1) Storage and Transport of Sensors

3-Electrode sensors: Sensing (S) and Reference (R) electrodes are shorted to stabilise baseline current. The spring must be removed before operating in the electronic circuit.

3-Electrode sensors for nitrogen oxide: They are NOT shorted, because they are intend to be operated with a bias voltage.

2-Electrode sensors: Sensing (S) and Counter (C) electrodes are shorted to stabilise baseline current. The spring must be removed before operating in the electronic circuit.

Sensors must not be exposed to temperatures outside the range -30°C to 50°C and to organic vapours. For maximum shelf life sensors should be stored in the containers in which they are supplied in clean dry areas between 5°C and 20°C. They must not be stored in areas containing organic solvents or in flammable liquid stores.

2) Connection to Sensors with PCB Pins

Under no circumstances should pins be soldered to. Connection should be made via a PCB mounting socket. Alternatively the side tag version of the standard and slim series may be demanded, which are designed for solder connection.

WARNING: SOLDERING TO PINS WILL RENDER YOUR WARRANTY VOID.

3) Currents and Voltages Generated under Normal Operation at 20°C.

Current outputs

All sensor types are linear over the recommended operating range of gas concentration and the current generated is given by the equation:

sensitivity [nA/ppm] x gas concentration [ppm] = sensor output [nA]

3-Electrode sensors: The sensing electrode is controlled, relative to an unpolarised reference electrode, by an external operational amplifier circuit. Unlike 2-Electrode sensors, the sensing electrode potential is independent of the counter electrode polarisation.

3-Electrode sensors show a linearly increasing output with gas concentration until the output current exceeds the saturation current of the controlling external amplifier. At this point no further current change is possible with increases in gas concentrations. The maximum current limitation of amplifiers commonly used with a 3-Electrode sensor control is unlikely to exceed 50mA.

WARNING: EXPOSING THE SENSOR TO GAS CONCENTRATIONS ABOVE THE NOMINAL RANGE WILL RENDER YOUR WARRANTY VOID.

Voltages generated

3-Electrode sensors: In normal operation the cell potential will be the sum of the sensing-reference and reference-counter potentials.

For zero bias sensors the sensing-reference potential will be zero (<10mV). The counter electrode potential, however, is free to float relative to the reference electrode and will polarise as it produces the required cell current. The degree of polarisation is dependent on time and concentration. However once a polarisation of 1.05V has occurred the counter electrode will begin to evolve hydrogen and no further polarisation can take place. This means the maximum theoretical cell voltage for an unbiased sensor is 1.05V.

For biased sensors the above consideration of reference-counter potential applies equally, but the sensing-reference potential is greater than zero. The recommended bias setting for NO-sensors is + 300 mV.

Therefore the maximum theoretical cell voltage for biased sensors is 1.35V. However in practice counter electrodes do not polarise as far as hydrogen evolution. Therefore, in biased operation cell voltages are normally less than 1.2V.

4) Possible Maximum Open Circuit Voltage and Maximum Short Circuit Current

MAXIMUM OPEN CIRCUIT VOLTAGE	MAXIMUM CURRENT IN NORMAL OPERATION	MAXIMUM PEAK SHORT CIRCUIT CURRENT
1.2 Volt	0.05 Amps.	1 Amp.

Phone: +41 43 311 72 00
Fax : +41 43 311 72 01
Email: info@membrapor.ch
www.membrapor.ch

MEMBRAPOR AG
Rautistrasse 164
CH-8048 Zürich
Switzerland

5) Designing a Potentiostatic Circuit

Working Principle of an Electrochemical Sensor

The **working electrode** responds to the target gas, either oxidising or reducing the gas, creating a current flow that is proportional to the gas concentration. This current must be supplied to the sensor through the counter electrode.

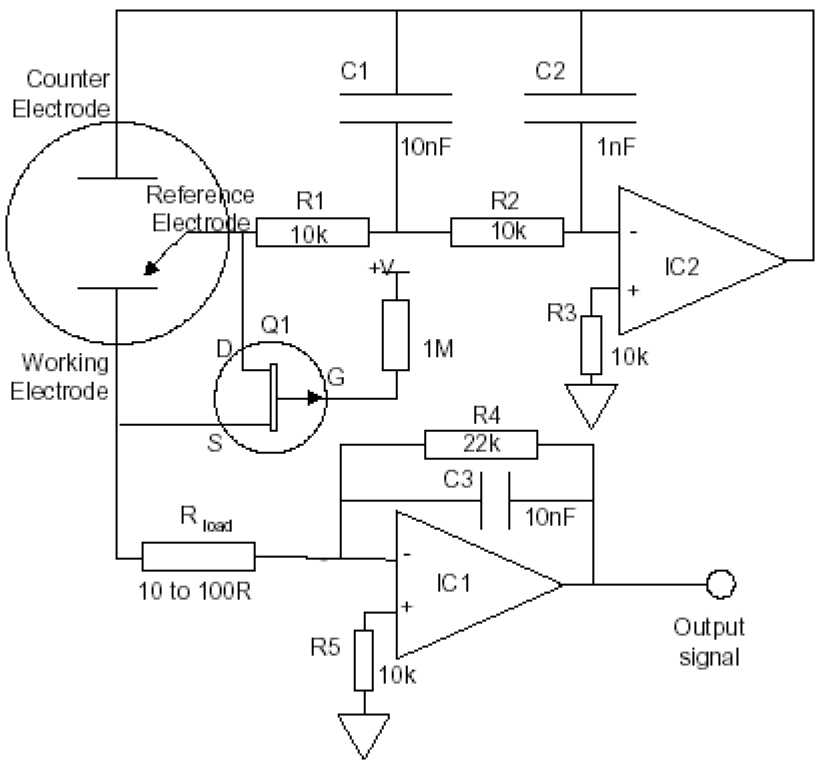
The **reference electrode** is used by the potentiostatic circuit to maintain a fixed potential at the working electrode. The working electrode potential must be maintained at the same potential as the reference electrode potential for unbiased sensors, or with an offset for sensors that require biasing.

