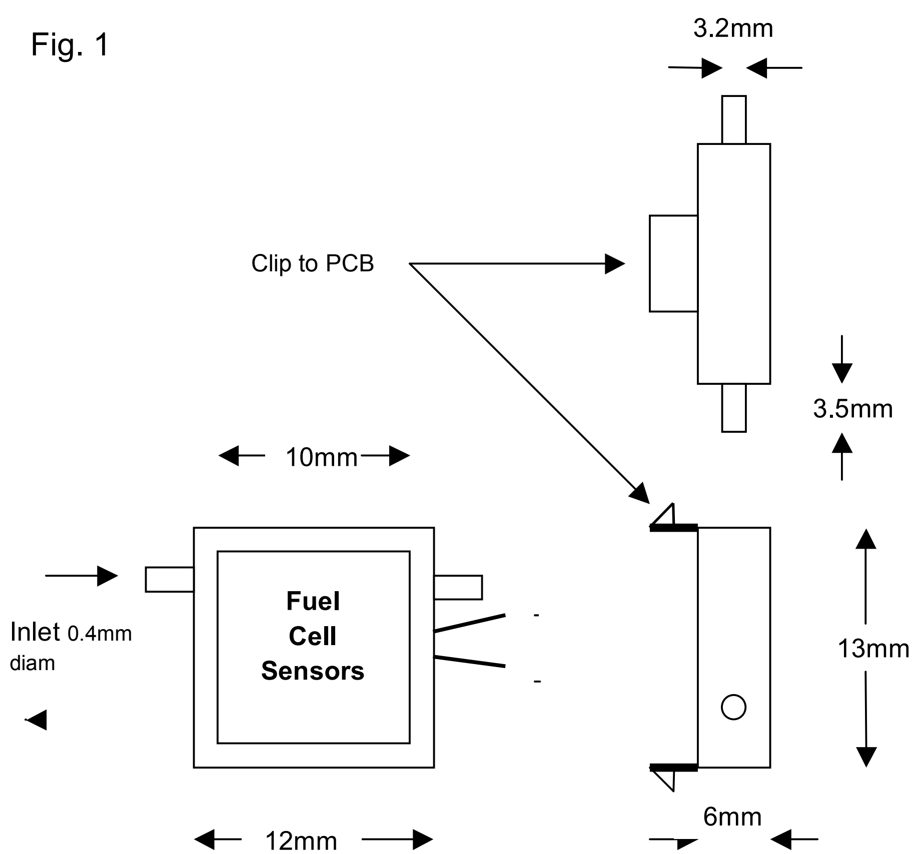
Fuel Cell Gas Sensor- Mini Cell FC4 for ALCOHOL DETECTION

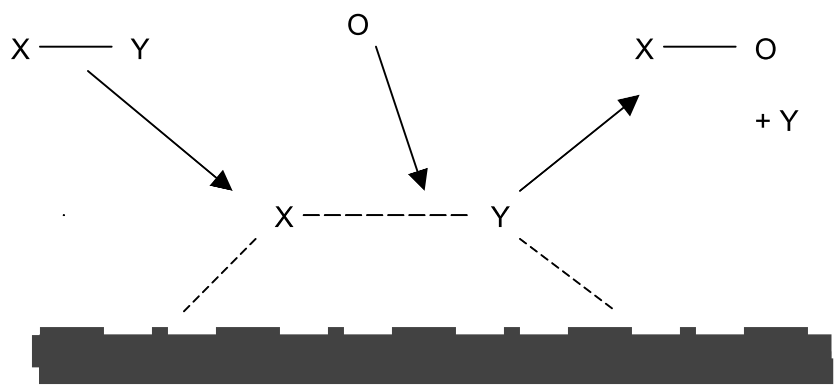
The FC4 is a Platinum based catalyst type of fuel cell gas sensor, which is highly sensitive to alcohol gas with speedy response. This model is suitable for ignition interlock, coin operated and hand held portable devices. The sensor needs no external power in its operation and it generates a peak output proportional to the gas concentration for any given sample volume. Fig. 1 below shows external dimensions.

