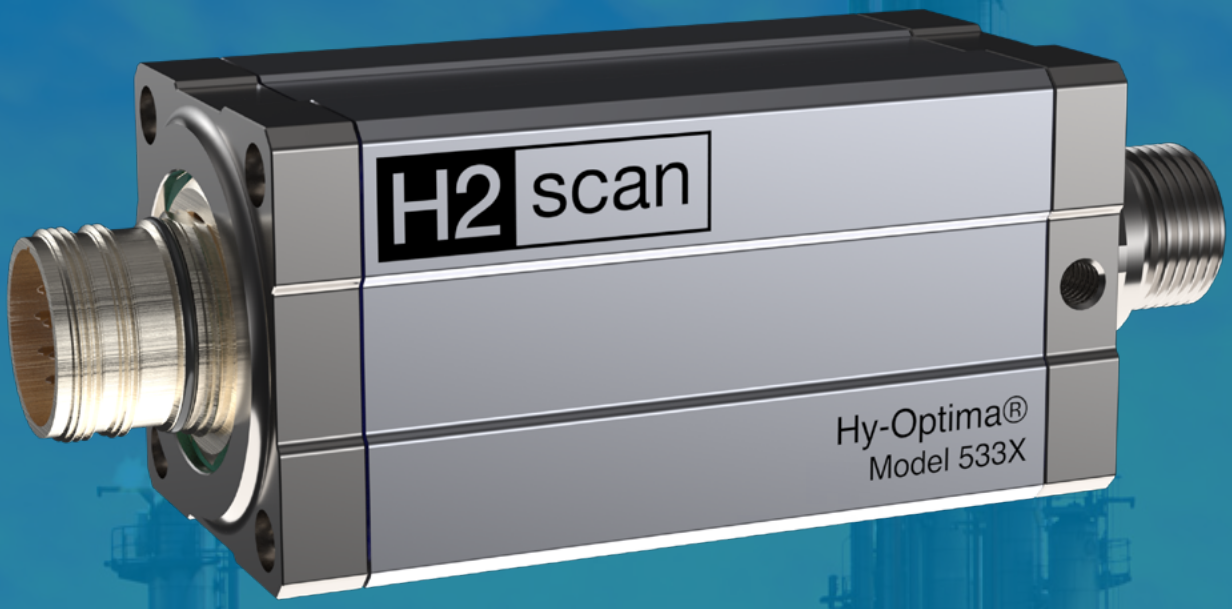
H2scan

Advanced Hydrogen Sensing



MODBUS REGISTER MAP

HY-OPTIMA®

5330 Series Hydrogen Analyzers

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. If the equipment is used in a manner not specified by the manufacturer, 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® 5330 Series 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.
Ex	According to its marking, the device is certified for hazardous areas.
!	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. OPERATION

The HY-OPTIMA 5330 Series Analyzers use Modbus RTU to communicate with external equipment.

Modbus protocol communicates over RS-485 and supports RTU packets. The HY-OPTIMA 5330 Series Hydrogen Analyzer default Modbus ID is 1. The Modbus ID can be changed by writing to holding register **150**.

The following tables comprise the list of Modbus packets, values, registers, and register definitions.

The maximum time for the analyzer to respond to a Modbus command is 10 seconds. Set the master's timeout to 10,000 milliseconds or greater.

Table 1: Modbus Read Request Packet

Byte	Modbus Parameter	Range	Meaning
1	Slave address	1–247	Unit ID Address
2	Function Code	03	Read Holding Register
3	Starting Address Hi	0x00–0xFF	Holding Register Hi Byte
4	Starting Address Lo	0x00–0xFF	Holding Register Lo Byte
5	Number of registers Hi	0	Limited by Modbus spec V1.1b
6	Number of Registers Lo	1–125	Number of 16-bit registers Lo Byte
7	CRC Lo	0x00–0xFF	CRC Low Byte
8	CRC Hi	0x00–0xFF	CRC High Byte

Table 2: Modbus Read Response Packet

Byte	Modbus Parameter	Range	Meaning
1	Slave address	1–247	Unit ID Address
2	Function Code	03	Returning Holding Registers
3	Byte Count	7–255	Number of data bytes returned = N
4	1st Data Value Hi	0x00–0xFF	
5	1st Data Value Lo	0x00–0xFF	
6	2nd Data Value Hi	0x00–0xFF	
7	2nd Data Value Lo	0x00–0xFF	
2N+4	CRC Lo	0x00–0xFF	CRC Low Byte
2N+5	CRC Hi	0x00–0xFF	CRC High Byte
N is the number of bytes returned based on the number of registers requested. If N registers are requested, 2N+5 bytes are returned.			

