FIGARO

an ISO9001 company

Application Notes for Combustible Gas Detectors Using TGS68-series Sensors

The TGS68-series gas sensors are unique catalytic-type sensors that have been designed with a unique fail safe concept. This brochure offers important technical advice for designing and manufacturing gas detectors which use Figaro's unique catalytic type sensors TGS6810 and TGS6812.

Page

Introduction..........2

Circuit Design
- **Basic Circuit..........2**
- **Sensor Malfunction..........3**
- **Alarm Prevention during Warmup..........3**
- **Alarm Delay Circuit..........3**

PCB and Housing Design
- **Sensor Position..........3**
- **Housing Design for Quick Response..........4**

Manufacturing Process
- **Handling and Storage of Sensors..........5**
- **PCB Assembly..........5**
- **Sensor Assembly..........5**
- **Pre-heating..........6**
- **Calibration..........6**
- **Final Assembly..........6**
- **Gas Test..........7**
- **Storage of Finished Products..........7**

1. Introduction

The sensor output in target gas of conventional catalytic-type sensors typically decreases over time due to deterioration of their catalyst. In the worst case, gas detectors using these sensors may not alarm despite the existence of gas leaks.

Figaro catalytic type sensors are designed so that their output in target gas will increase over time after slight decrease during the initial stage (*see Fig. 1*). This is accomplished by using different material and bead size between the detector and compensator elements. In addition, with catalyst deposited deep inside the detector element, these sensors have superior durability against poisoning gases such as silicone vapors and corrosive gases (such as SO_2) compared to conventional sensors. Furthermore, by using Figaro's self-developed internal filter, these sensors have no significant sensitivity to interference gases such as alcohol.

This brochure offers important technical advice for designing and manufacturing gas detectors which use Figaro's unique catalytic type sensor.

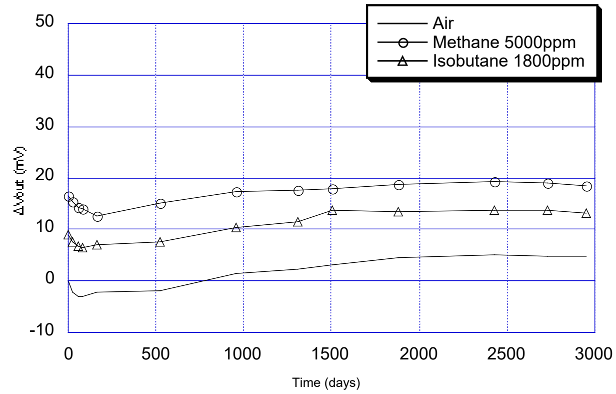

Figure 1 - TGS6810 long term stability

2. Circuit Design

2-1 *Basic circuit*
The TGS68xx series sensors are comprised of two elements:

1) detector element (D) - sensitive to combustible gases
2) compensator element (C) - not sensitive to combustible gases

These elements are installed into a "Wheatstone Bridge" as shown in Figure 2.

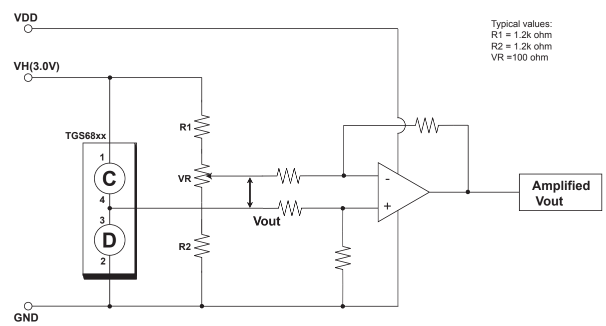

Figure 2 - Basic circuit

A variable resistor should be adjusted so that the bridge will produce a stable baseline signal when in an environment free of combustible gases (i.e. Vout=0). When combustible gases are present, they will be combusted on the detecting element, causing its temperature to rise. Accordingly the resistance of this element will increase. This results in an "out-of-balance" signal across the bridge (i.e. Vout ≠ 0) and produces a corresponding change in output voltage which can be measured.

