SA2 Smart Gas Sensor

Instruction Manual

Model SA2 Smart Gas Sensor
Rev: 1
Date: 03/03/2026

CONTENTS

1. SAFETY INFORMATION

⚠ The Model SA2 Smart Gas Sensor described in this manual must be installed, operated, and maintained in accordance with the information contained within this manual. Installation in a non-hazardous area must comply with all applicable restrictions, requirements, and guidelines.

⚠ It is the customer's responsibility to ensure that the SA2 Smart Gas Sensor is suitable for the intended use, installed correctly, and complies with all applicable electrical standards.

⚠ The SA2 sensors are designed and constructed to measure the level of certain gases in ambient air. Accuracy in atmospheres containing steam or inert gases cannot be guaranteed.

⚠ Bump test or calibrate with target gas at startup and check on a regular schedule based on sensor type, sensor location, and as-found test results over time.

2. GENERAL INFORMATION

2.1 Description

The Model SA2 Smart Gas Sensor platform is a complete gas detection solution. Integrated with conventional detection technologies, creating a standardized form factor and data output. As new detection technologies emerge, they can be adapted to this architecture.

Features Include:

- Electrochemical Integration
- NDIR Integration
- PID Integration
- Catalytic Pellistor Integration
- I2C Output
- Sensor Stabilization (Warm Up)
- Fault Diagnostics
- Zero and Span Calibration
- Environmental Data
- Environmental Compensation
- Alarm Profile Configuration

The device is fully configurable over its I2C output. The data structure is the same for all Safeguard SA2 Smart Sensors, making it a true plug-and-play detector for multiple gas-detection applications.

2.2 Model SA2 Smart Gas Sensor Modules

The sensor comprises a gas-detection sensor and an embedded signal-conditioning circuit. Both are housed in a metallic enclosure fitted with gold-plated connecting pins. Each Sensor is factory-programmed for a targeted gas type and sensitivity range. On power-up, the transmitter reads the serial number, gas type, measurement range, previous zero/span calibration data points, and last calibration date, facilitating a fully automated startup.

2.3 Specifications

System	
Detector Types	Electrochemical, NDIR, PID, MEMS,
Detection	Diffusion
User Interface	Serial interface

Electrical	
Input Voltage	3.3 VDC
Power	0.012 – 0.5W*
Serial Output	I2C

Mechanical	
Dimensions	9.17in(233mm) H x 5.25 in(133.4mm) W x 4.44 in(112.8mm) D

Environmental	
Temperature Range	-40◦C to +60◦C
Humidity Range	0-99% non-condensing

** Power consumption is sensor technology selection dependent.*

2.4 Principle of Operation

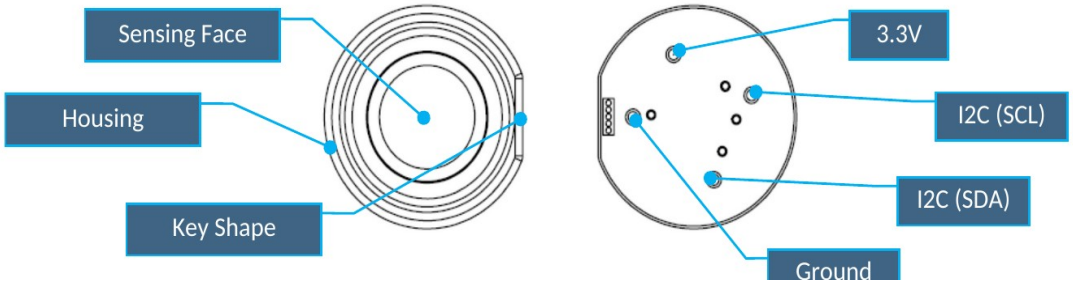
The smart sensor generates all the data for the associated sensing technology it is handling. The SA2 holds and processes:

- Compound
- Range
- Decimal Precision
- Units
- Serial Number
- Cal Dates
- Sensor Life
- Alarm Set Points
- Alarm Directional Logic
- Calibrations
- Configuration
- Fault Diagnostics
- Self-Testing
- Base Line Compensation
- Span Compensation
- Signal Conditioning
- Response Factor

