FES SENSOR TECHNOLOGY GMBH

H2-METCD 0-10V

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Thermal Conductivity Hydrogen Sensor with 0-10V Output for Industrial Applications

1. FEATURES

- Accurate detection of hydrogen levels in air and nitrogen up to 15% vol-%
- Fast response and recovery times
- Applicable in relative humidity (rh) between 0 % to 100 %
- Temperature range -20 °C to +85 °C
- Linear output up to 5 % vol-%
- Very low power consumption < 10 mW
- 0-10V output signal
- Supply voltage with reversed bias protection

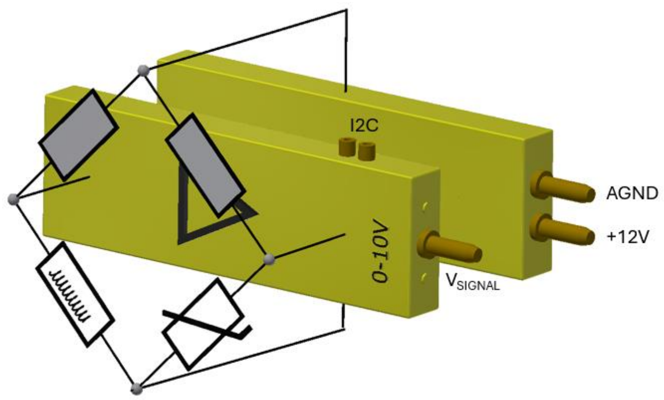
2. APPLICATION

- Precision hydrogen meters

3. DESCRIPTION

H2-meTCD 0-10V is a hydrogen sensor for applications without oxygen and is based on a thermal conductivity operation principle. The sensor contains a Si-based heated transducer, fabricated by anisotropic etching, and on-board electronics, including a precision voltage source for the transducer, a non-volatile digital-analog converter for adjusting the Wheatstone bridge with the transducer, and a non-volatile digital potentiometer in connection with a zero-drift operational amplifier to adjust the output voltage. It is designed for use in a variety of applications which require an accurate hydrogen determination in nitrogen or other non-oxygen-containing atmospheres.

4. SIMPLIFIED SCHEMATIC



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5. REVISION HISTORY

Date	Rev.	
April 14, 2025	1.0	Initial Version

6. PIN CONFIGURATION AND FUNCTION

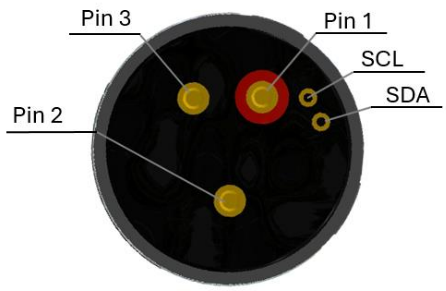

Figure 1: Bottom view of sensor

Table 1	
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
SCL	Serial clock line of I2C bus, referenced to ground (pin 3)*
SDA	Serial data line of I2C bus, referenced to ground (pin 3)*
*The sensor can be operated without connecting the I2C bus. If connected, provide necessary pull-up resistors to SCL and SDA (e.g. 4.7 kOhm).	

7. SPECIFICATIONS

7.1.ABSOLUTE MAXIMUM RATINGS

At ambient temperature T_a = 20 °C.

Table 2	
Input supply voltage	+12 V
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 be subjected to severe shocks which might result from suddenly applied forces or abrupt changes in motion. 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	+10	+12	+15	V

7.5. MECHANICAL

Table 4

Housing material	Stainless steel (1.4404; SUS316L)
Potting	Epoxy
Base plate	FR4, flame retardant, according to UL-94
Weight	15 g
Diameter	20.0 mm
Height (housing)	16.6 mm
Height (overall)	21.6 mm
Pins	Gold over nickel
Pin diameter	1.57 mm
Pin length	4.78 mm

7.6. ELECTRICAL

Table 5

Supply current	1 mA @ 20 °C

7.7.ENVIRONMENTAL

Table 6	
Ambient temperature range during operation	-20 to +80 °C
Operation humidity	0 … 100 % r.h.

