H2scan®

Advanced Hydrogen Sensing

OPERATION MANUAL

HY-OPTIMA®

5232

27215 Turnberry Lane, Suite A
Valencia, California 91355, U.S.A.

Tel: (661) 775-9575 / Fax: (661) 775-9515
E-mail: hello@h2scan.com
Website: www.h2scan.com

IMPORTANT NOTICES

Read and understand this operation manual before installing or using the unit. If this equipment is used in a manner not specified by H2scan, the warranty may be void and the protection provided by the equipment may be impaired.

⚠ WARNING

If the product seems defective, DO NOT attempt to repair it. Immediately send the product back to H2scan for repairs.

LIMITATION OF LIABILITY - seller shall under no circumstances be liable for any incidental, consequential, special, punitive, or other damages, including, but not limited to, loss of business or profit, promotional or manufacturing expenses, injury to reputation, or loss of customer, based on any alleged negligence, breach of warranty, strict liability, breach of contract, or any other legal theory arising out of the use, misuse, purchase, sale or possession of its goods or its performance of this contract to the extent that such liability extends seller's obligations beyond the price paid by buyer to seller for the item on which such claim is based. Seller advises buyer to perform acceptable tests on all hardware prior to deployment and to perform maintenance as described in the seller's instruction guide. Under no circumstances shall the equipment provided hereunder be used in a manner where it is the sole protective system for facilities, equipment, and personnel safety; the equipment is intended for use in conjunction with other appropriate protective systems.

LIMITED WARRANTY

H2scan Limited Warranty: Each HY-OPTIMA® 5232 Hydrogen Analyzer ("Product") will conform, as to all substantial operational features, to the Product specifications set forth in this Manual and will be free of defects which substantially affect such Product's performance for 36 months from the ship date for such Product.

Must Provide Notice of Defect: If you have a Product that you believe is defective, you must notify H2scan in writing, within the warranty period of your claim regarding any such defect.

Return Product to H2scan for Repair, Replacement or Credit: The customer is responsible for shipping and handling costs. If the Product is found defective by H2scan, H2scan's sole obligation under this warranty is to either (i) repair the Product, (ii) replace the Product, or (iii) issue a credit for the purchase price for such Product, the remedy to be determined by H2scan on a case-by-case basis. A valid RMA number must be assigned by H2scan and clearly marked on the package when the unit is returned.

Voided Warranty: H2scan's three-year Limited Warranty is void for any of the following:

- **Unauthorized repair work performed at the customer's location or conducted by anyone other than H2scan's factory trained technicians.**
- **Equipment or parts that have been tampered with, misused, neglected, mishandled, improperly adjusted, or modified in any way without the written consent of H2scan.**
- **Equipment or parts that have been damaged due to shipping, misuse, accidents, mishandling, neglect, or problems with electrical power sources.**
- **Repair work performed during the warranty period does not prolong the warranty period past the original period.**
- **System operation in incorrect or inappropriate environments.**
- **Usage that is not in accordance with system guidelines or an operator's failure to follow manual instructions.**

Limitation of Warranty: THE ABOVE IS A LIMITED WARRANTY AS IT IS THE ONLY WARRANTY MADE BY H2SCAN. H2SCAN MAKES NO OTHER WARRANTY EXPRESS OR IMPLIED AND EXPRESSLY EXCLUDES ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. YOUR SOLE REMEDY HEREUNDER IS REPAIR OR REPLACEMENT OF THE PRODUCT OR A CREDIT FOR THE PURCHASE PRICE FOR SUCH PRODUCT, THE PARTICULAR REMEDY TO BE DETERMINED BY H2SCAN ON A CASE-BY-CASE BASIS. H2SCAN SHALL HAVE NO LIABILITY WITH RESPECT TO ITS OBLIGATIONS UNDER THIS AGREEMENT FOR CONSEQUENTIAL, EXEMPLARY, OR INCIDENTAL DAMAGES, EVEN IF IT HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THE STATED EXPRESS WARRANTY IS IN LIEU OF ALL LIABILITIES OR OBLIGATIONS OF H2SCAN FOR DAMAGES ARISING OUT OF OR IN CONNECTION WITH THE DELIVERY, USE OR PERFORMANCE OF THE PRODUCTS.

