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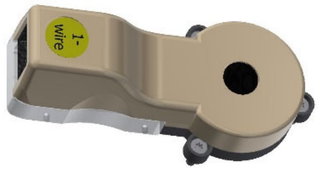


PRECVS-PGA-ADC 3.6

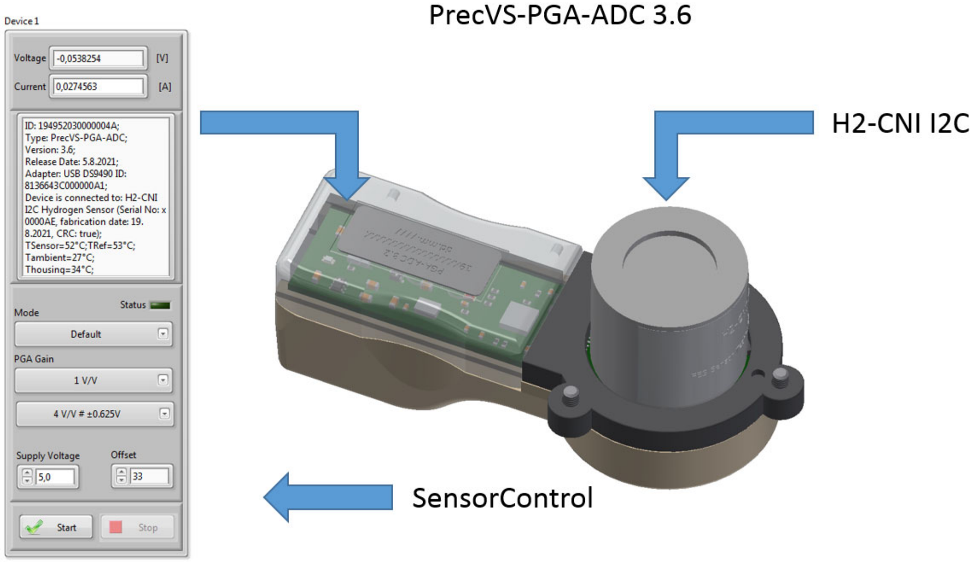
Evaluation Kit for H2-CNI I2C Hydrogen Sensors

1. DESCRIPTION

The controller PrecVS-PGA-ADC 3.6 serves as evaluation kit for calorimetric, non-isothermally operated H2-CNI I2C hydrogen sensors with I^2C bus. The controller contains an adjustable (256 steps) 300-mA LDO voltage regulator and the second branch of a Wheatstone bridge to power up the sensor. It delivers an excitation voltage up to 12 V. The bridge is zeroed with a 64-position digital rheostat which is a component of the second branch of the Wheatstone bridge. The balance voltage of the bridge is measured with a precision, zero-drift programmable gain instrumentation amplifier (G : 0.125, 0.172, 0.25, 0.344, 0.5, 0.688, 1, 1.375, 2, 2.75, 4, 5.5, 8, 11, 16, 22, 32, 44, 64, 88, 128, 176 V/V) and a 16-bit analog-to-digital converter with input current cancellation and a bandgap reference with very high accuracy and low thermal drift of 10 ppm/°C (max). The controller contains a ±1.0°C accurate digital temperature sensor with 12-bit resolution for ambient temperature measurement and a 1K bit electrically erasable PROM. PrecVS-PGA-ADC 3.6 also provides SDA and SCL junctions to the internal I^2C bus of the H2-CNI I2C sensor to access the sensor´s EEPROM and housing temperature sensor.

The evaluation kit is operated through a 1-wire bus connector with a personal computer, an installed LabVIEW® runtime and the SensorControl software.

2. APPLICATION



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3. REVISION HISTORY

Date	Rev.	
May 15, 2021	1.0	Initial Version

4. PIN CONFIGURATION OF SENSOR CONNECTOR

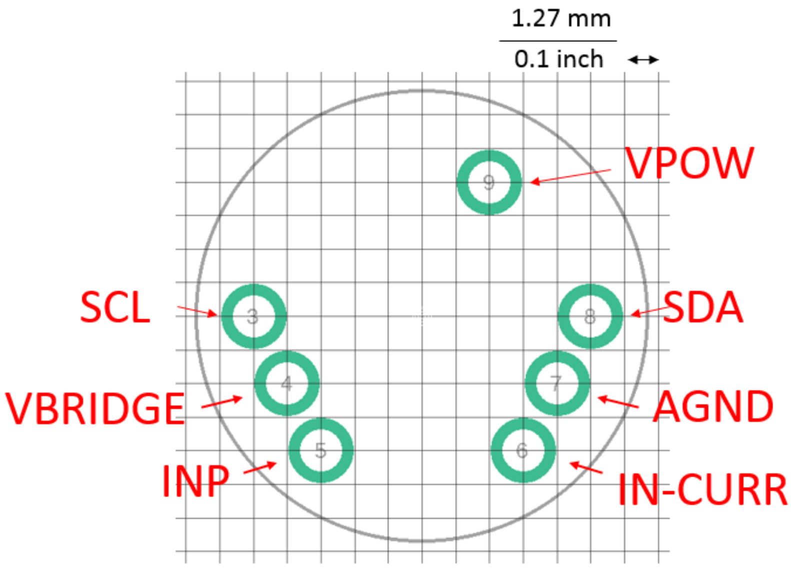


Figure 1: Top view of connections

PIN NO.	SIGNAL NAME	DESCRIPTION
3	SCL	SCL line of I2C bus
4	VBRIDGE	Bridge excitation voltage connected to 1st junction of reference sensing element
5	INP	Junction between active sensor element and reference element
6	IN-CURR	1st junction of sensing element
7	AGND	I2C ground
8	SDA	SDA line of I^2C bus
9	VPOW	+Vpower Output

5. PIN CONFIGURATION OF 1-WIRE CONNECTOR

Do not connect the evaluation kit to other 1-wire components as the pins 4, 5 and 6 have a different function in common 1-wire networks. Connect the evaluation kit only to our special USB bipolar power source SBPS-eFuse-LDO. This power source also contains a socket for a jack plug which is connected to the +Vpower line.

