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MiCS – 5131 Application Note 1

Automotive Pollution Gas Sensor

This application note contains additional information on the characteristics of the MiCS-5131 pollution gas sensor. A typical application consists of measuring the pollution level outside the car to prevent disturbing gases from entering the passenger cabin. The sensor is placed inside a housing to protect the sensing element from water and dust projections. This module can be mounted in front of the ventilation fan of the engine to expose the sensor to the outside air. Depending on the concentration of pollution gases, such as carbon monoxide (CO), hydrocarbons (HC), and volatile organic compounds (VOC), the sensing resistance increases or decreases. An electronic control unit can detect this signal, for example to close or open the flaps for fresh air intake.

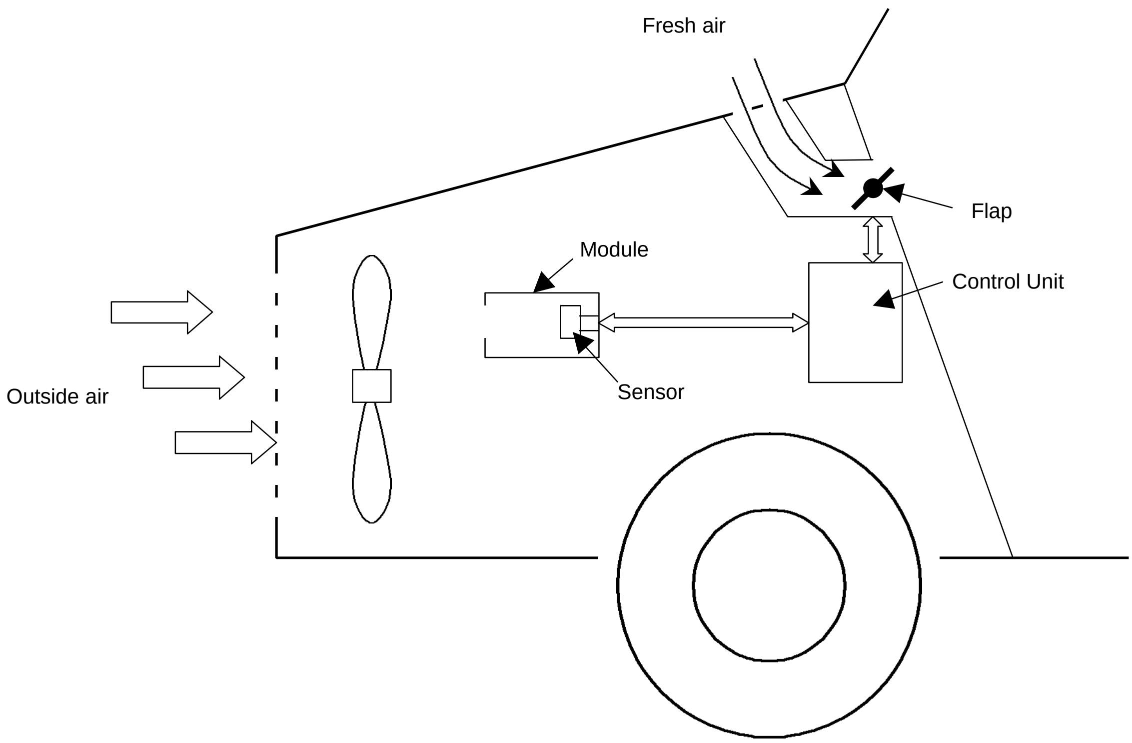

Fig. 1: Schematic of pollution gas detection system in a car to improve air quality in the passenger cabin.

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Operating Conditions:

The MiCS-5131 pollution gas sensor is designed to meet typical automotive requirements such as listed in the table below:

Parameter	Symbol	Typ	Min	Max	Unit
Life time	tl	10	10	-	year
Power on time over the life time	tp	6000	6000	-	hrs
Heating Power	P_H	102	85	120	mW
Relative Humidity Range	RH	50	5	95	%RH
Ambient Operating Temperature	T_{amb}	20	-40	120	°C

Measurement Circuit:

The sensor module can be powered with 5V as shown in figure 2. In order to obtain a nominal heating power of 102mW, a resistor Rserial of 56Ohm is connected in series with the heating resistor Rheater.