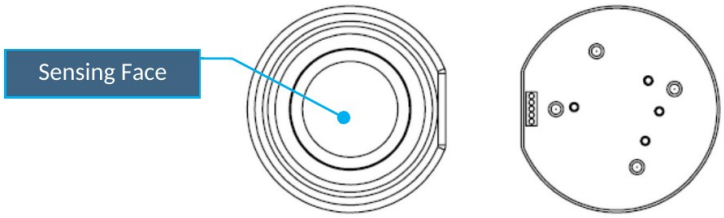
Sensor internally updates and generates readings every 250ms. The user can request data faster than this at their discretion, but this is the internal limit of the device.

3. PRODUCT OVERVIEW

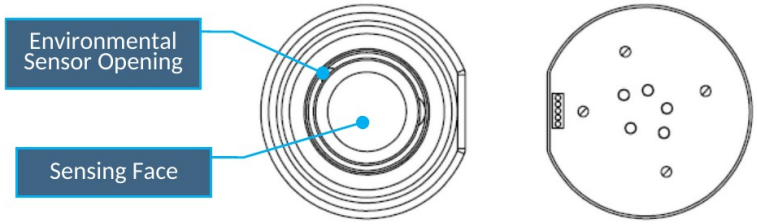
SA2 Common Overview:



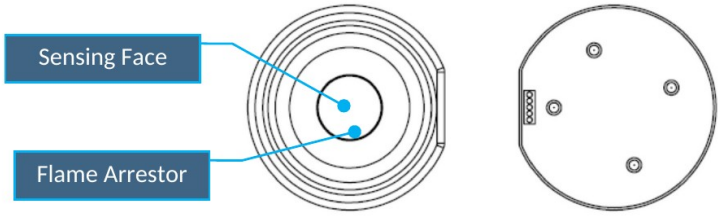
SA2 Electrochemical Sensor:



SA2 NDIR Sensor: (PID Shares the same configuration)



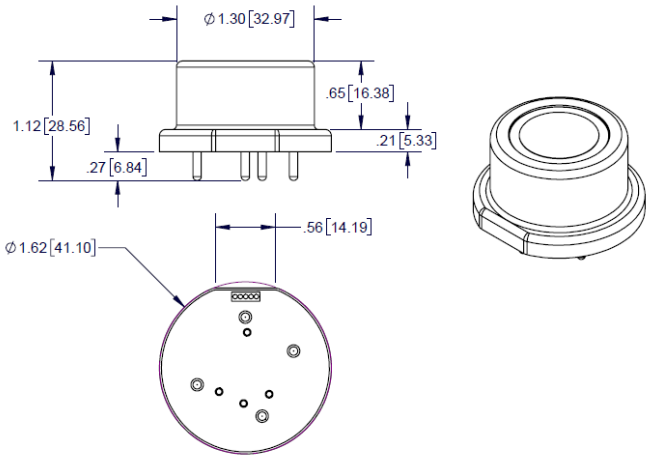
SA2 Catalytic Pellistor Sensor:



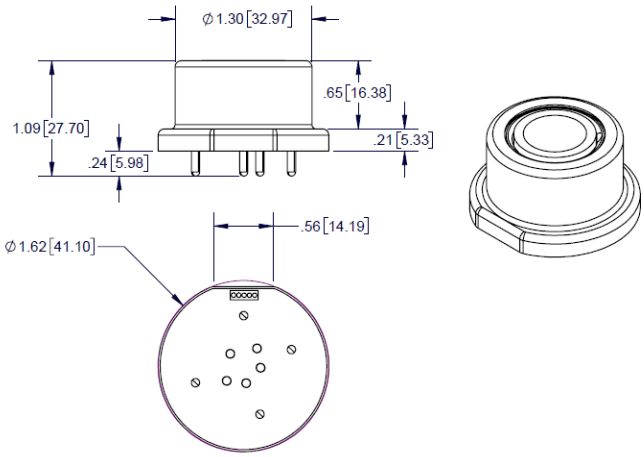
3.1 Product Dimensions

All SA2's share the same dimensional layout.
NOTE: some PIDs may stick out an extra 2mm from the sensor face

