FIGARO

an ISO9001 company

Technical Information for Combustible Gas Sensors

Figaro TGS 8-series sensors are a type of sintered bulk metal oxide semiconductor which offer low cost, long life, and good sensitivity to target gases while utilizing a simple electrical circuit. The TGS813 displays high selectivity and sensitivity to LP Gas and methane.

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

1. Specifications

1-1 *Features*

* General purpose sensor for a wide range of combustible gases
* High sensitivity to LP gas and methane
* Low cost
* Long life
* Uses simple electrical circuit

1-2 *Applications*

* Domestic gas leak detectors and alarms
* Recreational vehicle gas leak detectors
* Portable gas detectors

1-3 *Structure*

Figure 1 shows the structure of TGS813. This sensor is a sintered bulk semiconductor composed mainly of tin dioxide (SnO_2). The semiconductor material and electrodes are formed on an alumina ceramic tube. A heater coil, made of 60 micron diameter wire, is located inside the ceramic tube. Lead wires from the sensor electrodes are a gold alloy of 80 microns in diameter. Heater and lead wires are spotwelded to the sensor pins which have been arranged to fit a 7-pin miniature tube socket.

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 (SUS316). 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.

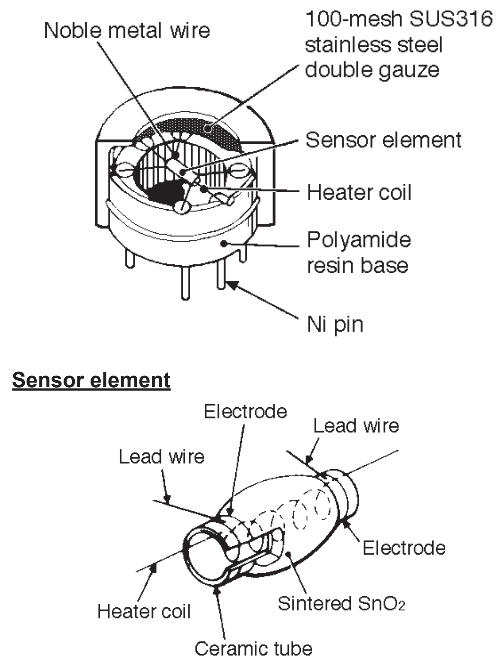


Fig. 1 - Sensor structure

1-4 *Basic measuring circuit*

Figure 2 shows the basic measuring circuit for use with TGS813. Circuit voltage (Vc) is applied across the sensor element which has a resistance between the sensor's two electrodes and the load resistor (R_L) connected in series. The sensor signal (V_{RL}) is measured indirectly as a change in voltage across the R_L. The Rs is obtained from the formula shown at the right.

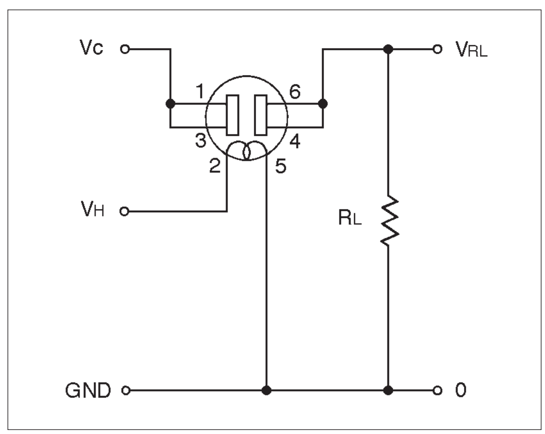


Fig. 2 - Basic measuring circuit

$$Rs = \frac{Vc - V_{RL}}{V_{RL}} \times R_L$$

Formula to determine Rs

1-5 *Circuit & operating conditions*

The ratings shown below should be maintained at all times to insure stable sensor performance:

Item	Specification
Circuit voltage (V_C)	max. 24V AC/DC
Heater voltage (V_H)	5.0V ± 0.2V AC/DC
Heater resistance (room temp)	30 ± 3Ω
Load resistance (R_L)	variable (min = [V_C^2/60]kΩ)
Sensor power dissipation (P_S)	≤15mW
Operating & storage temperature	-40˚C ~ +70˚C
Optimal detection concentration	500 ~ 10,000ppm

