

# DIN Rail Transmitter

## M100 DR



**METTLER TOLEDO**



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# 1 Introduction

## 1.1 Information Regarding the Operating Instructions

These operating instructions offer important notes on handling of the M100 DR transmitter of METTLER TOLEDO. A prerequisite for safe work is compliance with all indicated safety notes and instructions.

Furthermore, local work safety regulations and general safety provisions applicable for the application of the transmitter must be complied with.

The operating instructions must be read carefully before starting up any work! It is part of the product and must be kept in direct proximity of the transmitter, accessible for the staff at all times.

When passing on the transmitter to third parties, the operating instructions must be passed on as well.

Observe also the safety regulations and instructions of the connected sensor or of components from other suppliers.

## 1.2 Explanation of Symbols

Warning notes are marked by symbols in these operating instructions. The notes are initiated by signal words that express the scope of the danger.

Always comply with the notes and act carefully to prevent accidents, personal injury and property damage.

### Warning notes

#### **DANGER**



DANGER indicates a directly dangerous situation that will lead to death or serious injury if not avoided.

#### **WARNING**



WARNING indicates a potentially dangerous situation that may lead to death or serious injury if not avoided.

#### **CAUTION**



CAUTION indicates a potentially dangerous situation that may lead to slight or minor injury if not avoided.

#### **ATTENTION**



ATTENTION indicates a potentially harmful situation that may lead to property damage if not avoided.

### Advice and recommendations



NOTE emphasizes useful advice and recommendations, as well as information for efficient and interference-free operation.

## 1.3 Scope of Delivery

The following is included in the scope of delivery:

- M100 DR Transmitter
- Quick Setup Guide
- CD-ROM with documentation, device description (DD), configuration tool PACTWare™ and a demo version of iSense software

## 1.4 Customer Service

Our customer service is available for technical information.

You can find your local office on the last page.



### NOTE!

For quick processing of the call, note the data on the product's label, such as serial number, part number, etc.

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## 1.5 Environmental Protection

### ATTENTION



### **Danger for the environment by improper disposal of the transmitter or components!**

In case of improper disposal of the transmitter or components, damage to the environment may result.

- Observe the local and national laws and directives.
  - Disassemble the transmitter according to its components (plastic, metal, electronics). Supply sorted components for recycling.
-

## 2 Safety

### 2.1 Intended Use

The M100 DIN rail transmitter is a 2-wire transmitter for analytical measurements with HART communication capability. The M100 DR is a single-channel, multi-parameter transmitter for pH/ORP, pH/pNa, Dissolved Oxygen and Conductivity measurement. It is only compatible with ISM sensors.

METTLER TOLEDO accepts no liability for damages resulting from incorrect use or use other than that intended.

### 2.2 General Safety Instructions

The following is a list of general safety instructions and warnings. Failure to adhere to these instructions can result in damage to the equipment and/or personal injury to the operator.

- Installation of cable connections and servicing of this product requires access to shock hazard voltage levels.
- Mains power wired to a separate power source must be disconnected before servicing.
- Switch or circuit breaker shall be in close proximity to the equipment and within easy reach of the operator; it shall be marked as the disconnecting device for the equipment.
- Main power must employ a switch or circuit breaker as the disconnecting device for the equipment.
- Electrical installation must be in accordance with the National Electrical Code and/or any other applicable national or local codes.
- The transmitter should be installed and operated only by personnel familiar with the transmitter and who are qualified for such work.
- The transmitter must only be operated under the specified operating conditions. See Chapter 9 “Technical Data” on Page 44.
- Repair of the transmitter must be performed by authorized, trained personnel only.
- With the exception of routine maintenance, cleaning procedures or fuse replacement as described in these operating instructions, the transmitter must not be tampered with or altered in any manner.
- METTLER TOLEDO accepts no responsibility for damage caused by unauthorized modifications to the transmitter.
- Follow all warnings, cautions, and instructions indicated on and supplied with this product.
- Install equipment as specified in these operating instructions. Follow appropriate local and national codes.
- The transmitter’s protective lid must be in place at all times during normal operation.
- If this equipment is used in a manner not specified by the manufacturer, the protection provided by it against hazards may be impaired.



## **2.3 Changes and Conversions**

Changes or conversions of the transmitter or the installation may cause unexpected dangers.

The manufacturer's written approval is required before any technical changes and expansions of the transmitter can be carried out.

## 3 Function and Design

### 3.1 Function

The M100 DIN rail transmitter is a 2-wire transmitter with HART® communication capability for analytical measurements. The M100 DR is a single-channel, multi-parameter transmitter for pH/ORP, pH/pNa, dissolved oxygen and conductivity measurement. It is only compatible with ISM sensors.

#### M100 DR parameter fit guide

Parameter	M100 DR
	ISM
pH/ORP	•
pH/pNa	•
Conductivity 4-e	•
Amp. DO ppm <sup>1)</sup> /ppb <sup>2)</sup> /trace <sup>2)</sup>	•

1) Ingold and Thornton sensors

2) Ingold sensors

Table 1: M100 DR parameter fit guide

### 3.2 Design

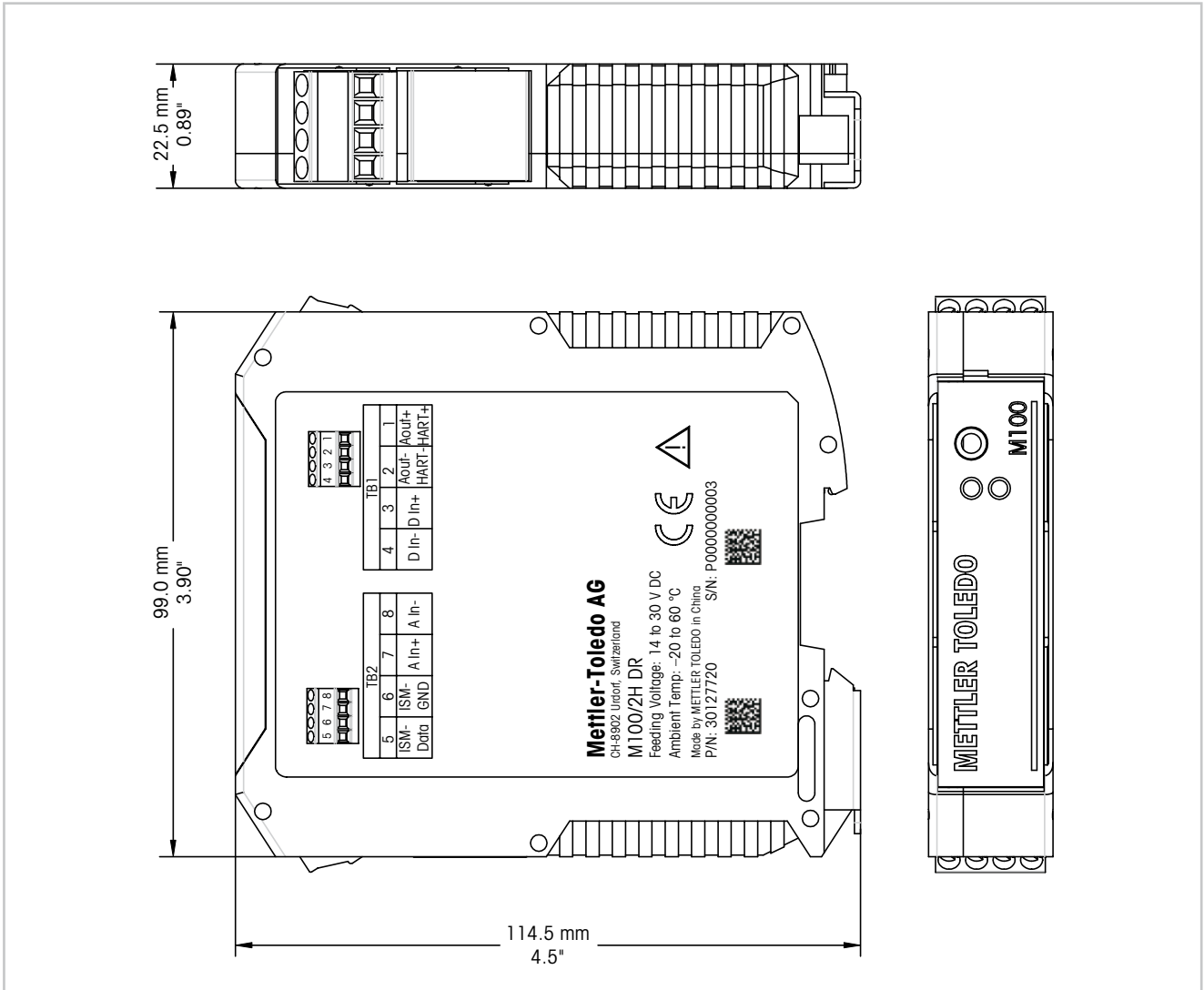


Fig. 1: Dimensions M100 DR transmitter

### 3.3 LED Functionality

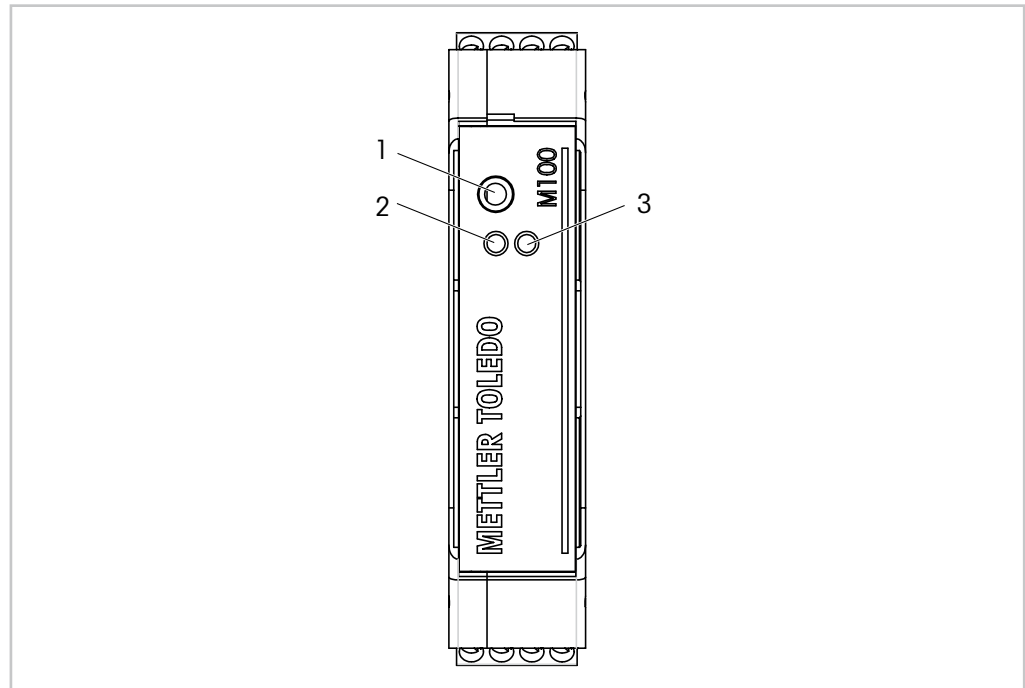


Fig. 2: LED functionality M100 DR

- 1 Port: Interface for service e.g. firmware update
- 2 LED green
- 3 LED red

LED Green	LED Red	Description
On	Off	Operation correct
On	On	Error For further information see Table 9 on Page 28.
On	Blinking	Warning For further information see Table 9 on Page 28.