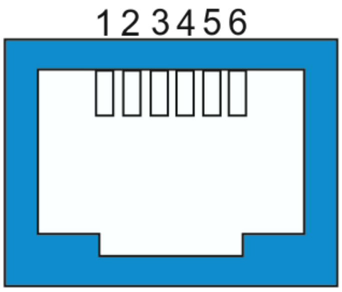


Figure 2: Pinout 6P6C-RJ12 socket

PIN NO.	SIGNAL NAME	DESCRIPTION
1	VDC	+6 V Input
2	AGND	Power Ground
3	OW	1-Wire Data
4	VPOW	+Vpower Input
5	VPOS	+12V Input
6	VNEG	-12V Input

6. SPECIFICATIONS

6.1. ABSOLUTE MAXIMUM RATINGS

At ambient temperature T_a = 20 °C.

Input supply voltage at pin 4 of the 6P6C-RJ12 socket	+15 V
Storage temperature	-40°C to 100 °C

6.2. ESD CAUTION

ESD (electrostatic discharge) sensitive device. Although this product features protection circuitry, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

6.3. LIST OF REQUIRED ADDITIONAL COMPONENTS

PART	DESCRIPTION	QUANTITY
H2-CNI I2C	Calorimetric hydrogen sensor for non-isothermal operation with I^2C bus	1
SBPS-eFuse-LDO 3.10	Bipolar power source, version 3.10	1
PS 12 Volt	Power supply 12 Volt	1
DS9490R	1-Wire USB Adapter (Maxim Integrated)	1
6p6c RJ12 0,3	Cable 6p6c RJ12 0,3 m	2
	Optional:	
TC-1/4	Gas flow test chamber with ¼“ tubes and Swagelok®	1

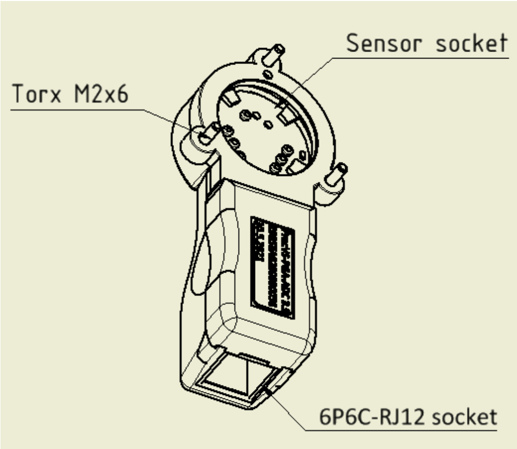
6.4. RECOMMENDED OPERATING CONDITIONS

At ambient temperature T_a = 20 °C (unless otherwise noted).

	MIN	NOM	MAX	UNIT
VPOW	+6	+12V	+15	V

6.5. MECHANICAL

Length	70 mm
Height	23 mm
Width	33 mm



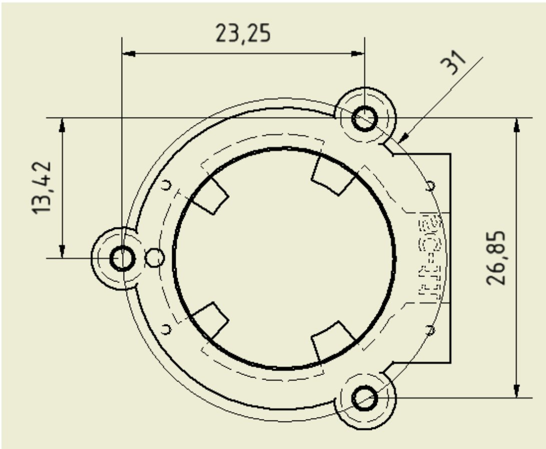


Figure 4: Drawing of PrecVS-PGA-ADC 3.6 (left). Flange with three Torx M2x6 screws (right). All dimensions are in mm.

