# Anexo I

Hojas de datos de los distintos elementos que forman parte del proyecto

Índice:

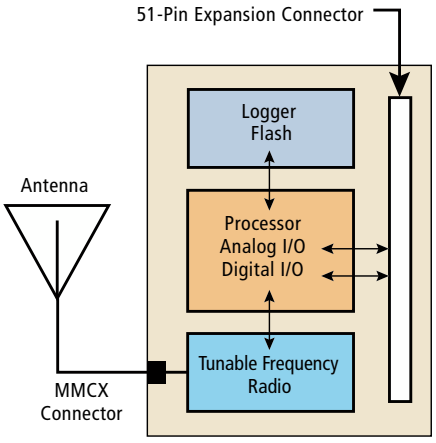
# MICA2

WIRELESS MEASUREMENT SYSTEM

- 3rd Generation, Tiny, Wireless Platform for Smart Sensors
- Designed Specifically for Deeply Embedded Sensor Networks
- > 1 Year Battery Life on AA Batteries (Using Sleep Modes)
- Wireless Communications with Every Node as Router Capability
- 868/916 MHz Multi-Channel Radio Transceiver
- Expansion Connector for Light, Temperature, RH, Barometric Pressure, Acceleration/Seismic, Acoustic, Magnetic and other Crossbow Sensor Boards

## Applications

- Wireless Sensor Networks
- Security, Surveillance and Force Protection
- Environmental Monitoring
- Large Scale Wireless Networks (1000+ points)
- Distributed Computing Platform




MPR400 Block Diagram

## MICA2

The MICA2 Mote is a third generation mote module used for enabling low-power, wireless, sensor networks. The MICA2 Mote features several new improvements over the original MICA Mote. The following features make the MICA2 better suited to commercial deployment:

- 868/916 MHz multi-channel transceiver with extended range
- Supported by MoteWorks™ wireless sensor network platform for reliable, ad-hoc mesh networking
- Support for wireless remote reprogramming
- Wide range of sensor boards and data acquisition add-on boards

MoteWorks enables the development of custom sensor applications and is specifically optimized for low-power, battery-operated networks. MoteWorks is based on the open-source TinyOS operating system and provides reliable, ad-hoc mesh networking, over-the-air-programming capabilities, cross development tools, server middleware for enterprise network integration and client user interface for analysis and configuration.

## Processor and Radio Platform (MPR400)

The MPR400 is based on the Atmel ATmega128L. The ATmega128L is a low-power microcontroller which runs MoteWorks from its internal flash memory. A single processor board (MPR400) can be configured to run your sensor application/processing and the network/radio communications stack simultaneously. The MICA2 51-pin expansion connector supports Analog Inputs, Digital I/O, I2C, SPI and UART interfaces. These interfaces make it easy to connect to a wide variety of external peripherals.

## Sensor Boards

Crossbow offers a variety of sensor and data acquisition boards for the MICA2 Mote. All of these boards connect to the MICA2 via the standard 51-pin expansion connector. Custom sensor and data acquisition boards are also available. Please contact Crossbow for additional information.

Document Part Number: 6020-0042-08 Rev A

| Processor/Radio Board | MPR400CB | Remarks |
|---|---|---|
| **Processor Performance** | | |
| Program Flash Memory | 128K bytes | |
| Measurement (Serial) Flash | 512K bytes | >100,000 Measurements |
| Configuration EEPROM | 4K bytes | |
| Serial Communications | UART | 0-3V transmission levels |
| Analog to Digital Converter | 10 bit ADC | 8 channel, 0-3V input |
| Other Interfaces | DIO,I2C,SPI | |
| Current Draw | 8 mA | Active mode |
| | < 15 µA | Sleep mode |
| **Multi-Channel Radio** | | |
| Center Frequency | 868/916 MHz | ISM bands |
| Number of Channels | 4/ 50 | Programmable, country specific |
| Data Rate | 38.4 Kbaud | Manchester encoded |
| RF Power | -20 to +5 dBm | Programmable, typical |
| Receive Sensitivty | -98 dBm | Typical, analog RSSI at AD Ch. 0 |
| Outdoor Range | 500 ft | 1/4 Wave dipole, line of sight |
| Current Draw | 27 mA | Transmit with maximum power |
| | 10 mA | Receive |
| | < 1 µA | Sleep |
| **Electromechanical** | | |
| Battery | 2X AA batteries | Attached pack |
| External Power | 2.7 - 3.3 V | Connector provided |
| User Interface | 3 LEDs | User programmable |
| Size (in) | 2.25 x 1.25 x 0.25 | Excluding battery pack |
| (mm) | 58 x 32 x 7 | Excluding battery pack |
| Weight (oz) | 0.7 | Excluding batteries |
| (grams) | 18 | Excluding batteries |
| Expansion Connector | 51-pin | All major I/O signals |

Notes: Specifications subject to change without notice

## Base Stations

A base station allows the aggregation of sensor network data onto a PC or other computer platform. Any MICA2 Mote can function as a base station when it is connected to a standard PC interface or gateway board. The MIB510/MIB520 provides a serial/USB interface for both programming and data communications. Crossbow also offers a stand-alone gateway solution, the MIB600 for TCP/IP-based Ethernet networks.

MIB520 Mote Interface Board

## Ordering Information

| Model | Description |
|---|---|
| WSN-START900CA | MICA2 Starter Kit 868/916 MHz |
| WSN-PRO900CA | MICA2 Professional Kit 868/916 MHz |
| MPR400CB | 868/916 MHz Processor/Radio Board |

Document Part Number: 6020-0042-08 Rev A

# MIB510

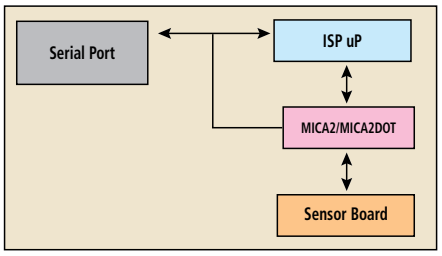
SERIAL INTERFACE BOARD

- Base Station for Wireless Sensor Networks
- Serial Port Programming for IRIS, MICAz and MICA2 Hardware Platforms
- Supports JTAG code debugging

## Applications

- Programming Interface
- RS-232 Serial Gateway
- IRIS, MICAz, MICA2 Connectivity

MIB510 with Mote and Sensor Board




MIB510 Block Diagram

## MIB510

The MIB510 allows for the aggregation of sensor network data on a PC as well as other standard computer platforms. Any IRIS/MICAz/MICA2 node can function as a base station when mated to the MIB510 serial interface board. In addition to data transfer, the MIB510 also provides an RS-232 serial programming interface.

The MIB510 has an onboard processor that programs the Mote processor/radio boards. The processor also monitors the MIB510 power voltage and disables programming if the voltage is not within the required limits. Two 51-pin Hirose connectors are available, allowing sensor boards to be attached for monitoring or code development. The MIB510 is also compatible with the Atmel JTAG pod for code development.

## Specifications

**RS-232 Interface**

- Connector: 9-pin "D"
- Baud Rates:
  - User defined (57.6k typical)
  - Programming: 115.2k (uisp controlled)

**Mote Interface**

- Connectors:
  - 51 pin (2)
- Indicators:
  - Mote LEDs: Red, Green, Yellow

**Programming Interface**

- Indicators:
  - LEDs - Power Ok (Green), Programming in Progress (Red)
- Switches:
  - On/Off switch to disable the Mote serial transmission
  - Temporary switch to reset the programming processor and Mote

**Jtag Interface**

- Connector: 10-pin male header (2)

**Power**

- 5V @ 50mA using external power supply (included with unit)
- 3.3-2.7V @ 50mA using Mote batteries

## Ordering Information

| Model | Description |
|---|---|
| MIB510 | Serial PC Interface Board |

Document Part Number: 6020-0057-03 Rev A

# 6 MDA100CA/MDA100CB

MD100CA and MDA100CB have the same content in this chapter except for some minor changes.

The MDA100 series sensor boards have a precision thermistor, a light sensor/photocell, and general prototyping area. The prototyping area supports connection to all eight channels of the Mote's analog to digital converter (ADC0–7), both USART serial ports and the I2C digital communications bus. The prototyping area also has 45 unconnected holes that are used for breadboard of circuitry.

### *6.1.1 Thermistor*

The thermistor, (YSI 44006, http://www.ysi.com) sensor is a highly accurate and highly stable sensor element. With proper calibration, an accuracy of 0.2 °C can be achieved. The thermistor's resistance varies with temperature. (See Table 6-1 and the resistance vs. temperature graph in Figure 6-3) This curve, although non-linear, is very repeatable. The sensor is connected to the analog-digital converter channel number 1 (ADC1) thru a basic resistor divider circuit. In order to use the thermistor, the sensor must be enabled by setting digital control line INT2 high. See the Figure 6-1 below.

**Table 6-1.** *Thermistor Specifications*

| Type | YSI 44006 |
|---|---|
| Time Constant | 10 seconds, still air |
| Base Resistance | 10 kΩ at 25 °C |
| Repeatability | 0.2 °C |

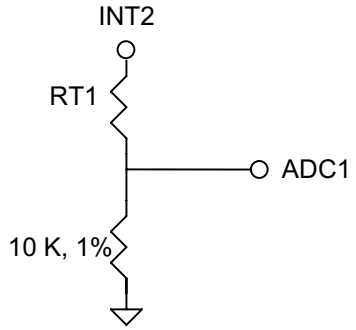



**Figure 6-1(a).** *Schematic of the Thermistor on MDA100CA*

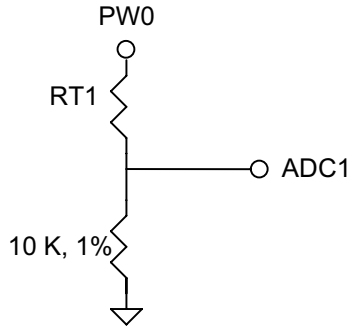


**Figure 6-2(b).** *Schematic of the Thermistor on MDA100CB*

**Table 6-2.** *Resistance vs. Temperature, ADC1 Reading*

| Temperature (°C) | Resistance (Ohms) | ADC5 Reading (% of VCC) |
|---|---|---|
| -40 | 239,800 | 4% |
| -20 | 78,910 | 11% |
| 0 | 29,940 | 25% |
| 25 | 10,000 | 50% |
| 40 | 5592 | 64% |
| 60 | 2760 | 78% |
| 70 | 1990 | 83% |

