FES SENSOR
TECHNOLOGY GMBH

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H2-CNI 0V-I

H2-CNI 0V-I ULTD

Precision Hydrogen Sensor with Voltage Output for Industrial Applications

1. FEATURES

- Detection of hydrogen levels up to 100% LEL with 100 ppm resolution in air
- No sensitivity against typical catalyst poisons such as volatile siloxanes and carbon monoxide
- Fast response and recovery times
- No humidity-induced base line drift
- Applicable in relative humidity (rh) between 0 % to 100 %
- Industrial temperature range from -40 to +80 °C
- High mechanical stability
- Linear output up to 100 % LEL
- Available with ultra-low thermal drift (ULTD) and test protocol
- On-board instrumentation amplifier and voltage output
- Supply voltage with reversed bias protection

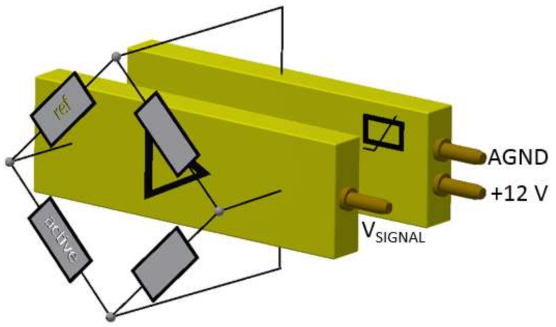
2. APPLICATION

Precision hydrogen meters

3. DESCRIPTION

H2-CNI 0V-I ULTD is a precise calorimetric hydrogen sensor with a catalytically highly active and siloxane-resistant sensor element and is based on a non-isothermal calorimetric operation principle. It contains on-board electronics to reduce the effect of ambient temperature changes on hydrogen sensitivity and to provide appropriate output signals. It is designed for use in a variety of applications which require an accurate hydrogen determination in air.

4. SIMPLIFIED SCHEMATIC



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5. REVISION HISTORY

Date	Rev.	
Mai 2, 2023	1.0	Initial version

6. PIN CONFIGURATION AND FUNCTION

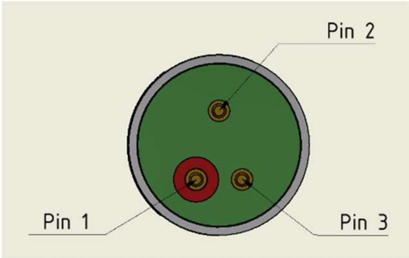

Figure 1: Bottom view

PIN NO.	DESCRIPTION
1 (red marking)	+12 V positive supply voltage with respect to ground
2	Sensor signal with respect to ground
3	Ground of the internal electronics. The pin is electrically not connected to the housing

7. SPECIFICATIONS

7.1. ABSOLUTE MAXIMUM RATINGS

Table 2	
Input supply voltage	+15 V at ambient temperature T_a = 20 °C.
Storage temperature	-40°C to 100 °C

7.2. 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.

7.3. HANDLING RATINGS

The sensor must not subjected to severe shocks which might result from suddenly applied forces. They may cause permanent damage to the device.

7.4. RECOMMENDED OPERATING CONDITIONS

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

Table 3

	MIN	NOM	MAX	UNIT
Input supply voltage	+9	+12	+15	V
Load resistor between pin 2 and pin 3		≥ 1		kΩ

7.5. MECHANICAL

Table 4

Housing material	Stainless steel (1.4404; SUS316L)
Potting	Epoxy
Weight	15 g
Maximum diameter	20.0 mm
Height (housing)	16.6 mm
Height (overall)	21.0 mm (pin-type)
Pins	Gold over nickel
Pin length	4.78 mm
Pin diameter	1.57 mm

7.6. ELECTRICAL

Table 5		
	Ambient temperature	*Supply Current*
	20 °C	42 mA

7.7. ENVIRONMENTAL

Table 6	
Ambient temperature range during operation	-40 to +80 °C
Operation humidity	0 … 100 % r.h.