7. THEORY OF OPERATION

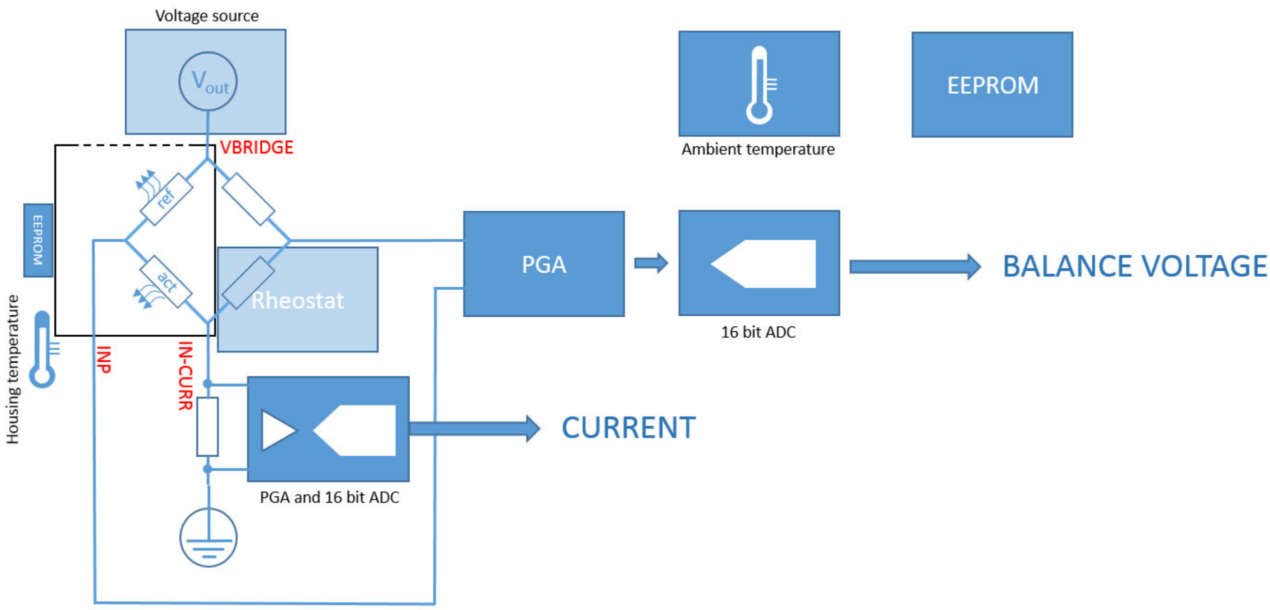


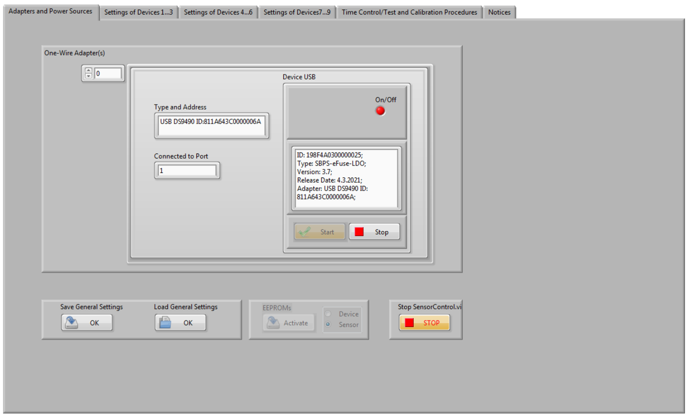
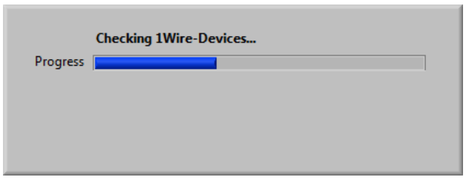
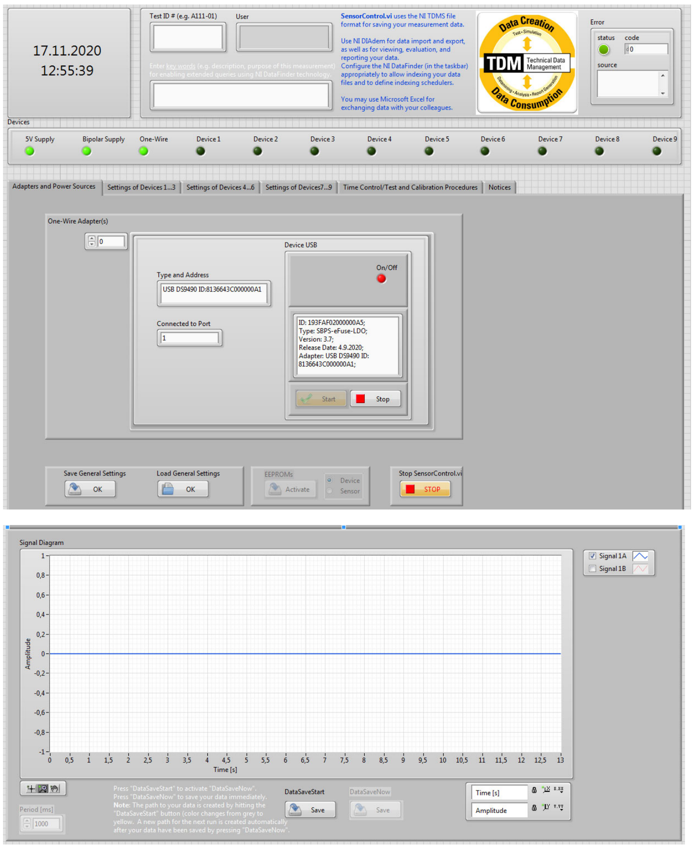
Figure 3: Sketch of sensor and main components of H2-CNI I2C (black frame) and PrecVS-PGA-ADC 3.6