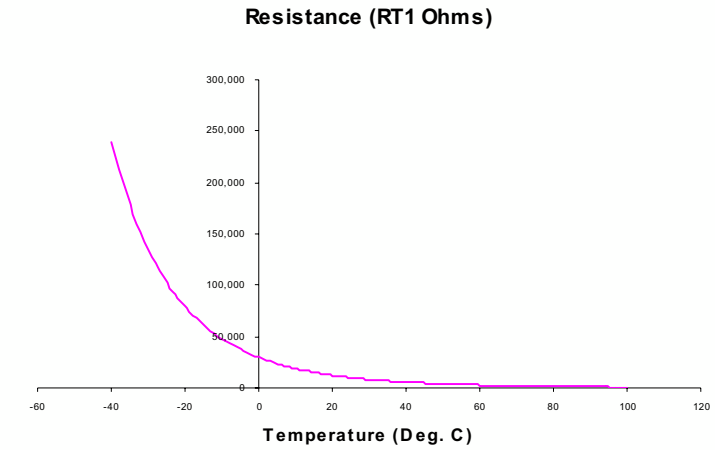



**Figure 6-3**. *Resistance vs. Temperature Graph*

## 6.2 Conversion to Engineering Units

The Mote's ADC output can be converted to Kelvin using the following approximation over 0 to 50 °C:

$$1/T(K) = a + b \times \ln(R_{thr}) + c \times [\ln(R_{thr})]^3$$

where:

$R_{thr} = R1(ADC\_FS-ADC)/ADC$

$a = 0.001010024$

$b = 0.000242127$

$c = 0.000000146$

$R1 = 10\ k\Omega$

$ADC\_FS = 1023$, and

ADC = output value from Mote's ADC measurement.

## 6.3 Light Sensor

The light sensor is a simple CdSe photocell. The maximum sensitivity of the photocell is at the light wavelength of 690 nm. Typical on resistance, while exposed to light, is 2 kΩ. Typical off resistance, while under dark conditions, is 520 kΩ. In order to use the light sensor, digital control signal PW1 must be turned on. The output of the sensor is connected to the analog-digital converter channel 1 (ADC1). When there is light, the nominal circuit output is near VCC or full-scale, and when it is dark the nominal output is near GND or zero. Power is controlled to the light sensor by setting signal INT2.

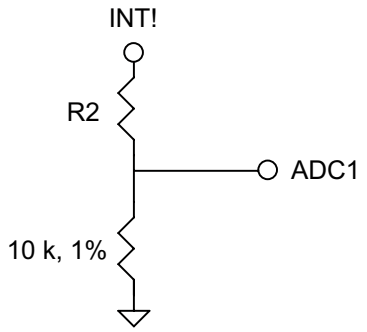



**Figure 6-4.** *Schematic of the light sensor*

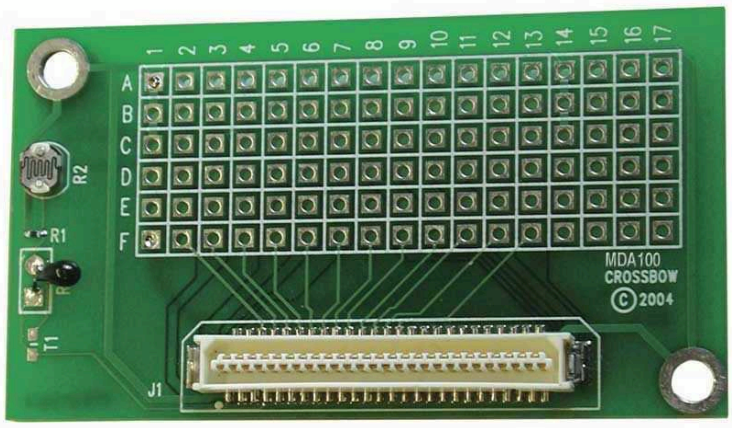
## 6.4 Prototyping Area

The prototyping area is a series of solder holes and connection points for connecting other sensors and devices to the Mote. The prototyping area layout is shown in the diagram and tables below.

**Table 6-3.** *Connection Table for MDA100. Use the photo (top view) below the table to locate the pins.*

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| **1** | GND | GND | GND | VCC | VCC | VCC |
| **2** | OPEN | OPEN | USART1_CK | INT3 | ADC2 | PW0 |
| **3** | OPEN | OPEN | UART0_RX | INT2† | ADC1† | PW1† |
| **4** | OPEN | OPEN | UART0_TX | INT1 | ADC0† | PW2 |
| **5** | OPEN | OPEN | SPI_SCK | INT0 | THERM_PWR | PW3 |
| **6** | OPEN | OPEN | USART1_RX | BAT_MON | THRU1 | PW4 |
| **7** | OPEN | OPEN | USART1_TX | LED3 | THRU2 | PW5 |
| **8** | OPEN | OPEN | I2C_CLK | LED2 | THRU3 | PW6 |
| **9** | OPEN | OPEN | I2C_DATA | LED1 | RSTN | ADC7 |
| **10** | OPEN | OPEN | PWM0 | RD | PWM1B | ADC6 |
| **11** | OPEN | OPEN | PWM1A | WR | OPEN | ADC5 |
| **12** | OPEN | OPEN | AC+ | ALE | OPEN | ADC4 |
| **13** | OPEN | OPEN | AC- | PW7 | OPEN | ADC3 |
| **14** | GND | GND | GND | VCC | VCC | VCC |
| **15** | OPEN | OPEN | OPEN | OPEN | OPEN | OPEN |
| **16** | OPEN | OPEN | OPEN | OPEN | OPEN | OPEN |
| **17** | OPEN | OPEN | OPEN | OPEN | OPEN | OPEN |

†Shared functionality




**WARNING:** Never connect signals that are greater than VCC (3V typical) or less than 0 V to any of the holes that connect to the Mote Processor Radio board. It is okay to connect different voltages to the non-connected holes. However, be careful. If a voltage out of the range of 0 to Vcc should reach the Mote Processor Radio Board damage will occur.

FIGARO

PRODUCT INFORMATION

# TGS 5042 - for the detection of Carbon Monoxide

## Features:

* Battery operable
* High repeatability/selectivity to CO
* Linear relationship between CO gas concentration and sensor output
* Simple calibration
* Long life
* UL recognized component
* Meets UL2034, EN50291, and RoHS requirements

## Applications:

* Residential and commercial CO detectors
* CO monitors for industrial applications
* Ventilation control for indoor parking garages
* Recreational vehicle CO detectors
* Marine CO detectors
* Fire detection

Figaro's **TGS5042** is a battery operable electrochemical sensor which offer several advantages over traditional electrochemical sensors. Its electrolyte is environmentally friendly, it poses no risk of electrolyte leakage, can detect concentrations as high as 1% CO, operates in a range from -40˚ and +70˚C, and it has lower sensitivity to interferant gases. With a long life, good long term stability, and high accuracy, this sensor is the ideal choice for CO detectors with digital display. OEM customers will find individual sensors data printed on each sensor in bar code from, enabling users to skip the costly gas calibration process and allowing for individual sensor tracking. TGS5042 utilizes a standard AA battery-sized package.

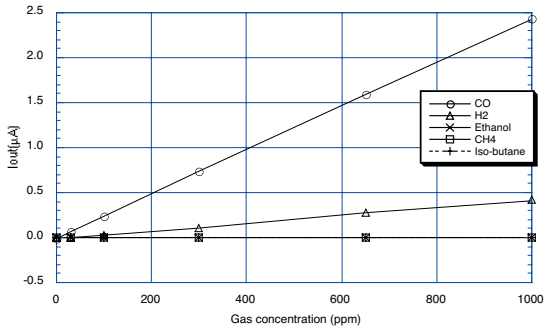
The figure below represents typical sensitivity characteristics, all data having been gathered at standard test conditions (see reverse side of this sheet). The Y-axis shows theoutput current of the sensor (Iout/$\mu$A) in each gas. Output current is linear to CO concentration, with a deviation of less than ±5% in the range of 0~500ppm.

The figure below represents typical temperature dependency characteristics. The Y-axis shows the sensor output ratio (I/Io) as defined below. The linear relationship between I/Io and CO concentration is constant regardless of the CO concentration range.

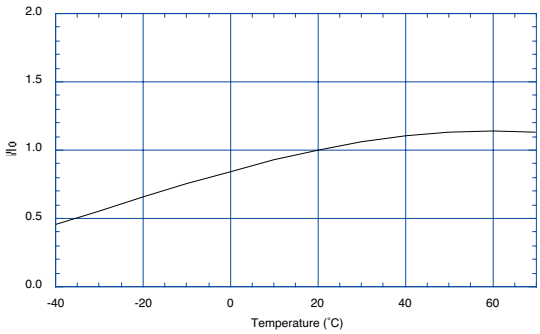
I = Sensor output current in 400ppm of CO at various temperatures

Io = Sensor output current in 400ppm at 20˚C/50%RH

**Sensitivity Characteristics:**




**Temperature Dependency:**




**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.

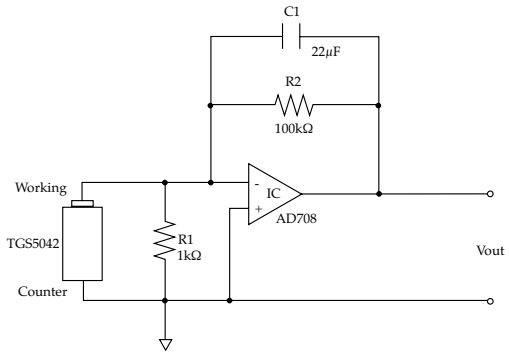
## Basic Measuring Circuit:

The diagram at the right shows the basic measuring circuit of TGS5042. The sensor generates a minute electric current which is converted into sensor output voltage (Vout) by an op-amp/resistor (R2) combination. An additional resistor (R1) is required to prevent polarization of the sensor when circuit voltage is off.

Figaro recommends the following electrical parts:

R1 : 1kΩ
R2 : 100kΩ
C1 : 22μF
IC : AD708

**NOTE:** When voltage is applied to the sensor output terminal, the sensor may be damaged. Voltage applied to the sensor should be strictly limited to less than ±10mV.




