HLS-440P

Automotive Hydrogen Leak Sensor

General Description

The HLS-440P automotive hydrogen sensor monitors hydrogen leakage concentrations of 0 - 10% in air. The design fulfills Zone 2 requirements according to ATEX 100a. The predicted concentration is transmitted to the host via the CAN bus interface or with PWM output.

Type A:
The sensor shall measure the hydrogen concentration in high humidity conditions, e.g. in the exhaust of a fuel cell system, to ensure compliance with defined upper thresholds.

Type B:
The sensor shall measure the hydrogen concentration under ambient humidity conditions, to ensure compliance with defined upper thresholds.

Ordering Information and Content Guide appear at end of datasheet.

Key Benefits & Features

The benefits and features of HLS-440P, Automotive Hydrogen Leak Sensor are listed below:

Figure 1:
Added Value of Using HLS-440P

Benefits	Features
• High sensitivity over large concentration range	• 0 – 10% H_2 in air or nitrogen • Accuracy ±0.5% vol. • Resolution 500ppm
• Low cross sensitivity	• Heated field-effect transistor technology • No detection towards HC, H_2S, N_2, CO, CO_2, NO_x
• Designed for humid environment	• Humidity influence <0.5% typical • Operating humidity range 5–100% relative humidity including condensation
• Fast response time	• Start-up time <5s • Speed of response (t_{90}) < 5s • Speed of recovery < 5s • CAN bus interface 500 kbit/s (ISO11898-2) • PWM output (optional)
• Low power consumption	• 70 mA (typical)
• Long-term stability and reliability	• ESD and EMC protection • Operating temperature range –40°C to 90°C • Operating pressure range 0.5 – 1.2 bar (absolute)

Benefits	Features
• Safety integrity level and explosion proof	• Designed for SIL2 (IEC 61508) and ATEX 100a zone 2
• Long lifetime	• IP6K7 and IP6K9K qualified with expected lifetime of 10 years

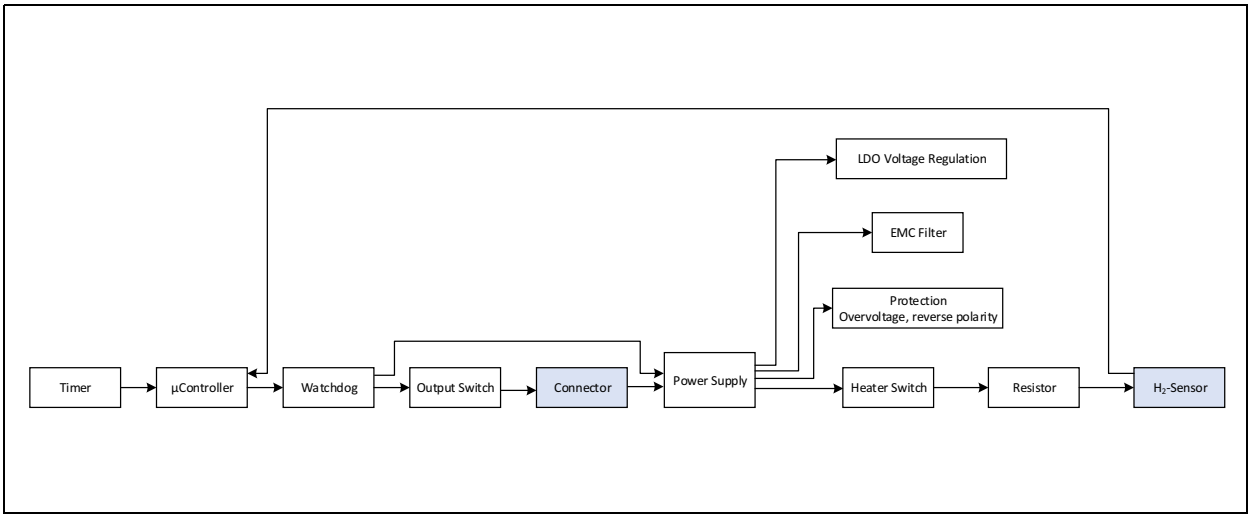
Applications

Detection of hydrogen gas leaks in fuel cell systems and other in-process applications.

Block Diagram

The functional blocks of this device for reference are shown below:

Figure 2:
HLS-440P Block Diagram



Overview

Figure 3:
HLS-440P Overview

Installation

The HLS-440P is designed for process connection with metric straight screw thread with o-ring M14x1.5 in accordance with ISO 6149-3 (stud end) and to fit into ISO 6149-1 (port).

