check the 20.9% value hold the input tube in into air and produce an air segment with approx. 4 cm length. Then hold the input tubing into the vessel bubbled with room air (20.9% O_2). Wait until the new solution is in the electrode flow through

channel. Some seconds later a new 21% value is indicated on the display.
Adjust again to 20.9 with a screwdriver on trimmer Zero FINE below the ZERO rotary switch.

As a check the two calibration points should be checked again alternatively. In case of larger deviations repeat steps 8 and 9.
For a daily calibration it is only necessary to check the two calibration points. By using 20.9% as lower calibration point the procedure must be done twice. But mainly only the fine adjustment of Zero or Gain must be performed. If you use the special zero solution you don't have to repeat the calibration of the two calibration points. You only have to check first the zero value and then the 95% value.

5.2 Calibrating the connected pO_2 electrode in mmHg

The description below assumes that a pO_2 electrode Type 733 or the ZABS pO_2 electrode Type pO_2 ZABS-DSK No. 1 is used.

Basic principle of calibrating pO_2 electrodes:
In order to avoid measurement errors it is important that calibration takes place at the same temperature as the subsequent measurements. The entire measurement in the flow through electrode chamber depends on flow rate and it is therefore important that the pumping speed of the roller pump is the same during calibration and during measurement. The recommended flow rate through the chamber should be between 0.5 and 2 ml/min (check pump output volumetrically). In principle the calibration should be repeated daily.

To calibrate the pO_2 electrode in **mmHg** first some calculations have to be done.

The standard mean air pressure at sea level is 760 mmHg. Depending on the weather this value changes by ±25 mmHg. Depending on the sea level of your location it also changes. On higher locations the air pressure becomes lower. See table below.

height [meter]	pressure [mmHg]
0	760
100	751
200	742
300	733
400	725
500	716
600	708
700	699
800	691
900	682
1000	674

When a setup is used in which a gas mixture of known composition is dissolved in saline, the gas equilibrated with the saline will be saturated with water vapor. Because the water vapor dilutes the oxygen, resulting in a lower pO_2, the following correction should be made for a precise calibration.

$$\mathbf{pO2corr = \%\, O_{2dry} * (p_{atm} - p_v) / 100}$$

where
- pO_{2corr} = the corrected pO_2 in the liquid
- $\%O_{2dry}$ = the percentage of oxygen in the dry gas mixture e.g. 20.9% in room air
- p_{atm} = the current atmospheric pressure
- p_v = the vapor pressure as obtained from Table below

The table below shows the vapor pressure of water at various temperatures:

Temp [°C]	p [mmHg]
20.0	17.5
21.0	18.7
22.0	19.8
23.0	21.1
24.0	22.4
25.0	23.7
26.0	25.2
27.0	26.7
28.0	28.3
29.0	30.0
30.0	31.8
31.0	33.7
32.0	35.7
33.0	37.7
34.0	39.9
35.0	42.2
36.0	44.6
37.0	47.1
38.0	49.7
39.0	52.4
40.0	55.3

For an accurate calibration we have to calculate the oxygen partial pressure values for the used calibration solutions. For using the formula we have to measure the barometric pressure (depends on weather) or we can use the standard mean air pressure depending on the level of you location above the sea level.
For the following example we suppose we are on a level of 200 meters above the sea level and we work on 37 °C. If we use soultions bubbled with room air (20.9% O_2) and Carbogen (95% O_2) we get the following corrected values.

$$pO_{2corr} = \%O_{2dry} * (p_{atm} - p_v) / 100$$

for room air: $145.2\ mmHg = 20.9\% * (742\ mmHg - 47.1\ mmHg) / 100$

for carbogen: $660.1\ mmHg = 95\% * (742\ mmHg - 47.1\ mmHg) / 100$

Procedure:
In order to ensure chemical stability the Diamond electrode should already have been stored in electrolyte solution for at least 24 hours. Using the ZABS pO_2 electrode the flow through channel should be filled with electrolyte solution.

