

Special Documentation

Cerabar PMC71B, PMP71B

Deltabar PMD75B, PMD78B

HART

Application package
Heartbeat Verification + Monitoring



1 About this document

1.1 Document function

This manual is a Special Documentation and does not replace the Operating Instructions included in the scope of supply. It is a part of the Operating Instructions and serves as a reference for using the Heartbeat Technology function integrated in the measuring device.

1.2 Content and scope

This document contains descriptions of the additional parameters and technical data of the application package and detailed explanations regarding:

- Application-specific parameters
- Advanced technical specifications

1.3 Symbols used

1.3.1 Safety symbols

CAUTION

This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.

DANGER

This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.

NOTICE

This symbol contains information on procedures and other facts which do not result in personal injury.

WARNING

This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.

1.3.2 Symbols for certain types of information and graphics



Warns against radioactive substances or ionizing radiation



Permitted

Procedures, processes or actions that are permitted



Preferred

Procedures, processes or actions that are preferred



Forbidden

Procedures, processes or actions that are forbidden

**Tip**

Indicates additional information



Reference to documentation



Reference to page



Reference to graphic



Notice or individual step to be observed

1., 2., 3.

Series of steps



Result of a step



Operation via local display



Operation via operating tool



Write-protected parameter

1, 2, 3, ...

Item numbers

A, B, C, ...

Views

**Safety instructions**

Observe the safety instructions contained in the associated Operating Instructions

1.4 Documentation



For an overview of the scope of the associated Technical Documentation, refer to the following:

- *W@M Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from nameplate
- *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2D matrix code (QR code) on the nameplate

This documentation is not a substitute for the Operating Instructions supplied with the device.

Detailed information: Operating Instructions, additional documentation, Device Viewer.

This documentation is an integral part of the Operating Instructions for the device.

1.5 Registered trademarks

HART®

Registered trademark of the FieldComm Group, Austin, Texas, USA

2 Product features and availability

2.1 Product features

Heartbeat Technology offers diagnostic functionality through continuous self-monitoring, the transmission of additional measured variables to an external Condition Monitoring system and the in-situ verification of measuring devices in the application.

The test scope achieved using these diagnostic and verification tests is referred to as the **total test coverage** (TTC). The total test coverage is calculated using the following formula for random errors (calculation based on FMEDA as per IEC 61508):

$$TTC = (\lambda_{TOT} - \lambda_{du}) / \lambda_{TOT}$$

λ_{TOT} : Rate of all theoretically possible failures

λ_{du} : Rate of undetected dangerous failures

The undetected dangerous failures are not diagnosed by the device diagnostics. If these failures occur, they can falsify the measured value that is displayed or interrupt the output of measured values.

Heartbeat Technology checks the device function with a defined TTC.

TTC > 96 % for output of measured values via 4 to 20 mA output

- Simulation operation not active
- Error behavior, current output set to Minimum alarm or Maximum alarm and evaluation unit recognizes both alarms
- Settings for diagnostic behavior correspond to factory settings

TTC > 93 % for output of measured values via HART output

- Simulation operation not active
- Error behavior, HART bus configured according to "HART Communication Protocol" and evaluation unit recognizes alarms (e.g. device errors)
- Settings for diagnostic behavior correspond to factory settings

2.2 Availability

The application package can be ordered together with the device or can be activated subsequently with an activation code. Detailed information on the order code is available via the Endress+Hauser website www.endress.com or from your local Endress+Hauser Sales Center.

2.2.1 Order code

If ordering directly with the device or subsequently as a retrofit kit:

Order code 540 "Application package", option EH "Heartbeat Verification + Monitoring"

The availability of the application package can be checked as follows:

- Order code with breakdown of the device features on the delivery note
- On the Web using the Device Viewer (www.endress.com/deviceviewer): enter the serial number from the nameplate and check whether the order code is displayed
- In the operating menu: The menu indicates whether the application package is activated.

2.2.2 Activation

A retrofit kit is supplied if the application package is ordered subsequently. This kit includes a tag plate with device data and an activation code.

