Operating Instructions

for the
PLUGSYS® Module

pH control module pHCM Type 694/1

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1. Introduction, manufacturer's details

These Operating Instructions describe the operation and use of the **pHCM** Module Type 694/1. 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:

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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, application

The **pHCM** module Type 694/1 is a module of the HSE PLUGSYS measuring system and is used for maintaining a constant pH in perfusion systems. It can only be used in conjunction with a pH measurement module pHMM Type 694.

The main application is in ensuring a constant pH of biological solutions, as e.g. in the perfusate for isolated organs. To control the pH a gas flow bubbling through the perfusion solution is switched on and off. Fine adjustment of the rate of gas flow is by a built-in needle valve. The required pH value and the permitted fluctuations (differential) can be adjusted on trimmer potentiometers and can be indicated on the corresponding pHMM module by pressing a key.

In order to operate the **pHCM** module it has to be installed (on the right of a pHMM module) in a PLUGSYS Series 600 housing.

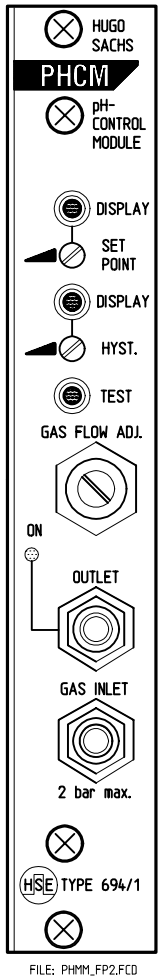


Fig. 2: Front panel

4. Installing the module in a housing

(If the module has been supplied already installed you can omit this Section and continue with Section 5. If you have received the module as a separate unit you should continue here.)

Before you can use the **pHCM** module it has to be installed, together with the pHMM module, in a suitable HSE PLUGSYS housing Series 600 (Nov. 95: 601 to 607). The **pHCM** module can only be installed on the right next to the pHMM module.

If the module is supplied as part of a completely installed PLUGSYS measuring system the work described below has already been carried out.

When installing the pHMM module, follow the details given in the corresponding Operating Instructions.

Before the **pHCM** module is installed it is necessary to fit a jumper.

The jumper A (4) is used to set the switching action of the valve. It selects whether the valve should open or should close on reaching a certain pH value.

In the basic setting (jumper fitted as shown in 4) the valve is normally closed and opens when the set pH is exceeded. This is also the factory setting.

The two modules pHMM and **pHCM** are linked by a 10-way ribbon cable which is plugged into the appropriate connectors on the circuit boards.

WARNING: do not twist the ribbon cable when making the connection!:

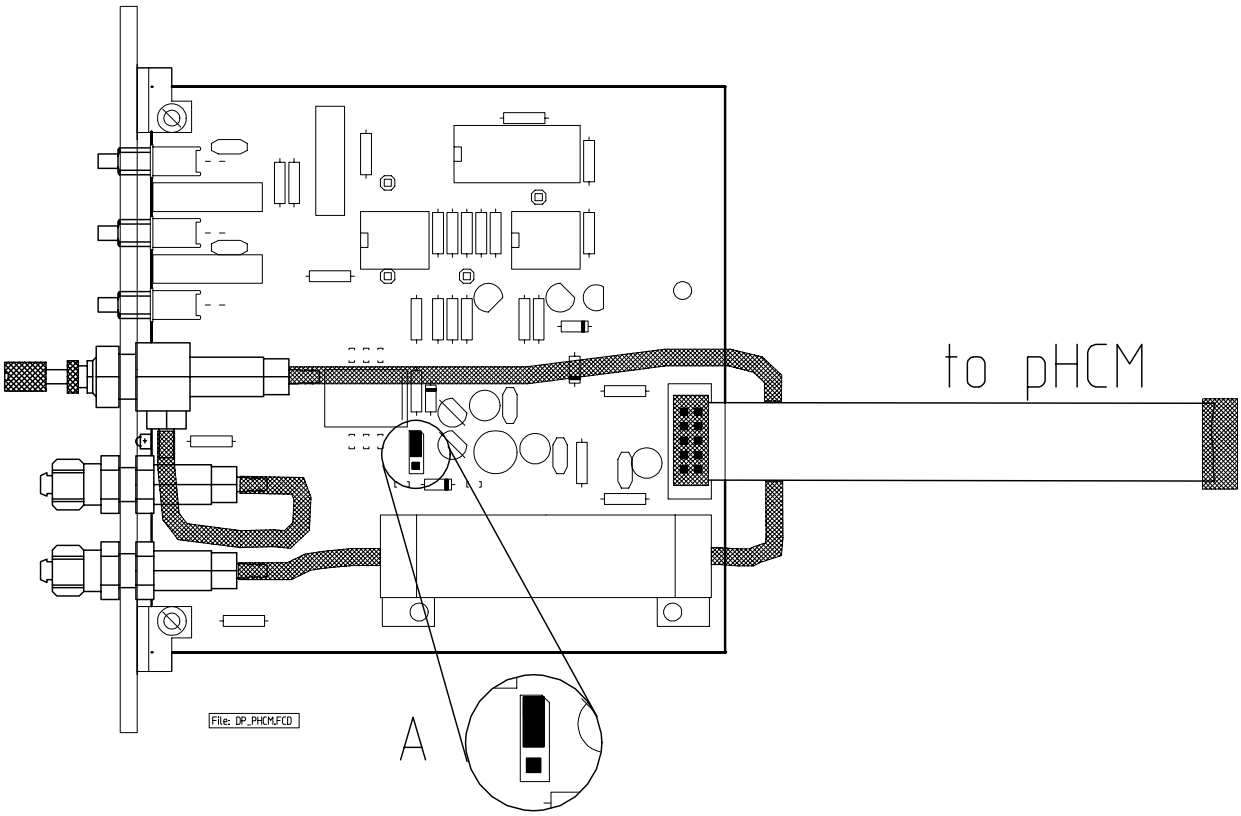


Fig. 4 Position of the internal jumper. When the jumper is set as shown in the diagram, the valve on the pHCM is normally closed and opens when the set value is exceeded.

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

- Pull out the mains plug on the housing.
- Remove the blank panel(s) at the housing slot position intended for the **pHCM** module (and for the pHMM module).
- Insert the prepared modules (cables and jumpers fitted on the pHMM, ribbon cable fitted between **pHCM** and pHMM) into the housing. Note the guide rails.
- Push the pHMM module firmly into the bus connectors.
- Screw on the front panels.
- Connect the pH electrode to pHMM.
- Make the gas connections as shown in 7 Section 0. Note maximum supply pressure 2 bar.
- Reconnect the mains plug to the housing.
- Switch on the housing, open up the gas supply.

5. Starting up

After the pHMM module has been calibrated to the pH electrode used it is possible to start up the pH control.

5.1 Operating principle

In order to ensure correct operation of the **pHCM** module it is necessary to consider first the solution to be aerated.

For example, if a Krebs-Henseleit solution has to be set at a physiological value of pH 7.4, the standard composition of the Krebs-Henseleit solution has to contain 13.2 mM $NaHCO_3$ in solution. As the name implies, the solution pH is maintained constant through the so-called bicarbonate buffer. The KH solution is so adjusted that a gas flow with 5% CO_2 has to be used to achieve a pH of 7.4. It is usual to use Carbogen gas (95% O_2, 5% CO_2) for this purpose.

There are however applications where the perfusate has to have a lower oxygen content differing from 95%. Since readily prepared gas mixtures are quite costly, this module for maintaining a constant pH has been developed.

In the perfusion of the isolated lung, for example, it is desirable to have an oxygen content of 21% as in the atmosphere. If a KH solution is aerated with normal room air the pH rises to about 8.9 which is already toxic.

In order to hold the pH at 7.4, CO_2 is pumped into the buffer solution from time to time. The pHMM measures the pH of the solution using a pH electrode. The **pHCM** connected to it opens and closes the CO_2 supply and thereby controls the pH at the required physiological value.

