

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 |
|---|---|
| <ul style="list-style-type: none"> High sensitivity over large concentration range | <ul style="list-style-type: none"> 0 – 100% H₂ in nitrogen Accuracy ±2% vol. Resolution ±0.5% vol. |
| <ul style="list-style-type: none"> Low cross sensitivity | <ul style="list-style-type: none"> Heated field-effect transistor technology No detection towards HC, H₂S, N₂, CO, CO₂, NO_x |
| <ul style="list-style-type: none"> Designed for humid environment | <ul style="list-style-type: none"> Humidity influence <1% typical Operating humidity range 5–100% relative humidity including condensation |
| <ul style="list-style-type: none"> Fast response time | <ul style="list-style-type: none"> Start-up time <5s Speed of response (t₉₀) < 5s Speed of recovery < 5s CAN bus interface 500 kbit/s (ISO11898-2) PWM output (on request) |
| <ul style="list-style-type: none"> Low power consumption | <ul style="list-style-type: none"> 70 mA (typical) |
| <ul style="list-style-type: none"> Long-term stability and reliability | <ul style="list-style-type: none"> ESD and EMC protection Operating temperature range –40°C to 90°C Operating pressure range 0.3 – 3 bar (absolute) |
| <ul style="list-style-type: none"> Safety integrity level and explosion proof | <ul style="list-style-type: none"> Designed for SIL2 (IEC 61508) and ATEX 100a zone 2 |
| <ul style="list-style-type: none"> Long lifetime | <ul style="list-style-type: none"> IP6K7 and IP6K9K qualified with expected lifetime of 5 years |

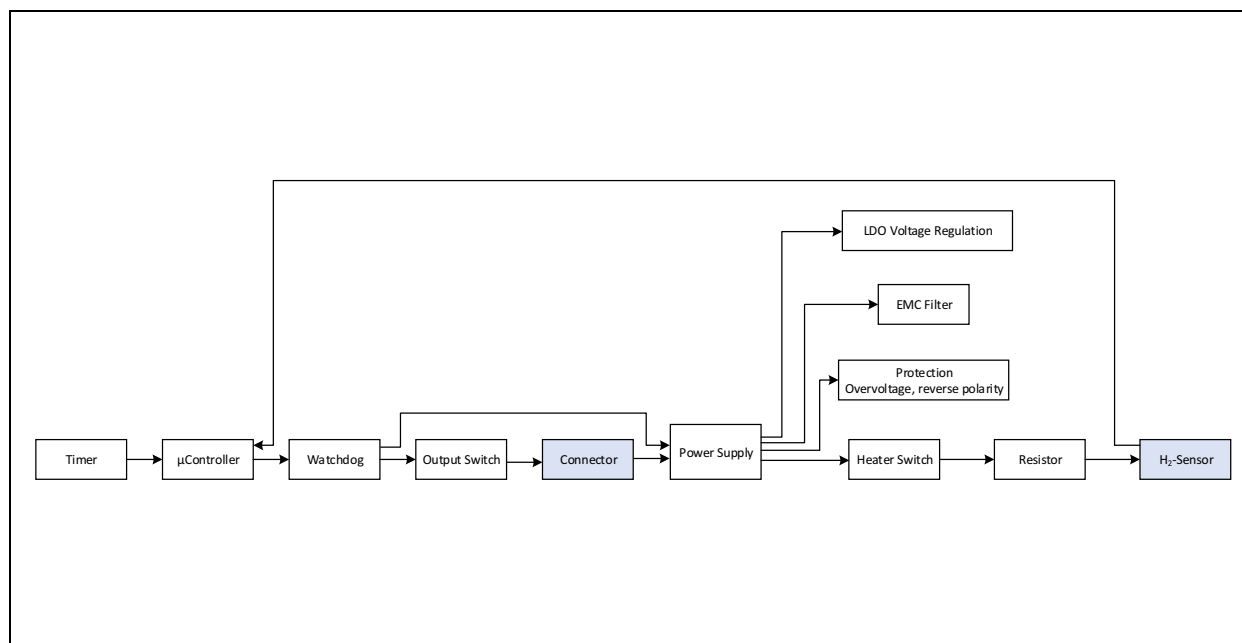
Applications

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).