**Basic measuring circuit of TGS5042**

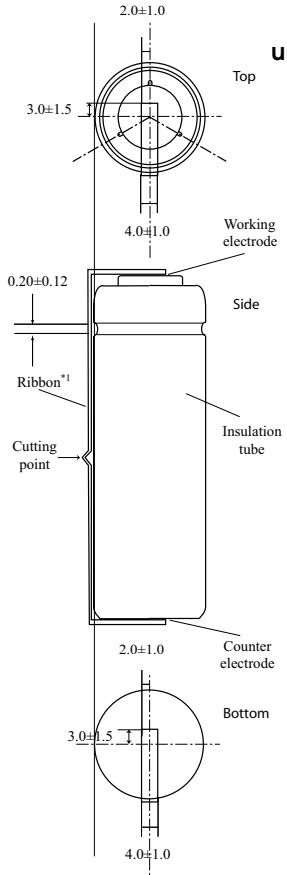
## Specifications:

| Item | Specification |
|---|---|
| Model number | TGS 5042 |
| Target gases | Carbon monoxide |
| Typical detection range | 0 ~ 10,000 ppm |
| Output current in CO | 1.00~3.75nA/ppm |
| Baseline offset | <±15ppm equivalent |
| Operating temperature | -10˚C ~ +60˚C (continuous)<br>-40˚C ~ +70˚C (intermittent) |
| Operating humidity | 5 ~ 99%RH (no condensation) |
| Response time (T90) | within 60 seconds |
| Expected accuracy (*) | ±20% at 0-100ppm of CO<br>±15% at 100-500ppm of CO<br>(at 20±5˚C/50±20%RH) |
| Storage conditions | -10˚C ~ +60˚C (continuous)<br>-40˚C ~ +70˚C (intermittent) |
| Weight | approx. 12g |
| Standard test conditions | 20±2˚C, 40±10%RH |

(*) assumes calibration points of 0 and 500ppm of CO, exposure time of 4 minutes, one day of aging in detector.

## Structure and Dimensions:

**unit: mm**




**NOTE 1:** When the sensor is shipped, the working electrode and counter electrode are connected (i.e. short circuited) by the metal ribbon in order to avoid polarization of the electrodes. To measure the sensor outout, the ribbon should be cut and the sensor connected to a measuring circuit (*see example above*). The cutting point as indicated can be used to cut the ribbon easily.

REV: 03/06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# Ultralow Offset Voltage Dual Op Amp

# AD708

**FEATURES**

**Very High DC Precision**
- **30 μV max Offset Voltage**
- **0.3 μV/°C max Offset Voltage Drift**
- **0.35 μV p-p max Voltage Noise (0.1 Hz to 10 Hz)**
- **5 Million V/V min Open Loop Gain**
- **130 dB min CMRR**
- **120 dB min PSRR**

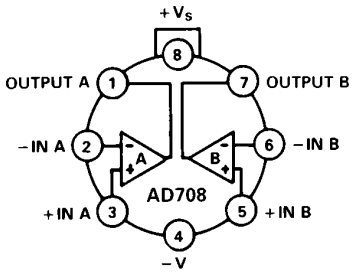
**Matching Characteristics**
- **30 μV max Offset Voltage Match**
- **0.3 μV/°C max Offset Voltage Drift Match**
- **130 dB min CMRR Match**

**Single Version: AD707**

**Available in 8-Pin Plastic Mini-DIP, Hermetic Cerdip and TO-99 Metal Can Packages, Chips and /883B Parts Available.**

**CONNECTION DIAGRAMS**

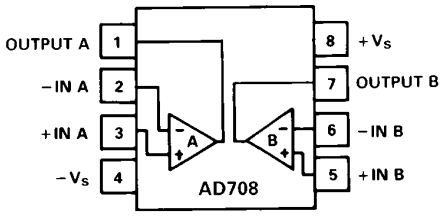
**TO-99 (H) Package**




TOP VIEW

NOTE: PIN 4 CONNECTED TO CASE

**Plastic (N ), and Cerdip (Q) Packages**




TOP VIEW

**PRODUCT DESCRIPTION**

The AD708 is a very high precision, dual monolithic operational amplifier. Each amplifier individually offers excellent dc precision with the best available max offset voltage and offset voltage drift of any dual bipolar op amp. In addition, the matching specifications are the best available in any dual op amp.

The AD708 sets a new standards for dual precision op amps by providing 5 V/μV min open loop gain and guaranteed max input voltage noise of 350 nV p-p (0.1 Hz to 10 Hz). All dc specifications show excellent stability over temperature, with offset voltage drift typically 0.1 μV/°C and input bias current drift of 25 pA/°C max. Both CMRR (130 dB min) and PSRR (120 dB min) are an order of magnitude improved over any available single monolithic op amp except the AD707.

The AD708 is available in four performance grades. The AD708J is rated over the commercial temperature range of 0°C to +70°C and jis available in a plastic mini-DIP package. The AD708A and AD708B are rated over the industrial temperature range of –40°C to +85°C and are available in a cerdip and TO-99 package. The AD708S is rated over the military temperature range of –55°C to +125°C and is available in cerdip and TO-99 packages. Military versions are available processed to MIL-STD-883B, Rev. C.

**APPLICATION HIGHLIGHTS**

1. The combination of outstanding matching and individual specifications make the AD708 ideal for constructing high gain, precision instrumentation amplifiers.
2. The low offset voltage drift and low noise of the AD708 allows the designer to amplify very small signals without sacrificing overall system performance.
3. The AD708's 10 V/μV typical open loop gain and 140 dB common-mode rejection make it ideal for precision applications.
4. Unmounted dice are available for hybrid circuit applications.
5. The AD708 is an improved replacement for the LT1002.

REV. B



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**Tel: 617/329-4700** **Fax: 617/326-8703**

# AD708—SPECIFICATIONS (@ +25°C and ±15 V dc, unless otherwise noted)

| Model | Conditions | AD708J/A Min | AD708J/A Typ | AD708J/A Max | AD708B Min | AD708B Typ | AD708B Max | AD708S Min | AD708S Typ | AD708S Max | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| INPUT OFFSET VOLTAGE[1] | | | 30 | **100** | | 5 | **50** | | 5 | **30** | µV |
| | $T_{MIN}$ to $T_{MAX}$ | | 50 | 150 | | 15 | 65 | | 15 | **50** | µV |
| Drift | | | 0.3 | 1.0 | | 0.1 | 0.4 | | 0.1 | **0.3** | µV/°C |
| Long Term Stability | | | 0.3 | | | 0.3 | | | 0.3 | | µV/Month |
| INPUT BIAS CURRENT | | | 1.0 | **2.5** | | 0.5 | **1.0** | | 0.5 | **1** | nA |
| | $T_{MIN}$ to $T_{MAX}$ | | 2.0 | 4.0 | | 1.0 | **2.0** | | 1.0 | **4** | nA |
| Average Drift | | | 15 | 40 | | 10 | 25 | | 10 | 30 | pA/°C |
| OFFSET CURRENT | $V_{CM}$ = 0 V | | 0.5 | **2.0** | | 0.1 | **1.0** | | 0.1 | **1** | nA |
| | $T_{MIN}$ to $T_{MAX}$ | | 2.0 | 4.0 | | 0.2 | 1.5 | | 0.2 | **1.5** | nA |
| Average Drift | | | 2 | 60 | | 1 | 25 | | 1 | 25 | pA/°C |
| MATCHING CHARACTERISTICS[2] | | | | | | | | | | | |
| Offset Voltage | | | | **80** | | | 50 | | | **30** | µV |
| | $T_{MIN}$ to $T_{MAX}$ | | | 150 | | | 75 | | | **50** | µV |
| Offset Voltage Drift | | | | 1.0 | | | 0.4 | | | **0.3** | µV/°C |
| Input Bias Current | | | | **4.0** | | | **1.0** | | | **1.0** | nA |
| | $T_{MIN}$ to $T_{MAX}$ | | | 5.0 | | | 2.0 | | | **2.0** | nA |
| Common-Mode Rejection | | **120** | 140 | | **130** | 140 | | **130** | 140 | | dB |
| | $T_{MIN}$ to $T_{MAX}$ | 110 | | | 130 | | | **130** | | | dB |
| Power Supply Rejection | | **110** | | | **120** | | | **120** | | | dB |
| | $T_{MIN}$ to $T_{MAX}$ | 110 | | | 120 | | | **120** | | | dB |
| Channel Separation | | 135 | | | 140 | | | 140 | | | dB |
| INPUT VOLTAGE NOISE | 0.1 Hz to 10 Hz | | 0.23 | 0.6 | | 0.23 | 0.6 | | 0.23 | **0.35** | µV p-p |
| | f = 10 Hz | | 10.3 | 18 | | 10.3 | 12 | | 10.3 | 12 | nV/√Hz |
| | f = 100 Hz | | 10.0 | 13.0 | | 10.0 | 11.0 | | 10.0 | 11 | nV/√Hz |
| | f = 1 kHz | | 9.6 | 11.0 | | 9.6 | 11.0 | | 9.6 | 11 | nV/√Hz |
| INPUT CURRENT NOISE | 0.1 Hz to 10 Hz | | 14 | 35 | | 14 | 35 | | 14 | 35 | pA p-p |
| | f = 10 Hz | | 0.32 | 0.9 | | 0.32 | 0.8 | | 0.32 | 0.8 | pA/√Hz |
| | f = 100 Hz | | 0.14 | 0.27 | | 0.14 | 0.23 | | 0.14 | 0.23 | pA/√Hz |
| | f = 1 kHz | | 0.12 | 0.18 | | 0.12 | 0.17 | | 0.12 | 0.17 | pA/√Hz |
| COMMON-MODE REJECTION RATIO | $V_{CM}$ = ±13 V | **120** | 140 | | **130** | 140 | | **130** | 140 | | dB |
| | $T_{MIN}$ to $T_{MAX}$ | 120 | 140 | | 130 | 140 | | **130** | 140 | | dB |
| OPEN-LOOP GAIN | $V_O$ = ±10 V | | | | | | | | | | |
| | $R_{LOAD}$ ≥ 2 kΩ | **3** | 10 | | **5** | 10 | | **4** | 10 | | V/µV |
| | $T_{MIN}$ to $T_{MAX}$ | 3 | 10 | | 5 | 10 | | **4** | 7 | | V/µV |
| POWER SUPPLY REJECTION RATIO | $V_S$ = ±3 V to ±18 V | **110** | 130 | | **120** | 130 | | **120** | 130 | | dB |
| | $T_{MIN}$ to $T_{MAX}$ | 110 | 130 | | 120 | 130 | | **120** | 130 | | dB |
| FREQUENCY RESPONSE | | | | | | | | | | | |
| Closed Loop Bandwidth | | 0.5 | 0.9 | | 0.5 | 0.9 | | 0.5 | 0.9 | | MHz |
| Slew Rate | | 0.15 | 0.3 | | 0.15 | 0.3 | | 0.15 | 0.3 | | V/µs |
| INPUT RESISTANCE | | | | | | | | | | | |
| Differential | | | 60 | | | 200 | | | 200 | | MΩ |
| Common Mode | | | 200 | | | 400 | | | 400 | | GΩ |
| OUTPUT VOLTAGE | $R_{LOAD}$ ≥ 10 kΩ | **13.5** | 14 | | **13.5** | 14.0 | | **13.5** | 14 | | ±V |
| | $R_{LOAD}$ ≥ 2 kΩ | **12.5** | 13.0 | | **12.5** | 13.0 | | **12.5** | 13 | | ±V |
| | $R_{LOAD}$ ≥ 1 kΩ | **12.0** | 12.5 | | **12.0** | 12.5 | | **12.0** | 12.5 | | ±V |
| | $R_{LOAD}$ ≥ 2 kΩ $T_{MIN}$ to $T_{MAX}$ | 12.0 | 13.0 | | 12.0 | 13.0 | | **12.0** | 13 | | ±V |
| OPEN-LOOP OUTPUT RESISTANCE | | | 60 | | | 60 | | | 60 | | Ω |

