TpH

Manual

Table of contents

1 General information **4**
1.1 Introduction 4
1.2 Health and safety instructions 5
1.3 Warning notices 6
1.4 User and operating requirements 6
1.5 Intended use 6
1.6 Disposal instructions 7
1.7 Certificates and approvals 7

2 Introduction **8**
2.1 Introduction 8
2.2 Product identification 8
2.3 Scope of delivery 8
2.4 Measurement principle and structure 9

3 Commissioning **10**
3.1 Electrical installation 10
3.1.1 Fixed cable with M12 industrial plug 10
3.2 Interfaces 10
3.2.1 Serial interface 10

4 Application **11**
4.1 Normal operation 11
4.2 Bypass installation 11
4.3 Support pipe installation 12
4.4 Storage 12

5 Calibration **14**
5.1 pH calibration 14
5.2 Measurement properties 15

6 Malfunction and maintenance **17**
6.1 Cleaning and care 17
6.2 Maintenance and testing 17
6.3 Return shipment 18

7 Technical data **20**
7.1 Technical specifications 20
7.2 Outer dimensions 22

8 Accessories **23**
8.1 TriBox3 23
8.2 TriBox mini 23
8.3 Flow cell 23
8.4 pH buffer set 24

9 Warranty **25**

10 Technical support **26**

11 Contact us **27**

12 Index **28**

13 Appendix **30**

13.1 CE declaration of conformity 30

13.2 Modbus RTU 31

1 General information

1.1 Introduction

Welcome to TriOS.

We are pleased that you have chosen our pH sensor TpH.

The TpH is based on the electrochemical measuring method with a measuring electrode and a reference electrode. Calibrations made are stored internally by this intelligent sensor. This enables a “plug-and-play” system without recalibration when changing the location or transmitter.

In this manual you will find all the information you need for commissioning the TpH. Technical specifications as well as detection limits and dimensions can be found in chapter 7.

Please note that the user is responsible for complying with regional and national regulations for the installation of electronic devices. Any damage caused by incorrect use or unprofessional installation is not covered by the warranty.

All sensors and accessories supplied by TriOS Mess- und Datentechnik GmbH must be installed and operated in accordance with TriOS Mess- und Datentechnik GmbH specifications. All parts have been designed and tested according to international standards for electronic instruments. The device complies with international standards for electromagnetic compatibility. Please use only original TriOS accessories and cables to ensure smooth and professional use of the devices.

Read this manual carefully before using the device and keep it for future reference. Before using the sensor, make sure that you have read and understood the safety precautions described below. Always ensure that the sensor is operated correctly. The safety precautions described on the following pages are intended to ensure problem-free and correct operation of the device and the associated accessories and to prevent you, other persons or devices from being harmed.

NOTICE

If translations differ from the original German text, the German version is binding.

Firmware updates

This manual refers to firmware version 1.0.1. and higher. Updates include troubleshooting and new functions and options. Devices with older firmware versions may not have all the functions described here.

Copyright notice

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1.2 Health and safety instructions

This manual contains important information on health and safety regulations. This information is marked in accordance with the international specifications of ANSI Z535.6 (“Product safety information in product manuals, instructions and other collateral materials”) and must be followed. The following categories are distinguished:

⚠ DANGER

Danger / Will cause serious injury or death

⚠ WARNING

Warnings / May cause serious injury or death

⚠ CAUTION

Caution / May cause moderate injury

NOTICE

May lead to material damage

Tip / Useful information

Electromagnetic waves

Devices that emit strong electromagnetic waves can influence the measurement data or cause the sensor to malfunction. Avoid operating the following devices in the same room as the TriOS sensor: cell phones, cordless phones, transceivers or other electrical devices that generate electromagnetic waves.

Reagents

Follow the manufacturer's safety and operating instructions when using reagents. Observe the applicable Hazardous Substances Ordinance for reagents (GefStoffV)!

Biological safety

Liquid waste may be biologically hazardous. You should therefore always wear gloves when handling such materials. Observe the currently valid Biological Substances Ordinance (BioStoffV)!

Waste

When handling liquid waste, the regulations for water pollution, drainage and waste disposal must be observed.

1.3 Warning notices

General notices:

- This sensor has been developed for use in industry and science. It should only be used to measure aqueous solutions such as process waste water, river water or seawater.
- The material resistance should be tested for each application.
- Do not cut, damage or modify the cable. Ensure that there are no heavy objects on the cable and that the cable does not kink. Ensure that the cable does not run close to hot surfaces.
- If the sensor cable is damaged, it must be replaced with an original part by TriOS Mess- und Datentechnik GmbH customer support.
- Plug the sensor if it becomes excessively hot (i.e. more than lukewarm). Switch off the sensor immediately and disconnect the cable from the power supply. Please contact your dealer or TriOS technical support.
- Never attempt to disassemble or modify any part of the sensor unless specifically described in the manual. Inspections, modifications and repairs may only be carried out by the device dealer or by TriOS authorized and qualified specialists.
- Devices from TriOS Mess- und Datentechnik GmbH comply with the highest safety standards. Repairs to the devices (which include the replacement of the connecting cable) must be carried out by TriOS Mess- und Datentechnik GmbH or an authorized TriOS workshop. Incorrect, improper repairs can lead to accidents and injuries.

NOTICE

TriOS does not assume any warranty for the plausibility of the measured values. The user is always responsible for monitoring and interpreting the measured values.

1.4 User and operating requirements

The TpH sensor was developed for use in industry and science. The target group for operating the TpH is technically experienced specialist personnel in companies, sewage treatment plants, waterworks and institutes.

The application often requires the handling of hazardous substances. We assume that the operating personnel are familiar with the handling of hazardous substances due to their professional training and experience. In particular, the operating personnel must be able to correctly understand and implement the safety markings and safety instructions on the packaging and in the package inserts of the test kits.

1.5 Intended use

The intended use of the TpH is exclusively to carry out measurements of pH values in aqueous solutions as described in this manual. In this respect, the TpH is an immersion sensor that is used underwater or in conjunction with flow cells. Please observe the technical data of the accessories. Any other use is considered improper.

The compact and robust sensor is particularly suitable for the following areas of application:

- Industrial and municipal sewage treatment plants
- Waste water management
- Monitoring of surface waters
- Aquaculture and fish farming
- Drinking water monitoring

Use in other media may damage the sensor. To use the TpH in media other than those specified here, please contact TriOS Mess- und Datentechnik GmbH support (support@trios.de).

According to current scientific knowledge, the device is safe to use if it is handled in accordance with the instructions in this manual.

NOTICE

Damage caused by improper use is excluded from the warranty.

1.6 Disposal instructions

At the end of its service life or useful life, the device and its accessories can be returned to the manufacturer (see address below) for disposal in an environmentally friendly manner. Proof of prior professional decontamination must be provided in the form of a certificate. Please contact us before returning the device for further details.