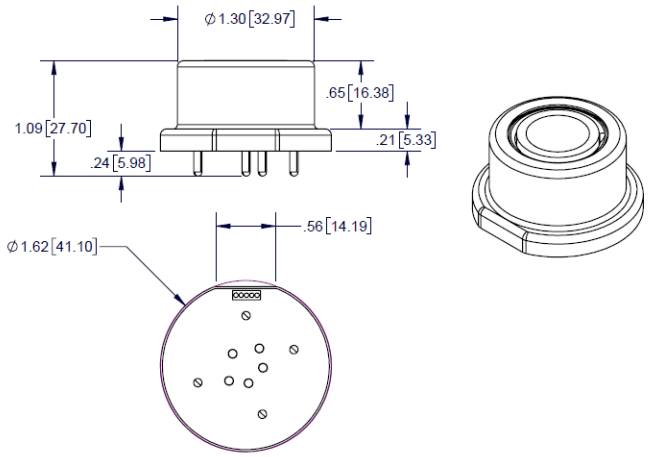
SA2 Electrochemical Sensor:



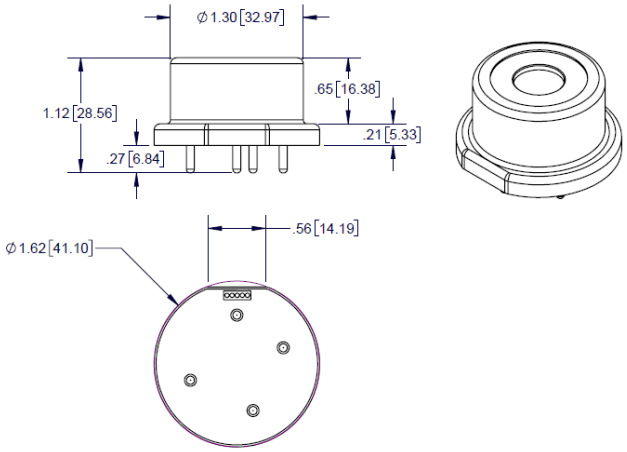
SA2 PID Sensor:



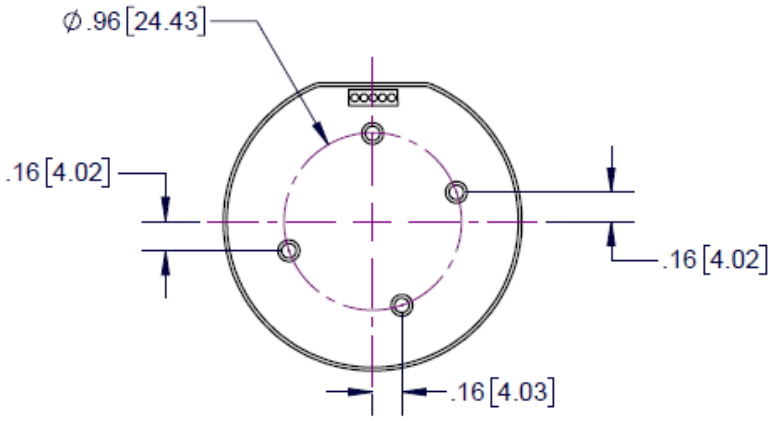
SA2 NDIR Sensor:



SA2 Catalytic Pellistor Sensor:



Pin Out Dimensions:



4. INSTALLATION

4.1 Mounting

Diffusion:

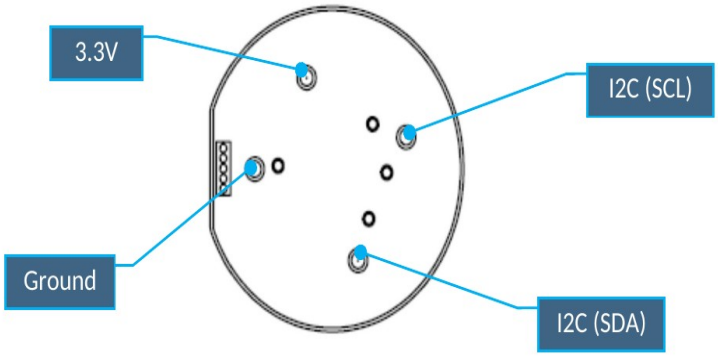
The sensor must be placed with the sensing face facing the ground to allow for proper diffusion.

