Data sheet H₂ sensor system NEO974M for hydrogen detection in ambient environments

Product description:
Hydrogen measuring system in ambient air with temperature, pressure and humidity compensated signal evaluation and output via Modbus RS485 (Modbus RTU) or TCP (Ethernet)

Typical applications:
- Detection of hydrogen for indoor monitoring
- Determination of hydrogen concentrations under atmospheric conditions
- Evaluation via PLC

Properties:
- Measurements to slightly above the lower explosion limit, i.e. 0-5 vol% H₂
- Minor cross-sensitivities to oxygen
- Independent of pressure and humidity
- Determination and output of the lower explosion limit (LEL)
- Output of the H₂ concentration without water vapor volume fraction
- Error control and explosion hazard warnings
- Signal output by Modbus RTU via RS485 or TCP interface
- Gas adapter available as screw-in version or for measuring gas in a tube

Figure 1: H₂ sensor system Version NEO974M
Sensor system characteristics:

Supply voltage: 9 – 30 V DC

Processor: ATSAMD21G18, 48 MHz

Energy consumption: < 1.6 W

H₂-Sensitivity: 0 – 5 Vol.-% H₂

Accuracy: ± 0.3 Vol.-% H₂¹

Detection limit: < 0.2 Vol.-% H₂ in air at 0% r.h, RT, normal pressure

Response time t₉₀: < 3 s

Decay time t₁₀: < 3 s

Start up time after cold start: < 5 s until first message
< 70 s until quantification of H₂ concentration²

Media temperature: - 40°C – 90°C

Ambient temperature: - 40°C – 85°C

Pressure range: 0.6 – 5 bar absolute

Humidity: 0 – 100 % r.h. (non-condensing)

Carrier gas: air³

Cross sensitivities: helium and slightly oxygen⁴, tbd

Harmful gas: glycol

Signal: Modbus RTU via RS485 or Modbus TCP

Measurement interval: 100 ms

Resolution: 0.025 vol-% H₂

Housing: Dimensions: 95 x 83 x 74 mm³, Alloy EN AW 6060 or 1.4404 for the base plate in contact with the media, fastened with M5 screws to the measuring chamber with 3Nm

Leak rate: 10⁻⁵ mbar l / s ⁵

¹ For V₂O₂ < 25 Vol.-%
² The system is constructed for continuous use
³ The NEO974 can also be obtained with the carrier gas oxygen
⁴ Sensor signal remains within accuracy at 6 to 20.9 vol% O₂
⁵ Measured with forming gas 90/10, 1.5 bar absolute, room temperature
IP Code: IP6K9 (dust-proof & protected against water during high-pressure cleaning when assembled!)

Weight: < 700 g

ASIL: Developed for SIL2 (IEC 61508)

ATEX: Developed for ATEX Zone 2

Life time: IP6K9 qualified housing has an expected life time of 10 years

Assembly:
During installation it must be ensured that the opening is not obstructed, e.g. by a condensing water film. We recommend mounting the sensor system as shown in Figure 2a so that the gas flows past the sensor. The retaining pins or screws may have a maximum diameter of 5.5 mm or 6.5 mm. We recommend a tightening torque of 3 Nm. The adapters NEO120, NEO130 and NEO150 are available on request. If the sensor is mounted in a different spatial direction, there will be a small offset, which requires the sensor to be readjusted.

Figure 2a: H₂ sensor system on exhaust pipe or adapter

6 Measuring components are purely inorganic and do not consume during measurement
The sensor is equipped with a ribbed plug to protect it from splashing water. Care must be taken to install the sensor so that this plug works properly.

Figure 2b: mounting ribbed plug against the direction of flow

Hole pattern:

Figure 3a: hole pattern from H₂ sensor system from below
Drilling template:

4x Bohrungen für M5-Gewinde

Figure 3b: drilling template

PIN Assignment for Modbus RTU

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9...+30V DC (min.: 1.6W)</td>
</tr>
<tr>
<td>2</td>
<td>0V DC (GND)</td>
</tr>
<tr>
<td>3</td>
<td>(service port A)*</td>
</tr>
<tr>
<td>4</td>
<td>(service port B)*</td>
</tr>
<tr>
<td>5</td>
<td>Reset 1</td>
</tr>
<tr>
<td>6</td>
<td>Reset 2 (GND)</td>
</tr>
<tr>
<td>9</td>
<td>RS485 - B</td>
</tr>
<tr>
<td>10</td>
<td>RS485 - A</td>
</tr>
</tbody>
</table>

*) not intended for customer use

10-pin housing socket:
Amphenol LTW: ACD-10PMMS-LC7001 (CONN RCPT MALE 10POS SOLDER CUP)

white (thin, light blue wire end sleeves): VCC (+9...+30V DC, minimal: 1.6W)
brown (thin, light blue wire end sleeves): GND (for supply)
### PIN Assignment for Modbus TCP

| Pin 1: 9...+30V DC (min.: 1.6W) |
| Pin 2: 0V DC (GND) |
| Pin 3: (service port A)* |
| Pin 4: (service port B)* |
| Pin 5: ADD 1 |
| Pin 6: ADD 2 |
| Pin 7: TX+ |
| Pin 8: TX- |
| Pin 9: RX+ |
| Pin 10: RX- |