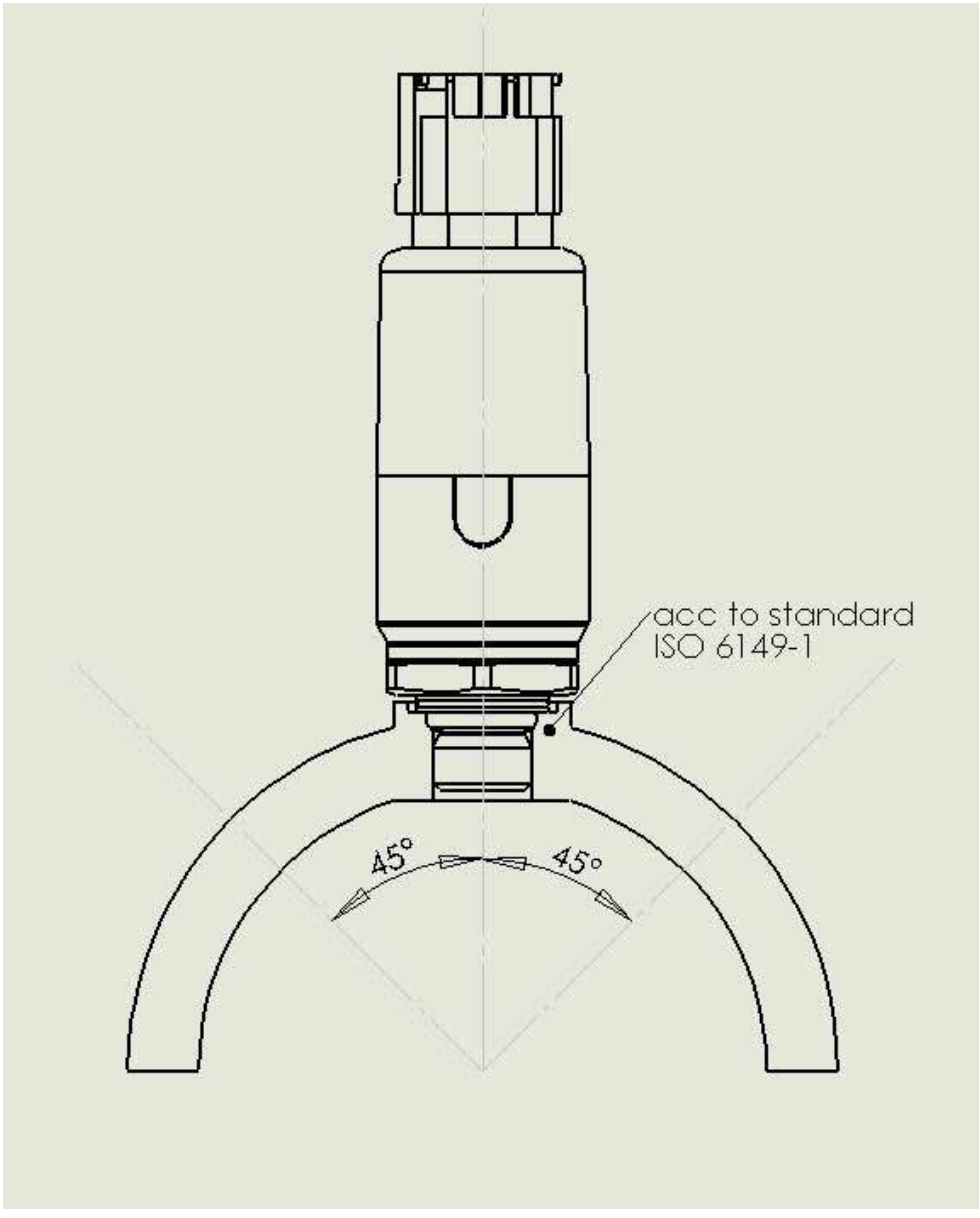
The HLS-440P can also be mounted on a holder for open-air application.

Recommended O-ring 11.3±0.2, 2.2±0.08 or 11.3±0.2, 2.4±0.08 EPDM 70 "Peroxide crosslinked" or FPM 75 (Viton)

Recommended torque for fixation: 15 Nm (+10% -0%) acc. ISO 6149-3

Recommended orientation of the sensor, see below.

Figure 4:
Recommended Mounting Position of the Sensor



Electrical Interface

Electrical Connector

The sensor connector is a A2105404381 - Code A with mating connector MQS 4-pin, TE Connectivity AMP p/n 1-967640-1 Code A.