Address of the manufacturer:

TriOS Mess- und Datentechnik GmbH
Bürgermeister-Brötje-Str. 25
26180 Rastede
Rastede, Germany
Phone: +49 (0) 4402 69670 - 0
Fax: +49 (0) 4402 69670 - 20

1.7 Certificates and approvals

The product meets all requirements of the harmonized European standards. It therefore fulfills the legal requirements of the EU directives. TriOS Mess- und Datentechnik GmbH confirms the successful testing of the product by affixing the CE mark (see appendix).

2 Introduction

2.1 Introduction

The TpH is based on the electrochemical measuring method with a measuring electrode and a reference electrode. Calibrations are stored internally by this intelligent sensor. This enables a “plug-and-play” system without recalibration when changing the location or transmitter.

Reliability through integrated encapsulated preamplifier

The encapsulated design protects the sensor's integrated preamplifier from moisture and humidity to ensure that the sensor works reliably. The preamplifier generates a strong signal so that the sensor can be located up to 300 m away from the controller.

2.2 Product identification

All TriOS Mess- und Datentechnik GmbH products are provided with a product label that clearly shows the product designation.

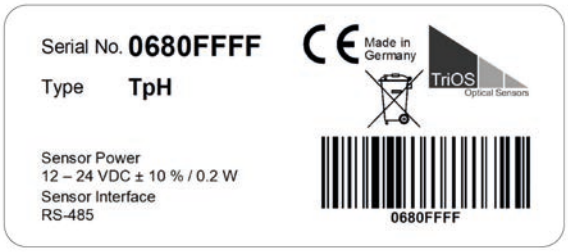
There is also a type plate on the device with the following information, which you can use to clearly identify the product:

TpH

Serial number

Product type

Power supply



The nameplate also contains the product barcode, the TriOS Optical Sensors logo and the CE quality mark.

Please note that the specifications given here are for illustrative purposes only and may vary depending on the product version.

2.3 Scope of delivery

The delivery includes the following components:

- Sensor
- Manual/Short Instruction
- Accessories (if applicable)

Keep the original packaging of the device for possible return shipment for maintenance or repair purposes.

2.4 Measurement principle and structure

* High-density polyethylene.

3 Commissioning

This chapter covers the commissioning of the sensor. Pay particular attention to this section and follow the safety precautions to protect the sensor from damage and yourself from injury.

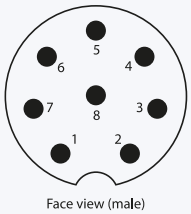
Before putting the sensor into operation, make sure that it is securely fastened and that all connections are made correctly.

3.1 Electrical installation

The sensor is supplied with a fixed cable with an M12 industrial plug.

> ***NOTICE***
>
> **The sensor can be operated with 12 – 24 VDC.**

3.1.1 Fixed cable with M12 industrial plug



1. RS-485 A (commands)
2. RS-485 B (data)
3. do not connect
4. do not connect
5. do not connect
6. do not connect
7. ground (power + serial interface)
8. power (12 - 24 VDC)

The sensor is ready for commissioning as soon as the mounting of accessories has been completed, it has been connected to your control device and the configuration has been completed.

> ***NOTICE***
>
> **Ensure that the polarity of the operating voltage is correct, otherwise the sensor may be damaged.**

3.2 Interfaces

3.2.1 Serial interface

The serial interface of the sensor is RS-485 (9600/8-N-1).

With RS-485, voltages from -5 V to +5 V with respect to ground are possible. RS-485 uses a differential signal, whereby the sign-negated potential of the A line is applied to the B line. The decisive factor is the difference A-B, which makes the transmission as robust as possible against interference signals.

The protocol used is Modbus RTU. A detailed description of the Modbus RTU protocol for the sensor can be found in the appendix.

4 Application

The TpH sensor can be operated with all TriOS controllers. You will find notices for correct installation in the respective controller manual. The sensor is automatically recognized on all TriOS controllers during the sensor scan after the controller is switched on.

4.1 Normal operation

The sensor is ready for commissioning as soon as the mounting of accessories has been completed, it is connected to your control unit and the configuration has been completed.

Remove the black protective cap by holding the sensor vertically downwards and unscrewing the cap. The sensor is supplied with the protective cap filled with a solution of pH4 buffer and potassium chloride. Therefore, the sensor does not need to be activated to achieve optimal readings. Please note the minimum immersion depth up to the ring.

NOTICE

If the sensor is dry, it must first be conditioned in pH4 buffer for 24 hours.

The sensor is now immersed in the measuring medium. The black sensor head should be completely surrounded by the medium. Otherwise, measurement fluctuations may occur.

To take a measurement, all air bubbles under the membrane must first be removed by gently shaking the sensor.

As soon as the sensor is connected to the power supply, it starts measuring. This can be recognized optically by the green glow in the upper sensor area. To obtain stable and safe measured values, please wait for the temperature to stabilize after inserting the sensor into the measuring environment.

The TpH sensor should be calibrated at regular intervals. The intervals depend on the respective application. If the TpH measures in the strongly alkaline range, the calibration intervals should be as short as possible. Information on calibration can be found in chapter 5.

The TpH are considered consumables and therefore have a limited service life, depending on the user's application. Under normal conditions, a typical service life would be about one year. The service life of the TpH can be extended by regular cleaning.

4.2 Bypass installation

To integrate the sensor into a bypass installation, there is a suitable TriOS flow cell. This is designed according to a modular system and allows the system to be adapted or expanded as required.

Installation in the FlowCell

Follow the steps in the following instructions to install the TpH in the TriOS FlowCell.

1. Remove the pressure ring from the FlowCell. It can easily be opened by hand.
2. In the next step, slide the o-ring (attached to the FlowCell in a bag) onto the TpH. Then insert the TpH into the FlowCell.
3. When the TpH is positioned, run the pressure ring along the cable above the sensor to fix it on the Flow-Cell.
4. When the TpH has been positioned correctly, tighten the pressure ring hand-tight.

4.3 Support pipe installation

TriOS offers two adapter pieces for the TpH sensor for installation in existing pipe systems:

- NPT1 adapter ZM46 (incl. lock nut ZM13)
- G1 adapter ZM41 (incl. lock nut ZM13)

Assembly diagram

1. Feed the sensor cable through the adapter from the side onto which the screw cap will later be screwed (short thread).
2. Pull the complete cable through and push the sensor into the adapter as far as it will go (up to the guide obstacle).
3. Secure the sensor with the fastening cap.
4. The sensor and adapter can now be installed in the holder tube.

4.4 Storage

Never store the sensor in a dry place. Always keep the protective cap and reuse it for storage in a solution of pH4 buffer and potassium chloride or a 3 molar KCl solution.

NOTICE

Never store the TpH sensor dry.

If a sensor or the electrode of the sensor does fall dry, the swelling layer on the electrode must be re-formed. To do this, the sensor must be immersed in a 3 molar KCl solution for several hours (> 12 h).

NOTICE

Never store the TpH sensor in distilled water!

