HPS-100

Automotive Hydrogen Sensor

General Description

The HPS-100 is an automotive hydrogen sensor that monitors hydrogen concentrations of 0 – 100 Vol%. The design fulfills Zone 2 requirements according to ATEX 100a. The predicted concentration is transmitted to the host via the CAN bus interface or PWM.

Ordering Information and Content Guide appear at end of datasheet.

Key Benefits & Features

The benefits and features of HPS-100, Automotive Hydrogen Sensor are listed below:

Figure 1:
Added Value of Using HPS-100

Benefits	Features
• High sensitivity over large concentration range	• 0 – 100% H_2 in nitrogen • Accuracy ±2% vol. • Resolution ±0.5% vol.
• 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 <1% 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 (on request)
• 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 0.3 – 3 bar (absolute)
• 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 5 years

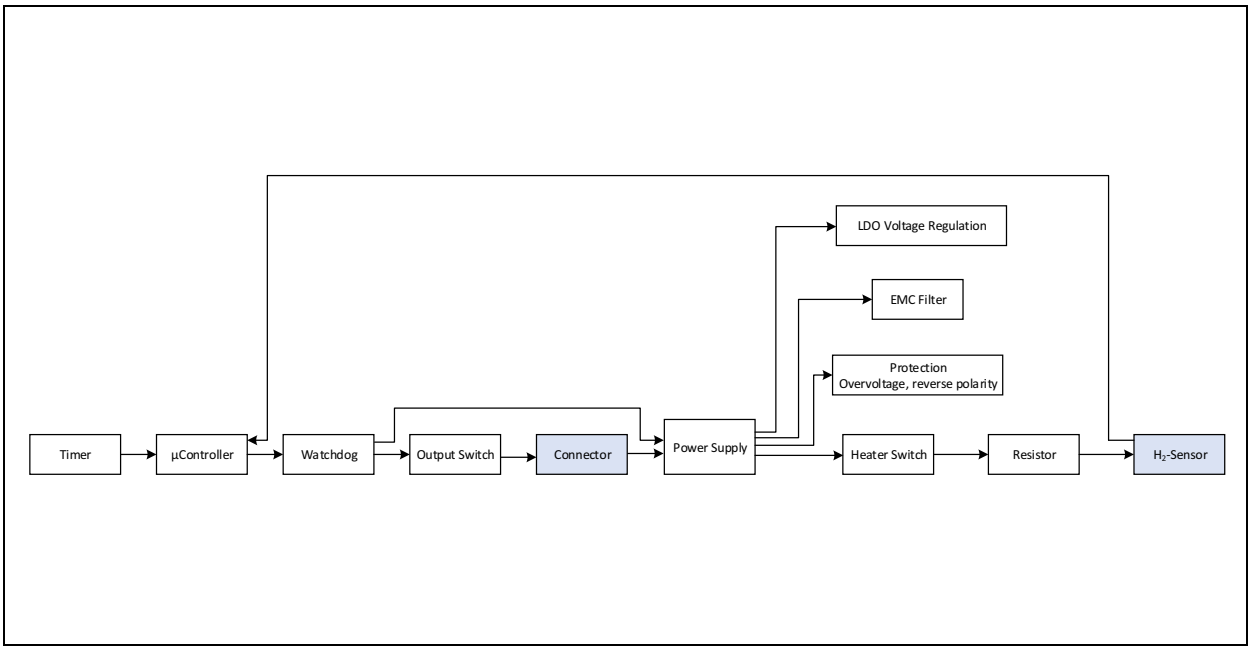
Applications

Hydrogen gas measurement in fuel cell systems and other in-process applications.

Block Diagram

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

Figure 2:
HPS-100 Block Diagram



Overview

Figure 3:
HPS-100 Overview

Installation

The HPS-100 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).

