NBN..-F135/135L-...-IO-... Series

Installation and Parameterization of Inductive Sensor Sets with IO-Link Interface

Manual

IO-Link

Your automation, our passion.

PEPPERL+FUCHS

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Worldwide

Pepperl+Fuchs Group

Lilienthalstr. 200

68307 Mannheim

Germany

Phone: +49 621 776 - 0

E-mail: info@de.pepperl-fuchs.com

North American Headquarters

Pepperl+Fuchs Inc.

1600 Enterprise Parkway

Twinsburg, Ohio 44087

USA

Phone: +1 330 425-3555

E-mail: sales@us.pepperl-fuchs.com

Asia Headquarters

Pepperl+Fuchs Pte. Ltd.

P+F Building

18 Ayer Rajah Crescent

Singapore 139942

Phone: +65 6779-9091

E-mail: sales@sg.pepperl-fuchs.com

https://www.pepperl-fuchs.com

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1 Introduction

1.1 Content of this Document

This document contains information required to use the product in the relevant phases of the product life cycle. This may include information on the following:

- Product identification
- Delivery, transport, and storage
- Mounting and installation
- Commissioning and operation
- Maintenance and repair
- Troubleshooting
- Dismounting
- Disposal

Note

For full information on the product, refer to the further documentation on the Internet at www.pepperl-fuchs.com.

Note

For specific device information such as the year of construction, scan the QR code on the device. As an alternative, enter the serial number in the serial number search at www.pepperl-fuchs.com.

The documentation comprises the following parts:

- This document
- Datasheet

In addition, the documentation may comprise the following parts, if applicable:

- EU-type examination certificate
- EU declaration of conformity
- Attestation of conformity
- Certificates
- Control drawings
- Instruction manual
- Functional safety manual
- Other documents

1.2 Target Group, Personnel

Responsibility for planning, assembly, commissioning, operation, maintenance, and dismounting lies with the plant operator.

Only appropriately trained and qualified personnel may carry out mounting, installation, commissioning, operation, maintenance, and dismounting of the product. The personnel must have read and understood the instruction manual and the further documentation.

Prior to using the product make yourself familiar with it. Read the document carefully.

1.3 Symbols Used

This document contains symbols for the identification of warning messages and of informative messages.

Warning Messages

You will find warning messages, whenever dangers may arise from your actions. It is mandatory that you observe these warning messages for your personal safety and in order to avoid property damage.

Depending on the risk level, the warning messages are displayed in descending order as follows:



Danger!

This symbol indicates an imminent danger.

Non-observance will result in personal injury or death.



Warning!

This symbol indicates a possible fault or danger.

Non-observance may cause personal injury or serious property damage.



Caution!

This symbol indicates a possible fault.

Non-observance could interrupt the device and any connected systems and plants, or result in their complete failure.

Informative Symbols



Note

This symbol brings important information to your attention.



Action

This symbol indicates a paragraph with instructions. You are prompted to perform an action or a sequence of actions.

1.4 Intended Use

The NBN...-F135/F135L...-IO -... inductive sensor set for high temperature applications is a modular inductive sensor consisting of an inductive sensor head for the high temperature range and a separate amplifier that is mounted remotely in the normal temperature range. The product portfolio of NBN...-F135/F135L...-IO -... inductive sensor sets with IO-Link is optimized for the binary detection of objects in extreme temperature ranges up to 250 °C. The integrated IO-Link interface enables the unique identification of the sensor, comprehensive individual settings of parameters, switching behavior and operating modes, and diagnostics of the sensor status and the application.

Read through this manual carefully. Familiarize yourself with the device before installing, mounting, or operating.

Only operate the device as described in these instructions to ensure the correct functioning of the device and the connected systems. The protection of operating personnel and the plant is guaranteed only if the device is operated in accordance with its intended use.

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1.5 General Safety Instructions

Responsibility for planning, assembly, commissioning, operation, maintenance, and dismounting lies with the plant operator.

Installation and commissioning of all devices may be performed only by trained and qualified personnel.

It is dangerous for the user to make changes and/or repairs. Additionally, doing so voids the warranty and excludes the manufacturer from any liability. In the event of any serious errors, stop using the device. Secure the device against unintended operation. To have the device repaired, return it to your local Pepperl+Fuchs representative or your sales center.

Note

Disposal

Electronic waste is dangerous. When disposing of the equipment, observe the current statutory requirements in the relevant country of use and local regulations.

2 Product Description

2.1 Use and Application

The NBN...-F135/F135L...-IO -... inductive sensor set for high-temperature applications is a modular inductive sensor consisting of an inductive sensor head for the high temperature range and a separate amplifier that is mounted remotely in the normal temperature range. The product portfolio of IO-Link NBN...-F135/F135L...-IO -... inductive sensor sets with IO-Link is optimized for the binary detection of objects in extreme temperature ranges up to 250 °C.

The components can be disconnected using connectors. This gives you the flexibility of being able to mount and replace components easily and independently of each other.

With the NBN...-F135/F135L...-IO -... family, the user has the option of two basic set version types:

- NBN25-F135-M*-*M-SET/NBN50-F135L-M*-SET: Inductive sensor head with fixed cables of different lengths with plug, amplifier
- NBN25-F135-L4-M*-*M-SET/NBN50-F135L-L4-M*-SET: Inductive sensor head with 0.2 m fixed cable with plug for high temperature range, special high-temperature extension cables of different lengths, amplifier

The integrated IO-Link interface enables clear identification of the sensor, extensive individual configuration of the parameters, switching characteristics and operating modes, and diagnosis of the sensor status and application.

The NBN...-F135/F135L...-IO-... product family also supports SIO mode. SIO mode (standard IO mode) can be used to perform conventional signal transmission (= On/Off signal) between the device and the higher-level control panel.

For flexible use in confined spaces, several sensor heads can be mounted side by side or opposite each other. Mutual interference is prevented by an independent synchronization process. This takes place within defined distance ranges either directly using inductive neighbor detection for up to two sensors or on a wired basis using the sync connection for up to four sensors.

The advantages of the product portfolio of the NBN...-F135/F135L...-IO -... inductive sensor sets are as follows:

- Use over extreme temperature ranges up to 250 °C
- Low temperature drift of the operating distance (typically < 5 %)
- Long service life
- An amplifier suitable for different sensor heads and cable lengths
  - Cable lengths 1 m - 30 m
  - Small sensor head = 25 mm operating distance
  - Large sensor head = 50 mm operating distance
- Sensor heads can be replaced without reparameterizing the amplifier
- No adjustment of the operating distance using a potentiometer required
- The sensor head status and maintenance warnings are made available using IO-Link process data
- Switching cycle and operating hours counter
- Direct connectability of up to 4 sensor heads through synchronization in both SIO mode and IO-Link mode
- Flush mounting on metal reduces the risk of damage to the sensor head due to accidental collision
- End-to-end communication between the control panel and field level via IO-Link

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Sensor Monitoring, Diagnosis, and Predictive Maintenance

The NBN...-F135/F135L...-IO -... inductive sensor sets deliver a wide range of methods for analyzing and monitoring the application. Additional internal function and quality measurement data on the status of the sensor head and adjustable limit values enable condition monitoring and predictive maintenance. You can adjust these measures perfectly to the existing framework conditions using the appropriate parameters. For evaluation purposes, 4 bits are provided in the process data and are transferred cyclically. It is also possible to query acyclic maintenance information using the appropriate "Maintenance Data" and "Observation Data".