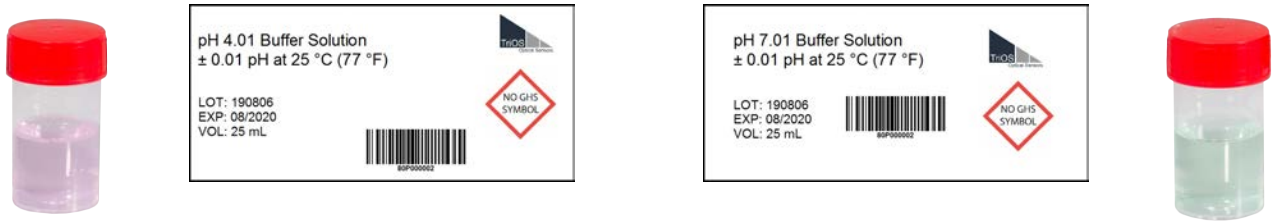
5 Calibration

TpH sensors that have not been used for a long time or new sensors should be calibrated before measurement. The calibration should also be repeated at regular intervals. The intervals between calibrations depend on the type of application (strongly fluctuating pH values, abrasive measuring medium or deposits that build up on the measuring electrodes). Tests with standard solutions are recommended to determine the intervals. TriOS offers suitably filled buffer solutions pH4 and pH7 (see chapter 8). The frequency of calibration depends on experience. For newly installed systems, hourly testing and calibration may be necessary. If you notice stable values, the calibration interval can be increased.

Calibration is possible both on the controllers (see chapter 8) and via Modbus. Calibrations carried out are stored internally by this intelligent sensor. This means that the current calibration is always available.

5.1 pH calibration

Calibration is used to calibrate the zero value (pH7) and the scaling factor (pH4 or pH10, depending on the application). For calibration, select pH buffer solutions with an accuracy of ± 0.01 pH and observe the temperature. Fresh or newly prepared solutions must be used for each calibration! TriOS offers a set of pH buffer solutions ideally matched to the TpH with sensor holder for 6 calibrations.



Buffer solution pH4
6 x 25 mL

Buffer solution pH7
6 x 25 mL

Procedure:

- Since the pH value is temperature-dependent, it is recommended to check the temperature with a reference thermometer before the first pH calibration.
- If the temperature measured with the sensor deviates more than 1 °C from the temperature measured with a reference thermometer, a calibration of the temperature offset is necessary (see 6.2).
- Rinse the sensor with distilled water.

NOTICE

The electrode must not be wiped off.

pH7 calibration

- Immerse the TpH in pH7 buffer solution; the sensor head (black) should be as completely immersed as possible (see illustrations below). Otherwise, measurement fluctuations may occur.
- Slowly immerse the sensor in the beaker and move it slightly back and forth so that the membrane is wetted with the buffer solution.
- Allow the sensor to warm up for as long as possible until the measured values have stabilized (at least 5 minutes) and then calibrate to pH7. Pay attention to the temperature!

NOTICE

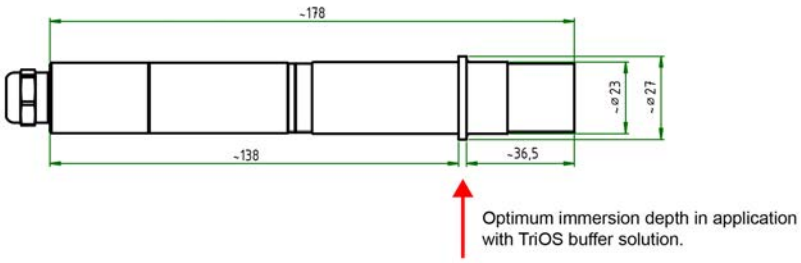
Do not stir the sensor in the buffer solution!

NOTICE

The pH value is temperature-dependent!

pH4 or pH10 calibration

- Rinse the sensor again with distilled water.
- Immerse the TpH in pH4 buffer solution (or pH10 buffer solution, if necessary). The sensor head (black) should be completely immersed. Otherwise, measurement fluctuations may occur.
- Allow the sensor to warm up for as long as possible until the measured values have stabilized (at least 5 minutes) and then calibrate to pH4 (or pH10). Pay attention to the temperature!
- Rinse the sensor again with distilled water.
- You can now start your measurements.
- Dispose the buffer solutions after use.



5.2 Measurement properties

Influences on the measurement

The pH measurement depends on the following parameters:

- The temperature of the measuring medium also has an influence on the ageing of the electrode.
- Observe the immersion depth: an immersion depth that is too shallow can lead to fluctuating measured values.
- Air bubbles on the sensor can cause measurement errors.

- Alkali error: at pH values above pH12, alkali ions (Li+, Na+) can cause lower pH values to be displayed, as the alkali ions are detected in addition to the H+ ions.
- Flow can influence the measured value.

Temperature compensation

Temperature compensation is performed automatically by the integrated temperature sensor (Pt1000).

6 Malfunction and maintenance

6.1 Cleaning and care

The sensor requires only minimal maintenance. In applications that cause heavy soiling on the sensor, the sensor should be serviced more often.

NOTICE

Do not disassemble the sensor for cleaning and maintenance purposes.

- The sensor should always be kept clean. If there is a biofilm on the sensor, this can lead to measurement errors.
- A dirty sensor should be cleaned with buffer solution.
- If possible, mechanical impact on the glass membrane should be avoided.
- For stubborn soiling, a very soft brush or a soft sponge can be used carefully.
- For more solid deposits, the sensor can be immersed in a diluted HCl solution or a base. In the case of organic deposits, pepsin can also be used.

NOTICE

Always rinse the sensor and the sensor system carefully with distilled water after cleaning.

If the sensor is taken out of service, it should be stored cleaned. The protective cap must be filled with a 3 molar KCl solution.

NOTICE

Damage caused by improper cleaning is not covered by the warranty!

6.2 Maintenance and testing

NOTICE

Avoid touching the sensor as this could damage it. If this is the case, the functionality of the sensor can no longer be guaranteed.

The average service life of a TpH sensor is about 1 year. If difficulties occur during calibration, the sensor will probably need to be replaced.

Temperature calibration

As the pH value is temperature-dependent, it is recommended to check the temperature of the buffer solution with an accurate reference thermometer before pH calibration. If the temperature measured by the sensor deviates more than 1°C from the one measured by the reference thermometer, a calibration of the temperature offset is necessary.

1. Set the controller to “Maintenance mode” / “Service mode” under Options.
2. Select the TpH sensor under “Sensors” and the corresponding connection (COM port).
3. Press the “Calibrate” button and select the temperature.
4. The following calibration wizard will guide you through the next steps:

- Enter the measured temperature (reference thermometer) as the target value and press the “Next” button.
- Then initiate a measurement by pressing the “Measurement” button.
- Wait until the “Next” button is active and press it.

5. At the end, you will be asked whether you want to save the calibration. The new calibration is saved in the sensor by pressing the “Next” button; the previous calibration is restored by pressing “Cancel”.