This simple circuit compensates heating power variations caused by changes of Rheater as demonstrated by the graph in figure 3. The relative heating power variation is ±3% for heating resistor values between 90 and 120Ohm.

Further improvement of the power compensation can be achieved by increasing Vcc from 5 to 6.4V and by choosing a Rserial of 100Ohm. Figure 4 shows that the power variation in this case is less than ±1% for the same heating resistor range of 90 to 120Ohm.

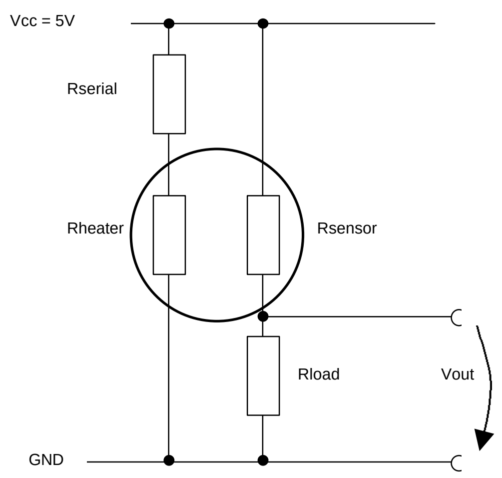

Fig. 2: Electronic circuit to power the heating resistor and to measure the sensing resistor.

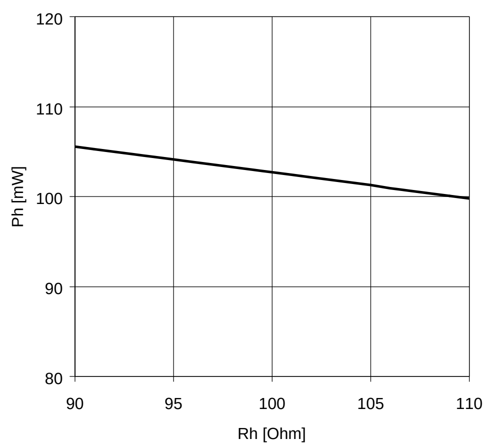

Fig. 3: Ph as a function of Rh. Rserial = 56Ohm and Vcc = 5V

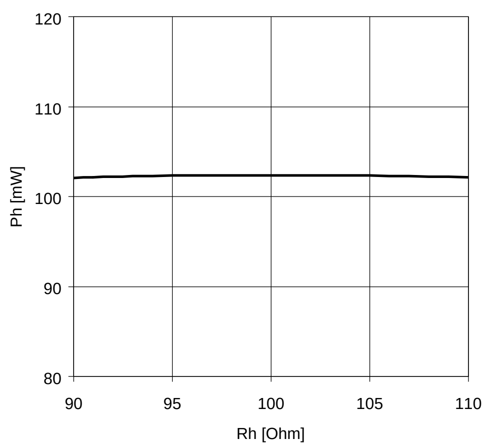

Fig. 4: Ph as a function of Rh. Rserial = 100Ohm and Vcc = 6.4V

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Heating Resistor:

The temperature of the sensing layer depends on the heating power and on the ambient temperature. To obtain good sensitivity to the pollution gases, the sensing layer temperature should stay within a temperature range of 350°C to 550°C. Below 350°C the sensitivity decreases significantly and the sensor response becomes slower. Above 550°C the sensitivity also decreases and the sensor structure can deteriorate due to overheating. Figure 5 shows the relationship between the applied heating power Ph and the resulting temperature increase ΔT with respect to the ambient temperature.

