

**FIGARO**

an ISO9001 company

**Application Notes for Methane Gas Detectors using TGS2611-E00**

The TGS2611-E00 methane gas sensor has been presorted into groupings which will allow users to simplify the manufacturing process for methane gas detectors. This brochure offers example application circuits and important technical advice for designing and manufacturing gas detectors which use classified TGS2611-E00 sensors.



	<u>Page</u>
<i>Introduction</i> .....	2
<i>Detector Circuit Design</i>	
Basic Circuit with Temperature Compensation.....	2
Selecting a Load Resistor.....	2
Compensation for Internally Generated Heat.....	3
Heater Breakage Detection Circuit.....	3
Sensor Malfunction Detection Circuit.....	3
Prevention of Intermittent Alarming.....	4
Alarm Prevention during Warmup.....	4
Alarm Delay Circuit.....	5
Application Circuit.....	5
<i>Manufacturing Process</i>	
Handling and Storage of Sensors.....	5
RL Selection.....	5
PCB Assembly.....	5
Sensor Assembly.....	5
Final Assembly.....	6
Preheating of Final Assembly.....	6
Gas Test.....	6
Storage of Finished Products.....	6
<i>Anticipated Performance at 10%LEL of Methane</i> .....	6
<i>Pre-calibrated Sensor Module</i> .....	7
<i>Appendix</i> .....	8

See also Technical Brochure 'Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors'.

**IMPORTANT NOTE:** OPERATING CONDITIONS IN WHICH FIGARO SENSORS ARE USED WILL VARY WITH EACH CUSTOMER'S SPECIFIC APPLICATIONS. FIGARO STRONGLY RECOMMENDS CONSULTING OUR TECHNICAL STAFF BEFORE DEPLOYING FIGARO SENSORS IN YOUR APPLICATION AND, IN PARTICULAR, WHEN CUSTOMER'S TARGET GASES ARE NOT LISTED HEREIN. FIGARO CANNOT ASSUME ANY RESPONSIBILITY FOR ANY USE OF ITS SENSORS IN A PRODUCT OR APPLICATION FOR WHICH SENSOR HAS NOT BEEN SPECIFICALLY TESTED BY FIGARO.



TGS2611-E00 is a UL recognized component in accordance with the requirements of UL2075. Please note that component recognition testing has confirmed long term stability in 60ppm of methane; other characteristics shown in this brochure have not been confirmed by UL as part of component recognition.

To facilitate ease in manufacturing gas detectors, TGS2611-E00 methane gas sensors are individually marked with an ID number (see Figure 1) indicating a factory presorted classification which corresponds to narrow ranges of sensor resistance in methane. When the sensor's ID number is properly used, the calibration process can be greatly simplified, eliminating long preconditioning time and the complicated handling of calibration gas.

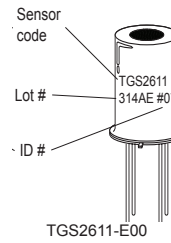


Fig. 1 - Sensor markings

## 1. Detector Circuit Design

### 1-1 Basic circuit with temperature compensation

Figure 2 shows an example of a basic circuit for gas detection, including temperature compensation for variations caused by ambient temperature fluctuations. Typical values for the circuit components are as follows:

- $R_L$  : refer to Table 1
- $R_{TH}$  :  $4.7k\Omega$  ( $\pm 3\%$ ),  $B=3977$  ( $\pm 5\%$ )
- $R_A$  :  $11.5k\Omega$  ( $\pm 1\%$ )
- $R_B$  :  $4.32k\Omega$  ( $\pm 1\%$ )
- $R_C$  :  $8.25k\Omega$  ( $\pm 1\%$ )