- The inductive sensor set therefore monitors the maintenance operating hours and can set a "Maintenance Warning Event" in the process data when a parameterized limit value is reached. This means that the system can automatically signal that the machine requires maintenance.
- In the same way, additional application values, such as the number of switch state changes made, can be monitored, and the need for machine maintenance can be signaled automatically.
- The impedance of the coil system (resistance Rs, inductance Ls) in the sensor head can be monitored to draw conclusions about aging processes and therefore replace a sensor head promptly.
- The signal strength can also be determined, monitored, and evaluated. This means that changes in object detection and changing object distances can be detected and faults can be identified and rectified at an early stage.

What is IO-Link?

IO-Link enables seamless communication and digital data transfer from the control panel level down to the sensor level. The intelligence of sensors can be used to their full potential with IO-Link, paving the way for Industry 4.0 in automation technology. The internationally standardized interface delivers impressive efficiency and sustainable cost reduction, from plant design and installation through to operation and servicing.

Standardized device description files (IODDs) and parameterization via software tools ensure convenient configuration and integration of IO-Link sensors. Intelligent and transparent parameter management increases application flexibility and keeps downtimes to a minimum. Parameters can be customized quickly and easily, even for complex production and batch changes. Transparency right down to the sensor gives users access to a comprehensive range of parameterization options and device diagnosis functions, allowing them to perform predictive maintenance.

The technology offers particular benefits for service activities (troubleshooting, maintenance, and device replacement), for commissioning (cloning, identification, configuration, and localization), and during operation (job changeover, continuous parameter monitoring, and online diagnosis).

Device Description File (IODD)

The device parameters are different for each device. A standardized description of these parameters can be found in the IODD (IO Device Description). IODDs can be integrated into a control environment to allow IO-Link devices to be used for IO-Link operation. Both parameterization and process data exchange can be performed with a PLC, for example. The IODD can also be imported into a range of engineering tools from various system providers for parameterization and diagnosis, provided these tools support IODD.

Offline parameterization

For offline parameterization, IO-Link devices are already configured before mounting. To do this, use the Pepperl+Fuchs IO-Link USB master.

We recommend using the "PACTware" software as the FDT frame application and user interface.

The software components required in each case are collated in the latest version of the "IO-Link Offline Parameterization Tool" software package. The software package can be found online at www.pepperl-fuchs.com along with the corresponding documentation for installation and operation.

If you use the "IO-Link Offline Parameterization Tool" software package, have active internet access, and have connected your device via the Pepperl+Fuchs IO-Link USB master, you can integrate the IODD directly into the IO-Link Offline Parameterization Tool via the "IODD DTM Configurator."

The device description file (IODD) required for integration in an IO-Link system and for the parameterization and diagnosis is available online. Visit www.pepperl-fuchs.com and go to the corresponding product page for the NBN...-F135L...-IO-... /NBN...-F135L...-IO-....

Online Parameterization

When commissioning machines and plants, master and IO-Link devices must be integrated into the relevant control environment. Depending on the components used, different software is required.

The devices can then be configured and parameterized using an IO-Link configuration tool. During ongoing operation, you can check the parameter settings for the IO-Link devices and read and monitor status data and diagnostic data. IO-Link data is integrated into an application program using function blocks.

2.2 LED Indicators

The NBN...-F135/F135L...-IO -... inductive sensor set has a double LED display in yellow/green in the amplifier. The LED display has different meanings depending on whether the inductive sensor set is operated in IO-Link mode or SIO mode.

The LED lights up as follows in yellow or green depending on its function:

- On
- Off
- Flashing

Note

The display behavior of the double LED also depends on certain parameter settings. Depending on the settings of parameters 61 (0x3D) "SSC Config: Logic" and **64 (0x40) "SSC Config Ext: Substitute Behavior"**, " yellow" or "green" may have different meanings. Details of the LED display behavior are provided in the following tables, taking the parameter settings into account.

Standard Display behavior of the LEDs in SIO Mode (SSC Config: Logic = High active)

Color	Description
Green	ON = Power supply is present and no object was detected in the detection range
Yellow	ON = Power supply is present and an object was detected in the detection range.
Off	Off = No power supply
Flashing green	Flashing (approx. 4Hz) = A short circuit was detected on the amplifier outlet
Green or yellow	Behavior in the event of a fault (STAT sensor head status = 0): ON = The LED follows the output according to the set error substitute behavior in parameter 64 (0x40) "SSC Config Ext: Substitute Behavior"

Standard Display behavior of the LEDs in SIO Mode (SSC Config: Logic = Low Active)

Color	Description
Green	ON = Power supply is present and an object was detected in the detection range
Yellow	ON = Power supply is present and no object was detected in the detection range.
Off	Off = No power supply
Flashing green	Flashing (approx. 4Hz) = A short circuit was detected on the amplifier outlet
Green or yellow	Behavior in the event of a fault (STAT sensor head status = 0): ON = The LED follows the output according to the set error substitute behavior in parameter 64 (0x40) "SSC Config Ext: Substitute Behavior"

Using IO-Link Mode

Color	Description
Green flashing quickly	Flashing briefly (100 ms on, 900 ms off, period 1 Hz) = IO-Link communication is active
Flashing green	Localization function using the striking flashing behavior of the LED to locate the amplifier/sensor set in the application environment Flashing = Flashing pattern as per the IO-Link Common profile You can activate the localization function using IO-Link or PACTware. After disconnecting the sensor from the power supply, the flashing behavior is deactivated again by default.
Flashing green	Flashing (approx. 4Hz) = A short circuit was detected on the amplifier outlet

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2.3 Accessories

Various accessories are available.

2.3.1 Parameterization Aids

The following parameterization aids are available:

Designation	Description
Pepperl-Fuchs-NBN...F135...-IO-...IODDx.x	IO device description (IODD)—device description for operating the sensor, integration in the system environment Visit **www.pepperl-fuchs.com** and go to the product page for the relevant sensor in the NBN...-F135/F135L...-IO-... series
IO-Link Offline Parameterization Tool	FDT frame application for operating IODDs and DTMs. This tool contains PACTware, IODD Interpreter DTM, and IO-Link USB Master DTM. Visit **www.pepperl-fuchs.com** and go to the product page for the relevant sensor in the NBN...-F135/F135L...-IO-... series
IO-Link-Master02-USB	IO-Link USB adapter box to communicate with the IO-Link device via a PC, M12 connection for sensor

2.3.2 Connection Cable

The following cordsets are suitable for the electrical connection of the NBN...-F135/F135L...-IO-... inductive sensor set with M12 connector plug (amplifier). They are available in various lengths and in an angled version:

Illustration	Material	M12 x 1 cordset, 4-pin	M12 x 1 cordset, 5-pin
M12 x 1, straight 	PUR	V1-G-*-PUR-V1-G	V15-G-*-PUR-V15-G

Note

If the cordset will be used in environments with significant potential for electromagnetic interference, please use shielded single-ended female cordsets from our extensive range of accessories.

3 Installation

3.1 Safety Information



Caution!

Risk of short circuit

Carrying out work while the system is energized may result in damage to the device.

- Always disconnect the supply voltage before carrying out work on the device.
- Only connect the device to the supply voltage once all work has been completed.

3.2 Preparation



Unpacking the Device

1. Check the packaging and contents for damage.

   ↳ In the event of damage, inform the shipping company and notify the supplier.