7.8.SENSOR PARAMETERS

Table 7	
Signal at 100 Vol-% H_2	10 V (typical)
Resolution	0.5 vol-% H_2
Linearity	in 10 vol-% ranges signals are linear to a good approximation
Response time	< 5 s
Thermal zero point drift	< ...V/°C

7.9.SENSOR CROSS SENSITIVITIES

H2-meTDC 0-10V sensors which are calibrated to measure hydrogen levels in air or nitrogen due to the large difference of of H_2 (0.15 W/mK) in comparison to nitrogen (0,02598 W/mK) and oxygen (0.02674 W/mK). Since for most gases and vapors thermal conductivity ranges between 0.01 and 0.03 W/mK at room temperature, cross-sensitivities are low in many applications. Among the light gases, which have high thermal conductivity, a notable interferent to hydrogen is helium (0.18 W/mK). Also, dense gases like xenon or others, which have low thermal conductivity, may affect the sensor´s output signal. The cross sensitivity of water vapor in humid air depends on the temperature and may be notably for ambient temperature well above room temperature.

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), calibrated hydrogen mixtures (5 vol-% H_2 in nitrogen), and pure hydrogen. Room temperature data are determined with the sensor attached to our test chamber TC 2x1/4”.

8.1. INITIAL WARM-UP PHASE

The sensors are operational immediately after the power supply is switched on without a relevant warm-up phase.

8.2. CALIBRATION CURVE

The slope and zero-level of the output levels of the sensors can be adjusted to different applications. As an example, figure 2 shows the signal-*versus*-H_2 volume fraction of a sensor operation in a 90 to 100 vol-% regime.

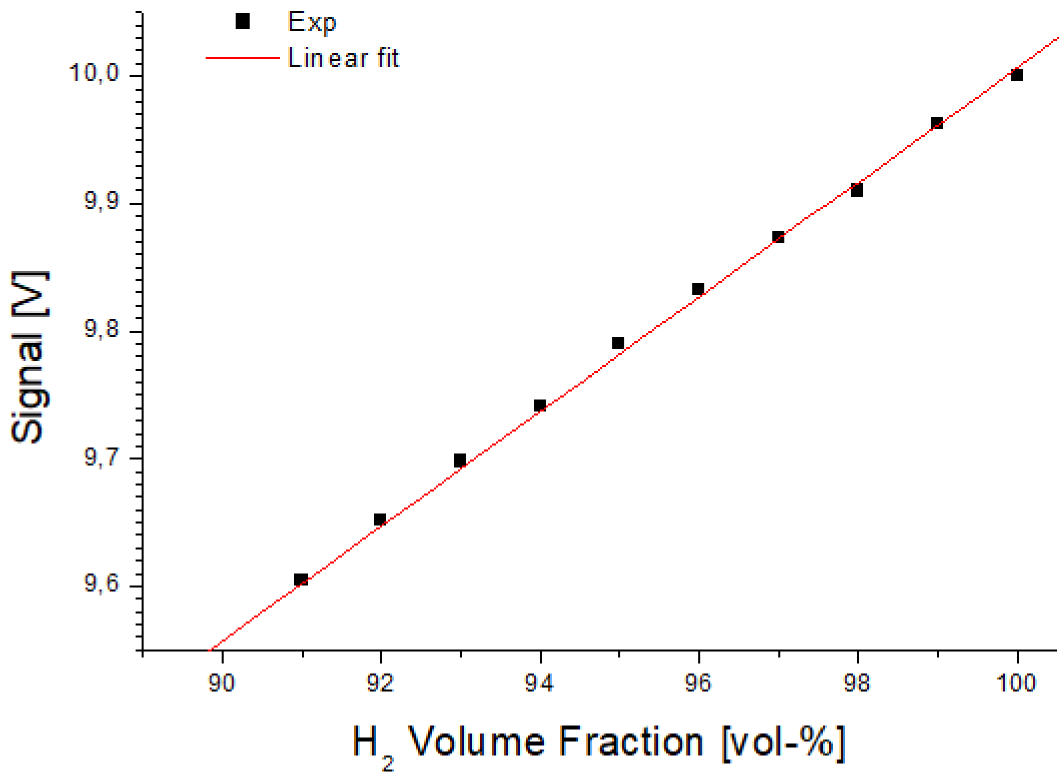

Figure 2. Typical values of the output voltage (sensor signal) as a function of hydrogen volume fraction in synthetic dry air or nitrogen (for H_2 volume fractions ≥ 90 vol-% at 20 °C. Data (Exp) are determined for a total flow of 50 sccm/min.