Symbol	Meaning
CE	CE marking according to the current applicable directive.
	Safety instructions that must always be followed: The respective data must be noted and/or the safety-related instructions contained in the operating instructions must be followed for devices with this symbol!

1. INTRODUCTION

Using H2scan's patented solid-state, non-consumable, hydrogen-specific sensing element as well as patented algorithms and a robust design, the analyzers report accurate hydrogen readings through a digital interface without periodic calibration. If used in typical industrial streams under normal operation following the guidelines in this manual, expect the measurement algorithm to maintain its stated accuracy over the life of the device.

This product series improves efficiency/yields and provides safe, effective operations for real-time, in-line petrochemical processing and industrial hydrogen applications, such as electrolyzers and fuel cells as well as hydrogen distribution, blending, and storage.

IP66-rated as fully dust-tight and protective against direct high-pressure jets, the HY-OPTIMA 5232 hydrogen analyzers have a rugged, waterproof mechanical assembly design for industrial applications.

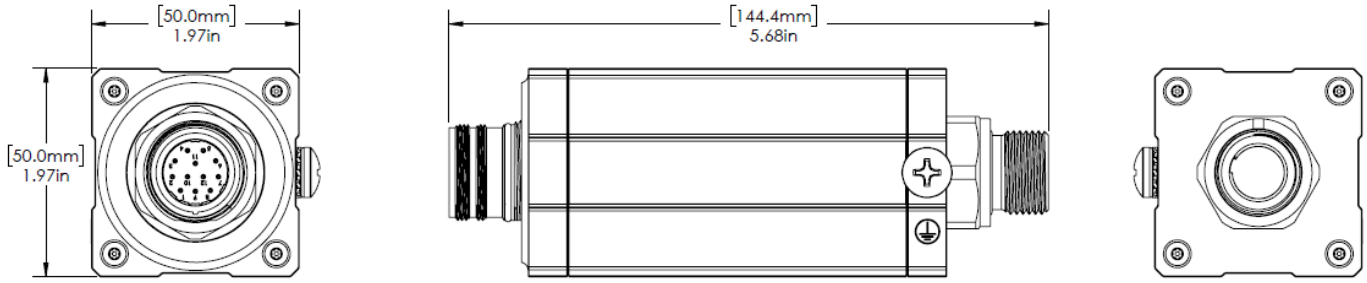

Figure 1: HY-OPTIMA 5232 Hydrogen Analyzer Dimensions

2. PRE-INSTALLATION REQUIREMENTS

2.1 PACKING LIST

Every HY-OPTIMA 5232 hydrogen analyzer is shipped with the following:

- Grounding hardware
- 5 m cable

NOTE: The safety of any system incorporating the equipment is the responsibility of the assembler of the system.

2.2 TOOLS FOR MOUNTING AND COMMISSIONING

The end user must provide the following tools:

- #2 Phillips head drive screwdriver
- Adjustable wrench to tighten gas plumbing fittings
- Wire cutters to trim wires to length and trim cable ties
- Wire strippers to prepare wires for connection

2.3 GAS CONNECTION

As user applications and installations may vary, H2scan has made available various gas connection adapter accessories that adapt from the standard M20 thread connection on the HY-OPTIMA 5232 Hydrogen Analyzer. These adapters include:

- M20 to 1/2" NPT
- M20 to 3/4" NPT
- M20 to 3/4" tube (for compression fittings)

These adapters are available for purchase with any HY-OPTIMA 5232 hydrogen analyzer.

2.4 CABLING AND WIRING

The H2scan cable assembly is available in lengths of 5, 10, 20, or 30 m. For cable assembly pinout and wiring information refer to 3.2 Electrical Connection, Figure 3.

2.5 POWER SUPPLY

Each HY-OPTIMA 5232 hydrogen analyzer incorporates an internal voltage regulator for operation in harsh electrical environments. An external DC power source is required to energize the analyzer for operation. The DC Input Power range is 9 - 30 V.

DC power is electrically isolated from the metal enclosure of this device.