The heating resistor tends to increase slowly during operation life. This increase depends on the temperature of the heater and on the time as shown in figure 6. Consequently, the heating power decreases slowly with time. By using a power compensation circuit as shown in figure 2, the power loss can be contained within reasonable limits. After 1500hours at 120°C ambient temperatrue, which typically represents an accelerated lifetime of 6000hours powered-on, the heating power changes from 102mW (nominal) to 98mW.

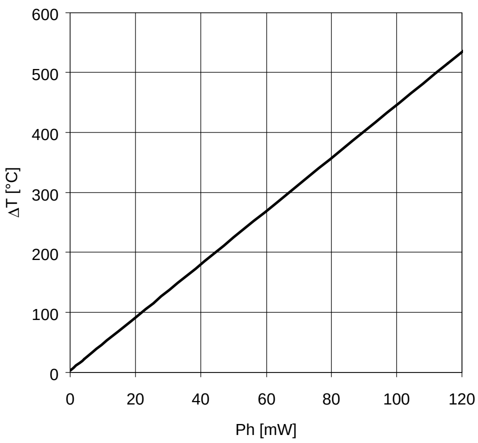

Fig. 5: DT as a function of Ph

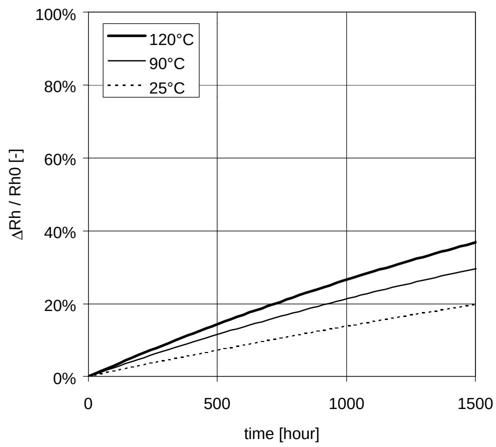

Fig. 6: Increase of Rh as a function of power-On time at ambient temperatures of 120°C, 90°C, and 25°C.

Gas Sensitivity:

Typical pollution gases encountered on the road are CO, HC's, and VOC's. These gases are emitted by car engines and can reach concentration levels up to several hundred ppm. All three types of gases are reducing gases and cause the sensing resistor to decrease with increasing concentration. Figure 7 depicts the resistance variations recorded during a road test in an urban area. The two large resistance drops marked by arrows occur when the car enters a tunnel with highly polluted air.

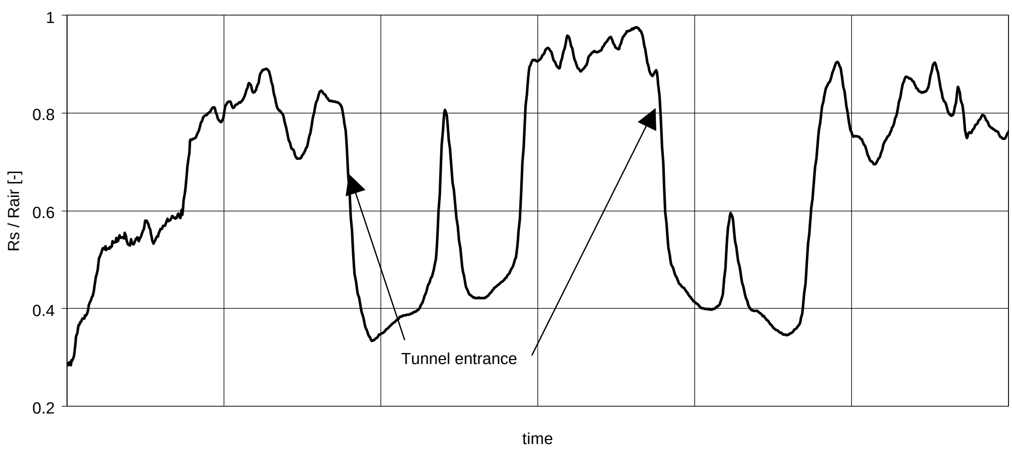

Fig. 7: Normalized resistance variations during a 20-minute road test

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Figure 8 shows the sensitivity of the MiCS-5131 to CO, H2, CH4 (HC), and Ethanol (VOC). Depending on the location and on the traffic situation, gases from all three types can be present in a mixture. Since all these gases produce a decrease of the sensor resistance the presence of a mixture generates an even larger decrease. Therefore, the sensor signal is a reliable indication for the presence of pollution gases.