| Model | Conditions | AD708J/A Min | AD708J/A Typ | AD708J/A Max | AD708B Min | AD708B Typ | AD708B Max | AD708S Min | AD708S Typ | AD708S Max | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| POWER SUPPLY | | | | | | | | | | | |
| Quiescent Current | | | 4.5 | 5.5 | | 4.5 | 5.5 | | 4.5 | 5.5 | mA |
| Power Consumption | $V_S$ = ±15 V | | | | | | | | | | |
| | No Load | | 135 | **165** | | 135 | **165** | | 135 | **165** | mW |
| | $V_S$ = ±3 V | | 12 | **18** | | 12 | **18** | | 12 | **18** | mW |
| Operating Range | | ±3 | | ±18 | ±3 | | ±18 | ±3 | | ±18 | V |

NOTES
[1]Input offset voltage specifications are guaranteed after 5 minutes of operation at $T_A$ = +25°C.
[2]Matching is defined as the difference between parameters of the two amplifiers.
All min and max specifications are guaranteed. Specifications in **boldface** are tested on all production units at final electrical test. Results from those tests are used to calculate outgoing quality levels.
Specifications subject to change without notice.

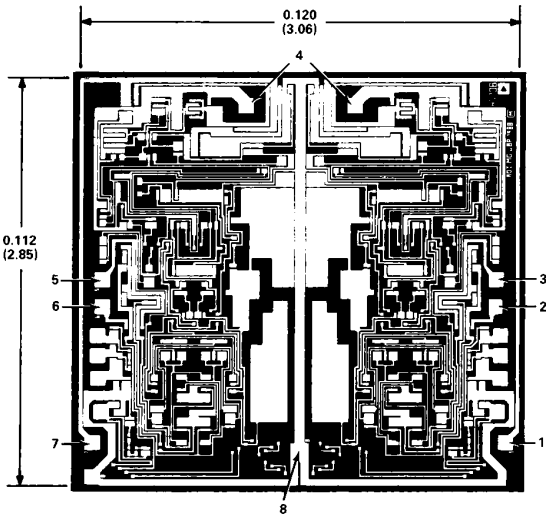
## ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage . . . . . ±22 V
Internal Power Dissipation[2]
Input Voltage[3] . . . . . $\pm V_S$
Output Short Circuit Duration . . . . . Indefinite
Differential Input Voltage . . . . . $+V_S$ and $-V_S$
Storage Temperature Range (Q, H) . . . . . –65°C to +150°C
Storage Temperature Range (N) . . . . . –65°C to +125°C
Lead Temperature Range (Soldering 60 sec) . . . . . +300°C

NOTES
[1]Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
[2]Thermal Characteristics
8-Pin Plastic Package: $\theta_{JC}$ = 33°C/Watt, $\theta_{JA}$ = 100°C/Watt
8-Pin Cerdip package: $\theta_{JC}$ = 30°C/Watt, $\theta_{JA}$ = 110°C/Watt
8-Pin Metal Can Package: $\theta_{JC}$ = 65°C/Watt, $\theta_{JA}$ = 150°C/Watt.
[3]For supply voltages less than ±22 V, the absolute maximum input voltage is equal to the supply voltage.

## METALIZATION PHOTOGRAPH

Dimensions shown in inches and (mm).
Contact factory for latest dimensions.




## ORDERING GUIDE

| Model | Temperature Range | Package Description | Package Option* |
|---|---|---|---|
| AD708JN | 0°C to +70°C | 8-Pin Plastic DIP | N-8 |
| AD708AQ | –40°C to +85°C | 8-Pin Cerdip | Q-8 |
| AD708BQ | –40°C to +85°C | 8-Pin Cerdip | Q-8 |
| AD708SQ | –55°C to +125°C | 8-Pin Cerdip | Q-8 |
| AD708AH | –40°C to +85°C | 8-Pin Header | H-08A |
| AD708BH | –40°C to +85°C | 8-Pin Header | H-08A |
| AD708SH | –55°C to +125°C | 8-Pin Header | H-08A |
| AD708SH/883B | –55°C to +125°C | 8-Pin Header | H-08A |
| AD708J Grade Chips | 0°C to +70°C | Die | |
| AD708S Grade Chips | –55°C to +125°C | Die | |

*N = Plastic DIP; Q = Cerdip; H = Hermetic Metal Can.

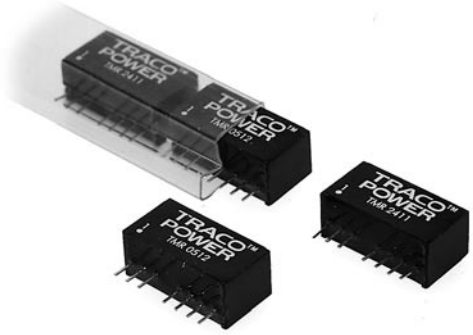
# DC/DC Converters

## TMR 2 Series, 2 Watt

RoHS compliant

### Features

- Wide 2:1 Input Voltage Range
- Compact SIP-8 Package
- Small Footprint
- Full SMD Design
- Temperature Range –40° to +75°C
- High Efficiency
- Excellent Load and Line Regulation
- Indefinite Short-circuit Protection
- I/O-Isolation 1000VDC
- Remote On/Off Control
- Fully RoHS compliant
- 3 Year Product Warranty



The TMR-2 series is a family of isolated 2W dc-dc converter modules with regulated output, featuring wide 2:1 input voltage ranges. The product comes in a compact SIP-8 plastic package with small footprint occupying only 2.0 cm2 (0.3 square in.) of board space.
An excellent efficiency allows –40° to +75°C operation temperatures at full load. Further features include remote On/Off control and continuous short circuit protection. The ultra-compact dimensions of these converters make them an ideal solution for many space critical applications in communication equipment, instrumentation and industrial electronics.

### Models

| Ordercode | Input voltage range | Output voltage | Output current max. | Efficiency typ. |
|---|---|---|---|---|
| TMR 0510 | 4.5 – 9.0 VDC | 3.3 VDC | 500 mA | 64 % |
| TMR 0511 | | 5 VDC | 400 mA | 66 % |
| TMR 0512 | | 12 VDC | 165 mA | 71 % |
| TMR 0521 | | ±5 VDC | ±200 mA | 64 % |
| TMR 0522 | | ±12 VDC | ±85 mA | 69 % |
| TMR 0523 | | ±15 VDC | ±65 mA | 71 % |
| TMR 1210 | 9 – 18 VDC | 3.3 VDC | 500 mA | 70 % |
| TMR 1211 | | 5 VDC | 400 mA | 73 % |
| TMR 1212 | | 12 VDC | 165 mA | 80 % |
| TMR 1221 | | ±5 VDC | ±200 mA | 73 % |
| TMR 1222 | | ±12 VDC | ±85 mA | 78 % |
| TMR 1223 | | ±15 VDC | ±65 mA | 78 % |
| TMR 2410 | 18 – 36 VDC | 3.3 VDC | 500 mA | 71 % |
| TMR 2411 | | 5 VDC | 400 mA | 74 % |
| TMR 2412 | | 12 VDC | 165 mA | 81 % |
| TMR 2421 | | ±5 VDC | ±200 mA | 74 % |
| TMR 2422 | | ±12 VDC | ±85 mA | 78 % |
| TMR 2423 | | ±15 VDC | ±65 mA | 80 % |
| TMR 4810 | 36 – 75 VDC | 3.3 VDC | 500 mA | 70 % |
| TMR 4811 | | 5 VDC | 400 mA | 73 % |
| TMR 4812 | | 12 VDC | 165 mA | 79 % |
| TMR 4821 | | ±5 VDC | ±200 mA | 71 % |
| TMR 4822 | | ±12 VDC | ±85 mA | 77 % |
| TMR 4823 | | ±15 VDC | ±65 mA | 77 % |

## Input Specifications

| | | |
|---|---|---|
| Input current at full load (nominal input) | 5 Vin models: | 645 mA max. |
| | 12 Vin models: | 242 mA max. |
| | 24 Vin models: | 117 mA max. |
| | 48 Vin models: | 62 mA max. |
| Surge voltage (100 msec. max.) | 5 Vin models: | 15 V max. |
| | 12 Vin models: | 25 V max. |
| | 24 Vin models: | 50 V max. |
| | 48 Vin models: | 100 V max. |
| Input voltage variation (dv/dt) | | 5 V/ms, max. (complies to ETS 300 132 part. 4.4) |
| Input Filter | | capacitor type |
| Start up time | | 1 ms typ. (at nominal input and resistive load) |

## Output Specifications

| | | |
|---|---|---|
| Voltage set accuracy | | ±1 % |
| Regulation | – Input variation Vin min. to Vin max. | 0.5 % max. |
| | – Load variation 10–100 % 3.3 VDC models: | 0.85 % max. |
| | single output models: | 0.75 % max. |
| | dual output models balanced load: | 1.0 % max. |
| | dual output models asymetric load: | 5.0 % max. (25% /100%) |
| Ripple and noise (20 MHz Bandwidth) | | 50 mVpk-pk max. |
| Temperature coefficient | | ± 0.1 %/°C |
| Short circuit protection | | continuous, automatic recovery |
| Minimum load | | 10% of rated max current (operation at lower load condition is safe but a higher output ripple will be experianced) |
| Capacitive load | 3.3 VDC / 5 VDC output models: | 2'200 µF max. / 1'000 µF max. |
| | 12 VDC / ±5 VDC output models: | 170 µF max. / ±470 µF max. |
| | ±12 VDC / ±15 VDC output models: | 100 µF max. / ± 47 µF max. |