2.6 RS-485 COMMUNICATION

HY-OPTIMA 5232 hydrogen analyzers offer digital communication using Modbus over a three-wire, half-duplex RS-485 interface that is galvanically isolated. Fail-safe resistors and a 120 Ohm termination resistor are installed in the analyzer.

2.7 ANALOG OUTPUT

The HY-OPTIMA 5232 hydrogen analyzers offer a 4–20 mA analog output that is powered by an external voltage source. The output current has the following properties:

- 0 mA indicates the device is disconnected or not powered
- 3.5 mA indicates an error condition
- 4–20 mA indicates the hydrogen measurement
- 22 mA indicates the device is warming up and not ready

The 4–20 mA analog output is derived from the measured hydrogen value and scaled based on the measurement range of 0-5% H_2.

2.8 DIGITAL OUTPUT

The HY-OPTIMA 5232 hydrogen analyzers offer two digital outputs that share a common reference. These digital outputs are electrically isolated from the other electrical systems. They can be independently configured via Modbus to indicate high levels of hydrogen or a fault condition with the device. Typically, DOUT-1 is configured for hydrogen alarm and DOUT-2 is configured to indicate fault conditions.

The digital outputs have “open-collector” logic, which is similar to a normally open relay. That is, when deactivated, current will not flow from DOUT to DOUT-REF. When activated, current will flow from DOUT to DOUT-REF.

When using a digital output as a hydrogen threshold alarm while the hydrogen measurement is below the alarm threshold, the digital output will be in a deactivated state and will not allow current to flow from DOUT to DOUT-REF. As soon as the hydrogen measurement exceeds the threshold, the digital output activates and allows current to flow.

When using a digital output to detect faults while no fault is detected, the digital output is activated and allows current to flow from DOUT to DOUT-REF. When a fault occurs, the digital output deactivates and stops current from flowing.

3. INSTALLATION

CAUTION

Avoid damage to the analyzer assembly during handling by:

Ensuring nothing comes in contact with the sensor end of the device.

Keeping the cap in place until installation.

3.1 MECHANICAL CONNECTION

⚠ WARNING

Do not subject the analyzer to high-impact forces or tamper with the seals. Doing so may compromise the gas seal.

1. If required, install an M20 gas connection adapter.
2. Ensure the adapter is properly torqued to the analyzer M20 fitting until metal-to-metal contact is made between the bottom of the adapter and the flange of the M20 fitting. This will ensure the o-ring maintains a gas-tight connection.

NOTE: Various adapters are available as accessories for different user applications and installations. A recommended torque is provided with each adapter.

Ensure a gas-tight connection between the HY-OPTIMA 5232 hydrogen analyzer and the end user plumbing to prevent gas leakage and ensure proper operation.