Menu path for entering the activation code

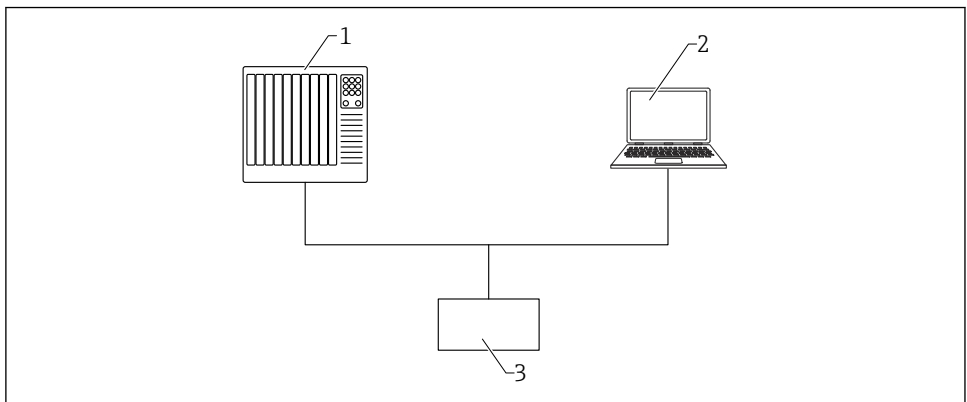
System → Software configuration → Activate SW option

2.2.3 Access

Heartbeat Technology is compatible with all the system integration options. Interfaces with digital communication are required to access the data saved in the device. The speed of data transmission depends on the type of communication interface used.

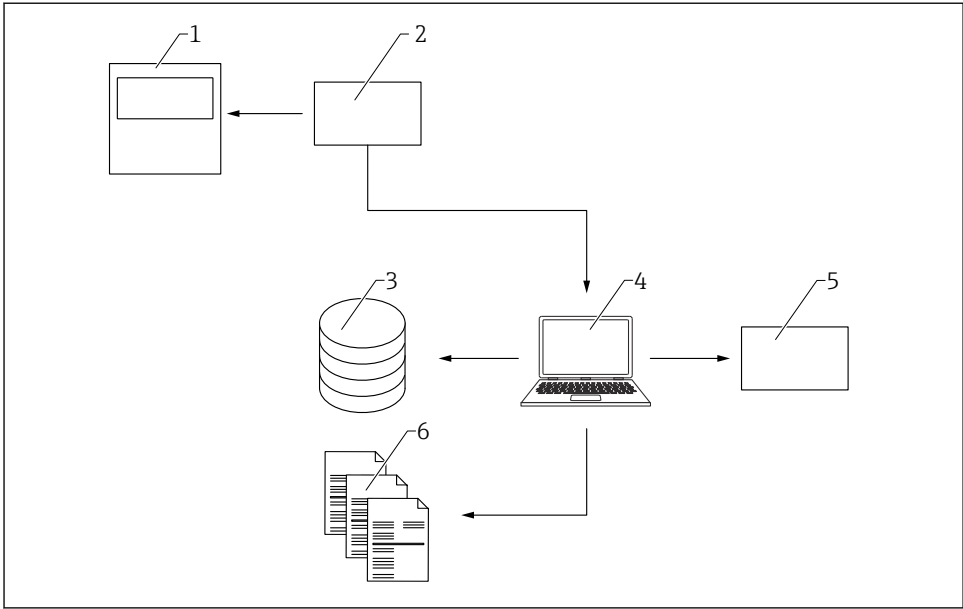
3 System integration

The **Heartbeat Technology** features are available via the digital interfaces. The features can be used via an asset management system and the automation infrastructure (e.g. PLC).



A0040019

- 1 PLC
- 2 Asset management system
- 3 Measuring device



A0040020

- 1 Local display
- 2 Measuring device
- 3 Data archive
- 4 FieldCare
- 5 Netilion Library or W@M Portal
- 6 Verification report

Run **Heartbeat Verification** via one of the following interfaces:

- System integration interface of a higher-level system
- Common Data Interface (CDI)
- Display (optional)
- Bluetooth (optional)

To start a verification and signal the result (Passed or Failed) the device must be accessed externally from a higher-level system via the system integration interface. It is not possible to start the verification via an external status signal and relay the results to a higher-level system via the status output.