2. Check the package contents against your order and the shipping documents to ensure that all items are present and correct.

   ↳ Should you have any questions, direct them to Pepperl+Fuchs.

3. Retain the original packaging in case the device is to be stored or shipped again at a later date.

3.3 Mounting

3.3.1 Installation Conditions

To ensure that the inductive sensor sets in the NBN...-F135/F135L...-IO -... series can function safely, they should be installed in the application environment at minimum distances from metallic surfaces. Flush mounting is possible in metallic and non-metallic environments.

Mutual interference must be prevented if mounting several inductive sensor heads near to each other (side-by-side). You can achieve this either by maintaining minimum distances or, if this is not possible, by using one of two synchronization options. For details, see chapter 3.3.2.

Note

The following details provide an overview of the minimum distances required to metallic surfaces and between neighboring sensor heads. For applications where these minimum distances to neighboring sensor heads cannot be observed and to avoid possible interference, the sensors should be connected using their sync line.

When mounting sensor heads side-by-side, several aspects must be taken into account depending on the situation. For details, see chapter 3.3.2.

If necessary, contact our product specialists.

Installation Conditions in a Metallic Environment

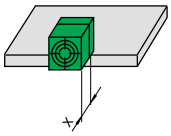
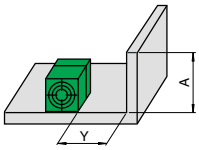
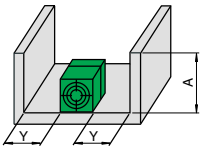
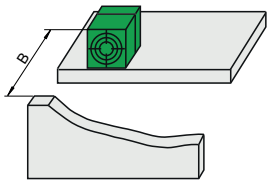
Type	Installation situation			
		 A = any	 A = any	
Dimensions in mm	**X**	**Y**	**Y**	**B**
NBN25-F135*	≥ 0	≥ 15	≥ 40	≥ 45
NBN50-F135L*	≥ 0	≥ 40	≥ 60	≥ 75

Table 3.1

Recommended Distance Ranges

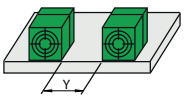
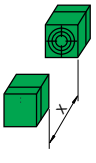
Type	Installation situation	
		
Dimensions in mm	**Y**	**X**
NBN25-F135*	0 ≤ Y ≤ 80 or Y ≥ 160	≥ 50
NBN50-F135L*	0 ≤ Y ≤ 160 or Y ≥ 300	≥ 100

Table 3.2

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3.3.2 Direct Connectability of Sensor Heads through Synchronization

For flexible use in confined spaces, several sensor heads can be mounted directly next to each other or opposite each other. Mutual interference is prevented by an independent synchronization process.

This is done using one of the two synchronization options:

- Inductive neighbor detection for up to 2 sensors and lateral mounting distances between 0 $\leq Y \leq Y_1$ or
- Wired with the help of the sync connection for up to 4 sensors for any mounting distances.

The inductive neighbor detection is continuously active and ensures smooth operation in most mounting and operating conditions. In especially critical installation situations see the following sections, however we recommend that you use the synchronization options in the sync connection.

3.3.2.1 Inductive Neighbor Detection

The inductive neighbor detection feature is based on the detection of the magnetic field of the relevant neighbor sensor head. If the sensor set amplifier detects a neighboring sensor head or its induced interference signal, the coil current duration is regulated to create a status in which mutual interference is excluded. This process is fully automated and does not depend on the use of the IO-Link interface.

Inductive Sensor Heads Mounted Side by Side

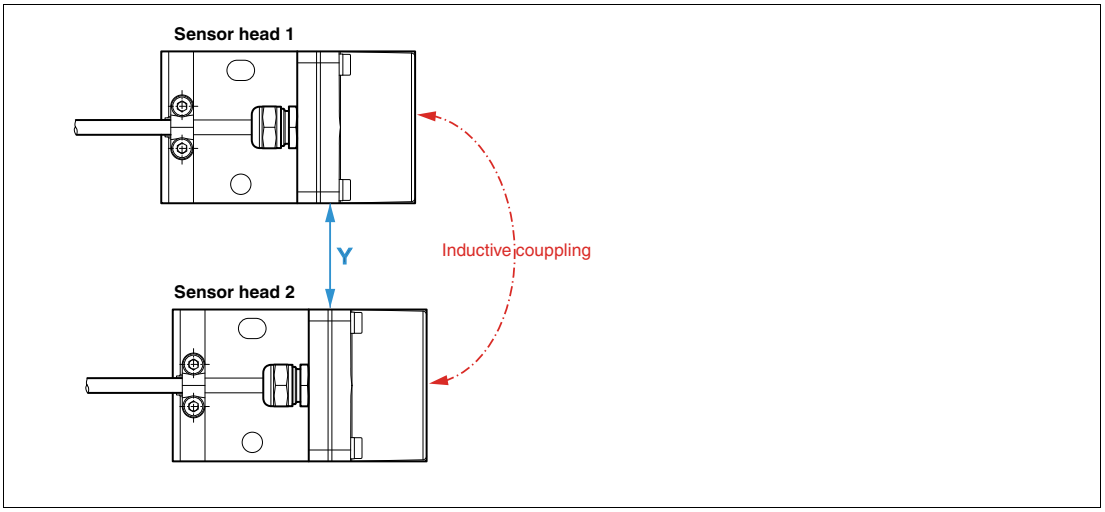


Figure 3.1

Mounting Distances Y Depending on Sensor Heads NBN25-F135-/NBN50-F135L-*:

Mounting distances	Distance values depending on sensor head pairings	Description
$0 \le Y \le Y_1$ Y_1 see next column	NBN25-F135-* with NBN25-F135-*: Y_1 = 80 mm	Inductive neighbor detection stable No interference
	NBN50-F135L-* with NBN50-F135L-*: Y_1 = 160 mm	
	NBN25-F135-* with NBN50-F135L-*: Y_1 = 150 mm	
$Y_1 \le Y \le Y_2$ Y_1, Y2 see next column	NBN25-F135-* with NBN25-F135-*: Y_1 = 80 mm NBN25-F135-* with NBN25-F135-*: Y_2 = 160 mm	Inductive neighbor detection may be unstable Interference in the area of unsafe object distances ($s \approx s_r \pm 5$ %)
	NBN50-F135L-* with NBN50-F135L-*: Y_1 = 160 mm NBN50-F13L5-* with NBN50-F135L-*: Y_2 = 300 mm	
	NBN25-F135-* with NBN50-F135L-*: Y_1 = 150 mm NBN25-F135-* with NBN50-F135L-*: Y_2 = 250 mm	
$Y \ge Y_2$ Y_2 see next column	NBN25-F135-* with NBN25-F135-*: Y_2 = 160 mm	No interference
	NBN50-F135L-* with NBN50-F135L-*: Y_2 = 300 mm	
	NBN25-F135-* with NBN50-F135L-*: Y_2 = 250 mm	

Table 3.3

To ensure inductive neighbor detection, the maximum distances Y_1 listed in the previous table must be observed when mounting the sensor heads.

At mounting distances between Y_1 and Y_2, the synchronization of the sensors may be lost temporarily, for example due to a short-term reduction in the inductive coupling of the sensors due to a metallic object passing close to the sensor end face. In this case, mutual interference may occur in the "unsafe" object distances range (≈ effective operating distance ± 5 %).