Temperature and humidity also affect the resistance value of the sensor. Humidity is water (H2O) in gas phase, which reacts with the sensing layer like a reducing gas. Increasing humidity causes a decrease of the sensing resistance. As for the temperature, the effect is the same as for the humidity, i.e. decreasing resistance with increasing temperature. This negative temperature coefficient is due to the semiconductor properties of the sensing layer material. Resistance changes caused by temperature and humidity are slow compared to the changes induced by pollution gas variations. Therefore, temperature and humidity are not interfering.

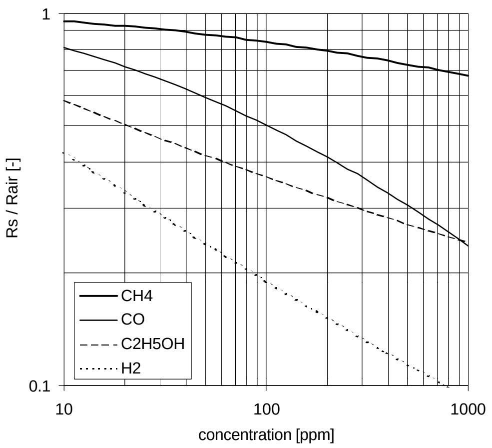

Fig. 8: Sensitivity to CO, H2, CH4, and C2H5OH at 25°C and 50% RH.

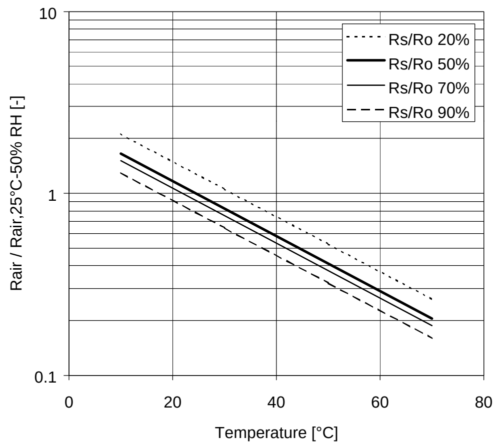

Fig. 9: Temperature dependence of baseline resistance Rair for 20%, 50%, 70% and 90% RH.

Response time is important in this application because the car is constantly moving through regions of varying pollution levels. The sensor signal must change fast enough to allow the control unit to close the flaps before susceptible amounts of polluted air can enter the passenger cabin. A typical response curve under laboratory conditions is shown in figure 10. The test gas is 60ppm of C2H5OH and the sensing resistance reaches 90% of its final change in about one second.

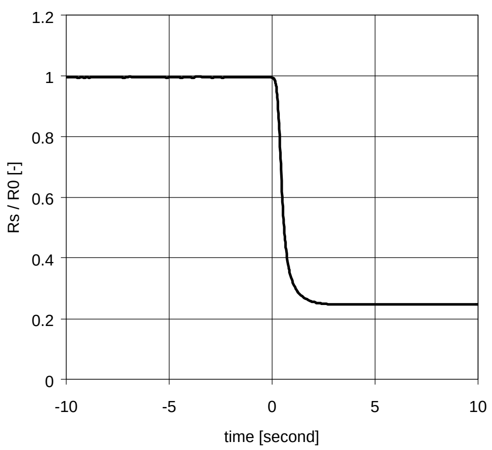

Fig. 10: Response time to 60ppm C2H5OH

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