The detailed results of the verification are saved in the device and provided in the form of a verification report. The last verification report is saved in the device.

Verification reports can be created using Endress+Hauser's FieldCare plant asset management software.

3.1 Data transfer by the user

3.1.1 Heartbeat Verification

- Start the verification
- Upload, archive and document the verification results including detailed results

Prerequisites include HART-7-compatible IO cards and the use of manufacturer-specific HART commands.

3.1.2 Heartbeat Monitoring

- Configuration of the monitoring function: specify which monitoring parameters are output continuously via the system integration interface.
- The user can read the monitoring measured variables in the verification report or in the operating menu.
- Heartbeat Monitoring data can be transmitted to higher-level systems and used for predictive maintenance and process optimization.

3.1.3 Monitoring data in the cyclic HART signal

Data to detect blocked impulse lines / process KPIs

The **SSD: Statistical Sensor Diagnostics** wizard must be started to transmit the following data:

- Median of pressure signal
- Current Baseline noise

Loop integrity data

- Terminal voltage
- Terminal current

Temperature profiling / heat tracer data

- Process Temperature
- Electronic temperature

3.1.4 Acyclic monitoring data via HART command

Mechanical stress data

- Counter limit underruns sensor Pmin
- Counter limit overruns sensor Pmax
- Counter underruns of user limit Pmin
- Counter overruns of user limit Pmax
- Pressure min
- Pressure max

Thermal stress data

- Counter limit underruns sensor Tmin
- Counter limit overruns sensor Tmax
- Counter underruns of user limit Tmin
- Counter overruns of user limit Tmax
- Minimum sensor temperature

- Maximum sensor temperature
- Minimum electronics temperature
- Maximum electronics temperature

Electrical stress data

- Minimum terminal voltage
- Maximum terminal voltage

3.2 Data management

The result of a **Heartbeat Verification** is saved as a non-volatile parameter set in the measuring device memory:

New verification results overwrite old data following the FIFO ¹⁾ principle

3.2.1 Verification result

A verification report is created in PDF format.



Prerequisite: A verification has already been performed.

3.2.2 File management

W@M Portal

Heartbeat verification reports can be saved electronically and assigned to the tested device with the Endress+Hauser W@M portal. This way, the reports are:

- online
- easy to find
- automatically assigned to their digital twin
- always accessible

Netilion Library

Heartbeat verification reports can be saved in Netilion with the Netilion Library (www.netilion.endress.com). They can be uploaded by notebook, smartphone or a Field Xpert tablet.

The verification reports are then:

- online
- automatically assigned to their digital twin
- even easier to find
- always accessible



The stored reports are always available and easy to find for everyone requiring access to the reports. Both tools allow document forwarding and linking, and notification.

1) First In – First Out

4 Heartbeat Verification

Heartbeat Verification uses the self-monitoring function of the measuring devices to check the measuring device functionality. During the verification process, the system checks whether the measuring device components comply with the factory specifications. Both the sensor and the electronics modules are included in the tests.

Heartbeat Verification checks the device function on demand with the total test coverage (TTC) specified in Section 2.1. The result of the verification is "Passed" or "Failed". The verification data are saved in the device and, optionally, are archived on a PC with the FieldCare asset management software. A verification report is generated automatically on the basis of these data to ensure the traceable documentation of the verification results.


It is possible to manually record reference data relating to the operator and the location. These reference data appear on the verification report.



Operation continues while the reference data are being recorded.

4.1 Performance characteristics

Heartbeat Verification is performed on demand and complements the self-monitoring function, which is performed constantly, with other tests.

The verification confirms on demand the device function with the specified total test coverage (TTC) →  4.

4.2 Operation

4.2.1 Device behavior and interpretation

Result "Passed"

All the test results are within the specifications whose limits are indicated in the verification report.

Result "Failed"

One or more test results are outside the specifications.

The cause of the error can be narrowed down if the test group whose result is **Failed** is identified.