The **counter electrode** completes the circuit with the working electrode, reducing some chemical species (normally oxygen) if the working electrode is oxidising, or oxidising if the working electrode is reducing the target gas. The potential of the counter electrode is allowed to float, sometimes changing as the gas concentration increases. The potential on the counter electrode is not important, so long as the potentiostat circuit can provide sufficient voltage and current to maintain the working electrode at the same potential as the reference electrode.

All three electrodes are connected internally through the electrolyte. The electrolyte can be modelled simply as a resistor. Each electrode can be modelled simply as a large capacitor. The electrodes also have a small resistive component, but this is included as part of the electrolyte resistance.

SCHEMATIC CIRCUIT DIAGRAM FOR ELECTROCHEMICAL SENSORS (UNBIASED OPERATION)

This schematic circuit gives positive output for gases which are oxidised such as CO, H_2S, SO_2, H_2, HCl, NH_3, and negative output for gases such as NO_2, Cl_2 and O_3.



Preferred potentiostat circuit for zero bias toxic gas sensors. ICs require +/-, not single ended power supply.

The **IC2** provides the current to the counter electrode to balance the current required by the working electrode. The IC2 amplifier should have either a low offset or have its offset nulled out. (When switching on the circuit, the depletion mode JFET, Q1, goes to a high impedance state and IC2 provides the current to maintain the working electrode at the same potential as the reference electrode. Any offset due to the input offset voltage in IC2 will therefore cause a sudden shift in potential at switch-on.) The inverting input into IC2 is connected to the reference electrode and must not draw any

Phone: +41 43 311 72 00
Fax : +41 43 311 72 01
Email: info@membrapor.ch
www.membrapor.ch

MEMBRAPOR AG
Rautistrasse 164
CH-8048 Zürich
Switzerland

significant current from the reference electrode. The PMI OP-07 and OP-90, Intersil or Teledyne 7650, and Linear Technology LT1078 are all suitable.

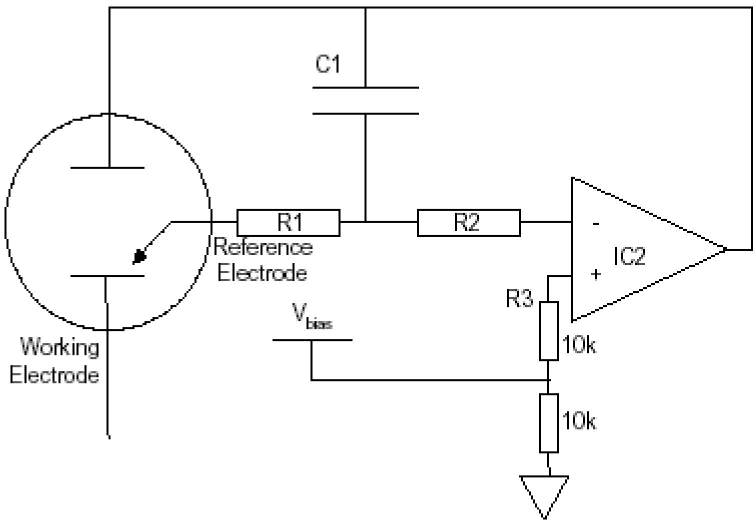
The **IC1** acts as an current to voltage converter and its offset performance is less critical. The OP-07 or similar is a suitable choice. The R_{load} should have a low value e.g. 10 – 33 Ohm. The gain can be controlled by R4.

All electrochemical sensors for unbiased operation are supplied with a shorting link across the sensing and reference terminals. This must be removed in case the sensor is connected to the circuit. When the circuit is switched off shorting of the sensor is achieved by the shorting JFET Q1. This ensures that the working electrode is maintained at the same potential as the reference electrode when the circuit is switched off.

BIAS VOLTAGE

Normally, electrochemical gas sensors are operated in the zero bias mode; however, certain sensors, such as NO sensors, require a bias voltage of +300mV.

If you wish to inject a bias voltage then also ensure that your bias voltage is stable: Changes of even a few mV can affect sensitivity to gases and rapid changes in the bias voltage by only a mV will generate transient effects for up to hours on the sensor output. A simple method of biasing the sensor is shown in the figure below. The 10K load resistor to ground can be removed to reduce the current on V_{bias}.



Applying a bias voltage to the control op amp.

Biasing should be maintained when the instrument is switched off - this is normally accomplished by using a button cell battery that remains on at all times. In this case, the input offset of IC2 is not critical, but its drift with temperature etc. must be kept small. It is recommended that, for biased circuits, the bias voltage be maintained on at all times. This will not affect the operating life of the sensor.

Noise

Ideally, the measuring and controlling op amps in a potentiostat are fitted directly underneath the sensor to keep the shortest leads because of the low impedance and low sensor currents.

6) Sensor Calibration

Note that electrochemical gas sensor sensitivities are variable, typically ±15%. So you must calibrate in software to correct for sensor-to-sensor sensitivity variations. Additionally, the sensitivity will drift downwards with time, typically 0.5% to 2% per month. Refer to the data sheet of the respective sensor.

It is also normal to correct for temperature dependence of the sensitivity.

Phone: +41 43 311 72 00
Fax : +41 43 311 72 01
Email: info@membrapor.ch
www.membrapor.ch

MEMBRAPOR AG
Rautistrasse 164
CH-8048 Zürich
Switzerland