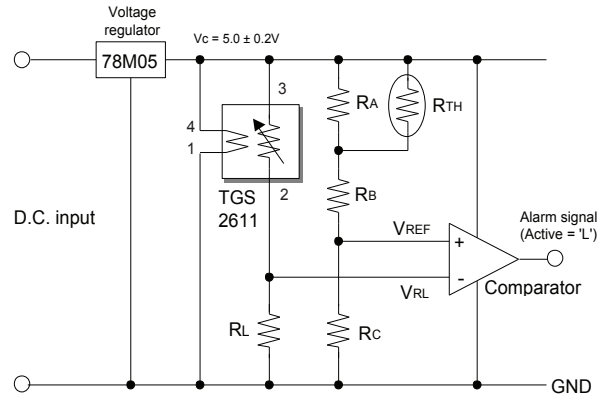


Fig. 2 - Basic circuit with temperature compensation

The values for components related to temperature compensation should be chosen so that  $V_{ref}$  is one-half of the  $V_c$  value at standard temperature ( $20^\circ\text{C}$ ). The  $V_{ref}$  curve should approximate the temperature dependency curve of the  $V_{RL}$  when compensation is properly done.

### 1-2 Selecting a load resistor ( $R_L$ )

To optimize resolution of the output signal at the desired alarming concentration, it is necessary to adjust the resistance of the load resistor ( $R_L$ ). It is recommended that  $R_L$  be selected at a value which is equal to the sensor's resistance ( $R_s$ ) at the alarming concentration (i.e.  $R_s/R_L = 1.0$ ). Please refer to the brochure "General Information for TGS Sensors" for more details.

Since the ID number corresponding to sensor resistance in methane gas is indicated on the sensor cap, the load resistor value can be selected according to Table 1. For example, for an alarm setting at 10% LEL, when using a sensor having an ID number of 7, the  $R_L$  value should be set at  $1.27k\Omega$ . By using the recommended  $R_L$ , the  $V_{RL}$  value at the alarming point typically will be  $2.5V$ , which is equal to half of the circuit voltage ( $V_c$ ).

Sensor ID#	RL with $\pm 1\%$ tolerance			
	5% LEL	10% LEL	15% LEL	20% LEL
03	1.21	0.866	0.715	0.619
04	1.33	0.953	0.787	0.682
05	1.47	1.05	0.866	0.750
06	1.62	1.16	0.953	0.826
07	1.78	1.27	1.05	0.909
08	1.96	1.40	1.15	1.00
09	2.15	1.54	1.27	1.10
10	2.37	1.70	1.40	1.21
11	2.61	1.87	1.54	1.33
12	2.87	2.05	1.70	1.47
13	3.16	2.26	1.87	1.62
14	3.48	2.49	2.05	1.78
15	3.83	2.74	2.26	1.96
16	4.22	3.02	2.49	2.16
17	4.64	3.32	2.74	2.37
18	5.11	3.65	3.01	2.61
19	5.62	4.02	3.32	2.88
20	6.19	4.43	3.65	3.16
21	6.81	4.87	4.02	3.48
22	7.50	5.36	4.42	3.83
23	8.25	5.90	4.87	4.22
24	9.09	6.50	5.36	4.65
25	10.0	7.15	5.90	5.11
26	11.0	7.87	6.49	5.63

Table 1 - Recommended  $R_L$  by sensor ID

Note: Lower explosion limit (LEL) of methane = 50,000ppm

1-3 Compensation for internally generated heat

Depending on the design of the case and the PCB, there is often a difference between the temperature near the thermistor's placement in the detector and the ambient temperature. Therefore it is recommended to measure the actual temperature difference between the inside and the outside of the detector and select the value of  $R_C$  according to Table 2. When  $R_C$  is selected in this manner and used in the basic circuit (Figure 2), the result would be that  $V_{ref} = 1/2 V_c$ .

