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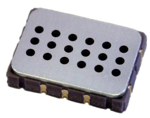
MiCS Application Note
How to set-up load resistance for MiCS sensors measurements

This application note describes the use of the MiCS sensors and the way to set-up the load resistance for measurements

MiCS-5521 sensor
TO39 package



MiCS-5524
SMD package

OPERATION PRINCIPLE

MiCS gas sensors need a defined voltage (V_H) to power the heater resistance.

The output signal (Vo) is usually read between the sensitive layer resistance RS and a load resistor. To obtain the best readings it is advised to follow some basic design rules presented here.

MEASUREMENT CIRCUIT

One of the simplest circuits used for powering SGX sensors is the following:

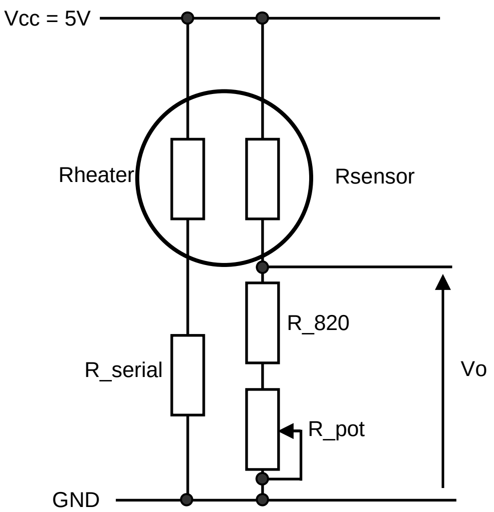


Figure. 1 : Operation cicruit

LOAD RESISTANCE DEFINITION

A resistor R_serial is used to build a voltage divider with the heater resistance (Rheater). The two resistors in series are powered with 5V. The simplest way to measure sensor resistance changes is to add a load resistor to Rsensor and to measure the voltage drop in this resistor when the bridge (Rsensor + Rload) is operated between typically 5V and GND.

The sensing output (Vo) is then measured with an analog output indicator (voltmeter), an AD converter or a microcontroller for example.To perform reliable and long term stable measurements it is necessary to limit the amount of current passing through the sensing layer. This is the reason why it is proposed to use a-two resistors load circuit where a first load resistor of 820 Ohms (R_820) is in serie with a 500kOhms potentiometer (R_pot). R_820 is the minimum value to limit sensor current.

LOAD RESISTANCE ADJUSTMENT

Operate the sensor and monitor output in ambient air (no target gas present in large amount) for one hour.

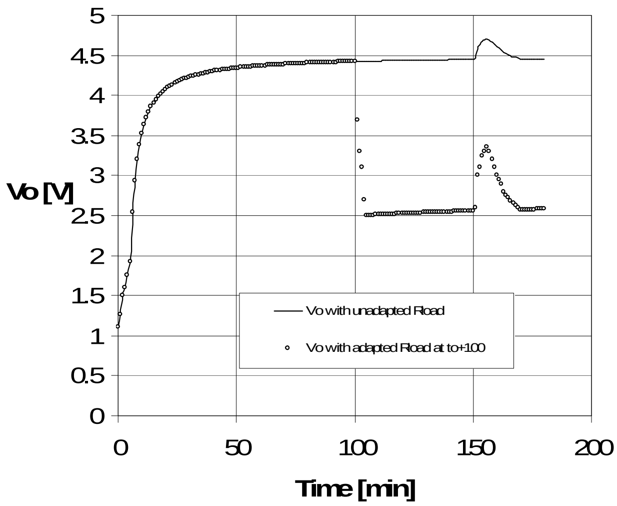


Figure. 2 : Measurement voltage

In this example one can observe that stabilized Vo value is around 4.5V in these test conditions. To obtain the best resolution it is advised to work around the mid-operating range (i.e. Vcc/2 = 2.5V). To adjust Vo at 2.5V, load resistance has to be reduced. This is done by decreasing the resistance value of the potentiometer. This action has been done at time t0+100 min and is shown in the chart.