Figure 5:
Pin Coding AMP 1-967640-1 Code A

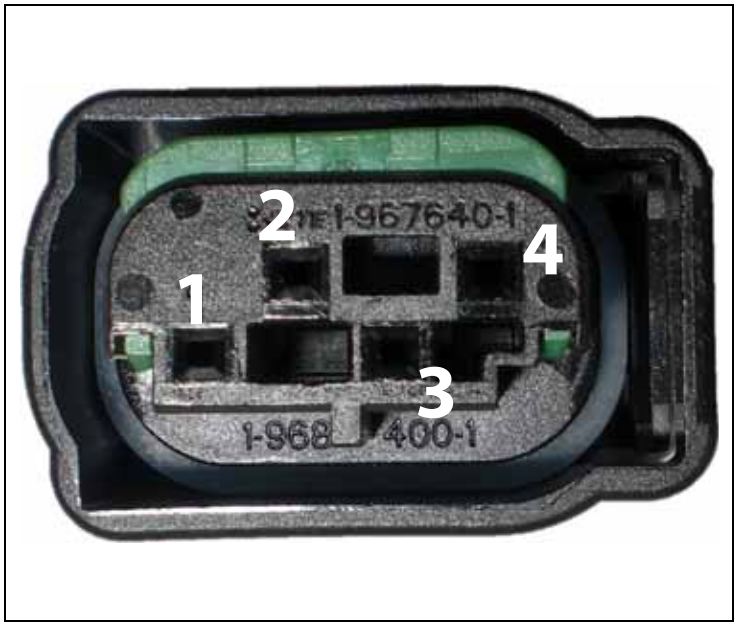


Figure 6:
Pin Assignment

Pin	Function
1	Vcc
2	GND
3	CAN – High Type A with termination resistor Type B no termination resistor
4	CAN – Low Type A with termination resistor Type B no termination resistor

CAN Bus Interface

This section describes the CAN bus interface that is available in some variants of HLS-440P.

Physical Interface

The physical interface is two-wire balanced. It is a high speed CAN interface (ISO 11898-2) with bus bit rate at 500 kbit/s.

Type A: 120 Ohm CAN bus termination

Type B: no termination

CAN Matrix HLS-440P

HLS-440P will send the first CAN message 0.1 s after start-up. The repetition rate of the CAN message is 100ms ±2ms. The first H_2 concentration will be delivered after 5 s. The CAN messages prior to that will have the "Not_ready" bit set, indicating that the concentration value of the message is not valid.

In case of a warm restart (<5s) error category 1 will be set for 10 s.

The Msg Counter increments with each CAN message.

Each CAN message is sent twice. The first time it is sent with ID 1592 (0x0638) for type A and 1600 (0x0640) for type B. The second time it is sent with ID 1595 (0x063B) for type A and ID 1603 (0x0643) for type B. The second time all bytes excluding byte 7 are inverted. Byte 7 has the fix value 170 (hex AA) in the second message.

Figure 7:
CAN Matrix Message Layout HLS-440P

System:	H2ES		**Receiver**												
Name:	**A:** H2 Exhaust Sensor **B:** H2 Ambient Sensor														
ID: (hex)	**A:** 0x638 **B:**0x640														
Datalengthcode:	8														
Interrupt:	no			**Rev. 3.3**											
Transceive:	Tx														
Remote:	no														
Repetition rate:	100 ms							MSB							LSB

variables	**short name**	**datatype**	**resolution**	**phys. range / unit**	**raw range**	**no value**	**b7**	**b6**	**b5**	**b4**	**b3**	**b2**	**b1**	**b0**	**Byte-No.**
H2 Concentration	H2ES_Con	byte	0,05	0 .. 10 Vol.% H2	0 .. 200	255									Byte 0
Status															
Sensor not ready	H2ES_not_ready	bit												b0	Byte 1
Error Category	H2ES_Err_Cat	2 bit										b2	b1		
EMC correction active	H2ES_EMC_Corr	bit									b3				
negative drift info	H2ES_neg_drift1	bit								b4					
negative drift warning	H2ES_neg_drift2	bit							b5						
negative drift alarm	H2ES_neg_drift3	bit						b6							
Error 5		bit					x								
SW Version y.z	H2ES_SW	byte	1	0 .. F . 0 .. F	0.. 255		y	y	y	y	z	z	z	z	Byte 4
HW Version															
Type	H2ES_HW_Type	2 bit	1	0	0		b7	b6							Byte 5
HW revision	H2ES_HW_Rev	6 bit	1	0 .. 63	0 .. 63				b5	b4	b3	b2	b1	b0	Byte 5
Msg Counter	H2ES_Count	byte	1	0 .. 127	0 .. 127	255	to be incremented each message !								Byte 6
Safety Byte - CRC Byte 0 .. Byte 6	H2ES_Safety	byte	1		0.. 255										Byte 7