In the present example, we wish to have a pH of 7.4 and an oxygen proportion of 21% in our solution. We therefore aerate the solution continuously with room air (20.9%). After a certain time the solution pH has increased and a valve in the **pHCM** opens to pass pure CO_2 from a CO_2 cylinder into the solution. To keep the pH within the range 7.35 to 7.4 it is necessary to adjust the "SET POINT" to 7.4 and the differential (HYST.) to 0.05. As the pH rises above 7.4 the valve in the **pHCM** opens and starts the supply of CO_2. The CO_2 is now bound by the bicarbonate and thereby lowers the pH. When the pH has fallen by the differential to 7.35 (7.4 - 0.05) the valve closes and the cycle starts again from the beginning. With these adjustments the solution pH is therefore held within the range 7.35 to 7.4, and the tissue is always provided with solution at the correct pH. Fig. 3 shows the variation of the pH during control by the **pHCM**.

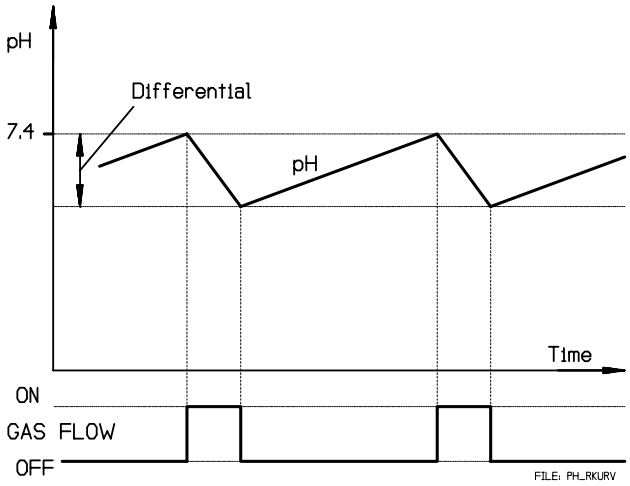


Fig. 5 Variation of the pH when CO_2 aeration is switched on and off

This system could of course also be used to maintain a toxic value of the pH; this may be important in certain applications. It is only necessary to set an appropriate set point value.

5.2 Connecting the tubing for the gas supply of the pHCM

Using the tubing supplied, connect first the gas connection OUTLET to a glass frit in the solution reservoir.

Then connect the pressure tubing supplied (approx. 2 m) to the pressure regulator on your CO_2 cylinder. When adjusting the pressure regulator on the gas cylinder, note please that a pressure of 2 bar must not be exceeded. An inlet pressure of between 1 and 1.5 bar is quite sufficient.

Warning: The specified maximum input pressure of 2 bar must not be exceeded !

After filling the reservoir and introducing the frit, press the TEST key on the **pHCM**. Gas bubbles should now rise up from the frit. The strength of the gas bubble stream is regulated with the needle valve "GAS FLOW ADJ." so that there is thorough bubbling but the solution does not foam. The pH setting (SET POINT) and the differential (HYST.) can then be adjusted.