Table 3: Modbus Write Request Packet

Byte	Modbus Parameter	Range	Meaning
1	Slave address	1–247	Unit ID Address
2	Function Code	06	Write Holding Registers
3	Register Address Hi	0x00–0xFF	Unit Register Address Hi byte
4	Register Address Lo	0x00–0xFF	Unit Register Address Lo byte
5	Data Value Hi Byte	0x00–0xFF	
6	Data Value Lo Byte	0x00–0xFF	
7	CRC Lo	0x00–0xFF	CRC Low Byte
8	CRC Hi	0x00–0xFF	CRC High Byte

Table 4: Modbus Write Response Packet

Byte	Modbus Parameter	Range	Meaning
1	Slave address	1–247	Unit ID Address
2	Function Code	06	
3	Register Address Hi Byte	0x00–0xFF	Unit Register Address Hi byte
4	Register Address Lo Byte	0x00–0xFF	Unit Register Address Lo byte
5	Data Value Hi Byte	0x00–0xFF	
6	Data Value Lo Byte	0x00–0xFF	
7	CRC Lo	0x00–0xFF	CRC Low Byte
8	CRC Hi	0x00–0xFF	CRC High Byte

1.1 EXCEPTION RESPONSE

Normally, after receiving a query from the master, the slave device processes the request and returns a response to the master. An abnormal communication between the two devices produces one of four possible events.

1. The slave does not receive the query due to a communications error and does not return a response. The master device eventually processes a timeout condition for the query.
2. The slave receives the query, but detects a communication error (UART or CRC) and does not return a response. The master device eventually processes a timeout condition for the query.
3. The slave receives the query without a communications error, but takes longer than the master's timeout setting, and does not return a response. The master device eventually processes a timeout condition for the query. To prevent this condition, set the master timeout longer than the slave's maximum response time (10,000 milliseconds).
4. The slave receives the query without a communications error, but cannot process it due to reading or writing to a non-existent slave command register. The slave returns an exception response message informing the master of the error.

The exception response message has two fields that differentiate it from a normal response.

1. Function code – byte **2**. The high-order bit is set to one (i.e., 0x83 for a read exception and 0x86 for a write exception).
2. Exception code – byte **3**. The total exception response length is five bytes rather than normal message length.

Table 5: Exception Response Packet

Byte	Modbus Parameter	Range	Meaning
1	Slave Address	1–247	
2	Function Code	0x83 or 0x86	Read or Write
3	Exception Code	See Table 6	
4	CRC High	0x00–0xFF	
5	CRC Low	0x00–0xFF	

Table 6: Exception Response Codes

Code	Name	Reasons for Error
1	Illegal Function Code	1. The function code may only apply to newer devices and was not implemented in the unit selected. 2. The slave is in the wrong state to process a request of this type, e.g., it cannot return register values because it is not configured.
2	Illegal Data Address	The combination of reference number and transfer length is invalid. For a controller with 100 registers, the PDU addresses the first register as 0, and the last as 99. If a request is submitted with a starting register address of 96 and a quantity of four registers, this request will successfully operate (address-wise at least) on registers 96–99. If a request is submitted with a starting register address of 96 and a quantity of five registers, this request will fail with Exception Code 0x02 “Illegal Data Address” since it attempts to operate on registers 96–100, the latter of which does not exist.
3	Illegal Data Value	A fault is in the structure of the remainder of a complex request, e.g., the implied length is incorrect. This code does NOT mean a data item submitted for storage in a register has a value outside the expectation of the application program, since the Modbus protocol is unaware of the significance.
4	Slave Device Failure	An unrecoverable error occurred while the slave was attempting to perform the requested action.

1.2 MODBUS COMMAND REGISTER DEFINITIONS

NOTE: When reading registers containing 32- or 64-bit integers, read the high-order word first, followed by the lower-order word(s). Reading the high-order word saves the low-order word in a temporary location for the next register read. The firmware automatically reads the second register from the temporary location. Likewise, with a write, the high value is stored until the second value is received, at which time both values are written to the instrument.