Since the absolute value of Vout is small in the presence of gas, a differential amplifier circuit with an Op-Amp should be utilized to increase signal resolution. Amplification gain should be chosen depending on the maximum allowable voltage of the user's circuit.

Since the sensor has a compensator element inside, it is not necessary to make a peripheral temperature compensation circuit under operating temperature. In addition, since the sensor has no significant humidity dependency, it is not necessary to compensate for humidity in the circuit.

Values of R1, R2 and VR should be set taking into consideration the initial range of offset voltage (i.e the tolerance of Vout in clean air) and ±5mV of long term offset voltage change. The recommended values of R1, R2 and VR are 1.2kΩ, 1.2kΩ and 100Ω, respectively.

2-2 *Sensor malfunction*
When wire breakage or a short circuit occurs in the sensor, Vout will be equal to GND or VDD. The threshold for a malfunction signal (GND output) should be set considering the ±5mV variation in offset voltage. In the circuit shown in Figure 2, trouble detection is set to activate when Vout ≤ 0.2V.

2-3 *Alarm prevention during warm-up*
As described in Sec. 2-6 of *Technical Information for TGS6810/6812*, when energizing the sensor after an unpowered period, sensor output increases sharply, regardless of the presence of gases, before reaching to a stable level. This 'initial action' may cause activation of an alarm during the first few moments of energizing since ΔVout would exceed the alarm threshold. It is recommended to wait for 30sec. or longer until Vout ≤ 2V for residential applications.

2-4 *Alarm delay circuit*
The sensor has an internal filter to eliminate the influence of interference gases. As a result, it is not necessary to implement an alarm delay circuit.

3. PCB and Housing Design

3-1 *Sensor position dependency*
The sensor has position dependency. Figure 3-1 shows sensor output change at different orientations. Sensor **A** is laid horizontally and then rotated by 45 degrees in sequence. Since there are two heated elements, when the thermal balance between the elements is changed, sensor output will be changed. At position G (when the detector element is above compensator element), sensor output will be at its maximum, while at position C (when compensator element is above the detector element), sensor output will be at its minimum. The difference between maximum and minimum is about 3.5mV in 5,000ppm of methane.

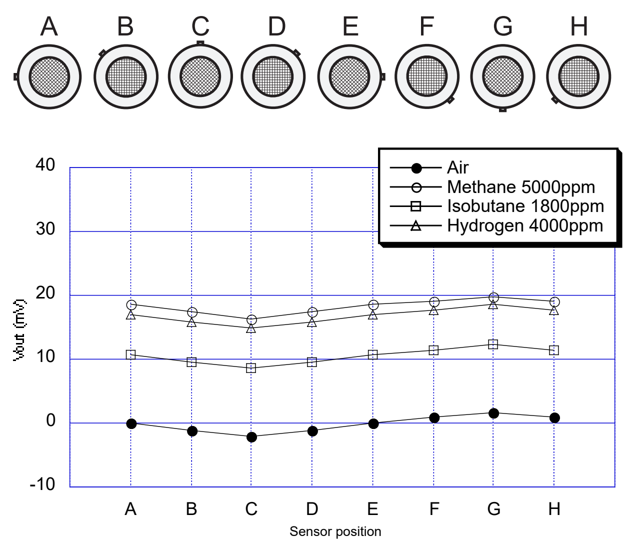

Figure 3-1 - Sensor position dependency (horizontal placement)

When internal temperature is changed, sensor output will be changed. Figure 3-2 shows sensor output change at diffirent orientations. Sensor **a** is positioned vertically. The sensor position is rotated clockwise by 45 degrees in sequence. At positions c and g (when the sensor is positioned horizontally), which is the optimal heat dissipation position, sensor output will be maximum. At position e (when the sensor is upside down), which is the worst heat dissipation position, sensor output will be minimum. The difference between maximum and minimum is about 3mV.

Based on the above information, it is recommended to perform calibration (*see Sec. 4-4*) with the sensor oriented in the same position as will be in when the detector is in use.

