GENERAL CHARACTERISTICS

...TGS #813 is a general purpose Sensor which has good sensitivity characteristics to a wide range of gases.

...TGS ß813 is designed to operate with a stabilized 5V heater supply and a circuit voltage not exceeding 24V.

. ..The most suitable application for the TGS #813 is the detection of methane, propane and butane which makes it an excellent Sensor for domestic gas leak detectors.

. ..The initial stabilization time of the TGS 8813 is very short and the relative and elapsed characteristics are very good over a long period of Operation.

...TGS #813 has a very low sensitivity to 'noise-gases' which considerably reduces the Problem of nuisance alarming.

The TGS 8813 is most practically employed in a circuit design which maintains circuit voltages at fixed values under 24V (Ex. 5,6,12, or 24V are suitable) and with the heater voltage stabilized at 5V.

These voltage ratings are very practical when determining your design specifications because of the wide range of available components. This makes the use of the TGS #813 an especially econimical way to design low-tost, highly reliable gas detection circuits.

Because of its especially high sensitivity to methane, propane and butane, the TGS #813 is very practical for Town Gas and LPG monitoring. With the added features of a short-initial stabilization period and highly reliable elapsed characteristics, the TGS #813 represents a new generation of gas Sensors from Figaro.

1. Structure and Configuration of the TGS #813

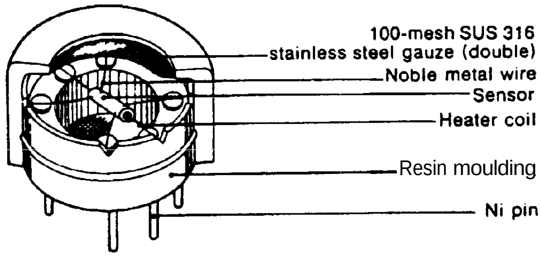


FIG.1. TGS #813 CONFIGURATION.

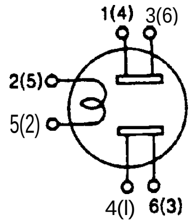


FIG.2. TGS #813 DIAGRAM OF THE ELECTRIC CIRCUIT.

- Remarks:
  Pins numbered 1 and 3 are connected internally.
  Pins numbered 4 and 6 are connected internally.

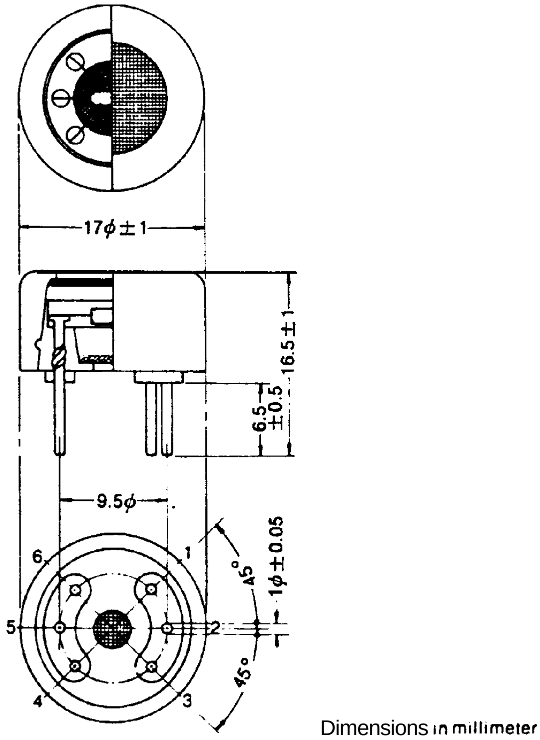


FIG.3. TGS #813 STRUCTURAL SPECIFICATIONS.

Figs.1 & 3 show the structure and configuration of the TGS #813 Sensor.

The TGS #813 is a sintered bulk semiconductor composed mainly of tio dioxide (SnO_2). The semiconductor material and electrodes are deposited on a ceramic tubular former.

The heater coil is located inside the ceramic former. This coil, made of 60 micron diameter wire, has a resistance of 30Ω.

The lead wires from the Sensor electrodes are a gold alloy of 80 micron diameter. The heater and lead wires are spotwelded to the Sensor pins which are arranged to fit a 7 pin miniature tube socket. The pins can withstand a withdrawal force in excess of 5Kg.

The Sensor base and cover are made of nylon 66 conforming to UL 94HB Authorized Material Standard. The deformation temperature for this material is in excess of 240°C.

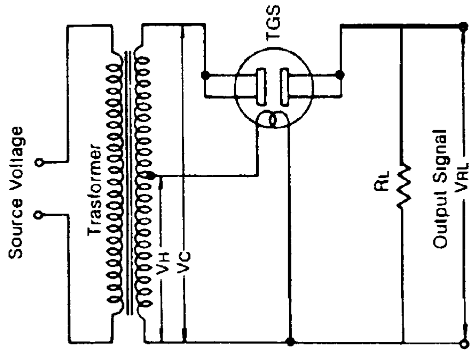
The upper and lower openings in the Sensor case are covered with a flameproof double layer of 100 mesh stainless steel gauze conforming to SUS 316. Independent tests confirm that this mesh will prevent a spark produced inside the flameproof cover from igniting an explosive 2 : 1 mixture of hydrogen/oxygen.