Table 7: Modbus Holding Register Descriptions

Register	Parameter	Function	Data Type	Data Range	
Measurements					
0	Hydrogen, ppm H_2	High word	32-bit binary number	0–20,000,000	R
1		Low word			
2-30	Reserved for future use				
Information					
31–40	Model Number		ASCII String		R
41–50	Product Serial Number		ASCII String		R
51–60	Analyzer Serial Number		ASCII String		R
61–88	Reserved for future use				
89–98	Firmware Revision		ASCII String		R
99–110	Reserved for future use				
Status/Error Information					
111	Status	Refer to section 1.6.1	16-bit binary flags	Table 8: Unit Status	R
112	Error Status	Refer to section 1.6.2 High word	32-bit binary flags	Table 9: Error Status	R
113		Low word			
114–125	Reserved for future use				
Calibration Functions					
126	Calibration Gas 1, ppm H_2	High word	32-bit binary number	0–1,000,000	R/W
127		Low word			
128	Calibration Complete Date	High byte: Month Low byte: Day	32-bit binary number		R/W
129		Year			
130	Calibration Gas 2, ppm H_2	High word	32-bit binary number	0–1,000,000	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	Refer to 4.2 of HY-OPTIMA 5330 Series Hydrogen Analyzers Operation Manual	R
135	Gas start command	Gas 1 or 2 started	8-bit binary number	1: gas 1 2: gas 2	W

Register	Parameter	Function	Data Type	Data Range	
Configuration Settings					
136–149	Reserved for future use				
150	Set Unit ID		8-bit binary number	1–247	R/W
151–158	Reserved for future use				
159	Stop Bit Selection		16-bit binary number	1 (stop bit = 1) 2 (stop bit = 2)	R/W
160	Baud Rate		8-bit binary number	1 = 9600 2 = 14400 3 = 19200 4 = 38400 5 = 57600 6 = 115200	R/W
161–185	Reserved for future use				
Alarm and Digital Output Configuration					
186	Config Window I/O Operation	Open/Close/Save configuration for Analog Output, Digital Output (Reg 187–196) Refer to sections 1.10 and 1.11	16-bit binary number	1 = open edit 2 = close save 3 = abort edit	R/W
187	Aout Low Signal Range	Low Signal Range, % x100 scale	16-bit binary number	0–100%	R/W
188	Aout High Signal Range	High Signal Range, % x100 scale	16-bit binary number	0–100%	R/W
189	Aout Unit Not Ready	Not Ready, mA x100 scale	16-bit binary number	0–<4 mA, >20–24 mA	R/W
190	Aout Fault x100 scale	Fault, mA	16-bit binary number	0–<4 mA, >20–24 mA	R/W
191	Digital Output 1 Trigger	Trigger, % x100 scale	16-bit binary number	0–100%	R/W
192	Digital Output 1 Hysteresis	Hysteresis, % x100 scale	16-bit binary number	0–100%	R/W
193	Digital Output 1 Trigger Qualification	Trigger Qualification, seconds x1 scale	16-bit binary number	Unsigned 16-bit	R/W
194	Digital Output 2 Trigger	Trigger, % x100 scale	16-bit binary number	0–100%	R/W
195	Digital Output 2 Hysteresis	Hysteresis, % x100 scale	16-bit binary number	0–100%	R/W

Register	Parameter	Function	Data Type	Data Range	
196	Digital Output 2 Trigger Qualification	Trigger Qualification, seconds x1 scale	16-bit binary number	Unsigned 16-bit	R/W
197-200	Reserved for future use				
User Information					
201-210	User ID #1	Must start reading from low address; Must write low and high addresses to save string	ASCII String		R/W
211-220	User ID #2		ASCII String		R/W
221-230	User ID #3		ASCII String		R/W
231-255	Reserved for future use				

1.3 HYDROGEN MEASUREMENT

The HY-OPTIMA 5330 Series Hydrogen Analyzers report the most recent hydrogen measurement in registers **0–1**. The 32-bit unsigned integer value is not scaled and reports the integer value of hydrogen in ppm H_2.

NOTE: Read the device status in register 111 bit 15 to determine if the device is ready. The hydrogen value is zero until the ready bit is set.