$\Delta T$ (°C)	$R_C$ (k $\Omega$ )
0	8.25
5	7.68
10	7.15
15	6.65
20	6.34

$\Delta T = (\text{temp near thermistor}) - (\text{temp outside detector})$

Table 2 - Effect on selection of  $R_C$  by temperature differential inside and outside of detector

1-4 Heater breakage detection circuit

Figure 3 shows an example of how breakage of the sensor's heater wire and/or heater element can be detected. By adding  $R_E$  (3.57 $\Omega \pm 1\%$ ) into the circuit and monitoring  $V_{RE}$ , a malfunction can be considered to have occurred when  $V_{RE}$  (0.2V typ.) drops to near 0V. Please note that a circuit voltage ( $V_c$ ) of 5.2V should be applied to a circuit which incorporates a heater malfunction detection circuit.

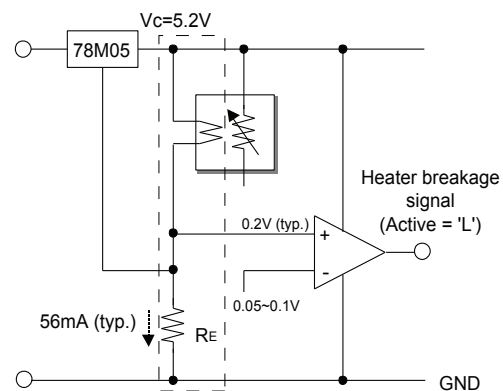


Figure 3 - Heater breakage detection circuit ( $R_E = 3.57\Omega \pm 1\%$ )

1-5 Sensor malfunction detection circuit

Breakage of lead wires to the sensor's electrodes and/or sensor element can be detected by using a circuit such as that shown in Figure 4. This involves replacing  $R_C$  with  $R_{C1}$  and  $R_{C2}$ , selecting their values so that  $R_{C1}/R_{C2} \approx 35$ . Since  $V_{RL}$  is normally greater than 70mV in any atmospheric conditions, by comparing  $V_{RL}$  to a reference voltage of 70mV, breakage of the lead wires and/or sensor element can be considered to have occurred if  $V_{RL}$  drops below 70mV.

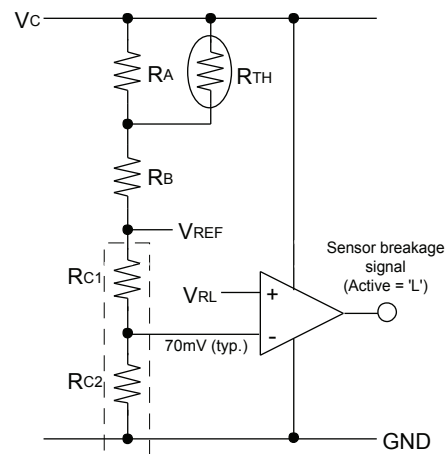


Figure 4 - Sensor malfunction detection circuit ( $R_{C1}/R_{C2} \approx 35$ )

1-6 Prevention of intermittent alarming

When gas concentration fluctuates right at the alarming threshold, dropping just below and rising just above, the detector would intermittently alarm in short bursts. In order to prevent the nuisance of intermittent alarming, a circuit such as that shown in Figure 5 can be used. By adding  $R_D$  to the original circuit, a Schmidt trigger circuit which includes a comparator can be created (the value of  $R_D$  should be set at 20-30 times that of  $R_C$ ). As a result, a range for the alarming threshold is created. An alarm is then generated when the upper range of the threshold is breached and the alarm signal would cease after the signal drops below the lower end of the threshold range, thus eliminating frequent intermittent alarming.

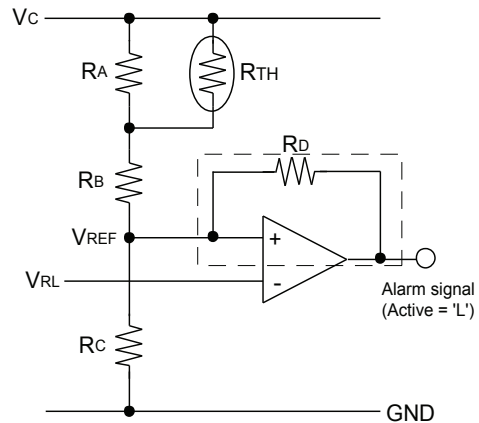


Figure 5 - Circuit for prevention of intermittent alarming ( $R_D/R_C = 20\sim30$ )