(1) Connect the pO_2 electrode to the OPPM, socket **"ELECTRODE FLOATING INPUT"**.

(2) Set Display switch into the left position and adjust the polarisation voltage to -0.750 V

(3) Set Display switch into the right position and select **mmHg** with the unit switch.

(4) Place approx. 100 ml of the used solution into a small vessel and bubble this solution with room air (20.9% O_2 approx. 149 mmHg at sea level and 37 °C, calculate here your accurate value according to example above).
Another possibility is to use a special pO_2 zero solution. This avoids a longer calibration procedure.

Calibration Zero solution from:

Radiometer Deutschland GmbH
P.O.Box 3
D-47862 Willich, Germany

Phone: (int. + 49) 2154 / 818-0
Fax: (int. + 49) 2154 / 818-184

Local representatives of Radiometer should also be able to supply these zero solution.

(5) Place approx. 100 ml buffer solution into a small vessel and bubble that solution with carbogen (95% O_2, 5%CO_2 approx. 677 mmHg at sea level and 37 °C, calculate here your accurate value according to example above).

(6) After the solutions have been bubbled for about 5 minutes start with the calibration.
The Diamond pO_2 electrode requires a coarse gain of 10^{-8} or 10^{-9}.
The ZABS pO_2 electrode which has a higher sensitivity requires a coarse gain of 10^{-7} or 10^{-6}.
If you use a different electrode from another manufacturer, set the rotary switch **GAIN** into middle

position 10^{-8}. Set rotary switch **ZERO** to 10^{-10}.
Now start the roller pump and hold the input tubing of the electrode chamber into the vessel with 95% O_2 (677 mmHg). Where precision measurements are required, the solution should also be warmed to the temperature which is used later in the experiment. Wait until the solution is in the electrode chamber. Some seconds later a new value is indicated on the display.
Now search the GAIN with the rotary switch, where a value around +677 mmHg appeares on the display. Adjust Gain with a screwdriver with trimmer **Gain FINE** below the rotary switch to **+677 mmHg.** If you don't reach +677 mmHg change coarse **GAIN** with the rotary switch and adjust again with trimmer Gain **FINE** to +677 mmHg.

(7) Now hold the input tubing into air and produce an air segment with approx. 4 cm length in the tube to avoid mixtures of solution with different oxygen concentrations. Then hold the input tubing into the vessel bubbled with room air (+20.9% - 149 mmHg). Wait until the new solution is in the electrode flow through channel. Some seconds later a new value is indicated on the display.
Now adjust Zero with a screwdriver on trimmer **Zero FINE** below the ZERO rotary switch to **+149 mmHg**. If you don't reach +149 mmHg change coarse Zero with the rotary switch and adjust again with trimmer Zero **FINE** to +149 mmHg.

If you use the special O_2 zero solution the calibration procedure is much more easy. In this case after you have produced an air segment in the tube you have to hold the input tubing into the vessel with the zero solution. Wait some seconds until the zero solution is in the electrode flow through channel. Some seconds later a value around zero is indicated on the display.
Now adjust display to zero with a screwdriver on trimmer **Zero FINE** below the ZERO rotary switch. If you have no success to reach 0 mmHg change coarse Zero with the rotary switch and adjust again with trimmer Zero **FINE** to 0 mmHg.

(8) Now the high value (677 mmHg) must be repeated. Hold the input tubing again into air and produce an air segment with approx. 4 cm length in the tube. Then hold the input tubing into the vessel bubbled with carbogen (95% O_2, 5% CO_2). Wait until the new solution is in the electrode flow through channel. Some seconds later a new 677 mmHg value is indicated on the display.
Adjust again to 677 mmHg with a screwdriver on trimmer **Gain FINE** below the Gain rotary switch.