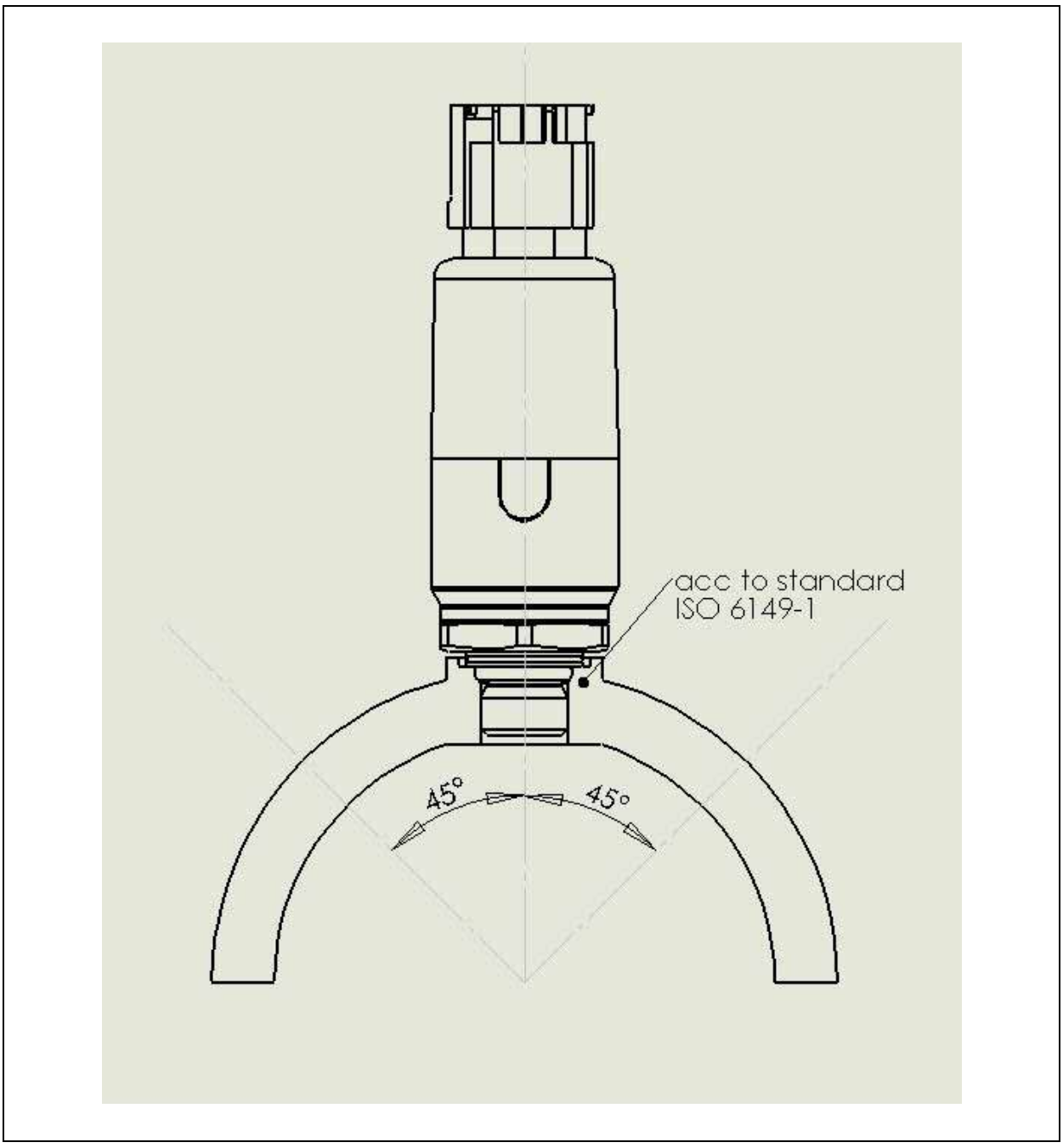
Recommended O-ring, 11.3±0.2, 2.2±0.08 or 11.3±0.2, 2.4±0.08 EPDM 70 “Peroxide crosslinked” or FPM 75 (Viton)

Note(s): The O-ring is currently part of the delivery

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 A2105404381 - Code A

Figure 6:
Pin Assignment

Pin	Function
1	Vcc
2	GND
3	CAN – High no termination resistor
4	CAN – Low no termination resistor

CAN Bus Interface

This section describes the CAN bus interface that is available in some variants of HPS-100.

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.

CAN Matrix

HPS-100 will send the first CAN message within 0.1 s after reset. The repetition rate of the CAN messages 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 (<5 s) error category 1 will be set for 10 s. The Msg Counter increments with each CAN message.

The CAN message has the ID 1120 (0x0460). The byte 7 is not used and has the value 0.