1-6 *Specifications* NOTE 1

Item	Specification
Sensor resistance (1000ppm methane)	5kΩ ~ 15kΩ
Sensor resistance ratio (Rs/Ro)	0.60 ± 0.05
Rs/Ro = Rs(3000ppm methane)/Rs(1000ppm methane)	
Heater current (R_H)	approx. 167mA
Heater power consumption (P_H)	approx. 835mW

Mechanical Strength:

The sensor shall have no abnormal findings in its structure and shall satisfy the above electrical specifications after the following performance tests:

Withdrawal Force - withstand force > 5kg in each direction

Vibration - frequency-1000c/min., total amplitude-4mm, duration-one hour, direction-vertical

Shock - acceleration-100G, repeated 5 times

1-7 *Dimensions*

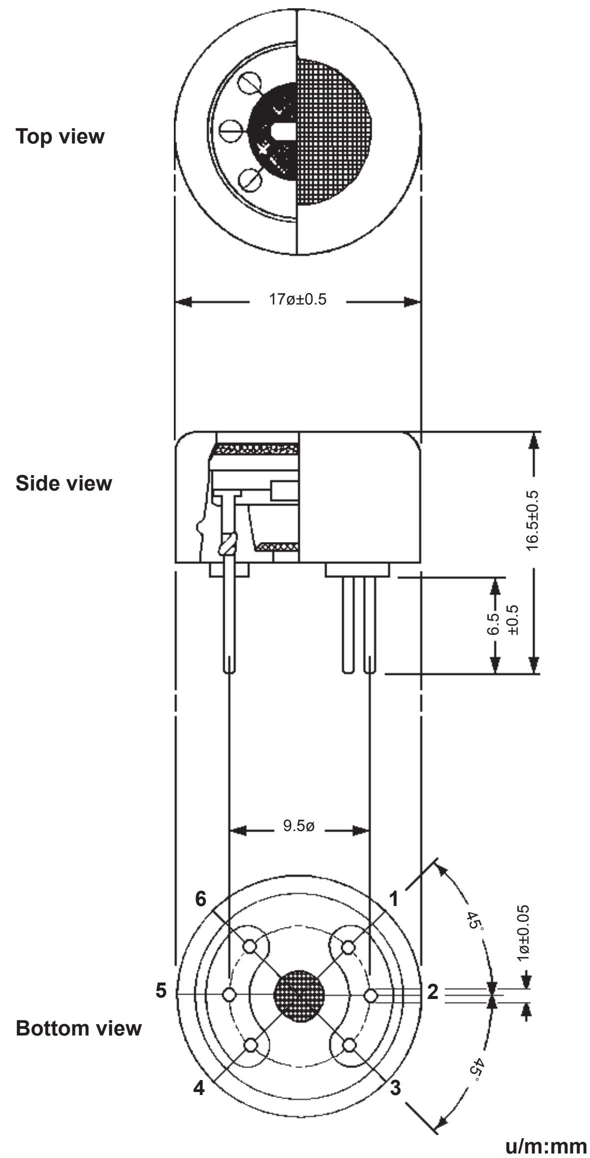


Fig. 3 - Sensor dimensions

NOTE 1: Sensitivity characteristics are obtained under the following standard test conditions:

(Standard test conditions)
Temperature and humidity: 20 ± 2˚C, 65 ± 5% RH
Circuit conditions: V_C = 10.0±0.1V AC/DC
V_H = 5.0±0.05V AC/DC
R_L = 4.0kΩ ± 1%
Preheating period: 7 days or more under standard circuit conditions

2. Basic Sensitivity Characteristics

2-1 *Sensitivity to various gases*

Figure 4 shows the relative sensitivity of TGS813 to various gases. The Y-axis shows the ratio of the sensor resistance in various gases (Rs) to the sensor resistance in 1000ppm of methane (Ro).

Using the basic measuring circuit illustrated in Figure 2, these sensitivity characteristics provide the sensor output voltage (VRL) change as shown in Figure 5.

<u>**NOTE**</u>:
All sensor characteristics in this technical brochure represent typical sensor characteristics. Since the Rs or output voltage curve varies from sensor to sensor, calibration is required for each sensor (*for additional information on calibration, please refer to the Technical Advisory 'Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors'*).