(9) If the calibration with room air bubbled solution is performed the 149 mmHg value must be repeated checked. With the Zero solution this is not necessary. To check the 149 mmHg value hold the input tube in into air and produce an air segment with approx. 4 cm length. Then hold the input tubing into the vessel bubbled with room air (20.9% O_2 - 149 mmHg). Wait until the new solution is in the electrode flow through channel. Some seconds later a new 149 mmHg value is indicated on the display.
Adjust again to 149 mmHg with a screwdriver on trimmer Zero FINE below the ZERO rotary switch.

As a check the two calibration points should be checked again alternatively. In case of larger deviations repeat steps 8 and 9.

For a daily calibration in mmHg it is only necessary to check the two calibration points. The correct barometric pressure should be measured and the new accurate calibration values have to be calculated. By using room air 20.9% ~ 149 mmHg as lower calibration point the procedure must be done multiple times. But mainly only the fine adjustment of Zero or Gain must be performed.
If you use the special zero solution you don't have to repeat the calibration of the two calibration points. You only have to check first the zero value and then the 95% ~ 677 mmHg value.

5.3 Setting the pO_2 simulation values for calibrating a recorder or computer system

Calibration of a recorder or data acquisition system always requires two calibration points. Since the entire calibration procedure is rather time-consuming a simulation device is incorporated in the OPPM module to simplify the operation. It simulates two pO_2 values and their output voltages.

The factory settings of the two simulation values are 20.9% (149 mmHg) and 95% (677 mmHg)
If you intend to use different simulation values follow the described procedure.

Procedure:
Move the switch **"SIMULATE 1 / MEAS / SIMULATE 2"** to **SIMULATE 1** (right) and hold it in that position. Adjust the reading to your wished value with the **SIMULATE 1** trimmer using a screwdriver.

Move the switch to **SIMULATE 2** (left) and hold it in that position. Adjust the reading to your wished value with the **SIMULATE 2** trimmer using a screwdriver.

If now the switch is moved to **SIMULATE 1** (right) or **SIMULATE 2**, the predefined value as if the pO_2 electrode measures is now simulated on the output.

The switch automatically returns to the **MEAS** position but the simulated value is retained for a further 10 seconds on the display and at the output.

5.4 Arranging a pO_2 scale on the recorder

After the simulation values have been set as indicated in Section 0 the recorder can readily be calibrated.
It is now assumed that the PLUGSYS housing is switched on and ready for use and that a recorder with 8 cm writing width per channel is connected up.
It is of course possible to use some other recorder with a different writing width and chart scaling. It is however necessary to have adequate sensitivity of at least 1 Volt for full-scale deflection.

Assumptions:	
Required pO_2 range:	0 to 750 mmHg
Writing width:	80 mm
Chart scale grid:	every cm and mm

With these conditions the simulation values of the OPPM should be set to 0 and +800 mmHg. See the example in Section 0. The recording span can now be adjusted accurately to fit the chart scaling. A distance of 8 cm is available, i.e. the 0 line is positioned at the bottom edge and the 800 mmHg line at the top edge. The midpoint (i.e. 4 cm) corresponds to 400 mmHg, so that 1 cm represents 100 mmHg.

Follow the procedure indicated below:

(A) Position the recorder pen at the bottom edge of the chart. Zero the recorder input. Set the pen to the zero line.

(B) On the OPPM set the **DISPLAY** switch into the right position. Set unit switch on **mmHg**. The green light **mmHg** is on.
Set SIMULATE 1 to 0 mmHg and Simulate 2 to 800 mmHg (See section 0)

(C) Start the chart drive with low speed. Move switch **SIMULATE 1 / MEAS / SIMULATE 2** to **SIMULATE 1** and hold it there. The display shows 0000; 0 mmHg is being simulated.
After releasing the switch the value is maintained for a further 10 sec. Since the adjustment probably takes somewhat longer it is best to hold the switch in that position. Now the recorder pen should be on zero. If not adjust with position knob. The zero line now corresponds to 0 mmHg.