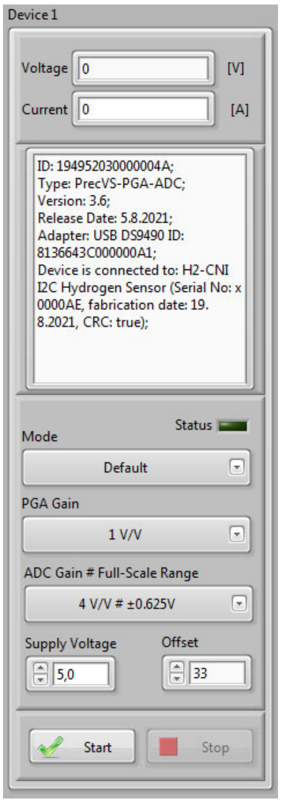
The active and reference element of the sensor forms one branch of a Wheatstone bridge configuration and are heated by the current that flows from the adjustable 256-step voltage source V_{bridge} through a precision resistor to ground. The voltage, that decays at the resistor, is measured by a 16 bit analog-to-digital converter (ADC) with an integrated programmable gain amplifier and is used to calculate the current, applying Ohm´s law. accurately measure the temperature of the sensor. The Wheatstone bridge is zeroed by means of a 64-position digital rheostat. The balance voltage is measured with a precision, zero-drift and high-voltage programmable amplifier, the output of which is connected to a 16 bit ADC. The ambient temperature is determined using a ±1.0°C accurate digital temperature sensor with 12 bit resolution. Sensor parameters are stored in a 1k EEPROM. All integrated circuits are part of an internal I2C bus that is interfaced to a 1-Wire slave to I2C master bridge device. The controller is connected to a Windows® PC via an USB-to-1 Wire adapter and operated by the software SensorControl as described in the next section.

The H2-CNI I2C sensor contains a catalytically active element and an inactive reference element. They are heated by the power which is delivered from the voltage source. The power at the active element is approximately $P = {}^{1}/_{2}\, V_{\text{bridge}}\, I$ with I as current. The operation temperature is adjusted well above the temperature of the ambient oxygen-containing atmosphere. The temperature of the active element can be approximately kept constant and independent from the ambient temperature by choosing and appropriate voltage V_{bridge}. The underlying function between V_{bridge} and T_{ambient} can be stored within the sensors EEPROM, together with other parameters such as the resistances of the sensor elements. Exposure to hydrogen leads to a flameless oxidation of H_2 molecules that generates a chemical heat. It is proportional to the reaction rate, i.e. the number of H_2 molecules that undergoes oxidation towards H_2O. The chemical heat increases the electrical resistance of the active element which in turn results in a change of the balance voltage. The latter is accurately determined with a with a precision, zero-drift programmable gain instrumentation amplifier and a 16-bit analog-to-digital converter with input current cancellation and a bandgap reference with very high accuracy and low thermal drift of 10 ppm/°C (max).

8. OPERATION WITH SENSORCONTROL

#	Step	Figure
Follow "Installation Guide 1-Wire Driver"		
Run SensorControl.vi or SensorControl.exe		
1	Plug 1-Wire USB Adapter to an USB port of the running PC.	
2	Connect RJ12 socket (labeled USB) of the bipolar power source with the 1-wire USB adapter using a 6pc6 cable.	
3	Connect a 5 V plug-in power supply* with the power line and connect it with the bipolar power source. (* recommended for an operation temperature of 80°C at an ambient temperature of 20 °C; 6 or 9 V power supplies can also be used and are recommended for lower ambient temperatures and higher operation temperatures)	**Attention:** When using SBPS-eFuse-LDO 3.7 or lower versions you must start with steps 1 and 2 before plugging the 12 V power supply. Do not unplug the USB adapter from the computer while the 12 V power supply is still inserted. Later versions of SBPS-eFuse-LDO (> 3.8) have two safety relais to ensure that the 12 V is not passed to the heating element of the sensor before the software has started the controller and controls its actions. However, it is a good practice to perform steps 1 to 5 quickly in the recommended sequence thus enabling the SensorControl software to get ful control over the hardware. Also follow the advice to remove first the 12 V power supply when you have complete the evaluation.
4	Plug the H2-CI 2C sensor into the controller PrecVS-PGA-ADC and connect one RJ12 socket of the bipolar power source with the sensor controller PrecVS-PGA-ADC using a low-ohmic 6p6c cable	**Note:** Many commercial 6p6c RJ12 cables are used for communication networks. We recommend for the connection between the SBPS-eFuse-LDO and the PrecVS-PGA-ADC a low-ohmic, short cable.

5	Choose “Sensor” in the EEPROM selection box*  to ensure reading of the controller adjustments from the sensor´s internal EEPROM and not from the device´s internal EEPROM. *) see Comment on page 9	
6	Run SensorControl (see User Guide SensorControl.vi for further explanations)	Wait until initialization is completed  and the yellow LED of the SBPS-eFuse-LDO bipolar power source stops blinking. It indicates that the software accesses the I2C bus of the sensor controller and of the sensor. Finally, you get the frontpanel 

<table>
<tr>
<td>7</td>
<td>Click on the register card “Settings of Sensors 1…3”</td>
<td>


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<td>

Voltage shows the balance voltage of the Wheatstone bridge configuration of the H2 CNI I2C sensor.

Current will show the current through the active and reference sensor elements.

Display shows “Notices to Operators”:

ID of device (controller);

Type of device; Version of device

Release date of device;

Adapter to which the device is connected;

Type of sensor to which the device is connected; serial number of the sensor, fabrication date and the result of the CRC check of the data integrity.