7.8. SENSOR PARAMETERS

Table 7	
Signal at 50% LEL	3 V (typical)
Resolution	< 0.25 % LEL or 100 ppm
Linearity	Typical value: 1.5 V/(25 % LEL) or 1.5 V/(1 vol-% H_2) at 20 °C
Response time	< 5 s
Thermal zero point drift	1 mV/°C (ULTD)

7.9.SENSOR CROSS SENSITIVITIES

Table 8

Gas / Vapor	Chemical Formula	Concentration Applied	Output $V_{Signal, Gas} – V_{Signal, air}$ (V)
Methane	CH_4	0 to 99.99 vol-%	0
Ethane	C_2H_6	0 to 99.95 vol-%	0
Propane	C_3H_8	0 to 30 vol-%	0
Butane	C_4H_{10}	0 to 70 vol-%	0
Ammonia	NH_3	0 to 5 vol-%	0
Chlorine	Cl_2	0 to 5 vol-%	0
Carbon dioxide	CO_2	1 vol-%	0
Carbon monoxide	CO	1500 ppm	0
Nitrogen dioxide	NO_2	5 ppm	0
Nitrogen monoxide	NO	15 ppm	0

7.10. EFFECT OF PRETREATMENTS OF THE SENSOR TO SILOXANES

OCTAMETHYLCYCLOTETRASILOXANE ($C_8H_{24}O_4SI_4$)

A laboratory beaker with 100 g $C_8H_{24}O_4Si_4$ (98%) is heated to 250 °C in a 2-liter glass together with the sensor for one hour. The sensor is tested with 2 vol-% H_2. A 12% decline of the sensor signal is found with respect to the initial signal.

HEXAMETHYLDISILOXANE ($C_6H_{18}OSI_2$)

A laboratory beaker with 40 ml $C_6H_{18}OSi_2$ is placed with in a 2-liter glass together with the sensor for one hour. The sensor is tested with 2 vol-% H_2. A 15% decline of the sensor signal is found with respect to the initial signal.

8. TYPICAL PERFORMANCE CHARACTERISTICS

All data presented below are acquired in an automated gas mixing system with mass flow controllers and pressurized gas bottles with synthetic air (21 vol-% oxygen in nitrogen) and calibrated hydrogen mixtures (5 vol-% H_2 in nitrogen). Room temperature data are determined with the sensor attached to our test chamber TC 2x1/4”. Ambient temperatures are adjusted in a cooled or heated test chamber. Data for figures 3 to … are collected with a 7 ½ digit precision multimeter with RS232 interface. For figures 4, 5 and 7 the evaluation kit PGA-ADC 3.3 and a stabilized 12 V power supply are used to provide very short electrical connections between the sensor and the amplifier and a constant 12 V operation voltage.

8.1. INITIAL WARM-UP PHASE

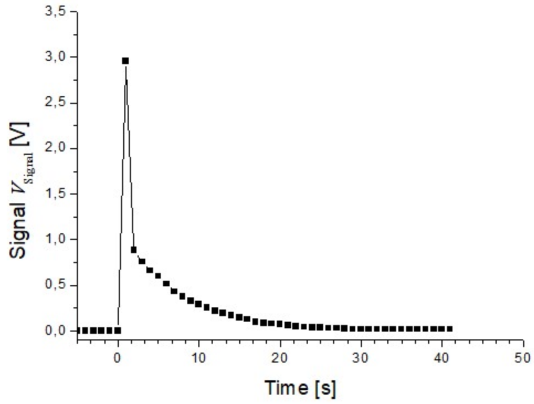

Figure 3. Typical signal characteristics (signal voltage at pin 2) of the sensor after applying the operational voltage of 12 V at time 0.