4.2.2 Verification

Perform verification via tooling (SmartBlue and DTM-based tools like FieldCare/ DeviceCare)

Guidance → Heartbeat Technology → Heartbeat Verification

Select the "START" option here

Displaying the verification status and result

The result of the verification is displayed in the **Verification result** parameter




4.2.3 Verification results

Access to the verification results via:

- SmartBlue
- DTM-based tools (e.g. FieldCare or DeviceCare)

Classification of results


Individual results:

-  **Failed**
At least one individual test in the test group was outside the specifications.
-  **Passed**
All individual tests in the test group complied with the specifications. The result is also "Passed option" if the result of an individual test is "Not done option" and the result of all other tests is "Passed option".
-  **Not done**
No test has been performed for this test group. For example, because this parameter is not possible or not enabled in the current device configuration.

Overall results:

- **Failed**
At least one test group was outside the specifications.
- **Passed**
All verified test groups complied with the specifications (result "Passed option").



Heartbeat Verification confirms on demand the device function with a TTC ²⁾ > 95 %
→  4.

4.2.4 Verification report

The results of the verification can be documented in the form of a verification report via the FieldCare, Device Care or SmartBlue operating tool. The verification report is created on the basis of the data records saved in the measuring device after verification. As the verification results are automatically and uniquely identified with the operating time, they are suitable for the traceable documentation of the verification of measuring devices.

2) Total test coverage

Verification report, section 1

Measuring point identification, identification of the verification result and confirmation of completion:

- Plant operator
 - Customer reference
- Device information
 - Information on the place of operation
 - Device name
 - Management of the information in the device
 - Firmware and hardware version
- Calibration
 - Setting: **Calibration offset** parameter, **Lower range value** parameter, **Upper range value** parameter, **Checksum** parameter, information on loop diagnostics (if enabled): Timestamp Baseline, Resistance Baseline, Supply voltage Baseline
- Verification information
 - Operating time for the clear assignment of the results. This aids the traceable documentation of the verification.
 - The system time is indicated in addition to the current operating time in the measuring device
- Verification result
 - The overall result of the verification is "passed" if all of the individual results are "passed"

Verification result, section 2

Details on the individual results for all test groups:

- Device and verification information
- Test groups
 - Verification pre-condition
 - Mainboard module
 - Sensor module

Verification result- values, section 3

Details with values for the individual tests from section 2

Verification result, section 4

Additional data that can influence the assessment of the measurement results or the appraisal of the process conditions. Information regarding:

- Process condition
 - HART signal
 - HART signal quality
 - Sensor pressure
 - Zero adjustment offset
 - Sensor temperature
 - Electronic temperature
 - System status
- Historical values of the measuring device
 - Pressure min
 - Pressure max
 - Minimum sensor temperature
 - Maximum sensor temperature
 - Minimum electronics temperature
 - Maximum electronics temperature
 - Minimum terminal voltage
 - Maximum terminal voltage
- Sensor history
 - Counter limit underruns sensor Tmin
 - Counter limit overruns sensor Tmax
 - Counter limit underruns sensor Pmin
 - Counter limit overruns sensor Pmax
 - Counter limit underruns sensor Pmin
 - Counter limit overruns sensor Pmax
 - Counter underruns of user limit Pmin
 - Counter overruns of user limit Pmax
 - Counter underruns of user limit Pmin
 - Counter overruns of user limit Pmax
 - Counter for power-on
 - Counter Baseline creation SSD

4.2.5 Verification criteria for the test objects

Verification pre-condition

Check: **System status** parameter

Function: Checks active measurement device errors at diagnostical behavior 'alarm'. If an active error is detected, then verification will be performed but the overall result will always be 'Failed'.

Mainboard module

- Check: **Terminal voltage** parameter
Function: Checks if the voltage at the supply terminals is within the specified limits.
If the maximum terminal voltage is exceeded, this can damage the device. If the supply voltage is constantly in the maximum range, this can reduce the operating life of the device.
A device failure can occur if the terminal voltage drops below the minimum terminal voltage level.
- Check: **Output current** parameter
Function: Checks whether read-back current at the output matches the current set by the device.
- Check: **Software integrity** parameter
Function: Checks whether the function blocks of the software are executed in the correct order.
- Check: **RAM check** parameter
Function: Checks the correct function of the RAM (Random Access Memory).
- Check: **ROM check** parameter
Function: Checks the correct function of the ROM memory (Read-Only-Memory).
- Check: loop diagnostics
Function: checks whether the voltage/current is within the thresholds of the voltage/current baseline. Only visible if enabled.