1-7 Alarm prevention during warm-up

As described in Sec. 2-5 of "Technical Information for TGS2611", when energizing the sensor after an unpowered period, the sensor's resistance ( $R_s$ ) drops sharply for the first few seconds after energizing, regardless of the presence of gases, before recovering to a stable level. This 'initial action' may cause activation of an alarm during the first few moments of energizing since  $V_{RL}$  would exceed  $V_{ref}$ . To prevent this from happening, a circuit modification such as that shown in Figure 6 may be used. After powering the detector, sensor output ( $V_{RL}$ ) should be set to zero for a pre-determined period (2.5 minutes is recommended--the timer function should be created by selecting the proper combination of  $C_3$  and  $R_{11}$ ). In order to restrict current to the sensor during this period, the recommended value of  $R_F$  should exceed  $5k\Omega$ .

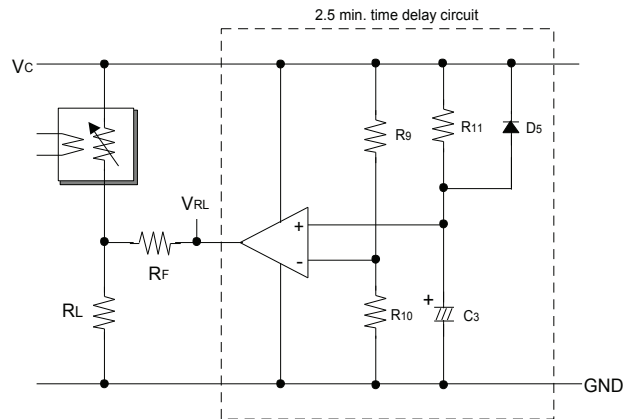


Figure 6 - Circuit for alarm prevention during warmup ( $R_F > 5k\Omega$ )

1-8 Alarm delay circuit

To prevent false alarms caused by transient interference gases such as alcohol in cooking vapors, a delay circuit modification such as that shown in Figure 7 can be used. The alarm signal generated by this circuit should be connected to the comparator in the basic circuit (see Figure 1). The recommended timer period for alarm delay is 15 seconds--the timer function should be created by selecting the proper combination of C4 and R15.

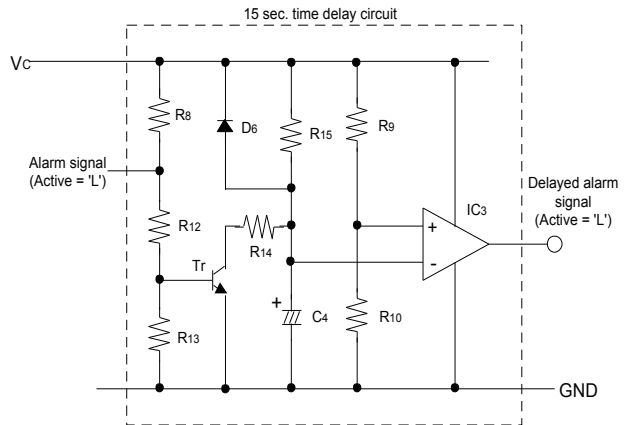


Figure 7 - Alarm delay circuit

1-9 Application circuit

An application circuit which incorporates all of the advice included in Secs. 1-1 through 1-8 can be seen in Appendix 1.

2. Manufacturing Process (see Fig. 8)

2-1 Handling and storage of sensors

Prior to usage, sensors should be stored at room temperature in a sealed bag containing normal clean air. During manufacturing, sensors should be handled in a clean air environment and at room temperature. Clean air refers to air free of contaminants, excessive dust, solvent vapors, etc. Room temperature should be 20~25°C.

2-2 RL selection

Choose the proper resistor for RL by referring to the ID number of the sensor and Table 1.