8.2. CALIBRATION CURVE AND LINEARITY

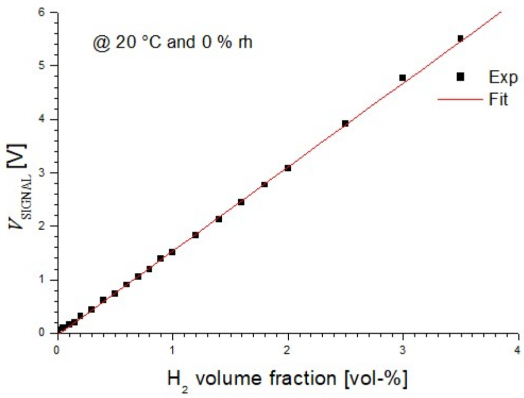

Figure 4. Typical values of the signal voltage V_{Signal} as a function of hydrogen volume fraction in synthetic dry air at 20 °C. Data (Exp) are determined for a total flow of 50 sccm/min. Red: Linear fit with a slope of 1,5 V/1 vol-%.

8.3. LOW DETECTION LIMIT AND RESOLUTION

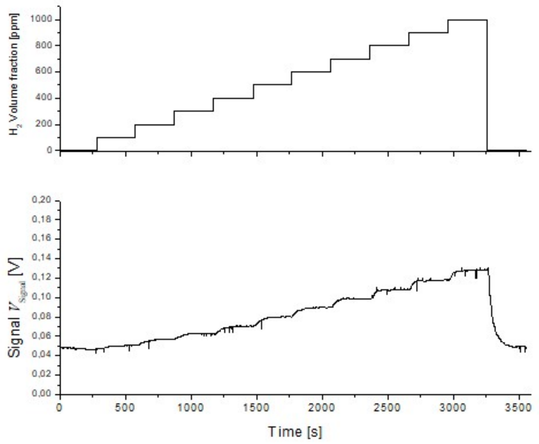

Figure 5. Bottom: Sensor signal as a function of the time (top) in dry air at 20 °C at low volume fractions of hydrogen between 100 and 1000 ppm. Offset of the signal voltage is 50 mV. Total flow 100 sccm/min. Top: Corresponding changes of H_2 volume fractions.

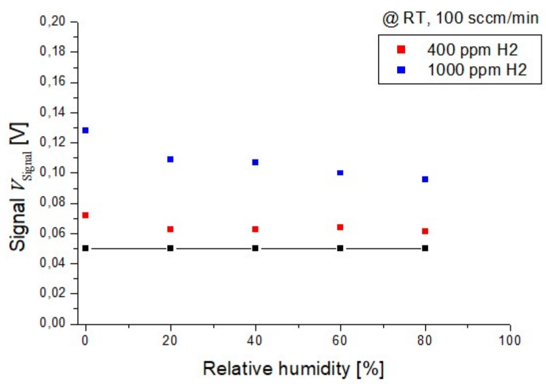

Figure 6 Bottom: Sensor signal as a function of humidity (0, 20, 40, 60, and 80% at 20 °C at low volume fractions of hydrogen.

8.4. TEMPERATURE-DEPENDENCE

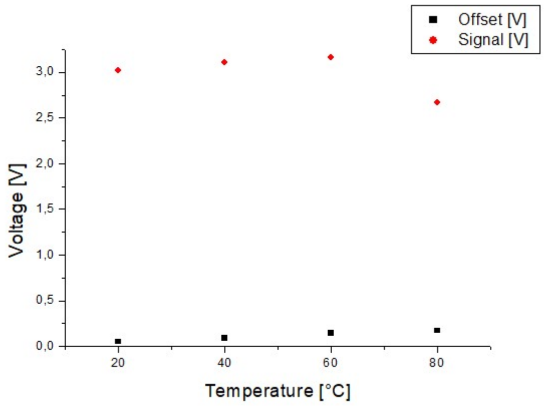

Figure 7. Red: Sensor signal for a hydrogen volume fraction of 2 vol% at temperatures of 20 °C, 40 °C, 60 °C, and 80 °C. Black: Offset voltage at 0 vol% H_2.

