HYDROGEN (H_2) SENSOR

(PART NUMBER 20624)

OPERATIONS MANUAL

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Introduction
This sensor is designed to accurately measure Hydrogen through thermal conductivity technology. It is capable of providing additional computations based on the Hydrogen measurement, and it has multiple methods of digital and analog communications capabilities.

Features
- Measures H_2 from 0 to 100% with 0.01% resolution
- Calculates NH_3, DA, and K_N for nitrider applications
- Two isolated analog outputs capable of outputting current (4-20 mA or 0-20 mA) as well as voltage (2-10 VDC, 0-10 VDC, 1-5 VDC, or 0-5 VDC)
- One RS-232 port with Modbus RTU or a simple ASCII protocol
- One RS-485 port with Modbus RTU protocol
- Wide power supply input range (9 to 30VDC)
- Small physical size

Specifications

Hydrogen measurement
- Range: 0 to 100%
- Accuracy: ±1%
- Repeatability: ±1%
- Resolution: ±0.01%

Calculated Variables for simple nitrider applications
- %NH_3 0 to 100%
- %DA (dissociated ammonia) 0 to 100%
- K_N nitriding potential

Analog Outputs
- Two isolated analog outputs with common supply; capable of outputting current (4-20 mA or 0-20 mA) as well as voltage (2-10 VDC, 0-10 VDC, 1-5 VDC, or 0-5 VDC)
- Output variables: %H_2, %NH_3, %DA, and K_N on either output
- Adjustable range of PV: zero and span
- Resolution: 0.005 mA
- Accuracy: ±0.01% of range
- Linearity: ±0.01%
- Minimum load resistance: 0 Ohms
- Maximum load resistance: 500 Ohms

Sample flow rate
- 1.5 to 2 cfh

RS-232 Serial Communications
- Protocols: Modbus RTU or a simple ASCII
- Baud rates: 9600, 19200, or 38400
- Format: 8 bits No parity, 1 stop bit, No handshaking
- Connection: DB-9F

RS-485 Serial Communications:

- Protocol: Modbus RTU
- Baud rates: 9600, 19200, or 38400.
- Format: 8 bits No parity, 1 stop bit, No handshaking

Power requirement

- 9 to 30 volts DC @ 2 watts

Temperature and Humidity

- Electronics Operating: 0 to 50 °C, RH 0 to 90% non-condensing
- Sample gas: 0 to 70 °C, RH 0 to 90% non-condensing
- Storage: -20 to 70 °C, RH 0 to 90% non-condensing

Calibration

It is suggested that this device should be calibrated on a routine basis, such as once per year or as prescribed by the user's quality system requirements.

Dimensions: See Figure 1.