The use of the sync connection is therefore recommended for mounting distances between Y_1 and Y_2 (see below). From a distance of $Y > Y_2$, it is no longer possible to detect any mutual interference of the sensors even in the effective operating distance range.

Inductive Sensor Heads Mounted Opposite Each Other

With regard to mounting opposite each other, the inductive neighbor detection is stable over significantly larger ranges, so that with two inductive sensor heads mounted opposite each other, only the condition $X > 2\ s_n$ must be observed. s_n = 25 mm applies to small sensor heads of type F135 and s_n = 50 mm for large sensor heads of type F135L.

For smaller distances $X \le 2\ s_n$, despite reliable inductive neighbor detection, a change in the effective operating distance should be expected due to the metallic and ferritic components of the respective opposite sensor head. To suppress this interference, the sensor heads can be installed diagonally opposite each other, in other words offset in the Y direction, if necessary (e.g., offset in the Y direction by one sensor head width).

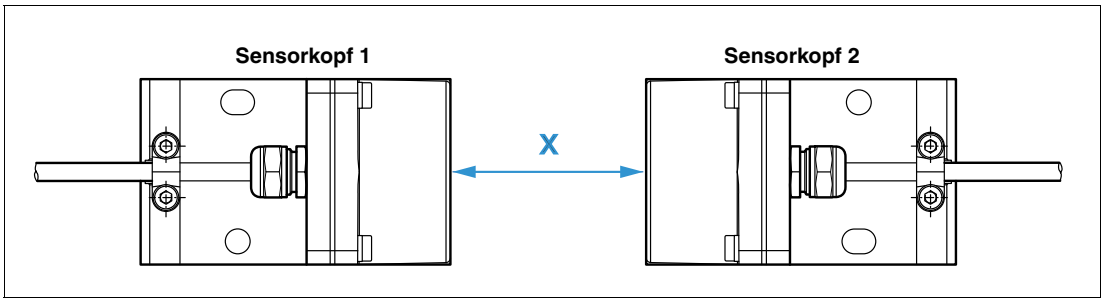


Figure 3.2

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3.3.2.2 Synchronization via Sync Connection

Inductive sensor sets that are electrically connected to each other via the sync connection of the sensor set amplifiers automatically synchronize with each other so that mutual interference is reliably avoided. This is advantageous for any lateral mounting distances of $Y \geq 0$ and even for up to four neighboring sensor heads.

Note

The following information for synchronization is explained using the example of NBN...-F135/F135L...-IO -... sets, the same also applies to NBN...-F135/F135L-L4...-IO -... sets.

Example of Synchronization via Sync Connection

The following figure shows an example of a combination of a total of eight sensors. Sensor sets "A to D" and "E to F" form two groups, which have been electrically connected to each other via sync line 1 and sync line 2.

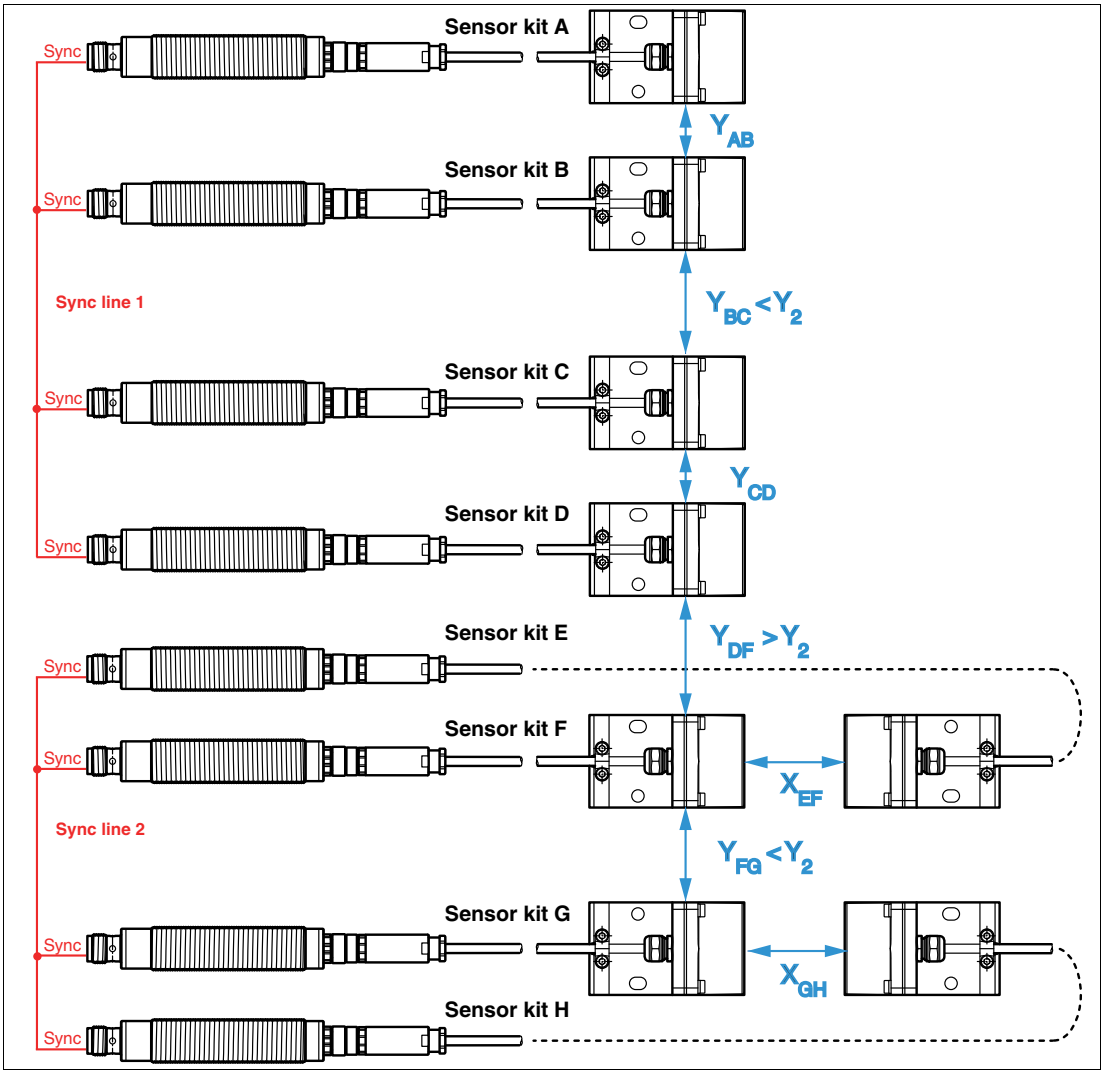


Figure 3.3

Note

For detailed information on mounting distances Y_1 and Y_2, see chapter 3.3.2.1.

In this example, sensor sets A/B, C/D, E/F, and G/H are mounted in pairs side by side or opposite each other, e.g., for redundancy purposes. The distances between the sensor set pairs can always be selected in such a way that synchronization using the inductive neighbor detection would be possible without using the sync line (e.g., $Y_{AB} < Y_1$ and $Y_{CD} < Y_1$).

However, if the distances between the sensor pairs are less than Y_2 (in this case $Y_{BC} < Y_2$ and $Y_{FG} < Y_2$), we recommend that the appropriate sensors are connected in groups of up to four sensors using the sync line. To avoid mutual interference between sensor sets in different synchronization groups, a distance greater than Y2 must be selected (in this case $Y_{DF} > Y_2$).