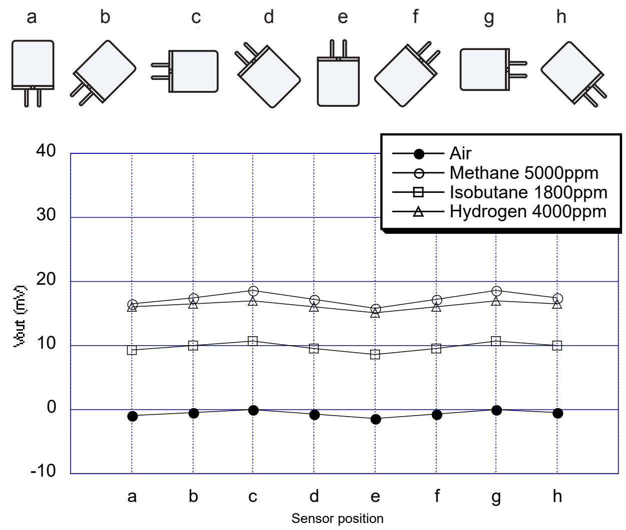

Figure 3-2 - Sensor position dependency (vertical placement)

3-2 *Housing design for quick response*
The case should have a small partition around the sensor (*refer to Figure 4-1*). Such a compartment promotes quick sensor response via convection and minimizes influence on the sensor from high temperatures which may be generated by other components within the detector. A sufficient number of wide slits should be made in at least two sides of the detector housing to facilitate gas flow around the sensor (*refer to Figure 4-2*).

The case should be designed so that heat dissipation from the case is maximized.

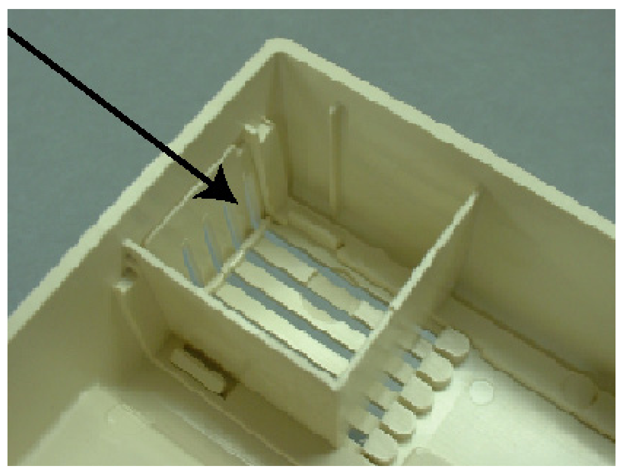
Figure 4-1 - Example sensor compartment in detector housing

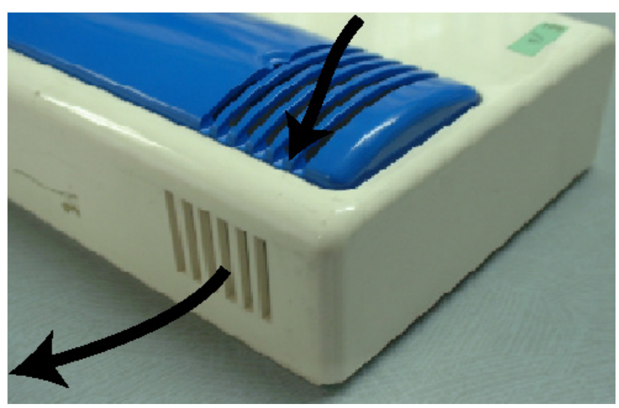
Figure 4-2 - Example of slits in detector housing to facilitate airflow through sensor compartment

4. Manufacturing Process Flowchart (Figure 5)

4-1 *Handling and storage of sensors*
The sensor should be stored in a sealed bag containing clean air--do not use silica gel.

4-2 *PCB assembly*
Flux should be sufficiently dried before sensors are assembled onto the PCB to avoid any contamination of the sensor by flux vapors.

4-3 *Sensor assembly*
The recommended conditions for manual soldering are:

Temp of soldering copper head: 390˚C
Period: < 3 sec.

Although wave soldering may be done, a test should be conducted prior to the start of production to determine if there would be any influence to sensor characteristics.