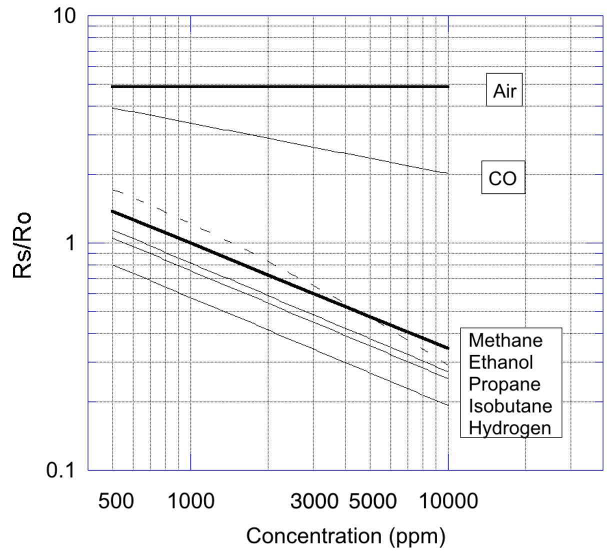


Fig. 4 - Sensitivity to various gases (Rs/Ro)

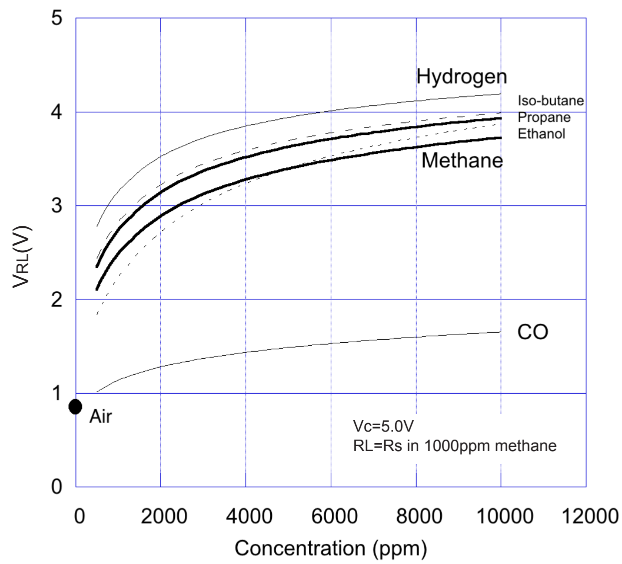


Fig. 5 - Sensitivity to various gases (VRL)

2-2 *Temperature and humidity dependency*

Figure 6 shows the temperature and humidity dependency of TGS813. The Y-axis shows the ratio of sensor resistance in 1000ppm of methane under various atmospheric conditions (Rs) to the sensor resistance in 1000ppm of methane at 20˚C/65%RH (Ro).

RH / (˚C)	0% RH	20%RH	40%RH	65%RH	100%RH
-10	1.860	1.742	1.676	1.609	1.556
0	1.792	1.523	1.441	1.353	1.303
10	1.733	1.346	1.247	1.150	1.102
20	1.684	1.211	1.095	1.000	0.955
30	1.643	1.117	0.984	0.903	0.861
40	1.612	1.065	0.914	0.858	0.820

Table 1 - Temperature and humidity dependency
(typical values of Rs/Ro for Fig. 6)

Table 1 shows a chart of values of the sensor's resistance ratio (Rs/Ro) under the same conditions as those used to generate Figure 6.

Figure 7 shows the sensitivity curve for TGS813 to methane under several ambient conditions. While temperature may have a large influence on absolute Rs values, this chart illustrates the fact that effect on the slope of sensor resistance ratio (Rs/Ro) is not significant. As a result, the effects of temperature on the sensor can easily be compensated.

For economical circuit design, a thermistor can be incorporated to compensate for temperature (*for additional information on temperature compensation in circuit designs, please refer to the Technical Advisory 'Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors'*).