Table 2: LED functionality M100 DR

## 4 Wiring

### 4.3.1 Safety Instructions for Wiring

- Power off transmitter during wiring.
- Connect wires firmly to the connection terminals.

### 4.3.2 HART System Architecture

Configure the M100 DR transmitter either via a configuration tool, an asset management tool or via a HART handheld terminal.

The DD and the DTM files can be downloaded via the Internet "www.mt.com/M100". The DD is also on the supplied CD-ROM.

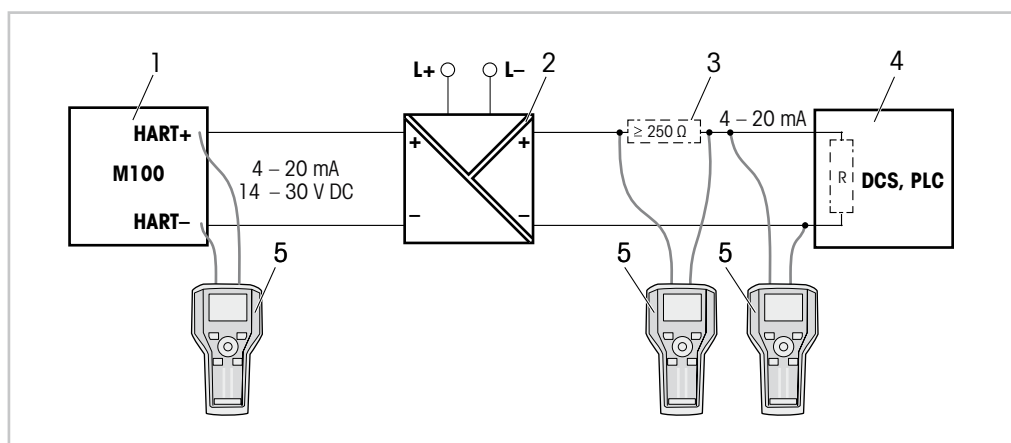


Fig. 3: HART® connection with HART handheld terminal

- 1 M100 DR transmitter
- 2 Repeater power supply, preferably HART transparent
- 3 Load resistor, is not required if one is installed in the repeater power supply
- 4 DCS (Distributed Control System) or PLC (Programmable Logic Controller)
- 5 HART handheld terminal e.g. 475 FieldCommunicator from Emerson

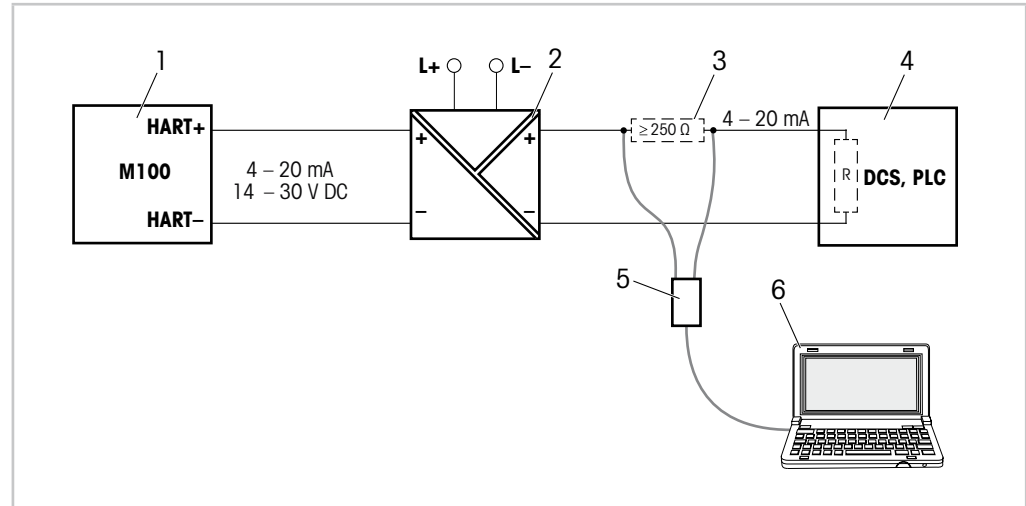


Fig. 4: HART® connection with HART modem and configuration tool

- 1 M100 DR transmitter
- 2 Repeater power supply, preferably HART transparent
- 3 Load resistor, is not required if one is installed in the repeater power supply
- 4 DCS (Distributed control system) or PLC (Programmable logic controller)
- 5 HART modem
- 6 PC with configuration tool, e.g. PACTWare™ from Pepperl+Fuchs.  
PACTWare™ is on supplied CD-ROM or available as freeware.

### 4.3.3 Terminal Block (TB) Definition

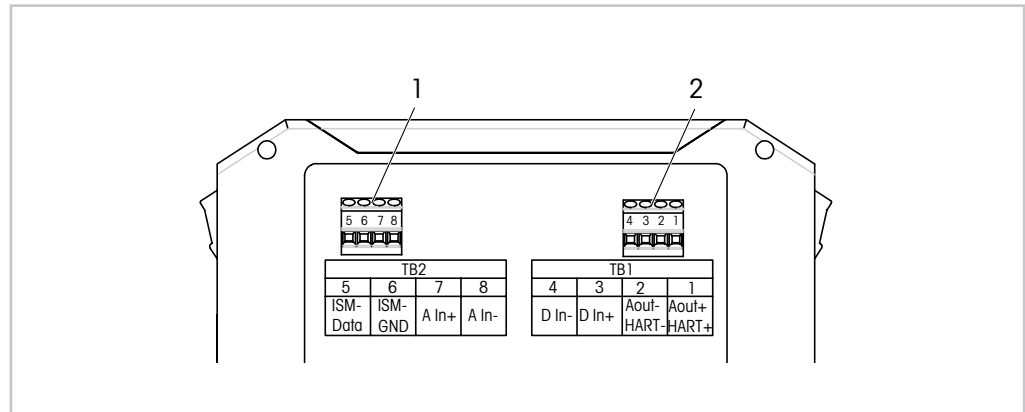


Fig. 5: Terminal block (TB) definition M100 DR

Terminal		Description	
TB2	5	ISM-DATA	Sensor input, see Table 1 on Page 10.
	6	ISM-GND	
	7	Ain+	Analog input: 4 to 20 mA (for pressure compensation)
	8	Ain-	
TB1	4	DI-	Digital input (for switching transmitter in Hold state)
	3	DI+	
	2	Aout-, HART-	– Power connection: 14 to 30 V DC – Analog output – HART signal
	1	Aout+, HART+	

Table 3: Terminal block (TB) definition M100 DR

## 5 Operation

Configure the M100 DR transmitter either via a configuration tool, an asset management tool or via a HART handheld terminal.

### 5.1 Start-up Operation via Configuration Tool or Asset Management Tool



#### NOTE!

The configuration tool PACTWare™ is on the supplied CD-ROM. You can download the DTM via the Internet "[www.mt.com/M100](http://www.mt.com/M100)".

**Prerequisite:** The M100 DR transmitter and the sensor are mounted and electrically connected.

For steps 1 to 5 and for step 13 refer to the documentation of the configuration tool or asset-management tool.

1. Install configuration tool e.g. PACTWare™ or asset management tool.
2. Install DTM for HART interface and DTM for M100 DR transmitter.
3. Update device catalog.
4. Make a connection between the transmitter and the software. Check COM port settings if necessary.
5. Select **Sensor Type**.  
Menu path: Detailed Setup > Measurements > Channel Setup > Sensor Setup.
6. Load configuration from device.
7. Set **Date** and **Time**. Set the time in the 24 hour format.  
The time format cannot be changed. Menu path: Device Setup
8. Set **Tag** or/and **Long Tag**. Menu path: Device Setup > Detailed Setup > System
9. Set range of the analog output signal.  
Menu path: Detailed setup > Output Condition > Analog Output > Range
  - **URV** (Upper Range Value) and **LRV** (Lower Range Value)  
The values have to be within the measurement limits of the sensor.
  - **USL** (Upper Sensor Limit) and **LSL** (Lower Sensor Limit)  
The limits are defined by the sensor and cannot be changed.
10. Define the process variables **PV**, **SV**, **TV** and **QV**  
Menu path: Device Setup > Detailed Setup > Measurements > Channel Setup
11. Calibrate sensor. Menu path: Device Setup > Sensor Calibration  
See Chapter 6 "Sensor Calibration" on Page 18.
12. Perform further settings. See Chapter 7 "Menu Overview and Menu Description" on Page 24.
13. Store configuration to device.



## 5.2 Start-up Operation via HART Handheld Terminal



### NOTE!

The DD "008E8E7F0101.hhd" is on the supplied CD-ROM. You can also download the DD via the Internet "www.mt.com/M100".

**Prerequisite:** The M100 DR transmitter and the sensor are mounted and electrically connected.

For step 1 refer to the documentation of the HART handheld terminal.

1. Check if the DD of the M100 DR transmitter has already been installed on the HART handheld terminal. Install the DD if necessary.
2. The communication is made automatically.
3. Select **Sensor Type**.  
Menu path: Detailed Setup > Measurements > Channel Setup > Sensor Setup.
4. Load configuration from device. Menu path: Device Setup > Detailed Setup
5. Set **Date** and **Time**. Set the time in the 24 hour format. The time format cannot be changed. Menu path: Device Setup
6. Set **Tag** or/and **Long Tag**. Menu path: Device Setup > Detailed Setup > System
7. Set range of the analog output signal.  
Menu path: Detailed setup > Output Condition > Analog Output > Range
  - **URV** (Upper Range Value) and **LRV** (Lower Range Value)  
The values have to be within the measurement limits of the sensor.
  - **USL** (Upper Sensor Limit) and **LSL** (Lower Sensor Limit)  
The limits are defined by the sensor and cannot be changed.
8. Define the process variables **PV**, **SV**, **TV** and **QV**  
Menu path: Device Setup > Detailed Setup > Measurements > Channel Setup
9. Calibrate sensor. Menu path: Device Setup > Sensor Calibration  
See Chapter 6 "Sensor Calibration" on Page 18.
10. Perform further settings. See Chapter 7 "Menu Overview and Menu Description" on Page 24.

## 5.3 Change Sensor Type

If you change the sensor type e.g. a conductivity sensor with a pH sensor, perform the following procedure:

**Prerequisite:** The M100 DR transmitter and another sensor type are mounted and electrically connected.

1. Make a connection between the transmitter and the software/HART device.
  2. Select **Sensor Setup**.  
Menu path: Detailed Setup > Measurements > Channel Setup > Sensor Setup.
  3. Start "Sensor Setup".
  4. Select the new sensor type for the **Sensor Type** parameter.
  5. Load configuration from device.
- ⇒ The configuration in the configuration tool or in the HART handheld is updated.  
If you have selected the correct sensor type, the **Verify** menu will be shown.

## 6 Sensor Calibration

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### NOTE!

Via configuration tool, asset-management-tool or HART handheld terminal you can calibrate the sensor with the "Process", "1-point" or "2-point" calibration method.