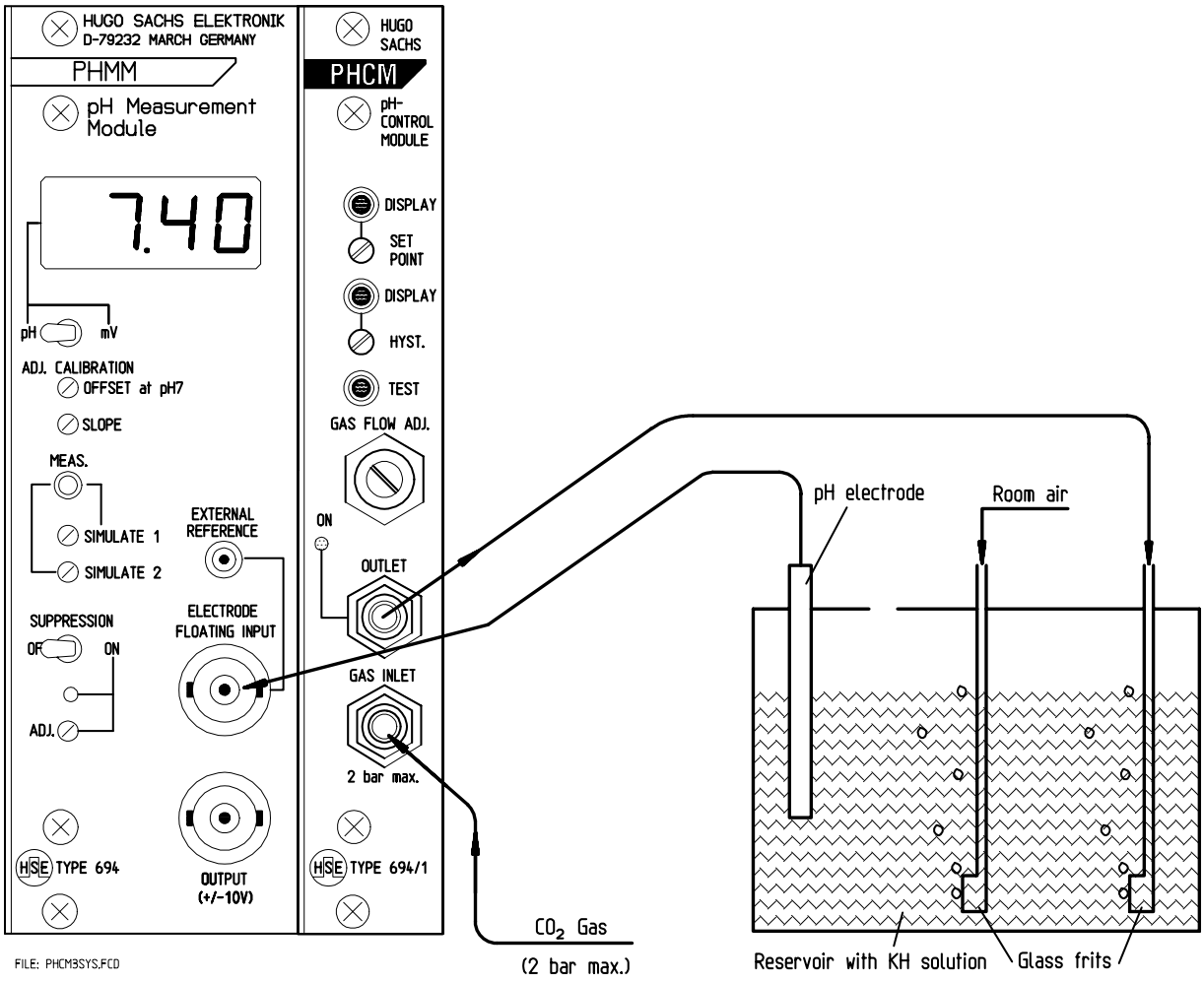


Fig. 7: Connection of the tubing on the **pHCM**.

5.3 Adjusting the pH setting (SET POINT) and differential (HYST.)

For example, to achieve a perfusion solution with a pH within the range 7.3 to 7.4, the procedure is as follows:

- Press the "DISPLAY" key above "SET POINT".
  The current setting is now displayed on the pHMM module.

- The required pH setting can now be produced by rotating the "SET POINT" trimmer potentiometer using a small screwdriver. Clockwise rotation increases the value, anticlockwise rotation reduces it. The setting is shown throughout on the pHMM. For the example indicated above the SET POINT has to be set at 7.4.

- Press the "DISPLAY" key above "HYST."
  The current setting of the differential (permitted variation band) is now indicated on the pHMM module.

- The required differential can now be set by rotating the "HYST." trimmer potentiometer using a small screwdriver. Clockwise rotation increases the value, anticlockwise rotation reduces it.
  For the example indicated above the differential "HYST." should be set to 0.1.

After these settings have been made the experimental measurements can be started.

6. Experiment

Before each experiment the pH electrode should be calibrated in buffer solutions at pH 7.00 and pH 4.00 (see Instructions for the pHMM). The response time of pH electrodes is usually about 10 seconds (combination pH electrode Type 830). This electrode has a stability of 0.05 pH/day. The slope of the pH electrode is approx. 55 mV/pH.

During the actual experiment the valve can be heard to switch from time to time. It is useful to check that sufficient numbers of gas bubbles are rising from the frit. If there are only few bubbles the process of saturation with CO_2 takes correspondingly longer. Also check that no bubbles are formed at the tip of the pH electrode which could lead to incorrect measurement.

7. Description of the controls

(1) Key DISPLAY SET POINT. On pressing this key the setting (SET POINT) is indicated on the display of the pHMM, e.g. 7.40.

(1a) Setting trimmer for the required value of the pH which has to be maintained constant (setpoint).

(2) Key DISPLAY HYST. On pressing this key the differential (HYST.) is indicated on the display of the pHMM, e.g. 0.05.