## General Specifications

| | | |
|---|---|---|
| Temperature ranges | – Operating | – 40 °C ... + 75 °C (no derating) |
| | – Storage | – 55 °C ... + 105 °C |
| Humidity (non condensing) | | 95 % rel. H max. |
| Reliability, calculated MTBF (MIL-HDBK-217 F) | | > 2.3 Mio h @ 25°C |
| Isolation voltage (60 sec) | – Input/Output | 1'000 VDC |
| Isolation capacity | – Input/Output | 300 pF max. |
| Isolation resistance | – Input/Output (500 VDC) | > 1'000 MOhm |
| Switching frequency | | 100 to 650 kHz (PFM) |
| Remote On/Off | – On: | open or high impedance |
| | – Off: | 4...8 mA input current applied via 1KW resistor |
| | – Off stand by input current | max. 1mA |

## Physical Specifications

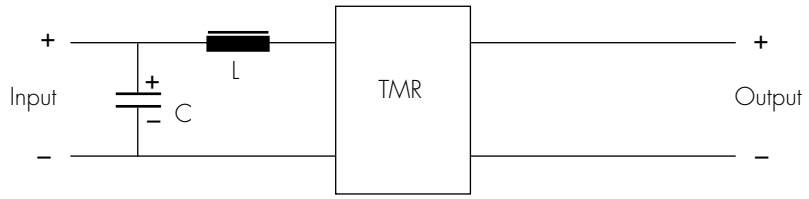
| | |
|---|---|
| Case material | non-conductive plastic |
| Potting material | epoxy, UL 94V-0 - rated |
| Weight | 4.8g (0.17oz) |

Application notes can be downloaded under:
www.tracopower.com/products/tmr2_application.pdf

All specifications valid at nominal input voltage, full load and +25°C after warm-up time unless otherwise stated.

## EMC Characteristics

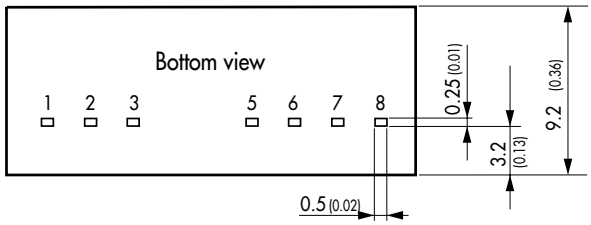
- Use an electrolytic low ESR capacitor at input side to reduce reflected ripple current.
- In order to meet EN55022 class B additionally use a choke to build an L/C filter as follows:

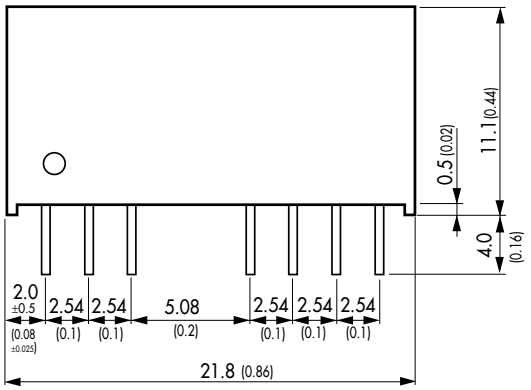



Recommended values for filter:

| Input | C | L |
|---|---|---|
| 5VDC | 100µF | 10µH |
| 12VDC | 100µF | 10µH |
| 24VDC | 10µF | 120µH |
| 48VDC | 10µF | 120µH |

## Outline Dimensions mm (inches)




| Pin-Out | | |
|---|---|---|
| **Pin** | **Single** | **Dual** |
| **1** | –Vin (GND) | –Vin (GND) |
| **2** | +Vin (Vcc) | +Vin (Vcc) |
| **3** | Remote On/Off | Remote On/Off |
| **5** | No function | No function |
| **6** | +Vout | +Vout |
| **7** | –Vout | Common |
| **8** | No function | –Vout |

Specifications can be changed any time without notice

FIGARO

*an ISO9001 and 14001 company*

## *Technical Information for the CDM4161 $CO_2$ Module*

**CDM4161 is a new unit which uses TGS4161, Figaro's low-power consumption solid electrolyte $CO_2$ sensor. Due to Figaro's proprietary idea for signal processing with a microcomputer, no maintenance is required for this module. When compared with traditional $CO_2$ sensor modules using IR sensors, Figaro's $CO_2$ module is much more cost effective, making this module the ideal choice for indoor air quality control systems.**

***Page***

## 1. Basic Information

1-1 *Features*

* High selectivity to $CO_2$
* Maintenance free
* Low power consumption
* Long life
* Compact size
* Pre-calibrated
* Low cost

1-2 *Applications*

* *Indoor air quality control*
* *$CO_2$ monitors*

1-3 *Specifications*

The specifications of CDM4161 are contained in Table 1. Depending on the customer's target concentration range, Figaro offers two versions of this module as indicated in Table 1. Customized modules are available according to special requests from customers. Please consult with Figaro.

1-4 *Dimensions (see Fig. 1 below)*

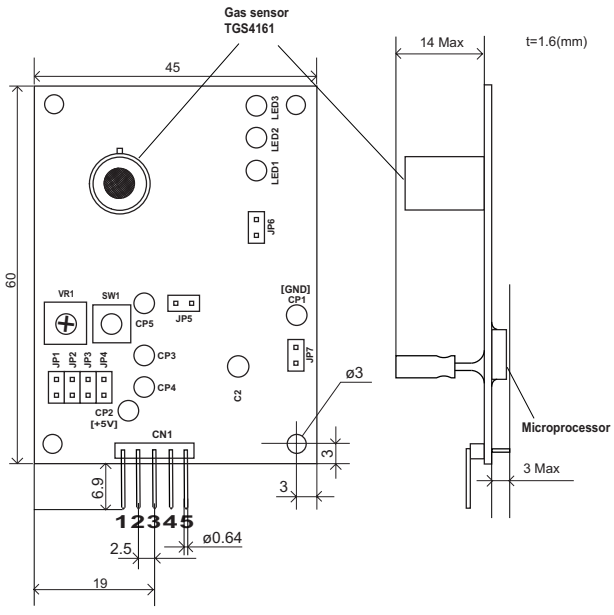



Fig. 1 - CDM4161 dimensions

## 2. Structure and Functions

2-1 *Solid electrolyte $CO_2$ sensor TGS4161*

The sensor changes its output voltage in response to exposure to $CO_2$ gas. The sensor should not be directly connected with low-input impedance equipment. To read sensor output, amplified voltage (CP3) should be used. Please refer to *"TGS4161 Technical Information"* for details as to the characteristics of the sensor.

2-2 *Sensor's output signal voltage (CP3)*

The sensor's output can be read as an amplified voltage (as taken from the differential amplifier). Voltage should be read from this port.

2-3 *Variable resistor (VR1)*

This resistor is pre-calibrated at Figaro's factory prior to shipment. Do not turn the screw—if this would be done, the module may not meet specifications.

2-4 *Microprocessor*

The microcomputer takes data and renews it once per second. The processor calculates $CO_2$ concentrations based on the difference between current sensor output and a baseline value (which represents the sensor output value in fresh air).

2-5 *Thermistor signal output voltage (CP4)*

The thermistor's output signal voltage, which is used for compensation of the sensor's temperature dependency, can be read at this port.

2-6 *Concentration setting for control signal (JP3, JP4)*

Concentrations utilized for control signals (i.e. the *control concentration*) can be changed by modifying

| Pin No. | Name | Description |
|---|---|---|
| 1 | $V_{IN}$ | Power supply input |
| 2 | $V_{CONC}$ | $CO_2$ concentration output |
| 3 | CTRL | Control signal output |
| 4 | TRBL | Trouble signal output |
| 5 | GND | Common ground |

Table 2 - CDM4161 pin designations of CN1
**NOTE:** CN1 should be MB5P-90S, mfg. by JST.
Recommended receptacle for connector: 05JQ-BT, mfg. by JST.

| | | |
|---|---|---|
| Product name | Carbon dioxide ($CO_2$) sensor module | |
| Model No. | CDM4161-L00 | CDM4161-M00 |
| Detection range | 400 to 4,000ppm | 400 to 8,000ppm |
| Sensor (principle) | TGS4161 (solid state electrolyte) | |
| Accuracy (*1) | approx. ±20% full scale | |
| Power supply | DC5.0±0.2V regulated | |
| Power consumption | 300mW (Max) | |
| Operational temperature & humidity range | -10˚~+50˚C, 5~95%RH (avoid condensation) | |
| Storage temperature & humidity range | -20˚~+60˚C, 5~90%RH (pack in a moisture proof bag) | |
| Warm up time | 2 hours | |
| $CO_2$ concentration signal (*2) | Continuous analog output proportional to $CO_2$ concentration | |
| | Vconc = $CO_2$ concentration/1,000 (DC 4V full scale) | Vconc = $CO_2$ concentration/2,000 (DC 4V full scale) |
| Control signal | ON: HIGH output (when $CO_2$ conc. exceeds threshold)<br>OFF: LOW output | |
| | 800/ 1,000/ 1,500/ 2,000 (ppm) | 1,000/ 2,000/ 5,000/ 8,000 (ppm) |
| Malfunction signal | ON: LOW output (sensor malfunction)<br>OFF: FLOAT NC | |
| LED display | Green LED: Lights while power is on (blinks during warm up) | |
| | Yellow LED: Blinks during trouble | |
| | Red LED: Lights when $CO_2$ concentration exceeds the threshold | |
| Reset switch | Establishes the ambient $CO_2$ concentration as 400ppm when pushed | |
| Dimensions | 45 x 60 x 19mm (45 x 67 x 19mm incl. CN1) | |
| Weight | approx. 17g | |

Table 1 - Specifications

**Note 1:** Assumes benchmark is set accuractely at 400ppm of $CO_2$. This value does not contain long term drift.

**Note 2:** In this module, the $CO_2$ concentration is calculated by measuring the relative change of sensor output at the measuring point from sensor output in clean air (assumed to be 400ppm of $CO_2$).