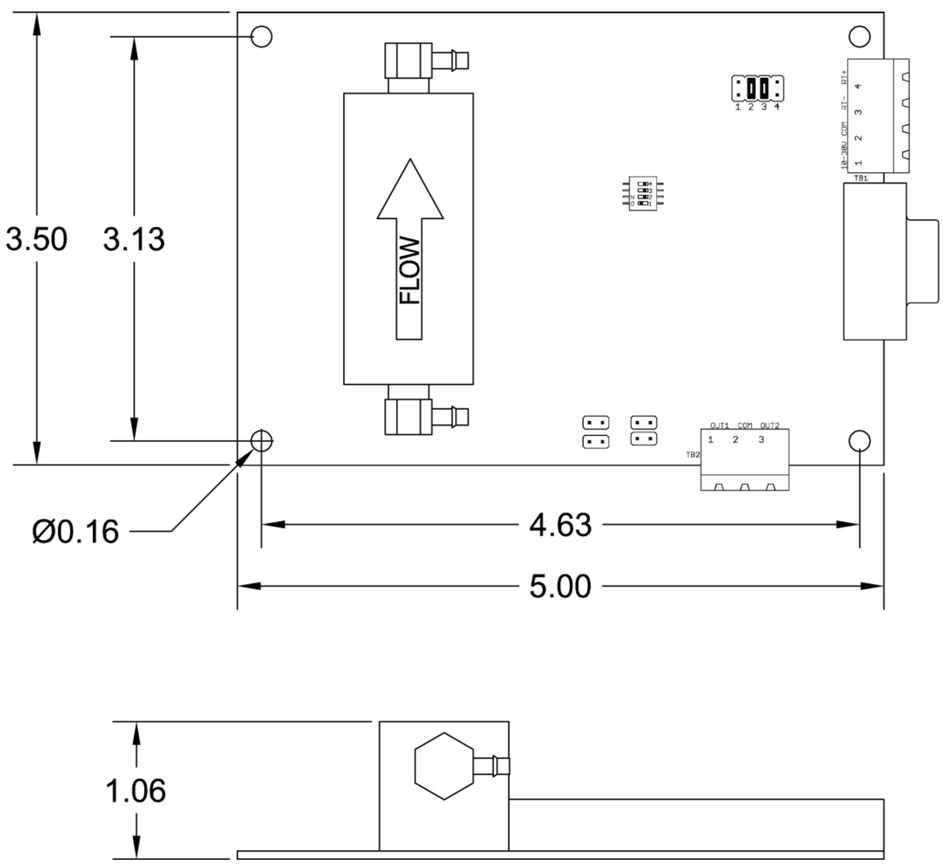

Figure 1 - H_2 Sensor Dimensions

Weight: 350 g

Material: Stainless steel sensor housing

Wiring: See Figure 2.

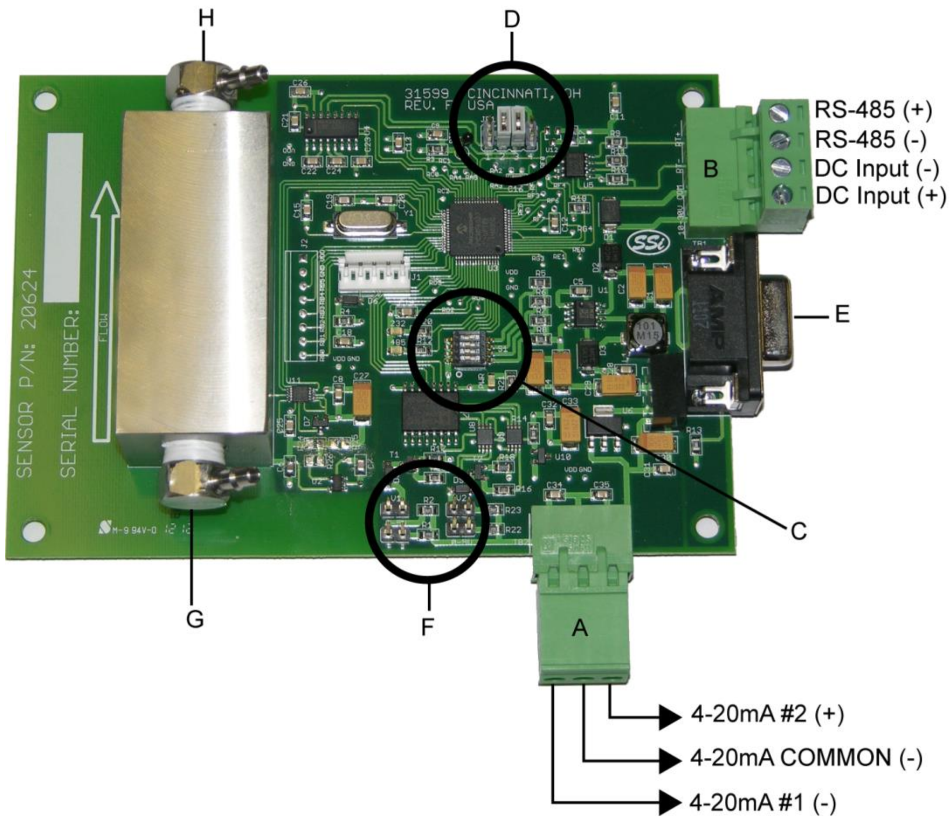

Figure 2 - H_2 Sensor Wiring

Switch Settings, Jumper Settings, and Connector Assignments

<u>Location of RS-485, DC Input, and Analog Output Terminals</u>
(Items "A" and "B" in Figure 2)
There are two terminal blocks on the H_2 cell circuit board. Figure 2 shows their locations.

One block ("A") contains the analog output terminals. Jumper settings on the circuit board are used to change whether resistance or voltage is generated. These jumper settings can be found in "Analog Output Jumpers" below.

Another block ("B") contains the digital communications (RS-485) and power (DC) terminals.

<u>Dip Switch Settings</u>
(Item "C" in Figure 2)
The first three dip switches determine the Modbus address. The address can be set for any number between 1 and 8 using a binary numbering system where Bit #1 is the least significant bit and Bit #3 is the most significant bit. The diagram below describes the switch position for each possible address. The shaded area indicates the location of the switch.