The type 8813 Sensor meets the mechanical requirements listed in Table 1.

TABLE 1 VIBRATION AND SHOCK TEST

1. VIBRATION TEST		2. SHOCK TEST	
◆ **Conditions:**		◆ **Conditions:**	
Frequency	1 000cpm	Acceleration	100G.
Total amplitudes	4mm	Number of tests	5
Duration	1hr.		
Direction of Vibration	Vertical		

2. Basic Measuring Circuit



Vc : Circuit Voltage
VH : Heater Voltage
RL : Load Resistance

FIG. 4. BASIC MEASURING **CIRCUIT** WITH TGS SENSOR.

Fig.4 shows the basic test circuit for use with sensor type #813. The Variation in resistance of the TGS sensor is measured indirectly as a change in voltage appearing across the load resistor RL. In fresh air the current passing through the sensor and RL in series is steady, but when a combustible gas such as propane, methaoe etc. comes in contact with the sensor surface, the sensor resistance decreases in accordance with the gas concentration present. The voltage change across RL is the same when VC and VH are supplied from AC or DC sources. The circuit must conform to the values listed in Table II.

We feel that this circuit is most suitable for evaluating the TGS #813 performance because of the ease in measuring the output signal. However, when measuring the output signal (VRL) of this circuit we suggest that you convert this value into RS (Sensor resistance) by means of the following formula:

$$R_S = \frac{V_C \times RL}{V_{RL}} - RL$$

Zn this way, the other data in this brochure will be readily available for your use and your test results will be standardized in-line with other engioeering data available from FIGARO concerning TGS #813 Performance.

3. Circuit Configurations

Table II lists the safe operating area for type ß813 Sensor. The values of V_C, V_H and PS cannot be exceeded. Subject to a maximum sensor dissipation of 15 mW, the values of VC and R_L can be chosen to meet design requirements. In practice VC can be 5,6,12 or 24 volts, and be supplied from a hattery or A.C. Source.

When using the basic circuit PS (Sensor power dissipation) becomes maximum when RS = R_L. We strongly recommend that the value of PS be kept under 15 mW. Therefore you must carefully decide VC and R_L values so that the maximum PS value will not be exceeded.

TABLE 11 AREA OF SAFE OPERATION

◆ SENSOR POWER DISSIPATION (Ps)	Max. 15mW
◆ CIRCUIT VOLTAGE (Vc)	Max. 24V
◆ HEATER VOLTAGE (V_H)	5.0V±0.2V

4. STANDARD TEST CONDITIONS AND SENSOR SPECIFICATIONS

Table III Standard Test Conditions

1. Atmospheric Condition

   Fresh air with 20°C ± 2°C and R.H.

   65% ± 5%

2. Circuit Condition:

   Basic measuring circuit

   V_C : 10V ± 0.1V, V_H : 5.00V ± 0.05V, R_L :4.0K - OHM ± 1%

3. Conditioning Time:

   7 days or more

4. Test Gas:

   Methane Gas

The Standard conditions under which the TGS #813 should be tested are illustrated in Table III. We must stress the importance of adhering to these conditions for several reasons. For example, if the sensor is tested or evaluated in very humid or dirty air, or if the heater voltage value is not maintained precisely, then proper evaluation of actual sensor characteristics can not be achieved and the accuracy that you require in your detectors will not occur. We also suggest that you follow these guidelines in order that the data you receive from your testing will be in-line with the engineering data available from FIGARO.

TABLE IV SENSOR PERFORMANCE

HEATER RESISTANCE (RH)	30Ω±3Ω
SENSOR RESISTANCE (Rs)	5～15KΩ in Methane 1 000ppm/air
RATIO OF RESISTANCE	$\frac{\text{Rs in Methane 3000ppm/air}}{\text{Rs in Methane 1000ppm/air}}$ = 0.60 ± 0.05