Via iSense software you can calibrate the sensor with the "1-point" or "2-point" calibrate method. For further information see operating instructions of the iSense software.

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### NOTE!

As soon as the calibration is in progress no other calibration can be started.

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### 6.1 Terminate Sensor Calibration

After every successful calibration the following options are available:

- **Adjust:** Calibration values are adopted and used for the measurement. Additionally, the calibration values are stored in the calibration history.
- **Calibrate:** Calibration values are stored in the calibration history for documentation, but cannot be used for the measurement. The calibration values from the last valid adjustment are further used for the measurement.
- **Abort:** Calibration values are discarded.

### 6.2 Process Calibration

The "Process calibration" method is suitable for all sensor types.

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### NOTE!

For best process calibration results observe the following points:

- Take grab sample as close as possible to the measurement point of the sensor.
  - Measure the sample at process temperature.
- 

#### 6.2.1 Perform Sensor Calibration via Configuration Tool or Asset Management Tool

1. Select **Sensor Calibration** menu. Menu path: Device Setup > Sensor Calibration
  2. Select calibration method. Click [Step 1: Capture current measured value].
  3. For O<sub>2</sub> calibration select calibration unit.
- ⇒ The current "Sensor Value" and "Status" are shown.

4. Click [Next] to store the measured value.  
⇒ The following message appears: "Captured value is stored. Take a grab sample to measure in the lab or perform parallel measurement."
5. Click [OK].
6. Click [Step 2: Enter reference value]. NOTE! You can perform "Step 2" at any time.  
⇒ The captured value of "Step 1" is shown.
7. Enter the measured reference value.
8. Click [Next] to store the reference value.  
⇒ If the reference value is within the valid range, the "Slope" and "Offset" are shown.
9. Click [OK].  
⇒ The following message appears "Complete calibration procedure. Select either Adjust, Calibrate or Abort".
10. Select Adjust, Calibrate or Abort.
11. Click [OK].

## 6.2.2 Perform Sensor Calibration via HART Handheld Terminal

1. Select **Sensor Calibration** menu. Menu path: Device Setup > Sensor Calibration
2. Select calibration method.  
⇒ The following message appears: "Capture act. value".  
⇒ For O<sub>2</sub> calibration the following message appears: "Select calibration unit".
3. For O<sub>2</sub> calibration select calibration unit. Press [ENTER].  
⇒ The current "Sensor Value" and "Status" are shown.
4. Press [Next] to capture the current measured value.  
⇒ The following message appears "Captured value is stored. Take a grab sample to measure in the lab or perform parallel measurement."
5. Press [OK].  
⇒ The following message is shown "Enter reference value". You can perform this step at any time.
6. Enter the measured reference value.
7. Press [ENTER] to store the reference value.  
⇒ If the reference value is within the valid range, the "Slope" and "Offset" are shown.
8. Press [OK].  
⇒ The following message appears "Select process, select either Adjust, Calibrate or Abort".
9. Select Adjust, Calibrate or Abort.
10. Press [ENTER].

## 6.3 pH/ORP and pH/pNa Sensor Calibration

The M100 DR features for pH/ORP and pH/pNa sensors the following sensor calibration methods: pH Process, pH 1-point, pH 2-point, ORP Process, ORP 1-point and OPR 2-point.

### 6.3.1 Perform Calibration for pH/ORP and pH/pNa Sensors

After selecting the calibration method, you will be guided through the required steps.

Below, one calibration method is described in detail. For the other calibration methods follow the menu. For the "Process" calibration method see Chapter 6.2 "Process Calibration" on Page 18.

For further information concerning the sensor see the used sensor's documentation.

#### Example: pH sensor, "2-point" calibration method, asset management tool as operating tool

1. Select the **Measurements** menu.  
Menu path: Device Setup > Detailed Setup > Measurements
2. Select for the **Stability** parameter the stability criteria of the sensor signal.  
See Chapter 7.6.2.2 "pH (pH/ORP and pH/pNa)" on Page 33.
3. Select for the **Buffer** parameter the used Buffer.
4. Select **Sensor Calibration** menu. Menu path: Device Setup > Sensor Calibration
5. Select calibration method, here "pH 2-point".  
⇒ The following message appears: "Press [OK] when sensor is in Buffer 1".
6. Place sensor in the first buffer.
7. Click [OK].  
⇒ If for the **Stability** parameter the option "Manual" is selected, the current "Reference Value", "Sensor Value" and "Status" will be shown. Click [Next] if the "Sensor value" is stable enough. If for the **Stability** parameter the option "Low", "Medium" or "Strict" is selected, the transmitter saves the sensor value automatically as soon as the stability criteria are fulfilled.
- ⇒ The following message appears "Press [OK] when sensor is in Buffer 2".
8. Place sensor in the second buffer.
9. Click [OK].  
⇒ If for the **Stability** parameter the option "Manual" is selected, the current "Reference Value", "Sensor Value" and "Status" will be shown. Click [Next] if the "Sensor value" is stable enough. If for the **Stability** parameter the option "Low", "Medium" or "Strict" is selected, the transmitter saves the sensor value automatically as soon as the stability criteria are fulfilled.
- ⇒ If the calibration is within the valid range, the "Slope" and "Offset" are shown.
10. Click [OK].  
⇒ The following message appears "Complete calibration procedure. Select either Adjust, Calibrate or Abort".
11. Select Adjust, Calibrate or Abort.
12. Click [OK].

## 6.4 O<sub>2</sub> Sensor Calibration

The M100 DR features for O<sub>2</sub> sensors the following sensor calibration methods: O<sub>2</sub> Process Slope, O<sub>2</sub> Process Offset, O<sub>2</sub> 1-point Slope, O<sub>2</sub> 1-point Offset and Air.

### 6.4.1 Perform Calibration for O<sub>2</sub> Sensors

After selecting the calibration method, you will be guided through the required steps.

Below, one calibration method is described in detail. For the other calibration methods follow the menu. For the "Process" calibration method see Chapter 6.2 "Process Calibration" on Page 18.

For further information concerning the sensor see the used sensor's documentation.

#### **Example: O<sub>2</sub> sensor, "1-point Slope" calibration method, asset management tool as operating tool**

1. Select **Sensor Calibration** menu. Menu path: Device Setup > Sensor Calibration
2. Select calibration method, here "O<sub>2</sub> 1-point Slope".
3. Select calibration unit.
4. Click [OK].  
⇒ The current "Sensor Value" and "Status" are shown.
5. Enter for the "New Value" the reference value for the calibration gas. The current measured value is shown as "Old Value".
6. Click [Next] to store the measured value.  
⇒ The following message appears: "Press [OK] when sensor is in Gas 1".
7. Place sensor in the calibration gas.
8. Click [OK].  
⇒ If the calibration is within the valid range, the "Slope" and "Offset" are shown.
9. Click [OK].  
⇒ The following message appears "Complete calibration procedure. Select either Adjust, Calibrate or Abort".
10. Select Adjust, Calibrate or Abort.
11. Click [OK].

## 6.4.2 Perform Calibration for Current Input Ain

For O<sub>2</sub> measurement you can connect an external pressure sensor for pressure compensation. The pressure sensor is connected to **Ain** terminals.

To improve the accuracy of the O<sub>2</sub> measurement we recommend to calibrate the current input Ain.

1. Connect reference meter to **Ain** terminals.
2. Select **Sensor Calibration** menu. Menu path: Device Setup > Sensor Calibration
3. Select calibration method. Click [Ain Calibration].  
⇒ The following message appears: "Set output to 4 mA".
4. Click [OK].  
⇒ **Reference Value 1:** The old value for the 4 mA value is shown.
5. Enter the new reference value measured with the reference meter.
6. Click [OK] to store the new reference value for 4 mA.  
⇒ "Reference Value", "Sensor Value" and "Status" are shown.
7. Click [Next].  
⇒ The following message appears "Set output to 20 mA".
8. Click [OK].  
⇒ **Reference value 2:** The old value for the 20 mA value is shown.
9. Enter the new reference value measured with the reference meter.
10. Click [OK] to store the new reference value for 20 mA.  
⇒ "Reference Value", "Sensor Value" and "Status" are shown.
11. Click [Next].  
⇒ The following message appears "Complete calibration procedure. Select either "Adjust or Abort".
12. Select Adjust or Abort.

## 6.5 Conductivity Sensor Calibration

The M100 DR features for conductivity sensors the following sensor calibration methods: Conductivity Process, Conductivity 1-point, Conductivity 2-point, Resistivity Process, Resistivity 1-point and Resistivity 2-point.

### 6.5.1 Perform Calibration for Conductivity Sensors

After selecting the calibration method, you will be guided through the required steps.

Below, one calibration method is described in detail. For the other calibration methods follow the menu. For the "Process" calibration method see also Chapter 6.2 "Process Calibration" on Page 18.

For further information concerning the sensor see the used sensor's documentation.

#### **Example: Conductivity sensor, "1-point" calibration method, asset management tool as operating tool**

1. Select **Sensor Calibration** menu. Menu path: Device Setup > Sensor Calibration
2. Select the calibration method, here "Conductivity 1-point".
3. Select the compensation mode. See also Chapter 7.6.2.4 "Cond 4e (Conductivity 4e)" on Page 35.
4. Click [OK].
5. Select the calibration unit.
6. Click [OK].  
⇒ The current "Sensor Value" and "Status" are shown.
7. Enter for the "New Value" the reference value. The current measured value is shown as "Old value".  
⇒ The current "Reference Value", "Sensor Value" and "Status" are shown.
8. Click [Next] to store the measured value.  
⇒ If the reference value is within the valid range, the "M" and "A" values are shown.  
"M" means: Cell multiplier or slope calibration factor i.e. cell constant.  
"A" means: Adder or offset calibration factor.
9. Click [OK].  
⇒ The following message appears "Complete calibration procedure. Select either Adjust, Calibrate or Abort".
10. Select Adjust, Calibrate or Abort.
11. Click [OK].