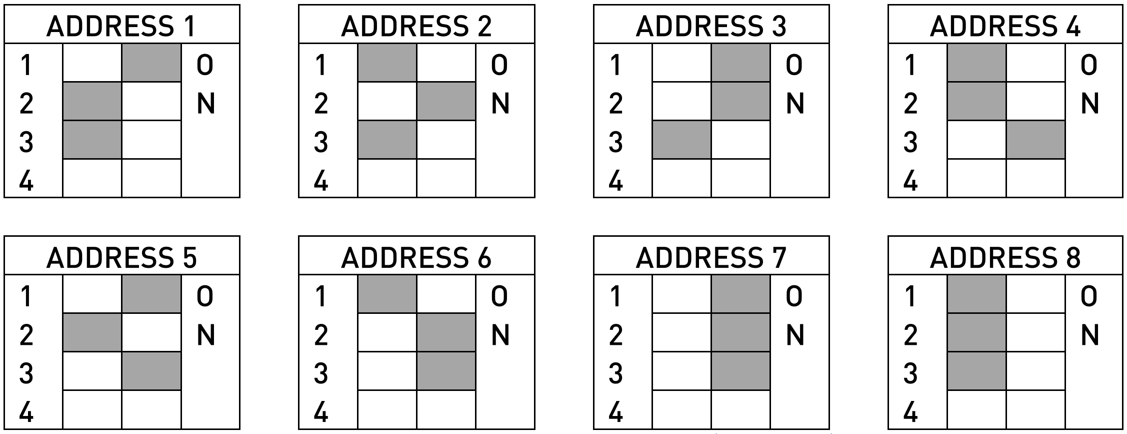

Figure 3 - Dip Switch Settings (#1, #2, #3)

The last dip switch (#4) indicates the communication protocol. The 'Off' position is Modbus RTU mode, and the 'On' position emulates the simple ASCII protocol of the previous version of the SSI Hydrogen Sensor. The diagram below describes the switch position for each protocol. The shaded area indicates the location of the switch.

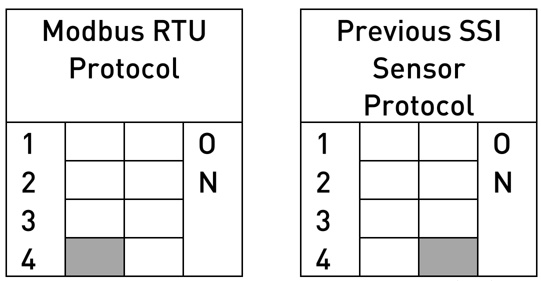

Figure 4 - Dip Switch Positions (#4)

<u>Jumper Positions – Modbus RTU/ASCII</u>

(Item "D" in Figure 2)

Four jumper terminals can be found on the board approximately 1.5" (3.81cm) to the left of the RS-485 connections (specifically, when looking at the board in the orientation shown in Figure 2). These jumpers determine the pins that transmit and receive data via RS-232 communication. The jumpers should be on Pins 2 and 3 for normal Modbus RTU operation (pin 2 is receiving and pin 3 is transmitting). The jumpers should be on Pins 1 and 4 if the sensor is being used to communicate via the simple ASCII protocol used on the previous version of the SSI Hydrogen Sensor (pin 2 is transmitting and pin 3 is receiving).

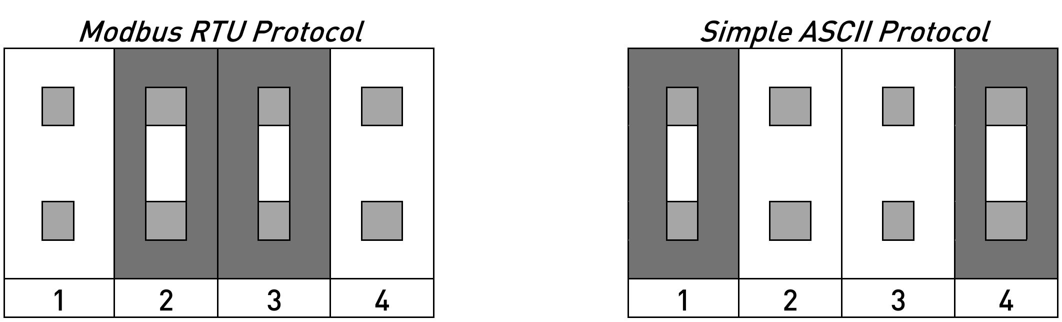

Figure 5 - Jumper Positions (Modbus RTU/ASCII)

