Pre-amplifier for Oxygen sensor

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Introduction

The text describes a simple pre-amplifier intended to be used to amplify the output signal from an electro chemical fuel-cell.

The design

The general fuel-cell has an output between 15mV (new fresh cell) and down to 7mV (old depleted cell) in air, a P_{O2} of 21 kPa.

A simple OP-amp amplifier is used, see figure 1, the potentiometer R_2 gives an adjustable gain and the capacitor C_1 low pass filters the output with a time constant in the order of a few ms. The OP-amp used for the design (Analog Devices OP191) is a low power device that can run on a 3V single supply and also has the capability to operate with both input and output very close to the supply voltages. Analog Devices OP90, OP290 and OP490 will also work fine

The gain of the pre-amplifier is adjustable so it can provide an output of 10mV /kPa oxygen (i.e. 210mV in air) for new and old cells.

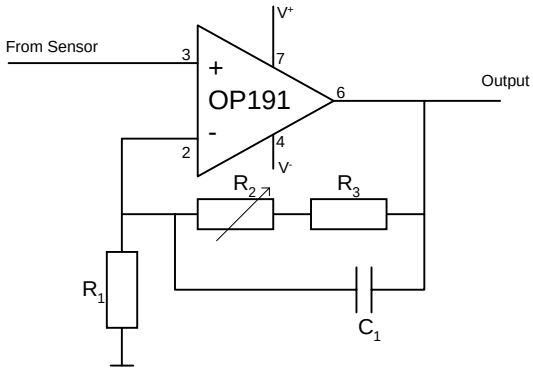

Figure 1. The Pre-amplifier schematics.

The gain of the amp is:

$$V_{out} = V_{in} \cdot \frac{R_1 + R_2 + R_3}{R_1 +}$$

Assuming a high output cell with 25mV output gives the minimum gain (i.e. $R_2 = 0\ \Omega$) of the amp:

$$V_{out} = 210mV = 25mV \cdot \frac{R_1 + R_3}{R_1} \Rightarrow$$

$$R_3 \approx 7R_1$$

Thus the mimimum gain will be about 8.

A depleted cell with an output of 5mV gives the maximum gain (about 40) of the amp:

$$V_{out} = 210mV = 5mV \cdot \frac{R_1 + R_2 + R_3}{R_1} = \{R_3 = 7R_1\} = 5mV \cdot \frac{R_1 + R_2 + 7R_1}{R_1} \Rightarrow$$

$$R_2 \approx 32R_1$$

Thus the maximum gain wil be about 40,

The R_1 is selected to be 3kΩ, thus
R_2 = 100kΩ
R_3 = 20kΩ

To limit the bandwidth of the amp, the capacitor, C_1, is selected so the low pass time constant is about 2 ms:

$$\tau = R_3 C_1 = 2ms \Rightarrow$$

$$C_1 = \frac{2ms}{20k\Omega} = 0.1\mu F$$