(D) Move switch **SIMULATE 1 / MEAS / SIMULATE 2** to **SIMULATE 2** and hold it there. The display shows 800; 800 mmHg is being simulated.
Now adjust the recorder gain so that the pen is at the top edge of the chart (8 cm). This value corresponds to a pO_2 of 800 mmHg.

(E) Checking the adjustment:
Run the recorder at a slow speed. Switch **SIMULATE 1 / MEAS / SIMULATE 2** on **MEAS**. The value measured by the pO_2 electrode is being indicated and shown on the chart. Move the switch briefly to **SIMULATE 1**. The value 0 mmHg is now being simulated for 10 sec, the pen is against the bottom edge of the chart. Next move the switch to **SIMULATE 2**. 800 mmHg is now being simulated for 10 sec, the pen is at the top edge of the chart.

By quickly keying in the simulation values it is possible at any time (also during an experiment) to check the recorder settings.

Please note:
Simulation does not replace the calibration! Simulation only provides output values for a recorder. During a measurement these are only correct if the electrode has been calibrated correctly!
A pO_2 electrode can only be calibrated by the use of at least one pre-oxygenated solution and one solution oxygenated with room air! See Section 0 or 0.

Calibration or checking of calibrated values should be performed at least once a day. The better method is to follow GLP and check before and after each experiment.

5.5 Experiment

If the pO_2 electrode has been calibrated the measurement can now be started under the same conditions (constant temperature, constant flow).
The reaction time of the Diamond and the ZABS electrodes is about 10 seconds.
Please note: During the experiment it is important to ensure that there are no air bubbles in the electrodes flow through channel.

6. Input

The **OPPM** module carries a LEMOSA input socket for O_2 electrodes. Alternatively, electrodes with an external reference electrode can be used; the reference electrode is connected to the black input socket EXTERNAL REFERENCE (2 mm socket).
The input is floating, i.e. isolated from ground. This is necessary in order to prevent mutual interference if

several electrochemical values such as pH, pCO_2, Na^+, K^+ oder Ca^{++} are being measured continuously at the same time.
Isolation also prevents hum interference. The input circuit is isolated from the output circuit and the housing by an isolating amplifier. The input impedance of the OPPM is 10^{15} Ohms

Input socket type Lemosa ERA.1S.302.CLL

HSE-No.: #H21060

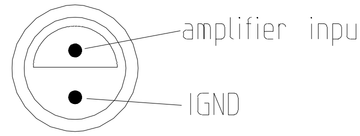


Fig. 3 Input socket

Suitable connector type Lemosa FFA.1S.302.CLAC 52 ZN

HSE-No.: #H11065

Warning: The input of the **OPPM** module must be protected against electrostatic discharges.
Before disconnecting the electrode cable from the electrode you must ensure potential equilibration before touching the input sockets of the cable. Best is to touch the shielded metallic case of the ZABS electrode or touching some grounded metal part, e.g. water tap, central heating radiator, grounded housing, PLUGSYS housing or similar).

7. Installing the module in a housing

(If the module has been supplied already installed you can omit Section 0. If you have received the module as a separate unit you should continue here.)

Before you can use the **OPPM** module it has to be installed in a suitable HSE PLUGSYS housing Series 600 (April. 96: 601 to 607). If the module is supplied as part of a completely installed PLUGSYS measuring system the work described below has already been carried out and the selected signal paths have been entered in the bus diagram.

Before the module is installed in a housing the connections of the module to the bus lines have to be determined by plugging in links as described in the next section (Section 0).

Do not forget to enter the selected connections in the bus diagram (in the white Operating Manual folder under Section 1).

Brief procedure (for full details see the Operating Manual of the housing):

- Pull out the mains plug on the housing.
- Remove the blank panel at the housing slot position intended for the **OPPM** module.
- Prepare module according to Section 0 (set lines and links).
- Insert the **OPPM** module, note the guide rails.
- Push the module firmly into the bus connector.
- Screw on the front panel.
- Connect up the pO_2 electrode.
- Reconnect the mains plug to the housing.
- Switch on the housing.