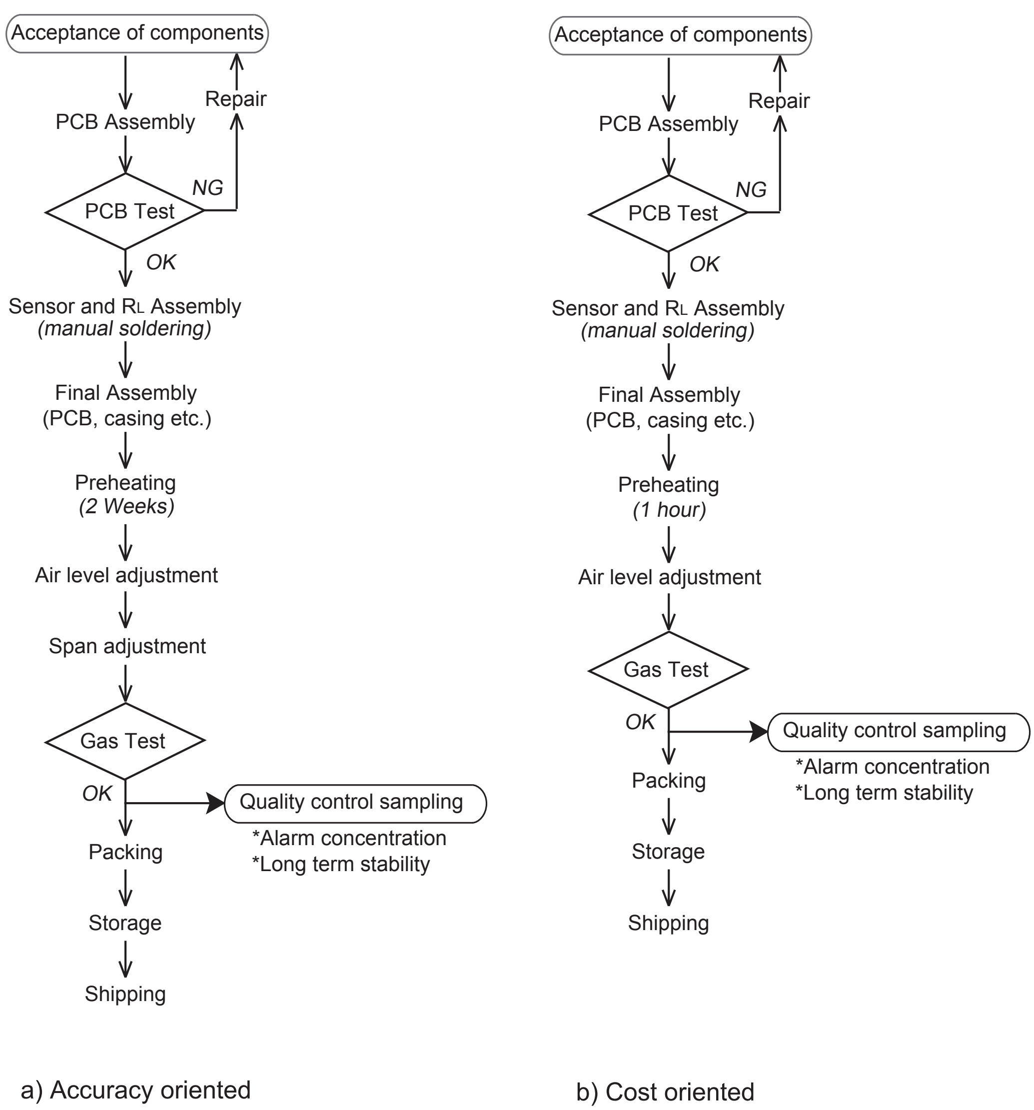

Figure 5 - Manufacturing process flowchart

4-4 *Pre-heating*
Figure 6 shows sensor output change after storage for one month. A 2-week preheating period is recommended for an accuracy oriented application in order to stabilize sensor output perfectly. However, for cost oriented applications, one hour of preheating may be an option if estimated sensor output change occurring during the first 2 weeks after such preheating can be compensated.

4-5 *Calibration*
For accuracy oriented applications, it is recommended to perform calibration in both clean air and the target gas. For cost oriented applications, calibration in clean air may be an option if span adjustment can be done by using typical sensitivity characteristics. See *Technical information on TGS6810/6812* for typical gas sensitivity characteristics.