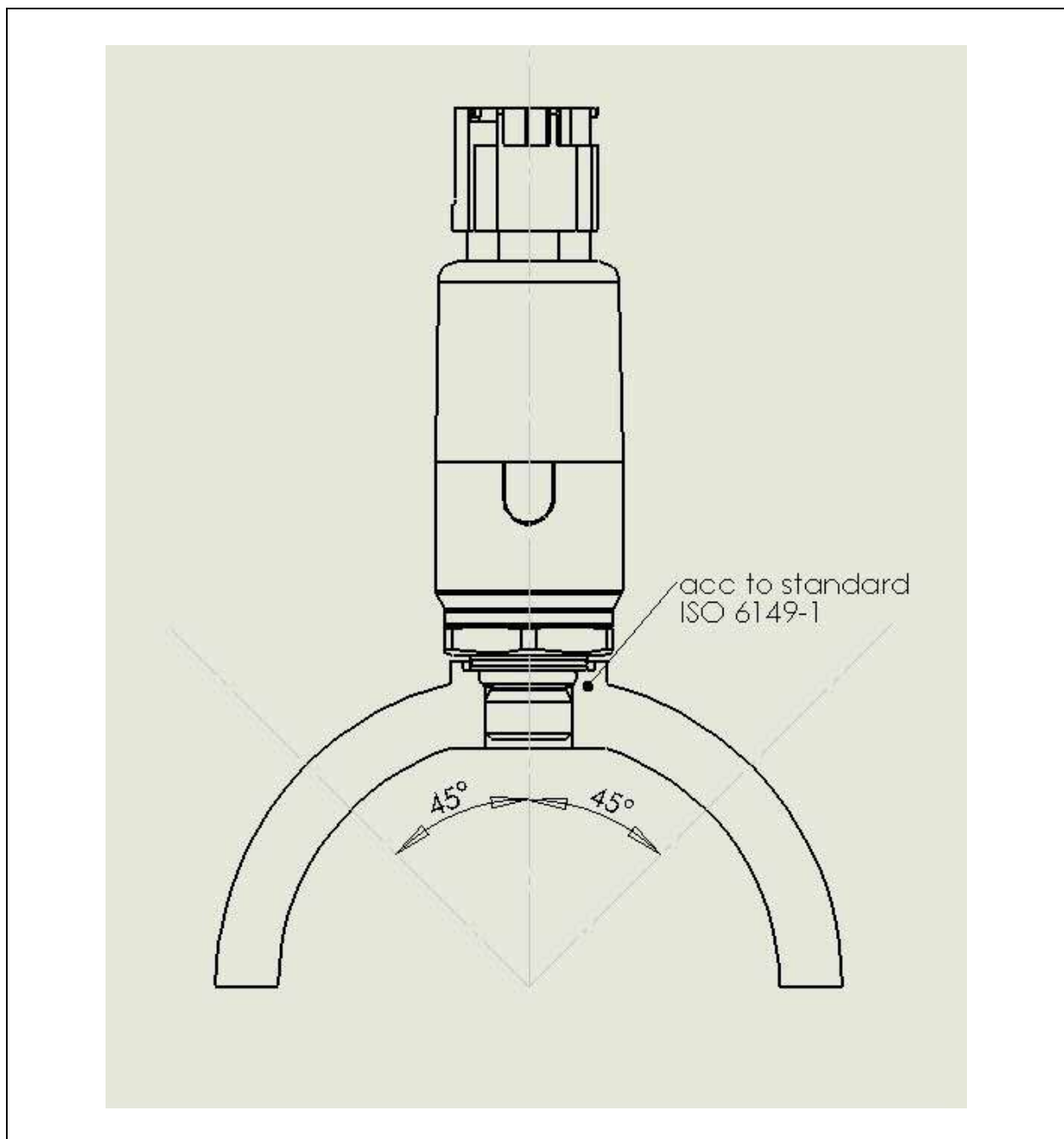
Recommended O-ring, 11.3±0.2, 2.2±0.08 or 11.3±0.2, 2.4±0.08 EPDM 70 "Peroxide crosslinked" or FPM 75 (Viton)

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 $100\text{ms} \pm 2\text{ms}$. 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.

Byte 0, H₂ 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 H₂ concentration in a resolution of 0.5.

x = Concentration in % Hydrogen

(EQ1) $\text{Byte Value} = (x \% \text{H}_2) * 200 / (100 \% \text{H}_2)$

(EQ2) $x \% = \text{Byte Value} * (100\% \text{H}_2) / 200$

Range: 0 - 200 (Hexadecimal 0 - C7)

No Value: 255 (Hexadecimal FF)

Values: 0 - 100% H₂

Resolution: $0.5 = (100 \% \text{H}_2) / 200$

The No Value is sent if there is no valid H₂ 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.