Replacing the sensor

NOTICE

If the sensor is replaced, the controller settings must be reconfigured for the new sensor.

1. If you need to replace your sensor with a new one, you should set your TriBox3 to maintenance mode: “Options” ► “Maintenance mode”.

2. Remove the sensor from the FlowCell / from the pipe. At this point, you should also check whether the O-rings are still in good condition. Replace the O-rings if necessary.

3. Configuration of the new sensor:

   Connect the new sensor to the TriBox3. Press “Sensor Scan”. After a short time, the TriBox3 should have recognized the sensor.

   Display:
   “Display” ► Select the window ► Select the window(s) to be changed for the TpH ►“Current value” ► Select the measured value to be displayed.

   Automatic measurements:
   Select the TpH sensor in the “Sensor” menu (blue field).

   Select “Automatic measurement” ► “Automatic measurement” or “Burst mode” (as required).

   To set the automatic measurements (if “Burst mode” has not been selected), go to “Options” ► “Automatic measurements” ► “Raster” ► Select the measurement interval from the drop-down menu as required.

   Set Modbus address:
   “Sensor” menu ► press TpH sensor button ► “Modbus server settings” ►“Slave address” ► set the address required for your system.

   Analog outputs:
   “Options” ► “Analog outputs” ► select the analog output on which the previous TpH sensor was set ► “measured value used” ►select the new sensor from the drop down menu ►set scaling information.

   Post-processing:
   If you want to retain the previous post-processing settings, you can do this via “Sensor” ►“pH”. Here you can configure the sensor settings as required.

6.3 Return shipment

Please note the procedure for your return shipment.

If you are returning a sensor or device, please use the URL **trios.de/rma** to go to our **online form**, which you can use to register your return shipment to TriOS **technical support**.

To ensure a smooth return shipment process, please fill out the online form completely. Please note the mandatory fields, otherwise the form cannot be sent. The system **automatically assigns an RMA number**.

After submitting your entries, you will immediately receive an e-mail with the data you have entered, a link to **free DHL shipping** and a label with the **RMA number of your case**.

Please make sure you stick this label **clearly visible on the** outside of **your return package** so that the package can be assigned more quickly.

Please note! Return shipments without an RMA number cannot be accepted and processed!

Please note that sensors or devices may need to be cleaned and disinfected before shipping.

In order to ship the goods undamaged, use the original packaging. If this is not available, ensure that safe transportation is guaranteed and that the sensors are secured with sufficient packing material.

We will contact you as soon as possible after receipt of the return shipment.

7 Technical data

7.1 Technical specifications

TpH

Measurement technology	pH electrode	
Measurement principle	Potentiometry	

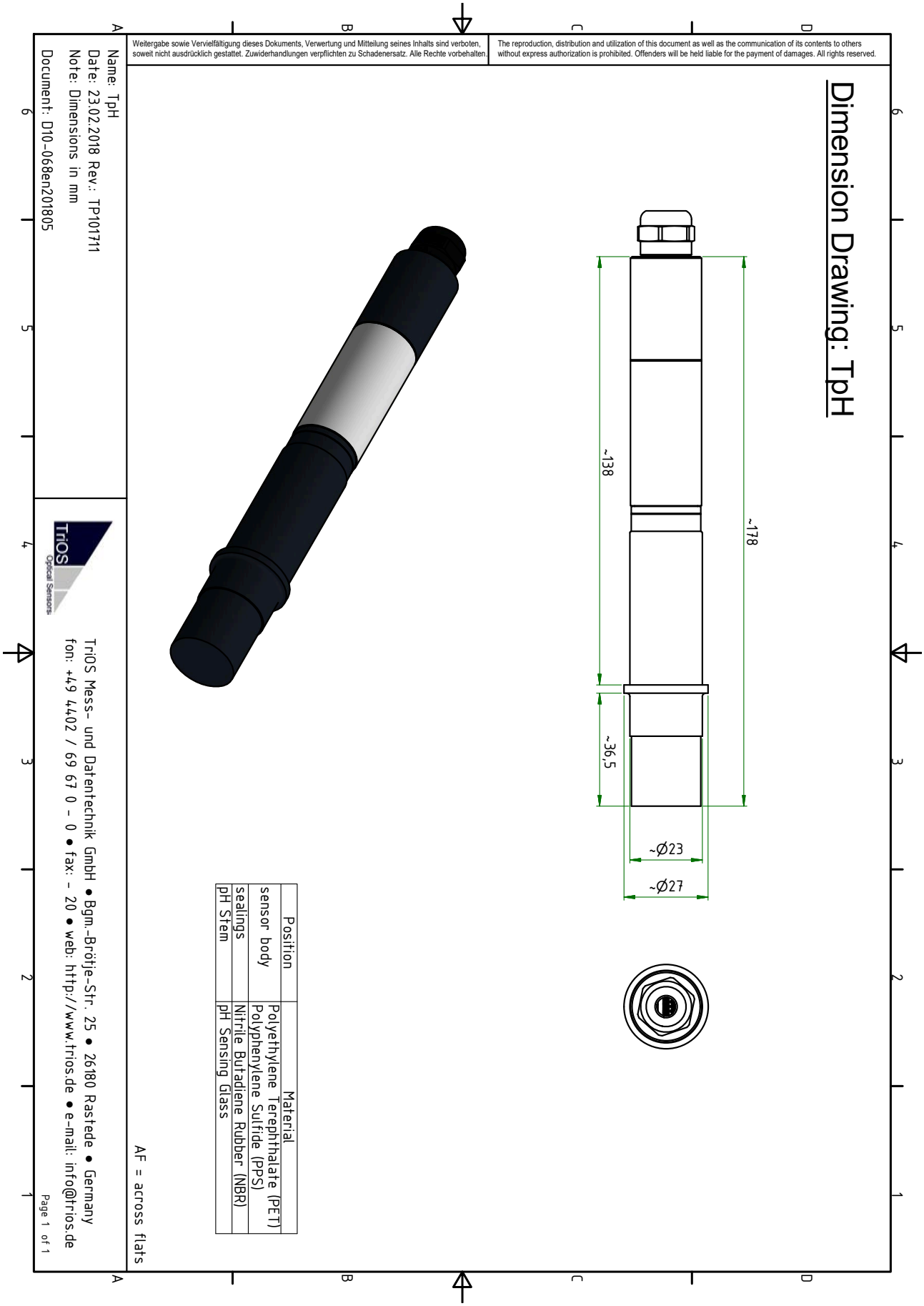
Parameters		pH value, temperature	
Measurement range	**pH**	0...14 pH	
	Temperature	0...+65 °C	~ +32 to +149 °F
pH resolution	**pH**	0.01 pH	
	Temperature	0,1 °C	~ +32.2 °F
Measurement accuracy	**pH**	± 0.06 pH	
	temperature	± 0,5 °C	± +32.9 °F
Intrinsic deviation	**pH1**	± 0.05 pH	
	pH7	± 0.05 pH	
	pH13	± 0.35 pH	
Linearity measurement error		± 0.1 pH	