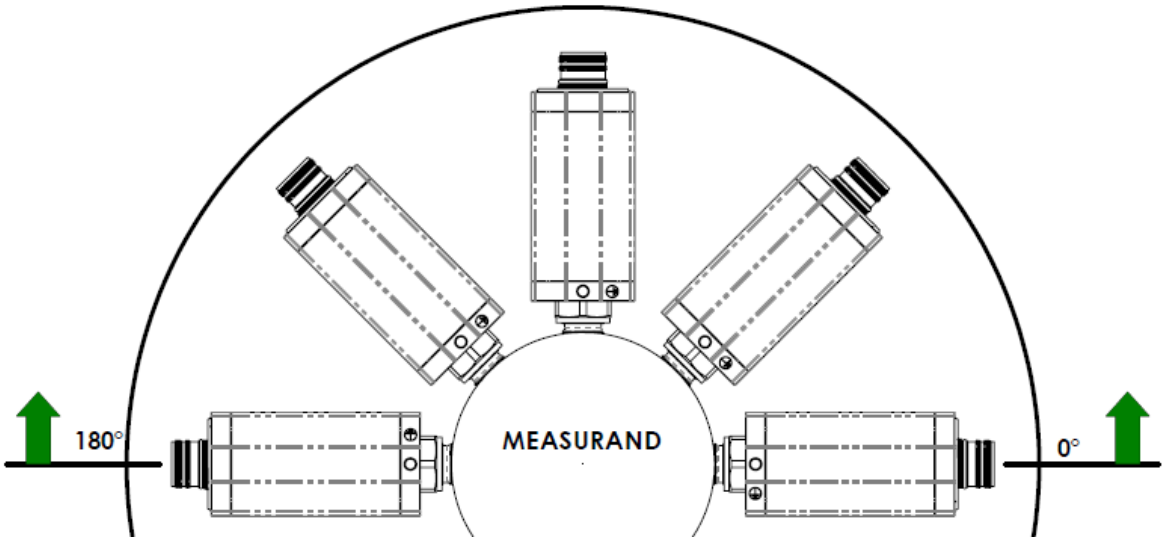

Figure 2: Acceptable Mounting Orientations

⚠ WARNING

Mounting the analyzer such that the sensor cavity accumulates condensed liquids will damage the sensor and void the warranty.

3.2 ELECTRICAL CONNECTION

Electrical connection to the HY-OPTIMA 5232 hydrogen analyzer is achieved through a single connector using an H2scan cable assembly. Using a different cable assembly may degrade performance and safety of the installation.

Make all electrical connections to associated equipment before connecting cable to the analyzer. The cable includes four separate circuits (DC Power, RS-485, Analog Output, Digital Outputs). Wires within each circuit have unique colors, however, the same color wire is used in different circuits. To ensure proper connection it is important to check continuity from connector pin to wired connection. Figure 3 identifies the cable pinout, and wire colors. Use the following check list to complete wiring:

1. Route cable from analyzer to associated equipment, confirm sufficient length.
2. Dress flying leads as needed to route wires to terminals, any unused wires/circuits must be secured and isolated.

3. Connect two wires to the DC power supply, confirm polarity.
4. Connect three wires to the RS-485, confirm polarity of signal wires, connect the RS485-GND to the ground reference.
5. Connect the two Analog Output wires (4–20 mA), confirm polarity of signal wires.
6. Connect three wires to the Digital Output with a jumper between (-) terminals to DOUT-REF wire, confirm polarity of connections.
7. Check continuity of all connections to the respective pins at the connector.

Attach the connector to the analyzer before energizing the system. The connector must be fully engaged and hand tightened.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS			
NO.	MNEMNIC	FUNCTION	WIRE COLOR
1	VDC	Positive Supply Voltage.	BROWN
2	VDC_GND	Ground Reference for Supply Voltage. This pin must be connected to 0V with respect to VDC.	WHITE
3	NIC	Not Internally Connected. This pin is not connected to the internal circuity.	-
4	RS485-A	RS-485 Noninverting Driver Output/Receiver Input.	BLUE
5	RS485-B	RS-485 Inverting Driver Output/Receiver Input.	BLACK
6	AOUT+	Analog Output Current.	BLUE
7	AOUT-	Analog Output Return.	GREY
8	DOUT-1	Digital Output 1 (Open Collector).	GREEN
9	DOUT-2	Digital Output 2 (Open Collector).	WHITE
10	NIC	Not Internally Connected. This pin is not connected to the internal circuity.	-
11	RS485-GND	RS-485 Ground Reference.	GREY
12	DOUT-REF	Ground Reference for Digital Outputs 1-2.	YELLOW

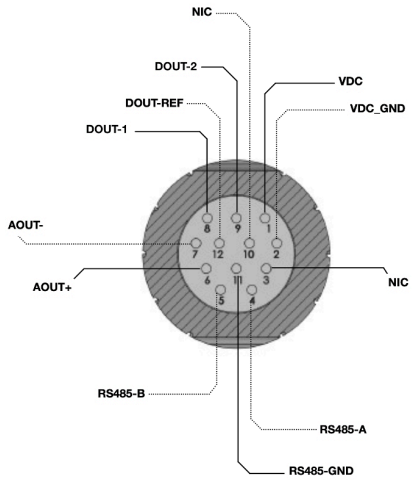

Figure 3: H2scan Cable Pinout and Wire Colors

NOTE: The connector to the HY-OPTIMA 5232 hydrogen analyzer must be fully engaged and hand-tightened to ensure the IP66 rating.

4. COMMISSIONING

NOTE: If operating at a pressure other than 1.0 atmosphere absolute (ATA), the hydrogen reading must be compensated by performing a two-point field calibration or by dividing the hydrogen reading by the known pressure in atmosphere absolute. See 4.2 for two-point field calibration instructions.