<u>9-Pin Connector</u>

(Item "E" in Figure 2)

The sensor has a female 9-pin connector used for RS-232 communication. Only three of the nine pins are used, and their assignments are:

Pin #2: Transmit or Receive (Depends on jumper positioning)
Pin #3: Transmit or Receive (Depends on jumper positioning)
Pin #5: Ground

<u>Analog Output Jumpers</u>

(Item "F" in Figure 2)

Jumpers near the analog output terminal block are used to determine whether a current or a voltage is produced. Figure 6 shows the locations of the four jumpers: JP2, JP3, JP4, and JP5.

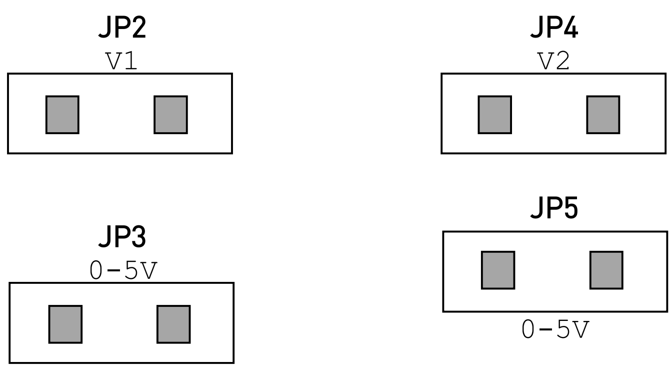

Figure 6 - Layout of Analog Output Jumpers

If all jumpers are OPEN, a 4-20mA signal is produced.

Note the location of terminals #1 and #2, as well as the COMMON terminal, in Figure 7. #1 and COMMON, in combination, constitute loop 1, or the "left side" of the block. #2 and COMMON, in combination, constitute loop 2, or the "right side" of the block.

JP2 and JP3 are used for loop 1. JP4 and JP5 are used for loop 2.

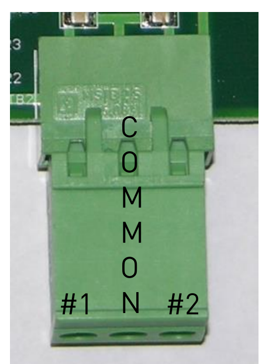

Figure 7 – Analog Output Terminal Block

The following table shows how the jumpers are used to change settings for the analog outputs.

Applies to Loop 1 (#1 and COMMON)		
JP2	**JP3**	**Resulting Output**
Open	Open	4-20mA (current)
Closed	Open	2-10 VDC
Open	Closed	4-20mA (current)
Closed	Closed	1-5 VDC
IMPORTANT: If Modbus register 43 is set to 0, the above conditions are true. If Modbus register 43 is set to 1, the following changes take place (depending on jumper settings): • 4-20mA becomes 0-20mA • 2-10 VDC becomes 0-10 VDC • 1-5 VDC becomes 0-5 VDC.		

Applies to Loop 2 (#2 and COMMON)		
JP4	**JP5**	**Resulting Output**
Open	Open	4-20mA (current)
Closed	Open	2-10 VDC
Open	Closed	4-20mA (current)
Closed	Closed	1-5 VDC
IMPORTANT: If Modbus register 44 is set to 0, the above conditions are true. If Modbus register 44 is set to 1, the following changes take place (depending on jumper settings): • 4-20mA becomes 0-20mA • 2-10 VDC becomes 0-10 VDC • 1-5 VDC becomes 0-5 VDC.		

Table 1 - Analog Output Jumper Settings

Plumbing Connections
(Items "G" and "H" in Figure 2)
The sensor is provided with barb fittings (Items "G" and "H") that are intended for use with 1/8" ID flexible tubing. Flow goes into "G" and out through "H". The barb fittings can be removed at the user's discretion, and any fitting with a 1/8" male pipe thread can be used in their place. If the fittings are going to be replaced with different fittings, they must be replaced while the stainless steel sensor block is still attached to the circuit board. Do not remove the sensor block since its alignment with the sensors is a critical function that should only be performed by a trained technician.

Analog Output Assignments
There are two analog outputs on the sensor. The default settings result in Output 1 being set for Percent H2 (0-100%) and Output 2 being set for Percent Dissociation (0-100%). Both of these outputs can be configured for any of the following parameters:

Percent Hydrogen (H_2)
Percent Dissociation (DA)
Percent Ammonia (NH_3)
Nitriding Potential (K_N)
External

In "External" output mode, no calculation is performed, and the output is set to match a specific value. Modifications to the Analog Output Assignments can be performed with the SSI H_2 Cell Configuration Utility Software, which is described in the next section of this manual.