Aspirated:

If sensors are receiving a target compound via an aspirated system, the grade/direction is irrelevant.

4.2 Wiring

Sensor pin out are as follows:



The recommended sockets for the sensors are:

Mill-Max Manufacturing Corp.
Mill-Max CONN PIN RCPT .065-.082 SOLDER
PN: 8837-0-15-15-14-14-10-0

5. OPERATION

5.1 Power On

⚠ Before powering up, ensure that all field wiring connections are correctly terminated and connected to the host device.

5.2 Startup

When powered on, the SA2 will go through a 5-second initialization period. During this period, the sensor will perform hardware integrity checks and prepare for operation. Output of all registers will be 0 until this initialization period is complete.

During Sensor Operation, the user can obtain the current sensor state by reading the SENSOR_STATUS register (see APPENDIX A for register definitions).

Before the device enters normal operation, it will enter Warm Up Mode:

- Warm Up Mode (Sensor Status 41) will vary from sensor to sensor based on technology and stabilization requirements.
- Example:
- Some fast-reacting and higher-range cells will stabilize very quickly.
- Biased electrochemical cells can have up to a 12hr warmup period from cold storage.
- Profiled warm-up timers come standard with each sensor, depending on range, technology, and application.
- Warm Up Mode will hold the reading of the output at 0 until the Warmup Counter has reached 0 to not trigger any erroneous reading while the sensor stabilizes. **NOTE: for 0-25% O2 it will hold the output at 21%**
- The user can wait until this Counter Subsides or can “Abort Warm Up” via a serial command by sending 0x41 to the SYS_REMOTE register.

Once the sensor stabilizes, it will enter normal operation.

5.3 Normal Operation

When the sensor enters Normal Operation (Status 0), it responds to gas and provides the user with status and fault diagnostics based on the sensor's current state of operation.

SENSOR_STATUSES include:

- Status 41: Warm Up
- Status 0: Normal Operation
- Status 32: Calibration (Zero or Span)
- Status 2: Calibration Fault
- Examples:
- No Gas Applied
- Stability Failure
- Clearing failure
- Status 4: Over Range
- Over Range is considered > 100% of FULL_SCALE.
  NOTE: Sensors will output readings up to 120% of FULL_SCALE
- Status 16: Under Range
- Under Range is considered as any negative Reading.
- Status 1: Sensor Fault
- Examples:
- Hardware Fault
- Serial Sensor Comm Fault (NDIR only)

There are configurable alarm threshold levels for the sensor, but these are only profile configurations; they have no impact on the sensor output or status. Their purpose is to store alarm levels for the higher-level integration device to manage.

6. CALIBRATION

6.1 Calibration Notes

1. All Safeguard Analytics gas detection sensors are thoroughly tested and calibrated before shipment.
2. Once installed and commissioned, sensors should be zeroed and bump tested with span gas.
3. Use calibration gas cylinders provided by Safeguard Analytics or similarly approved calibration gas standards traceable to the National Institute of Standards and Technology (NIST).
4. Do not use calibration gas that is beyond its expiration date.

6.2 Calibration Frequency

The interval between maintenance and recalibration varies by technology, gas type, and environmental conditions surrounding the gas detector. In low-risk areas or clean-air environments, less frequent maintenance schedules may be suitable. In higher-risk or highly corrosive areas, more frequent maintenance may be required.

Sensor Technology	Typical Calibration Frequency
Catalytic Pellistor Combustible Sensors	~ 6-12 months
Electrochemical Toxic Sensors	~ 6-12 months
Photo Ionization Detectors	~ 1 month
Non-Dispersive Infrared Sensors	12 months

6.3 Calibration Initiation

To perform a calibration, the user must write commands to the SYS_REMOTE register. The following commands will initiate the following calibration sequences:

- Zero Calibration: 0x10
- Span Calibration: 0x20

6.4 Recommended Calibration Setup

Use **0.5 LPM regulators** unless otherwise specified in the sensor's data sheet. Special tubing is generally not required unless specified for compound-specific calibrations (see sensor datasheets for details). Tygon is generally used, but for reactive gases, use Viton or PTFE tubing. Calibration adapters should be fashioned to flow “across” the sensor face or jetted directly into the sensor face for faster response to reactive gases.