4.1 STARTUP

Power on the analyzer before flowing gas across the sensor. Once powered on, the analyzer will execute a startup sequence and begin reporting hydrogen after approximately 90 seconds. During this period, the analyzer will:

- Perform a power on system self-test
- Restore configuration settings from non-volatile memory

If the analyzer is being powered on for the first time or has been in storage for more than a week, the hydrogen measurement may initially be inaccurate due to oxygen absorption on the sensor. The model 5232 is designed for this mode of operation, whereas other models require a steady hydrogen exposure to remove this absorbed oxygen and the analyzer reading will gradually decrease until it reaches the true hydrogen concentration. See 5.4 for more

information.

A two-point field calibration (4.2) is recommended as part of the commissioning process to account for differences in gas stream parameters, especially pressure, from the factory calibration.

If using Modbus, the default communication settings are:

- RS-485, half-duplex, 19200 baud, 8 data bits, 2 stop bits, no parity
- Default Modbus ID is 1

The Modbus status register 111 bit 15 will indicate Ready when the first valid hydrogen measurement is available. After the startup sequence completes, measurement data will be available in the Modbus registers.

If an error is reported, turn off power to the analyzer and check the electrical connections and power supply voltage before restoring power. If the error persists, contact H2scan customer service at help@h2scan.com.

4.2 TWO-POINT FIELD CALIBRATION

It is strongly recommended to condition the gas stream at the analyzer to have a stable operating pressure and constant flow. Even if the system is designed to operate at 1.0 atmospheres absolute (matching factory calibration), a two-point field calibration is recommended upon installation for best measurement accuracy (especially if measuring high hydrogen concentrations) and to remove any measurement error due to small offsets in pressure.

If operating at constant pressure other than 1.0 atmosphere absolute, a two-point field calibration can normalize the hydrogen reading. By applying two known gas concentrations, the analyzer will calculate and apply a gain and offset to its measurements to match its hydrogen reading with the known gas concentrations.

⚠ WARNING

Do NOT use gases with a hydrogen concentration exceeding 10% at 1.0 ATA for the 5232.

4.2.1 Calibration Gases

Two calibration gases are required: one high and one low. Primary standard (±0.02%) tolerance is recommended. The given accuracy specification of the analyzer does not include the error of the calibration gas certification and is only valid with an exposure time of at least 60 minutes per gas.

For best results, use a calibration gas concentration just below the lowest expected reading and just above the highest expected reading.

EXAMPLE: If the process stream is expected to operate between 61% and 78% H_2, calibration gases of 60% and 80% H_2 are ideal.

It is not necessary to use an expensive custom blend. Use commercially available gases where possible, keeping in mind the accuracy of the gas contributes to the accuracy of the calibration.

Table 1: Calibration Gas Limits (assuming 1.0 ATA)

Model	Minimum	Maximum
5232	0.4%	5%

⚠ WARNING

Do NOT use gases exceeding the H_2 concentration limit specified for the model as this will damage the analyzer. Do NOT use 100% air, 100% N_2, or any gas with an H_2 concentration below the LDL of the product model.

Recommended flow rate is 1.0 ± 0.2 SLPM.

Apply gases to the analyzer through user's plumbing. Confirm the system allows the calibration gases to be applied at the same pressure the analyzer sees during normal operation.

4.2.2 Background Gases

For the 5232 analyzer operated where hydrogen may be present in air or oxygen, the calibration can be performed using hydrogen in an air background or the backgrounds listed above. The recommended gases are 1% H_2 in air and 2% H_2 in air. A verification/calibration kit is available from H2scan.

4.2.3 Field Calibration Procedure

NOTE: The exposure time per gas is a minimum of 60 minutes per exposure. Exposures shorter than 60 minutes can generate erroneous calibration data.

NOTE: The calibration can be aborted at any time (See: 4.2.4).