Status indicates overdrive condition of the ADC

Ring to select the gain of the programmable gain amplifier that amplifies the balance voltage.

Ring to adjust the gain of 16 bit ADC´s internal PGA. This ADC measures the voltage of a 1 Ohm resistor in series with the sensor/compensator

Supply voltage V_{bridge} to excite the Wheastone bridge

Offset of the 64-position rheostate

Start and **Stop** button

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<td colspan="4">

Comment: If you do not have the SensorControl.vi software but using SensorControl.exe you have no LabVIEW tools to select between “Sensor” and “Device” since the selection box is disabled. *Workaround*: start SensorControl with device, proceed with step 8, click back to the register card “Adapters and Power Sources” and find the selection box enabled. Select “Sensor” and proceed with step 12 (Stop program). You can now re-start the entire procedure from step 6.

</td>
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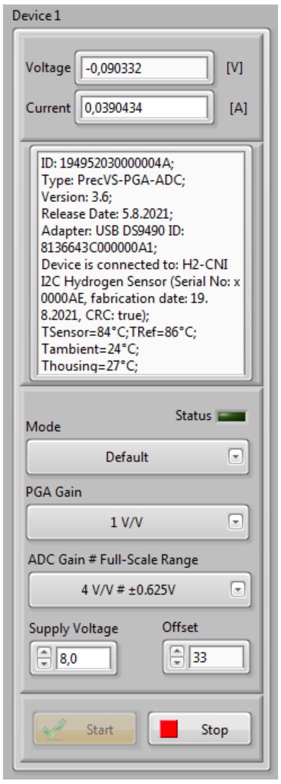
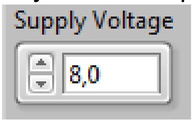
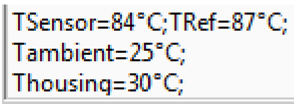
</table>

<table>
<tr>
<td>8</td>
<td>Click “Start”</td>
<td>


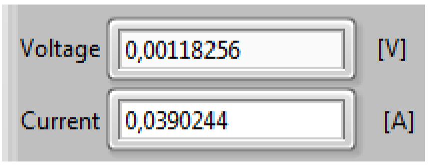
</td>
<td>
Adjust the supply voltage (bridge excitation voltage) to


As the result of the applied voltage to the sensor elements, the correspondingly flowing current through the sensor, the temperatures of the active and reference sensor elements and the sensor housing increase

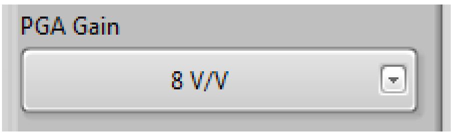


After equilibration adjust the offset to

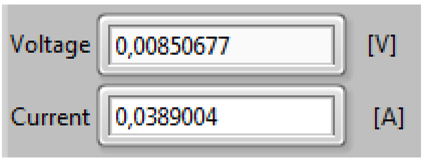
(value depends on sensor) and observe the corresponding reduction of the bridge balance voltage



The voltage can be further amplified by increasing the PGA gain from 1 V/V to 8 V/V.

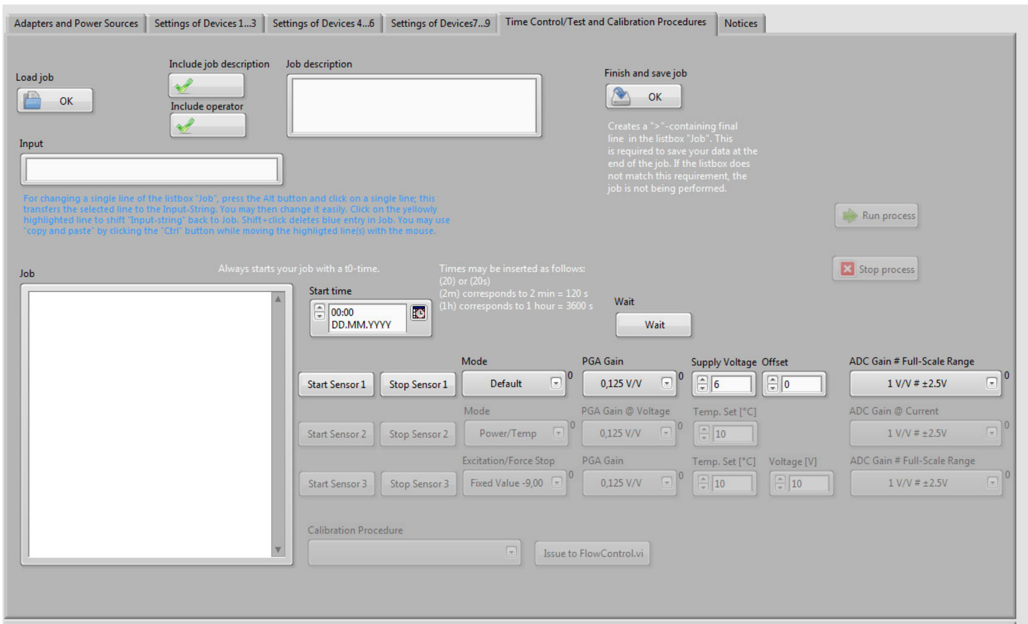


The effect is the 8 times higher voltage



The current generates a small voltage of 0,0389 V by passing an 1 Ohm precision resistor in series with the sensor and compensator. You may adapt the ADC gain to have a better use of the 16 bit resolution (compare its full-scale range and the input voltage of 0,089 V). It is, however, indispensable as the current itself is only used to calculate the approximate sensor elements´ temperatures.
</td>
</tr>
</table>

<table>
<tr><td>9</td><td>Click on register card “Adapters and Power Supplies” and activate EEPROM</td><td>
</td><td>Return to register card“ Settings of Sensors 1…3”.