Sensor module

- Check: **Sensor integrity** parameter / **Membrane integrity** parameter³⁾
Function: checks the integrity of the sensor. The scope of the check depends on the type of sensor.
- Check: **Statistical Sensor Diagnostics** parameter
Function: checks whether the current measured values are within the limits of the signal/signal noise baseline values that were built. Only visible if enabled.

4.2.6 Additional verification information

Process conditions at the time of the verification

- Display **Sensor temperature** parameter
Function: current temperature and permitted min/max range
- HART signal quality indicator
Function: share of defective data frames in relation to the total number of data frames received.
Possible reasons for poor signal quality include:
 - EMC influence
 - A defective device on the same bus
 - Poor contacts
 - A resistor of the wrong size

3) The membrane integrity cannot be checked on all sensors

Device history

Current value and min/max values for:

- Electronic temperature
- Sensor temperature
- Sensor pressure
- Terminal voltage

Sensor history

- Counter **Sensor temperature** parameter, **Sensor pressure** option
Function: number of times the specified limits are overshoot or undershot
- Counter **Sensor temperature** parameter, **Sensor pressure** option: user-defined limits
Function: number of times the defined limits are overshoot or undershot
- Counter for power-on
Function: number of device reboots
- Counter Baseline creation SSD
Function: number of built baselines

4.3 Proof testing

Proof testing wizards are provided for devices with the SIL option and the "Heartbeat Verification + Monitoring" application package. See the Functional Safety Manual.

5 Heartbeat Monitoring

Several Heartbeat Monitoring Wizards are available. Furthermore, additional monitoring parameters can be displayed and used for predictive maintenance or application optimization.

5.1 "SSD: Statistical Sensor Diagnostics" Wizard

A statistical analysis of the raw pressure signal (SSD) can detect a variety of unwanted process anomalies.

5.1.1 Areas of application

All process anomalies that deviate from the programmed standard operation and affect the signal noise. Typical applications include blocked impulse lines, incorrect valve position following maintenance, or air entrainment in water-based media.

A number of conditions must be met for successful detection in the application:

- There should be signal noise, e.g. flow applications
- There should be an adequate ratio of signal noise to actual pressure. This is usually the case in differential pressure applications with Deltabar, but rare in high-pressure applications with Cerabar
- Process dynamics should be at a minimum so a usable baseline can be created.

A number of prerequisites are checked during baseline creation or commissioning to ensure correct operation.

5.1.2 Commissioning

As the Wizard does not interfere with the 4-20 mA signal circuit, the SSD configuration can be performed during operation.

The settings must be adapted to the process conditions to ensure the device functions in line with user needs. Build the **Current Baseline signal** and **Current Baseline noise** parameters under recurrent process conditions. The diagnostic function is only active if the current process conditions are within the signal baseline bandwidth that is to be defined. If the current process conditions are outside the programmed process conditions, e.g. at the weekend or during system start-up, statistical analysis does not take place. Unwanted messages are avoided in this way.

The following parameters must be configured:

Current Baseline signal

Arithmetic average of the pressure signal (25 measured values). Perform under recurrent process conditions. This measured variable is analyzed in order to characterize the process conditions in the normal state. If process conditions are outside the defined limits, the function is set to "Idle".