8.5. EFFECT OF RELATIVE HUMIDITY ON THE BASE LINE

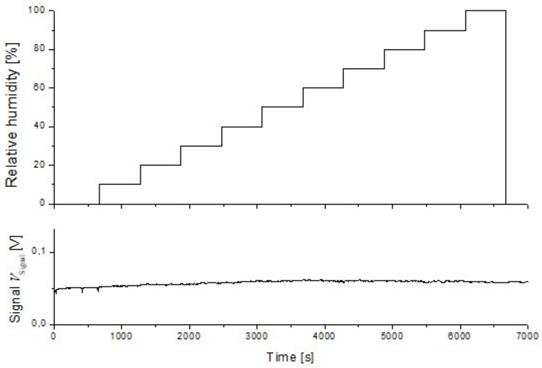

Figure 8. Top: Sensor signal as a function of time at different levels of relative humidity from dry air to 100 % at 20 °C (total flow = 50 sscm/min). Bottom: Corresponding changes of the relative humidity in the test chamber as a function of time.

8.6. EFFECT OF RELATIVE HUMIDITY ON THE SIGNAL

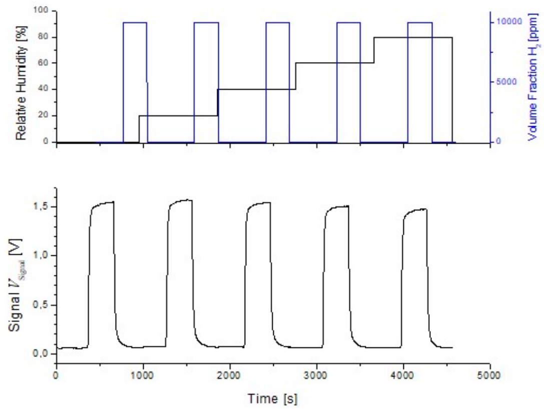

Figure 9. Sensor signal at 1 vol-% H_2 in air of varying relative humidity at 20 °C (total flow = 50 sscm/min).

8.7. EFFECT OF FLOW RATES ON THE BASE LINE

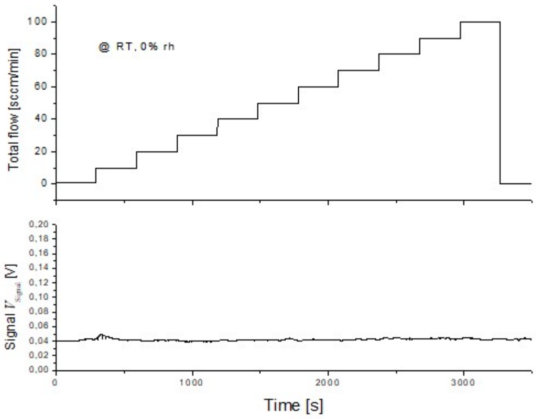

Figure 10. Sensor signal as a function of the total flow in dry air at 20 °C.

8.8. EFFECT OF FLOW RATES ON THE SIGNAL

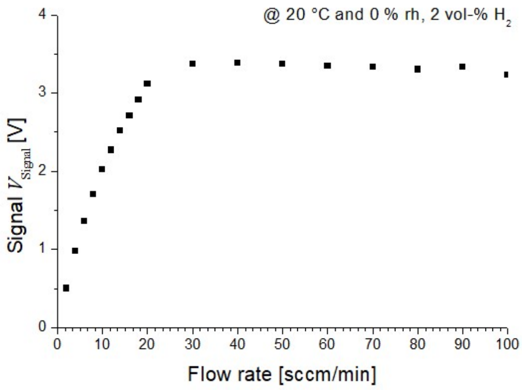

Figure11. Sensor signal as a function of the total flow for 2 vol-% H_2 in dry air at 20 °C. Because of the catalytic sensing principle and the hydrogen-to-water oxidation, a steady-state signal cannot be generated at a zero-flow rate.