Calibrating and Configuring the Sensor using the H_2 Configuration Utility Software

The simplest way to set up the analog outputs, calibrate the analog outputs, and calibrate the Hydrogen sensor is to use the SSi H_2 Configuration Utility software. This software provides a simple to use graphical interface for performing the setup and calibration functions. It communicates via Modbus (either RS-232 or RS-485). This is set by moving dip switch #4 to the off position. To communicate via RS-232, use the 9-pin connector with the jumpers in positions 2 and 3. To communicate via RS-485, use the RT+ and RT- terminals on the 8 pin terminal strip.

<u>Minimum Computer Requirements</u>

- Microsoft Windows XP/Vista/7
- 500 MHz CPU
- 128MB RAM
- 2MB hard disk storage space
- 1 RS-232 or RS-485 Serial Port

<u>Configuring Communications</u>

Open the H2 Configurator and click **Options → Settings** to open the dialog that allows you to set the serial port, baud rate and target address of the H2 cell. (See Figure 8.)

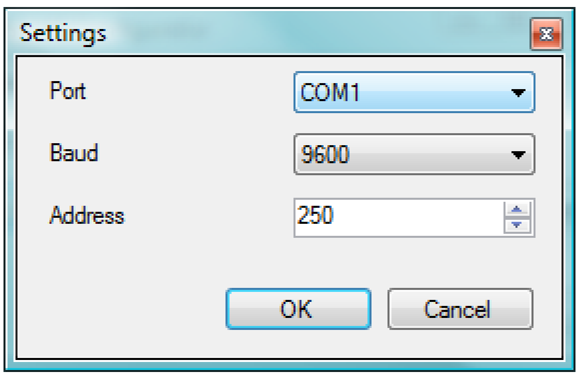

Figure 8 - Settings window

When using the RS-232 port, the baud rate should be set to 9600 and the address should be set to 250. 250 is an SSi broadcast address and any H_2 cell that sees the message will answer, so while the 250 address should be used for RS-232 it should not be used for RS-485 if there are multiple SSi instruments on the same serial port. The Port setting may need to be adjusted to match the port on your PC that is connected to the H_2 cell. RS-232 communications use a simple straight through cable to the DB9 connector.

<u>Overview Screen</u>

The Overview screen (Figure 9) displays the current % H_2 and the three buttons used to configure or calibrate the H2 cell.

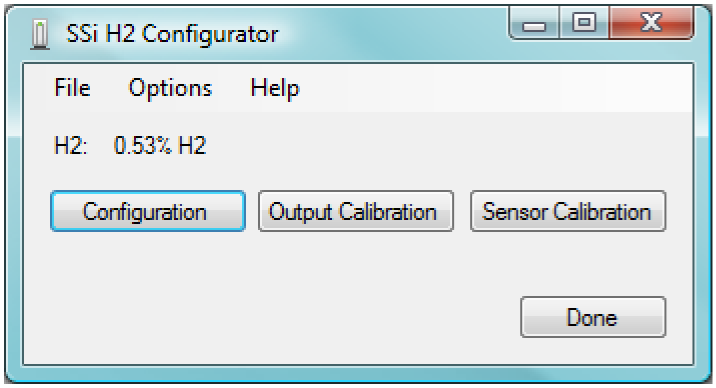

Figure 9 - Overview screen

Sensor Output Configuration

The Configuration screen (Figure 10) allows basic configuration of the H_2 cell.