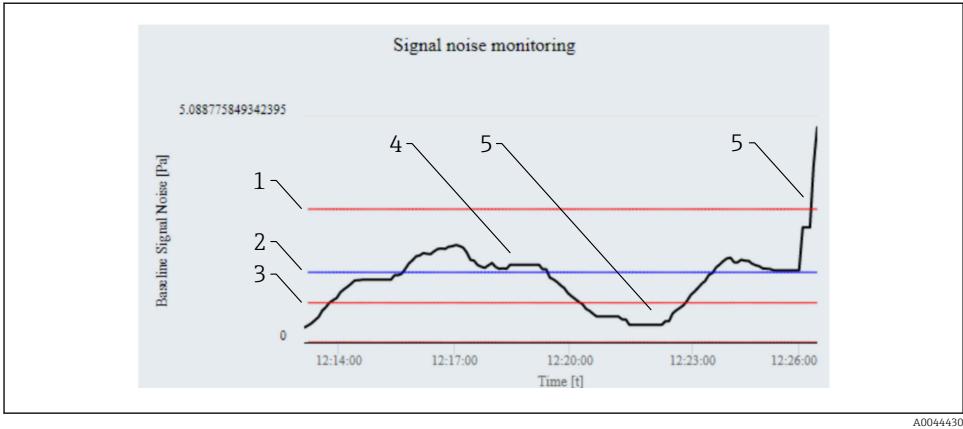
Baseline Signal Lower Control Line ⁴⁾ and Baseline Signal Upper Control Line ⁵⁾

Defines the bandwidth above (UCL) or below (LCL) the baseline in which statistical analysis or anomaly detection is "**Active** option".

Perform under recurrent process conditions. The recorder function and/or the min/max values in the Wizard can be used to specify as narrow a bandwidth as possible. The value must be > 0 .

4) Lower limit value for signal noise

5) Upper limit value for signal noise



- 1 Upper threshold
- 2 Baseline
- 3 Lower threshold
- 4 Current signal noise
- 5 Anomaly

Current Baseline noise

The signal noise is determined with this process value.

The interquartile range indicates the width of the interval that contains the middle 50 % of the measuring points. This measured variable is analyzed in order to detect process anomalies.

Baseline Signal Noise Lower Control Line and Baseline Signal Noise Upper Control Line

Ideally, these limit values are defined by actively simulating the process anomaly that is to be detected. For example, the valve for the differential pressure transmitter can be closed in order to simulate a blocked impulse line. It is possible to define the limit value at precisely this point using the recorder function. If this is not possible, the user can define the LCL and UCL values that were produced when the signal baseline was built. Deviations and process anomalies can be identified on the basis of this "normal" state.

Signal Noise Baseline Min

For differential pressure if the two impulse lines are blocked.

"Sample rate" parameter

Specifies the scan rate depending on the process conditions (frequency of transmission of measurement data points for analysis).

- **Fast** option: homogeneous, stable process (factory setting)
One measured value every 200 milliseconds
- **Medium** option: dynamic process
One measured value every second
- **Slow** option: extremely dynamic, variable process
One measured value every 5 seconds.

The time required to build the baseline depends on the scan rate and can take between 3 minutes (**Fast** setting) and up to several minutes (**Slow** setting). The factory setting is **Fast**. Only choose different settings if it is not possible to build a baseline with the **Fast** setting.

Status information

Different status parameters are displayed in order to assess the current process conditions and the monitoring function:

- System status
- Signal noise status
- Signal median status

"SSD Monitoring Delay Time" parameter

Time during which the "Out of range" status must apply before an event message is displayed. Required if conditions are present for a short time. Example: pump start-up phase which the user wants to ignore in order to avoid unwanted event messages.

"Diagnostic behavior" parameter

In addition to the NE107 category (factory setting: "M" maintenance required), the event level specifies how the recognized "Process anomaly" event is to be communicated:

- Logbook entry: no digital or analog communication of the message
- Warning: current output is not changed
Message is output digitally (factory setting)
- Alarm: not allowed

The message is always shown on the display. If a process anomaly event (out of range, signal noise) is recognized and the measurement returns to the permitted range afterwards due to the process conditions, the warning is no longer active in the device.

Enable / Disable

Specify whether the SSD function should be activated. If **"Disable"** is selected, an analysis is not performed and no event message is displayed.

5.2 "Process window" Wizard

Using user-defined limit values, undesired installation and application anomalies can be detected with this Wizard. Pressure shocks < 20 ms are detected here. Therefore it is possible to quantify thermal or mechanical stress on the device or in the process.