POSITIVE PRESSURE CALIBRATION OPTION

Positive Pressure Regulator: Use a fixed flow 0.5 LPM regulator.

6.5 Zero Calibration

Zero calibration sets the sensor's zero data point. If the atmosphere surrounding the system intake contains no target or interference gases, **Zero Calibration** can be performed. If the atmosphere surrounding the sensor contains target or interference gases, use a certified zero gas cylinder.

⚠ Caution: The regulator used with the zero-gas cylinder should not be the same as the regulator used for highly reactive span gases.
⚠ Caution: 0.5 LPM positive pressure regulator is the recommended flow rate for calibrating all SA2 sensors.

NOTE: for O2-deficient sensors, zero calibration sets the data point for 20.9% O2; use Zero Air (20.9% O2 balance N2) to perform this calibration

Prepare Calibration Setup:

1. Connect the calibration adapter to the sensor.
   - Attach tubing from the zero-gas bottle to the calibration adapter.
2. Apply Zero Gas:
   - Turn on the regulator to deliver zero gas to the sensor.
   - Monitor the SYS_READING of the sensor to confirm a stable zero baseline before proceeding.
3. Initiate Zero Calibration:
   - Write 0x10 to SYS_REMOTE register.

4. Monitor CAL_STATUS.
    - Monitoring Calibration Status: Calibration progress and outcomes are tracked in the CAL_STATUS register. See the sequences below for specific codes.

Zero Cal: Write 0x10 to SYS_REMOTE Register	
CAL_STATUS Response	**Description**
0x10	Zero Calibration in Process
0x12	Zero Calibration Complete
0x13	Zero Calibration Fault (Fault)

6.6 Span Calibration

Span calibration ensures that the sensor accurately responds to a known gas concentration. SA2 sensors are set by default to calibrate at 50% of the full-scale range for most compounds. This level can be factory configured for any level at the user's discretion. Some sensors require lower calibration levels due to sensitivity or safety reasons. Always confirm the calibration level before **Span Calibration**.

**NOTE: The user can also configure calibration level (Safeguard recommends ordering sensors with cal level preconfigured using the factory calibration level; changing in-field calibration can skew sensor life calculation. Change at own risk.) **

⚠ Caution: The regulator used with the zero-gas cylinder should not be the same as the regulator used for highly reactive span gases.

⚠ Caution: 0.5 LPM positive pressure regulator is the recommended flow rate for calibrating all SA2 sensors.

NOTE: for O2-deficient sensors, span calibration default sets the data point for 10% O2; use 10% O2 balance N2 to perform this calibration

Prepare Calibration Setup:

2. Connect the calibration adapter to the sensor.
   - Attach tubing from the span-gas bottle to the calibration adapter.
3. Apply Span Gas:
   - Turn on the regulator to deliver span gas to the sensor.
4. Initiate Span Calibration:
   - Write 0x20 to SYS_REMOTE register.
5. Monitor CAL_STATUS.
   - Monitoring Calibration Status: Calibration progress and outcomes are tracked in the CAL_STATUS register. See the sequences below for specific codes.

Span Cal: Write 0x20 to SYS_REMOTE Register	
CAL_STATUS Response	**Description**
0x20	Apply Span Gas
0x21	No Gas Detected (Fault)
0x22	Gas Detected
0x24	As Found Reading Saved *(visible in transmitter "AS_FOUND register)*
0x26	Cal Adjusted
0x28	Stability Test in Progress
0x29	Stability Test Failed (Fault)
0x2A	Remove Gas
0x2C	Span Calibration Complete
0x2D	Clearing Failed (Fault)

6. During Calibration when the "As Found" sequence is done this captured level will be available on the I2C output for the user to log at their discretion.
7. Upon completion SENSOR_LIFE will be updated and sensor will return to normal operation.

6.7 Span Calibration Faults

The SA2 sensors have fault diagnostics during span calibration to inhibit erroneous calibrations. If any calibration fault occurs, the sensor will revert to its previous calibration set point and allow the user to reset the calibration fault by writing 0x40 to SYS_REMOTE.