# 7 Menu Overview and Menu Description

## 7.1 Menu Overview

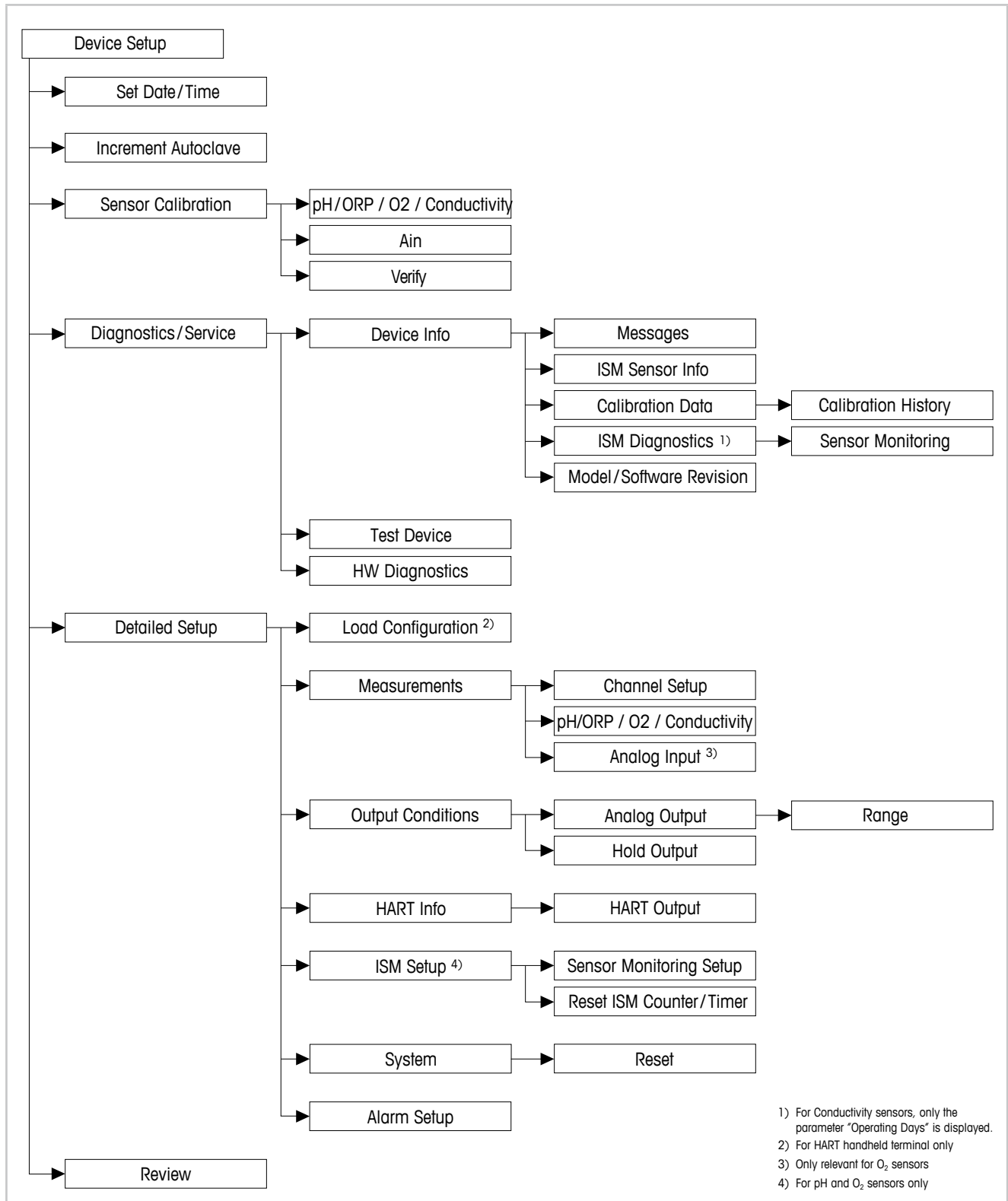


Fig. 6: Menu overview



## 7.2 Set Date/Time

Menu path: Device > Detailed Setup



NOTE!

We recommend setting the **Date** and **Time** before performing any further configuration. The set Date and Time is used, for example for the calibration history and the ISM diagnostics and sensor monitoring function.

Parameter	Description
Set Date and Time	Set Date and Time. – Date: YY-MM-DD – Time: HH-MM-SS in 24 hour format
YY/MM/DD/HH/MM/SS	Display of the Date and Time stored in the transmitter.

Table 4: Set Date/Time

## 7.3 Increment Autoclave

Menu path: Device > Detailed Setup

Parameter	Description
Increment Autoclave	If a sensor is disconnected from the transmitter and then connected again, the function "Increment Autoclave" is active. You can increment the autoclave cycle counter.  If another sensor is connected to the transmitter, the function is inactive. – Yes: The autoclave cycle counter is incremented. – No: The autoclave cycle counter is not incremented. The current value is kept.

## 7.4 Menu "Sensor Calibration"

The **Sensor Calibration** menu is dependent on the connected sensor. This menu guides you through the sensor calibration process. See Chapter 6 "Sensor Calibration" on Page 18.

The **Ain Calibration** function is only applicable for O<sub>2</sub> sensors. See Chapter 6.4.2 "Perform Calibration for Current Input Ain" on Page 22.

## 7.4.1 Verify

The **Verify** menu is dependent on the connected sensor. This menu shows the raw signals of the connected sensor.

### 7.4.1.1 pH/ORP and pH/pNa

Menu	Description
UpH	Display of the raw voltage signal for pH measurement.
UORP	Display of the raw voltage signal for ORP measurement.
Rref	Display of the raw reference electrode resistance.
Rglass	Display of the raw glass electrode resistance.
Temperature	Display of the raw temperature signal.

Table 5: Menu "Verify" – pH/ORP and pH/pNa

### 7.4.1.2 O<sub>2</sub>

Menu	Description
Measured current	Display of the measured current.
Temperature	Display of the raw temperature signal.

Table 6: Menu "Verify" – O<sub>2</sub>

### 7.4.1.3 Conductivity

Menu	Description
Resistivity	Display of the raw resistance signal without temperature compensation.
Resistance	Display of the raw resistance signal with temperature compensation.
Temperature	Display of the raw temperature signal.

Table 7: Menu "Verify" – Conductivity

## 7.5 Menu “Diagnostics & Service”

Menu path: Device > Diagnostics & Service

The **Diagnostics & Service** menu shows information about the transmitter and the connected sensor and supports you in troubleshooting.

Menu	Description
Loop Test	<p>With the <b>Loop Test</b> function you can check the hardware of the analog output by defining a constant analog output value. During the test we recommend to remove the loop from automatic control.</p> <ul style="list-style-type: none"> <li>– 4 mA: The analog output is set to 4 mA.</li> <li>– 20 mA: The analog output is set to 20 mA.</li> <li>– Other: The analog output is set to the entered current value.</li> <li>– End: The test is terminated.</li> </ul>
D/A Trim	<p>With the <b>D/A Trim</b> function you can calibrate the hardware of the analog output. During the trim we recommend to remove the loop from automatic control. For the D/A Trim you connect a reference meter to the <b>Aout</b> terminals and enter for the 4 mA and 20 mA values the values of the reference meter.</p>

Table 8: Diagnostics & Service

### 7.5.1 Device Info

#### 7.5.1.1 Messages

Menu path: Device > Diagnostics & Service > Device Info > Messages

The **Messages** menu shows current active alarms or current status returned in HART Command #48.

You can deactivate some alarms in the **Alarm Setup** menu. If an alarm occurs but is deactivated in the “Messages” menu, the alarm will not be shown in the “Messages” menu and the red LED on the transmitter is off. See Chapter 7.6.7 “Alarm Setup” on Page 42.

Some messages are only displayed for certain sensors or for specific settings. The column “Prerequisites” of the following table shows the dependencies.

Status group (Byte)	Bit	Meaning	Class <sup>1)</sup>	Prerequisites
0	0	Software failure	Error	In "Alarm Setup" menu enabled.
	1	Sensor disconnected	Error	–
	2	Wrong sensor connected	Error	–
	3	Broken sensor (Rg, RpNa < 5 MOhm)	Error	In "Alarm Setup" menu enabled.
	4	Open circuit (Rg, RpNa > 2000 MOhm)	Error	In "Alarm Setup" menu enabled.
	5	Dry cond sensor	Error	– Conductivity sensors – In "Alarm Setup" menu enabled.
	6	Shorted cell	Error	– Conductivity sensors – In "Alarm Setup" menu enabled.
	7	Electrolyte level too low	Warning	– Amperometric O <sub>2</sub> sensors – In "Alarm Setup" menu enabled.
1	0	Rg < 0.3 Rgcal	Warning	pH/ORP sensors
	1	Rg > 3 Rgcal	Warning	pH/pNa sensors
	2	Rr or RpNa < 0.3 Rrcal	Warning	pH/ORP sensors
	3	Rr or RpNa > 3 Rrcal	Warning	pH/pNa sensors
	4	Maintenance required (TTM expired) <sup>2)</sup>	Warning	TTM monitoring enabled.
	5	Calibration required (ACT expired) <sup>2)</sup>	Warning	ACT monitoring enabled.
	6	Change sensor (DLI expired) <sup>2)</sup>	Warning	DLI monitoring enabled.
	7	Cell constant deviation	Warning	– Conductivity sensors – In "Alarm Setup" menu enabled.
2	0	CIP cycle counter expired <sup>2)</sup>	Warning	CIP Limit enabled.
	1	SIP cycle counter expired <sup>2)</sup>	Warning	SIP Limit enabled.
	2	Autoclave cycle counter expired <sup>2)</sup>	Warning	–
	3	Hold activated	Warning	–
	4	Calibration values out of range	Warning	–
	5 to 7	Not used	–	–
	3	0	Change parameter	–
1		Change sensor type	–	–
2		Autoclave cycle counter increment	–	–
3		Process calibration active	–	–
4 to 7		Not used	–	–

1) Error: Red LED is on. Warning: Red is blinking. See Chapter 3.3 "LED Functionality" on Page 12.

2) In the "Reset ISM Counter/Timer" menu you can reset ISM Counter and Timer. See Chapter 7.6.5.2 "Reset ISM Counter/Timer" on Page 41.

Table 9: Messages

### Clear Status Group

With the **Clear Status Group** function you can refresh the reading of the status. The status of the transmitter and the sensor is read constantly.

### Increment Autoclave

See Chapter 7.3 "Increment Autoclave" on Page 25.

## 7.5.1.2 ISM Sensor Info

Menu path: Device > Diagnostics & Service > ISM Sensor Info

Parameter	Description
Sensor Type	Display of the connected sensor type.
Cal. Date	Display of the date of the last adjustment or calibration.
Serial-No	Display of the serial number of the transmitter.
Part-No	Display of the part number (order number) of the transmitter.

Table 10: ISM Sensor Info

## 7.5.1.3 Calibration Data and Calibration History

Menu path: Device > Diagnostics & Service > Device Info > Calibration Data

Parameter	Description
Calibration Data	<p>Display of the current "Slope" and "Offset". For ORP sensors the OPR Offset is displayed additionally.</p> <p><b>Note!</b> The <b>Calibration Data</b> function requires the correct setting of <b>Date</b> and <b>Time</b>. See Chapter 7.2 "Set Date/Time" on Page 25.</p>

Table 11: Calibration Data

### Calibration History

Menu path:

Device > Diagnostics & Service > Device Info > Calibration Data > Calibration History

Definitions:

- "S" means "Slope". "Z" means "Offset".
- **Adjustment:** The calibration procedure is completed with the "Adjust" command. The calibration values are adopted and used for measurement. Additionally, the calibration values are stored in the calibration history. The dataset "Act" and "Cal1" are identical. The current calibration dataset "Act" moves to "Cal2".
- **Calibration:** The calibration procedure is completed with the "Calibrate" command. The calibration values are stored in the calibration history as dataset "Cal1" for documentation, but cannot be used for the measurement. The measurement continues with the last valid adjustment dataset "Act".