*) not intended for customer use

10-pin housing socket: Amphenol LTW: ACD-10PMMS-LC7001 (CONN RCPT MALE 10POS SOLDER CUP)

- **white** (thin, light blue wire end sleeves): VCC (+9...+30V DC, minimal: 1.6W)
- **brown** (thin, light blue wire end sleeves): GND (for supply)
- **gray** (thin, light blue wire end sleeves): service port A
- **blue** (thin, light blue wire end sleeves): service port B
- **yellow** (thin, light blue wire end sleeves): ADD 1
- **green** (thin, light blue wire end sleeves): ADD 2
- **red** (thin, light blue wire end sleeves): TX+
- **black** (thin, light blue wire end sleeves): TX-
- **orange** (thin, light blue wire end sleeves): RX+
- **purple** (thin, light blue wire end sleeves): RX-
- **white** (thick, black wire sleeves): shielding (optional GND)
Information on hydrogen ignition by the NEO974M of neo hydrogen sensors GmbH according to J2578 SAE international

The sensor is only approved in Ex-Zone 2. In the H₂-sensor NEO974M a heating element is used, which is heated with 12V from a fixed voltage component. During the explosion and detonation tests carried out, the supply voltage of the heater was incrementally increased, which is not possible with the fixed voltage component installed in the NEO974M (a Zener diode prevents operating voltages > 15V). At 32V, the heating element burnt through and still did not cause the highly reactive, stoichiometric gas mixture to explode. In the current sensor version, the current flowing through the heating element is monitored by the microcontroller and an error is displayed via the status byte if the heating current is outside the normal range. The heating temperature is 320°C; 265°C below the hydrogen ignition temperature of 585°C. The heating element is located in a 120mm³ small measuring chamber. The sample gas must diffuse through a membrane and pass two 100µm steel meshes.

The housing of the sensor is made of anodised aluminium. This housing is screwed with steel screws mainly to metallic housings, which allows possible static charges to drain off. The electronic ground has been connected to the housing ground.

Catalytic materials are not built into the H₂ sensor NEO974M, so that self-ignition cannot occur.

Extensive in-house explosion and detonation sensor tests have been carried out with the H₂-sensors NEO974M. During normal operation, neither an explosion nor a detonation, even with a stoichiometric H₂/O₂ mixture, could be induced.
Resolution and response:

Figure 4a: Test of a sensor system up to 5 vol% H₂ in 21 vol% O₂. Measured with a total flow of 1,000 sccm.

Figure 4b: $t_{90}$ time determination for a sensor by switching from 0 vol% H₂ to 3.5 vol% H₂. Measured with a total flow of 1,000 sccm.
Figure 4c: Comparison measurement of the set hydrogen concentration and the measured hydrogen concentration, with an error bar of three standard deviations of the measurement signal.

Output via RS485 (Modbus RTU) - NEO974M
RS485 (Modbus RTU) Factory settings:

Address: 1
Baudrate: 9600
Parity: none
Stop Bits: 1

Modbus-Register:

Input-Register:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen concentration</td>
<td>hydrogen concentration = ( x ) / 100 – 20 Vol.-% (example: 2750 = 7,50 Vol.-%)</td>
<td>0x7531 / 30001</td>
</tr>
<tr>
<td>Lower explosion limit</td>
<td>LEL = ( x ) / 100 – 20 Vol.-% (example: 2405 = 4,05 Vol.-%)</td>
<td>0x7532 / 30002</td>
</tr>
<tr>
<td>Empty register</td>
<td>value not assigned</td>
<td>0x7533 / 30003</td>
</tr>
<tr>
<td>Pressure</td>
<td>pressure = ( x ) – 20 mbar (example: 1033 = 1013 mbar)</td>
<td>0x7534 / 30004</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
<td>Address</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Absolute humidity</td>
<td>[\text{absolute humidity} = \text{x} / 100 - 20 \text{ g/m}^3] (example: 5200 = 32,00 g/m³)</td>
<td>0x7535 / 30005</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>[\text{operating voltage} = (\text{x} - 20) / 1000 \text{ V}] (example: 12020 = 12,00 V)</td>
<td>0x7536 / 30006</td>
</tr>
<tr>
<td>Message counter</td>
<td>\text{continuous message counter}</td>
<td>0x7537 / 30007</td>
</tr>
<tr>
<td>Temperature</td>
<td>[\text{temperature} = \text{x} / 100 - 40 \degree\text{C}] (example: 4250 = 22,5°C)</td>
<td>0x7538 / 30008</td>
</tr>
<tr>
<td>Water concentration H₂O</td>
<td>(\text{H}_2\text{O volume concentration} = \text{x} / 100 - 20 \text{ Vol.-}%) (example: 2330 = 3,3 Vol.-%)</td>
<td>0x7539 / 30009</td>
</tr>
<tr>
<td>Hydrogen conc. raw value</td>
<td>(\text{hydrogen concentration} = \text{x} / 100 - 20 \text{ Vol.-}%) (example: 2750 = 7,50 Vol.-%)</td>
<td>0x753A / 30010</td>
</tr>
<tr>
<td>Raw value</td>
<td>\text{raw value} = 100 in the absence of water and hydrogen and otherwise normal air</td>
<td>0x753B / 30011</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>[\text{relative humidity} = \text{x} / 100 - 20 %] (example: 5200 = 32,00 %)</td>
<td>0x753C / 30012</td>
</tr>
</tbody>
</table>