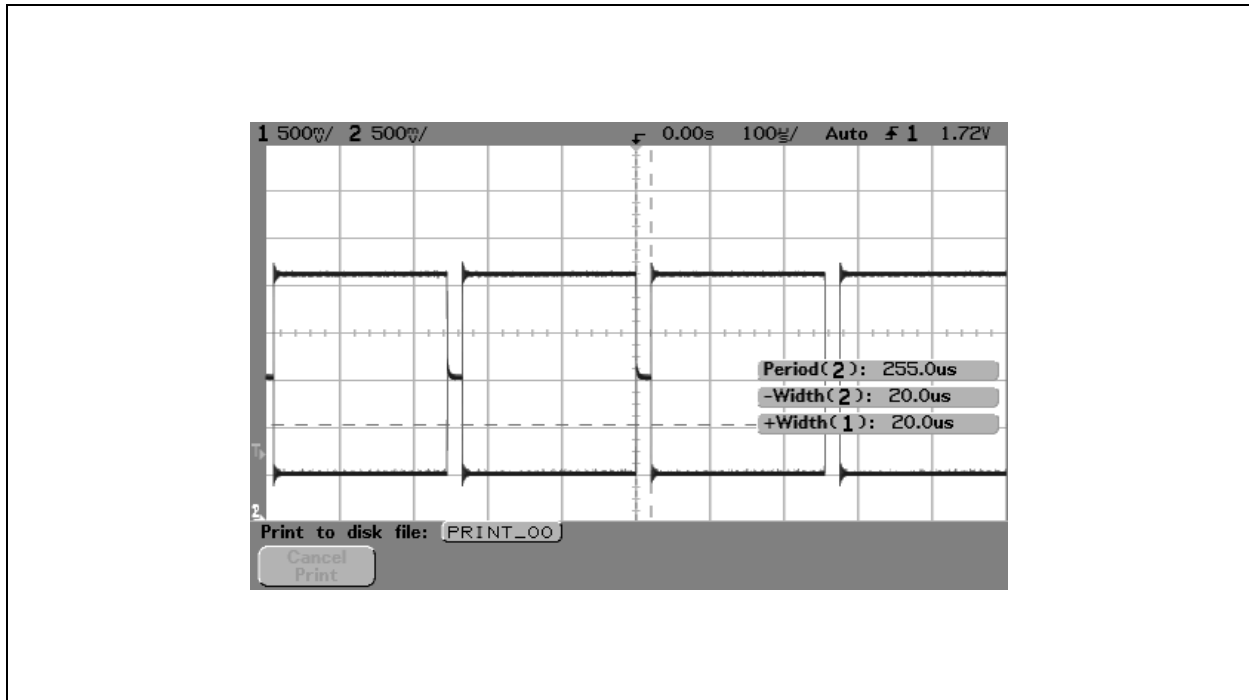
The PWM Signal

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 H₂ concentration (in ppm) and pulse width (in μs) is:

$$(EQ3) \quad H_2 = (\text{pulse width} - 20) * 5000$$

The figure below shows the relation between H₂ prediction and pulse width.

Figure 18:
Relation Between H₂ 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 ₂ S, 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 H₂ Pulse Width of 2 min and Nominal Concentration 10%, 30%, 50%, 70% and 90% vol. H₂