Definition Error Category :

Code	**Name**	**Description**
0	No Error	H2ES Sensor OK
1	Performance Error	General function still given (e.g. tolerance range may be increased to 1 % vol.)
2	Slight functional error	General function still given but high likelihood for upcoming severe error (sensor should be replaced)
3	Severe functional error	Severe error, general function NOT given anymore, sensor not longer trustable (= signal not available)

Definition HW Version Type :

Code	**Name**		**Description**
0	**H2ES**	**Type A**	**H2 Exhaust Sensor**
1	H2AS		H2 Anode Sensor
2	H2S		H2 Ambient Sensor
3	**H2ES**	**Type B**	**H2 Stack Module Vent Sensor**

Byte 0 H_2 Concentration

Figure 8:
Byte 0 Bit Order

Bit	MSB 7	6	5	4	3	2	1	LSB 0
Byte 0	X	X	X	X	X	X	X	X

This byte shows the H_2 concentration in a resolution of 0.05.

x = Concentration in % Hydrogen

(EQ1) Byte value = (x % H_2)* 200/ (10 % H_2)

(EQ2) x % = byte value *(10 % H_2)/200

Range: 0 - 200 (Hexadecimal 0 - C8)

No value: 255 (Hexadecimal FF)

Values: 0 - 10 % H_2

Resolution: 0.05 = (10 % H_2) / 200

The No value is sent if there is no valid H_2 concentration (accompanied by Not_ready bit in status byte (Byte 1))

Byte 1 Status

Figure 9:
Byte 1 Status Bit Assignment

Bit	MSB 7	6	5	4	3	2	1	LSB 0
Byte 1	Bit 7	Bit 6 Neg_ drift3	Bit 5 Neg_ drift2	Bit 4 Neg_ drift1	Bit 3 EMC_ Corr	Bit 2 Err_ Category	Bit 1 Err_ Category	Not_ready

This byte shows the status of the module.

Bit 0: If the not_ready bit is set, the module is not up or not working.

Value: 0 or 1

Bit 1 + 2: The error category

Value: 0 - 3

The figure below describes the error category definition

Figure 10:
Definition of Error Category

Code	Name	Description
0	No error	Sensor OK
1	Performance error	General function still given; Warm start-up indication (<5 s)
2	Slight functional error	General function still given but high likelihood for upcoming severe error (sensor should be replaced)
3	Severe functional error	Severe error, general function NOT given anymore, sensor not longer trustable (=signal not available)

Bit 3: EMC_Corr...EMC correction active

Value: 0 or 1

Bit 4: Negative drift info. If this bit is set, the prediction has gone below the first of three warning levels.

Bit 5: Negative drift warning. If this bit is set, the prediction has gone below the second warning level.

Bit 6: Negative drift alarm. If this bit is set, the prediction has gone below the third warning level.

Bit 7 is not used.

Byte 4 Software Version Y.Z

Figure 11:
Byte 4 Software Version Numbering Code

Bit	MSB 7	6	5	4	3	2	1	LSB 0
Byte 4	Y	Y	Y	Y	X	X	X	X

This byte shows the firmware version.

View: Y.Z

Range: 0 - 255 (Hexadecimal 0 - FF)

Value: 0.0 - 15.15 (Hexadecimal 0.0 - F.F)

Byte 5 Hardware Version

Figure 12:
Byte 5 Hardware Version Numbering Code

Bit	MSB 7	6	5	4	3	2	1	LSB 0
Byte 5	HW Type	HW Type	Rev.	Rev.	Rev.	Rev.	Rev.	Rev.

This byte is divided into two parts. The first part shows the hardware type

Figure 13:
Definition of HW Version Type

Code	Name	Description
0	HLS-440P type A	H_2 Exhaust Sensor (H2ES Type A)
1	HPS-100	H_2 Anode Sensor (H2AS)
2		H_2 Ambient Sensor (H2S)
3	HLS-440P type B	H_2 Stack Module vent Sensor (H2ES Type B)

Range: 0 - 3 here 0

The second part of byte 5 shows the revision of the hardware.