NOTE: To convert ppm to %, divide ppm reading by 10,000. To convert % to ppm, multiply % value by 10,000.

1.4 TEMPERATURE MEASUREMENT

The HY-OPTIMA 5330 Series Hydrogen Analyzers monitor the internal electronics temperature. The temperature is reported as a scaled 16-bit unsigned integer in °C. Dividing the integer value by 100 and subtracting 100 will provide the measured temperature with two decimal places.

1.5 ASCII STRINGS

HY-OPTIMA 5330 Series Hydrogen Analyzer information is available as ASCII strings terminated with a zero byte (0x00). Each string can be up to 19 characters long with two characters per Modbus register. Use the read holding register function and read ten registers; each byte is an ASCII character.

- Model number: Registers **31–40**
- Product Serial Number: Registers **41–50**
- Analyzer Serial Number: Registers **51–60**
- Firmware Revision: Registers **89–98**
  - Format x:y:z
    - x is the major revision
    - y is the minor revision
    - z is the product designator

1.6 STATUS AND ERROR INFORMATION

The HY-OPTIMA 5330 Series Hydrogen Analyzers provide status and error information for the user to determine if it is operating normally.

1.6.1 Unit Status

Unit status information is maintained in Modbus register **111**.

Table 8: Unit Status

Bit #	Description
15	Unit ready, hydrogen readings are valid.
14	New measurement data available, auto clear after register read.
13	Unlisted bits are not used and may be 0 or 1.
12	Error, indicates an unrecoverable error occurred, read registers 112,113 for more information.
6–11	Unlisted bits are not used and may be 0 or 1.
3 and 5	Field calibration is active.
4	Unlisted bits are not used and may be 0 or 1.
0–2	Unlisted bits are not used and may be 0 or 1.

1.6.2 Error Status

When the error flag (bit 12) of the Unit Status register **111** is set, refer to the 32-bit register **112**,**113** for more information about the error cause.

Table 9: Error Status

Bit #	Hex	Description
31	0x8000 0000	Analyzer: Heater Fault.
30	0x4000 0000	Analyzer: Temperature Analyzer Fault.
29	0x2000 0000	Analyzer: Hydrogen Analyzer Fault.
5–28	0x0000 0020- 0x1000 0000	Unlisted bits are not used and may be 0 or 1.
4	0x0000 0010	Over temperature error.
0–3	0x0000 0001– 0x0000 0008	Unlisted bits are not used and may be 0 or 1.

1.7 SET UNIT ID

Read register **150** to confirm the selected Modbus ID is in use. Write to register **150** to set the unit to the specified ID. The device ID can range from 1–247 or as limited by the Modbus master. If the current device ID is unknown, write the desired ID to device 0 to broadcast the ID to all connected HY-OPTIMA 5330 Series devices.

1.7.1 Configuring Multiple Units

Prepare multiple units to share a common RS-485 bus by connecting one unit at a time to a Modbus controller and writing the desired ID for that unit to register **150** at device ID 0.

For PC-based configuration, use ComTest Pro from Baseblock Software LLC, Software for the Motor Control Industry. for a Modbus controller. The device must be power cycled for the new ID to take effect. Label each device with the new device ID.

1. Disconnect all units from the RS-485 cable.
2. Connect first unit to the RS-485 cable.
3. Use Modbus Controller to write a single holding register (function 6) to register **150**, with the desired ID for the connected unit.
4. Wait up to 10 seconds for the Modbus response.
5. Disconnect this unit and connect the next one to the RS-485 cable.
6. Repeat steps 3, 4, and 5 until all units are configured.

7. Attach all units to the RS-485 cable and read register **150** from each of the configured devices.

1.8 STOP BIT SELECTION

To select which stop bit to use in the RS-485 communication port settings, write a 1 or 2 to Modbus register **159** (default selection is 1).

NOTE: Changing to 2 may require writing a 3 to register 160 (baud rate – 19,200) and power cycling the HY-OPTIMA 5330 Series Hydrogen Analyzer.

1.9 BAUD RATE

Modify the HY-OPTIMA 5330 Series Hydrogen Analyzer RS-485 baud rate from the default 19,200 baud by writing to Modbus register 160 with the number corresponding to the desired value in Table 10. The device must be power cycled for the new baud rate to take effect.