Figure 7:
CAN Matrix Message Layout HPS-100

System:	H2AS		**Receiver**													
Name:	H2 Anode Sensor															
ID: (hex)	0x460															
Datalengthcode:	8															
Interrupt:	no			**Rev. 3.1**												
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	H2AS_Con	byte	0.5	0 .. 100 Vol.% H2	0 .. 200	255									Byte 0	
Status																
Sensor not ready	H2AS_not_ready	bit												b0	Byte 1	
Error Category	H2AS_Err_Cat	2 bit										b2	b1			
EMC correction active	H2AS_EMC_Corr	bit									b3					
Error 2		bit								x						
Error 3		bit							x							
Error 4		bit						x								
Error 5		bit					x									
Board Temperature	H2AS_BT	2 byte	0.1	-40°C .. 155°C	0 .. 1950	65535	b15	b14	b13	b12	b11	b10	b9	b8	Byte 2	
	(Motorola format)						b7	b6	b5	b4	b3	b2	b1		Byte3	
SW Version y.z	H2AS_SW	byte	1	0 .. F . 0 .. F	0.. 255		y	y	y	y	z	z	z	z	Byte 4	
HW Version																
Type	H2AS_HW_Type	2 bit	1	1	1		b7	b6							Byte 5	
HW release	H2AS_HW_Rev	6 bit	1	0 .. 63	0 .. 63				b5	b4	b3	b2	b1	b0	Byte 5	
Msg Counter	H2AS_Count	byte	1	0 .. 127	0 .. 127	255	to be incremented each message !								Byte 6	

Definition Error Category :

Code	Name	Description
0	No Error	H2AS Sensor OK
1	Performance Error	General function still given (e.g. tolerance range may be increased to x % 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	valid for this component!
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 0.5.

x = Concentration in % Hydrogen

(EQ1) Byte Value = (x % H_2)* 200/ (100 % H_2)

(EQ2) x % = Byte Value *(100% H_2)/200

Range: 0 - 200 (Hexadecimal 0 - C7)

No Value: 255 (Hexadecimal FF)

Values: 0 - 100% H_2

Resolution: 0.5 =(100 % 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	Error 5	Error 4	Error 3	Error 2	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

No Value: 1

Bit 1+2: The error category

Value: 0 - 3

Figure 10:
Definition of Error Category

Value	Name	Description
0	No error	Sensor OK
1	Performance error	General function still given; warm start-up indication (<5s)
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 disturbance detected, compensation active (0-no disturbance, 1-disturbance)

Bit 4 to 7: Not used.

Byte 2 + Byte 3, Board Temperature

Figure 11:
Byte 2 + Byte 3 Board Temperature Bit Order

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

These two bytes show the board temperature in °C.

Range: 0 - 1950 (Hexadecimal 0 – 79E)

Value: -40 °C to 155 °C

No value: 65335 (Hexadecimal FFFF)

Resolution: 0.1 °C

0-399 = -40 °C to -0.1°C

400 = 0 °C

401–1950 = 0.1 °C to 155 °C

Byte 2 is the high byte and byte 3 the low byte.

Byte 4, Software Version Y.Z

Figure 12:
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 13:
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.

Bit 6 and 7: HW Type

Range: 0 - 3 here 1

Figure 14:
Definition of HW Version Type

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

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

Bit 0 - 5: Revision of the hardware.

Range: 0 - 63

Byte 6, Msg Counter

Figure 15:
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 message

Range: 0 - 127 (Hexadecimal 0 - 7F)

Value: 0 - 127

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

Byte 7, Empty

Figure 16:
Byte 7 Default Values

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

This byte is needed to fulfill the CAN data length code of 8 bytes. This byte is not used and has the value 0.

PWM

This section describes the PWM output that is available in some variants of HPS-100.

Physical Interface

The electrical connector is the same as in the variants with CAN bus interface (see Electrical Connector).

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.