Resolutions are better than 0.5 vol-%. Other regions-of-interest can be factory set, e.g. 0…4 V for a 0…20 vol-% range or 0…10 V for 0 to 100 vol-%.

For other sensor properties such as the behavior with respect to humidity, gas flow, or temperature, see “Specification Sheet H2-meTCD 4-20mA Rev. 1.4”.

8.3. CALIBRATION PROCEDURE

The sensor contains a 12 bit digital-analog converter with non-volatile memory for adjusting the offset voltage of the Wheatstone bridge, and a nonvolatile 256-position digital potentiometer to adjust the output signal for a constant hydrogen volume fraction. It is usually not necessary to make any changes of the settings. Refer to section 10 for further information.

8.4. 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 an alternating acceleration test stand with 8 G.

9. THEORY OF OPERATION

The hydrogen sensors H2-meTCD 0-10V contains a Si-based heated transducer, fabricated by anisotropic etching, with a thin membrane that is heated by a thin-film resistor. The membrane´s temperature is higher than the temperature of the adjacent solid silicon chip which carries a second temperature-dependent resistor. Both resistors form a Wheatstone bridge arrangement together with additional resistors in the two branches of the bridge. The out-of-balance voltage is set to zero by means of a 12 bit digital-analog converter, connected to one arm of the Wheatstone bridge. Changes of the thermal conductivity of the surrounding atmosphere lead to the formation of an out-of-balance voltage that is amplified and converted into a 0-10V signal.

10. APPLICATION AND IMPLEMENTATION

The H2-meTCD 0-10V sensors are optimized for the use as hydrogen detectors in nitrogen or air. They can be operated with only a few additional components, such as a +12 V voltage supply and a voltmeter (see section 14). The following sections describe the I2C bus to enable the read-out of the internal EEPROM and the control of the signals, i.e. the zero-level or the slope of the signal-*versus*-H_2 volume fraction curve.

10.1. I^2C BUS

Two pull-up resistors are required to ensure that the SCL and SDA lines of the I^2C bus are at high potential.

The following 7bit addresses are used in the H2-meTCD 0-10V sensors:

Table 8: 7bit Addresses

Binary code	Hexadecimal code	IC
1010000	x50	1K bit serial electrically erasable PROM
1100000	X60	12-Bit digital-to-analog converter used for offset adjustment
0101110	x4E	Nonvolatile 256-position digital potentiometer used to adjust the amplification

All command and data information is transferred with the Most-Significant Bit (MSB) first.

10.2. EEPROM

The EEPROM is organized as a single block of 128 x 8-bit memory. The following table indicates the information, kept under the different word addresses. The word addresses 0x00 to 0x03, 0x05 and 0x06 keep basic information about the sensor, including a CRC value calculated from the entries and stored in 0x04. This information must not be altered.

Table 9. Contents of the EEPROM

Word address	Data byte	Remarks
0x00	Device code	Data must not be changed
0x01	Serial number (upper byte)	
0x02	Serial number (middle byte)	
0x03	Serial number (lower byte)	
0x04	CRC value	
0x05	Fabrication date/month	See (a)
0x06	Fabrication month/year	
0x07...0x02F	Fabrication-related data	Encrypted data. Not intended for users
0x30	Excitation	Default settings for evaluation kit PGA-ADC 3.4
0x31	Gain preamplifier	
0x32	Gain	
0x33	Offset A (upper byte)	
0x34	Offset A (lower byte)	
0x35	Offset B U(upper byte)	
0x36	Offset B (lower byte)	
0x37…0x4D	Control data for other evaluation kits not useful for H2-CNI 0-10V-I sensors	Encrypted data. Not intended for users
0x4E…0x52	Resistances and thermal coefficients of sensor and reference elements	Encrypted data. Not intended for users
0x53…0x6E		Encrypted data. Not intended for users
0x6F		Not used
0x70	Calibration offset (upper byte)	See equation (b) for decoding
0x71	Calibration offset (lower byte)	
0x72	Calibration gain (upper byte)	See equation (c) for decoding
0x73	Calibration gain (lower byte)	
0x74…0x7F		Not used