5. SENSITIVITY CHARACTERISTICS

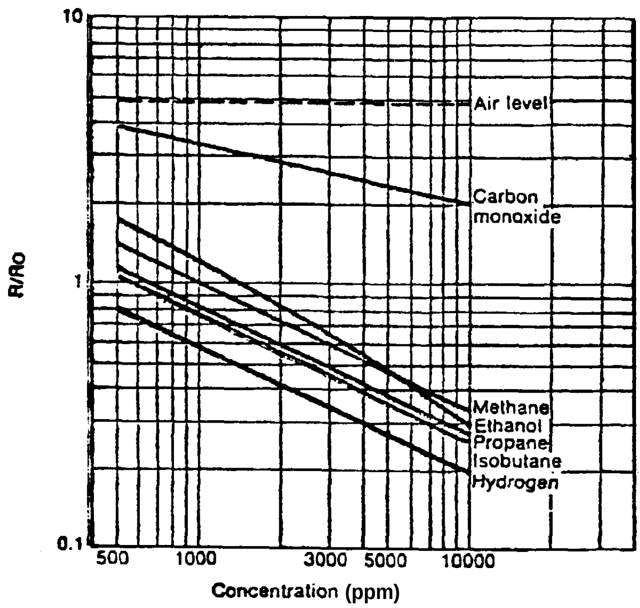


FIG. 5. RATIO OF RESISTANCE (**R/Ro**) VS.
CONCENTRATION FOR **#813.**

- **Remarks: Ra: Sensor resistance in air containing 1000ppm of Methane.**
  R: Sensor resistance at different concentrations of gases.

Fig.5 shows the changing resistance values of the type #813. sensor in relation to various types and concentrations of gases. This graph is fixed at 1000 ppm of methane. so once the Ro value is found out by the user it is a simple process to determine the resistance for other concentrations of gas. Remember that R/Ro represents the ratio of resistance to the Rs at 1000 ppm methane and not an actual resistance value. Therefore, the R/Ro value for 1000 ppm methane, according to Fig.5, is 1.

The actual resistance value for a particular gas concentration can be calculated as follows:

For instance, if the resistance of the sensor at 1000 ppm methane is found out to be 7kΩ in your measurement and you want to find the Rs for 4000 ppm of hydrogen of which R/Ro is 0.3 in Fig.5, simply multiply 7KΩ by 0.3 to result in 2.1KΩ

The important thing to remember is that the resistance of the sensor at 1000 ppm of methane must be determined by the user before this graph will be of any use for the determination of actual resistance values.

Likewise, this chart can be used to determine the various alarm points for different types and concentrations of gases. Again, if the alarm point for methane is set at a concentration of 1000 ppm, the related alarm point for propane will be at 700 ppm, isobutane at 600 ppm and ethanol at 1500 ppm.

However, it should be noted that the relative sensitivity to various gases based on methane differs to some extent from one sensor to another.

6. DEPENDENGY ON HEATER VOLTAGE

Fig. 6 shows the effect of VH fluctuation on the TGS #813's sensitivity. This value is based on the R/Ro value for methane at 1000 ppm with an illustrated ± 4% Variation of heater voltage.

You should note the general principle that if the heater voltage varies both the resistance andconsequentlythe alram point for the various gases will change accordingly. Thus, we recommend that your heater voltage be stabilized with a less than ± 1% Variation.

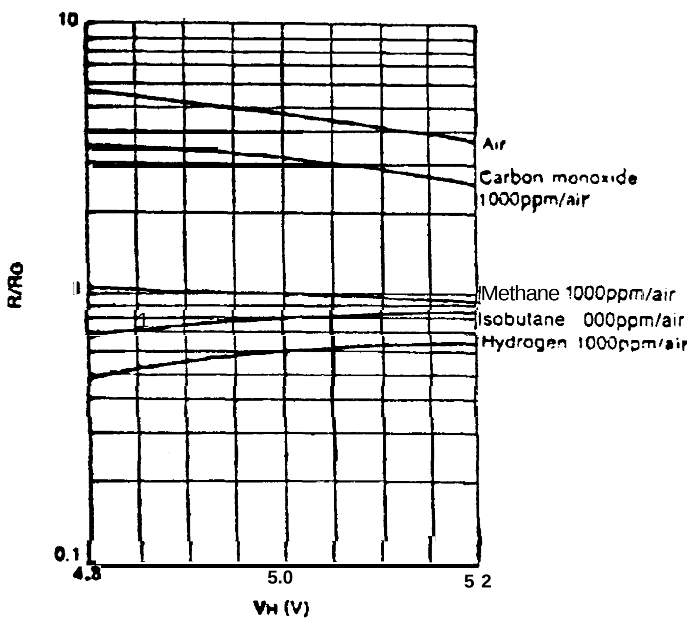


FIG. 6. EFFECT OF THE FLUCTUATIONS OF **HEATER** VOLTAGE ON #813 RATIO OF **RESISTANCE (R/Ro)**.

- **Rsnurk8: Ro: Sensor resistance in air containing 1000ppm of Methane at SV (VH).**
  R: Sensor resistance in air containing various gases at different heater voltages.

7. TEMPERATURE AND HUMIDITY

The sensitivity characteristics of the TGS #813 sensor are altered by changes in atmospheric temperature and humidity. The detection principle of the TGS is based on Chemical adsorption and desorption of gases on the sensor surface. Because these reactions are temperature dependent and water vapour can be considered a gas, the effects of temperature and humidity changes cannot be eliminated from the Sensor. These effects can however be reduced by circuit design as described in section 11. Figs. 7-9 show thetemperature and/or humidity dependency of the type #813 sensor.