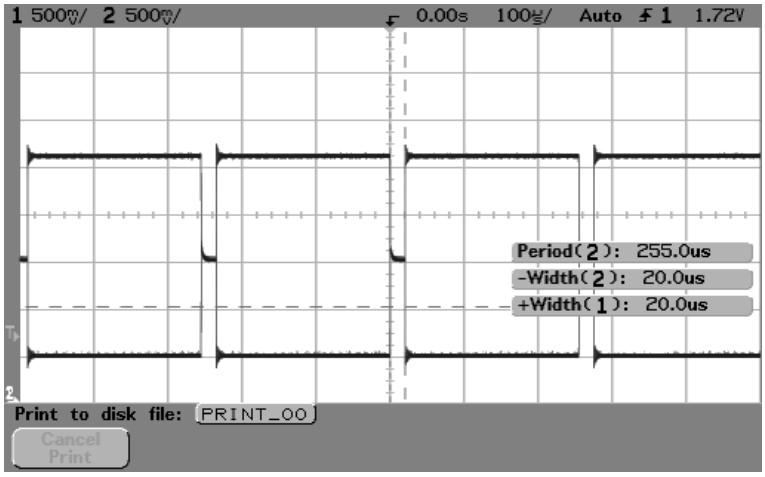
The PWM Signal

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 100% 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 17:
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 = (pulse width – 20)*5000

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

Figure 18:
Relation Between H_2 Prediction and Pulse Width

Pulse Width	Message Type
10 µs	Error
20 µs	0% H_2
21 µs	0.5% H_2
…	…
219 µs	99.5% H_2
220 µs	100% H_2

Specifications

Figure 19:
Typical Characteristics

Description	Value
Sensor Function	
Target gas	Hydrogen
Concentration range	0 – 100 Vol% H_2 in N_2
Accuracy	± 2 Vol% under typical conditions
Resolution	0.5 Vol%
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 Some influence of humidity, depending on application conditions (typically ±1 Vol% H_2) Humidity correction by subtracting 1.5%
Start-up time	5 s
Expected lifetime	5 years or 3000 operation hours
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
Environmental	
Operation temperature range	-40 °C to 90 °C
Storage temperature range	-50 °C to 95 °C
Humidity	5-100% including condensation

Description	Value
Operating Pressure	0.3 – 3 bar(a)
EMC	Automotive requirements
Mechanical	
Dimensions (L, Ø)	L=93.5mm Ø = 30mm
Stud	M14x1.5 acc. to standard 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
Weight	77 g
Material	Stainless steel and PBT GF30
Filter membrane	Pall SUPOR 450R, 0.45 µm
IP code	IP6K7 and IP6K9K

The figure below describes the specification of the different variants of HPS-100

Figure 20:
Specification of the Different Variants of HPS-100

Description	Default	On Request	
CAN interface	Version 2.0 ISO 11898		n.a.
CAN bit rate (kbits/s)	500	250	n.a.
PWM output	-		Yes

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 21:
Concentration Measurement with H_2 Pulse Width of 2 min and Nominal Concentration 10%, 30%, 50%, 70% and 90% vol. H_2