Read operations allow the master to access any memory location. Sequential reads are also possible. Any read operation is initiated by the bust master with the Start signal (S), followed by the address AD = 1010000, and the $R/\overline{W}$ bit, which is a logic low. The EEPROM will acknowledge (ACK) this byte during the ninth clock pulse. The next byte transmitted by the master is the word address and will be written into the address pointer of the EEPROM. After receiving another acknowledge signal from the EEPROM the master must transmit a Start signal (repeated Start, Sr), followed by the address AD= 1010000 and the $R/\overline{W}$ bit set to one. The EEPROM issues an acknowledge and the eight-bit data word.

For a single read operation, the master does not acknowledge the transfer but generates a Stop signal (P) which terminates the read operation.

S	AD,0	ACK	Word Address (n)	ACK	Sr	AD,1	ACK	Data word n	P

The sequential read of data bytes are initiated in the same way but the master transmits an acknowledge after the first data word is send by the EEPROM. This directs the EEPROM to transmit the next sequentially addressed data byte.

S	AD,0	ACK	Word Address (n)	ACK	Sr	AD,1	ACK

Data word n	ACK	Data word n+1	ACK	Data word n+2	…	Data word n+X	P

Use the following decoding procedure to get the required information from the word addresses:

a) Fabrication time from data bytes in 0x05 and 0x06

Data byte in 0x06								Data byte in 0x05							
MSB							LSB	MSB							LSB
+ 2000 = Fabrication year							Fabrication month				Fabrication date				

b) Calibration offset from data bytes in 0x70 and 0x71

Data byte in 0x70								Data byte in 0x71							
MSB							LSB	MSB							LSB
MSB															LSB
16 bit word															

$$Offset = -0.15\ \mathrm{V} + \frac{16\ \text{bit word}}{65535} \times 0.30\ \mathrm{V}$$

c) Calibration slope from data bytes in 0x72 and 0x73

Data byte in 0x72								Data byte in 0x73							
MSB							LSB	MSB							LSB
MSB															LSB
16 bit word															

$$Slope = \frac{16\text{ bit word}}{1{,}000{,}000}\text{ V/vol-\% } H_2$$

To write a single byte into a memory location, the master issues a Start signal, followed by the, address code AD=1010000, and the $R/\overline{W}$ bit, which is a logic low. The device will acknowledge this byte during the ninth clock pulse. The next byte transmitted by the master is the word address and will be written into the address pointer of the EEPROM. After receiving another acknowledge bit from the EEPROM the master device will transmit the data bye to be written into the addressed memory location. The EEPROM acknowledges again and the master generates a Stop condition. This initiates the internal write cycle, and during this time the EEPROM will not generate acknowledge signals.

S	AD,0	ACK	Word Address (n)	ACK	Data word n	ACK	P

Write operations should be limited to the free memory locations 0x75…0x7F or if the calibration offset and slope must be adapted to sensing conditions different from those used during the initial calibration of the sensor.

10.3. OFFSET ADJUSTMENT

The H2-meTCD 0-10V sensors contain a digital-analog converter with 12-bit output voltage resolution, operated in a “window” configuration, to enable a precise balancing of the Wheatstone bridge.

The adjustment is initiated by the following write operation to the digital-analog converter with the Start signal, followed by the address AD=1100000 and the $R/\overline{W}$ bit, which is a logic low. The DAC acknowledges and the master sends an instruction byte 01110000 (to update the volatile register) or 01010000 (to update the volatile and nonvolatile register). After receiving the next acknowledge condition the master transmits two data bytes. After the next ACK the master terminates the write operation with the Stop signal.

S	AD,0	ACK	Instruction byte	ACK	Data byte 1	ACK	Data byte 2	ACK	P

The data bytes adjust the 12-bit long output voltage of the DAC, coupled to the Wheatstone bridge through the resistor R_5 (see figure 17).

Data byte 1	Data byte 2
D11 D10 D09 D08 D07 D06 D05 D04	D03 D02 D01 D00 X X X X
	X = Don´t care

To save the offset adjustment permanently the output voltage must be written to nonvolatile memory of the DAC. This is done by using 01010000 as instruction byte, preceding the data bytes 1 and 2.