Parameter	Description
Calibration History	<p>The <b>Calibration History</b> parameter shows the history of calibration data.</p> <ul style="list-style-type: none"> <li>– Fact (Factory calibration): This is the original dataset, determined in the factory. This dataset remains stored in the sensor for reference and cannot be overwritten.</li> <li>– Act (Actual adjustment): This is the current calibration dataset which is used for the measurement. This dataset moves to "Cal2" position after the next adjustment.</li> <li>– 1. Adj (First adjustment): This is the first adjustment after the factory calibration. This dataset remains stored in the sensor for reference and cannot be overwritten.</li> <li>– Cal1 (latest calibration/adjustment): This is the latest executed calibration/adjustment. This dataset moves to "Cal2" when a new calibration/adjustment is performed.</li> <li>– Cal2 and Cal3: After calibration/adjustment the "Cal1" dataset moves to "Cal2" and "Cal2" moves to "Cal3". The former "Cal3" dataset is not available anymore.</li> </ul>

Table 12: Calibration History

### 7.5.1.4 ISM Diagnostics and Sensor Monitoring

Menu path: Device > Diagnostics & Service > Device Info > ISM Diagnostics

The **ISM Diagnostics** menu is not available for Conductivity sensors.

The **ISM Diagnostics** menu shows the limits and the current counts of the cleaning cycles counter as well as the maximum temperature. You can configure the cleaning cycles counter in the **ISM Setup** menu. See Chapter 7.6.5 "ISM Setup" on Page 40.



#### NOTE!

This function requires the correct setting of **Date** and **Time**. See Chapter 7.2 "Set Date/Time" on Page 25.

Parameter	Description
CIP Limit	Display of the limit for the CIP cycles counter.
CIP Cycles	Display of the current amount of executed CIP cycles.
SIP Limit	Display of the limit for the SIP cycles counter.
SIP Cycles	Display of the current amount of executed SIP cycles.
Autoclave Limit	Display of the limit for the Autoclave cycles counter.
Autoclave Cycles	Display of the current amount of executed Autoclave cycles.
Max. Temp.	Display of the maximum temperature of the sensor. During autoclaving the Max. Temp. is not recorded.
Max. Temp. Date	Display of the date of the maximum temperature.

Table 13: ISM Diagnostics

## Sensor Monitoring

Menu path:

Device > Diagnostics & Service > Device Info > ISM Diagnostics > Sensor monitoring

The **Sensor Monitoring** menu shows the status of the different timers.

Parameter	Description
DLI (d)	Display of the remaining days for the <b>Dynamic Lifetime Indicator</b> . The days are set by the manufacturer.
DLI (%)	Display of the remaining time for the <b>Dynamic Lifetime Indicator</b> in percentage. The days are set by the manufacturer.
TTM (d)	Display of the remaining days for the <b>Time To Maintenance</b> indicator. You can set the days with the Max TTM parameter in the Sensor Monitoring Setup menu. See Chapter 7.6.5.1 "Sensor Monitoring Setup" on Page 41.
TTM (%)	Display of the remaining time for the <b>Time To Maintenance</b> indicator in percentage. 100 percent corresponds to the set days for the Max TTM parameter.
ACT (d)	Display of the <b>Adaptive Cal Timer</b> in days.  The Adaptive Cal Timer estimates when the next calibration should be performed to keep the best possible measurement performance. The Adaptive Cal timer is reset to its initial value after a successful adjustment or calibration.  You can set the days with the Max ACT parameter in the Sensor Monitoring Setup menu. See Chapter 7.6.5.1 "Sensor Monitoring Setup" on Page 41.
ACT (%)	Display of the <b>Adaptive Cal Timer</b> in percentage. 100 percent corresponds to the set days for the Max ACT parameter.
Operating Days	Display of the operating days of the connected sensor.

Table 14: Sensor Monitoring

### 7.5.1.5 Model/Software Revision

Menu path: Device > Diagnostics & Service > Device Info > Model/Software Revision

Parameter	Description
Part-No	Display of the part number of the transmitter.
Serial-No	Display of the serial number of the transmitter.
Master	Display of the firmware revision number of the transmitter.
Comm	Display of the firmware revision number of the communication PCB.
Sensor FW	Display of the firmware version of the sensor.
Sensor HW	Display of the hardware version of the sensor.

Table 15: Model/Software Revision

## 7.5.2 Test Device

Menu path: Device > Diagnostics & Service > Test Device

Function	Description
Self Test	With the <b>Self Test</b> a diagnostic routine is performed. This test detects electronics failures or other failures that affect performance.
Device Reset	With the <b>Device Reset</b> a reset is performed. This reset is identical to a power reset, switching power off and on again.

Table 16: Test Device

## 7.5.3 HW Diagnostics

Menu path: Device > Diagnostics & Service > HW Diagnostics

Menu	Description
Analog Input	Display of the current analog input value.
Din1 Status	Display of the current status of the digital input. Options: High and Low

Table 17: HW Diagnostics

## 7.6 Detailed Setup

### 7.6.1 Load Configuration

Menu path: Device > Detailed Setup > Measurement > Load Configuration

The **Load Configuration** menu is only available via HART handheld terminal.

With this function you load the latest configuration data from the transmitter to the HART handheld terminal.



## 7.6.2 Measurements

The **Measurements** menu is dependent on the connected sensor.

### 7.6.2.1 Channel Setup

Menu path: Device > Detailed Setup > Measurements > Channel Setup

Parameter	Description
Sensor Setup	Select the measured variable of the connected sensor type. Options: pH/ORP, pH/pNa, Cond 4e, O <sub>2</sub> Hi, O <sub>2</sub> Lo, O <sub>2</sub> Trace
Sensor Channel	The <b>Sensor Channel</b> parameter is set to "ISM" and cannot be changed.
PV is	Select a measured variable as "Primary Value".
SV is	Select a measured variable as "Secondary Value".
TV is	Select a measured variable as "Tertiary Value".
QV is	Select a measured variable as "Quaternary Value".
PV/SV/TV and QV Average	With the <b>Average</b> parameters you set the averaging method (noise filter) for the corresponding value. <ul style="list-style-type: none"> <li>– None: No averaging or filtering</li> <li>– Low: Equivalent to 3 point moving average</li> <li>– Medium: Equivalent to 6 point moving average</li> <li>– High: Equivalent to 10 point moving average</li> <li>– Special (Default): Averaging dependent on the signal change, normally High averaging but Low averaging for large changes in input signal</li> </ul>

Table 18: Channel Setup

### 7.6.2.2 pH (pH/ORP and pH/pNa)

If a pH/ORP or pH/pNa sensor is connected, the pH menu is shown.

Menu path: Device > Detailed Setup > Measurements > pH

For pH measurement you can set the following parameters.

Parameter	Description
Stability	Select the stability criteria during calibration. <ul style="list-style-type: none"> <li>– Manual: The user decides when a signal is stable enough to complete the calibration.</li> <li>– Low, Medium or Strict: The transmitter works with the selected stability criteria during calibration. If the Stability is set to Medium the signal deviation has to be less than 0.8 mV over a 20 second interval to be recognized by the transmitter as stable. The calibration is done using the last reading.</li> </ul> <p>If the criteria is not met within 300 seconds, the message "Calibration not done" will be displayed.</p>

Parameter	Description
pH Buffer	Select <b>pH Buffer</b> for calibration. Options: Mettler-9, Mettler-10, Nist-Tech, Nist-Std, Hach, Ciba, Merck, WTW, None, JIS Z 8802, Na+3.9 For dual membrane pH electrodes (pH/pNa) select buffer Na+3.9. See Chapter 11 "Buffer Tables" on Page 49.
IP	Set the <b>Isothermal Point</b> value. For most applications use the default value. For specific compensation requirements or non-standard inner buffer values change the value.
STC Ref Mode	Use the <b>STC Ref Mode</b> parameter for STC compensation. – Yes: The measured pH value is compensated with values of the <b>STC Value</b> and <b>STC Ref Temp</b> parameter. – No: The measured pH value is compensated with the current measured temperature.
STC Value	Set the <b>STC Value</b> . The <b>STC Value</b> is the Solution Temperature Coefficient in pH/°C. The coefficient is referred to the temperature set with the STC Ref Temp.
STC Ref Temp	Set the reference temperature for the <b>STC Value</b> parameter.

Table 19: pH

### 7.6.2.3 O<sub>2</sub>

If a O<sub>2</sub> Lo, O<sub>2</sub> Hi or O<sub>2</sub> Trace sensor is connected, the **O<sub>2</sub>** menu is shown.

Menu path: Device > Detailed Setup > Measurement > O2

For O<sub>2</sub> measurement there is a difference between measuring mode and calibration mode. Measuring mode means the sensor is placed in the real process. Calibration mode means that the sensor is placed in a reference medium outside the real process.

For O<sub>2</sub> measurement you can set the following parameters.

Parameter	Description
Pcal_Pres Unit	Select the pressure unit for process calibration.
Pcal_Pressure	Set the pressure for process calibration.
Process Cal Pressure Source	Select the pressure source for process calibration. – Pcal_Pressure: The pressure is set with the Pcal_Pressure parameter. – Proc_Pressure: The pressure is set with the Process_Pressure Mode and Process_Pressure parameters.
Process_Pressure Mode	Select mode for entering the pressure during the measuring mode. – Edit: The process pressure is set manually with the Process_Pressure parameter. – Ain: The pressure is given by the input signal at the analog input terminals Ain.
Process_Pressure Unit	Select the pressure unit for measuring mode.

Parameter	Description
Process_Pressure	Set the pressure for measuring mode. For the Process_Pressure Mode parameter the option "Edit" has been selected.
Salinity	Set salinity of the measured solution.
Rel Humidity	Set relative humidity of the calibration gas. When no humidity measurement is available use 50 %.
UpolMeas	Set the polarization voltage of amperometric oxygen sensors in the measuring mode. NOTE: During a process calibration, the polarization voltage UpolMeas, defined for the measuring mode, will be used. – 0 to –550 mV: The connected sensor is set to a polarization voltage of –500 mA. – Less than 550 mV: The connected sensor is set to a polarization voltage of –674 mA.
UpolCal	Set the polarization voltage of amperometric oxygen sensors for the calibration mode. – 0 to –550 mV: The connected sensor is set to a polarization voltage of –500 mA. – Less than 550 mV: The connected sensor is set to a polarization voltage of –674 mA.

Table 20: O<sub>2</sub>

### 7.6.2.4 Cond 4e (Conductivity 4e)

If a conductivity sensor is connected, the **Conductivity** menu is shown.

Menu path: Device > Detailed Setup > Measurement > Conductivity

For conductivity measurement you can set the following parameters.

Parameter	Description
PV/SV/TV/QV Comp Mode	Select temperature compensation mode for the corresponding value. See table "Compensation Mode".
PV/SV/TV/QV Linear Coef	Set linear coefficient in %/°C for the compensation mode "Linear 25 °C" and "Linear 20 °C" of the corresponding value.

Table 21: Conductivity

#### Compensation Mode

Compensation Mode	Description
Standard	The <b>Standard</b> compensation mode includes compensation for non-linear high purity effects and conventional neutral salt impurities. This mode conforms to ASTM standards D1125 and D5391.