Use of the Sync Connection and Parameterization

The use of the IO-Link interface is not necessary for synchronizing the inductive sensor sets using the sync connection because the function is activated in "Line Sync on with timeout" mode by default .

The "Synchronization Mode" IO-Link parameter can be used to adjust the synchronization behavior if necessary. For details, see chapter 7.4.

The connection of the sync lines can be established or disconnected during ongoing operation. Synchronization using the sync connection works simultaneously and independently of inductive neighbor detection.

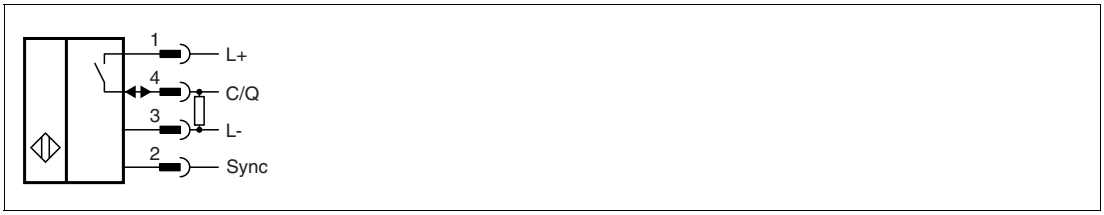


Figure 3.4

A sensor set pair that has initially been synchronized using inductive neighbor detection, for example, and is only then connected to each other via the sync line remains synchronized and vice versa. If the sync line is disabled in IO-Link using the "Synchronization mode" parameter (0 = line sync off), synchronization continues to function using inductive neighbor detection.

Note

Inductive sensor sets that synchronize using the sync connection must use a common reference potential. The potential of the sync line (pin 2) must not be accidentally short-circuited to another potential, e.g. a control panel or an IO-Link master, with low resistance to ensure that the synchronization nodes can communicate.

You can query the status of the sync line via the IO-Link interface using the "Synchronization Status" parameter, e.g. for troubleshooting purposes. For details, see chapter 8.7.

Caution!

Possible malfunctions with more than four inductive sensor sets connected using sync connections

If more than four inductive sensor sets are connected using your sync connections, the measurement sequence may be interrupted and the measurement rates of the sensor sets may be reduced. Therefore, only neighboring sensor sets should be electrically connected using the sync connections.

Alternatively, this option can also be disabled using IO-Link for all inductive sensor sets that are not to be synchronized using the sync connections("Line Sync off"). In "Synchronization Mode" "Line sync on" (without timeout), the measuring sequence of the sensor stops when a low potential is applied to its sync line (= potential of L-). As soon as an external potential is no longer specified or a high potential is applied, the sensor continues its measuring sequence. If required, this makes it possible to use a large number of sensor sets or groups of sensors using the time multiplexing method, for example.

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Note

Contact your Pepperl+Fuchs product specialist for more information on recommended activation times and processes for synchronization using sync connections.

4 Cybersecurity and Decommissioning Information

Cybersecurity Information

From a security perspective, the following precautions must be taken for the product by the responsible plant operator:

- Physically secure the device against unauthorized access.
- Ensure that the IO-Link device communicates with the remote station via a point-to-point connection.

The product features a proprietary Pepperl+Fuchs service interface that uses the existing connection lines. This interface is used exclusively for initially storing and updating the firmware during production. Once switched on, the interface is deactivated after 1 second.

Measures Required to Operate the IO-Link Sensor

Servicing and management: Check the website regularly for the release of security advisories and subscribe to the RSS feed: https://www.pepperl-fuchs.com/global/en/29079.htm

Measures Required to Shut Down the IO-Link Sensor

Configuration data, operating data, and log data (history, progress data, error data): The device stores adjustable parameter data and operating information.

All parameters, operating information, and reset options are specified in the IO-Link parameter data sheet. Parameters and operating information that cannot be reset can only be deleted by physically destroying the device.

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5 Commissioning

5.1 Commissioning with IO-Link on a Control Panel (Online Parameterization)

Note

The device description file (IODD) required for integration into an IO-Link system and for parameterization and diagnostics is available online at www.pepperl-fuchs.com on the corresponding product page for the NBN...-F135/F135L...-IO -...inductive sensor set.

Proceed as follows to communicate with the NBN...-F135/F135L...-IO -... inductive sensor set with IO-Link using a control panel:

1. Check the connection between the amplifier on the inductive sensor set and the IO-Link master.
2. Set the status to IO-Link on the relevant port on the IO-Link master to which the amplifier is connected.

↳ The inductive sensor set can now be either parameterized or diagnosed with the superimposed application using an IO-Link configuration tool. The device sends the binary switching information and other data in the form of process data.

5.2 Commissioning with IO-Link using the FDT Frame Application(Offline Parameterization)

IO-Link Offline Parameterization Tool

An IODD (IO-Link Device Description) file is available to download for the parameterization of the NBN...-F135/F135L...-IO -... inductive sensor set using IO-Link and diagnostics. See the product page for the relevant NBN...-F135/F135L...-IO-.. inductive sensor set online at **www.pepperl-fuchs.com** or use the IODDfinder at https://ioddfinder.io-link.com/.

For offline parameterization, IO-Link devices are already configured before mounting. To do this, use the Pepperl+Fuchs IO-Link USB master.

The software components required in each case are collated in the latest version of the "IO-Link Offline Parameterization Tool" software package. The software package can be found online at www.pepperl-fuchs.com along with the corresponding documentation for installation and operation.

If you are using the "IO-Link Offline Parameterization Tool" software package, have active Internet access, and have connected your device via the Pepperl+Fuchs IO-Link USB master, you can integrate the IODD directly into the IO-Link Offline Parameterization Tool via the "IODD DTM Configurator."

Note

A three-wire or four-wire M12 cordset is required to connect the inductive sensor set to the Pepperl+Fuchs IO-Link master. You can find suitable cordsets by visiting **www.pepperl-fuchs.com** and clicking on the product page for the relevant inductive sensor set.

To communicate with the inductive sensor set via IO-Link using the corresponding IODD, proceed as follows:

1. Make sure that the "IO-Link Offline Parameterization Tool" software package is installed on your computer.
2. Connect the amplifier of the inductive sensor set to an IO-Link master using a suitable M12 cordset.
3. Connect the IO-Link master to a USB connection on your PC via a USB cable.
4. Start PACTware.

   ↳ PACTware automatically communicates with the inductive sensor set if you are using PACTware from the "IO-Link Offline Parameterization Tool" and the IODD was found automaticallyonline.

6 Process Data Structure

The process data of the inductive sensor set with IO-Link consists of 5 bits , where the 4th bit (bit offset 3) does not contain any information and can be ignored. The following table provides an overview of the order and structure of the process data.

Name	Long Name	Data Type	Length	Bit Offset	Value
SSC -Switching Signal	Switching Signal Channel Switching Signal	Boolean	1 bit	0	0: Low 1: High
OPTION - Uncertainty Indication	OPTION - Uncertainty Indication	Boolean	1 bit	1	0: is OK 1: is not OK
STAT - Sensor Head Status	Status - Sensor Head Status	Boolean	1 bit	2	0 = is not OK 1 = is OK
DSC - Maintenance Warning	Diagnosis Signal Channel - Maintenance Warning	Boolean	1 bit	4	0 = Inactive 1 = Active

Table 6.1

6.1 DSC - Maintenance Warning

Diagnosis Signal Channel - Maintenance Warning

The "Maintenance Warning" is a collective warning signal to which several events can be mapped. The warning signal is triggered as soon as at least one of the parameterized limit values of the maintenance data is reached.