Fig. 1



Fuel Cell Function

Fig. 2 How Does Heterogeneous Catalysis



Catalytic Surface

Heterogeneous catalysis works by reducing the energy (usually in the form of heat) needed for a given reaction to take place. This works by the catalyst having an affinity (attraction) for the molecule to be reacted, in this case X-Y and thus stretching and weakening the bond between the two molecules. The position on the catalyst where this occurs is known as an active site and is on an intermolecular scale, measured in nanometres. While the bond is weakened in this way it takes less energy to break it down and form new bonds with other reactant molecules, shown as O above. This yields a new molecule X-O above and respective by-products at a lower required energy (temperature). In the case of the reduction of ethanol to ethanoic acid this would occur at normal ambient temperatures in presence of a suitable catalyst. At the end of such a reaction the catalyst is unchanged both chemically and physically and is subsequently reusable.

Reaction:

$$C_2H_6O + O_2 \longrightarrow C_2H_4O_2 + H_2O$$

Typical Test Parameters:

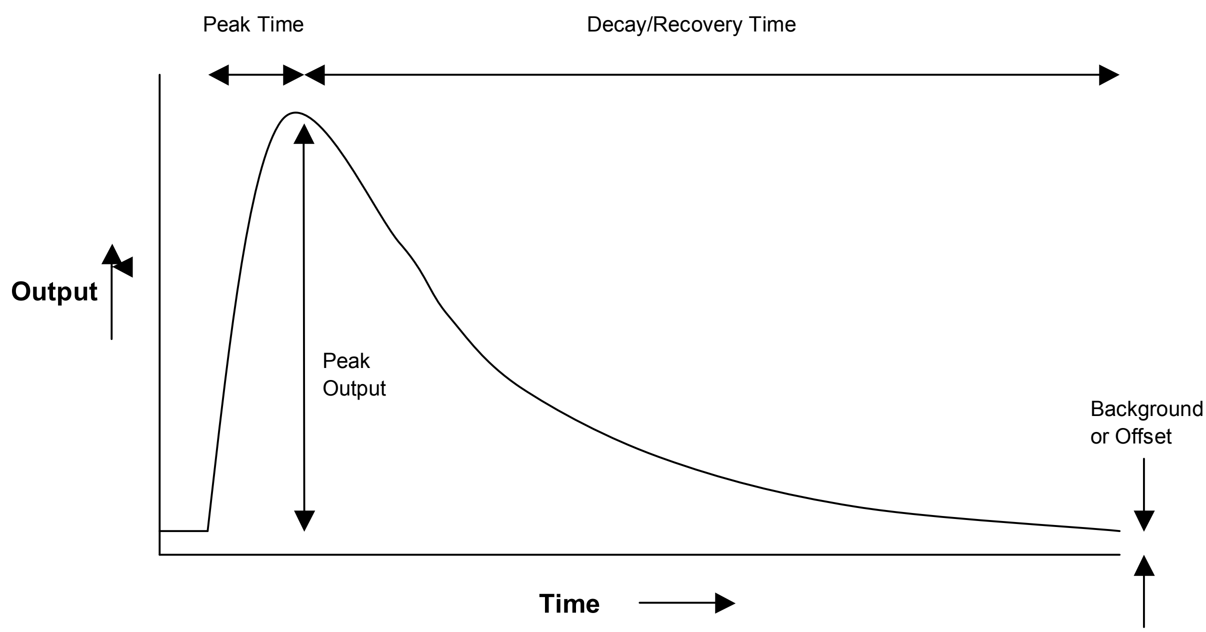
Gas concentration -	35 ug % BrAC (80mg% BAC equivalent)
Load resistance -	390 ohms
Sample volume -	0.3 mls
Atmospheric conditions -	STP

Expected Cell Performance when despatched:

Output -	>2mV (also available for measuring current)
Peak time -	5s approx
Clearing time -	< 1 minute to 5% of output
Linearity -	<5% at 4 times calibration level

Note: Sensor configuration and test parameters will depend on product application used and thus cell performance will vary accordingly

Fig. 3 Fuel Cell Performance Characteristics



Understanding Fuel Cells

In order to understand how fuel cells perform we must first look at the terminology utilized in their use –

Peak Output – The maximum voltage or current generated from the cell after a sample has been introduced.

Peak Time – The time taken to reach the Peak Output above.

Background/offset – The residual voltage or current from the cell prior to introduction of the sample.

Decay/clearing Time – The time taken for the cell to return to desired background above.

Repeatability – The precision in Peak Output values of successive samples.

Calibration Stability – The precision in Peak output values with samples taken over a long period of time.

Dead Space – A volume of air in the system that does not move until a sample is taken.

Linearity – The accuracy for the Peak Output at increasing gas concentration.

What are the Design Considerations for Fuel Cells?