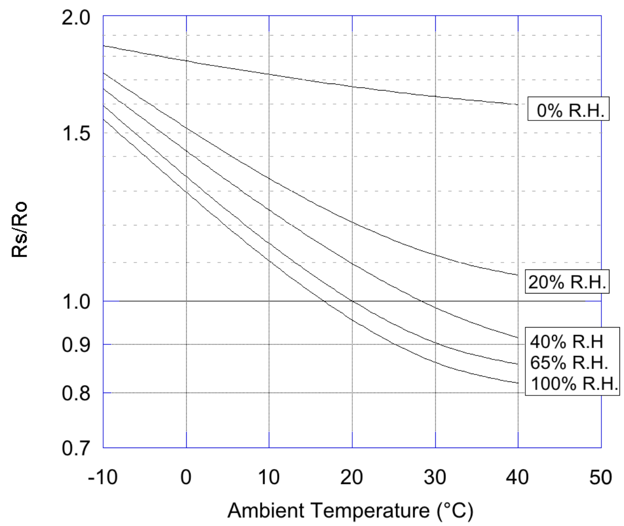


Fig. 6 - Temperature and humidity dependency (Rs/Ro)

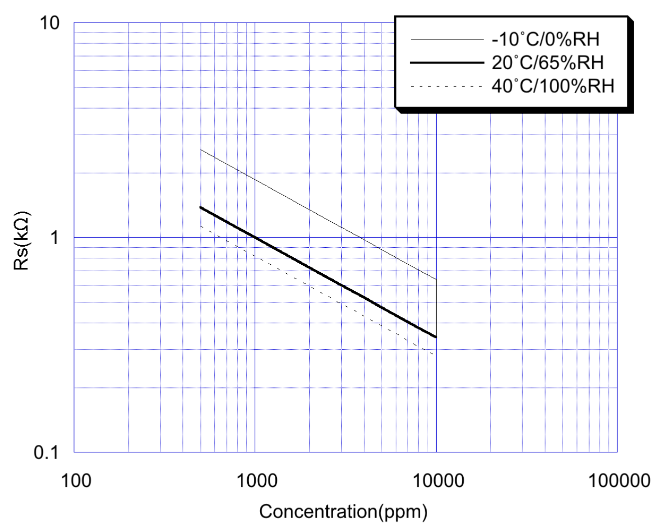


Fig. 7 - Resistance change ratio
under various ambient conditions

2-3 *Heater voltage dependency*

Figure 8 shows the change in the sensor resistance ratio according to variations in the heater voltage (VH).

Note that 5.0V as a heater voltage must be maintained because variance in applied heater voltage will cause the sensor's characteristics to be changed from the typical characteristics shown in this brochure.

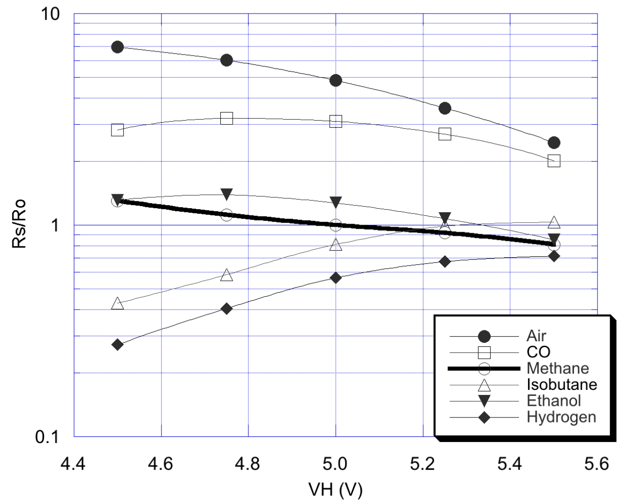


Fig. 8 - Heater voltage dependency
(Rs = Rs in 1000ppm of specified gas,
Ro = Rs at 1000ppm methane and VH=5.0V)

2-4 *Gas response*

Figure 9 shows the change pattern of sensor resistance (Rs) when the sensor is inserted into and later removed from 1000ppm of methane.

As this chart displays, the sensor's response speed to the presence of gas is extremely quick, and when removed from gas, the sensor will recover back to its original value in a short period of time.