You can use the following parameters to parameterize maintenance events that can trigger the "Maintenance Warning" collective warning signal:

- Maintenance Config Operating Time (0xD0)
- Maintenance Config - SSC limit (0xD1)
- Maintenance Config - Measurement (0xD2)

You can use the maintenance diag parameters to find out,which of the parameters mentioned ultimately triggered a "Maintenance Warning", see chapter 8.

6.2 OPTION - Uncertainty Indication

OPTION - Uncertainty Indication

After changing the switch state, the "Uncertainty Indication" informs you whether the sensor head of the inductive sensor set was safely damped during the last detection cycle.

- 0 = The operating distance of the sensor was safely undershot ($s < 0.8\ s_r$) and safely exceeded ($s > 1.2\ s_r$).
- 1 = The damping element was either not sufficiently far away from the sensor before the switch state was changed ($s_r < s < 1.2\ s_r$) or not sufficiently close to the sensor ($0.8\ s_r < s < s_r$).

This simple evaluation serves to point out at any critical detection distances at an early stage, which, in the case of large (mechanical) tolerances during continuous plant operation, may result in an object detection failure. For further explanations see chapter 8.4.4, Figure → see Figure 8.6 on page 38.

6.3 STAT - Sensor Head Status

STATUS - Sensor Head Status

The "Sensor Head Status" signal indicates that a sensor head is connected to the amplifier and it is functioning properly. The status is derived from the currently measured series resistance Rs of the sensor head coil including the sensor head cable resistance.

- 0" means that no sensor head is connected or a defective sensor head with a series resistance Rs > 45 Ω or Rs < 4 Ω has been connected.
  In this case, the output of the switching state is suppressed and the switching output behaves as if it were parameterized via "SSC Config Ext: Substitute Behavior"
- "1" means that the sensor head is OK, i.e., a sensor head with a series resistance of 4 Ω < Rs < 45 Ω has been connected. A normal sensor function is assumed based on the resistance measured value.

6.4 SSC – Switching Signal

Switching Signal Channel Switching Signal

The process data content "SSC Switching Signal" describes a signal bit that is used to detect an object. It is part of the cyclic signal transmission. Depending on the status of the inductive sensor set or the application, the signal bit can assume the value "0" or "1".

The following parameters influence the switching behavior of the SSC process data:

- SSC - Config: Logic
- SSC - Extended Config: Pulse Extension
- SSC - Extended Config: Substitute Behavior

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7 IO-Link Parameterization

Only the parameters for the inductive sensor sets NBN...-F135/F135L...-IO -.... that need explanation are listed below,

Note

A comprehensive overview of all parameters for the relevant inductive sensor set can be found online in the relevant document entitled "IO-Link Parameter Datasheet" at www.pepperl-fuchs.com on the corresponding product page for the NBN...-F135/F135L...-IO -... product group.

For a clear reference to the document "IO-Link Parameter Datasheet" and to make it easy to find all information on parameters, parameter names and some terms are listed below.

The abbreviations below are used in the following:

ro read only
wo write only
rw read and write

7.1 SSC Config: Logic

Switching Signal Channel: Configuration Logic

Index	Sub	Parameter	Access	Data Type	Length
57 (0x39)	0	SSC Config: Logic	rw	UInteger	8 bits

The "SSC Config: Logic" parameter indicates whether the "SSC" switching signal is transmitted as "high active" or "low active." This allows you to set the switching function on the output of the amplifier as an NO or NC contact.

- Normally open = High active
- Normally closed = Low active

Note

Setting this parameter affects the display behavior of the LED. The LED indicator in "yellow" or "green" then has different meanings. For details, see chapter 2.2.

7.2 SSC Config Ext

Switching Signal Channel Extended Configuration

Index	Sub	Parameter	Access	Data Type	Length
64 (0x40)	0	SSC Config Ext	rw	Record	48 bits
	2	SSC Config Ext: Pulse Extension	rw	UInteger	8 bits
	3	SSC Config Ext: Substitute Behavior	rw	UInteger	8 bits

The "SSC Config Ext" parameter allows you to set advanced options for the switching signal channel. The sub-indices are explained in more detail below.

"SSC.1 Config Ext: Pulse Extension" Parameter

The "SSC Config Ext: Pulse Extension" parameter enables you to extend active phases (with active high signal) or inactive phases (with active low signal) of the "Switching Signal Channel" where required.

You can choose between the following settings for the extension duration t_{pulse}:

- Off
- Auto
- 10 ms
- 100 ms
- 1000 ms

The "Auto" setting extends the signal for as long as necessary, so that even short switching events between two transmissions of the process data are reliably detected. Switching events longer than the set time t_{pulse} are not additionally extended.

Pulse Extension, Logic = High active

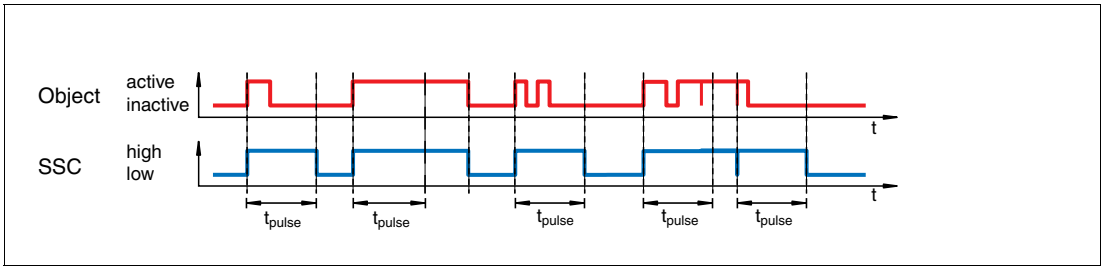


Figure 7.1

Pulse Extension, Logic = Low active

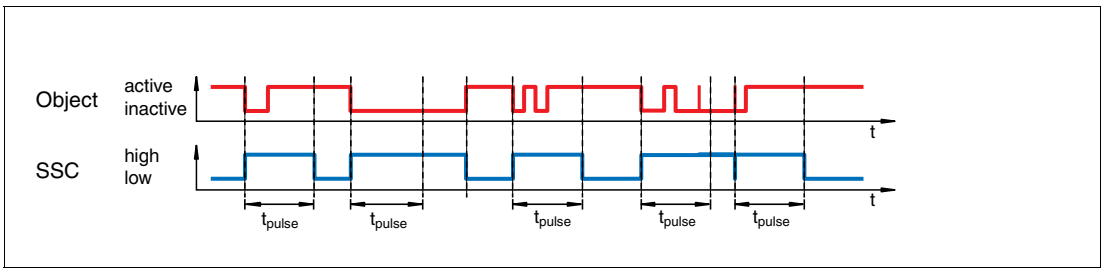


Figure 7.2

"SSC Config Ext: Substitute Behavior" Parameter

The "SSC Config Ext: Substitute Behavior parameter defines the configuration of the switching output if the sensor head is disconnected from the amplifier during ongoing operation or if there is a short circuit on the sensor head.

The status of the switching output is not relevant if the "STAT Sensor Head Status" bit = 0 in the process data (sensor is not OK).

In this case, either the last state is maintained or one of the two values is assumed to be "inactive" or "active."

Note

Setting this parameter affects the display behavior of the LED. The LED indicator in "yellow" or "green" then has different meanings. For details, see chapter 2.2.