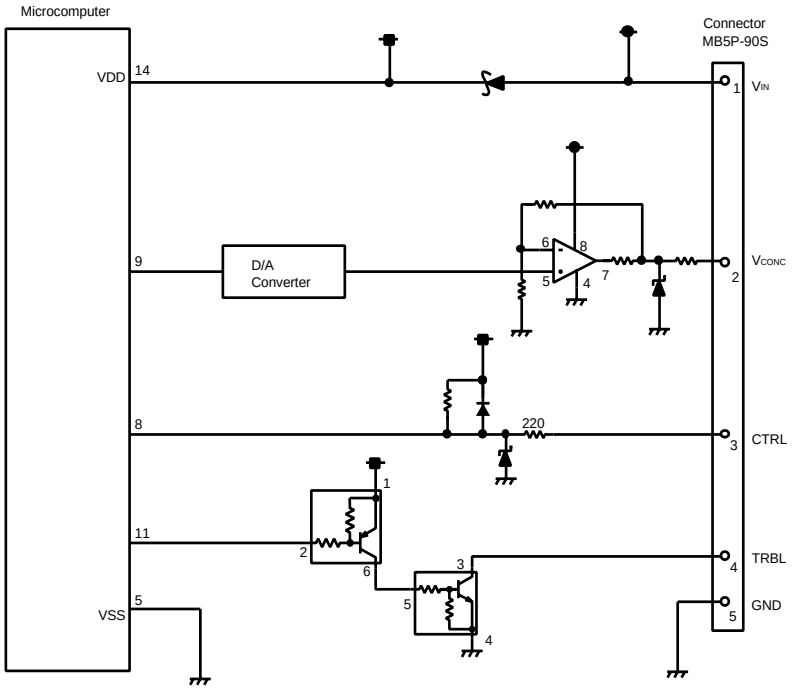



Fig. 2 - Circuit diagram of interface for circuit

the settings of JP3 and JP4 as shown in Table 3. The module is pre-set at Mode I before shipment.

2-7 *Baseline reset switch*

The baseline value may be manually reset using this switch. When this switch is pushed, the sensor's output at that moment is memorized as 400ppm of $CO_2$ (the baseline value in fresh air). When the switch is pushed during warm-up time (within the first two hours after the module is powered on), the baseline voltage is read at that moment and the module immediately goes into operation mode.

**Caution:** If the baseline reset switch is pushed while in a polluted environment where the actual $CO_2$ concentration is higher than 400 ppm (ambient levels), the accuracy of readings may become adversely affected.

2-8 *Input-output signal (CN1)*

Please refer to *Table 4-Rated input and output voltages* for rated values. Also please refer to *Fig. 2-Circuit diagram of interface for circuit.*

2-8-1 *Vin (Pin No. 1)*
Regulated voltage should be input into this port. The sensor's output may vary according to the sensor's voltage dependency characteristics if the input voltage fluctuates. Please refer to *"TGS4161 Technical Information"* for details.

2-8-2 *Concentration output (Pin No. 2)*
An analog voltage ($CO_2$ concentration/1000) corresponding to $CO_2$ concentration is output from this port.

| Mode | JP3 | JP4 | Threshold $CO_2$ Concentration of Control Signal | | | |
|---|---|---|---|---|---|---|
| | | | CDM4161-L00 | | CDM4161-M00 | |
| | | | ON | OFF | ON | OFF |
| I | OPEN | OPEN | 800ppm | 720ppm | 1,000ppm | 900ppm |
| II | OPEN | SHORT | 1,000ppm | 900ppm | 2,000ppm | 1,800ppm |
| II | SHORT | OPEN | 1,500ppm | 1,350ppm | 5,000ppm | 4,500ppm |
| IV | SHORT | SHORT | 2,000ppm | 1,800ppm | 8,000ppm | 7,200ppm |

Table 3 - CDM4161 jumper pin settings

2-8-3 *Control signal output (Pin No. 3)*
When $CO_2$ concentrations exceed the control concentration, output from this port will be "ON".

2-8-4 *Trouble signal output (Pin No. 4)*
This port will output "ON" in the following situations:

* when the sensor's heater is broken
* when the connection for control concentration setting is broken

2-9 *LEDs (refer to Table 5)*

2-9-1 *Green LED (LED 1)*
The green LED indicates the module's power condition. It will be lit when the power is on. The LED blinks on and off during warm-up time (for the first two hours after power is turned on).

2-9-2 *Yellow LED (LED 2)*
The yellow LED indicates a trouble condition. It

| Pin No. | Item | | Minimum | Typical | Maximum | u/m |
|---|---|---|---|---|---|---|
| 1 | Power supply input ($V_{IN}$) | | 3.5 | 5.0 | 5.5 | V |
| 2 | $CO_2$ conc. output ($V_{CONC}$) | Output voltage | 0.0 | - | $V_{IN}$ | V |
| | | Allowable voltage | - | - | 5.5 | V |
| 3 | Control signal output (CTRL) | Output voltage (OFF) $I_{OL}$=1mA | - | - | 0.2 | V |
| | | Output voltage (ON) $I_{OH}$=1mA | $V_{IN}$-0.6 | - | - | V |
| | | Allowable voltage | - | - | 5.5 | V |
| | | Allowable current | - | - | 25 | mA |
| 4 | Trouble signal output (TRBL) | Output voltage (ON) $I_C$=5mA | - | - | 0.3 | V |
| | | Allowable voltage | - | - | 50 | V |
| | | Allowable current | - | - | 100 | mA |

Table 4 - Rated input/output voltages

| Condition | Green LED | Yellow LED | Red LED | Control signal (CTRL) | Trouble signal (TRBL) | $CO_2$ concentration signal | |
|---|---|---|---|---|---|---|---|
| | | | | | | CDM4161-L00 | CDM4161-M00 |
| Warm up period | Blink ON/OFF | OFF | OFF | OFF | OFF | 0.4V | 0.2V |
| $CO_2$ Conc. < Threshold | ON | OFF | OFF | OFF | OFF | $CO_2$ conc./1000V | $CO_2$ conc./2000V |
| $CO_2$ Conc. ≥ Threshold | ON | OFF | ON | ON | OFF | $CO_2$ conc./1000V | $CO_2$ conc./2000V |
| Trouble | ON | Blink ON/OFF | OFF | OFF | ON | HIGH | HIGH |

Table 5 - Signal output in operation mode

blinks on and off when trouble signal output is "ON".

2-9-3 *Red LED (LED 3)*
The red LED indicates that $CO_2$ concentration is over the control concentration level. It lights when control signal output is "ON".

**3. Operation modes**

3-1 *Warm up*

The sensor is warmed up for two hours after the module is powered on. The green LED blinks on and off and a constant voltage (0.4V) is output from the concentration output port during this period. The green LED will be lit continuously after the warm-up period ends unless a power outage occurs.

3-2 *$CO_2$ concentration lower than calibrated concentration*

The green LED will be on if the calculated $CO_2$ concentration is lower than the calibrated concentration.

3-3 *$CO_2$ concentration exceeds calibrated concentration*

The red LED will be lit and the control signal output is turned "ON" if $CO_2$ concentration exceeds the calibrated concentration.
The control signal output is turned to "OFF" and the LEDs will return to the status described in Item 2-9-2 when $CO_2$ concentration drops to 90% of the calibrated concentration.

3-4 *Trouble*

Whenever a trouble situation occurs, such as heater breakage, the yellow LED blinks on and off and the TRBL signal is set to "ON.

**4. Cautions**

1) By assuming that the baseline level represents fresh air (400ppm of $CO_2$), actual $CO_2$ concentrations are calculated based on the difference between the baseline level and the current sensor output. As a result, the following cautions should be noted:

a) Accurate readings cannot be expected if an accurate baseline could not be acquired.

b) The sensor should be exposed to fresh air periodically to properly renew the baseline level. Performance shown in the specifications cannot be achieved if the module was used in an environment where $CO_2$ concentrations increased slowly and steadily for a long period of time.

c) The module should be located in fresh air during the warm-up period. Accurate readings cannot be expected until the baseline is acquired in fresh air. If the module is warmed up in an environment where $CO_2$ concentration is higher than normal fresh air, the baseline will represent a polluted level and the device will not be able to clean the air sufficiently.

d) Power should be on at all times. Since the baseline is memorized in a microcomputer, if the power should be cut off, the memory would be lost and operation would resume from the warm-up process.

e) The module is not intended for usage in life saving equipment. If the module is incorporated into life saving equipment, an alternative and secure measure for calculating $CO_2$ concentration should be used be used for the life safety function.

2) This module is designed only for indoor usage. The module should be protected from exposure to rain, wind, sun, heat radiation, etc.

3) Please apply a regulated voltage, otherwise the accurate reading cannot be expected. Application of excessive and/or reverse voltage would cause damage to the module.

4) The sensor may deteriorate if it is stored without power in a high humidity environment for a long period of time. Please keep the sensor in a humidity-proof bag with a desiccant if the sensor is to be stored

without power for a long period of time.

5) Please refer to *"TGS4161 Technical Information"* for other handling precautions of TGS4161.

**5. Important Notice**

Figaro Engineering Inc. (Figaro) reserves the right to make changes without notice to any products herein to improve reliability, functioning or design.

Information contained in this document is believed to be reliable. However, Figaro does not assume any liability arising out of the application or use of any product or circuit described herein; neither does it convey any license under its patent rights, nor the rights of others.

**IMPORTANT NOTE**
This product is not designed and authorized for use as a component in life support applications wherein a failure or malfunction of the products may result in injury or threat to life. Figaro Engineering Inc. reserves the right to make changes to this product without notice to improve reliability, functioning, and/or design.