Table 2: Two-Point Field Calibration Registers

Register	Parameter	Function	Data Type	Data Range	Access
126	Calibration Gas 1, ppm H_2	High word	32-bit binary number	0–10,000,000	R/W
127		Low word			
128	Calibration Complete/ Date	High byte: Month Low byte: Day	32-bit binary value		R/W
129		Year			
130	Calibration Gas 2, ppm H_2	High word	32-bit binary number	0–10,000,000	R/W
131		Low word			
132	Field Cal start command	Gas exposure duration (minutes)	16-bit binary number	60–1440	W
133	Field Cal abort command	Abort Field Cal or clear data	8-bit binary number	1: abort 2: clear	W
134	Field Cal get status command	High byte: Status Low byte: Error code	16-bit binary number	Tables 3 and 4	R
135	Gas start command	Gas 1 or 2 started	8-bit binary number	1: gas 1 2: gas 2	W

Read the status and error codes from register 134 after each write to the field calibration registers.

Upon calibration initiation, the status code should read ‘1’ (in-progress).

The error code should read ‘0’ (no errors detected) after register write until the procedure is completed. Upon completion, the status code should read ‘0’ (success) and the error code should read ‘0’ (no errors detected). Refer to 4.2.5 if an unexpected code appears.

1. Initiate calibration by writing the duration per gas exposure in minutes to register 132. The minimum time is 60 minutes per gas. Longer exposure times are preferable, up to 1440 minutes.
2. Apply the first gas to the unit at 1 SLPM.
3. If necessary, adjust the gas pressure at the analyzer to match the intended operating pressure.

NOTE: Ideally, the calibration gases are flowed through the same pressure regulation system as the measured gas stream and require no adjustment.

4. Indicate the first gas is flowing by writing ‘1’ to register 135.
5. Wait the exposure time.
6. Write the first gas concentration in ppm to registers 126, 127. To convert percentage to ppm, multiply percentage value by 10,000.
7. Apply the second gas at 1 SLPM.

8. Ensure the gas pressure at the analyzer has not changed, making any necessary adjustments.
9. Indicate the second gas is flowing by writing '2' to register 135.
10. Wait the exposure time.
11. Write the second gas concentration in ppm to registers 130, 131.
12. Finish the field calibration with the current date by writing to registers 128, 129.
13. The unit will automatically reboot.

4.2.4 Abort Field Calibration

To abort a field calibration while in progress, either power cycle the unit or write '1' to register 133.

4.2.5 Calibration Status and Errors

Check Register 134 for calibration status and errors.

Table 3: Field Calibration Status

Code	Definition
0	The calibration was completed successfully.
1	The calibration process is ongoing.
2	The calibration failed due to errors.
3	The calibration was cancelled by the user.
4	The calibration has been removed and factory settings restored.
5	The most recent command was not executed. See the error code for more details.

Table 4: Field Calibration Errors

Code	Definition	Resolution
0	No errors detected.	N/A
2	Field calibration already in-progress.	Abort in-progress field calibration. See 4.2.4.
3	The entered gas exposure time is outside the limits.	Ensure the time was entered in minutes and within the limits of the product (minimum of 60 minutes).
4	Internal problem with the unit.	Power cycle and try again. Contact H2scan if the error persists.
5	This code is used for diagnostic purposes only.	N/A
7	Entered gas concentration is outside limit.	Ensure the gas concentration is entered in ppm and within the range of the product model.
8	Command to start Gas 2 received before Gas 1 completed.	
10	Calibration could not complete based on measured data.	Retry the calibration. Contact H2scan if the error persists.
12	Calculated gain and/or offset are outside limits.	Confirm the gas was flowing and the concentrations entered in ppm and match the respective gases.

Code	Definition	Resolution
13	A step was skipped in the calibration process.	Restart the calibration, following the steps detailed above.
14	The gas exposure was not completed.	Retry the command once the full exposure time has elapsed. If an incorrect gas exposure time was entered, abort the field calibration and start over.

Once the calibration is complete, maintain operating pressure and do not adjust the pressure regulation to ensure the normal operating conditions match the field calibration conditions as closely as possible.

5. OPERATION

NOTE: If operating at a pressure other than 1.0 atmosphere absolute, the hydrogen reading must be compensated by performing a two-point field calibration or by dividing the hydrogen reading by the known pressure in atmosphere absolute. See 4.2 for two-point field calibration instructions.