(2a) Setting trimmer for the required value of the differential (hysteresis) of the controlled pH.

(3) TEST key to open the valve. This is used when adjusting the correct aeration using the needle valve.

(4) Needle valve for adjusting the gas flow rate. Use the locknut to lock the selected setting.

(5) Green LED. This LED lights up when the solenoid valve is activated and opens the gas flow to the outlet (5a).

(5a) Gas outlet connection OUTLET.

(6) Inlet connection INLET for the gas used.
IMPORTANT: maximum inlet pressure: 2 bar. The gas used must be clean, max. particle size 25 µm.

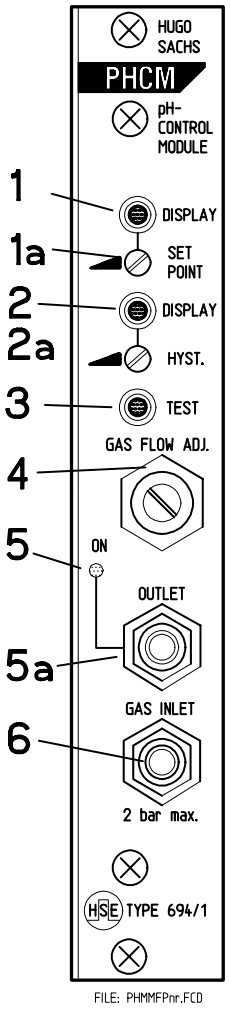


Fig. 8: Operating controls

8. Fault, cause, remedy

Fault: Although the valve is open (green LED alight) there is no bubbling in the reservoir.

Causes: The needle valve is closed.
The gas cylinder is empty.
The shut-off valve of the pressure regulator on the gas cylinder is not open.

Remedy: Check the shut-off valve on the pressure regulator. Adjust the pressure regulator to between 1 and 1.5 bar. Open the needle valve on the **pHCM** (turn anticlockwise). Check the tubing that they are not kinked.

9. Maintenance and cleaning

The PLUGSYS module requires no maintenance. The **pHCM** module is supplied fully calibrated. Any operation on or alteration of the electronic circuitry invalidates the manufacturer's warranty and product liability.

When the gas used is not clean (oily, dirt particles > 25 µm) there is a possibility of incorrect operation of the **pHCM**. If such dirt is present the solenoid valve may fail. In this case you,can try to blow down the gas lines with air and a large-size syringe (e.g. 50 ml).

Before you do this you have to disconnect the pressure tubing from the **pHCM**.
Then apply an air-filled 50 ml syringe to the gas outlet "OUTLET" and open the solenoid valve by pressing the TEST key while at the same time discharging the syringe. This should blow back any dirt particles which have clogged the valve.

Another possibility is to connect the inlet tubing to the OUTLET and press TEST. The needle valve may have to be opened a little further. This procedure, too, blows back any dirt particles which clog the valve.