Stop button has disappeared and Start button has changed to Save. Clicking on Save stores all adjustments in the EEPROM of the sensor.</td></tr>
<tr><td>10</td><td>Click “Stop”</td><td>
</td><td>Data collection and sensor stop.</td></tr>
<tr><td colspan="4">Systematic evaluation of sensor properties using register card “Time Control and Calibration Procedures”</td></tr>
<tr><td>11</td><td>Click on register card “Time Control/Test and Calibration Procedures”</td><td colspan="2">

This card allows you to define a job which is a list of instructions that are consecutively issued to SensorControl thereby enabling a time-controlled experiment.

The job is defined in the window “Job” and written by using the bottoms on the right-hand side of this window. Always use this method to define a job as it is strictly bond to certain format rules. Jobs are started by clicking “Run process” (Do this not now!). A job starts with defining is start value. Times in the past are considered as instruction to start immediately. Then, a sequence of commands follows; they always start with “!”. Clicking on “Wait” produces a line !Wait Start(t). t must be replaced by a waiting time You can insert them as follows:

(20) or (20s)

(2m) corresponds to 2 min = 120 s

(1h) corresponds to 1 hour = 3600 s

The wait command is very important as this is the only way to define a time-dependent consecution of other instructions.

Instead of writing in the window “Job” you can follow the blue instruction shown below the window “Input”.</td></tr>
</table>

Thus one can organize a list of instructions in the window “Job”. You can use the mouse to shift lines in the window; modifying and deleting is also possible.

As an example, try to type the job shown above.

Clicking or selecting certain values in “Mode”, “PGA Gain”, “Supply Voltage” or “Offset” generate corresponding entries in the job.

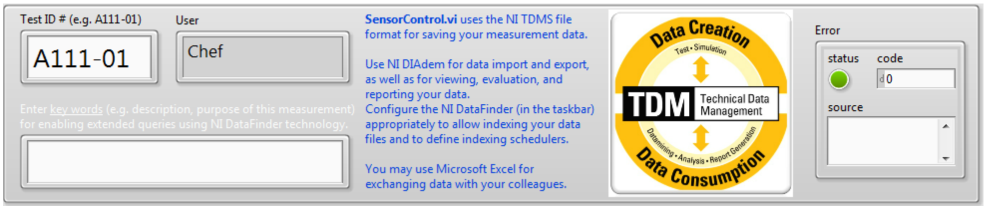
Clicking on Start Sensor 1 generates a line !Sensor: Start(1) and will be interpreted as to start sensor 1; same holds for clicking on Stop Sensor 1.

A job must be completed with a line that starts with >. This line is created by clicking on “Finish and save job”. It also allows you to save your job on the hard disk in the folder “LabView Data”. The > sign will be interpreted as to save your data and to stop the job.

You may also include a job description and/or the operator name. You can also load previous jobs by clicking on “Load job”.

Note: There must be no empty lines in the job; so if empty lines show up delete them or shift the instructions with the mouse. If you type a new entry and you do not see it scroll in the window to the bottom. If you see empty lines, delete them.

Define a Test ID# in the top box of SensorControl.vi.

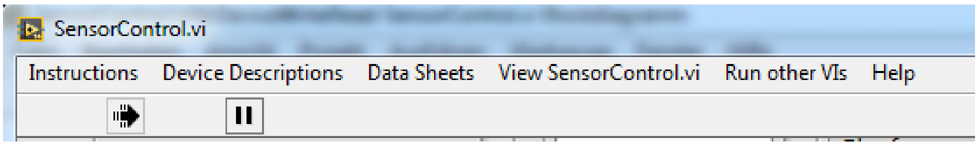


(You may also give some key words in the keywords window). The software only accepts Test ID# in the format Xnnn-nn. The “Run process” button is enabled.

The job starts and will be done by clicking on “Run process”. Then the subVI “TimeControl” will take over the control of the software until it is finished by reaching the line >… or by clicking on “Stop process”. You are not limited with the length of your job. They run very safely over long times. Note, however, that data will automatically be stored after 24 h operation. This does not affect running your job.