5.1 MONITORING

5.1.1 RS-485

During normal operation, poll the HY-OPTIMA 5232 hydrogen analyzer measurements through the RS-485 interface periodically for a measurement reading. The time between readings can be from one second to several hours or days depending on user requirements. Each reading should include the following Modbus holding registers.

- Status Register (111 bits 15 and 12): Bit 15 indicates the hydrogen measurement is available. Bit 12 indicates an error.
- Error Status Registers (112,113): Indicates which error is detected. These registers are active when register 111 bit 12 is high.
- Hydrogen Registers (0,1): Provides the hydrogen ppm values. Programming note: The high word (0) must be read to enable the low word (1) value to be available.

NOTE: Regarding Hydrogen Registers (0,1), to convert ppm to %, divide ppm reading by 10,000.

5.1.2 Analog Output

The hydrogen measurement can be monitored using the analog output. See 2.7 for details.

5.1.3 Digital Output

Two isolated digital outputs can be used as alerts to signal high levels of hydrogen as well as fault conditions within the electronics. See 2.8 for electrical information. For configuration details, consult the Modbus Register Map, which is available as a separate document.

5.2 SHUTDOWN

1. Purge the system using gas with a hydrogen concentration of less than 5% H_2 or with 100% N_2 for five minutes.

NOTE: For the 5232 model, hydrogen-free gases such as air or inert gases such as nitrogen, argon, or helium can be used.

2. Turn off all gas flow to the analyzer.
3. Power off the analyzer.

5.3 ERROR/EXCEPTION HANDLING

The HY-OPTIMA 5232 hydrogen analyzer is designed for continuous operation and will automatically recover from intermittent problems due to insufficient power, excessive electrical noise, or excessive internal ASIC temperature.

An internal algorithm maintains long-term measurement accuracy without periodic field calibrations. For this algorithm to run properly, the analyzers must be powered on continuously. If the analyzer is powered on only for durations less than two hours, the algorithm will not function properly and the analyzer accuracy may not meet the product specifications.

If the sensor element is damaged and unable to operate, the HY-OPTIMA 5232 hydrogen analyzer will shut down the measurement system and continue responding to Modbus for error reporting. This error will be reported via register 111 bit 12 with details specified in register 112,113. This type of error typically indicates a hardware fault that can only be repaired at H2scan. Power cycle the unit to attempt recovery. If the error condition persists, contact H2scan for repair at help@h2scan.com.

5.4 ATMOSPHERE-INDUCED ERRORS

⚠ WARNING

Do not exceed the maximum specified H_2 concentration for the given model.

5.4.1 5232

The HY-OPTIMA 5232 analyzer is designed for H_2 exposure of less than a few hours at a time, e.g., leak detection applications. While the analyzer is capable of continuous H_2 exposure, a temporary reduction in accuracy (the device reports lower H_2 content) three to six hours after the start of the continuous H_2 exposure may occur when the H_2 bonds with oxygen on the analyzer surface. Once the O_2 on the analyzer is completely depleted (a process that can take several hours, depending on the H_2 concentration), an internal algorithm will correct the measurement and allow the analyzer to measure accurately in the continuous H_2.

5.4.2 Non-Reducing and Non-Oxidizing Atmospheres

The analyzer experiences drift when powered on in a gas containing no hydrogen or oxygen for days or longer. While an internal algorithm ensures the reported H_2 remains at zero, eventual exposure to H_2 above the lower detection limit will cause an inaccurate initial response. An internal algorithm will restore the accuracy if exposed to any constant H_2 concentration (within the range of the model) for at least four hours.

5.5 EFFECT OF PRESSURE

Changes in overall gas pressure affect the analyzer's measurement of hydrogen partial pressure.

While the analyzer is not directly sensitive to fluctuations in gas temperature, temperature-induced fluctuations in pressure may affect the measurement accuracy.

EXAMPLE: At 1.0 atmosphere absolute, the analyzer will report a 50% H_2/N_2 as 50% by the analyzer. The reading will increase to 55% at 1.1 atmospheres absolute and 100% at 2.0 atmospheres absolute.

5.6 PRESSURE-NORMALIZED OPERATION

Hydrogen is reported as a volumetric concentration and pressure is assumed to be constant.