Range: 0 - 63

Byte 6 Msg Counter

Figure 14:
Byte 6 Message Counter Order

Bit	MSB 7	6	5	4	3	2	1	LSB 0
Byte 6	X	X	X	X	X	X	X	X

The Msg Counter byte numbers the CAN-messages and is incremented by 1 with each (non-inverted) message

Range: 0 - 127 (0 - 7F)

Value: 0 - 127

After reaching the value 127 the counter starts from 0 again.

Byte 7 Safety Byte CRC

Figure 15:
Byte 7 Safety Byte Order

Bit	MSB 7	6	5	4	3	2	1	LSB 0
Byte 7	X	X	X	X	X	X	X	X

The CRC byte shows the 7-bit CRC over byte 0-6 with the Polynomial 0xE5.

PWM

This section describes the PWM output that is available in some variants of HLS-440P.

Physical Interface

The electrical connector is the same as in the variants with CAN bus interface (see Electrical Connector). Type A has a termination resistor while type B does not.

The PWM signal is created as a differential CAN signal on pin 3 and 4. A CAN signal is said to be in a dominant state when the signal lines are separated (a dominant bit is transmitted). When the signal lines are at the same voltage level, the state is recessive. Recommended circuitry to convert CAN signals to TTL is specified in a separate document, available on request. The PWM signal is only an output signal. No other transmitting devices should be attached to the bus.

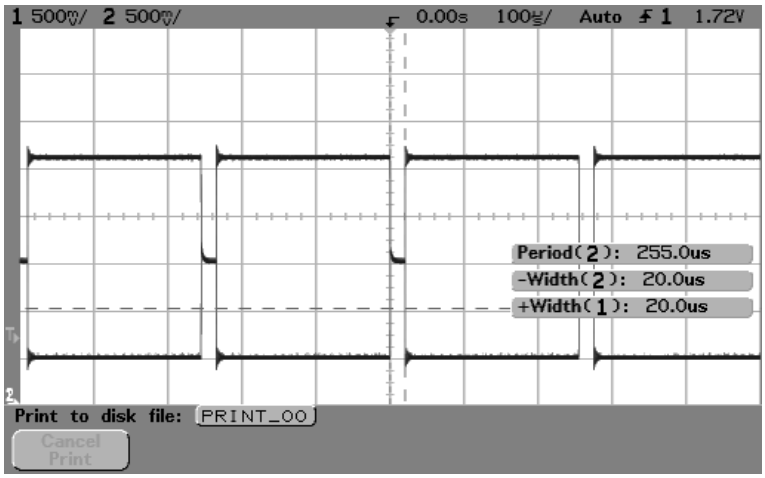
The PWM Signal

The PWM signal has a period time of 255 µs. The rather short period is chosen since modern CAN transceivers do not allow for a longer dominant state.

The duration of the recessive state can be translated into output H_2 prediction from the sensor module. The recessive duration (pulse width) ranges from 20 to 220 µs, which corresponds to 0 to 10% hydrogen. An error is shown as a 10 µs pulse width. At startup the pulse width will be 255 µs (100% duty cycle) until the first valid H_2 concentration is delivered after 5 s.

The figure below shows the output for 0% hydrogen (pulse width of 20 µs).

Figure 16:
Sensor Output for 0% Hydrogen (Pulse Width of 20 µs)



The relation between detected H_2 concentration (in ppm) and pulse width (in µs) is:

(EQ3) $H_2 = (\text{pulse width} - 20)*500$

The figure below shows the relation between H_2 prediction and pulse width.

Figure 17:
The Relation between H_2 Prediction and Pulse Width

Pulse Width	Message Type
10 µs	Error
20 µs	0% H_2
21 µs	0.05% H_2
…	…
219 µs	9.95% H_2
220 µs	10.0% H_2

Specifications

Figure 18:
Typical Characteristics

Description	Value
Sensor Function	
Target gas	Hydrogen
Concentration range	0 – 10 Vol% H_2 in air
Accuracy	± 0.5% vol. (1)
Resolution	500 ppm
Speed of response (t_{90})	<5 s
Speed of recovery	<5 s
Cross-sensitivity	None towards HC, H_2S, N_2, CO, CO_2, NO_x Humidity correction by subtracting 0.6% for type A (2) Humidity correction by subtracting 0.3% for type B (2)
Start-up time	5 s
Expected lifetime	10 years (1)
Safety	
Explosion proof	Designed to fulfill Zone 2 requirements according to ATEX 100a
Self test/Error handling	Yes
Electrical	
Supply voltage	8.5 – 16 V
Supply current	70 mA typical @ 13.8 V and 20 °C, increased current during start-up phase (avg. 200 mA during first 1s)
CAN interface	Version 2.0 ISO 11898
Connector	A2105404381 - Code A
Mating Connector	MQS 4-pin, AMP 1-967640-1 Code A
ESD/Reverse polarity	Yes