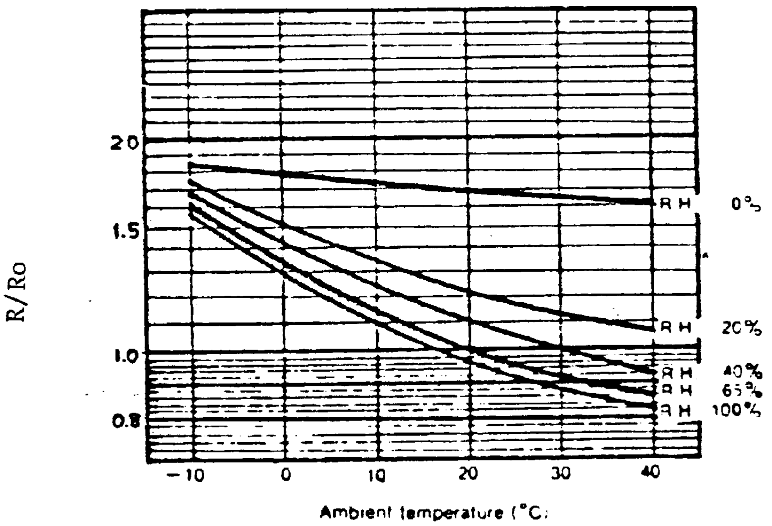


FIG.7 TGS #813 DEPENDENCY ON TEMPERATURE AND HUMIDITY

Test condition:
Vc 10V A.C. / VH 5.0V A.C. / R_L 4KΩ

Remarks: Ro: Sensor resistance in air containing 1000ppm of Methane gas at 20°C and 65% R.H.
R: Sensor resistance in air containing 1000ppm of Methane gas at different temperature and humidity

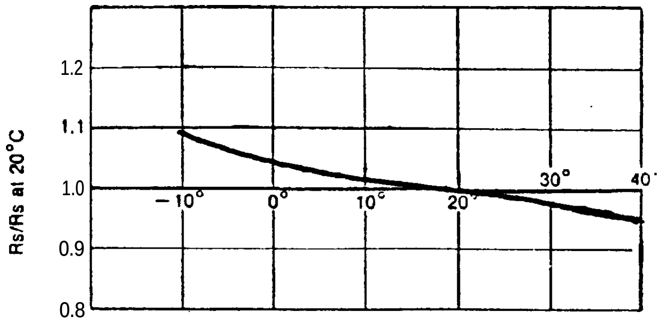


Fig.8 TGS #813. TEMPERATURE DEPENDENCE IN AIR CONTAINING VARIED CONCENTRATIONS METHANE.

Test condition: Vc 10V A.C. / VH 5.0V A.C. / R_L 4KΩ

Atmospheric condition: Temperature is changed at a fixed humidity of 0.2g H_2O/kg Air or less.

Measuring procedure: At respective temperature,wait for Outputs in air to stabilize and measure Outputs in gas. Following each change of temperature allow 2∿3 hours for sensors to stabilize at the new test conditions.

The data shown is the average ratio of ten sensors resistance at test temperatures relative to sensor resistance at 20°C, measured at 1000, 2000 and 3000ppm of methane.

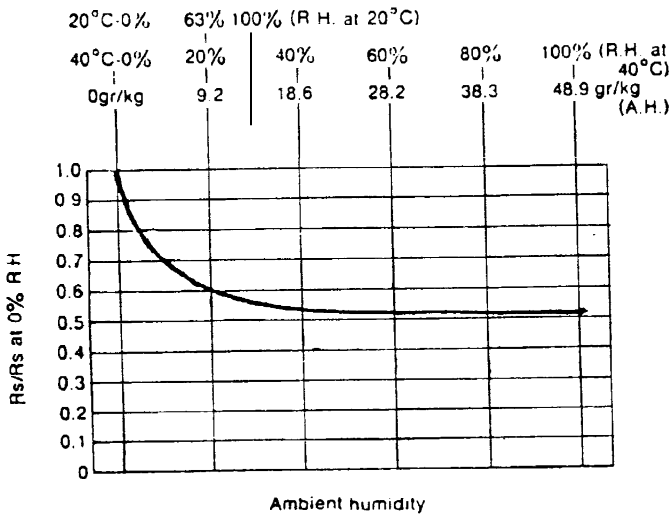


Fig.9 TGS #813 HUMIDITY DEPENDENCE IN AIR CONTAINING VARIED CONCENTRATIONS METHANE.

Test condition: Vc 10V A.C. / VH 5.0V A.C. / R_L 4KΩ

Atmospheric condition: Humidity is changed at a fixed temperature of 40°C.

Measuring procedure: At respective humidity conditions, wait for Outputs in air to stabilize and measure Outputs in gas. Following each changed of humidity allow 2∿3 hours for sensors to stabilize at the new test conditions.

The data shown is the average ratio of five Sensors resistance at various humidity levels relative to sensor resistance at 0% R.H. measured at 1000, 2000 and 3000ppm of methane.

