# Electrochemical Sensors Application Note 2
# Support Electronics for Toxic Electrochemical Sensors

## INTRODUCTION

There are several variations of control circuitry that will successfully operate a 3-electrode electrochemical sensor, and the principal aims of the control circuitry are very simple.

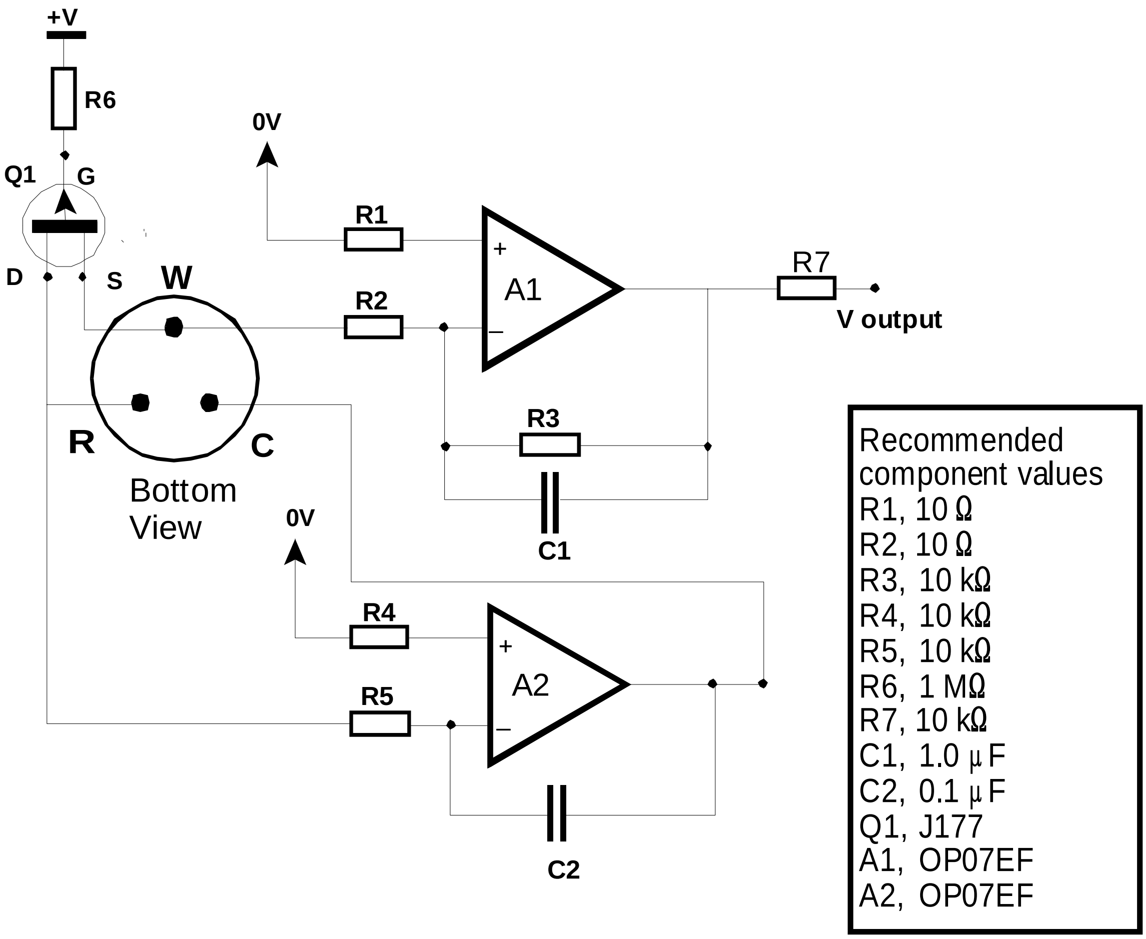
Firstly, it is a requirement in the design of the circuit to keep the working electrode and the reference electrode at a similar potential usually near ground.

Secondly, to draw a current from the electrochemical cell via the counter electrode equal to the current flowing into the working electrode which has been generated by exposure to the target gas. The electrochemical cell itself will need to operate within this circuit and produce an electrical current proportional to the applied gas concentration.

In most cases the circuit will also need to convert the current produced by the electrochemical cell in the target gas to a convenient useable output voltage.

These types of circuits are generally known as potentiostatic circuits and there are many slight variations but they all perform essentially the same.

### Example of 3-Electrode Potentiostatic Circuit

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A1A-EC_Sensors_AN2 Issue 1, February 2007
101129

# CIRCUIT OPERATION

## Working Or Sensing Electrode

When the sensor is exposed to Carbon Monoxide, the reaction at the working electrode oxidises the carbon monoxide to become carbon dioxide, which diffuses out of the sensor. Hydrogen ions and electrons are generated at the same time. The hydrogen ions migrate through the electrolyte towards the counter electrode. This process tries to leave a negative charge on the working electrode.

**$CO + H_2O = CO_2 + 2H^+ + 2e^-$**

The electrons flow out from the working electrode through R2 to produce the signal current (Ig) in to A1 proportional to the applied gas concentration. The operational amplifier configuration for A1 is set up as current to voltage converter and the signal current will be converted into a voltage proportional to the applied gas concentration.

**Output Voltage = Ig R2 x R3/R2**

**= Ig x 10 x 10000/10**

**= Ig x 10000**

A typical signal current of 500 nA, which is approximately 10 ppm Carbon Monoxide, will give an output in this circuit of 5.0 mV.

## Reference And Counter Electrode

The migrating hydrogen ions from the working electrode try to lift the potential of the reference electrode and the counter electrode. This small rise in potential at the reference electrode is converted into a negative potential by A2 and current flows out of the counter electrode to counteract the rise in potential at the counter electrode and hence the reference electrode. The electrons combine with the hydrogen ions and oxygen to form water as shown below.

**$\frac{1}{2}O_2 + 2H^+ + 2e^- = H_2O$**

This keeps the reactions on the electrodes in the sensor balanced. The P-type JFET Q1 and resistor R6 prevent the sensor from polarising when the circuit is unpowered.

In general the op-amp power rails should be high frequency decoupled with suitable capacitors as shown in the OP07 EF manufacturer's data sheet. All resistors should be 5% tolerance except R3 and R2, which should be 1%.