10.4. GAIN ADJUSTMENT

The H2-meTCD 0-10V sensors contain a nonvolatile 256-position digital potentiometer to adjust the output signal. The potentiometer picks up a fraction of the balance voltage which is amplified by an instrumentation amplifier. The gain adjustment hence controls the slope of the linear calibration curve.

The adjustment is initiated by the following write operation to the digital potentiometer with the Start signal, followed by the address AD= 0101110 and the R/$\overline{W}$ bit, which is a logic low. The digital potentiometer acknowledges and the master sends an instruction byte 00010001 (to update the volatile register) or 00100001 (to update the volatile and nonvolatile register). After receiving the next acknowledge condition the master transmits one data byte. After the next ACK the master terminates the write operation with the Stop signal.

S	AD,0	ACK	Instruction byte	ACK	Data byte	ACK	P

The data byte sets the taper of the digital potentiometer. A value close to zero means a high gain while values close to 255 represent low gains.

11.FOOTPRINT AND RECOMMENDED PLUG-IN SOCKETS

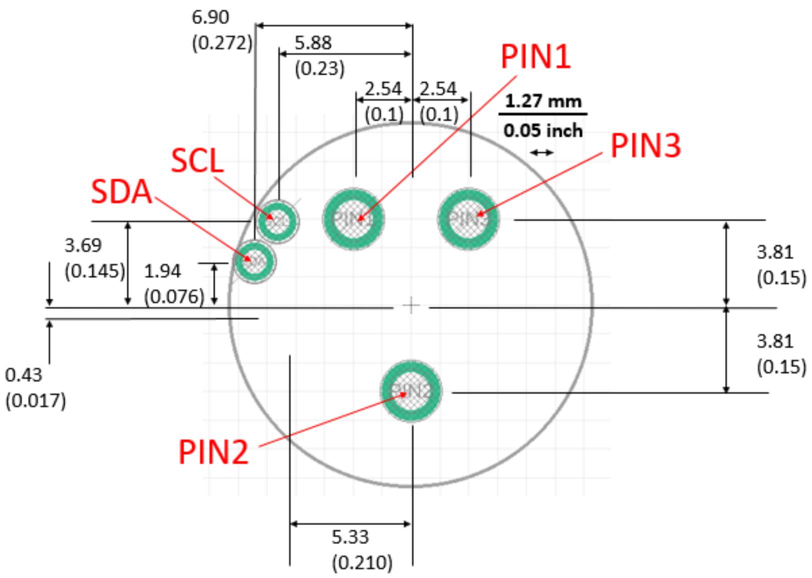

Figure 3: Footprint (dimensions shown in millimeter and inch). The SCL and SDA sockets accepts pins of 0.38 to 0.5 mm diameter.

Recommended plug-in sockets/PCB pins	Drill hole	Pin dameter
450-3326-01-03-00 (Cambion Electronics LTD)	2.6 mm	
5928-0-00-15-00-00-03-0 (Mill-Max)	0.61 mm	0.5 mm

12.ORDERING INFORMATION

Hydrogen sensor H2-meTCD 0-10V

13.PACKAGING/SHIPPING INFORMATION

This sensor is shipped individually in an ESD/EMI shielded and water vapor-proofed bag according to IPC/JDEC J-STAD-033.

14.ACCESSOIRES

The sensor requires only a +12V DC supply voltage and a 0…10 V display unit (such a digital multimeter) for operation. This sensor can also be operated with our display and data logger module "H2-Messmodul" that displays the hydrogen level. To allow the interaction with internal integrated circuits over the I2C bus, our kit "I2C-USB 1.1" can be intermediated between the sensor and the module or the +12V DC supply voltage. I2C-USB 1.1 can be linked with the USB port of a PC. The evaluation kit PGA-ADC is available to operate the sensor via a one-wire network and a PC. I2C-USB 1.1 and all versions of PGA-ADC run with our software "SensorControl", distributed with the kits. Only the latest version PGA-ADC 3.4 features a pin connector for the I2C bus.

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.WARNINGS

Warnings: The sensor H2-meTCD 0-10V 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.

17.NOTES

18.WORLDWIDE SALES AND CUSTOMER SUPPORT

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