8.9. RESPONSE AND DECAY TIMES

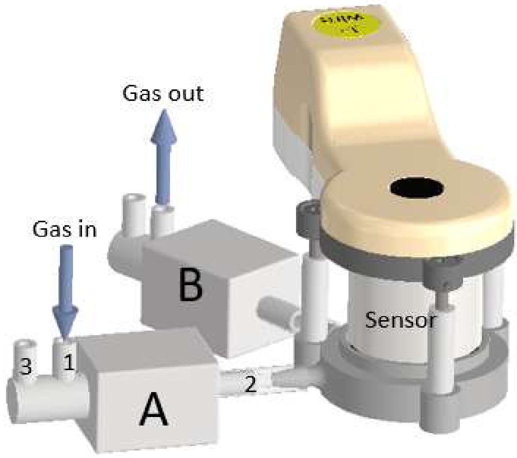

Figure 12. Special setup to determine the response and decay time of the sensor. Here, the evaluation kit PGA-ADC 3.3 is used to apply the 12 V voltage and to determine the signal voltage V_{SIGNAL} of the sensor. A flow of 2 vol-% H_2 in air with 50 sccm/min flows into the system at the “gas in” through port 1 of valve A. The valve can be switched electrically to pass the flow through port 3 to the ambient air or port 2 to the sensor, attached to a small test chamber. Valve B is operated together with valve A and cut off the test chamber from the outlet if A is switched into the 1-3 position.

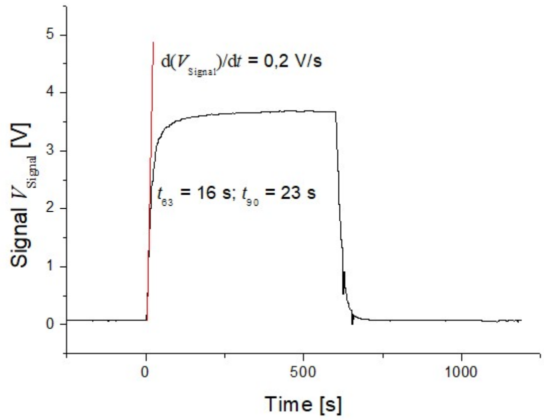

Figure 13. Sensor signal as a function of time after applying 2 vol-% H_2 in dry air at 20 °C. The sensor signal reaches a steady-state signal with a t_{64} response time of 16 s and a t_{90} response time of 44 s. The slope dVSignal/dt is approx. 0,2 V/s, i.e., a 1-Volt change of the signal is found after 5 s. After re-directing the test gas to the port “Out 1”, the signal decays to zero due to an oxidation and consumption of the hydrogen molecules at the sensor´s catalytic layer.

8.10. CALIBRATION PROCEDURE

The sensor contains a precision 12-turn trimmer for adjusting the offset voltage of the Wheatstone bridge, that consists of the sensing element, the reference element and two constant resistors, as well as a second 12-turn trimmer for adjusting the gain of the instrumentation amplifier. The trimmers are factory-set to provide a zero point of the sensor output voltage below 80 mV, a low detection limit of better than 500 ppm hydrogen and a sensitivity of approximately 1.5 V/1-vol % H_2. Both holes in the housing are closed with an adhesive foil and it is usually not necessary to make any changes of the trimmer settings.

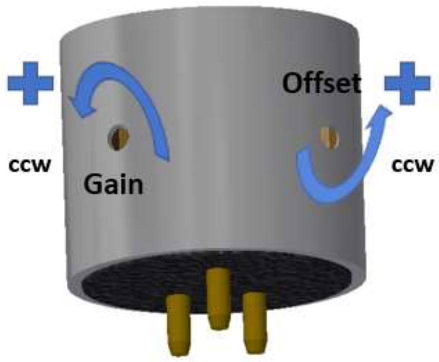

Figure 14. Adjustment the Wheatstone bridge offset (zero point of calibration straight line) and amplifier gain (slope of calibration straight line). If necessary, trimmer settings can be altered by means of a srew driver. Note, that both holes have a diameter of 1.8 mm. A ceramic type instrument (e.g., CD-15) is recommended. The orientation of the srew drivers should be to the middle of the opposite side of the housing and not to the center of the sensor. A counter-clock wise rotation increases the gain (i.e. leads to larger output signals) and shifts the offset to positive voltages.

8.11. MECHANICAL TESTS

The electronic board of the sensor has been tested in shock tests with the sensor placed on a vibrating plate (50 Hz) and on a alternating acceleration test stand with 8 G.