7.1 Internal instrument settings, links

Warning: The **OPPM** module must be protected against electrostatic discharges while it is outside the housing! The **OPPM** module contains highly sensitive MOS components which can be damaged or destroyed by electrostatic discharges. If you dismantle the module or if you carry out any operations on the dismantled module you must ensure potential equilibration before touching any part of the printed circuit (by touching some grounded metal part, e.g. water tap, central heating radiator,. grounded housing, PLUGSYS housing or similar).

Before you install the **OPPM** module into the PLUGSYS housing it is necessary to set a link on the circuit board in order that the output signal is linked to the appropriate or required bus line. The module can only be used in conjunction with the complete system if the bus lines have been connected up correctly.

Do not forget to enter the selected signal assignment in the bus diagram for the PLUGSYS housing (the bus diagram is filed in the Operating Manual folder under Section 1).

If the module is supplied as part of a completely installed PLUGSYS measuring system, the operations described below have already been completed and the selected signal paths have been entered in the bus diagram.

7.1.1 Signal output to transfer pO_2 value to the PLUGSYS bus

On the OPPM only one link has to be set. The location of the link is shown in the illustration below. The link is used to transfer the analog pO_2 value to the PLUGSYS bus system.

It is possible to give the O_2 concentration in **vol%** to the link or the pO_2 value in **mmHg**
The BNC socket **OUTPUT** on the front panel and this link carry the same value.

With output selection slide switch (C) on the circuit board the output can be selected.

Yellow slide switch in lower position **%**:

0 %	-	0 V
100 %	-	10.0 V

Yellow slide switch in upper position **mmHg**:

0 mmHg	-	0 V
1000 mmHg	-	10.0 V

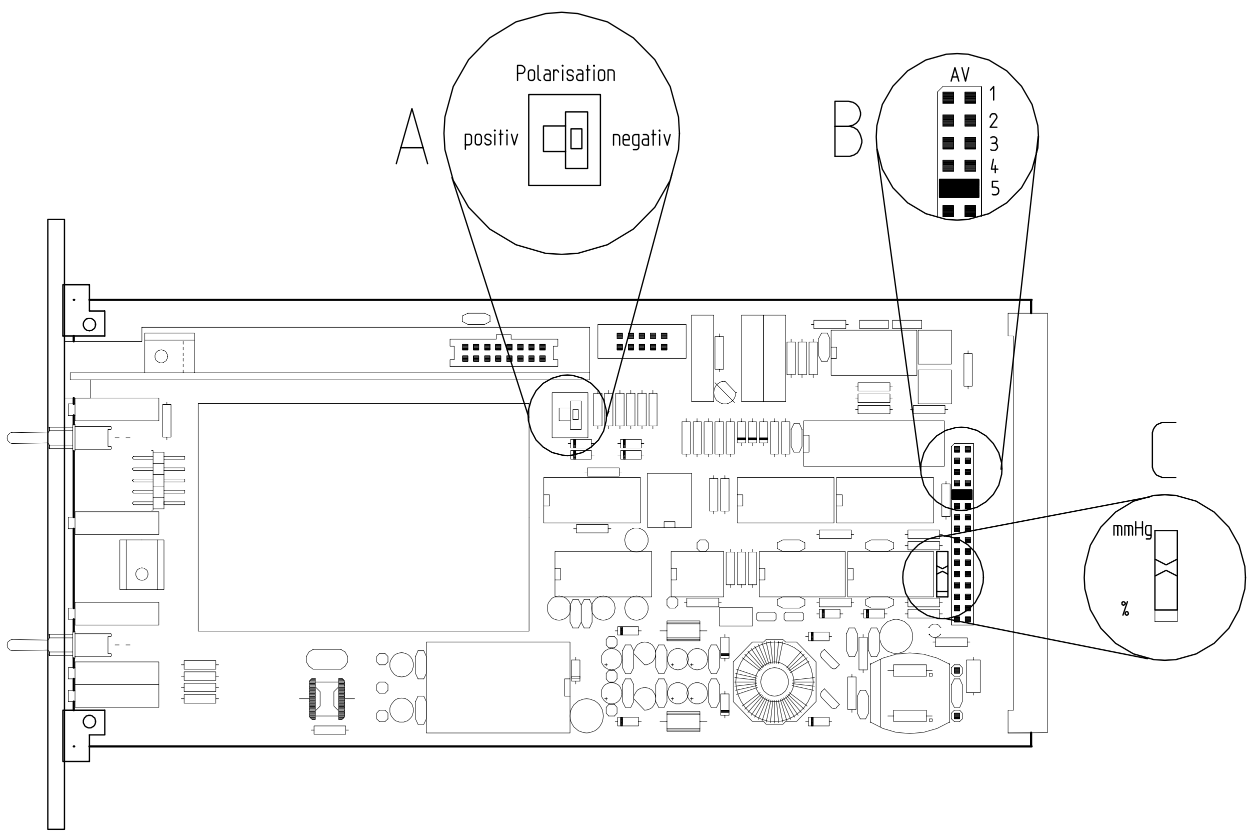


Fig. 4: Position of the internal links and the settings

In Fig. 4 shown above the signal output to the PLUGSYS bus system has been set so that the analog pO_2 signal is on bus line AV 5. The slide switch (A) is set to negative polarisation voltage for O_2-electrodes. The output selection slide switch is set to mmHg.

8. Faults, causes and remedies

Fault: Display shows +1 or -1

Cause: Amplifier overrange

Remedy: Change coarse Gain

Fault: pO_2 fluctuates strongly or appears unrealistic.

Cause: Air bubble in the electrode flow through channel, electrode shielding not grounded.

Remedy: Produce a large air bubble, e.g. by briefly opening the supply tubing. The large air bubble produced (approx. 20 - 30 mm long in the supply tubing) then joins up with the undesirable bubbles in the chamber and can be pushed out by the liquid following behind. Connect the shield case to the central ground point.

Fault: Measurement completely incorrect, instrument overloaded.

Cause: Ground not connected.

Remedy: Connect ground cables to central ground point.