Compensation Mode	Description
Linear 25°C	The <b>Linear 25°C</b> compensation mode adjusts the reading by a coefficient expressed as %/°C, deviation from 25 °C. Use this mode only if the solution has a well-characterized linear temperature coefficient. The coefficient is set with the <b>Linear Coef</b> parameter.
Linear 20°C	The <b>Linear 20°C</b> compensation mode adjusts the reading by a coefficient expressed as %/°C, deviation from 20 °C. Use this mode only if the solution has a well-characterized linear temperature coefficient. The coefficient is set with the <b>Linear Coef</b> parameter.
Light 84	The <b>Light 84</b> compensation mode matches the high purity water research results of Dr. T.S. Light published in 1984. Use this mode only if your institution has standardized on that work.
Std 75°C	The <b>Std 75°C</b> compensation mode is the Standard compensation algorithm referenced to 75 °C.
Glycol 0.5	The <b>Glycol 0.5</b> compensation mode matches the temperature characteristics of 50 % ethylene glycol in water. Compensated measurements using this solution may go above 18 Mohm-cm.
Glycol 1.0	The <b>Glycol 1.0</b> compensation mode matches the temperature characteristics of 100 % ethylene glycol. Compensated measurements may go well above 18 Mohm-cm.
Cation	The <b>Cation</b> compensation mode is used in power industry applications measuring the sample after a cation exchanger. This mode takes into account the effects of temperature on the dissociation of pure water in the presence of acids.
Alcohol	The <b>Alcohol</b> compensation mode provides for the temperature characteristics of a 75 % solution of isopropyl alcohol in pure water. Compensated measurements using this solution may go above 18 Mohm-cm.
Ammonia	The <b>Ammonia</b> compensation mode is used in power industry applications for specific conductivity measured on samples using ammonia and/or ETA (ethanolamine) water treatment. This mode takes into account the effects of temperature on the dissociation of pure water in the presence of these bases.
None	The <b>None</b> compensation mode does not make any compensation of the measured conductivity value.

Table 22: Conductivity – Compensation Mode

## 7.6.2.5 Analog Input

Menu path: Device > Detailed Setup > Measurement > Analog Input

For O<sub>2</sub> measurement you can connect an external pressure sensor for pressure compensation. The pressure sensor is connected to Ain terminals. To improve the accuracy of the O<sub>2</sub> measurement we recommend calibrating the current input Ain. See Chapter 6.4.2 "Perform Calibration for Current Input Ain" on Page 22.

Parameter	Description
4 mA Unit	Select pressure unit for the 4 mA analog input value.
4 mA Value	Set value for the 4 mA analog input value.
20 mA Unit	Select pressure unit for the 20 mA analog input value.
20 mA Value	Set value for the 20 mA analog input value.

Table 23: Analog Input

## 7.6.3 Output Conditions

### 7.6.3.1 Analog Output

Menu path: Device > Detailed Setup > Output Conditions > Analog Output

Menu/Function	Description
Loop Current Mode	Configure the signal of the analog output. <ul style="list-style-type: none"> <li>– Enabled: The output current depends on the current measured value and the settings for the analog output.</li> <li>– Disabled: The output current is set to 4 mA. Use this setting e.g. for multi-drop applications.</li> </ul>
Alarm Type	Select the output current for the case of an alarm for an alarm of the "Status group 0". See Chapter 7.5.1.1 "Messages" on Page 27. <ul style="list-style-type: none"> <li>– High: Output current is 22.0 mA.</li> <li>– Low: Output current is 3.6 mA.</li> </ul>
Hold Mode	Select the output current of the analog output during Hold state. You can change in the Hold state either by the parameter Manual Hold or by a signal at the digital input terminals. See Chapter 7.6.4.1 "HART Output" on Page 39. <ul style="list-style-type: none"> <li>– Last Value: The output current is the last valid output.</li> <li>– Fixed: The output current is set to the defined value of the <b>Hold Fixed</b> parameter.</li> <li>– Off: The output current is calculated by the PV, PV LRV and PV URV parameters.</li> </ul>
Hold Fixed	Set the output current of the analog output during Hold state for the <b>Hold Mode</b> parameter, option "Fixed".

Table 24: Analog Output

## Range

Menu path: Device > Detailed Setup > Output Conditions > Analog Output > Range

With the **Range** menu you can configure the upper and lower measurement value for the 4 mA and 20 mA output values.

Menu	Description
PV URV	Set the Upper Range Value for the Primary Value. The Upper Range Value corresponds to the 20 mA output value. The value has to be within the measurement limits of the sensor. Default: PV USL
PV LRV	Set the Lower Range Value for the Primary Value. The Lower Range Value corresponds to the 4 mA output value. The value has to be within the measurement limits of the sensor. Default: PV LSL
PV USL	Display of the Upper Sensor Limit of the connected sensor. This value cannot be changed.
PV LSL	Display of the Lower Sensor Limit of the connected sensor. This value cannot be changed.

Table 25: Range

### 7.6.3.2 Hold Output

Menu path: Device > Detailed Setup > Output Conditions > Hold Output

With the **Hold Output** menu you start and stop the Hold state. The behavior of the analog output during the Hold state you configure with the **Analog Output** menu.

Parameter	Description
CAL Hold Output	Select the output current of the analog output during calibration. This function applies for the "1-point" and "2-point" calibration method. <ul style="list-style-type: none"> <li>– Yes: The Hold mode is activated. The output current is set according to the setting of the <b>Hold Mode</b> parameter. See Chapter 7.6.3.1 "Analog Output" on Page 37.</li> <li>– No: The Hold mode is deactivated. The current measured value is output.</li> </ul>
Manual Hold	Start and stop the Hold state manually. <ul style="list-style-type: none"> <li>– Start: The transmitter changes in the Hold state.</li> <li>– Stop: The Manual Hold mode is determined.</li> </ul>
Din1 Hold State	Set the signal level to start and stop the Hold state with the signal at the digital input terminals (Din). <ul style="list-style-type: none"> <li>– Low: The transmitter changes in Hold state when the signal is Low. When the signal is High the Hold state is stopped.</li> <li>– High: The transmitter changes in Hold state when the signal is High. When the signal is Low the Hold state is stopped.</li> <li>– Off: A signal at the digital input terminals will not be evaluated.</li> </ul>

Table 26: Hold Output

## 7.6.4 HART Info

Menu path: Device > Detailed Setup > HART Info

Parameter	Description
Tag	Identifies the transmitter. 8 packed ASCII characters
Long Tag	Identifies the transmitter. 32 ISO Latin-1 characters
Date	Enter a date. The date is used for record keeping.
Write Protection	Display of the status of the write protection.
Descriptor	Enter a description for describing the transmitter.
Message	Enter a message.
Final assembly number	Enter a number to identify materials and electronics of the transmitter.

Table 27: HART Info

### 7.6.4.1 HART Output

Menu path: Device > Detailed Setup > HART Info > HART Output

Menu	Description
Poll addr	<p>Set the polling address of the transmitter.</p> <ul style="list-style-type: none"> <li>– 0: Point-to-point installations. The digital signal is overlaid on the 4 to 20 mA output current.</li> <li>– A number between 1 and 63: Multi-drop installations. Each transmitter needs to have a unique address to allow automatic identification by a master.</li> </ul> <p>In multi-drop only the digital signal is used. The analog output current is fixed at 4 mA. In multi-drop mode it is possible to have more than one transmitter at one signal cable.</p>
Num req preams	Display of the number of requested preambles.
Num resp preams	Set number of preambles.

Table 28: HART Output

## 7.6.5 ISM Setup

The **ISM Setup** menu is not available for Conductivity sensors.

Menu path: Device > Detailed Setup > ISM Setup

With the **ISM Setup** menu you configure the CIP cycle counter, SIP cycle counter and the Auto-clave cycle counter. You can reset each counter in the **Reset ISM Counter** menu. See Chapter 7.6.5.2 "Reset ISM Counter/Timer" on Page 41.

CIP or SIP cycles are automatically recognized by the sensor. The algorithm of the counter recognizes an increase of the measured temperature above the set temperature. If the temperature remains for longer than five minutes at the set temperature, the transmitter is locked for the next two hours. The counter is incremented by one.

Menu	Description
DLI Stress Adjustment	<p>This parameter is available for pH sensors with software version 7.0 and higher.</p> <p>With the <b>DLI Stress Adjustment</b> parameter you can adapt DLI, TTM and ACT to application requirements and/or experiences. This parameter is available for pH sensors only.</p> <ul style="list-style-type: none"> <li>– Low: DLI, TTM and ACT are increased approximately 25% compared to "Medium"</li> <li>– Medium (default): No change for DLI, TTM and ACT</li> <li>– High: DLI, TTM and ACT are reduced approximately 25% compared to "Medium".</li> </ul>
CIP Limit	Set limit of the CIP cycle counter. If the counter exceeds the set value, the message "CIP cycle counter expired" is shown. The function is switched off by entering the value "000".
CIP Temperature	Set the temperature at which the sensor recognizes CIP cleaning. If the sensor measures the entered temperature or higher, the CIP cycle counter is incremented by one.
SIP Limit	Set limit of the SIP cycle counter. If the counter exceeds the set value, the message "SIP cycle counter expired" is shown. The function is switched off by entering the value "000".
SIP Temperature	Set the temperature at which the sensor recognizes SIP cleaning. If the sensor measures the entered temperature or higher, the SIP cycle counter is incremented by one.
Autoclave Limit	Set limit of the Autoclave cycle counter. If the counter exceeds the set value, the message "Autoclave cycle counter expired" is shown. The function is switched off by entering the value "000".

Table 29: ISM Setup

### Increment Autoclave

See Chapter 7.3 "Increment Autoclave" on Page 25.



### 7.6.5.1 Sensor Monitoring Setup

Menu path: Device > Detailed Setup > ISM Setup > Sensor Monitoring Setup

Parameter	Description
DLI Monitoring	Switch on or off the <b>Dynamic Lifetime Indicator</b> .  The Dynamic Lifetime Indicator estimates the remaining lifetime to ensure a reliable measurement. For amperometric oxygen sensors, the Dynamic Lifetime Indicator is related to the inner-body of the sensor.
TTM Monitoring	Switch on or off the <b>Time To Maintenance</b> indicator.  The Time To Maintenance indicator estimates when the next cleaning cycle should be performed to keep the best possible measurement performance. The indicator is influenced by significant changes on the DLI parameters. For amperometric oxygen sensors, the Time To Maintenance indicator shows the maintenance cycle for the membrane and electrolyte.
ACT Monitoring	Switch on or off the <b>Adaptive Calibration Timer</b> .  The Adaptive Cal Timer estimates when the next calibration should be performed to keep the best possible measurement performance. The Adaptive Cal Timer is reset to its initial value after a successful adjustment or calibration.
Max TTM	Set the interval for the <b>Time to Maintenance</b> indicator. As soon as the timer reaches the set interval a message is shown in the Message menu.
Max ACT	Set the interval for the <b>Adaptive Cal Timer</b> . As soon as the timer reaches the set interval a message is shown in the Message menu.

Table 30: Sensor Monitoring Setup

### 7.6.5.2 Reset ISM Counter/Timer

Menu path: Device > Detailed Setup > ISM Setup > Reset ISM Counter/Timer

With the **Reset ISM Counter/Timer** menu you can reset each counter and timer individually. The view of this menu is dependent on the connected sensor.

## 7.6.6 System

Menu path: Device > Detailed Setup > System

Parameter	Description
Lock/Unlock Device	Lock or unlock the transmitter. In the "Lock" state no other master can write to the transmitter.

Table 31: System

### 7.6.6.1 Reset

Menu path: Device > Detailed Setup > System > Reset

Parameter	Description
Reset System	Reset all parameters to the default values. The meter calibration is not affected.
Reset MeterCal	Reset electronics factors to default values. Use this function after an incorrect analog input calibration.
ResetAnalogOutCal	Reset analog output factors to default values. Use this function after an incorrect analog output calibration.