8.12. EFFECT OF THERMAL SURROUNDING

As with all devices based on calorimetric concepts, the hydrogen sensor H2-CNI 0V-E-ULTD is sensitive against changes of its thermal surrounding. This gives rise to noticeable variations of the base line of such devices. H2-CNI 0V-E-ULTD has precisely adjusted sensor and reference elements that operate at virtually identical temperatures when a voltage is connected between pins 1 and 3. The best assembly place for the sensor should provide a constant thermal surrounding to minimize variations of the signal´s base line which can be lower than 100 mV under good conditions. Consider a vertical upside or upside-down direction of the sensor if possible.

9. THEORY OF OPERATION

The hydrogen sensor H2-CNI 0V-E ULTD comprises two temperature-sensitive transducers that form a Wheatstone bridge arrangement together with precision resistors R_2 and R_3. One transducer (the so-called active sensor element R_{active}) is covered with an advanced catalytic layer that promotes the hydrogen-to-water oxidation while the second transducer (the so-called inactive sensor element R_{ref}) is used as a reference to compensate variations of the out-of-balance voltage with changing ambient temperatures. The out-of-balance voltage is set to zero by means of R_5. Exposure of the sensor to hydrogen and oxygen containing atmospheres results in the generation of a chemical reaction heat that causes a temperature change and hence a resistance change of the active sensor element R_{active}. This leads to a non-zero out-of-balance voltage of the bridge which is amplified by means of a built-in amplifier and lead out at pin 2.

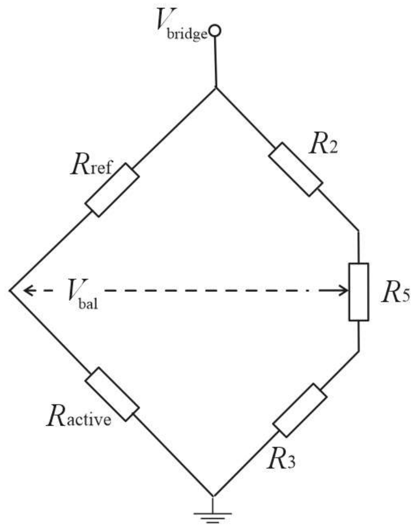

Figure 15. Wheatstone bridge with active and reference sensor element (schematic).

10.APPLICATION AND IMPLEMENTATION

A zero-voltage signal is adjusted at an ambient temperature of T_a = 20 °C. The device contains a special circuitry that reduces the effect of ambient temperature changes on the sensor sensitivity in the range of -40 to 120 °C.

11. FOOTPRINT AND RECOMMENDED PLUG-IN SOCKETS

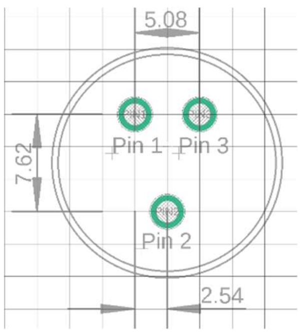

Figure 16: Footprint (dimensions shown in millimeter)

Table 9	
Recommended plug-in sockets	450-3326-01-03-00 (Cambion Electronics LTD)
Drill hole:	2.6 mm

12. ORDERING INFORMATION

Hydrogen sensor H2- CNI 0V-I

Hydrogen sensor H2-CNI 0V-I ULTD

13.PACKAGING/SHIPPING INFORMATION

This sensor is shipped individually in an antistatic bag.

14. WARNINGS

Warnings: The sensor H2-CNI 0V-E ULTD is intended to be part of a customer safety system, enabling audible alarms, system shutdown, ventilation, or other measures to ensure safe handling and use of hydrogen gas. The sensor itself does not provide protection from hydrogen/air explosion. Make sure that your application meets applicable standards, and any other safety, security, or other requirements.

15.QUALITY CONTROL

Each sensor is tested before delivery. The test includes standard protocols and an exposure of the sensor to a hydrogen/air mixture with H_2 volume fractions above the low-explosion limit, performed at ambient temperature and pressure.

16.NOTES

17.WORLDWIDE SALES AND CUSTOMER SUPPORT

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