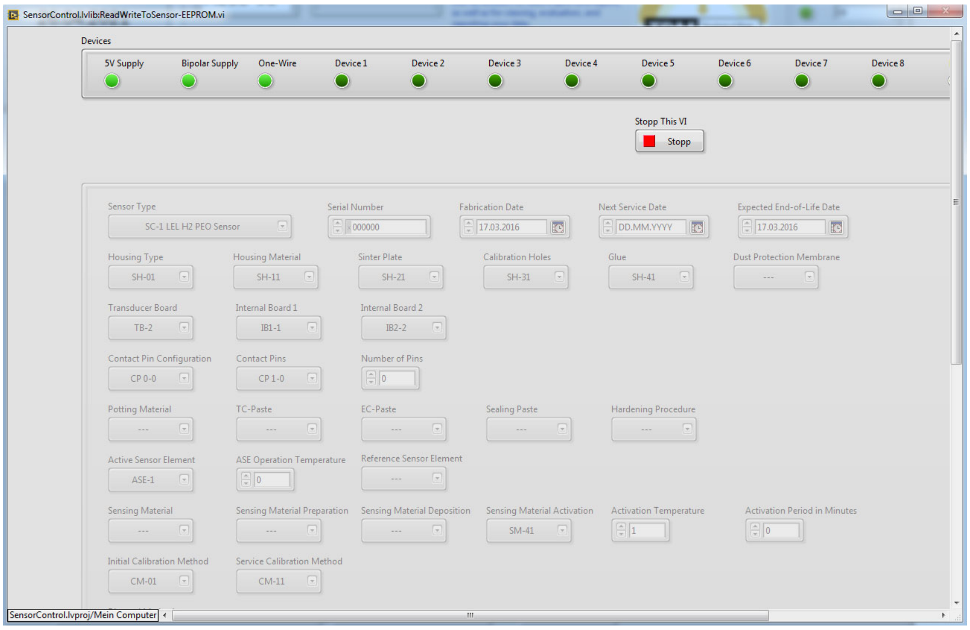
<table>
<tr><th colspan="3">Access to the sensor´s EEPROM</th></tr>
<tr><td>12</td><td>Open menu “Run other VIs” and select

“Read and Write to Sensor´s EEPROM/Login Required”</td><td>

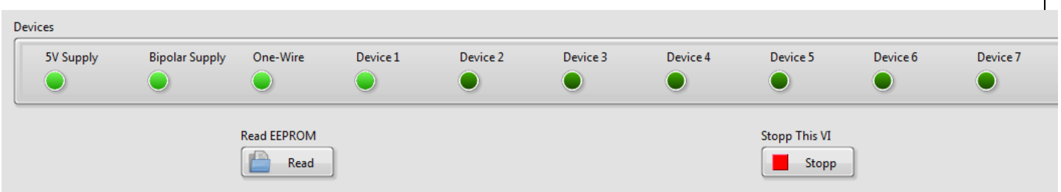


Enter “admin” and click on “OK” (The keyboard´s enter buttom is not accepted!)

A new window appears

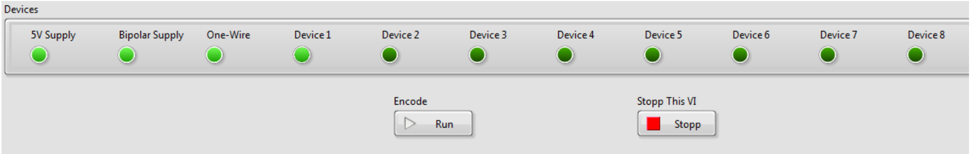


Click on “Device 1” to access the EEPROM of the sensor plugged in the device 1 controller.



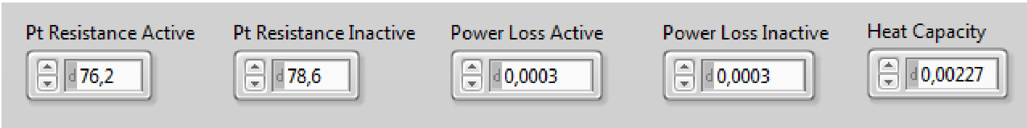
</td></tr>
</table>

The "Read EEPROM" button is shown. Click on this button and wait a couple of seconds. The EEPROM is read, entries are filled, the "Read EEPROM" disappears and



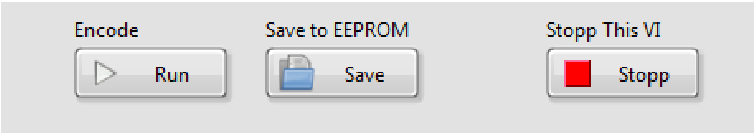
"Encode" is displayed.

Scroll, e.g. to the buttom and find

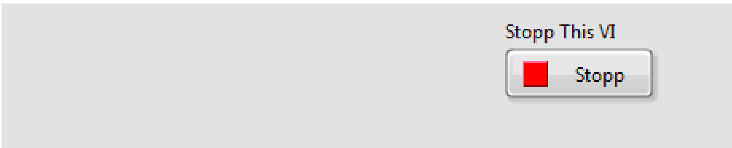


This entries are used to calculate the sensor elements´ temperatures from and the temperature-dependent platinum resistances and the thermal properties of the sensor elements.

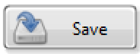
Entries can be changed (although it is not recommended) and encoded by clicking on "Encode"