Repeatability	**pH1**	± 0.1 pH
	pH7	± 0.05 pH
	pH13	± 0.1 pH
Output signal fluctuation	**pH7**	± 0.025 pH
	pH4	± 0.05 pH
Warm-up time		< 5 min
Drift	**Short-term drift 24 h**	≤ 0.03 pH
	Long-term drift 1 week	≤ 0.05 pH
10 % time and 90 % time	**T10 ascending**	< 2 s
	T10 falling	< 2 s
	T90 ascending	≤ 5 s

	T90 falling	≤ 5 s	
Temperature compensation		Pt1000	
Measurement interval		2 s	
Housing material		PPS / PET / NBR	
Dimensions (L x Ø)		~ 180 x 27 mm	~ 7.1″ x 1.1″
Weight		110 g	~ 0.2 lbs
Interface		RS-485, Modbus RTU	
Power consumption		0.2 W	
Power supply		12 - 24 VDC (± 10 %)	
Connection		8pin M12 plug	
Sensor cable		2 m and 10 m	
Maintenance effort		≤ 0.5 h/month typical	
Calibration / maintenance interval		Typically, 4 weeks	
System compatibility		Modbus RTU	
Warranty		1 year (EU & USA 2 years) on electronics; wearing parts are excluded from the warranty	
Max. pressure	**with fixed cable**	3 bar	~ 43.5 psi
	in FlowCell	1 bar, 2...4 L/min	~ 14.5 psi, 0.5 to 1 gpm
Degree of protection		IP68	
Sample temperature		+2...+40 °C	~ +36 to +104 °F
Ambient temperature		-5...+55 °C	~ +23 to +131 °F
Storage temperature		0...+40 °C*	~ +32 to +176 °F
Inflow velocity		0...3 m/s	~ 0 to 10 fps

Recommendation from TriOS: Storage at +5...+15 °C (+41 to +59 °F) for longer shelf life

7.2 Outer dimensions



8 Accessories

8.1 TriBox3

TriBox3 is a measuring and control system for all TriOS sensors. The device offers 4 sensor channels with selectable RS-232 or RS-485 function. In addition to Modbus RTU, various other protocols are available.
A built-in valve allows the use of compressed-air cleaning for the sensors. The TriBox3 also offers various interfaces, including an IEEE 802.3 Ethernet interface, a USB port and 6 analog outputs (4 .. 20 mA).
An integrated relay can be used to trigger alarms or control external devices. Low power consumption, a robust aluminum housing and a range of interfaces makes it suitable for all applications in environmental monitoring, drinking water, wastewater treatment plants and many other areas.

8.2 TriBox mini

Digital 2-channel controller

Die TriBox mini is an controller with two digital sensor inputs and two 4 .. 20 mA outputs and represent a cost-effective alternative to analog measuring points.
The TriBox mini is compatible with all TriOS sensors.
All stored measured values and diagnostic data can be read out via an integrated web browser.

8.3 Flow cell

Flow cell for eCHEM sensors

The flow cells specially developed for the eCHEM series are used for bypass installations of the eCHEM sensors manufactured by TriOS.

The measuring medium is fed through the cell via an inflow, thus enabling reagent-free measurement outside the process.

The flow cells are based on a modular system that can be expanded with additional modules.

8.4 pH buffer set

The pH buffer set contains 6 x pH 4 and 6 x pH 7 liquid standards, which are used for calibration of the TriOS sensors. This ensures reliable detection of the pH value.
Together with the sensor holder and the FlowCell, it also allows you to carry out a quick and precise check of our TriOS pH sensors on site.

pH values of the TriOS buffer solution as a function of temperature

pH 4.01

°C	°F	pH
0	32	4.05
5	41	4.04
10	50	4.02
15	59	4.01
20	68	4.00
25	77	4.01
30	86	4.01
35	95	4.01
40	104	4.01
45	113	4.00
50	122	4.00
55	131	4.00
60	140	4.00
65	149	4.00
70	158	4.00
75	167	4.00
80	176	4.00
85	185	4.00
90	194	4.00
95	203	4.00

pH 7.01

°C	°F	pH
0	32	7.13
5	41	7.07
10	50	7.05
15	59	7.02
20	68	7.00
25	77	7.00
30	86	6.98
35	95	6.96
40	104	6.95
45	113	6.95
50	122	6.95
55	131	6.96
60	140	6.96
65	149	6.96
70	158	6.96
75	167	6.96
80	176	6.97
85	185	7.00
90	194	7.00
95	203	7.00

9 Warranty

The warranty period for our devices within the EU and the USA is 2 years from the date of invoice. Outside the EU it is 1 year. Excluded from the warranty are all normal consumables
(depending on the product, e.g. light sources or windows).

The warranty is subject to the following conditions:

- The device and all accessories must be installed as described in the relevant manual and operated in accordance with the specifications.
- Damage caused by contact with aggressive and material-damaging substances, liquids or gases, as well as transport damage, are not covered by the warranty.
- Damage caused by improper handling and use of the device is not covered by the warranty.
- Damage caused by modification or unprofessional attachment of accessories by the customer is not covered by the warranty.

NOTICE

Opening the device will void the warranty!

10 Technical support

If you have a problem with a TriOS sensor / a TriOS device, please contact TriOS technical support.

We recommend sending in sensors every 2 years for maintenance and calibration. When returning devices, please be sure to follow the procedure described in Chapter 6.

Contact technical support:

E-mail: support@trios.de
Phone: +49 (0) 4402 69670 - 0
Fax: +49 (0) 4402 69670 - 20

To enable us to help you quickly, please send us the sensor ID number (serial number with 8 digits, consisting of letters and numbers, e.g. 6700003F) by e-mail.

11 Contact us

We are constantly working on improving our devices. Please visit our website for the latest news.

If you have found a fault in one of our devices or programs or would like additional functions, please contact us:

Technical Support: support@trios.de
General questions/sales: sales@trios.de
Website: www.trios.de

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12 Index

A

Accessories ... 23

B

Biological safety ... 5
Bypass installation ... 11

C

calibration ... 14
CE declaration of conformity ... 30
Certificates and approvals ... 7
Cleaning ... 17
Contact us ... 27
copyright ... 4

D

dimensions ... 22
disposal ... 7

E

Electrical installation ... 10
Electromagnetic waves ... 5

F

flow cell ... 11

H

Health and safety instructions ... 5

I

Intended use ... 6

M

M12 industrial plug ... 10
Maintenance ... 17
Measurement principle and structure ... 9
Measurement properties ... 15
Modbus RTU ... 31