8. TIME FOR INITIAL STABILIZATION

A TGS sensor which has been stored unenergized for a long period takes some time to reach its normal operating condition following switch on. This "Initial Action" characteristic in fresh air is shown in Fig.10.

From the moment of switch on the sensor's conductivity first rises rapidly and then falls towards its final stable value. The time taken to stabilize is a function of the sensor's storage time and atmosphere. In general, the longer the storage time the longer the initial action time. In the case of sensor type #813, the initial action time reaches its maximum value after about 20 days storage. In normal applications the initial action time will be less than 2 minutes.

It is important to note that if the sensor is placed in the air containing gas immediately after the "Initial Action", then the Rs value will appear according to the characteristics described in the next section.

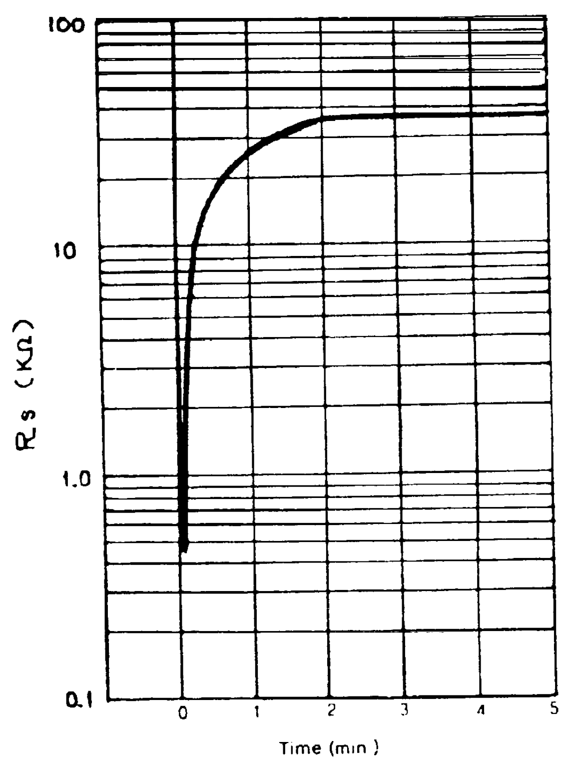


FIG. 10. INITIAL ACTION OF TGS #813 STORED FOR 3 weeks WITHOUT CURRENT-INPUT.

9. TIME DEPENDENCY CHARACTERISTICS

Fig.11 shows a typical pattern for a TGS #813 sensor which has been stored unenergized for a long period of time. This graph shows sensor resistance at a constant gas concentration.

When the sensor is energized after a long storage period it takes approximately 1-10 days for the sensor to reach a stable resistance level. Please note, that the actual transitional time necessary to reach stability is dependent on the amount of time the sensor has been stored and the atomospheric conditions under which it has been stored.

Table III suggested that the sensor be conditioned for at least 7 days prior to testing and evaluation. This period is necessary because of the phenomenon illustrated in Fig.11.

Caution at Calibration Time

Regardingtheabove characteristics of the sensor, we strongly recommend that you wait until the sensor has reached a stable output level before you calibrate. Failure to do so may result in non-standard sensor perfromance.

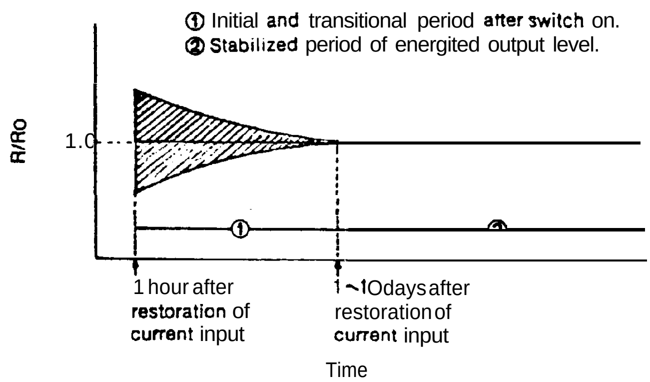


FIG. 11. TYPICAL PATTERN OF TGS $813 **SENSITIVITY** CHANGE WITH TIME.

◆**Remarks:** Ro: Sensor resistance at stabilized level.
R: Sensor resistance during stabilization.

10. SENSOR LIFE

The data in Fig. 12 shows fluctuations.in sensitivity with time based over a 9 year period using some of the TGS sensors originally produced. Current TGS sensors have been considerably improved since then but retain the same time dependency characteristics as the early ❑ odels. Fig.12 shows similar data on long term Operation, but is specifically related to TGS #813 Performance. It should be noted that since the TGS #813 is a relatively new product, the graph covers only a three year period of testing.

In both cases these measurements were made in natura1 air rather than in a temperature/humidity controlled environment. The cyclic change in sensitivity corresponds to the seasonal changes in Japan with the peak sensitivity occurring in July.

Although the data related to #813 Performance covers only a three year period, we have found based on our extensive laboratory testings and past experience with millions of sensors, that the TGS sensors have a long-term effectiveness for at least 8-10 years.