5.2.1 Areas of application

- **Temperature:**
Defective trace heating system or insulation, frozen process connections or empty condensate pipes.
- **Pressure:**
Pressure shocks from valves closing quickly, pulsating flow, other unwanted process events that generate dynamic pressure peaks.

5.2.2 Commissioning

The following parameters must be configured.

Temperature min/max. limit value

Specify the range. An event is generated if this limit value is exceeded or undershot. Factory setting: limit values as specified in the Technical Information. There is no hysteresis here.

Pressure min/max. limit value

Specify the range. An event is generated if this limit value is exceeded or undershot. Factory setting: LRL/URL. There is no hysteresis here.

Event level

In addition to the NE107 category (factory setting: "M" maintenance required), the event level specifies how the recognized "Process anomaly" event is to be communicated:

- **Logbook entry:** no digital or analog communication of the message
- **Warning:** current output is not changed
Message is output digitally (factory setting)
- **Alarm:** not allowed

The message is always shown on the display. If a process anomaly event (out of range, temperature) is recognized and the measurement returns to the permitted range afterwards due to the process conditions, the warning is no longer active in the device. Up to 100 events are saved in the logbook.

Enable/disable

Specify whether the function should be activated. If "Disable" is selected, an analysis is not performed and no event message is displayed.

5.2.3 Analysis

The number of times values were over/under range can be used to quantify the mechanical or thermal stress of the measuring point. This information is available in the menu **"Diagnostics"** menu → **Minimum/maximum values** submenu" and can be read out acyclically.

5.3 "Loop diagnostics" Wizard

Undesired electrical installation anomalies can be detected with this Wizard using a built current/voltage characteristic (baseline). Such installation anomalies can result in an incorrect 4 to 20 mA measured value.

5.3.1 Areas of application

Detection of changes in the circuit resistance as a result of anomalies.

Examples:

- Leak currents in the wiring, terminals or grounding caused by corrosion and/or moisture
- Detection of incorrect power supply

5.3.2 Commissioning

The following parameters must be configured.

Building the current/voltage characteristic (baseline)

The voltage at the terminal typically changes in a linear manner depending on the analog output. After initial installation, the current/voltage baseline characteristic is recorded by the measuring circuit via an active current simulation of 4 or 20 mA. The current/voltage characteristic is defined by the slope, i.e. the measuring circuit resistance, and the supply voltage point.

The bandwidth around this characteristic (factory setting 1.5 V) determines when an event is reported.

CAUTION: the current output is simulated. If necessary, bridge the PLC or take other appropriate measures to prevent the inadvertent triggering of alarm messages or changes in the behavior of the control circuit. The baseline cannot be built on a write-protected device.

The current and last baseline of the current/voltage characteristic are saved in the device. Rebuild the baseline if scheduled changes have been implemented in the measuring circuit.

Suggestion:

NOTICE

The current output is simulated. Alarms can be triggered by mistake. The behavior in the control loop can change.

- ▶ Take suitable measures:
- ▶ Bridge the PLC if necessary.
- ▶ Do not build the baseline on a write-protected device.

Delay time

Time during which the "Out of range" status must apply before an event message is displayed. Required if conditions are present for a short time. Factory setting: (in preparation) seconds .

Event level

In addition to the NE107 category (factory setting: "M" maintenance required), the event level specifies how the recognized "Measuring circuit anomaly" event is to be communicated:

- Logbook entry: no digital or analog communication of the message
- Warning: current output is not changed
Message is output digitally (factory setting)
- Alarm: not allowed

The message is always shown on the display.

Enable/disable

Specify whether the function should be activated. If "Disable" is selected, an analysis is not performed and no event message is displayed. In some cases, changes in the measuring circuit resistance can only be detected at high output currents. By rebuilding the baseline, characteristic values can be compared and changes detected.

5.4 Monitoring data

Additional data are available with the Heartbeat Verification + Monitoring application package (see 3.1). The data could be defined continuously as a HART output. The "Statistical Sensor Diagnostics" Wizard must be started and activated for the "Signal Median" and "Signal Noise" parameters.



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