Table 10: Baud Rate

Number	Description
1	9,600 baud
2	14,400 baud
3	19,200 baud (default)
4	38,400 baud
5	57,600 baud
6	115,200 baud

1.10 ANALOG OUTPUT

The HY-OPTIMA 5330 Series Hydrogen Analyzers are factory configured for 4–20 mA analog hydrogen output.

Sequence of operations to program the analog output configuration:

1. Write to register **186** with the value 1 to open the analog output configuration for editing.
2. Write to register **187** with the Aout Low Signal Range.
3. Write to register **188** with the Aout High Signal Range.
4. Write to register **189** with the Aout Unit Not Ready signal value.
5. Write to register **190** Aout Fault signal value.
6. Write to register **186** with value 2 to save the analog output configuration.

For example, to configure Aout Low Signal Range to 0%, Aout High Signal Range to 5%, Aout Unit Not Ready signal value to 23 mA and Aout Fault signal value to 3 mA.

1. Set Holding Register **186** = 1.
2. Set Holding Register **187** = 0.
3. Set Holding Register **188** = 500.
4. Set Holding Register **189** = 2300.
5. Set Holding Register **190** = 300.
6. Set Holding Register **186** = 2.

NOTE: Wait at least five seconds after the configuration save before sending a new Modbus command.

NOTE: Aout Low Signal Range must be a lower value than Aout High Signal Range.

1.11 DIGITAL OUTPUT

The HY-OPTIMA 5330 Series Hydrogen Analyzers are factory-configured with two user-configurable digital outputs.

- Digital Output Trigger is the hydrogen percentage that will trigger the digital output.
- Digital Output Trigger Qualification delays the assertion of the digital output after the trigger condition is met.
- Digital Output Hysteresis delays the deassertion of the digital output after the digital output condition is no longer met. The digital output will deassert once the hydrogen level drops below hysteresis.

1.11.1 Digital Output 1

Digital Output 1 is configured for H_2% trigger level.

Sequence of operations to program the H_2% trigger level digital output configuration:

1. Write to register **186** with the value 1 to open the digital output configuration for editing.
2. Write to register **191** with the Digital Output 1 Trigger value.
3. Write to register **192** with the Digital Output 1 Hysteresis value.
4. Write to register **193** with the Digital Output 1 Trigger Qualification value.
5. Write to register **186** with value 2 to save the digital output configuration.

For example, to configure Digital Output 1 to trigger on 2% H_2, 0.05% hysteresis, 2 second delay:

1. Set Holding Register **186** = 1.
2. Set Holding Register **191** = 200.
3. Set Holding Register **192** = 5.
4. Set Holding Register **193** = 2.
5. Set Holding Register **186** = 2.

NOTE: Wait at least five seconds after the configuration save before sending a new Modbus command.

1.11.2 Digital Output 2

Digital Output 2 may be configured for H_2% trigger level, or it may be configured for digital event to trigger on a fault condition.

If Digital Output 2 is configured for a digital event (fault condition), Holding Registers **194**, **195**, and **196** do not apply.

Sequence of operations to program the H_2% trigger level digital output configuration:

1. Write to register **186** with the value 1 to open the digital output configuration for editing.
2. Write to register **194** with the Digital Output 2 Trigger value.
3. Write to register **195** with the Digital Output 2 Hysteresis value.
4. Write to register **196** with the Digital Output 2 Trigger Qualification value.
5. Write to register **186** with value 2 to save the digital output configuration.

For example, to configure Digital Output 2 to trigger on 3.5% H_2, 0.2% hysteresis, 3 second delay:

1. Set Holding Register **186** = 1.
2. Set Holding Register **194** = 350.
3. Set Holding Register **195** = 20.
4. Set Holding Register **196** = 3.
5. Set Holding Register **186** = 2.

NOTE: Wait at least five seconds after the configuration save before sending a new Modbus command.

1.12 USER INFORMATION

The HY-OPTIMA 5330 Series Hydrogen Analyzers provide three ASCII strings the user can program to indicate where the analyzer is installed. Each string can be up to 20 characters, including null termination.

1.13 CALIBRATION STATUS AND ERRORS

Refer to 4.2 Two-Point Field Calibration in the HY-OPTIMA 5330 Series Hydrogen Analyzers Operation Manual.