Description	Value
Environmental	
Operation temperature range	-40ºC to 90ºC
Storage temperature range	-50ºC to 95ºC
Humidity	5 – 100% including condensation (1)
Pressure	0.5 – 1.2 bar(a)
EMC	Automotive requirements
Mechanical	
Dimensions (L, Ø)	L=93.5mm Ø = 30mm
Weight	77g
Stud	M14x1.5 in acc. to ISO 6149-3
O-ring	ID: 11.3 ± 0.2 mm, rec. cord size: 2.2 ± 0.08 mm alt. cord size: 2.4 ± 0.08 mm
Material	Stainless steel and PBT GF30
Filter membrane	Pall SUPOR 450R, 0.45 µm.
IP code	IP6K7 and IP6K9K

Note(s) and/or Footnote(s):

1. Preliminary values
2. Default offset compensation for humidity range.

The figure below describes the specification of the different variants of HLS-440P

Figure 19:
Specification of the Different Variants of HLS-440P

Part Number	Default		On Request	
CAN interface	Version 2.0 ISO 11898		-	
PWM output	-		Yes	
Type	A	B	A	B

Handling Instructions

Due to the fact that the sensor element consists of a silicon chip facing the surrounding the following precautions have to be taken into account:

During storage and handling avoid:

- Humidity (condensing conditions)
- Dropping (sensor must be replaced if dropped)
- Dust (especially if cap is removed)
- Mechanical impact (especially the entrance membrane)
- Electromagnetic radiation (RF fields, high magnetic fields)

In case of storage and transport it is recommended to keep the sensor within its original packaging (plastic cap and ESD protected bubble bag). The disassembly of any parts is not allowed, except for the removal of the plastic cap directly before final assembly.

Reference Data

Figure 20:
Concentration Measurement with H_2 Pulse Width of 2 min and Nominal Concentration 0.2%, 1.5%, 2.5% and 3.5% vol. H_2