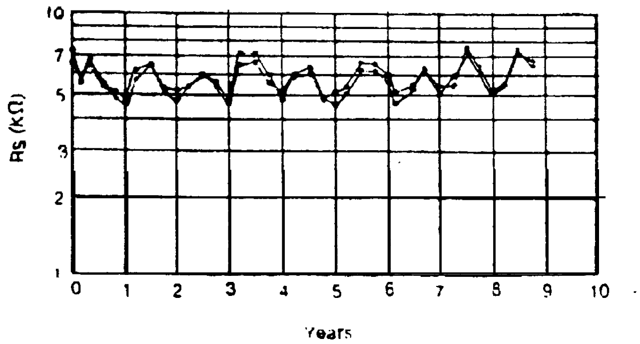


Fig.12 LONG TERM OPERATION

Sample: TGS #15S

Test'condition: Vc 100V A.C. / V_H 1.0V A.C. / R_L 4KΩ

Test gas: Isobutane 1000ppm/air

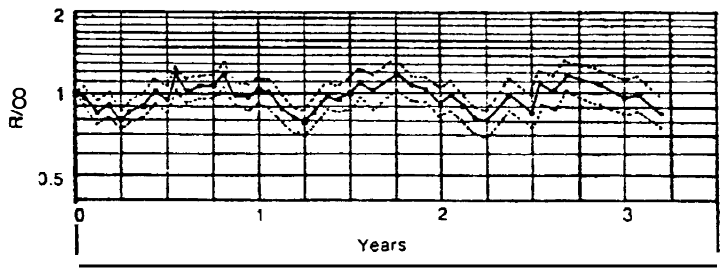


Fig.13 LONG TERM OPERATION

Sample: TGS #813 (100 pieces)

Test condition: Vc 10V A.C. / V_H 5.0V A.C. / R_L 4KΩ

Test gas: Methane 1000ppm/air

Remarks: —o— Average
------ $\pm 3\sigma$ (3 singma)
Ro: 1st Resistance Measurement After Stabilization
R : Subsequent Resistance Measurement

11. PRACTICAL DETECTOR CIRCUIT USING THE #813 SENSOR

As was mentioned above the TGS #813 is suitable for use in the detection of a wide range of gases such as naturalgas, L.P.G. and town gas. When you design a circuit employing the TGS #813 you must consider both the type and concentration of gas you wish to detect.

Because of its sensitivity characteristics, the action of the sensor will vary according to the type and concentration of gas it is detecting. Furthermore, the proper alarm point for the detector should be determined after considering the following factors.

a. Where the sensor is to be installed
b. Purpose of detector (gas leak, automatic fan control, air monitoring, etc.)
c. Operation of detector (sound, light, fan control, valve control, etc.)
d. Type of gas being detected or monitored.

When setting the actual alarm point, we recommend that you calibrate the detector for 5-10 % of the L.E.L. of the gas being detected.

This figure was decided to meet the requirements for high sensitivity while at the same time reducing the problem of nuisance alarming. This is an extremely important consideration for domestic gas-leak detectors because of the presence of 'noise gases' in the home enviroment such as those resulting from hair-spray, alcohol fumes or cooking fumes.

EXAMPLE CIRCUIT

Fig. 14 is an example of a simple and economic circuit for a domestic gas leak detectors. It is designed primarily for the detection of approximately 3000 ppm of methane (natural gas).

The constant 5V output of voltage regulator I_1 is available for the heater of the sensor and the detecting circuit. The detecting circuit consists of the TGS #813, R_1, and R_{ADJ} in series.

V_{RL} output, which is the output voltage across resistors R_1 and R_{ADJ}, enters the non-inverting input of the comparator.

Vr, which is the reference voltage for the comparator, is measured across R_4. This component is part of the Temperature Compensating Circuit which also consists of R_2, R_3 AND R_t (thermistor). The Vr value in this circuit is designed for 2.5V at 20°C.

Once you calibrate the detector at 3000 ppm by adjusting R_{ADJ} (under the conditions 20°C at 65% R.H.) you can get an approximate 2.5V(V_{RL}) in a concentration of 3000 ppm methane.

When a combustible gas such as natural gas contacts the sensor and the output of the detection circuit (V_{RL}) exceeds the Vr, the output of the comparator will go to 'High'. TR_1 is then activated and the buzzer is sounded.

TEMPERATURE AND HUMIDITY COMPENSATION METHOD

As was previously mentioned, Sensor resistance (Rs) is dependent upon the ambient temperature and humidity. Accordingly, this phenomenon will result in a fluctuation of the alarming Point. Possible variations in the effects of temperature and humidity changes are illustrated in TableV.

This Variation in Sensor Performance, however, is primarily related to the measure of Absolute Humidity in the detecting area. It is therefore recommended that you determine the mean or average temperature and humidity values in your projected detector sales or distribution area, to be able to compensate for seasonal variations in the alarming Point. The most efficient and economical way we have found to achieve this compensation is to carefully control the temperature dependency of the circuit. This Point is discussed below.