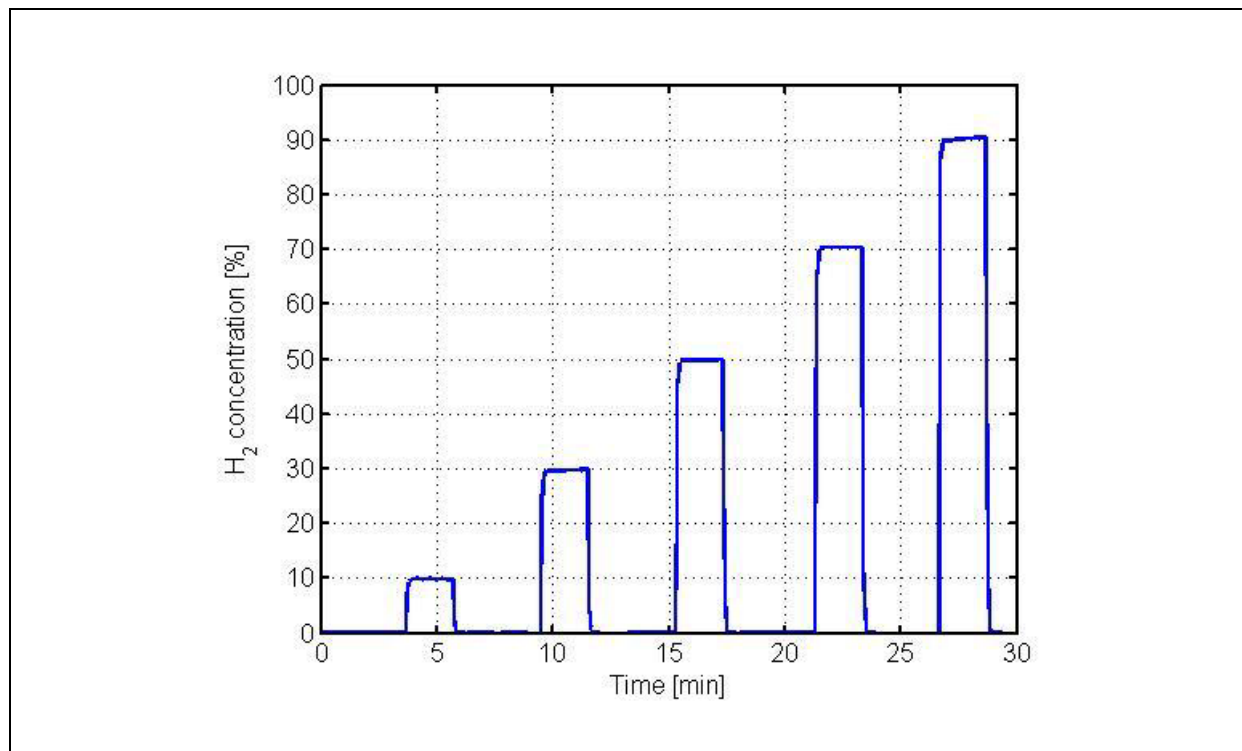
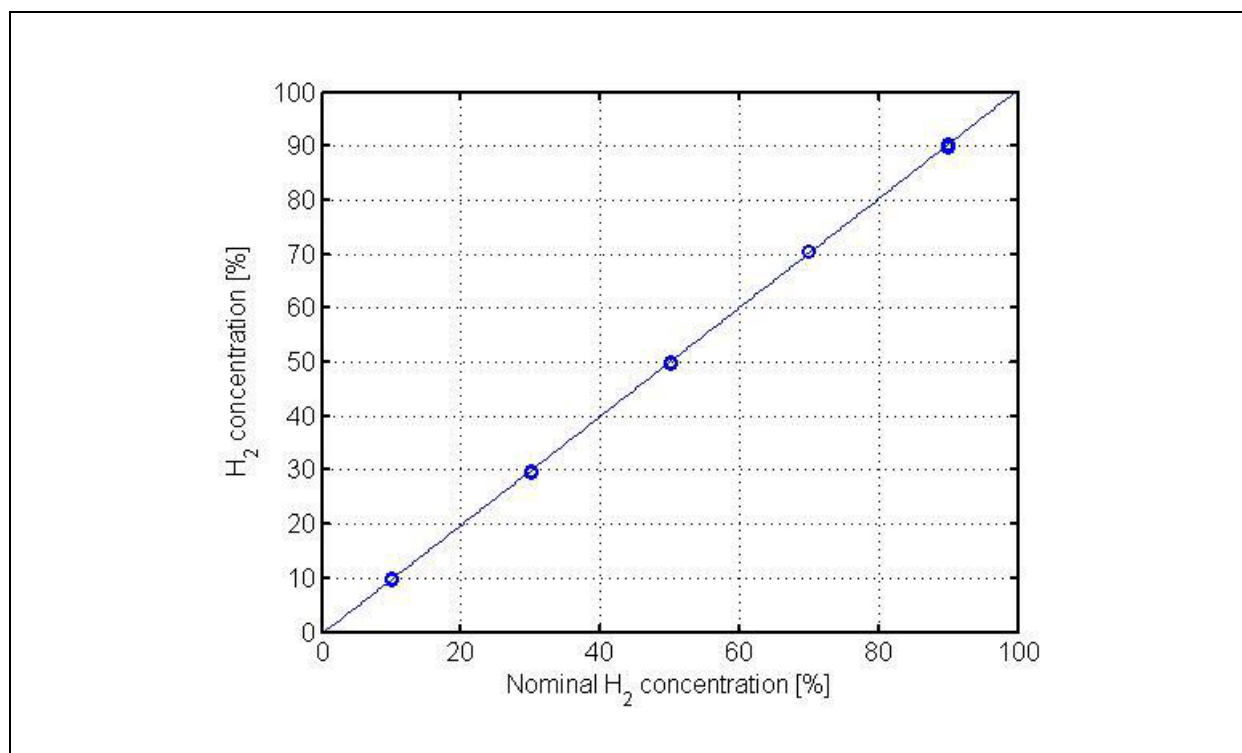
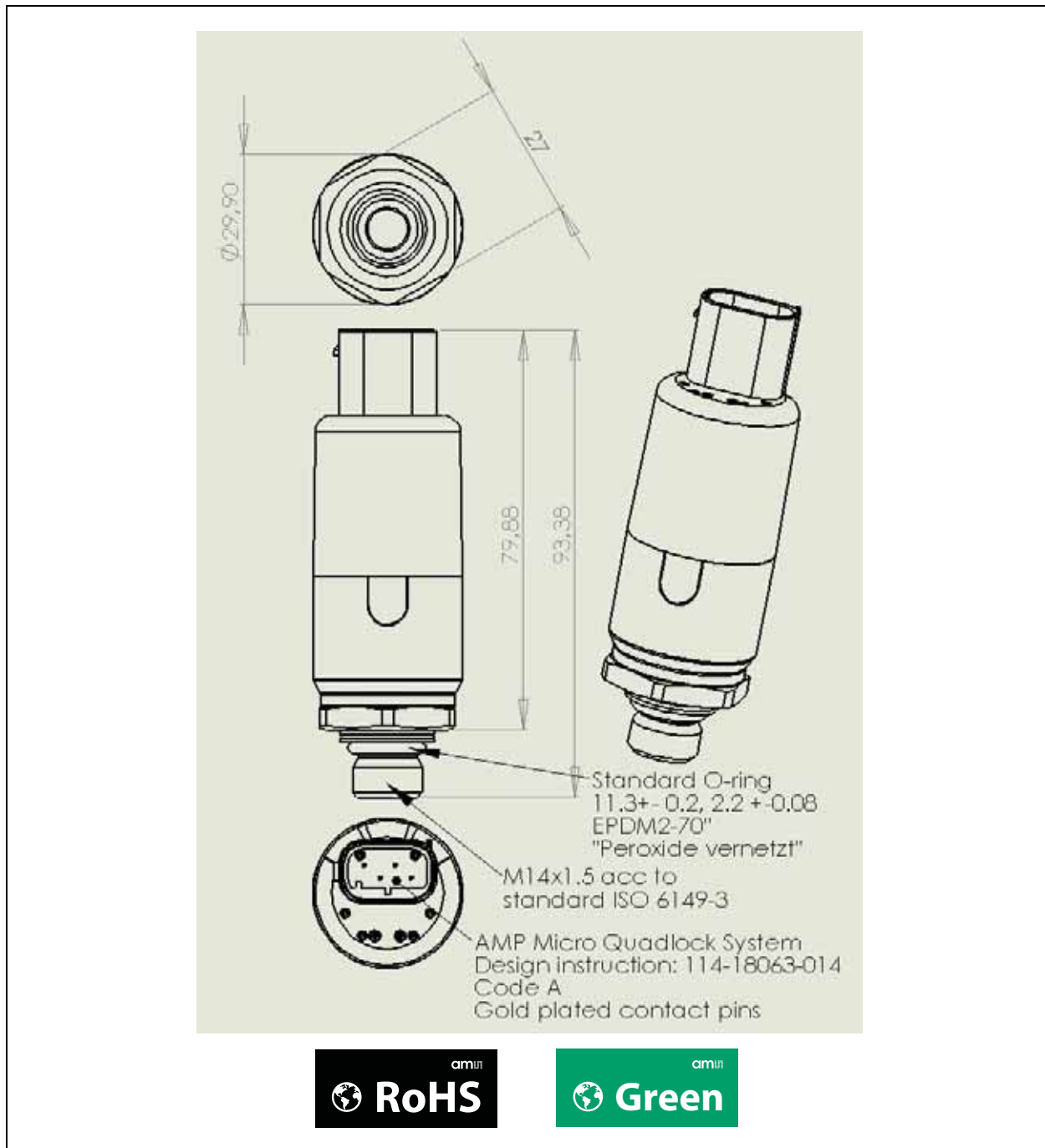


Figure 22:
Deviation of Prediction Over Nominal Concentration



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: $11.3 \pm 0.2, 2.2 \pm 0.08$ 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

| Document Status | Product Status | Definition |
|--------------------------|-----------------|--|
| Product Preview | Pre-Development | Information in this datasheet is based on product ideas in the planning phase of development. All specifications are design goals without any warranty and are subject to change without notice |
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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.

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