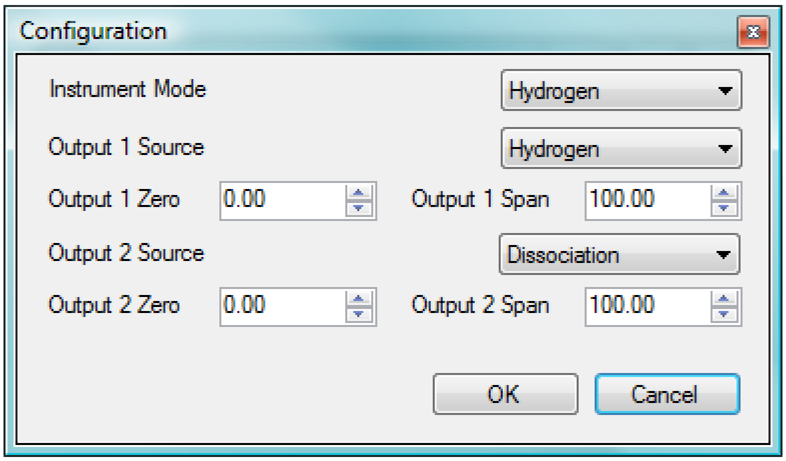

Figure 10 - Configuration screen

The Instrument Mode is the primary PV (Process Variable) setup. This is mainly used by the touch screen and normally does not need to be changed as the % H_2 is always available. The output sources are the PVs that will be retransmitted via the selected output. The Output Zero is the PV value that will result in a 4 mA output and the output span value is the PV value that will result in a 20 mA output.

Sensor Output Calibration

Output calibration calibrates the outputs. Each output can be zeroed and spanned. To perform this calibration a reliable measurement device capable of accurately measuring a 4-20mA signal will be required. An example screen is shown in Figure 11; a screen showing the success of an output calibration can be seen in Figure 12.

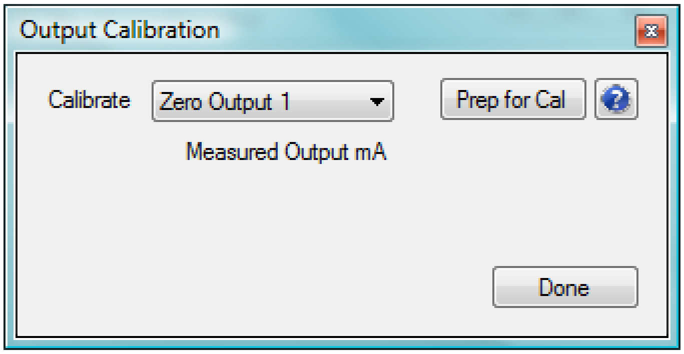

Figure 11 - Output Calibration screen

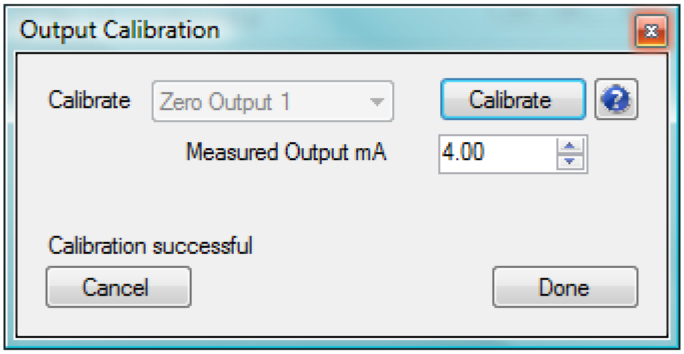

Figure 12 - Successful Output Calibration

The steps to performing an output cal are as follows:

- Select an output and whether you are going to do a zero or a span.
- Click Prep for Cal. The H_2 cell will set the output appropriately for measurement.
- Measure the output current at the H_2 cell's terminals and input that value into the box next to 'Measured Output mA'. For example, if you are performing a zero calibration and your measurement device is indicating 4.03mA, you would enter the value of 4.03 in the "Measured Output mA" box.
- Click the Calibrate button to perform the calibration.
- When the calibration is complete, the measurement device should display the target value. For a zero calibration that would be 4.00mA, and for a span calibration that would be 20mA.

Sensor Calibration

It is suggested that this device should be calibrated on a routine basis, such as once per year or as prescribed by the user's quality system requirements.

The sensor can be zeroed or spanned via Sensor Calibration (Figure 13). The gas should flow at a rate of 1.5 SCFH and the detected H_2 value needs to be steady before a calibration is performed. To perform a Zero cal select Zero in the drop down box next to Calibrate. Enter the % H_2 of the supplied gas (for zero this will be 0.00%). Wait for the readings to come to equilibrium and click Calibrate. To perform a Span cal select Span in the drop down list and repeat the process.