2-3 PCB assembly

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

2-4 Sensor assembly

Manual soldering of the sensor to the PCB is strongly advised. Solders composed of Sn63:Pb37 or Sn60:Pb40 with non-chloric resin flux (MIL: RMA Grade; for example, Almit KR-19) are recommended for usage.

2-5 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 physical damage to the sensor.

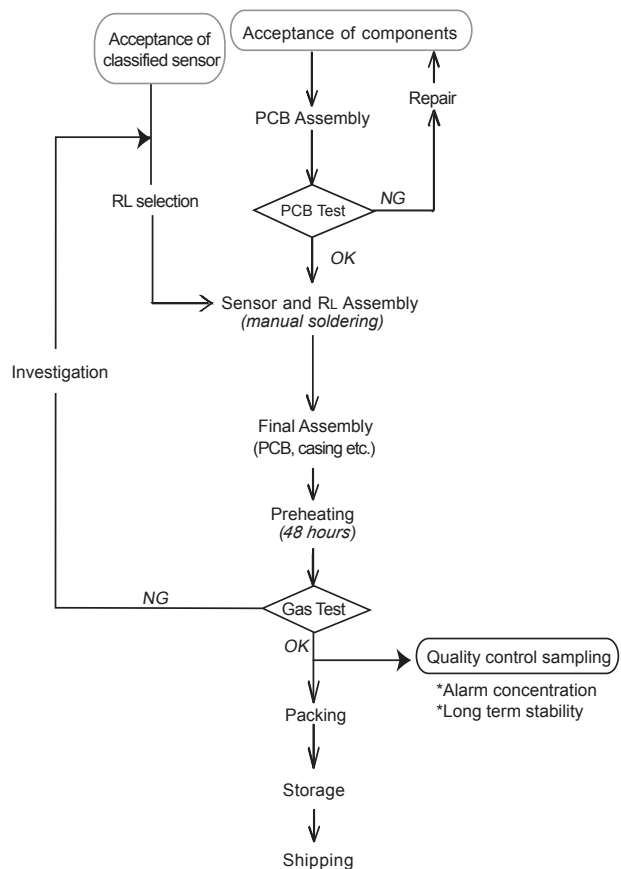


Figure 8 - Manufacturing process flowchart

2-6 Preheating of final assembly

To stabilize the detector assembly before gas testing, the minimum period for preheating final assemblies should be 48 hours at room temperature (20~25°C). Be certain to maintain clean atmospheric conditions for preheating.

2-7 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. **NOTE: Without testing after final assembly, detectors have no guarantee of accuracy or reliability.**

2-8 Storage of finished products

Detectors should be stored in a clean air environment at room temperature. Avoid storage in dirty or contaminated environments. Cautions listed in Sec. 6-1.3 of "General Information for TGS Sensors" should also be observed.

3. Anticipated Performance at 10%LEL of Methane

When using the classified TGS2611 with Figaro's recommended RL for 10%LEL (Table 1) and temperature compensated circuit design (Figure 2), typical alarm tolerances for 10%LEL of methane such as those shown in Figure 9 are expected. Each RL classification contains a range of tolerance as exemplified by the alarming range labelled as 'standard conditions' (i.e. these conditions are well-controlled). When factoring in the additional effects of environmental extremes and the allowable variation in circuit conditions, the resulting alarming range would be typified by the range labelled as 'operating conditions'. However, in actual usage, alarm thresholds may vary since the threshold is also affected by factors such as the tolerances of the thermistor and/or other components, load resistor value, test conditions, and heat generation inside the detector enclosure. As a result, Figaro neither expressly nor impliedly

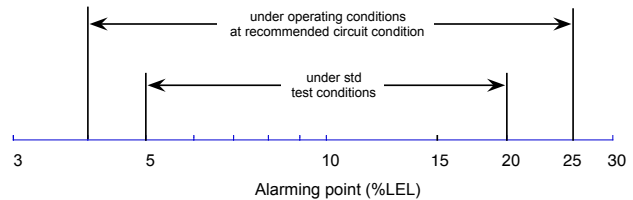


Figure 9 - Expected performance of methane detectors with classified TGS2611 & recommended RL for 10% LEL (refer to Table 3 for test conditions)