7.3 I/O Config - C/Q Type

I/O Configuration - C/Q Type

Index	Sub	Parameter	Access	Data Type	Length
112 (0x70)	0	I/O Config - C/Q Type	rw	UInteger	8 bits

You can set the output type using the "I/O Config - C/Q Type" parameter. On delivery, output Q is set as "PNP" if you activate SIO mode.

Value range:

- 0 = Output is "push-pull"
- 1 = Output is "PNP"

7.4 Synchronization Mode

Synchronization Mode

Index	Sub	Parameter	Access	Data Type	Length
101 (0x65)	0	Synchronization Mode	rw	UInteger	8 bits

The "Synchronization Mode" parameter defines whether synchronization using the sync connection is activated and which synchronization type is used.

The value range is as follows:

- 0 = Line Sync off
  The sensor carries out its periodic measurement procedure without paying attention to the potential of the sync connection.
  Synchronization via pin 2 is deactivated. Pin 2 is pulled to "HIGH" with high resistance (L+ potential).
- 1 = Line Sync on
  The amplifier temporarily pulls the potential of the sync connection pin 2 from "High" to "Low" during a measurement and also interrupts its measurement sequence as long as the potential is kept at "Low" by another node.
  Synchronization via pin 2 is activated. This enables both the synchronization of adjacent sensor heads by directly connecting the sync connections to each other, and starting and stopping the measurement sequences of the sensor sets by applying corresponding voltages to pin 2 using an external control panel.
- 2 = Line Sync on with timeout.(delivery state)
  Synchronization via pin 2 is activated with timeout. If the potential of pin 2 is "Low" for longer than 20 ms, the amplifier will ignore the sync connection until further notice and begin its measurement process. If the low state is exited again, the synchronization is restarted.

Note

Please refer to the information on the subject of "Synchronization" in the chapter entitled "Direct connectability of sensor heads through synchronization", see chapter 3.3.2.

7.5 Event Config

Event configuration

Index	Sub	Parameter	Access	Data Type	Length
120 (0x78)	0	Event Config	rw	Record	16 bits
	8	Warning - Maintenance Diagnosis	rw	Bool	1 bit
	9	Warning - Uncertainty Indication	rw	Bool	1 bit

The "Event Config" parameter enables you to activate the "DSC - Maintenance Warning" and "OPTION - Uncertainty Indication" process data warning messages individually using "1" or deactivate them using "0". Only the complete "Record" can be accessed, not the individual subindices.

Note

You can set various parameters as event sources for the "DSC Maintenance Warning"; refer to the corresponding explanations in this manual and in the IODD Parameter Datasheet. For more detailed explanations of diagnostics and maintenance functions, see see chapter 8.

7.6 Maintenance Config Operating Time

Maintenance Configuration Operating Time

Index	Sub	Parameter	Access	Data Type	Length
208 (0xD0)	0	Maintenance Config Operating Time	rw	UInteger	32 bits

You can use the "Maintenance Config Operating Time" parameter to set a limit value for the operating time in whole hours after which a maintenance warning should be output using the "DSC - Maintenance Warning" process data.

Value range:

- 0 = deactivated
- 1 - (2^{32} - 1)

Note

To trigger a maintenance event, the "Warning - Maintenance Diagnosis" option must be activated in the "Event Config" parameter.

7.7 Maintenance Config - SSC Incident Count Limit Value

Maintenance Configuration - Switching Signal Channel Incident Count Limit Value

Index	Sub	Parameter	Access	Data Type	Length
209 (0xD1)	0	Maintenance Config - SSC Incident Count Limit Value	rw	UInteger	32 bits

You can use the "Maintenance Config - SSC Incident Count Limit Value" parameter to set a limit value for the number of switching cycles after which a maintenance warning should be output using the "DSC - Maintenance Warning" process data.

Value range:

- 0 = deactivated
- 1 ... (2^{32} - 1)

Note

To trigger a maintenance event, the "Warning - Maintenance Diagnosis" option must be activated in the "Event Config" parameter.

7.8 Maintenance Config - Measurement

Maintenance Configuration - Measurement

Index	Sub	Parameter	Access	Data Type	Length
210 (0xD2)	0	Maintenance Config - Measurement	rw	Record	128 bits
	1	Lower Threshold Rs	rw	Integer	16 bits
	2	Upper Threshold Rs	rw	Integer	16 bits
	3	Comparative Value Rs	rw	UInteger	16 bits
	4	Lower Threshold Ls	rw	Integer	16 bits
	5	Upper Threshold Ls	rw	Integer	16 bits
	6	Comparative Value Ls	rw	UInteger	16 bits
	7	Lower Threshold Signal Strength	rw	UInteger	16 bits
	8	Upper Threshold Signal Strength	rw	UInteger	16 bits

The "Maintenance Config - Measurement" parameter enables you to set limits for monitoring the impedance of the sensor head coil system (sensor head coil + cable). By monitoring the series resistance R and the inductance Ls of the sensor head, you can draw conclusions about the condition of the sensor head and its service life. If the user observes a significant change or sporadic fluctuations of Rs and Ls compared to the new condition, this indicates irreversible aging processes.

Note

If you would like to make use of the options for monitoring the coil system, you must record and save current reference values promptly after commissioning.

By executing the "Teach actual Ls and Rs" command, you can save the current Ls and Rs values as comparison values in the amplifier ("Comparative Value Rs" and "Comparative Value Ls" parameters). Alternatively, you can enter comparison values yourself.

Value range:

- 0 = deactivated (to be entered in each subindex, only where *)
- *Lower Threshold Rs = - 90 to -2 %
- *Upper Threshold Rs = 2 to 300 %
- Comparative Value Rs = 5000 to 45000 mOhm
- *Lower Threshold Ls = - 90 to -1 %
- *Upper Threshold Ls = 10 to 200 %
- Comparative Value Ls = 2500 to 5500 µH
- *Lower Threshold Signal Strength = 0.806 to 1128.4 mV
- *Upper Threshold Signal Strength = 0.806 to 1128.4 mV

If one of the limit values is exceeded, a maintenance warning is issued using the "DSC - Maintenance Warning" process data

Note

To trigger a maintenance event, the "Warning - Maintenance Diagnosis" option must be activated in the "Event Config" parameter.

For more details on monitoring the impedance of the coil system, see chapter 8.

8 Diagnosis and Maintenance Functions

The NBN...-F135/F135L...-IO -... inductive sensor set features various options for monitoring the sensor set and the application using cyclic process data and acyclically retrievable "Maintenance Data" and "Observation Data". The following figure shows the various parameters and relationships.