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# FCM6812 - Pre-calibrated module for combustible gas

## Features:

* **Linear analog output proportional to gas concentration**
* **Maintenance free**
* **Compact size**
* **Meets RoHS requirements**
* **Meets IEC60079-15:2001 requirements**

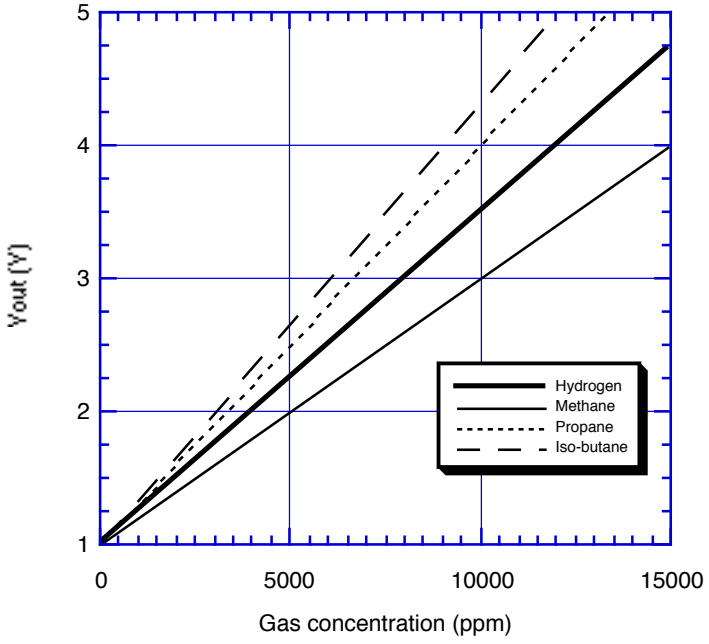
## Applications:

* **Gas leak detection in fuel cell systems**

The **FCM6812** combustible gas sensor module is a new unit which utilizes **TGS6812**, Figaro's catalytic pellistor type gas sensor which features durability, stability, and quick gas response. This module provides analog output voltage proportional to hydrogen gas concentration. FCM6812 is resin coated for waterproofing and electrical insulation purposes, and also is also capable of detecting sensor wire breakage. The unit has a wide range of operating temperature from -10˚ to +60˚C.

Because the TGS6812 sensor can detect methane and LP gas as well as hydrogen, this module is suitable for gas leak detection in stationary fuel cells which use hydrogen generated from combustible gases.

**Caution:**
The TGS6812 gas sensor offers a practical explosion-proof structure due to double 100 stainless mesh covering its opening which meets IEC60079-15:2001 requirements. However, this construction is not able to satisfy the requirements of an intrinsically safe structure. In the case where an intrinsically safe device is required, simple measures such as the addition of a sintered metal explosion-proof housing should be added in order to meet these requirements.




**Sensitivity Characteristics**
The figure to the right represents typical sensitivity characteristics, all data having been gathered at standard test conditions (*see reverse side of this sheet*). The Y-axis is indicated as output voltage.

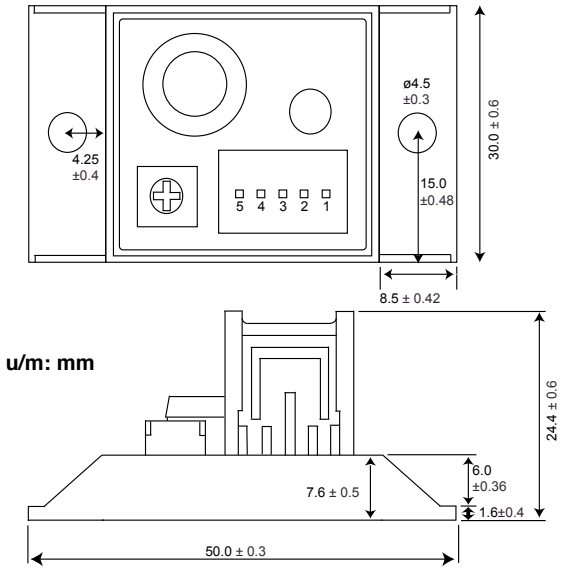
## Specifications

| | | |
|---|---|---|
| Product name | Combustible gas sensor module | |
| Model No. | FCM6812-P00 | |
| Gas sensor | TGS6812 (catalytic type) | |
| Detection range | 0 to 14,000ppm of $H_2$<br>(also can detect methane, iso-butane, and propane) | |
| Output signal | 0~4.5V DC (up to max $V_{IN}$) | |
| | Normal operation | Vout = [$H_2$ conc(ppm)/4000] + 1.0 |
| | Vout in air | 1.0±0.2V(*) |
| | Vout in 8000ppm $H_2$ | 3.0±0.2V(*) |
| | Trouble | Vout = 0~0.1V<br>(recommended threshold for trouble detection = 0.2V) |
| Response time (T90) to 4000ppn $H_2$ | ≤30 seconds | |
| Warm up time (Vconc<2.0V) | ≤30 seconds | |
| Operating conditions | -10˚~+60˚C, 5~95%RH (avoid condensation) | |
| Storage conditions | -10˚~+60˚C, 5~95%RH | |
| Input voltage | 5.0±0.2V DC | |
| Power consumption | approx 1.0W | |
| Weight | approx. 15g | |
| Dimensions | 50 x 30 x 24.4mm | |
| Position dependency | Since the module has position dependency, it should be mounted so the two lug-holes are in a horizontal position | |
| Standard test conditions | Ambient conditions | 20±2˚C, 65±5%RH |
| | Circuit conditions | 5.0±0.2V DC |
| | Conditioning period prior to test | ≥10 min. |

(*) represents sensor output under standard test conditions

| Pin No | Name | Description |
|---|---|---|
| 1 | GND | Common ground |
| 2 | - | Not connected |
| 3 | - | Not connected |
| 4 | Vconc | Concentration output voltage |
| 5 | Vin | Input voltage |

**FCM6812 pin connections**
(Connector model BH05B-XMSK)
Recommended receptacle for connector: XMP-05V




**FCM6812 dimensions**

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REV: 10/07

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# *Technical Information for Air Quality Control Module AM-1*

**The Figaro AM-1 is a sensor module which is useful for evaluating the application of Figaro's air quality sensors into air quality control products. The module contains a gas sensor, microprocessor, and control circuit.**

## 1. Product Description

Figaro Engineering, Inc. has developed excellent air contaminant gas sensors (TGS2600 and TGS2602) and a microcomputer (FIC-02667) for automatic control of air quality control devices such as air cleaners and ventilators. For such applications, rather than measuring actual contamination levels, the output signal of Figaro sensors is compared to a benchmark level. The degree of change from the threshold value determines the level of operation of the air cleaning device.

Due to the complexity of understanding sensor performance and processing sensor output to optimize air quality controller performance, the AM-1 sensor module was prepared. This module allows users to minimize development time and produce an automatic air quality device with high sensitivity to changes in indoor air pollution and intricate operation similar to human reaction.

The AM-1 unit is composed of a user-selected air contaminant sensor and the FIC02667 microprocessor—its purpose is to help users understand and evaluate the features of these components by observing their actual performance.

Figaro's air contaminant sensors detect deoxidizable gases contained in indoor pollutants with excellent sensitivity through electrical resistance change.

The FIC02667 microprocessor evaluates pollution levels in four degrees according to a signal sent from the gas sensor. FIC02667 com-pensates the effects of humidity, atmospheric temperature and transient gases on the sensor, and generates control signals for an air quality controller based on its estimation of pollution levels. To use TGS sensors for automatic ventilation applications, special software would be required—please refer to technical infor-mation titled "*Signal Processing for Automatic Ventilation Systems using TGS Gas Sensors*".

The illumination of LEDs on the AM-1 indicates the level of atmospheric pollution, allowing this sensor module to function as a pollution monitor. LED illumination is decided by a control signal sent from the microprocessor.

## 2. Components

Figure 1 (below) shows the components of AM-1 and their functions:

a) *Input terminal*: DC 5.0 ± 0.2V
b) *Gas sensor*
Users may choose among TGS2600 and TGS2602. A decrease in electrical resistance of the sensor (Rs) occurs when indoor atmospheric pollution increases. The gauze of the sensor cap usually gets warm because the sensing element is heated—this is not an abnormal condition.
c) *Load resistor (R4)*
Connected to the sensor in series. The change of the sensor's electrical resistance can be monitored by measuring voltage across the load

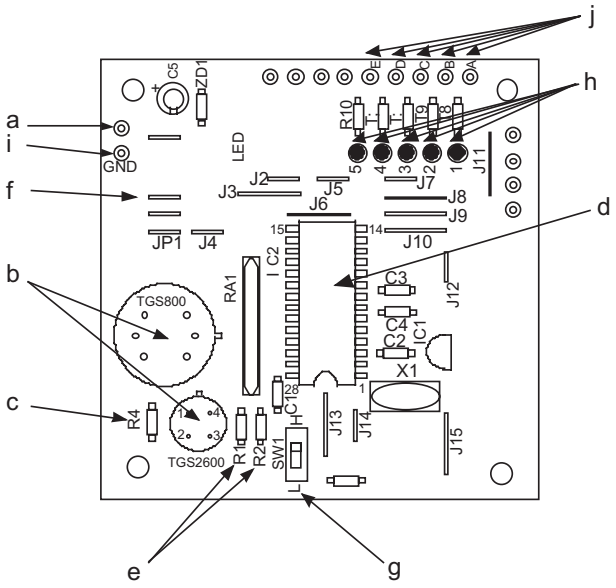


Figure 1 - AM-1 Components

resistor. This voltage is called sensor output (Vout).

d) *Microcomputer (FIC02667)*

The microprocessor reads the signal from the sensor, compares it to a memorized benchmark value corresponding to a clean atmosphere level, evaluates the degree of pollution and generates the appropriate signal to control an air quality controller.

e) *Operation mode resistors (R1, R2)*

See Appendix A (*Selection of Operation Modes for AM-1*)

f) *Operation mode jumper (JP3)*

See Appendix A (*Selection of Operation Modes for AM-1*)

g) *Sensitivity changeover switch*

The FIC02667 microcomputer contains software to control an air quality device at High and Low sensitivities. When in the down position (see Fig. 1), sensitivity is set to High. Setting the switch in the up position will make sensitivity Low.

h) *LED for pollution degree indication*

The degree of indoor atmospheric pollution is indicated by the LEDs as activated by the microcomputer. When LED 2 is on, one of the LEDs 3 through 5 lights up at the same time.

LED 1 (green) : Good
LED 2 (red) : Polluted
LED 3 (amber) : Pollution - low
LED 4 (amber) : Pollution - medium
LED 5 (amber) : Pollution - high

LEDs 3 through 5 are connected with the microprocessor's three control ports which generate one signal each to direct the air quality controller—Low Operation, Medium Operation and High Operation. When the level of atmospheric pollution changes from 'Good' to 'Pollution - low', LED 4 will light for one second, followed by LED 3 in order to shorten the warm-up time of the fan's motor.

i) *Terminal for GND:*

Common terminal for the microprocessor's output terminals (Item j below) and for the +5V power supply output terminal (Item k below).

j) *Terminals for the microprocessor's output*

LEDs 1 to 5 correspond to terminals A to E respectively. The output voltage at the terminal becomes 0 V when its corresponding LED is on and becomes 5V when its corresponding LED is off. Recording each terminal output together with the sensor output (measured across both ends of R4) on a chart, the user can examine the operation of AM-1 in detail. Furthermore, users can examine the effect of automatic control on air quality devices by connecting such devices to the desired terminals (A~E) via an interface circuit (*See Specifications—Page 4*).

k) *Output terminal of +5V power supply*

Can be used as power supply for an interface circuit (*See Specifications—Page 4*).