Table V illustrates possible variations in alarming Points in both compensated and non-compensated circuits. Another way of interpreting these variations is to say that if R/Ro = 1 at 20°C (65% R.H.) then at -10°C (65% R.H.) R/Ro is 1.6 and at 35°C (65% R.H.) is 0.9. The actual V_{RL} can.be expressed as: 2.5 V at 20°C, 1.9V at-10°C and 2.6 V at 35°C.

To compensate for these variations in temperature and humidity we suggest using a negative characteristic thermistor (Rt). In this example circuit, the Vr is automatically adjusted as a result of temperature changes. As was mentioned, Rt is set at 2.5V for 20°C in this circuit. At -10°C Vr will self-adjust to 2.1V, while at 35°C it will go to 2.7V.

The difference between V_{RL} and Vr is detected by the following Comparator I_2. . Therefore you can get rid of the seasonal Variation of alarming points which are caused by temperature and humidity fluctuations by adjusting Vr.

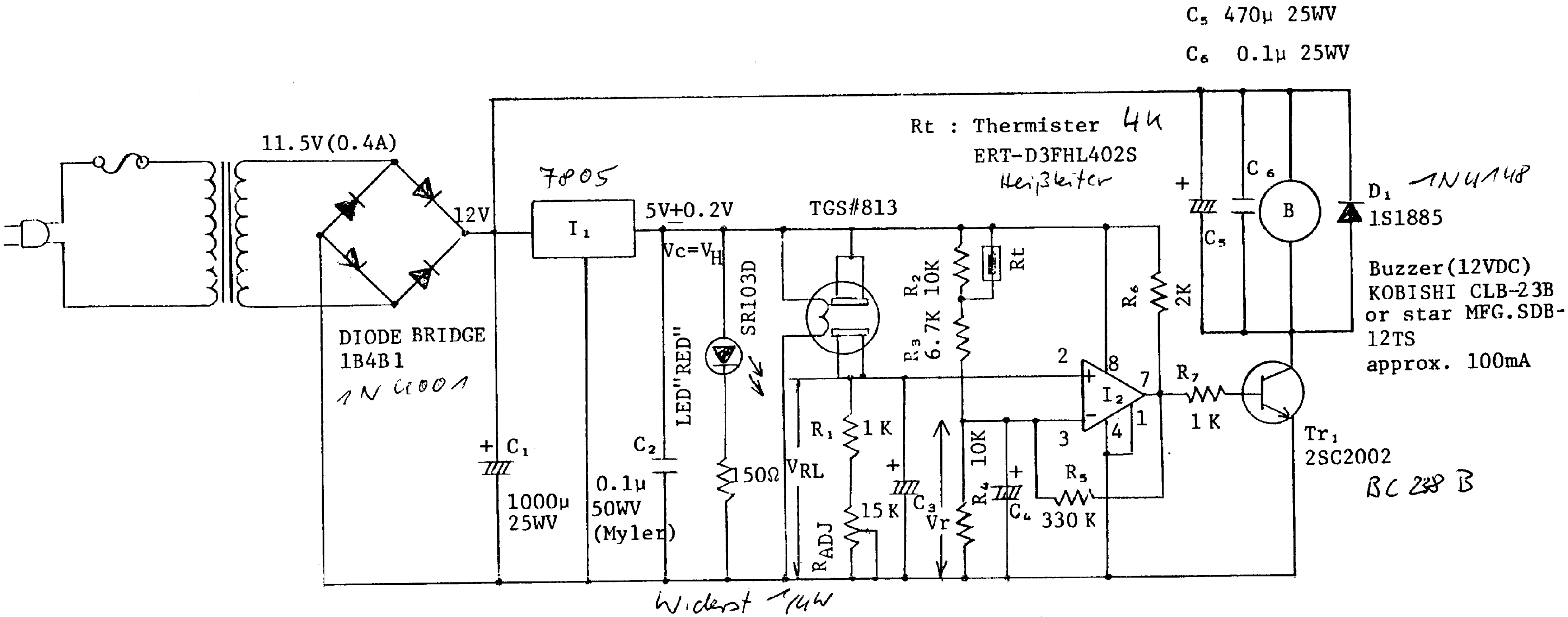
With the application of a temperature compensation circuit you will be able to control the alarming points as illustrated in Table V.

The temperature coefficient of the thermistor is larger than that of the sensor, therefore we have to adjust the coefficient of the thermistor by adjusting R_2 and R_9.

A final important consideration is the actual place where the thermistor is placed in the circuit. You should not install it near heat dissipating components such as the transformer or the Sensor. Also it should not be installed in a position where it is likely to receive a strong wind, as this will also effect the temperature characteristics of the Sensor.