Well as a general rule the design considerations depend on the application that the cell is intended for. Although most cells will give a Peak Output in any application, it is important to optimise the performance of the sensor for the preferred characteristics such as high Peak Output, fast Peak Time, quick Recovery Time etc…

Along with the fuel cell design the sampling system and sampling chamber need to be considered as these too will influence the design of each other. These issues are discussed more fully in our Design Considerations of Sampling Systems section later, but here we highlight the fundamental design issues for the cell, while noting that manufacturing processes are equally important.

Catalyst – Selection of catalytic material to gain the largest number of “active sites” as described in our Background section, is imperative. Predominantly these catalysts are platinum based but not always? Also the use of co-catalysts, inert fillers and doping materials are used to gain enhanced performance and/or specificity. When we discuss the catalyst itself the issues of form and structure are most influential in maximising the number of active sites per unit area, a term which is loosely called “activity” in the trade.

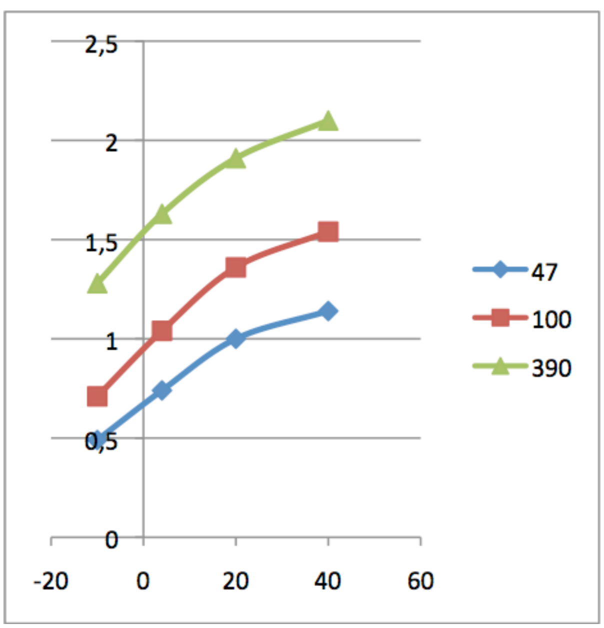
Ion Transfer Electrolyte – Typically ionic to give good conductivity and ion transfer capabilities. Such electrolytes are commonly acid or alkali in nature, but ion transfer membranes are also used. If acid or alkali electrolyte is preferred them the environmental stability and physical retention in the sensor need to be considered fully. This gives rise to the importance of surface tension effects and their affinity for a binding or holding material, which is normally referred to as a “substrate”.

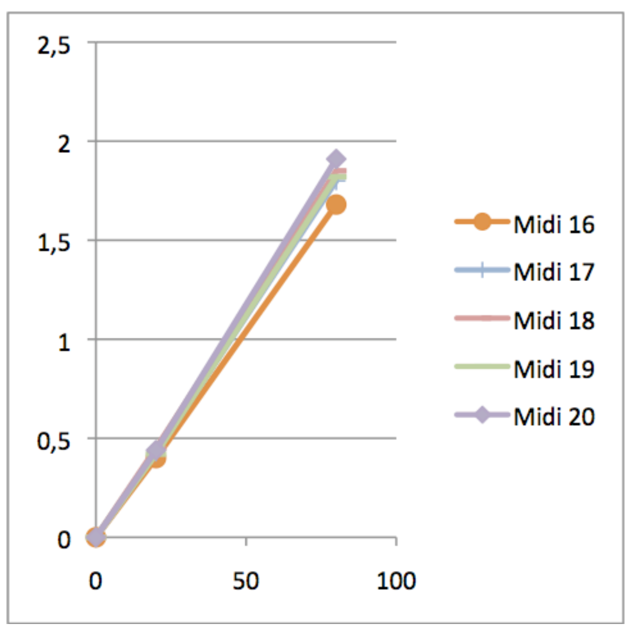
Size and Geometry – Clearly the size and geometry of the cell will affect its performance and thus can be optimised for the application. Here the gas path-flow, sample volume and dead space within the cell housing are the key issues. Also electrode configuration can vary greatly to give preferred sensor performance.

Diffusion Membrane – This is simply a physical barrier to reduce the rate that the sample reacts on the cell surface and can be polymeric in nature.