To know what is the potentiometer value; you can use an ohmmeter or measure the voltage over R_820 (5mV in this example) and calculate the current.
I = V_R_820/R_820 = 0.005/820 = 0.06 mA
R_pot = V_pot/I = (Vcc/2–V_R_820)/I
R_pot = (2.5-0.005)/0.000006 = 408 kOhms

At to +150 min, a pollution event, represented by the opening of a permanent ink pen in the vicinity of the sensor for example, is represented. The increase of Vo is representative of the increase in “gas detected” (drop of sensor resistance value). One can observe that the voltage change is then higher for the signal adjusted at 2.5V baseline than for the one at 4.5V.

	Baseline adjusted around Vcc/2	Baseline at 80%of Vcc	
Vout_0	2.56	4.45	[V]
Vout_event	3.35	4.70	[V]
Delta Vout	0.79	0.25	[V]
Delta Vout/Vout_0	31%	6%	
Rsensor_0	51.6	51.6	[kOhms]
Rsensor_event	26.6	26.6	[kOhms]
∆ Rsensor	-25.0	-25.0	[kOhms]
∆ Rsensor/Rsensor_0	-48%	-48%	

Table 1 : Numeric evaluation

SENSITIVITY CALCULATION

Value of Rsensor is given by:

Rsensor = RLOAD x (Vcc – Vout) / Vout

with Vo = voltage monitored on pin Sensor Out
RLOAD: load resistor (R_pot+R_820)
Vcc = 5.0 [Volts]

Sensitivity can then be calculated as:

S = (Rsensor-Rsensor_0)/Rsensor_0

With:
S: sensitivity to the pollution event
Rsensor_0: resistance value before pollution event (usually called the baseline)
Rsensor: resistance value in presence of pollution event

When using the data from Table 1 one can see that absolute sensitivity is the same for any load resistance (i.e. -48%) but the measurement can be done with much more accuracy when load resistor is adapted to have baseline measurement range around Vcc/2.

If we consider a measure with an 8-bit ADC and Vcc 5V as reference, we can use then 256 measurement steps of 19.53 mV (5V/256).

In the case where baseline is adjusted at 80% of Vcc, the change in measurement is of 0.25V (4.70-4.45). This means 250mV/19.53mV = 12 ADC steps

With baseline adjusted around 50% of Vcc, the change in measurement is of 0.79V (3.35-2.56). This means 790mV/19.53mV = 40 ADC steps

This gain in ADCsteps used for the measurement is an image of the gain in accuracy and detection ability of the measurement circuit. Using bad balanced load resistor may lead to poor sensor measurement according to the pollution level to detect and to bad estimation of how the sensor is able to perform in your application.

MULTI-RANGE CIRCUIT

For final application where gas concentration range generates large resistance changes it is advised to use an auto-setting of the load resistor in order to perform measurement within the optimized voltage zone.

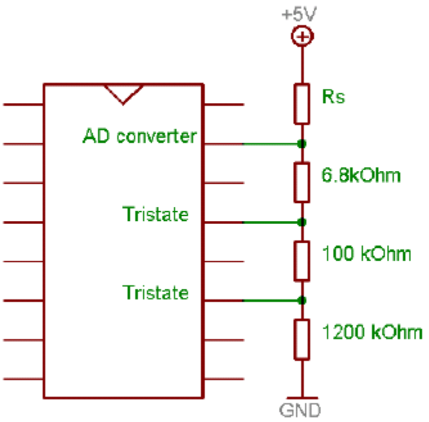


Figure. 3 : Electric circuit for multi-range operation

An application of this setting principle is described in figure 3 with ADC measurement circuit.
To adapt the scale to the resistance range, the microcontroller can switch two or three resistors in series. The number of resistors to be switched varies with the precision of the ADC. With a 10-bit ADC, two switching resistors may be sufficient to cover a range of sensing resistance extending for example from 2kOhms to 1MOhms.

SGX semiconductor gas sensors are well suited for leak detection and applications requiring limited accuracy. Their use for absolute gas concentration detection is more complicated because they typically require temperature compensation, calibration, and sometimes as well, humidity compensation. Their base resistance in clean air and their sensitivity can vary overtime depending on the environment they are in. This effect must be taken into account for any application development. (1104 1.0)