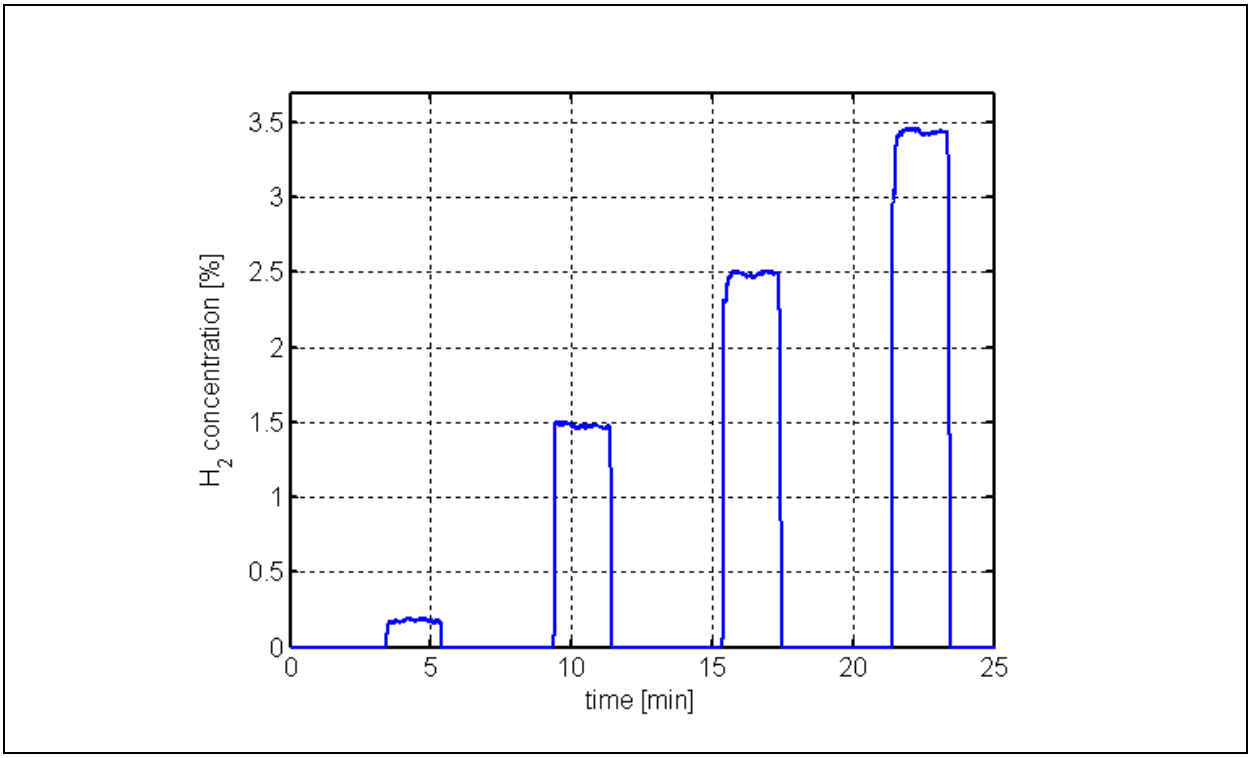
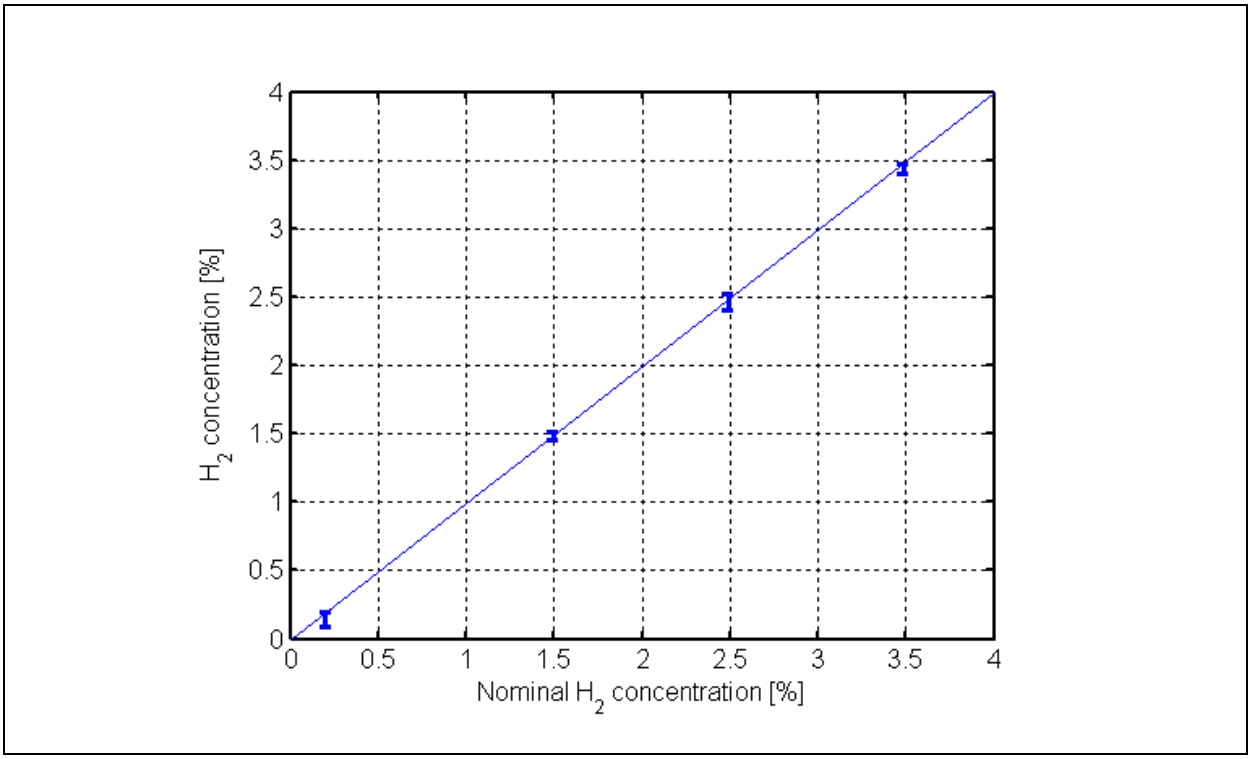