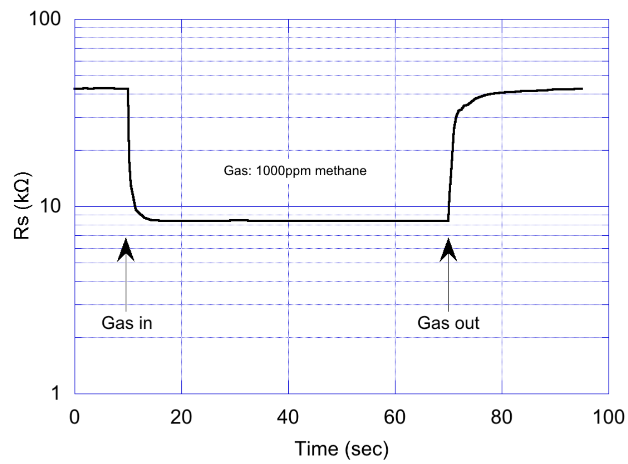


Fig. 9 - Response speed

Figure 10 demonstrates the sensor's repeatability by showing multiple exposures to a 1000ppm concentration of methane. The sensor shows good repeatability according to this data.

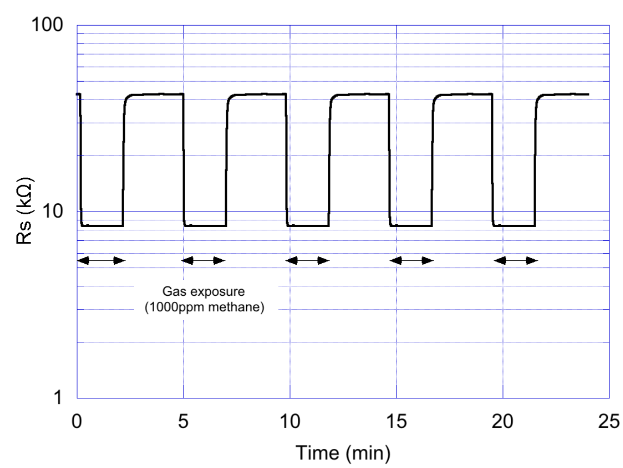


Fig. 10 - Repeatability

2-6 *Initial action*

Figure 11 shows the initial action of the sensor resistance (Rs) for a sensor which is stored unenergized in normal air for 30 days and later energized in clean air.

The Rs drops sharply for the first seconds after energizing, regardless of the presence of gases, and then reaches a stable level according to the ambient atmosphere. Such behavior during the warm-up process is called "Initial Action".

Since this 'initial action' may cause a detector to alarm unnecessarily during the initial moments after powering on, it is recommended that an initial delay circuit be incorporated into the detector's design (*refer to Technical Advisory 'Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors'*). This is especially recommended for intermittent-operating devices such as portable gas detectors.

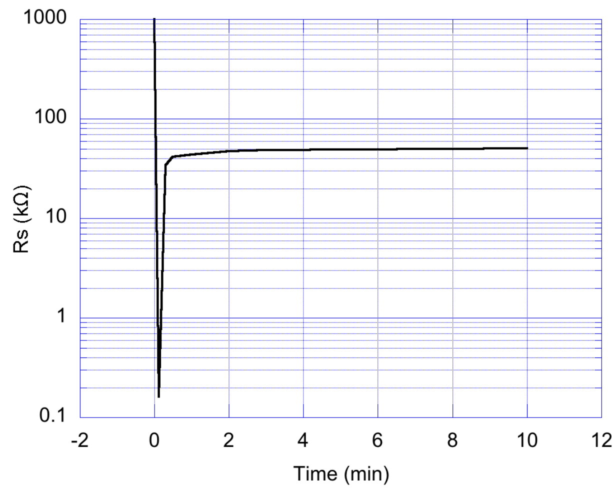


Fig. 11 - Initial action

2-7 *Long-term characteristics*

Figure 12 shows long-term stability of TGS813 as measured for more than 8 years. The sensor is first energized in normal air. Measurement for confirming sensor characteristics is conducted under ambient air conditions rather than in a temperature/humidity controlled environment. The cyclic change in sensitivity corresponds to the seasonal changes of temperature/humidity in Japan (*peak T/H conditions occur in July, as corresponds with the sensitivity peaks in this chart*). The Y-axis represents the ratio of sensor resistance in 1000ppm of methane on the date tested (Rs) to sensor resistance in 1000ppm of methane at the beginning of the test period (Ro).

