MEM6 Hydrogen-Compensated 4-Electrode-Sensors
Gas Sensors with Suppressed H_2 Interference

1) Principle

This type of MEMBRAPOR 4-electrode sensor is used for target gases like carbon monoxide (CO) or hydrogen sulfide (H_2S) and allows to compensate for interfering hydrogen (H_2) gas, which is not possible to eliminate with filters or other techniques. In applications, where the H_2 concentration is very high, or where the concentration of the target gas is very low, the sensor signal has to be corrected for the response to H_2. Here, the principle will be explained in the case of a H_2-compensated CO sensor but all the principles and equations apply to H_2S as well.

While both, the oxidation of CO and interfering H_2 occur at the sensing electrode, the signal at the auxiliary electrode is almost exclusively due to H_2. With two signals caused by two gases, the respective concentrations can easily be calculated and thus, a highly accurate CO reading is obtained in applications where 3-electrode sensors would fail.

2) Potentiostatic circuit

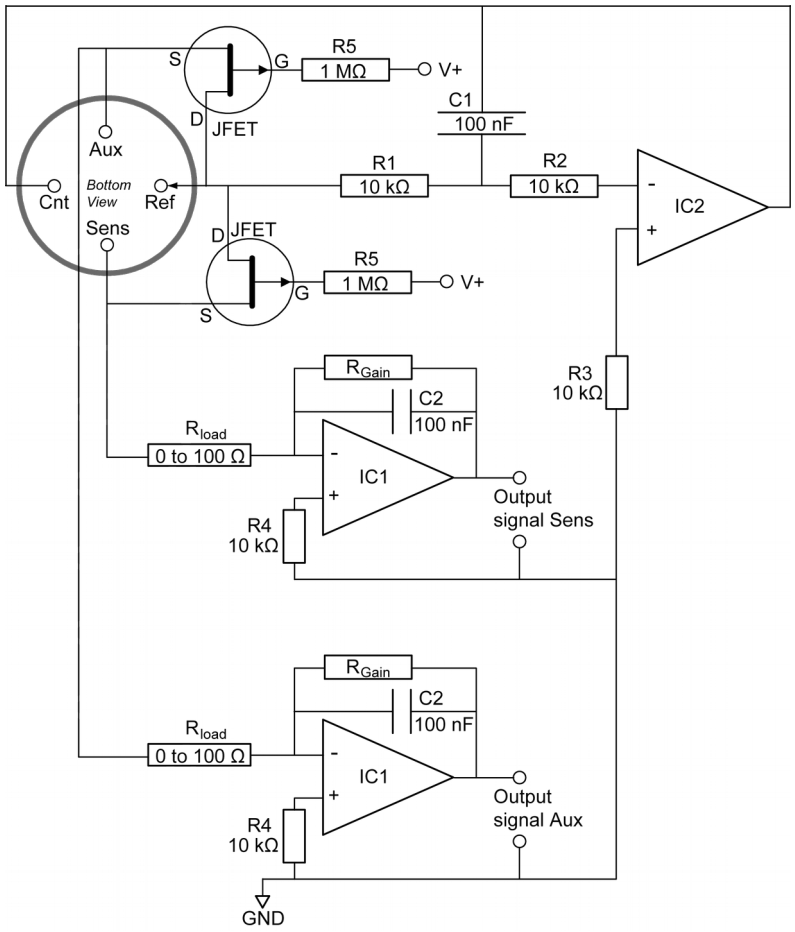

Figure 1 Schematic diagram of the electronic circuit for 4-electrode-sensor

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3) Calibration and Calculation

Three measurements and two different gas mixtures are needed for the calibration. In the case of an H_2-compensated CO sensor, the first gas mixture consists solely of CO gas, whereas the second is a mixture of both CO and H_2.

Definitions

The 4-electrode sensor gives two signals: A current at the sensing pin (I_{Sens}) and a current at the auxiliary pin (I_{Aux}). The three calibration measurements (zero point, 1. gas and 2. gas calibrations) yield three different values for both signals: $I0_{Sens}$, $I1_{Sens}$, $I2_{Sens}$ and $I0_{Aux}$, $I1_{Aux}$, $I2_{Aux}$ respectively.

Zero Point Calibration

$I0_{Sens}$ and $I0_{Aux}$ are determined with a zero point calibration at clean air at the temperature T_0.

1. Gas Calibration

The CO gas mixture with concentration $G1_{CO}$ is applied at the temperature T_0 and thus $I1_{Sens}$ and $I1_{Aux}$ are obtained.

2. Gas Calibration

The CO/H_2 gas mixture with concentrations $G2_{CO}$ and $G2_{H2}$ is applied at the temperature T_0, yielding $I2_{Sens}$ and $I2_{Aux}$.