N

Normal operation ... 11

O

operating requirements ... 6

P

Product identification ... 8

R

Reagents ... 5
Return shipment ... 18

S

Scope of delivery..... 8
Storage..... 12
Support pipe installation..... 12

T

Technical support..... 26, 27
type plate..... 8

W

Warning notices..... 6
Warranty..... 25

13 Appendix

13.1 CE declaration of conformity

Hersteller/Manufacturer/Fabricant:	TriOS Mess- und Datentechnik GmbH Bürgermeister-Brötje-Str. 25 D- 26180 Rastede

Konformitätserklärung
Declaration of Conformity
Déclaration de Conformité

Die TriOS GmbH bescheinigt die Konformität für das Produkt
The TriOS GmbH herewith declares conformity of the product
TriOS GmbH déclare la conformité du produit

Bezeichnung Product name Désignation	**TpH**
Typ / Type / Type	pH Art.Nr. 80S1000x0
Mit den folgenden Bestimmungen With applicable regulations Avec les directives suivantes	2014/30/EU EMV-Richtlinie 2011/65/EU RoHS-Richtlinie + (EU) 2015/863 + (EU) 2017/2102
Angewendete harmonisierte Normen Harmonized standards applied Normes harmonisées utilisées	EN IEC 61326-1:2021 EN 61010-1:2010 +A1:2019 +A1:2019/AC:2019 EN IEC 63000:2018
Datum / Date / Date	Unterschrift / Signature / Signature
23.05.2024	R. Heuermann

D05-068yy202405

Seite 1 von 1

13.2 Modbus RTU

Firmware version

This Modbus protocol refers to firmware version 1.0.x and higher

Serial interface

On delivery, the serial interface is configured with the following settings:

- Baud rate: 9600 bps
- Data bits: 8
- Stop bits: 1
- Parity: none

Data types

Data type name	register	format
Bool	1	false: 0x0000, true: 0xFF00
Uint8	1	8-bit positive integer. Values: 0x0000 - 0x00FF
Uint16	1	16-bit positive integer. Values: 0x0000 - 0xFFFF
Uint32	2	32-bit positive integer. Values: 0x00000000 - 0xFFFFFFFFFF
Float	2	IEEE 754 32-bit floating point number
Char[n]	$[\frac{n}{2}]$	Zero terminated ASCII character string consisting of n characters
Uint16[n]	n	Field of n 16-bit integers (cf. Uint16)
Float[n]	2n	Field of n floating point numbers (cf. Float)

Functions

The sensor supports the following Modbus functions:

Name	Code	Description / Use
Read multiple registers	0x03	Read serial number, configuration, calibration and measurement data
Write multiple registers	0x10	Write configuration and calibration
Write single register	0x06	Write configuration and calibration
Report slave ID	0x11	Read serial number and firmware version

Standard Modbus server address

On delivery, the sensor is set to address 20 (0x14).

Access restrictions

The R/W column describes the access restrictions for the registers. “R” can be read (0x03), “W” can be written (0x10).

Letter	Letter Description
R	Read access only
R/W	Read and write access

Read / Write multiple registers (0x03 / 0x10)

The registers contain the following values:

Designation	R/W	Address	Data type	Data type Description
Modbus slave ID	R/W	0	Uint16	The Modbus server address of the sensor.
Measurement time-out	R	1	Uint16	The time in [$^{10-1}$ s] that the currently active measurement process will continue
Serial Setting - baud rate	R/W	2	Uint16	- 0x0000: 9600 baud - 0x0001: 19200 baud - 0x0002: 38400 baud - 0x0003: 56700 baud
Serial Setting - Parity	R/W	3	Uint16	- 0x0000: None - 0x0001: Odd - 0x0002: Even
Serial Setting - Stop-bits	R/W	4	Uint16	- 0x0001: 1 stop bit - 0x0002: 2 stop bits
Device serial number	R	10	Char[20]	The serial number of the TpH sensor
Firmware version	R	15	Char[20]	The version number of the installed firmware
System date and time	R/W	107	Uint32	The current time in seconds since 01.01.1970. (Internal counter with ±0.9% accuracy @ 8.00MHz)
Device description	R/W	109	Char[64]	A free description of the sensor. E.g.: “southern inlet pipe”
Index for Moving Average / Offset / Scaling	R/W	400	Uint16	The index of the parameter for the following offset and scaling settings. The index is based on the parameter list in this description from register 1000: - 0x0000: pH - 0x0001: Temperature
Moving average	R/W	401	Uint16	The number of measurements over which a moving average is calculated. Value range: 1 - 25 Default value: 10

Designation	R/W	Address	Data type	Data type Description
Offset	R/W	402	Float	Offset parameter. Formula: scaled = (raw - offset) * scaling
Scaling	R/W	404	Float	Parameter Scaling factor. Formula: scaled = (raw - offset) * scaling
pH	R	1000	Float	pH value of the medium (original value)
Temperature	R	1002	Float	The temperature of the medium in °C (original value)
SQI	R	1004	Float	Sensor quality index
pH scaled	R	1500	Float	The pH value of the medium (customer scaled)
Temperature scaled	R	1502	Float	The temperature of the medium in °C (customer scaled)
FSM Control	R/W	5000	Uint16	FSM control register (calibration).
FSM Parameter	R/W	5001	Uint16	FSM parameter register (calibration), contains parameter index and calibration method. - 0x0001: pH - 0x0103: Temperature
FSM status	R	5002	Uint16	FSM status register (calibration)
Permanent errors	R	5100	Uint16	Permanent errors (bit field)
Permanent warnings	R	5101	Uint16	Permanent warnings (bit field)
Temporary errors	R	5102	Uint16	Temporary errors (bit field)
Temporary warnings	R	5103	Uint16	Temporary warnings (bit field)
Calibration control	R/W	6000	Uint16	Calibration control register, for complete restoration of the calibration (pH and temperature): 0x0001: Factory calibration 0x0002: Last calibration
Factory calibration parameter	R/W	6001	Uint16	Parameter index of the following calibration data (factory calibration): - 0x0000: pH - 0x0001: Temperature
Factory calibration - Offset	R/W	6002	Float	Offset of the factory calibration for the selected parameter
Factory calibration - Scaling	R/W	6004	Float	Scaling factor of the factory calibration for the selected parameter
Factory calibration - Square	R/W	6006	Float	Square coefficient of the factory calibration for the selected parameter

Designation	R/W	Address	Data type	Data type Description
				Not used, always 0
Factory calibration - Timestamp	R/W	6008	Uint32	Time of the factory calibration
Active calibration - Parameter	R/W	6010	Uint16	Parameter index of the following calibration data (active calibration): - 0x0000: pH - 0x0001: Temperature
Active calibration - Offset	R/W	6011	Float	Offset of the active calibration for the selected parameter
Active calibration - Scaling	R/W	6013	Float	Scaling factor of the active calibration for the selected parameter
Active calibration - Square	R/W	6015	Float	Square coefficient of the active calibration for the selected parameter Not used, always 0
Active calibration - Timestamp	R/W	6017	Uint32	Time of the active calibration.
Last calibration - parameter	R/W	6019	Uint16	Parameter index of the following calibration data (last calibration): - 0x0000: pH - 0x0001: Temperature
Last calibration - Offset	R/W	6020	Float	Offset of the last calibration.
Last calibration - Scaling	R/W	6022	Float	Scaling factor of the last calibration for the selected parameter
Last calibration - Square	R/W	6024	Float	Square coefficient of the last calibration for the selected parameter Not used, always 0
Last calibration - Timestamp	R/W	6026	Uint32	Time of the last calibration.