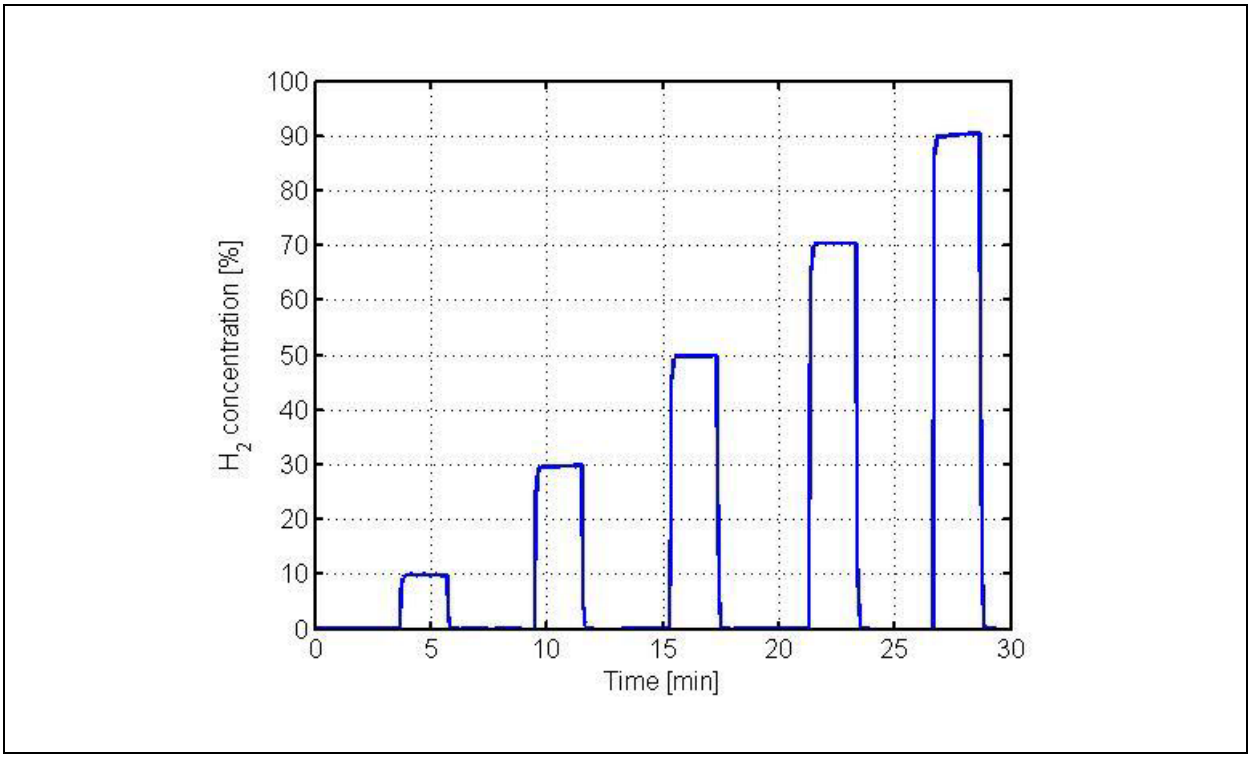
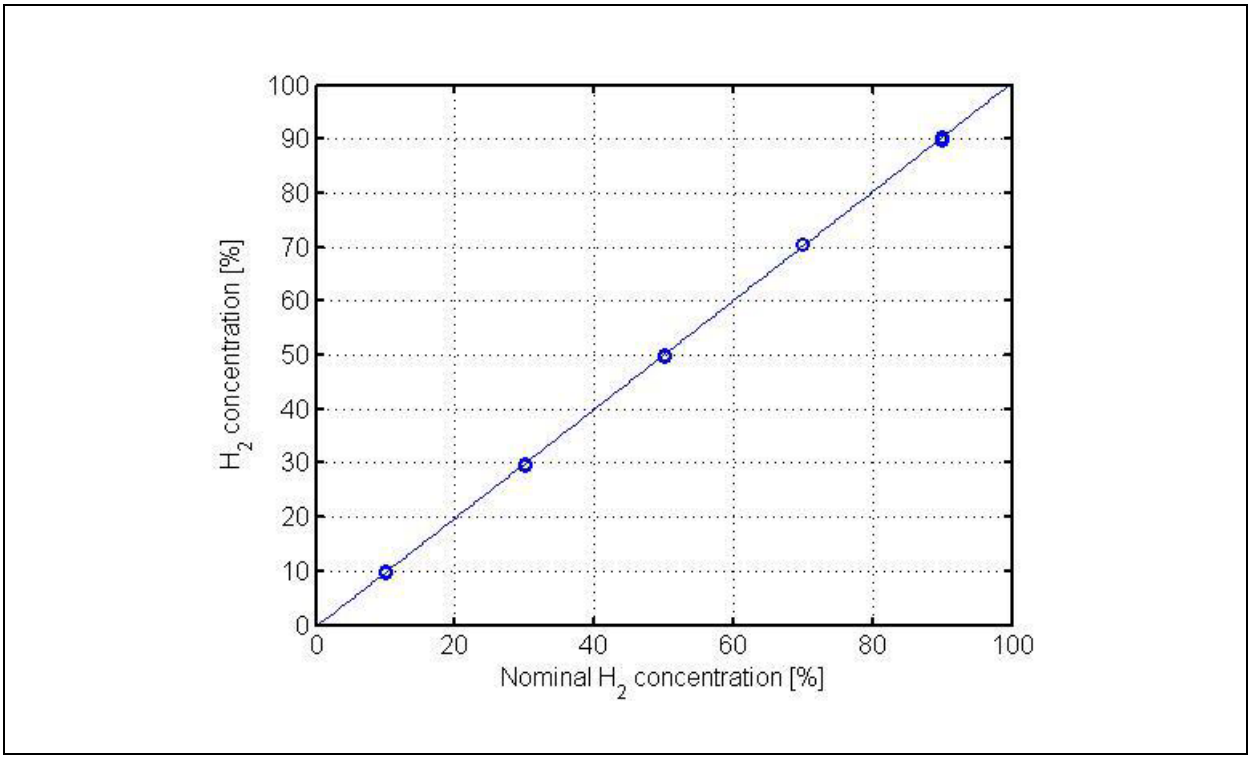
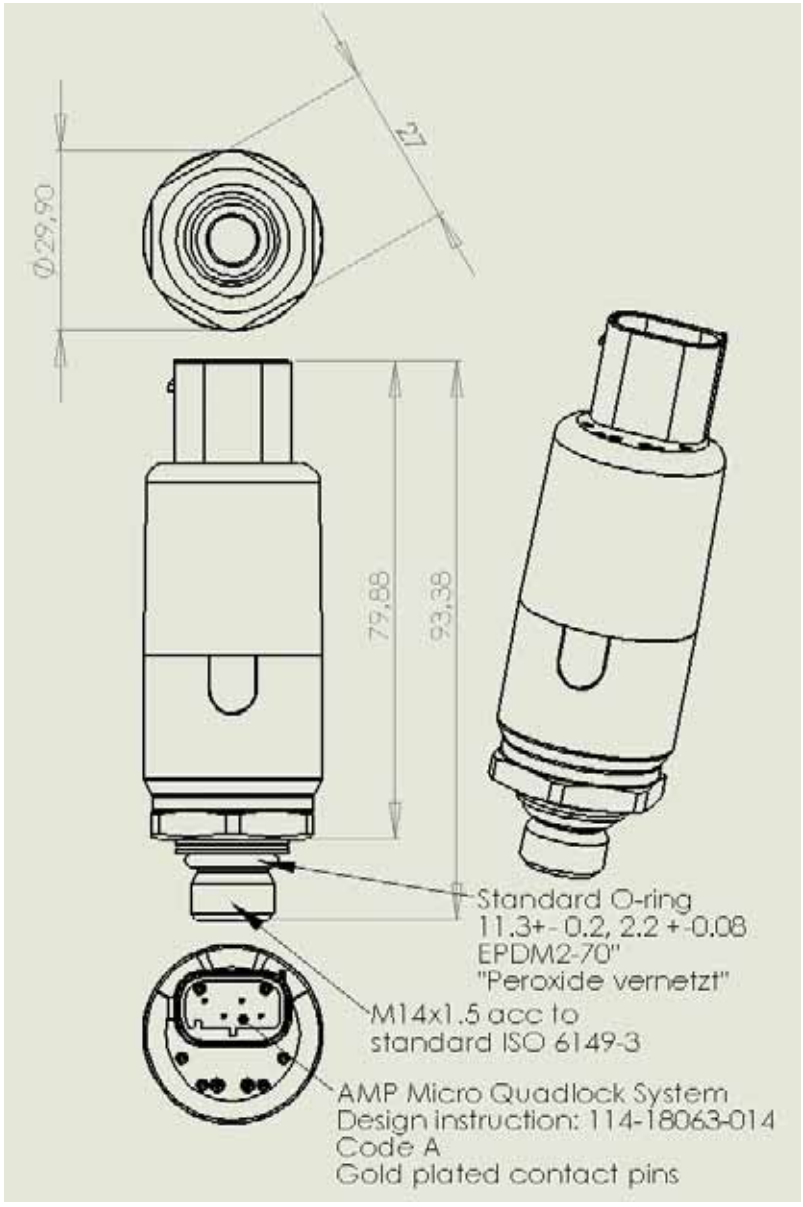


Figure 22:
Deviation of Prediction Over Nominal Concentration



Mechanical Information

Figure 23:
Sensor Dimensions



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

1. Dimensions are in millimeters.

Mating Connector: Housing: A2105404381 – code A
Contacts: A0135454526
Seals: A0005456980

O-ring: 11.3±0.2, 2.2±0.08 EPDM 70 "Peroxide crosslinked"

Ordering & Contact Information

Figure 24:
Ordering Information

Ordering Code	Type	Delivery Form	Delivery Quantity
HPS-100	CAN (500 kbit/s) (1)	Individually Wrapped	Single Item

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

1. For availability of other variants contact **ams**.

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Document Status	Product Status	Definition
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Revision Information

Changes from (2014-Nov) to current revision 1-00 (2015-Apr-06)	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