Calculation

$$a = \frac{I1_{Sens} - I0_{Sens}}{G1_{CO}} \quad [\frac{\mu A}{ppm}] \tag{1}$$

$$c = \frac{I1_{Aux} - I0_{Aux}}{G1_{CO}} \quad [\frac{\mu A}{ppm}] \tag{2}$$

$$b = \frac{(I2_{Sens} - I0_{Sens}) - a \cdot G2_{CO}}{G2_{H_2}} \quad [\frac{\mu A}{ppm}] \tag{3}$$

$$d = \frac{(I2_{Aux} - I0_{Aux}) - c \cdot G2_{CO}}{G2_{H_2}} \quad [\frac{\mu A}{ppm}] \tag{4}$$

$$Gain = \frac{b}{d} \quad [-] \tag{5}$$

$$Sensitivity = a - Gain \cdot c \quad [\frac{\mu A}{ppm}] \tag{6}$$

ppm-Display

The sensor is now characterized to display the correct CO concentration at the temperature T_0:

$$CO = \frac{I_{Sens} - Gain \cdot I_{Aux}}{Sensitivity} \quad [ppm] \tag{7}$$

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4) Temperature Compensation

It is important to note that the *Gain* and the *Sensitivity* are not constant, but temperature-dependent sensor parameters. Especially at higher temperatures, the H_2 reaction at the sensing electrode increases strongly, resulting in a higher *Gain*. In the graph below typical curves of an H_2-compensated CO sensor are shown.

The ppm-display can be corrected using the temperature curves TC_{Gain} and $TC_{Sensitivity}$:

$$CO = \frac{I_{Sens} - Gain \cdot TC_{Gain} \cdot I_{Aux}}{Sensitivity_{CO} \cdot TC_{Sensitivity}} \quad [ppm] \qquad (8)$$

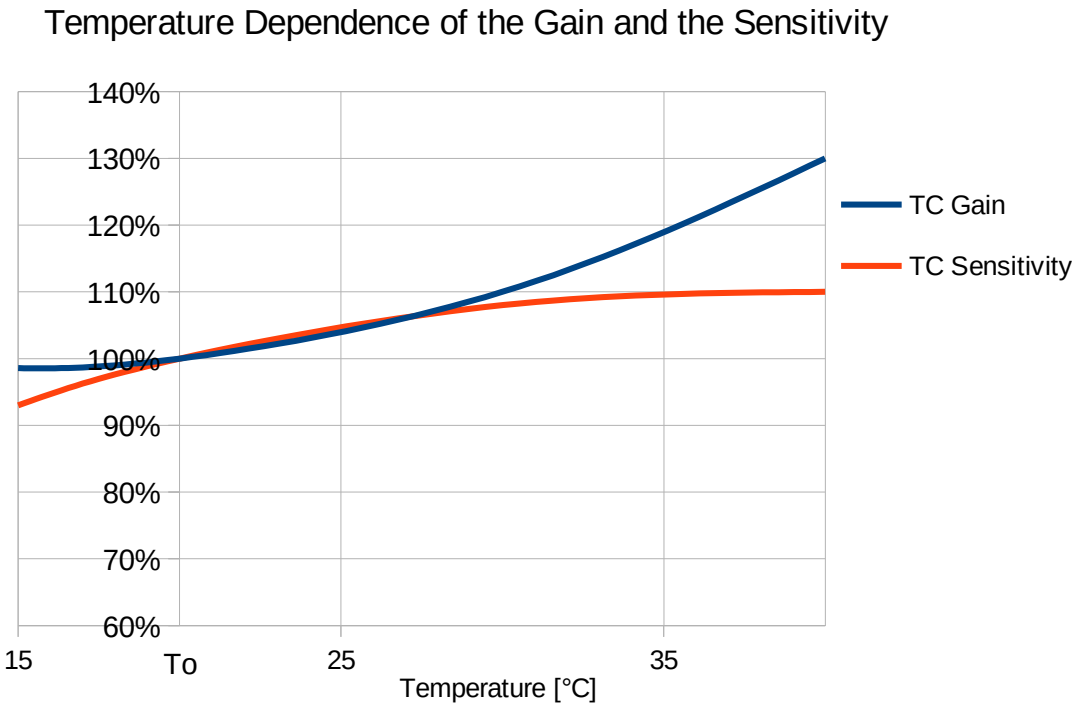

Figure 1 Temperature dependence curves of the Gain and the Sensitivity referenced to temperature T_0.

It is highly recommended to acquire the temperature dependence curves with the whole instrument. The sampling system, the electronics, the interaction between the electronics and the sensor, all have a significant impact on the temperature dependence of the final measurement reading.

5) Support

This application note is a concise note about hydrogen-compensated 4-electrode sensors. For further support, please contact MEMBRAPOR's technical department via email:
sensor@membrapor.ch

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