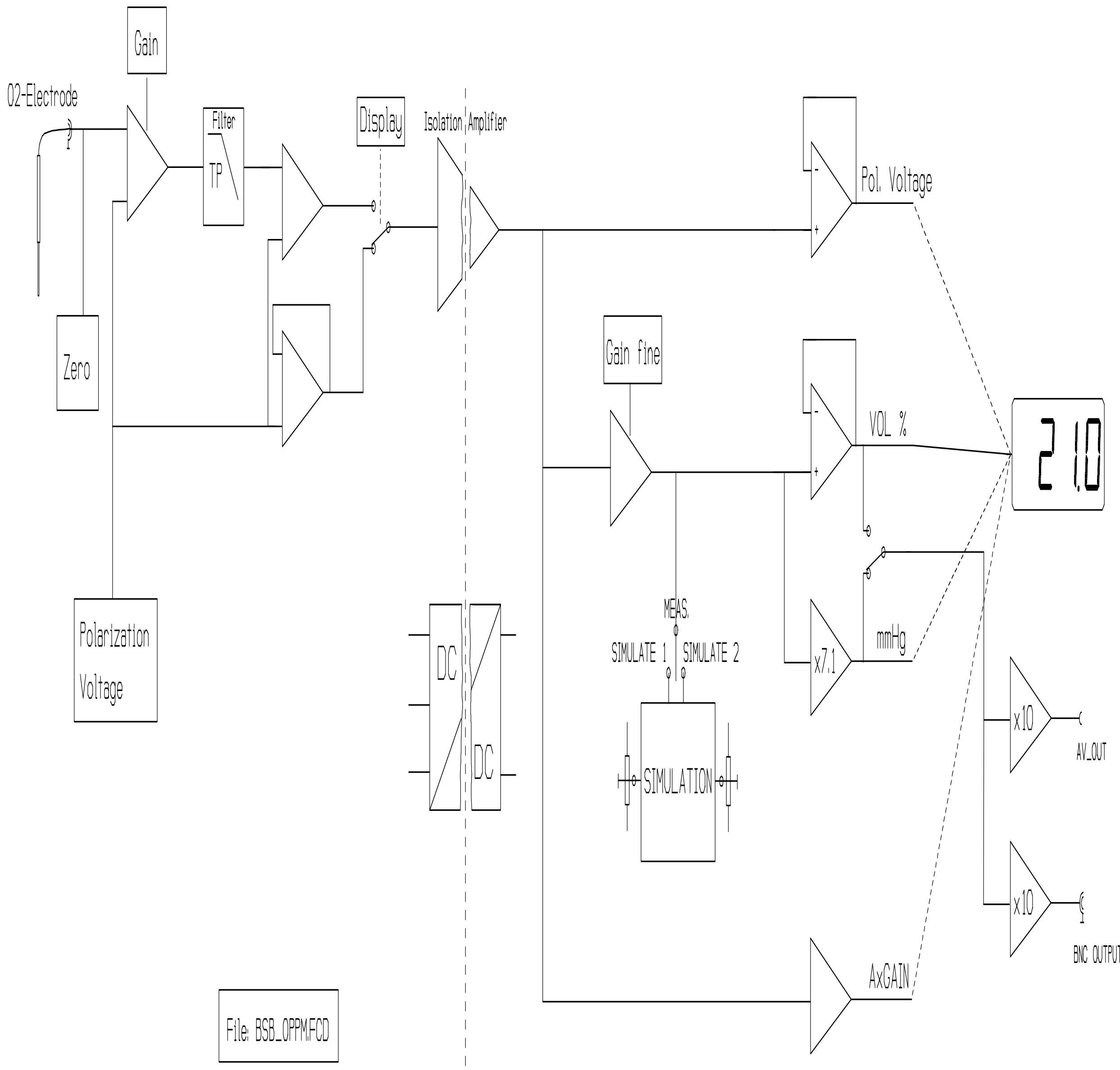
9. Maintenance and cleaning

The PLUGSYS module does not require any maintenance. The **OPPM** module is supplied fully matched, only the pO_2 electrode connected to the OPPM requires a calibration of the low and the high Calibration value. Any operation on or modification of the internal electronic circuit invalidates the warranty and the manufacturer's product liability.
The front panel can be cleaned if necessary with a lightly moistened (not a wet) cloth. Before cleaning always pull out the mains supply plug!
No moisture must find its way into the unit and especially not into the switches and keys, since this leads to corrosion at the switch contacts resulting in faulty operation. In general the PLUGSYS housing should be protected against splash water and salt solutions as this may damage individual components and may cause a short-circuit!

10. Transport and storage

In order to avoid transport damage when returning the unit to the factory, the PLUGSYS housing should be packed in a suitably large carton (the carton should allow a spacing of about 10 cm all round so that sufficient packing material such as polystyrene, hard foam panel or similar can be included to protect against impact damage). When shipping individual modules these should also be well packed, preferable enclosed in antistatic foil or envelope.

11. Block diagram of the OPPM module



12. CE Declaration of Conformity

This product and accessories conform to the requirements of the Low-voltage Directive 73/23 EEC as well as the EMC Directive 89/336 EEC and are accordingly marked with the CE mark. For conformity to the standards during operation it is essential that the details in the instructions provided are observed.