A gas containing 10% hydrogen by volume at 1.0 atmosphere absolute has a partial pressure of 0.1 atmospheres absolute of hydrogen, while 10% hydrogen by volume at 2 atmospheres absolute corresponds to 0.2 atmospheres absolute of hydrogen. For more information on the subject, refer to Dalton's Law.

5.7 VARIABLE-PRESSURE OPERATION

If the pressure is known or actively measured by a pressure sensor, the volumetric H_2 concentration can be calculated using the equation below:

$$H_{2_{vol}} = \frac{H_{2_{read}}}{P_{ata}}$$

- P_{ata} is the known or measured pressure in atmospheres absolute
- $H_{2_{read}}$ is the H_2 reading from the analyzer, under the assumption the analyzer is using the factory calibration at 1.0 atmosphere absolute

Any error in pressure measurement translates as an error in the H_2 concentration measurement. This effect is especially significant when the analyzer is measuring high hydrogen concentrations.

EXAMPLE: If an analyzer is measuring 100% H_2 at 1.0 atmospheres absolute and a pressure sensor actively compensates the reading for pressure with a relative error of 1% (0.01 atmospheres), the analyzer will have a measurement error of 1% H_2.

APPENDIX A: SPECIFICATIONS

Analyzer performance specifications are absolute and assume a dry process stream, an ambient temperature of 25 °C, and 1.0 ATA gas pressure, and are affected by errors in the calibration gases. Accuracy and repeatability are defined as ± the values listed. For other operating pressures, see 5.5. For the partial limits, see Table A.2.

While the analyzers can operate in gas containing no hydrogen, measurement performance specifications are valid only when the analyzer is exposed to gas containing hydrogen above the Lower Detection Limit shown in Table A.1.

Table A.1: 5232

Model	H_2 Range	Lower Detection Limit (LDL)	CO Limit	H_2S Limit	Response Time* (sec)	Gas Stream Temperature Range (°C)	Accuracy and Repeatability
5232	0 – 5% H_2	0.4% H_2	0	0	< 60	-20 – 60	0.3% H_2 (Absolute Error)

*For the model 5232, the response time is the time until the measured H_2 exceeds 1% when transitioning from air to 3% H_2/Air.

Table A.2: Partial Pressure Limits

Model	H_2 Limit (ATA H_2)	Lower Detection Limit (ATA H_2)	CO Limit (ATA CO)	H_2S Limit (ATA H_2S)
5232	0.05	0.004	0	0

Table A.3: Operating Conditions

Parameter	Value
Environment – Gas Stream	
Pressure	0.95 - 1.1 Bar Absolute

Parameter	Value		
	Minimum	Nominal	Maximum
Pressure Survival*		0.95 - 10 ATA	
Gas Flow Rate (1/4” tube)		1 - 10 SLPM	
Gas Flow Velocity		8 M/S	
Humidity		0 - 95% RH (non-condensing)	
Temperature		See Table A.1	
Environment – Ambient			
Ambient Temperature		-40 - 70 °C	
Storage Temperature		-40 - 85 °C	
Humidity		0 - 95% RH (non-condensing)	
Ingress Protection		IP66	
Altitude		0–2000 m above sea level	
Mechanical			
Vibration		ISTA 6-FEDEX-A TEST	
Shock		ISTA 6-FEDEX-A TEST	
Weight		1.65 lbs (748.43 g)	
Electrical			
Voltage Input		9 - 30 VDC	
Power Consumption		5 W	
Digital Output		10 VDC 40 mA 200 mW	
Analog Output		4 - 20 mA	
RS-485		Modbus RTU (three-wire)	

*Operating at pressures above or below 1 ATA will affect the measurement accuracy. See 5.5. Operating above the partial pressure limits listed in Table A.2 may damage the sensor.

APPENDIX B: STANDARDS

This equipment is in compliance with the following standards:

- IEC 60068-2-2 & EN 50155 Section 13.4.4
- IEC 60068-2-11 & DIN EN ISO 12944
- IEC 60068-2-6 table C.2
- IEC 60068-2-64 paragraph A.2, category no. 2
- IEC 60068-2-27
- FCC Part 15
- IC, RSS-Gen and RSS-210
- AS/NZS 426