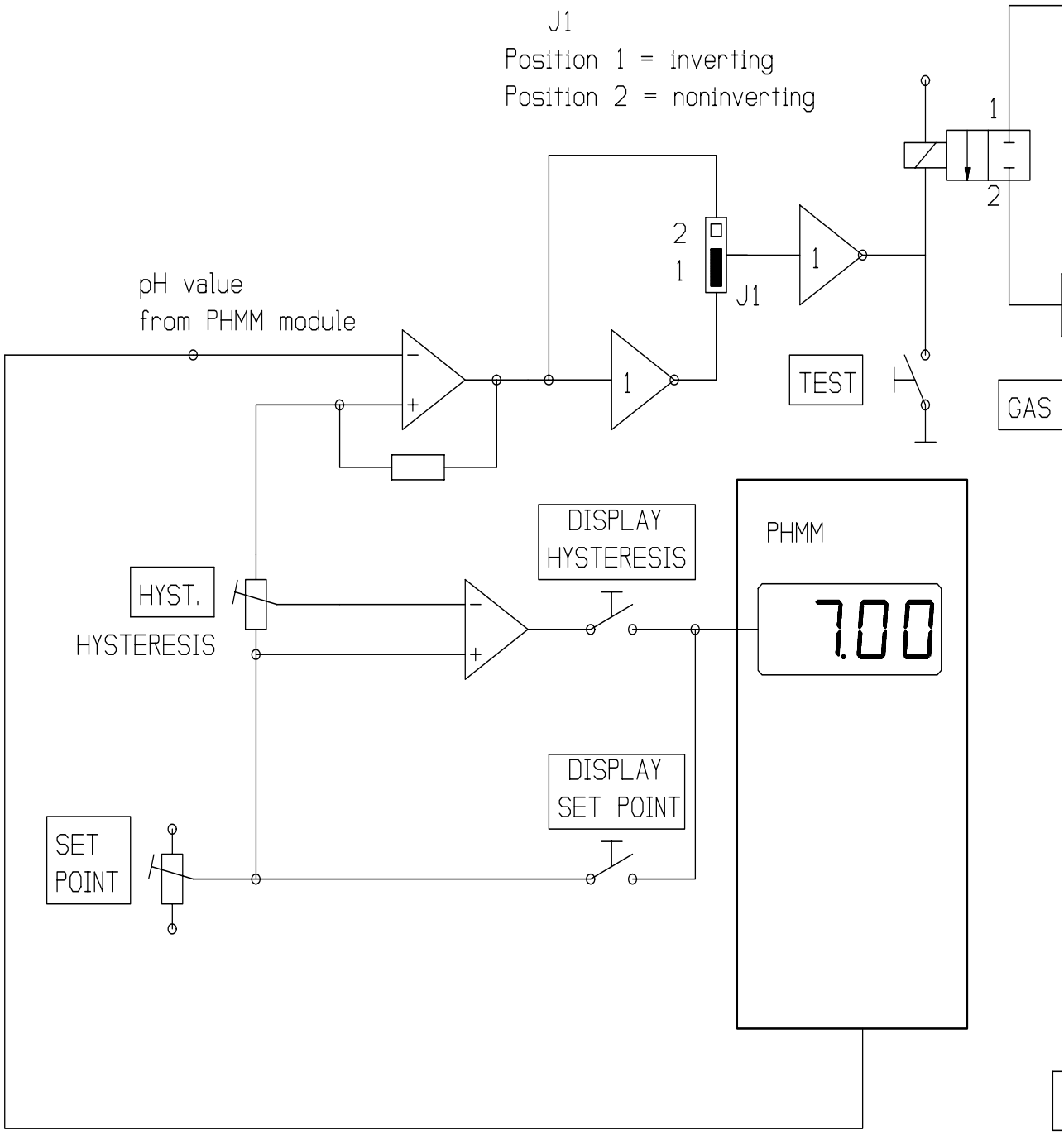
The front panel can be cleaned if necessary with a lightly moistened (not a wet) cloth. Before cleaning always pull out the mains supply plug!

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 water splashes 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 if the unit has to be returned 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 have to be protected against electrostatic discharges and should also be well packed. The module should first be enclosed in antistatic foil or envelope and then placed into a sufficiently large carton with adequate packing material.

11. Block diagram of the pHCM module



12. CE Declaration of Conformity

CE 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

Control range, setting:	SET POINT is adjustable between approx. pH 6.5 and pH 8.5. The set value is indicated on the pHMM module by pressing the DISPLAY key.
Differential:	adjustable between approx. 0.05 to 1 pH units. The setting is indicated on the pHMM module by pressing the DISPLAY key.
Controlled medium (gas):	depends on the perfusion solution used and on the control direction. When used on Krebs-Henseleit solution where the pH has to be reduced: CO_2 gas.
Required condition of the controlled medium (gas):	dirt particle size 25 µm max., dry gas pressure 2 bar max.
Gas flow:	continuously adjustable from 0 to approx. ### l/min
Ambient conditions:	(as for pHMM module): working temperature range: 10 to 40°C relative humidity: 20 - 80%, no condensation storage temperature range: -20 to +60°C
Supply:	from the pHMM module to which it is linked

Mechanical data:

Dimensions:	module for the PLUGSYS housing width: 4 E (20.4 mm) height: 3 U (128.7 mm) depth: 110 mm
Connector:	10-way ribbon cable to pHMM module
Weight:	100 g
Accessories:	Operating Instructions 2 m pressure tubing for connection to gas cylinder 2 m Tygon tubing for connection to frit