Temperature and humidity	Standard conditions	20±2°C, 65±5%RH
	Operating conditions	-10~40°C, 30~95%RH
Circuit conditions	Standard conditions	V <sub>c</sub> =5.0±0.01V DC V <sub>H</sub> =5.0±0.05V DC
	Operating conditions	V <sub>c</sub> =5.0±0.2V DC V <sub>H</sub> =5.0±0.2V DC
Conditioning prior to test		≥48 hours

Table 3 - Test conditions for measuring performance of methane detectors as shown in Figure 9

warrants the performance shown in Figure 9. If a large difference between the expected and actual performance of detectors is noticed, please consult with Figaro.

**Pre-calibrated sensor module**

Figaro has available a pre-calibrated methane sensor module NGM2611 (see Fig. 10). This module includes the classified TGS2611 sensor, a matched load resistor, and a factory preset temperature compensation circuit, all on a small PC board. The NGM2611 module is calibrated for a typical set point at 10% LEL, achieving performance as indicated in Figure 9 by simply plugging it into a main PC board. Please refer to the brochure "Product Information for NGM2611" for detailed information.

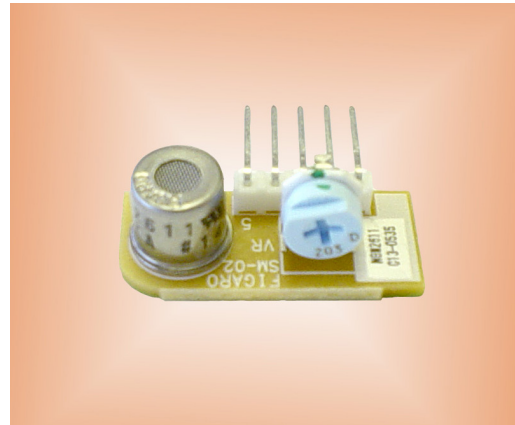


Figure 10 - Pre-calibrated sensor module NGM2611

**Important Reminder**

*Without testing alarm threshold after final assembly, detectors have no accuracy or reliability guarantee.*

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**HEAD OFFICE**

**Figaro Engineering Inc.**

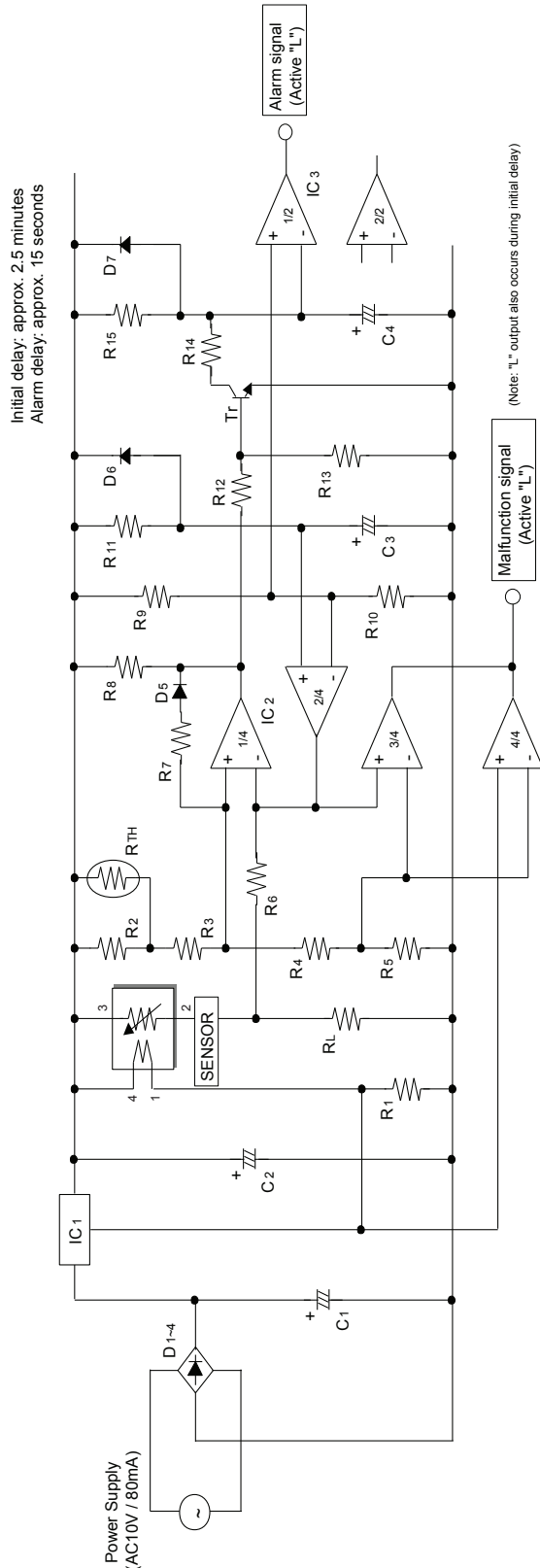
1-5-11 Senba-nishi  
Mino, Osaka 562-8505 JAPAN  
Tel.: (81) 72-728-2561  
Fax: (81) 72-728-0467  
email: figaro@figaro.co.jp