## 3. Performance

After powering on, the AM-1 goes through an Initial Clean-up Operation for two minutes, High Sensitivity Operation for three minutes, and then into Standard Operation.

a. *Initial clean-up operation*

For two minutes after first being powered on, LED 1 (Good) blinks on and off in a 0.5 second cycle regardless of pollution levels. If an air quality controller is connected to the unit, the device will not function during the Initial Clean-up Operation mode. At the end of this operation, LED 1 stays on continuously and the output signal level of the sensor is memorized by the microcomputer as a benchmark signal level for clean air.

**NOTE:** If polluted levels exist at the time of powering on, the initial baseline level would be set at such a high pollution level that the device would not activate despite the presence of pollutants.

b. *Standard operation*
AM-1 in Standard Operation mode continuously indicates the degree of pollution with the LEDs, based on ratio of sensor resistance to the benchmark resistance value of 'clean air'. The benchmark signal level for clean air in the microcomputer is periodically (factory preset is every 20 minutes) or manually reset.

## 4. Troubleshooting

| Problem | Cause | Solution |
|---|---|---|
| All LED's off | drop in power or disconnection | check power connections |
| | no power | check power |
| Other | malfunction of microcomputer caused by external noise | disconnect power, reconnect, and restart |
| | other | call for repair |

## 5. Specification

| Item | Specification | |
|---|---|---|
| Power Supply | DC 5 V±0.2 V | |
| Power Consumption | AM-1-2600 : Max 0.8W<br>Others: Max 1.2W | |
| Target Gas | Indoor atmospheric pollution caused by deoxidizable pollutant gases (**note**: *does not react to dust*) | |
| Sensitivity (factory preset) | High | 3ppm of $H_2$ |
| | Low | 6ppm of $H_2$ |
| LED display | LED1 (green) | good |
| | LED2 (red) | polluted |
| | LED3 (amber) | low pollution level |
| | LED4 (amber) | medium pollution level |
| | LED5 (amber) | high pollution level |
| Microprocessor output terminals | Active Level | "Low" (for C-MOS open drain output of each terminal) |
| | Max. output current | +20mA including LED driving current |
| Output terminal of +5V power supply | Max. output current | 0.5 A |
| Operational temperature range | -10 ~ 50˚C, 5 ~ 70%RH<br>(avoid condensation on the unit) | |
| Storage temperature range | -20 ~ 60˚C, 5~90%RH% | |
| Dimensions | 70mm x 70mm x 40 mm | |
| Weight | 20 g | |

**6. Product code for AM-1**

The AM-1 unit can use the following Figaro air quality monitoring sensors. When purchasing this unit, please indicate which sensor module is required:

| Sensor | Module Code # |
|---|---|
| TGS2600 | AM-1-2600 |
| TGS2602 | AM-1-2602 |

**7. Notes**

a. *Installation guidelines*

1) Avoid exposure to rain, direct sunlight and heat radiation
2) Protect against vibration
3) The sensor should not be located in an unventilated area. However, since the sensor is a heated element, it should not be placed where it is directly exposed to strong airflow.

b. Since AM-1 is designed for evaluation only, the operational stability of this unit against fluctuation of power supply voltage or external noise is not specified.

c. The air contaminant gas sensors used in this unit (TGS2600 or TGS2602) can also be purchased separately as well as the FIC02667 microprocessor.

## 8. Circuit diagram

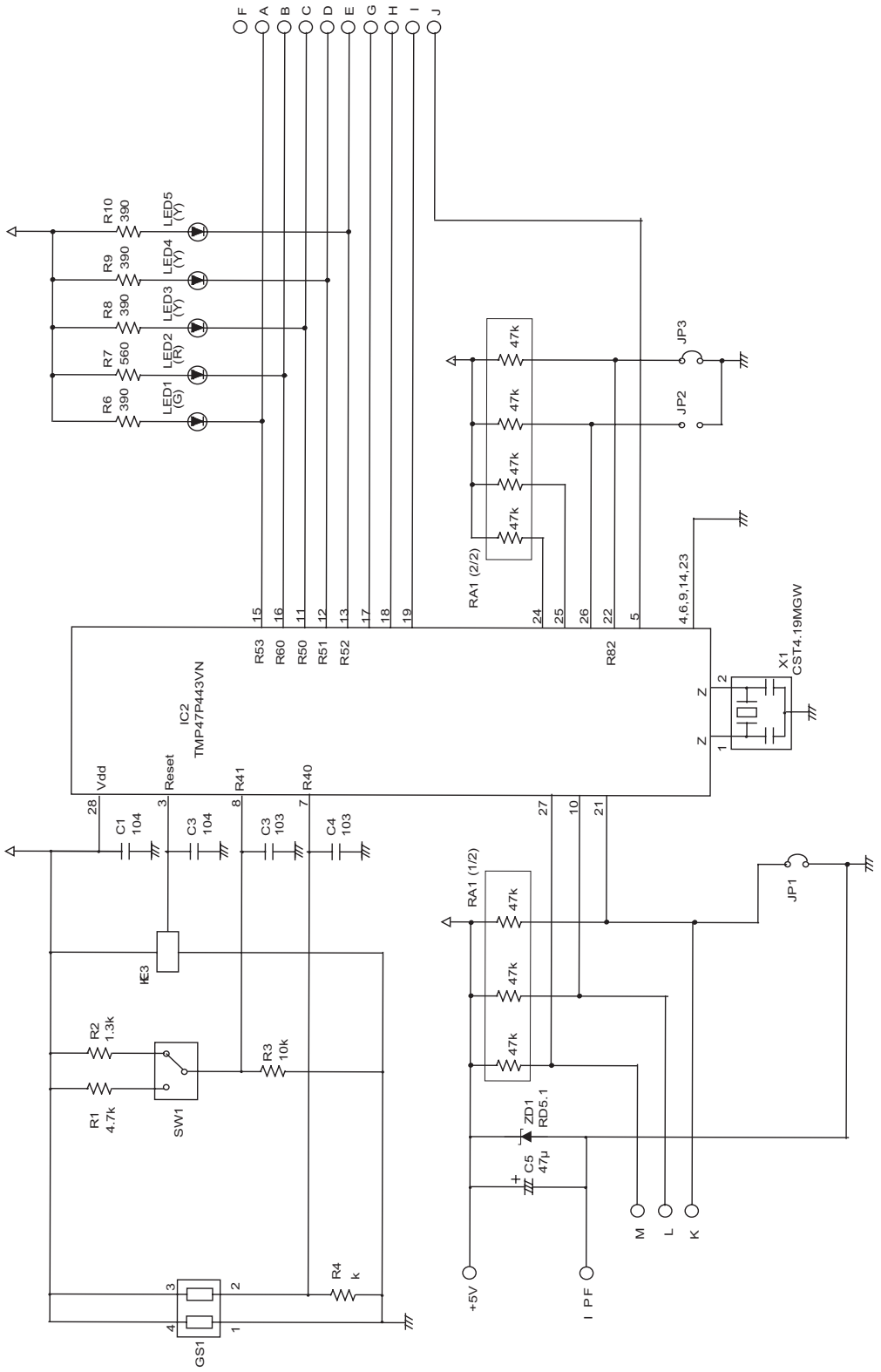


Figure 2 - Circuit diagram of AM-1

## Appendix A

The AM-1 unit has a specially developed microprocessor FIC02667 which has additional functions that can be selected by users according to the desired application.

### 1. Selection of Operation Modes

By using jumper J3, automatic operation can be selected according to the air quality controller's capacity control--two step (high/low) or three step (high/medium/low). Operation mode can be set by JP3 as follows:

| Capacity | JP3 |
|---|---|
| Two-step | Disconnect |
| Three step | Connect |

Figaro provides the initial setting for JP3 as connected.

JP1 and JP2 are determined at the factory. Regarding these jumpers, please do not change the original settings.

### 2. Specifying Sensitivity

The FIC02667 can evaluate the degree of pollution by comparing the sensor resistance ratio (sensor resistance / benchmark value) with the preset threshold value (ΔR). To change the ΔR value, the user should adjust the input voltage (V(K1)) applied to the sensitivity control port of the microprocessor (Pin 6). The higher the input voltage, the greater the sensitivity. The sensitivity control input voltage must be in the range of 1.0 V to 4.5 V.

In the AM-1 unit, the V(K1) value can be adjusted by changing the resistance value of R4 and R5 according to the following formula:

*Sensitivity = "H": V(K1) = 5 * R6 / (R4+R6)*

or

*Sensitivity = "L": V(K1) = 5 * R6 / (R5+R6)*

Threshold level for "On"

Low pollution level : V(K1) / 5
Medium pollution level : [V(K1) / 5] - 0.078
High pollution level : [V(K1) / 5] - 0.158

Threshold level for "Off":

Low pollution level : [V(K1) / 5] + 0.023
Medium pollution level : [V(K1) / 5] - 0.078 + 0.023
High pollution level : [V(K1) / 5] - 0.158 + 0.023

In order to avoid a chattering for generating the output signal corresponding to each pollution level, a difference is preset for threshold values between "On" and "Off" in the FIC02667.

Factory preset values for V(K1):

R4 = 1.3 kΩ
R5 = 4.7kΩ
R6 = 10 kΩ

According to the above listed formulas and factory preset values of R4~R6, threshold values for V(K1) can be calculated as follows:

*Sensitivity changeover switch "H"*

V(K1) = 4.42 V

| Pollution Level | On | Off |
|---|---|---|
| Low | 0.884 | 0.907 |
| Medium | 0.806 | 0.829 |
| High | 0.728 | 0.751 |

Table 1-Threshold value for V(K1) = 4.42v

b. Sensitivity changeover switch "L"

V(K1) = 3.40 V

| Pollution Level | On | Off |
|---|---|---|
| Low | 0.680 | 0.703 |
| Medium | 0.602 | 0.625 |
| High | 0.524 | 0.547 |

Table 2-Threshold value for V(K1) = 3.40v

**NOTE:**
The standard version of AM-1 does not have manual input functions.



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