Performance Charactistics

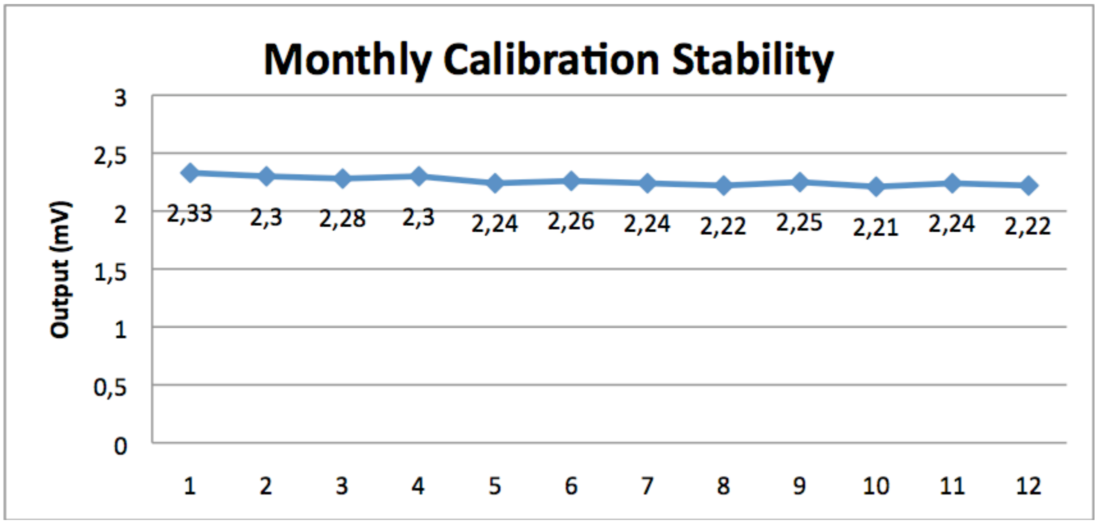
Effect of Load resistance and temperature on fuel cell output and output linearity with gas concentration below:





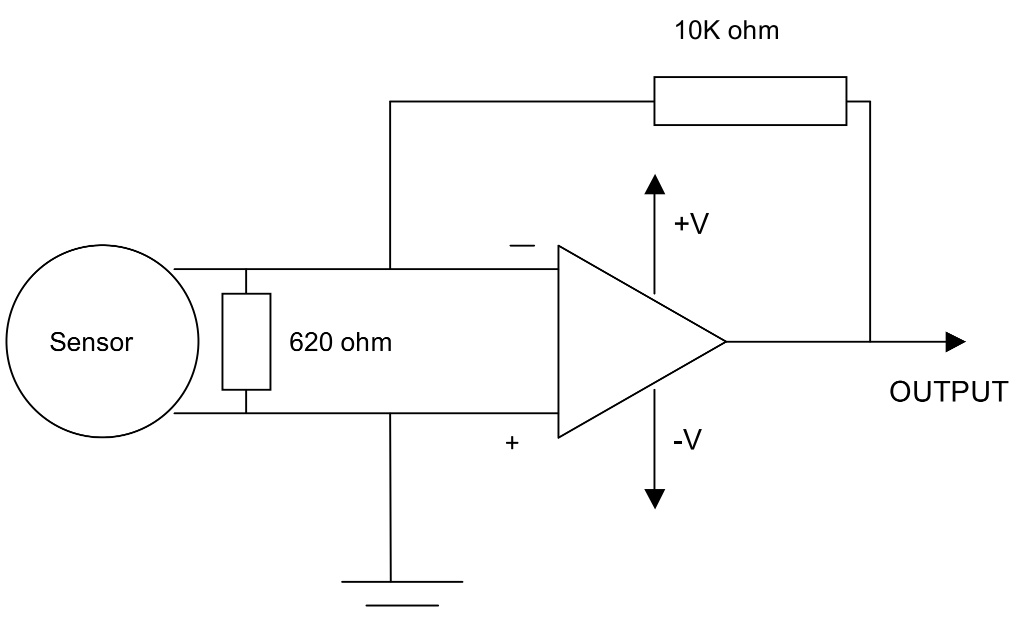
Temperature range: -10 to 60C

Storage: on short (where possible)



Fuel Cell Amplification

Fuel cell amplification can easily be achieved with a direct current to voltage amplifier as shown below:



The Burr-Brown OPA177 op-amp can be used in this circuit with the slightly noisier OPA 241 an good low power alternative. The use of a 680 ohm resistor across the fuel cell will help prevent the build up of small offset generation when the fuel cell in not in use.