As this chart illustrates, TGS813 shows stable characteristics over a very long period of time.

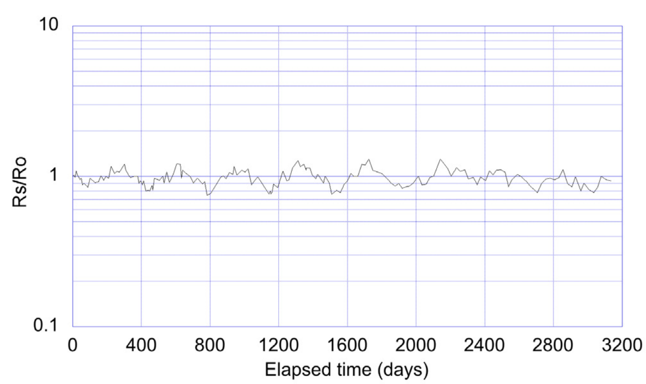


Fig. 12 - Long term stability
(Ro = Rs on day 1)

3 Cautions

3-1 *Situations which must be avoided*

1) Exposure to silicone vapors
If silicone vapors adsorb onto the sensor's surface, the sensing material will be coated, irreversibly inhibiting sensitivity. Avoid exposure where silicone adhesives, hair grooming materials, or silicone rubber/putty may be present.

2) Highly corrosive environment
High density exposure to corrosive materials such as H_2S, SO_x, Cl_2, HCl, etc. for extended periods may cause corrosion or breakage of the lead wires or heater material.

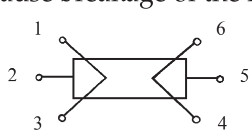
3) Contamination by alkaline metals
Sensor drift may occur when the sensor is contaminated by alkaline metals, especially salt water spray.

4) Contact with water
Sensor drift may occur due to soaking or splashing the sensor with water.

5) Freezing
If water freezes on the sensing surface, the sensing material would crack, altering characteristics.

6) Application of excessive voltage
If higher than specified voltage is applied to the sensor or the heater, lead wires and/or the heater may be damaged or sensor characteristics may drift, even if no physical damage or breakage occurs.

7) Application of voltage on lead wires
On six-pin type sensors, if a voltage is applied on the lead wires between pins 1 and 3 and/or pins 4 and 6, this would cause breakage of the lead wires.



8) Operation in zero/low oxygen environment
TGS sensors require the presence of around 21% (ambient) oxygen in their operating environment in order to function properly and to exhibit characteristics described in Figaro's product literature. TGS sensors cannot properly operate in a zero or low oxygen content atmosphere.

3-2 *Situations to be avoided whenever possible*

1) Water condensation
Light condensation under conditions of indoor usage should not pose a problem for sensor performance. However, if water condenses on the sensor's surface and remains for an extended period, sensor characteristics may drift.

2) Usage in high density of gas
Sensor performance may be affected if exposed to a high density of gas for a long period of time, regardless of the powering condition.

3) Storage for extended periods
When stored without powering for a long period, the sensor may show a reversible drift in resistance according to the environment in which it was stored. The sensor should be stored in a sealed bag containing clean air; do <u>not</u> use silica gel. *Note that as unpowered storage becomes longer, a longer preheating period is required to stabilize the sensor before usage*.

4) Long term exposure in adverse environment
Regardless of powering condition, if the sensor is exposed in extreme conditions such as very high humidity, extreme temperatures, or high contamination levels for a long period of time, sensor performance will be adversely affected.

5) Vibration
Excessive vibration may cause the sensor or lead wires to resonate and break. Usage of compressed air drivers/ultrasonic welders on assembly lines may generate such vibration, so please check this matter.

6) Shock
Breakage of lead wires may occur if the sensor is subjected to a strong shock.

7) Soldering
Ideally, sensors should be soldered manually. For soldering conditions of 8-series gas sensors, refer to *Technical Advisory for Soldering 8-type Gas Sensors*.

8) Polarity
If the polarity of Vc is reversed during powering, sensor characteristics may temporarily become unstable.

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