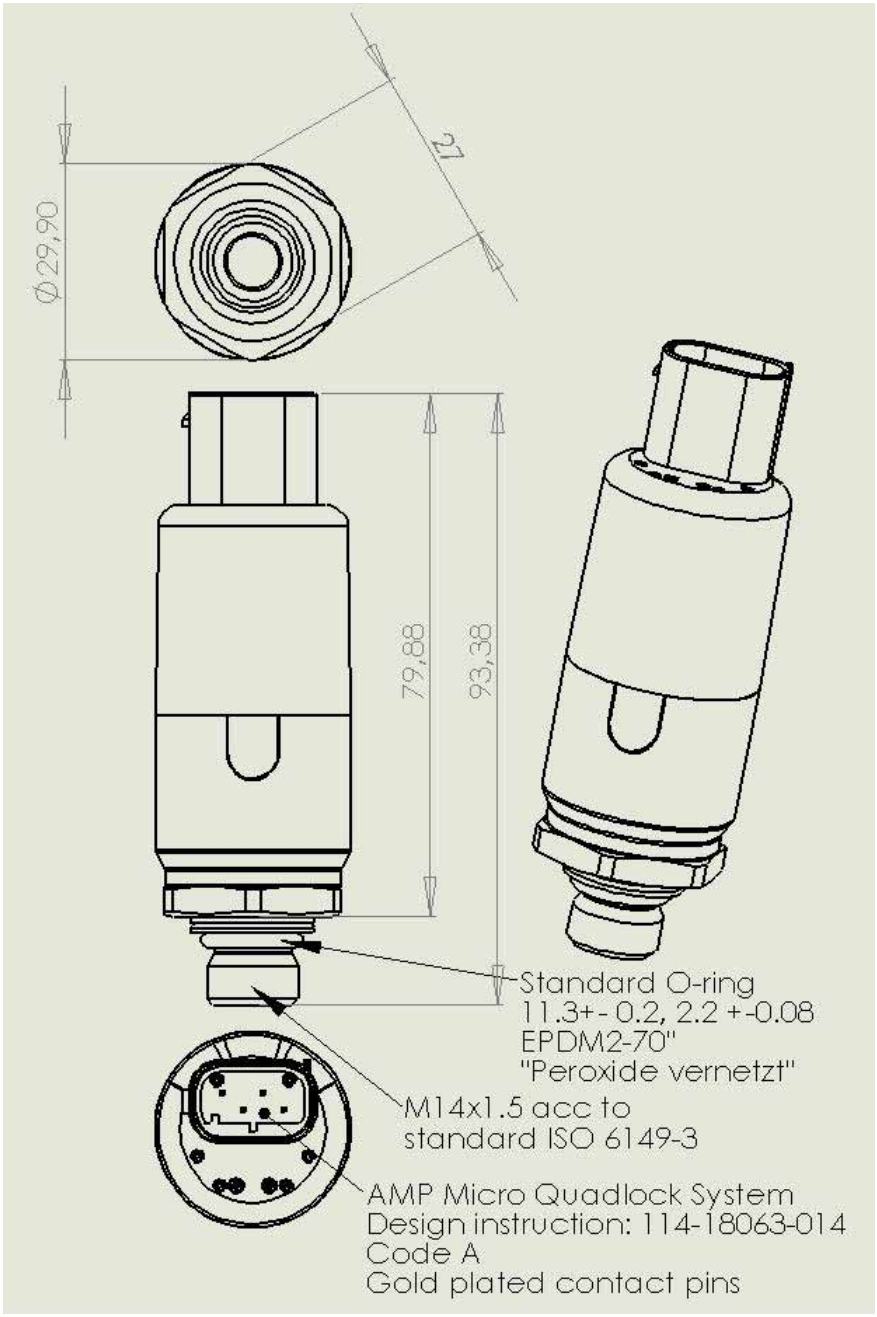
Figure 21:
Deviation of Prediction Over Nominal Concentration



Mechanical Information

Dimensions

Figure 22:
Sensor Dimensions



Note(s) and/or Footnote(s):

1. Dimensions are in millimeters.

Ordering & Contact Information

Figure 23:
Ordering Information

Ordering Code	Type	Delivery Form	Delivery Quantity
HLS-440P A (1)	CAN (500 kbit/s) (3)	Individually Wrapped	Single Item
HLS-440P B (2)	CAN (500 kbit/s) (3)	Individually Wrapped	Single Item

Note(s) and/or Footnote(s):

1. High humidity conditions.
2. Ambient humidity conditions.
3. For availability of other variants contact **ams**.

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Document Status

Document Status	Product Status	Definition
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Revision Information

Changes from (2014-Dec) to current revision 1-00 (2015-Apr-01)	Page
Content of Applied Sensor datasheet was updated to the latest **ams** design	

Note(s) and/or Footnote(s):

1. Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
2. Correction of typographical errors is not explicitly mentioned.

Content Guide