**Output via RS485 (Modbus RTU) – NEO974M**

**Holding-Register:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baudrate</td>
<td>define the baudrate of the Modbus RTU interface:</td>
<td>0x9C41</td>
</tr>
<tr>
<td></td>
<td>(4800) (9600) (19200) (\text{default: 9600}) (\text{restart the sensor to initiate changes})</td>
<td></td>
</tr>
<tr>
<td>Slave-ID</td>
<td>\text{Slave-ID of Sensors 1-200}</td>
<td>0x9C42</td>
</tr>
<tr>
<td></td>
<td>(\text{default: 1}) (\text{restart the sensor to initiate changes})</td>
<td></td>
</tr>
</tbody>
</table>
Modus | 0 = Parity: none, Stop Bit: 1  
1 = Parity: none, Stop Bit: 2  
2 = Parity: even, Stop Bit: 1  
3 = Parity: even, Stop Bit: 2  
4 = Parity: odd, Stop Bit: 1  
5 = Parity: odd, Stop Bit: 2  
default: Parity: none, Stop Bit: 1  
restart the sensor to initiate changes | 0x9C43

Information about the Registers:

The registers are defined as unsigned 16-bit integer, i.e. value range from 0 to 65535. When reading out with a PLC, care should be taken to set the data type to “Real” so that the unsigned integer can also be represented as a decimal.

Reset Function:

The sensor can be recalibrated if there are conditions within the gas mixture that may have been damaging. For this purpose, only the two reset lines must be short-circuited together. It must be ensured that the sensor is flushed with compressed air or ambient air for at least 5 minutes at room temperature. Only then can the readjustment be carried out precisely.
Output via Modbus TCP – NEO974M

Reading the sensor:

For reading out the sensor via Modbus TCP, a computer can also be used which is located in the same subnetwork. The program modpoll can be used for this purpose, which is available here:

https://www.modbusdriver.com/modpoll.html

Then the sensor can be read out with the following command (<IP> please replace):

    modpoll -m tcp -r 0x7532 -c 12 -t 3 -1 <IP>

The registers are defined as unsigned 16-bit integer. To read out the sensor, an IP can be set via a DHCP server, whereby the MAC address is communicated. Alternatively, a desired fixed IP can be set when the sensor is manufactured. When reading the sensor output with a PLC, care should be taken that the data type is set to “Real” so that the unsigned integer can also be represented as a decimal. The following figure shows the conversion of the sensor data for the PLC and the exemplary PLC output!

```
1  "d8E2"."Wasserstoffkonzentration" := UINT_TO_REAL("d8E2_Buffer"."Wasserstoffkonzentration") / 100.0 - 20.0;
2  "d8E2"."UEG" := UINT_TO_REAL("d8E2_Buffer"."UEG") / 100.0 - 20.0;
3  "d8E2"."NOx-Sensor" := "d8E2_Buffer"."NOx-Sensor" / 100 - 20;
4  "d8E2"."Druck" := "d8E2_Buffer"."Druck" - 20;
5  "d8E2"."AbsoluteFeuchtigkeit" := UINT_TO_REAL("d8E2_Buffer"."RelativeFeuchtigkeit") / 100.0 - 20.0;
6  "d8E2"."Betriebsspannung" := (UINT_TO_REAL("d8E2_Buffer"."Betriebsspannung") - 20.0) / 1000.0;
7  "d8E2"."Message-Counter" := "d8E2_Buffer"."Message-Counter";
8  "d8E2"."Temperatur" := UINT_TO_REAL("d8E2_Buffer"."Temperatur") / 100.0 - 40.0;
9  "d8E2"."H2Wert" := UINT_TO_REAL("d8E2_Buffer"."H2Wert") / 100.0 - 20.0;
10 "d8E2"."Wasserstoffkonzentration" := UINT_TO_REAL("d8E2_Buffer"."Wasserstoffkonzentration") / 100.0 - 20.0;
11 "d8E2"."RelativeFeuchtigkeit" := UINT_TO_REAL("d8E2_Buffer"."RelativeFeuchtigkeit") / 100.0 - 20.0;
```

Figure 5: Conversion of sensor data for the PLC

Figure 6: PLC output
Output via Modbus TCP – NEO974M

Modbus-Input-Register:

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Additional functionalities that can be integrated:

The sensor can be equipped with one of two selectable functions. Either an addressing or a reset option. The addressing ensures that up to 4 fixed IP’s can be assigned, which can be set externally. The reset option allows the system to be readjusted, which is recommended at regular intervals in particularly aggressive conditions. If one of the two functionalities is required, please contact us with your request.