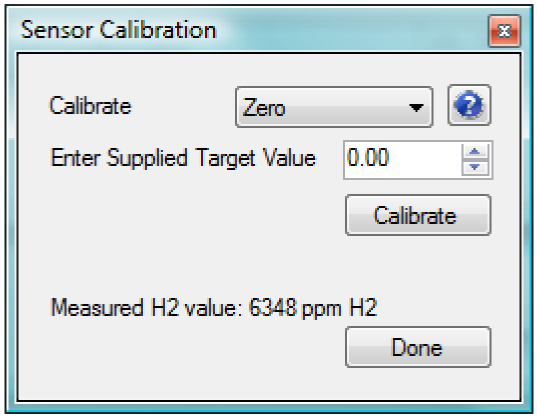

Figure 13 - Sensor Calibration screen

<u>About</u>

The About screen (Figure 14) is access from the overview screen by clicking Help…About. The About screen provides release information about the H_2 Configuration utility and the revision of the firmware in the SSi H_2 cell.

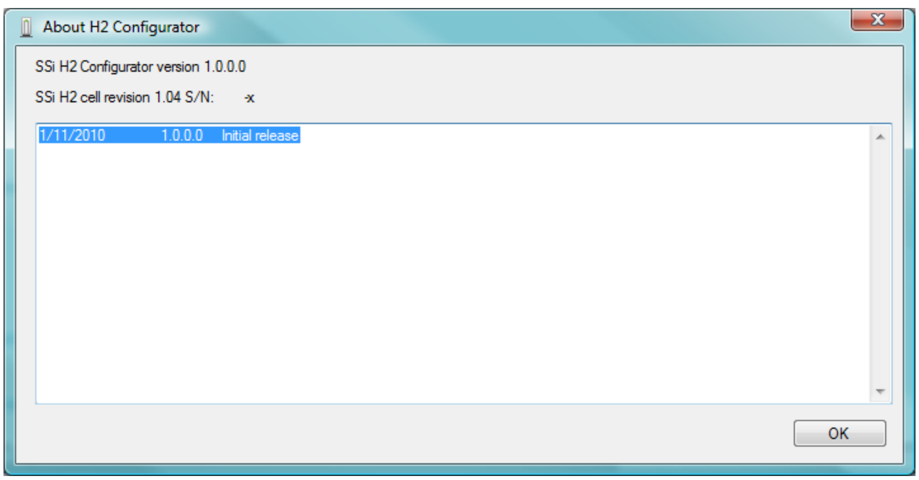

Figure 14 - "About" Screen

<u>Modifying Modbus Registers</u>

The setup parameters of the H_2 sensor can also be modified by adjusting the Modbus registers. A list of all Modbus registers can be found in "Appendix 1: Modbus Register Map". To make modifications, you must connect the sensor to a computer that uses SSI's "Configurator" software. When communicating with Configurator, use a straight-through serial extension cable connecting the computer to the sensor. Set the baud rate in Configurator to 9600. On the sensor, set DIP Switch #4 to Off for Modbus communication, and be sure that the jumpers are on pins 2 and 3.

Calibrating the Sensor using Modbus Registers

Performing a Zero Calibration

1. Begin the flow of Zero gas (Nitrogen or Argon) at a rate of 1.5 SCFH.
2. Allow the readings from the sensor to stabilize.
3. Set Register #13 to 0 (equal to 0% H_2).
4. Set Register 12 to 1.

Performing a Span Calibration

1. Begin the flow of Span gas (with a known %H_2) at a rate of 1.5 SCFH.
2. Allow the readings from the sensor to stabilize.
3. Set Register #13 to the H_2 value in the span gas. Multiply the gas value by 100 before entering the number (i.e. if the gas has 40.13%H_2, enter a 4013 or if the gas has 9.97% H_2 enter a 997 into Register 13).
4. Set Register 12 to 2.

Changing the 4-20mA Assignments using Modbus Registers

Register 19 denotes the assignment for 4-20mA #1, and register 23 denotes the assignment of 4-20mA #2. The default value for #1 is %H_2, and #2 is #DA. To change the assignment, enter a number into either register according to the following list:

- 0 = %H_2
- 1 = %DA
- 2 = %NH_3
- 3 = %Kn
- 4 = External Source

Appendix 1: Modbus Register Map

Register Functions and Default Values		
#	Function	Default
0	Current firmware revision level	Varies
1	RS-232 communication mode (0=Modbus slave, 1=ASCII /Previous SSI Sensor)	DIP Sw.
2	RS-232 baud rate (0=9600, 1=19200, 2=38400)	0
3	RS-485 communication mode (0=Modbus slave, 1=Modbus master [NOT USED])	0
4	RS-485 baud rate (0=9600, 1=19200, 2=38400)	1
5	Temperature trim for thermistor 1 / ambient temperature	200
6	A/d counts for thermistor 1	Varies
7	Thermistor 1 temperature	Varies
8	%H2 A/D counts – High (Right justified: 0x00 byte, high byte, mid byte, low byte)	Varies
9	%H2 A/D counts – Low (Right justified: 0x00 byte, high byte, mid byte, low byte)	Varies
10	%H2 measured voltage	Varies
11	%H2 as found from a polynomial	Varies
12	%H2 sensor calibration (0=none, 1=zero cal, 2=span cal)	0
13	%H2 gas composition (value/100 = %H2/N2 balance)	0
14	Sensor Modbus address (important for slave communications only)	DIP Sw.
15	Model Number	4100
16	Set Factory Defaults (23205=Full, 23206=%H2, 23207=Loop 1, 23208 = Loop 2)	0
17	4-20mA #1 DAC output counts	Varies
18	4-20mA #2 DAC output counts	Varies
19	4-20mA #1 Source (0=%H2, 1=%DA, 2=%NH3, 3=Kn, 4= External)	0
20	4-20mA #1 Zero value	Varies
21	4-20mA #1 Span Value	10000
22	4-20mA #1 External current loop (Used only if register 19 = 4)	0
23	4-20mA #2 Source (0=%H2, 1=%DA, 2=%NH3, 3=Kn, 4= External)	1
24	4-20mA #2 Zero value	0
25	4-20mA #2 Span Value	1000
26	4-20mA #2 External current loop (Used only if register 23 = 4)	0
27	Enable Calibration of 4-20ma output (0=disable, 1=enable)	0
28	Calibrate 4-20mA output (1=#1 zero, 2=#1 span, 3=#2 zero, 4=#2 span)	0
29	4-20mA calibration value (4000 to 20000 for 4-20mA)	0
30	Calibration result codes (9-12=successes, 13-16=failures, 20=no cal specified)	0
31	Percent DA value	Varies
32	Percent NH_3 value	Varies
33	Super Kn value	Varies
34	%N_2 flow	0
35	%NH_3 flow	0
36	%DA flow	0

Register Functions and Default Values		
#	Function	Default
37	Process variable mode (0=H_2, 1=DA, 2=NH_3, 3=K_N)	0
38	Process variable value	Varies
39	%H_2 mantissa	Varies
40	%H_2 exponent	Varies
41	Force theoretical current loop values	0
42	Minimum H_2 value	0

Warranty

Limited Warranty for Super Systems Products:

The Limited Warranty applies to new Super Systems Inc. (SSI) products purchased direct from SSI or from an authorized SSI dealer by the original purchaser for normal use. SSI warrants that a covered product is free from defects in materials and workmanship, with the exceptions stated below.

The limited warranty does not cover damage resulting from commercial use, misuse, accident, modification or alteration to hardware or software, tampering, unsuitable physical or operating environment beyond product specifications, improper maintenance, or failure caused by a product for which SSI is not responsible. There is no warranty of uninterrupted or error-free operation. There is no warranty for loss of data—you must regularly back up the data stored on your product to a separate storage product. There is no warranty for product with removed or altered identification labels. SSI DOES NOT PROVIDE ANY OTHER WARRANTIES OF ANY KIND, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OR CONDITIONS OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. SOME JURISDICTIONS DO NOT ALLOW THE LIMITATION OF IMPLIED WARRANTIES, SO THIS LIMITATION MAY NOT APPLY TO YOU. SSI is not responsible for returning to you product which is not covered by this limited warranty.

If you are having trouble with a product, before seeking limited warranty service, first follow the troubleshooting procedures that SSI or your authorized SSI dealer provides.

SSI will replace the PRODUCT with a functionally equivalent replacement product, transportation prepaid after PRODUCT has been returned to SSI for testing and evaluation. SSI may replace your product with a product that was previously used, repaired and tested to meet SSI specifications. You receive title to the replaced product at delivery to carrier at SSI shipping point. You are responsible for importation of the replaced product, if applicable. SSI will not return the original product to you; therefore, you are responsible for moving data to another media before returning to SSI, if applicable. Data Recovery is not covered under this warranty and is not part of the warranty returns process. SSI warrants that the replaced products are covered for the remainder of the original product warranty or 90 days, whichever is greater.

Revision History

Rev.	Description	Date	MCO #
A	Previous Release		
B	Changes made to reflect changes in board design. Changed pinout. Added content for setting analog outputs to volts.	11/1/2013	2132
C	Revised specifications for hydrogen measurement.	9/23/2015	2166
D	Added calibration interval text	3/25/2021	2308