Errors and warnings

Permanent errors indicate a defect in the sensor.

Description	Bit mask
General error	0x0001
ADC upper limit exceeded	0x0002
ADC lower limit exceeded	0x0004

Permanent warnings

Description	Bit mask
n/a	n/a

Temporary errors provide notice of the cause of questionable measured values (SQI) or calibration problems

Description n/a	Bit mask
ADC error	0x0001
ADC upper limit exceeded	0x0002
ADC lower limit exceeded	0x0004
FSM invalid status	0x0010
FSM invalid transition	0x0020
FSM insufficient authentication	0x0040
FSM invalid parameter index	0x0100
FSM invalid calibration method	0x0200

Temporary warnings give notice of the cause of questionable measured values (SQI)

Description	Bit mask
Temperature outside 0...+ 65 °C	0x0002
pH value outside 0.5...12.5	0x0008
Reference voltage outside 0.3...1.17 V	0x0010

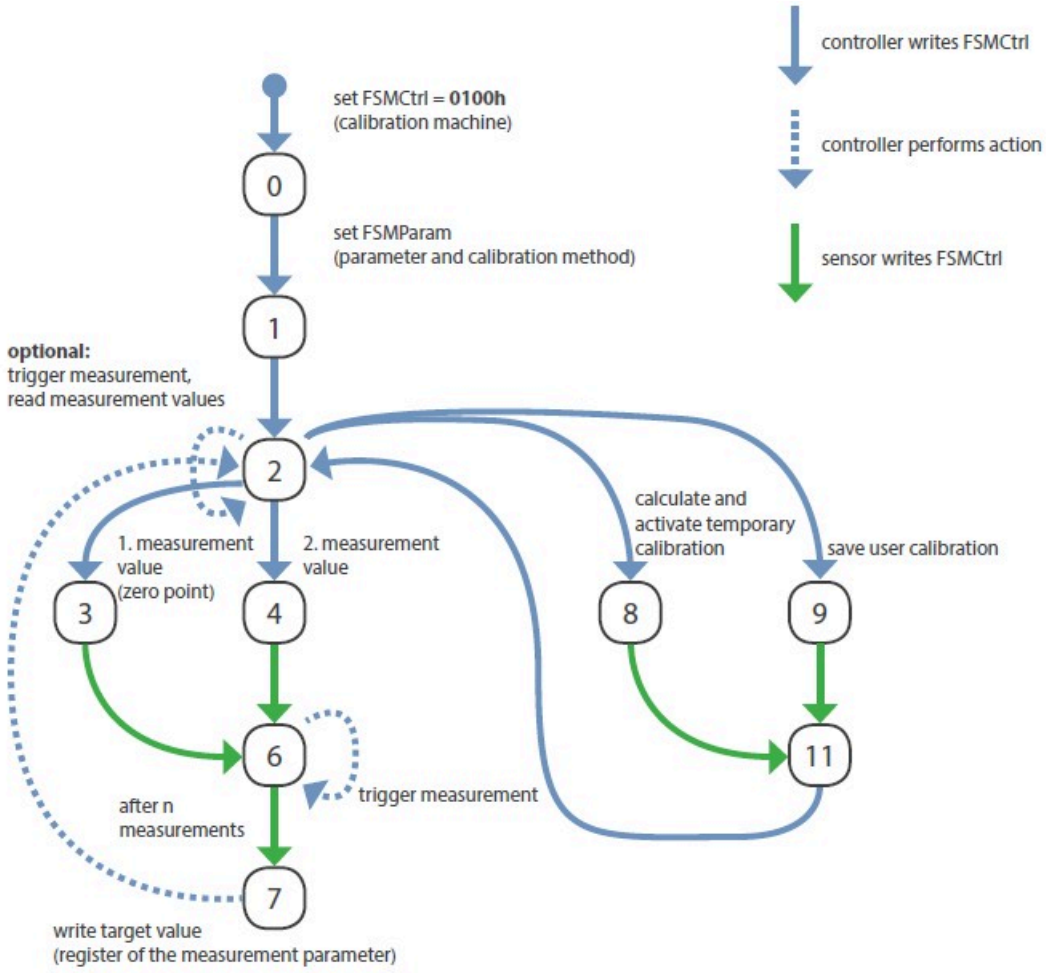
Report slave ID (0x11)

Returns the sensor designation, followed by the serial number, followed by the firmware version, each as a zero-terminated ASCII character string.

Example:

T	R	I	O	S	0x0	T	p	H	0x0	0	6	8	0	0	0	0	0	0x00	1	.	0	.	1	0x0

State machine for pH calibration



State machine number

The calibration machine has the number 1.

States

0: Activation of the state machine

The state machine is activated; the sensor exits normal operating mode.

1: Validation of parameters and calibration method

The calibration method (in the low byte) and the parameter to be calibrated (in the high byte) must be selected via the FSMParam parameter register. The state machine for this parameter and this calibration method is then initialized by changing to state 1.

If the selected calibration process is possible, the sensor switches to state 2 and deactivates the current calibration coefficients for the selected parameter.

Otherwise, it remains in state 1, whereby the reason for this can be determined by reading out the error register.

2: Idle state

The calibration machine has been successfully activated or the last action has been successfully completed. The sensor is now waiting for further commands.

3 and 4: Measurements

The control unit can now start the measurements required for this calibration method by switching to states 3 or 4. Regardless of the calibration method, state 3 is always used for the first measuring point, etc.

6: Performing measurement

After the control unit has informed the sensor to start the measurement by changing to state 3 or 4, the sensor changes to state 6 for the duration of the measurements. During this phase, the control unit should continuously trigger measurements and read out the measurement results. As soon as the sensor has collected a sufficient number of measured values, it switches to state 7 and awaits the transfer of the setpoint value.

7: Acquisition of the target value

The control unit writes the target value into the register of the measurement parameter of the calibrated parameter. This is the same register from which the measured values of the parameter are read out. If the terget value is accepted by the sensor, it acknowledges this by changing back to state 2. Otherwise, it remains in state 7.

8: Calculation of the coefficient

Once all the required measurements have been recorded and the target values stored, the sensor can be prompted to calculate a new calibration by switching to state 8. This new calibration is then temporarily activated and will be used to calculate the measurement values. However, this calibration is not saved yet and will be lost if you leave the calibration machine now.

After a successful calculation, the sensor changes to state 11 (see below). If the sensor cannot calculate a calibration, the sensor remains in state 8.