Fig. 14

USING TGS #813 SENSOR



I_1 : μA7805 or equivalent, 3 terminal voltage regulator 5V ± 0.2V 1A

I_2 : LM-311 or equivalent, voltage comparator

Note 1 - All resistors are of 1/4W

Note 2 - It is necessary to use a heat sink of 50(mm) x 50(mm) x 1(mm) thick (aluminum plate) for voltage regrlator I_1.

Note 3 - In the case of using buzzer SDB-12TS, C_4, C_5, C_6, D_1 are not necessary because of the low noise of the buzzer.

Table V CHANGES IN ALARM POINT RESULTING FROM TEMPERATURE FLUCTUATIONS AT FIXED HUMIDITY

Measuring Condition		Gas Concentration at Alarm(Methane/Air: ppm)	
Temperature (°C)	Humidity (% RH)	Circuit Compensated for Temperature	Circuit Not Compensated for Temperature
* 20	65	3000	3000
-10	65	2950	5200
5	65	3100	1800
35	65	2600	1400

* Original alarm calibration conditions

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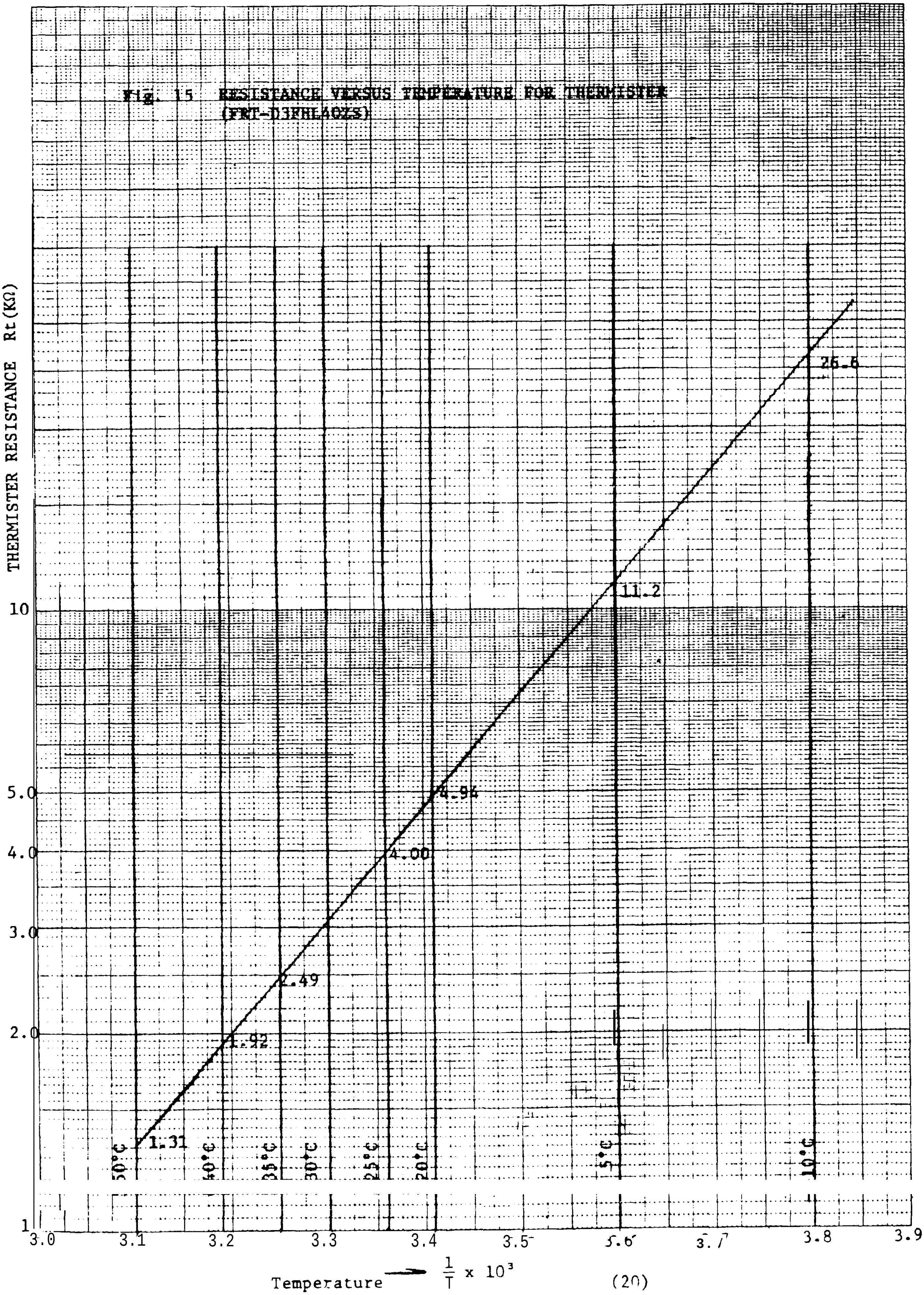

Fig. 15 RESISTANCE VERSUS TEMPERATURE FOR THERMISTER (FRT-D3FHL40ZS)