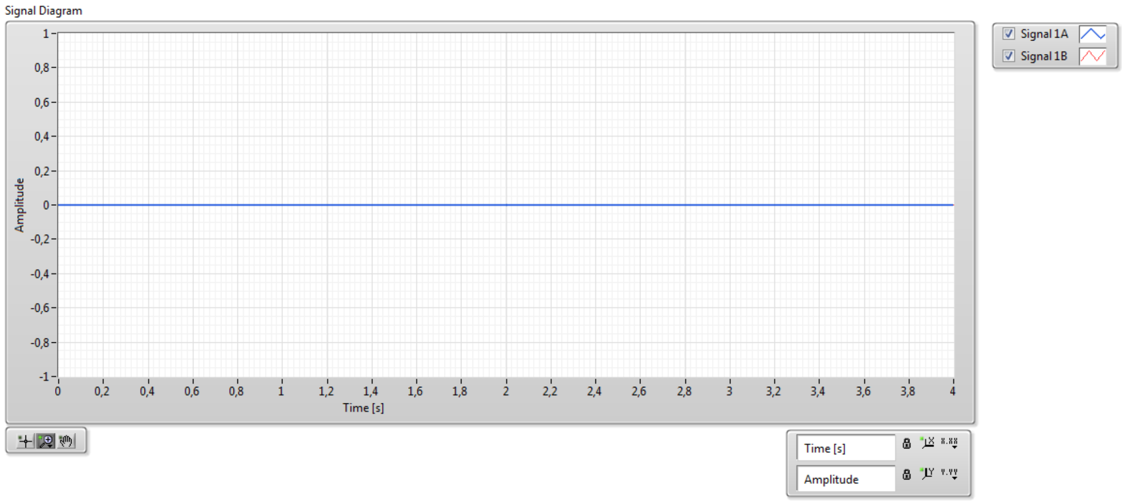


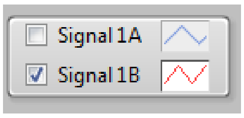
The "Save to EEPROM" option appears that can be clicked to save the encoded data into various registers of the sensors´s EEPROM. After clicking "Save to EEPROM" wait a couple of seconds until this buttom disappears and only

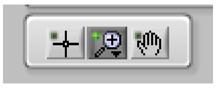


"Stopp This VI" remains. Now one can leave this SubVI by clicking on "Stopp This VI" which removes the window.

Saving data to the hard disk			
13	Click on DataSaveStart 	DataSaveStart DataSaveNow 	Press "DataSaveStart" to activate "DataSaveNow". Press "DataSaveNow" to save your data immediately. Note: The path to your data is created by hitting the "DataSaveStart" button (color changes from grey to yellow. A new path for the next run is created automatically after your data have been saved by pressing "DataSaveNow". Data are stored in the folder C:/Measurement data File names are given as “A111-01_14-05-2020-04-24-03.dat” with the Test ID#, followed by “_”, the date-time and the extension “.dat”. Data are automatically saved 24 h after running SensorContro.vi. Evaluate data with DIADEM (National Instruments). Export to EXCEL is possible.

<table>
<tr><th colspan="2">Working with the signal diagram</th></tr>
<tr><td>14</td><td>


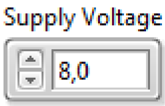
Signals can be removed from or included in the diagram by setting 

. You may also change colors etc.
Signals are always recorded independently of whether they are displayed in the diagram.
Click on the diagram to have access to further adjustments, e.g. automatic scaling for y and x.
Click on  to have more options with respect to handling the signals in the diagram.
</td></tr>
<tr><td>15</td><td>
All data are displayed as a function of time in the signal diagram at a rate of 1000 ms^{-1}. You may increase the period before you start SensorControl.vi


but only larger times are allowed.
</td></tr>
</table>

Working with the mode “Auto VSupply(Tambient)”

16

In this mode, the bridge voltage 

is controlled by the ambient temperature according to data given in Table 9 of the Specification Sheet H2-CNI I2C, Version 1.0. The data are fitted by a 5th order polynomial

$$V_{\mathrm{bridge}} = A + BT_{\mathrm{ambient}} + CT^2_{\mathrm{ambient}} + DT^3_{\mathrm{ambient}} + ET^4_{\mathrm{ambient}} + FT^5_{\mathrm{ambient}}$$

The parameters A to F are stored in the sensor´s EEPROM according to the following scheme

Sign of A: 0 means + and 1 means –

Upper byte of A

Lower byte of A

Divider A

For example +8.05 is converted into 805 × 10^{-2} and is stored as

Register address x56: x00

Register address x57: x03

Register address x58: x25 (0325 is the hexadecimal representation of the decimal number 805)

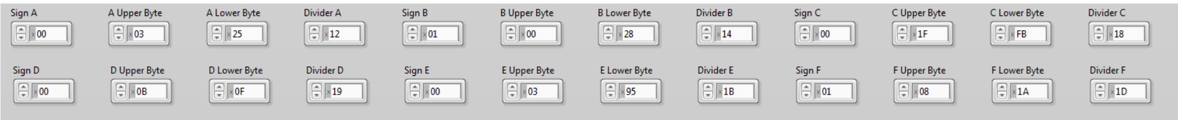
Register address x59: x12 (1 for – and 2 for the exponent).

The exponents are limited to -15 (or 1F) until +15 (or 0F)

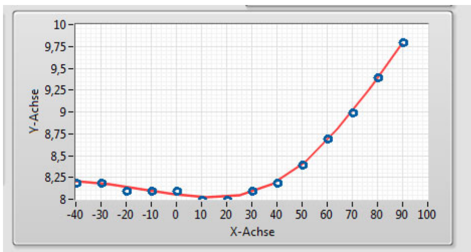
The parameters are stored in the register addresses x56 to x6A.

-2,074E-10 would give x01, x1A, x08, x1D.

For example



encodes the following T_{ambient}-dependency of the voltage V_{bridge} .



9. ORDERING INFORMATION

PrecVS-PGA-ADC 3.6

10.PACKAGING/SHIPPING INFORMATION

This item is shipped individually in an antistatic bag.

11.NOTES

12. WORLDWIDE SALES AND CUSTOMER SUPPORT

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