Cal Faults can be reset by:

- Successful recalibration (zero or span)
- Cal Fault Reset
- Write 0x40 to SYS_REMOTE
- Power Cycle

6.8 Calibration Dates

The sensor has reserved registers for managing calibration dates. There is no real-time clock on the sensor, so the user's responsible for managing this process.

The user must write the date code and then “Save” the changes by writing the save command 0x30 to SYS_REMOTE.

The date code scheme follows the following bit shift format:

DATE = ((YEAR - 2000) << 9) + (MONTH << 5) + DAY

Example for 03/03/2026:

((2026- 2000) << 9) + (3 << 5) + 3 = DATE

13312 + 96 + 3 = 13411

The user would write 13411 to the corresponding calibration date register, then write 0x30 to save.

NOTE: if the save command is not sent, the device will not store the value on power cycle

6.9 Connection

All SA2 sensors have the same I2C address and have the same available register map to request. This keeps the uniform data format, so any sensor that is plugged in will always connect and display the same uniform data scheme. Some sensors have more reading options than others, such as environmental data; see sensor datasheets for more info.

NOTE: With all sensors having the same I2C address, they cannot all lie on the same bus. If the user plans to connect multiple sensors to the same bus, they must use an I2C switch or have a processor that can handle multiple I2C Inputs

Protocol	I2C
Sensor Address (7bit)	0x61
Sensor Address (8bit)	0xC2
Update Rate	250ms

6.10 Sensor Configuration

The SA2 Smart Sensor module allows users to configure various operational parameters.

Field	Description
Alarm 1	Alarm 1 threshold
ASC/DSC	Ascending or descending alarm logic
Alarm 2	Alarm 2 threshold
ASC/DSC	Ascending or descending alarm logic
Alarm 3	Alarm 3 threshold
ASC/DSC	Ascending or descending alarm logic
Calibration Level	Set the calibration level of the sensor (not recommended to configure)
Response Factor	Set the sensor's response factor. *NOT CURRENTLY ACTIVE*

Saving Configuration Changes

To ensure configuration changes are retained:

1. Send the save command by writing 0x30 to the **SYS_REMOTE** register in the Sensor Map.
2. **Important**: If the save command is not issued, any changes will be reverted to the previous configuration upon power cycling the transmitter.

7. MAINTENANCE AND TROUBLESHOOTING

7.1 Maintenance

Depending on the Gas Type, the specified range, and Usage, it is recommended to establish a calibration schedule. This will ensure a longer sensor lifespan and continued targeted measurements. During scheduled calibration, it is recommended to inspect the following:

- The Sintered, PTFE, or Membrane Filters should be inspected for debris, oil, or water during calibration and removed. If there are errors during calibration or if the cell is damaged, it is recommended to replace the sensor.

7.2 Troubleshooting

There are a few items to consider if the following are observed.

- Negative Readings (under range), this is a baseline shift, and the user should Re-Zero the sensor.
- If during a bump test, the accuracy is off (reading does not match the gas being used to bump), if this occurs, it is recommended that the user should Re-SPAN
- With PIDs, they can leverage a cleaning kit or a spare part to “refresh” the sensor to get it back to factory specifications.
- If the sensor is ever broadcasting the Status 1 (Sensor Fault) sensor has an internal issue and needs to be replaced.

8. WARRANTY

Safeguard Analytics warrants each Model SA2 Smart Gas Sensor to be free from defects in workmanship or material under normal use and service for a period of two (2) years from the date of shipment from the factory. Safeguard Analytics will repair or replace, at no charge, any such equipment found to be defective during the warranty period. Defective or damaged equipment must be shipped prepaid to the Safeguard Analytics plant or the representative from which the shipment was made. Determination of the nature of, and responsibility for, defective equipment will be made by Safeguard Analytics factory personnel. In all cases, this warranty is limited to the replacement of the equipment supplied by Safeguard Analytics. The customer will assume all

liability for the misuse of this equipment by its employees or other personnel.