13. Technical data

Input:	isolated differential input, max isolation voltage 500 V
Input socket:	type Lemosa, ERA.1S.302.CLL, HSE-No.: #H21060
Input impedance:	10^{15} Ohm
Input current:	±300 fA
pO_2 range:	0 to 100% or 0 to 1000 mmHg
Resolution:	0.1% or 1 mmHg
Input current range:	10^{-6} to 10^{-10} Ampere
Zero current range:	Adjustable from 10^{-6} to 10^{-12}
Electrode polarisation range:	±1V
Indication:	3 ½ digit LED display
Absolute accuracy:	±2% depending on connected electrode
Linearity:	±1%
Output:	1 Volt per 10% or 1 Volt per 100mmHg at BNC socket OUTPUT on front panel (±10V, 5 mA max.) The same output voltage is also available internally on the PLUGSYS bus.
Calibration:	2-point calibration with two bubbled solutions
Simulation:	two physiological measurement points for calibrating a recorder can be set within the range 0 ... 100% or 0 ... 1000 mmHg. A switch is used to switch the simulation values to the display and to the output.
Recorder outputs:	the internal output AV_PO_2 is connected through a link to the PLUGSYS bus system. The pO_2 signal is connected to a recorder through the Recorder Output Module installed in the PLUGSYS system. Direct connection at the BNC socket OUTPUT on the front panel is also possible.
Ambient conditions:	Operating temperature: 10 to 40 °C
Relative humidity:	20 to 80% without condensation
Storage temperature:	-20 to +60 °C
Supply:	5 V 450 mA, supply via the PLUGSYS system bus

Mechanical data:

Dimensions:	module for PLUGSYS housing width 8 E (40.8 mm) height 3 U (128.7 mm) depth Eurocard (220 mm)
Connectors:	DIN 41612, 64-pin VG connector BNC
Weight:	400 g
Accessories:	BNC output cable and Operating Instructions

14. Appendix

14.1 A. Zero Calibration solution

For a fast calibration procedure a special designed pO_2 calibration Zero-solution is recommended.
This solution is supplied by:

Radiometer Deutschland GmbH
P.O.Box 3
D-47862 Willich, Germany

Phone: (int. + 49) 2154 / 818-0
Fax: (int. + 49) 2154 / 818-184

Order No.: S4150 pO_2 Zero Solution CODE 943-644
in packages of 30 ampulls with 3 ml

This solution contains 10mmol Sodium tetraborate, 100 mmol Sodium sulphite and a special catalyst which speeds up the rate of removal of oxygen. The pO_2 of the solution remains 0 mmHg (0%) for at least 24 hours after the ampoule has been opened, provided the ambient temperature is between 0 °C and 60 °C and the ampoule is not shaken.

Local representatives of Radiometer should also be able to supply these zero solution.

It is also possible to prepare a somewhat different zero solution: **a 2% Natriumdithionit or Sodium Hydrosulfite solution** also does not contain any oxygen.
Natriumdithionit or Sodium Hydrosulfite is supplied by SIGMA-Chemicals. Cat.No.: 15,795-3.
A a fresh made 2% solution does not contain any oxygen. The solution should not be stored under room air for longer time because in this case it starts saturation with oxygen. Best is to prepare the solution before calibration.
The Radiometer solution contains a special catalyst which speeds up the rate of removal of oxygen and keeps the soultion for at least 24 hour at 0% O_2.

14.2 B. Theory of polarographic oxygen measurements

If two electrodes are polarized with a potential of less than negative one volt in a solution containing electrolytes and dissolved oxygen, a current will flow as a result of the reduction of oxygen at the cathodic (negative polarized) surface. This reaction at the cathode is expressed as:

$$O_2 + 2H_2O + 4e^- \text{-->} 4OH^-$$

At the other electrode (reference) oxydation takes place. For an Ag/AgCl reference the reaction is:

$$4Ag + 4Cl^- \text{-->} 4AgCl + 4e^-$$

The voltage-current relationship for a polarographic oxygen electrode is represented by the characteristic curve below.