9: Save customer calibration

The customer calibration is saved by switching to state 9. This means that the previous calibration data is marked as the last calibration and the new calibration data is marked as the active calibration. Once the customer calibration has been saved, the parameters determined during this calibration remain active even after leaving the calibration machine.

After successful saving, the sensor changes to state 11 (see below). In the event of an error, the sensor remains in state 9.

11: Successful action

After successful calculation or saving, the sensor changes to state 11 and waits for an acknowledgement from the control unit. The control unit needs to transmit the sensor to change to state 2.

Termination / cancellation

The state machine can be terminated at any time by setting the state control register to the value 0 and thus switching back to normal operating mode. If the calibration has not yet been completed and the coefficients have not been saved, the original coefficients are restored.

If error bits are set, the control unit must reset the state machine by changing to state 0. The calibration must then be reinitialized by selecting the parameter and the calibration method.

Error states

If an error occurs during calibration and the sensor remains in one of the error states mentioned above, the calibration machine must be terminated in any case and restarted if necessary. Error recovery within the calibration machine does not take place.

Status parameter register

The status parameter register is divided into two parts:

FSMParam	
High byte	**Low Byte**
Parameter Index	Calibration method

The **parameter index** determines the parameter to be calibrated. The index is based on the parameter list as shown in the measured value register area.

The **calibration method** is determined by one of the following values:

Calibration method	**Meaning**	**States**
0 x 00	**No calibration (Reset FSM)**	-
0 x 01	Linear (2-point) calibration (offset, scaling)	3,4

pH calibration

Register		
5000	FSM Control	
5001	FSM parameters	1 = pH
	High byte	LOW Byte
5002	FSM on = 1 always	FSM status

Requirements and notes	Functionality	Function code	Register	Value	Length	FSM Status	Type	Result
Step 1	**pH calibration**							
Requirements:	Activate calibration mode pH							
Temperature is calibrated	Activate calibration mode	0x06	5000	0x0100				
Sensor in normal operation (LED green)	Activate pH calibration	0x06	5001	0x0001				
	Start calibration	0x06	5000	0x0101				
	Wait until sensor LED turns blue and FSM status 2	0x03	5002		1	2	Integer	LED turns blue
Step 2								
Requirements:	Calibrate pH 7							
FSM status 2	Start pH 7 calibration	0x06	5000	0x0103				
Insert pH 7 buffer								
Stable measured values (query until stable)	Query register FSM status regularly until it is set to 7 (may take a while)	0x03	5002		1	7	Integer	
	Write specified value of the standard solution	0x10	1000	IEEE 754 Float	2		IEEE 754 Float	
Note:								
Use 40E0 40E0 (pH7) if no floats can be written	Query register FSM status regularly until it is set to 2	0x03	5002		1	2	Integer	

Step 3								
Requirements:	Calibrate pH 10 or 4							
FSM status 2	Start pH 10 or pH 4 calibration	0x06	5000	0x0104				
Insert pH 10 or pH 4 buffer								
Stable measured values (query until stable)	Query FSM status register regularly until it is set to 7	0x03	5002		1	7	Integer	
	Write specified value of the standard solution	0x10	1000	IEEE 754 Float	2		IEEE 754 Float	
Note:								
Use 4120 4120 (pH10) or 4080 4080 if no floats can be written	Query register FSM status regularly until it is set to 2	0x03	5002		1	2	Integer	

Step 4								
Requirements:	Apply and check calibration							
Calibration was successful	Apply calibration and wait until FSM status is 11	0x06	5000	0x0108				
FSM status 2								
	Query FSM status register regularly until it is set to 11	0x03	5002		1	11	Integer	
	Set FSM status back to 2	0x06	5000	0x0102				
	Query register FSM status regularly until it is set to 2	0x03	5002		1	2	Integer	
Note:								
Query measured values to check whether values are satisfactory	Query pH data	0x03	1000		2		IEEE 754 Float	
The calibration has not yet been saved. If the calibration process is aborted between steps 1 and 6 or the power supply is switched off, the calibration is lost.								

Step 5								
Requirements:	Save calibration							
Calibration process was successful	Save calibration and wait until FSM status is 11	0x06	5000	0x0109				
	Query register FSM status regularly until it is 11	0x03	5002		1	11	Integer	
	Set FSM status back to 2	0x06	5000	0x0102				
	Query register FSM status regularly until it is set to 2	0x03	5002		1	2	Integer	
Calibration is saved								

Step 6								
Note:	Exit calibration	0x06	5000	0x0000				
If done between steps 1 and 6, the calibration is lost	Query FSM status register regularly until it is set to 0	0x03	5002		1	0	Integer	LED turns green

Temperature calibration

Register		
5000	FSM Control	
5001	FSM parameters	259 = Temp
	High byte	LOW Byte
5002	FSM on = 1 always	FSM status

Requirements and notes	Functionality	Function code	Register	Value	Length	FSM Status	Type	Result
Step 1	**Temperature calibration**							
Requirements:	Activate temperature calibration mode							
Sensor in normal operation (LED green)	Activate calibration mode	0x06	5000	0x0100				
	Activate temperature calibration	0x06	5001	0x0103				
	Start calibration	0x06	5000	0x0101				
	Wait until sensor LED turns blue and FSM status 2	0x03	5002		1	2	Integer	LED turns blue
Step 2								
Requirements:	Calibrate temperature							
FSM status 2	Start calibration Temperature	0x06	5000	0x0103				
Measure reference temperature								
Stable measured values (query until stable)	Query register FSM status regularly until it is set to 7 (may take a while)	0x03	5002		1	7	Integer	
	Write reference temperature value	0x10	1002	IEEE 754 Float	2		IEEE 754 Float	
Note:	Query register FSM status regularly until it is set to 2	0x03	5002		1	2	Integer	

Step 3								
Requirements:	Apply and check calibration							
Calibration was successful	Apply calibration and wait until FSM status is 11	0x06	5000	0x0108				
FSM status 2								
	Query register FSM status regularly until it is 11	0x03	5002		1	11	Integer	
	Set FSM status back to 2	0x06	5000	0x0102				
	Query register FSM status regularly until it is set to 2	0x03	5002		1	2	Integer	
Note:								
Query measured values to check whether values are satisfactory	Query temperature data	0x03	1002		2		IEEE 754 Float	
The calibration has not yet been saved. If the calibration process is aborted between steps 1 and 5 or the power supply is switched off, the calibration is lost.								

Step 4								
Requirements:	Save calibration							
Calibration process was successful	Save calibration and wait until FSM status is 11	0x06	5000	0x0109				
	Query register FSM status regularly until it is 11	0x03	5002		1	11	Integer	
	Set FSM status back to 2	0x06	5000	0x0102				
	Query register FSM status regularly until it is set to 2	0x03	5002		1	2	Integer	
Calibration is saved								

Step 5								
Note:	Exit calibration	0x06	5000	0x0000				
If done between steps 1 and 5, the calibration is lost	Query FSM status register regularly until it is set to 0	0x03	5002		1	0	Integer	LED turns green

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