Table 32: Reset

### 7.6.7 Alarm Setup

Menu path: Device > Detailed Setup > Alarm Setup

Tick checkbox for activating option. Multiple selection is possible.

If an alarm is activated and the alarm occurs, the alarm will be shown in the **Message** menu and the red LED on the transmitter is on. See Chapter 7.5.1.1 "Messages" on Page 27.

Parameter	Description
Alarm Byte 0	Diagnostic functions for pH sensors: <ul style="list-style-type: none"> <li>– Rg: Rg is out of tolerance, e.g. a broken measuring electrode.</li> <li>– Rr, RpNa: Rr is out of tolerance, e.g. coated or depleted reference electrode.</li> </ul>
Alarm Byte 1	General <ul style="list-style-type: none"> <li>– Software Failure: Watchdog time-out function.</li> </ul> Diagnostic functions for conductivity sensors: <ul style="list-style-type: none"> <li>– Dry Cond Sensor: The conductivity sensor is in air e.g. in an empty pipe.</li> <li>– Cell Constant Deviation: Cell constant is out of tolerance, i.e. has changed too much compared to the value thru factory calibration.</li> <li>– Cond Sensor Shorted: Conductivity sensor has a short circuit.</li> </ul> Diagnostic function for amperometric oxygen sensors <ul style="list-style-type: none"> <li>– Electrolyte Level: Electrolyte in the membrane body reaches such a low level that the connection between cathode and reference electrode is disturbed.</li> </ul>

Table 33: Alarm Setup

## 7.7 Review

Menu path: Device > Review

The **Review** menu shows important information of the transmitter and of the connected sensor.

## 8 Troubleshooting

If the transmitter is used in a manner not specified by METTLER TOLEDO the protection provided by the transmitter may be impaired.

Review the table below for possible causes of common problems.

Problem	Possible cause	Action
Error: Red LED on the transmitter is permanently on. The output current is either always 3.6 mA or 22 mA.	See Chapter 7.5.1.1 "Messages" on Page 27.	Perform the required steps dependent on which status bit is set.
Warning: Red LED on the transmitter is blinking.	See Chapter 7.5.1.1 "Messages" on Page 27.	Perform the required steps dependent on which status bit is set.
HART communication error	Wiring is incorrect	<ul style="list-style-type: none"> <li>– Check wiring. See Chapter 4 "Wiring" on Page 13.</li> <li>– Notice polarity of supply voltage. See Chapter 4.3.3 "Terminal Block (TB) Definition" on Page 15.</li> </ul>
	Device is in multi-drop mode	Set for the polling address "0". See Chapter 7.6.4.1 "HART Output" on Page 39.
Current output is always 4 mA	Parameter "Loop Current Mode" is set to "Disabled".	Select for parameter "Loop Current Mode" the option "Enabled". See Chapter 7.6.3.1 "Analog Output" on Page 37.
Incorrect measurement readings	Sensor is incorrectly configured.	<ul style="list-style-type: none"> <li>– Configure sensor correctly. See Chapter 7 "Menu Overview and Menu Description" on Page 24.</li> <li>– Perform reset. See Chapter 7.6.6.1 "Reset" on Page 42.</li> </ul>
Settings cannot be changed.	Transmitter is locked	Unlock transmitter. See Chapter 7.6.6 "System" on Page 41.

Table 34: Troubleshooting



**NOTE!**

The **Diagnostics & Service** menu shows information about the transmitter and the connected sensor and supports you in troubleshooting. See Chapter 7.5 "Menu "Diagnostics & Service"" on Page 27.

Alarms are shown in the **Messages** menu. See Chapter 7.5.1.1 "Messages" on Page 27.

## 9 Technical Data

### pH/ORP (incl. pH/pNa)

Measurement parameters	pH, mV and temperature
pH measuring range	-2.00 to +20.00 pH
ORP input range	-1500 to +1500 mV
Temperature measuring range	-30 to 130 °C (-22 to 266 °F)
Max. sensor cable length	80 m (260 ft)
Calibration	- Configuration tool: Process, 1-point and 2-point - iSense software: 1-point and 2-point

### Amperometric oxygen

Measurement parameters	Dissolved oxygen: Saturation or concentration and temperature
Oxygen measuring ranges	- Saturation: 0 to 500 % air, 0 to 200 % O <sub>2</sub> - Concentration: 0 ppb (µg/L) to 50.00 ppm (mg/L)
Polarization voltage	-550 mV or -674 mV (configurable)
Temperature input	NTC 22 kΩ, Pt1000, Pt100
Temperature compensation	Automatic
Temperature measuring range	-10 to +80 °C (+14 to +176 °F)
Max. sensor cable length	80 m (260 ft)
Calibration	- Configuration tool: Process and 1-point - iSense software: 1-point

### Conductivity 4-e

Measurement parameters	Conductivity/resistivity and temperature
Conductivity ranges	0.01 to 650 mS/cm (1.54 Ω x cm to 0.1 MΩ x cm)
Chemical concentration curves	NaCl: 0-26 % @ 0 °C to 0-28 % @ +100 °C NaOH: 0-12 % @ 0 °C to 0-16 % @ +40 °C to 0-6 % @ +100 °C HCl: 0-18 % @ -20 °C to 0-18 % @ 0 °C to 0-5 % @ +50 °C HNO <sub>3</sub> : 0-30 % @ -20 °C to 0-30 % @ 0 °C to 0-8 % @ +50 °C H <sub>2</sub> SO <sub>4</sub> : 0-26 % @ -12 °C to 0-26 % @ +5 °C to 0-9 % @ +100 °C H <sub>3</sub> PO <sub>4</sub> : 0-35 % @ +5 °C to +80 °C
TDS ranges	NaCl, CaCO <sub>3</sub>
Temperature input	Pt1000
Temperature measuring range	-40 to +200 °C (-40 to +392 °F)
Max. sensor cable length	80 m (260 ft)
Calibration	- Configuration tool: Process, 1-point and 2-point - iSense software: 1-point and 2-point

**General electrical specifications**

Output	Analog output 4 to 20 mA with HART®
HART Communication	Digital communication via FSK modulation of the analog output, device identification, measured values, status and messages, parameters, calibration, ISM diagnostics (DLI, ACT and TTM)
Operation	Via configuration tool, Asset Management Tool or HART handheld terminal
Supply voltage	14 to 30 V DC
Connection terminals	Spring cage terminals, appropriate for wire cross section 0.2 to 1.5 mm <sup>2</sup> (AWG 16–24)
Galvanic isolation	Inputs, output and earth/ground are galvanically isolated up to 500 V.
Analog output	Loop current 4 to 20 mA
Accuracy analog output	< ±0.05 mA over 4 to 20 mA
Analog input	4 to 20 mA (for pressure compensation)
Digital input	For switching transmitter in Hold state Switching voltage (selectable): – Low: 0.0 to 1.0 V DC – High: 2.3 to 30.0 V DC
Alarm	For sensor disconnected, 22 mA
Real time clock	Fixed time and date format. The format cannot be changed. Power reserve: > 5 days

**Environmental specifications**

Storage temperature	–40 to +70 °C (–40 to +158 °F)
Ambient temperature operating range	–20 to +60 °C (–4 to +140 °F)
Relative humidity	0 to 95 % non-condensing
EMC	According to EN 61326-1 (general requirements) Emission: Class B, Immunity: Class A
CE mark	The measuring system is in conformity with the statutory requirements of the EC Directives. METTLER TOLEDO confirms successful testing of the device by affixing to it the CE mark.

**Mechanical specifications**

Dimensions	See Chapter 3.2 “Design” on Page 11.
Suitable DIN rail systems	35 mm wide
Weight	0.5 kg
Material	PA-FR
Enclosure rating	IP 20

## 10 Default Values

### 10.1 Default Values for pH/ORP or pH/pNa Sensors

Menu	Sub menu	Parameter	Value	Unit	
Measurements	Channel Setup	PV is	pH	pH	
		SV is	Temperature	°C	
		TV is	DLI	days	
		QV is	TTM	days	
		PV/SV/TV/QV Average	Special	–	
	pH		Stability	Medium	–
			pH Buffer	pH/ORP: Mettler-9	–
				pH/pNa: Na+3.9M	–
			IP	7.0	pH
			STC Ref Mode	No	–
			STC Value	0.00	pH/°C
	STC Ref Temp	25	°C		
Output Condition	Analog Output	Loop Current Mode	Enabled	–	
		Alarm Type	Hi (22.0 mA)	–	
		Hold Mode	Last Value	–	
		Hold Fixed	3.6	mA	
	Analog Output > Range	PV LRV = PV LSL	2	pH	
		PV URV = PV USL	12	pH	
	Hold Output	CAL Hold Output	No	–	
		Manual Hold	Stop (when power on)	–	
Din1 Hold State		Low	–		
ISM Setup	–	CIP Limit	0	–	
		SIP Limit	0	–	
		Autoclave Limit	0	–	
	Sensor Monitoring Setup	DLI Monitoring	On	–	
		TTM Monitoring	On	–	
Alarm Setup	–	Alarm Byte 0	Rg diagnostics = Yes	–	
			Rr diagnostics = Yes	–	
		Alarm Byte 1	Software Failure = No	–	

## 10.2 Default Values for O<sub>2</sub> Sensors

Menu	Sub menu	Parameter	Value	Unit	
Measurements	Channel Setup	PV is	O2	O2 Hi: %air O2 Lo and O2 Trace: ppb	
		SV is	Temperature	°C	
		TV is	DLI	days	
		QV is	TTM	days	
		PV/SV/TV/QV Average	Special	–	
	O2	Pcal Pressure	759.8	mmHg	
		Process Cal Pressure Source	Pcal_Pressure	–	
		Process Pressure Mode	Edit	–	
		Process Pressure	759.8	mmHg	
		Salinity	0	g/kg	
		Humidity	100	%	
		Umeaspol	Reading from sensor	mV	
	Output Condition	Analog Output	Loop Current Mode	Enabled	–
			Alarm Type	Hi (22.0 mA)	–
Hold Mode			Last Value	–	
Hold Fixed			3.6	mA	
Analog Output > Range		PV LRV = PV LSL	0	Same as PV is	
		PV URV = PV USL	100	Same as PV is	
Hold Output		CAL Hold Output	No	–	
	Manual Hold	Stop (when power on)	–		
	Din1 Hold State	Low	–		
ISM Setup	–	CIP Limit	0	–	
		SIP Limit	0	–	
		Autoclave Limit	0	–	
	Sensor Monitoring Setup	DLI Monitoring	On	–	
		TTM Monitoring	On	–	
		ACT Monitoring	On	–	
Alarm Setup	–	Alarm Byte 1	Software Failure = No	–	
			Electrolyte Level = Yes	–	

### 10.3 Default Values for Conductivity Sensors

Menu	Sub menu	Parameter	Value	Unit
Measurements	Channel Setup	PV is	Conductivity	mS/cm
		SV is	Temperature	°C
		TV is	None	–
		QV is	None	–
		PV/SV/TV/QV Average	Special	–
	Conductivity	Compensation Mode	Standard	–
		Linear Coefficient	2.0 %/°C	–
Output Condition	Analog Output	Loop Current Mode	Enabled	–
		Alarm Type	Hi (22.0 mA)	–
		Hold Mode	Last Value	–
		Hold Fixed	3.6	mA
	Analog Output > Range	PV LRV = PV LSL	0	mS/cm
		PV URV = PV USL	500	mS/cm
	Hold Output	CAL Hold Output	No	–
		Manual Hold	Stop (when power on)	–
		Din1 Hold State	Low	–
Alarm Setup	–	Alarm Byte 1	Software Failure = No	–
			Dry Cond Sensor = No	–
			Cell Constant Deviation = No	–
			Cond Sensor Shorted = No	–



# 11 Buffer Tables

M100 DR transmitters have the ability to do automatic pH buffer recognition. The following tables show different standard buffers that are automatically recognized.