**OVERSEAS**

**Figaro USA Inc.**

121 S. Wilke Rd. Suite 300  
Arlington Heights, IL 60005 USA  
Tel.: (1) 847-832-1701  
Fax.: (1) 847-832-1705  
email: figarousa@figarosensor.com

**Appendix 1 - Example application circuit for gas detector using classified TGS2611**



Part No.	Part name	Model No./ Specification	Maker	Part No.	Part name	Model No./ Specification	Maker	Part No.	Part name	Model No./ Specification	Maker
Sensor	Gas sensor	TGS2610	Figaro	R9	Resistor	10kΩ, 5%, 1/8W		D1	Rectification diode	SS566G	Toshiba
RTH	NTC thermistor	4.7Ω, B=3977	Philips	R10	Resistor	10kΩ, 5%, 1/8W		D2	Rectification diode	SS566G	Toshiba
RL	Resistor	(See Table 1), 1%, 1/8W		R11	Resistor	470kΩ, 5%, 1/8W		D3	Rectification diode	SS566G	Toshiba
R1	Resistor	3.57Ω, 1%, 1/2W		R12	Resistor	10kΩ, 5%, 1/8W		D4	Rectification diode	SS566G	Toshiba
R2	Resistor	11.5kΩ, 1%, 1/8W		R13	Resistor	10kΩ, 5%, 1/8W		D5	Small signal diode	1S1588	Toshiba
R3	Resistor	4.32kΩ, 1%, 1/8W		R14	Resistor	1kΩ, 5%, 1/8W		D6	Small signal diode	1S1588	Toshiba
R4	Resistor	7.87kΩ, 1%, 1/8W		R15	Resistor	470kΩ, 5%, 1/8W		D7	Small signal diode	1S1588	Toshiba
R5	Resistor	226Ω, 1%, 1/8W		C1	Electrolytic capacitor	470μF/25V	Mitsubishi	Tr	NPN transistor	2SC2603	Mitsubishi
R6	Resistor	10kΩ, 5%, 1/8W		C2	Electrolytic capacitor	10μF/10V	Motorola	IC1	Voltage regulator	MC78M05CT	Motorola
R7	Resistor	200kΩ, 5%, 1/8W		C3	Electrolytic capacitor	470μF/10V, 10%	Motorola	IC2	Comparator	LM339	Motorola
R8	Resistor	10kΩ, 5%, 1/8W		C4	Electrolytic capacitor	470μF/10V, 10%	Motorola	IC3	Comparator	LM393	Motorola