When calibrating in gas, inject gas into the test chamber, activate a fan to mix the gas evenly, and read sensor output after confirming that the sensor output is stable.

For customers who would like to skip the calibration process, use of the CGM6812-B00 pre-calibrated module is recommended.

The recommended procedure for making a target gas concentration is batch type calibration. Gas should be injected into the test chamber to mix the target concentration. Calibration by exposing gas directly from a cylinder onto the sensor is not recommended for the following reasons:

- the sensor is influenced by air flow
- the sensor will not react to combustible gases not balanced with oxygen

Since long term sensor characteristics are different according to each target gas, it is recommended to change the alarm set level for each target gas. Please refer to Tables 1 and 2.

4-6 *Final assembly*
Avoid any shock or vibration which may be caused by air driven tools. This may cause breakage of the sensor's lead wires or other

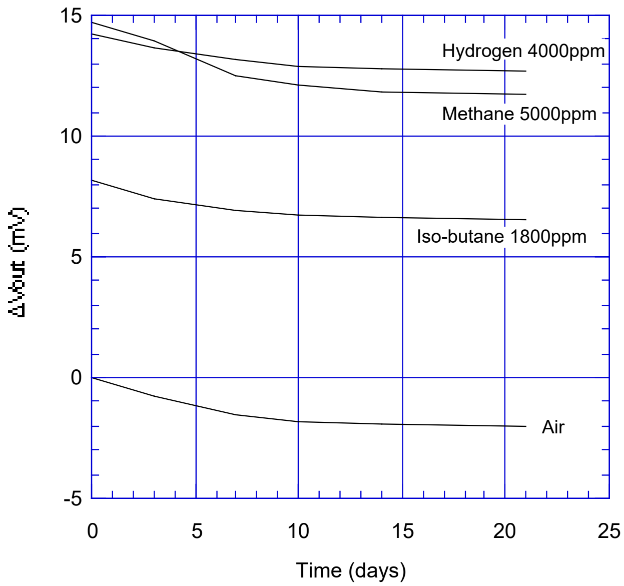

Figure 6 - Influence of storage

	Detector Life	
	5 years	10 years
Methane	6% LEL (*1)	6% LEL (*1)
Isobutane/Propane	8% LEL	10% LEL
Hydrogen	10% LEL	12% LEL

Table 1 - Recommended alarm set point

*1Recommended declared value for EN50194 is 8% LEL considering the required accuracy of the standard--*see Table 2*

	CEI EN50194	UL1484
Overall range	3 ~ 20%LEL	<25%LEL
Required accuracy	within ±3%LEL of declared value for Test A	Upper limit (U) U=(25%LEL+I)/2 where I = initial threshold
	within ±6%LEL of declared value for Test B	

Table 2 - Technical requirements of EN50194 and UL1484 for residential gas detectors

Test A: 5.3.4.1 Presset level and 5.3.12 slow increase of gas volume ratio
Test B: All tests other than Test A

physical damage to the sensor.

4-7 *Gas test*

Test all finished products in the target gas under normal operating conditions. Keep the atmospheric conditions in the chamber stable, utilizing a user-defined standard test condition which is based on applicable performance standards and on anticipated usage for detectors. Remove any traces of smoke, adhesives, gases, or solvents from the chamber. Do NOT use nitrogen balanced gas. Oxygen molecules are required for the oxidation reaction of the sensor with gas. ***NOTE*: Without testing after final assembly, detectors have no guarantee of accuracy or reliability.**

4-8 *Storage of finished products*

Detectors should be stored in a clean air environment at room temperature. Avoid storage in dirty or contaminated environments. The environment should be clean and free from organic vapors such as alcohol. Special attention should be paid to the environment around the preheating facility for sensors/detectors—keep these areas free from influencing gases, especially silicone vapors. If volatile cleaners such as trichloroethylene, freons, or floor sealants are to be used, all gas detection products should be removed from the area to be treated and not returned until the area has been thoroughly ventilated.

FIGARO ENGINEERING INC.
1-5-11 Senba-nishi
Mino, Osaka 562-8505 JAPAN
Phone: (81)-727-28-2045
URL: **www.figaro.co.jp/en/**