All warranties are contingent upon proper use in the application for which the product was intended and do not cover products that have been modified or repaired without Safeguard Analytics approval or that have been subjected to neglect, accident, improper installation or application, or on which the original identification marks have been removed or altered. Except for the express warranty stated above, Safeguard Analytics disclaims all warranties about the products sold, including all implied warranties of merchant ability and fitness and the express warranty stated herein are instead of all obligations or liabilities on the part of Safeguard Analytics for damages including, but not limited to, consequential damages arising out of/or in connection with the use or performance of the products.

APPENDIX A: I2C OUTPUT MAP

Safeguard Analytics provides a standard data output for all SA2 Smart sensors and includes configurable features, operational details, and expandable capabilities for future features.

SA2 I2C Output Map

Date: 03/12/2025

Primary Address: 0x61 (7bit) 0xC2 (8bit)

I2C Offset	Description	R/W	Format	Example
SENSOR READINGS				
Readings				
0-2	SYS READING	R	32-bit Float BE	0.0000
4	SENSOR STATUS	R	16-bit Integer Signed	0=Normal, 1=VDC Fault, 2=Cal Fault, 4=Over Range, 8=Missing Sensor, 16=Under Range, 32=Calibration, 64=Warm up
6	TEMPERATURE	R	16-bit Integer Signed	20C
8	HUMIDITY	R	16-bit Integer Signed	50% (support is sensor dependent)
10	PRESSURE	R	16-bit Integer Signed	90000Pa (support is sensor dependent)
12	**NOT CURRENTLY USED**			
14	**NOT CURRENTLY USED**			
16	**NOT CURRENTLY USED**			
18	**NOT CURRENTLY USED**			
20	SYS REMOTE	W	16-bit Integer Signed	0x10=Zero Cal, 0x20=Span Cal, 0x30=Save Changes, 0x40=Clear Fault, 0x41=Abort Warm up
22	CAL STATUS	R	16-bit Integer Signed	0 *SEE Cal Status Sheet FOR CAL RESPONSES*
Calibration				
24	ZERO CAL DATE	R/W	16-bit Integer Signed	12321 = Jan 1, 2024 = ((year - year0) <<9) + (month <<5) + day; year0=2000
26	SPAN CAL DATE	R/W	16-bit Integer Signed	12321 = Jan 1, 2024 = ((year - year0) <<9) + (month <<5) + day; year0=2000
28	SENSOR LIFE	R	16-bit Integer Signed	100
30-32	SPAN AS FOUND	R	32-bit Float BE	47.0000
34	**NOT CURRENTLY USED**			
36	**NOT CURRENTLY USED**			
38	**NOT CURRENTLY USED**			
Sensor Static Identity				
40	PRECISION	R	16-bit Integer Signed	0 (number of decimal places)
42-44	FULL SCALE RANGE	R	32-bit Integer Signed	100
46-54	COMPOUND	R	ASCII-HEX, 10 Characters	H2S

I2C Offset	Description	R/W	Format	Example
56-58	UNIT	R	ASCII-HEX, 4 Characters	PPM
60-64	SERIAL NUMBER	R	ASCII-HEX, 6 Characters	123456
66	WARMUP TIMER	R	16-bit Integer Signed	60s
68	WARMUP COUNTER	R	16-bit Integer Signed	60s (Counts down to 0; holds SYS_READING at 0 until counter completes. Abort with 0x41 in SYS_REMOTE)
Configurable				
70	ALARM 1	R/W	16-bit Integer Signed	1000 = (10% of FS * 100)
72	ASC/DSC	R/W	16-bit Integer Signed	1=Ascending 0=Descending
74	ALARM 2	R/W	16-bit Integer Signed	2000 = (20% of FS * 100)
76	ASC/DSC	R/W	16-bit Integer Signed	1=Ascending 0=Descending
78	ALARM 3	R/W	16-bit Integer Signed	5000 = (50% of FS * 100)
80	ASC/DSC	R/W	16-bit Integer Signed	1=Ascending 0=Descending
82	**NOT CURRENTLY USED**			
84	CAL LEVEL	R/W	16-bit Integer Signed	5000 = (50% of FS * 100)
86	RESPONSE FACTOR	R/W	16-bit Integer Signed	1000=(RF*1000) (Support is sensor dependent)