## 11.1 Buffers for pH/ORP Sensors

### 11.1.1 Mettler-9

Temp (°C)	pH of buffer solutions			
0	2.03	4.01	7.12	9.52
5	2.02	4.01	7.09	9.45
10	2.01	4.00	7.06	9.38
15	2.00	4.00	7.04	9.32
20	2.00	4.00	7.02	9.26
25	2.00	4.01	7.00	9.21
30	1.99	4.01	6.99	9.16
35	1.99	4.02	6.98	9.11
40	1.98	4.03	6.97	9.06
45	1.98	4.04	6.97	9.03
50	1.98	4.06	6.97	8.99
55	1.98	4.08	6.98	8.96
60	1.98	4.10	6.98	8.93
65	1.98	4.13	6.99	8.90
70	1.99	4.16	7.00	8.88
75	1.99	4.19	7.02	8.85
80	2.00	4.22	7.04	8.83
85	2.00	4.26	7.06	8.81
90	2.00	4.30	7.09	8.79
95	2.00	4.35	7.12	8.77

### 11.1.2 Mettler-10

Temp (°C)	pH of buffer solutions				
0	2.03	4.01	7.12	10.65	
5	2.02	4.01	7.09	10.52	
10	2.01	4.00	7.06	10.39	
15	2.00	4.00	7.04	10.26	
20	2.00	4.00	7.02	10.13	
25	2.00	4.01	7.00	10.00	
30	1.99	4.01	6.99	9.87	
35	1.99	4.02	6.98	9.74	
40	1.98	4.03	6.97	9.61	
45	1.98	4.04	6.97	9.48	
50	1.98	4.06	6.97	9.35	
55	1.98	4.08	6.98		
60	1.98	4.10	6.98		
65	1.99	4.13	6.99		
70	1.98	4.16	7.00		
75	1.99	4.19	7.02		
80	2.00	4.22	7.04		
85	2.00	4.26	7.06		
90	2.00	4.30	7.09		
95	2.00	4.35	7.12		

### 11.1.3 NIST Technical

Temp (°C)	pH of buffer solutions				
0	1.67	4.00	7.115	10.32	13.42
5	1.67	4.00	7.085	10.25	13.21
10	1.67	4.00	7.06	10.18	13.01
15	1.67	4.00	7.04	10.12	12.80
20	1.675	4.00	7.015	10.07	12.64
25	1.68	4.005	7.00	10.01	12.46
30	1.68	4.015	6.985	9.97	12.30
35	1.69	4.025	6.98	9.93	12.13
40	1.69	4.03	6.975	9.89	11.99
45	1.70	4.045	6.975	9.86	11.84
50	1.705	4.06	6.97	9.83	11.71
55	1.715	4.075	6.97		11.57
60	1.72	4.085	6.97		11.45
65	1.73	4.10	6.98		
70	1.74	4.13	6.99		
75	1.75	4.14	7.01		
80	1.765	4.16	7.03		
85	1.78	4.18	7.05		
90	1.79	4.21	7.08		
95	1.805	4.23	7.11		

### 11.1.4 NIST Standard (DIN and JIS 19266: 2000–01)

Temp (°C)	pH of buffer solutions			
0				
5	1.668	4.004	6.950	9.392
10	1.670	4.001	6.922	9.331
15	1.672	4.001	6.900	9.277
20	1.676	4.003	6.880	9.228
25	1.680	4.008	6.865	9.184
30	1.685	4.015	6.853	9.144
35	1.694	4.028	6.841	9.095
40	1.697	4.036	6.837	9.076
45	1.704	4.049	6.834	9.046
50	1.712	4.064	6.833	9.018
55	1.715	4.075	6.834	8.985
60	1.723	4.091	6.836	8.962
70	1.743	4.126	6.845	8.921
80	1.766	4.164	6.859	8.885
90	1.792	4.205	6.877	8.850
95	1.806	4.227	6.886	8.833



#### NOTE!

The pH(S) values of the individual charges of the secondary reference materials are documented in a certificate of an accredited laboratory. This certificate is supplied with the respective buffer materials. Only these pH(S) values shall be used as standard values for the secondary reference buffer materials. Correspondingly, this standard does not include a table with standard pH values for practical use. The table above only provides examples of pH(PS) values for orientation.

### 11.1.5 Hach

Buffer values up to 60 °C as specified by Bergmann & Beving Process AB.

Temp (°C)	pH of buffer solutions		
0	4.00	7.14	10.30
5	4.00	7.10	10.23
10	4.00	7.04	10.11
15	4.00	7.04	10.11
20	4.00	7.02	10.05
25	4.01	7.00	10.00
30	4.01	6.99	9.96
35	4.02	6.98	9.92
40	4.03	6.98	9.88
45	4.05	6.98	9.85
50	4.06	6.98	9.82
55	4.07	6.98	9.79
60	4.09	6.99	9.76

### 11.1.6 Ciba (94)

Temp (°C)	pH of buffer solutions			
0	2.04	4.00	7.10	10.30
5	2.09	4.02	7.08	10.21
10	2.07	4.00	7.05	10.14
15	2.08	4.00	7.02	10.06
20	2.09	4.01	6.98	9.99
25	2.08	4.02	6.98	9.95
30	2.06	4.00	6.96	9.89
35	2.06	4.01	6.95	9.85
40	2.07	4.02	6.94	9.81
45	2.06	4.03	6.93	9.77
50	2.06	4.04	6.93	9.73
55	2.05	4.05	6.91	9.68
60	2.08	4.10	6.93	9.66
65	2.07*	4.10*	6.92*	9.61*
70	2.07	4.11	6.92	9.57
75	2.04*	4.13*	6.92*	9.54*
80	2.02	4.15	6.93	9.52
85	2.03*	4.17*	6.95*	9.47*
90	2.04	4.20	6.97	9.43
95	2.05*	4.22*	6.99*	9.38*

\* Extrapolated

### 11.1.7 Merck Titrisole, Riedel-de-Haën Fixanale

Temp (°C)	pH of buffer solutions				
0	2.01	4.05	7.13	9.24	12.58
5	2.01	4.05	7.07	9.16	12.41
10	2.01	4.02	7.05	9.11	12.26
15	2.00	4.01	7.02	9.05	12.10
20	2.00	4.00	7.00	9.00	12.00
25	2.00	4.01	6.98	8.95	11.88
30	2.00	4.01	6.98	8.91	11.72
35	2.00	4.01	6.96	8.88	11.67
40	2.00	4.01	6.95	8.85	11.54
45	2.00	4.01	6.95	8.82	11.44
50	2.00	4.00	6.95	8.79	11.33
55	2.00	4.00	6.95	8.76	11.19
60	2.00	4.00	6.96	8.73	11.04
65	2.00	4.00	6.96	8.72	10.97
70	2.01	4.00	6.96	8.70	10.90
75	2.01	4.00	6.96	8.68	10.80
80	2.01	4.00	6.97	8.66	10.70
85	2.01	4.00	6.98	8.65	10.59
90	2.01	4.00	7.00	8.64	10.48
95	2.01	4.00	7.02	8.64	10.37

### 11.1.8 WTW

Temp (°C)	pH of buffer solutions			
0	2.03	4.01	7.12	10.65
5	2.02	4.01	7.09	10.52
10	2.01	4.00	7.06	10.39
15	2.00	4.00	7.04	10.26
20	2.00	4.00	7.02	10.13
25	2.00	4.01	7.00	10.00
30	1.99	4.01	6.99	9.87
35	1.99	4.02	6.98	9.74
40	1.98	4.03	6.97	9.61
45	1.98	4.04	6.97	9.48
50	1.98	4.06	6.97	9.35
55	1.98	4.08	6.98	
60	1.98	4.10	6.98	
65	1.99	4.13	6.99	
70		4.16	7.00	
75		4.19	7.02	
80		4.22	7.04	
85		4.26	7.06	
90		4.30	7.09	
95		4.35	7.12	

### 11.1.9 JIS Z 8802

Temp (°C)	pH of buffer solutions			
0	1.666	4.003	6.984	9.464
5	1.668	3.999	6.951	9.395
10	1.670	3.998	6.923	9.332
15	1.672	3.999	6.900	9.276
20	1.675	4.002	6.881	9.225
25	1.679	4.008	6.865	9.180
30	1.683	4.015	6.853	9.139
35	1.688	4.024	6.844	9.102
38	1.691	4.030	6.840	9.081
40	1.694	4.035	6.838	9.068
45	1.700	4.047	6.834	9.038
50	1.707	4.060	6.833	9.011
55	1.715	4.075	6.834	8.985
60	1.723	4.091	6.836	8.962
70	1.743	4.126	6.845	8.921
80	1.766	4.164	6.859	8.885
90	1.792	4.205	6.877	8.850
95	1.806	4.227	6.886	8.833

### 11.1.10 Buffer for Dual Membrane pH Electrodes (pH/pNa)

#### 11.1.10.1 Mettler-pH/pNa (Na+ 3.9M)

Temp (°C)	pH of buffer solutions			
0	1.98	3.99	7.01	9.51
5	1.98	3.99	7.00	9.43
10	1.99	3.99	7.00	9.36
15	1.99	3.99	6.99	9.30
20	1.99	4.00	7.00	9.25
25	2.00	4.01	7.00	9.21
30	2.00	4.02	7.01	9.18
35	2.01	4.04	7.01	9.15
40	2.01	4.05	7.02	9.12
45	2.02	4.07	7.03	9.11
50	2.02	4.09	7.04	9.10

## 12 Warranty

METTLER TOLEDO warrants this product to be free from significant deviations in material and workmanship for a period of one year from the date of purchase. If repair is necessary and not the result of abuse or misuse within the warranty period, please return by freight pre-paid and amendment will be made without any charge. METTLER TOLEDO's Customer Service Dept. will determine if the product problem is due to deviations or customer abuse. Out-of-warranty products will be repaired on an exchange basis at cost.

The above warranty is the only warranty made by METTLER TOLEDO and is lieu of all other warranties, expressed or implied, including, without limitation, implied warranties of merchantability and fitness for a particular purpose. METTLER TOLEDO shall not be liable for any loss, claim, expense or damage caused by, contributed to or arising out of the acts or omissions of the Buyer or Third Parties, whether negligent or otherwise. In no event shall METTLER TOLEDO's liability for any cause of action whatsoever exceed the cost of the item giving rise to the claim, whether based in contract, warranty, indemnity, or tort (including negligence).

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