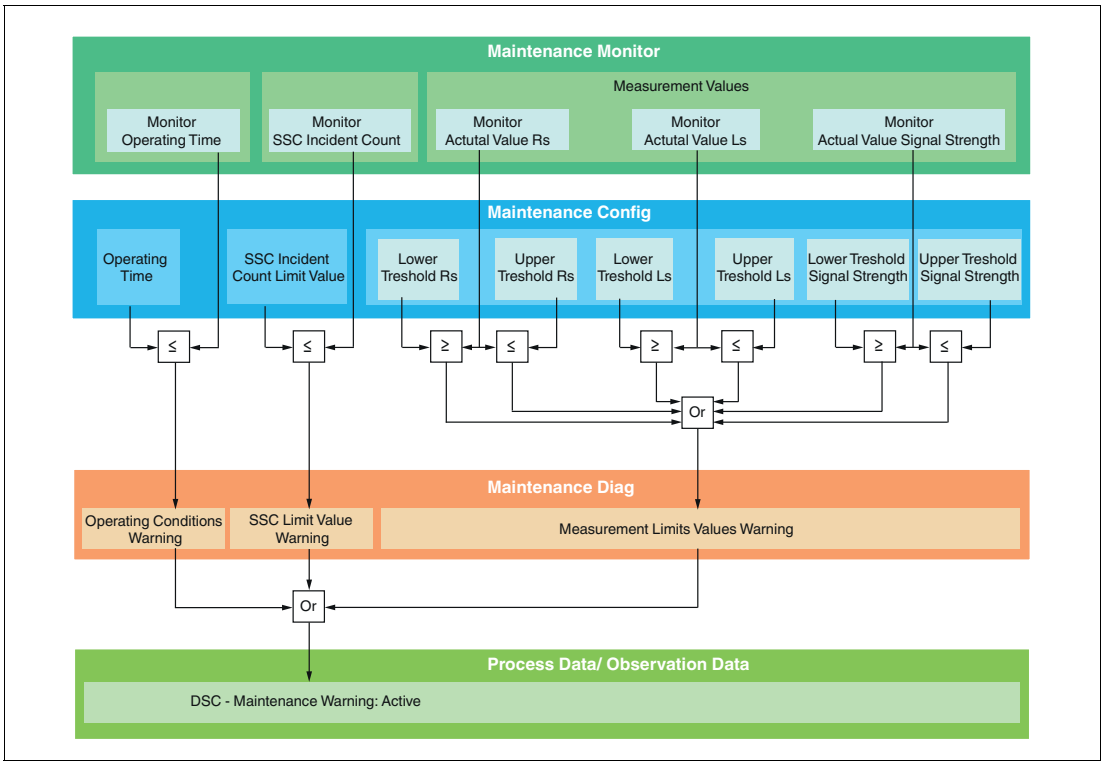


Figure 8.1

For the purpose of maintaining your machine or application, you can set limit values using the "Maintenance Config" parameter areas and read various pieces of additional information acyclically in the "Maintenance Monitor".

When one or more parameterized limit values are reached, a "Maintenance Warning" is transmitted in the process data. If activated using the "Event Configuration" parameter, the "Warning Maintenance Diagnosis" event is also executed.

It is also possible to read specific diagnostic information using the "Maintenance Diag" parameter.

Note

You can reset all maintenance values in the "Maintenance Diag", "Observation Data", and "Maintenance Monitor" parameters using the command "Maintenance Reset" = 176 (0xB0).

The following figure shows the relationships between configured "Events" and the output of "Warnings" using the process data (cyclic) and the "Observation Data" parameter (acyclic) if the event conditions are met.

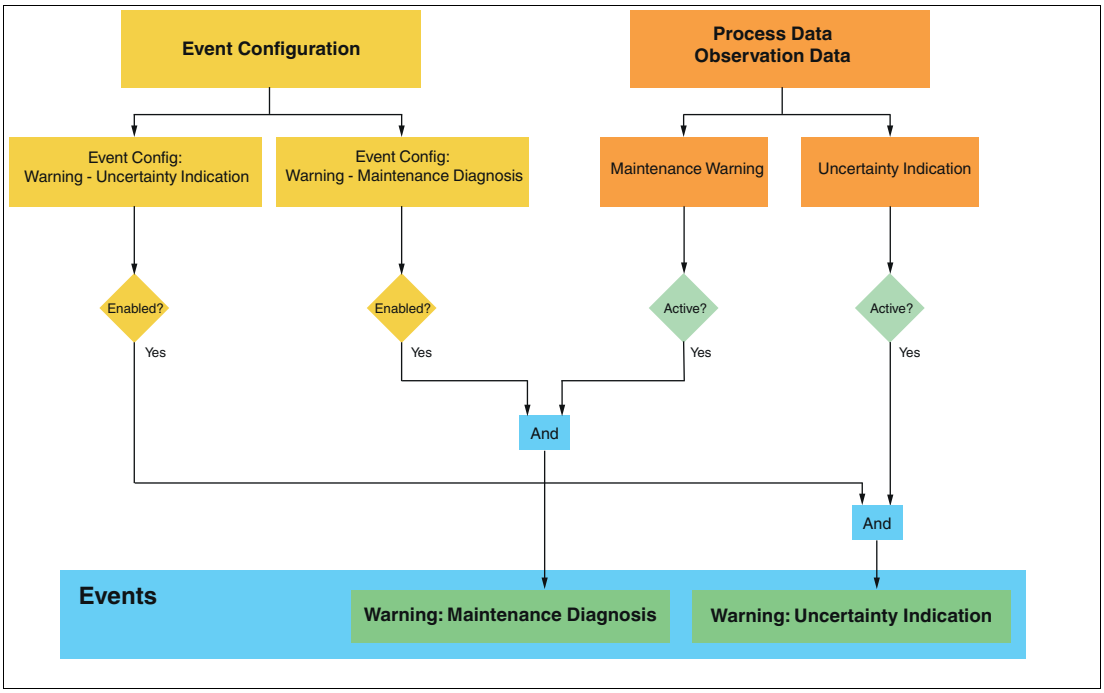


Figure 8.2

The following sections explain selected functions, parameters, and the technical relationships in the diagnosis and maintenance functions.

8.1 Device Characteristics

Device Characteristics

Index	Sub	Parameter	Access	Data Type	Length
176 (0XB0)	0	Device Characteristics	r	Record	48 bits
	1	Switching Distance	-	Integer	16 bits
	2	Maximum Temperature	-	Integer	16 bits
	3	Supply Current Requirement	-	UInteger	16 bits

This parameter provides some specific information about the connected inductive sensor set:

- **Switching Distance**
  The amplifier has the ability to detect the type of connected sensor head. The sensor head type detection is performed firstly by evaluating the coil impedance of the connected sensor head and secondly by querying specific wiring in the sensor head.
  The value range is as follows:
  - 0: No sensor head detected
  - 25 = Sensor head detected with 25 mm switching distance (type *F135*)
  - 50 = Sensor head detected with 50 mm switching distance (type *F135L*)
- **Maximum Temperature**
  Specifies the maximum permitted operating temperature for the sensor head (see also associated data sheet).
- **Supply Current Requirement**
  Specifies the maximum specified supply current without a load for the inductive sensor set.

8.2 Maintenance Monitor - Operating Time

Maintenance Monitor - Operating Time

Index	Sub	Parameter	Access	Data Type	Length
216 (0xD8)	0	Maintenance Monitor - Operating Time	r	UInteger	32 bits

The "Maintenance Monitor - Operating Time" parameter shows the operating time in whole hours since the last "Maintenance-Reset", "Application-Reset", or "Back to Box" command. You can read the parameter acyclically.

8.3 Maintenance Monitor - SSC Incident Count

Maintenance Monitor - Switching Signal Channel Incident Count

Index	Sub	Parameter	Access	Data Type	Length
217 (0xD9)	0	Maintenance Monitor - SSC Incident Count	r	UInteger	32 bits

The "Maintenance Monitor - SSC Incident Count" parameter displays the number of switching cycles since the last "Maintenance-Reset", "Application-Reset", or "Back to Box" command. You can read the parameter acyclically.

8.4 Maintenance Monitor Measurement

Maintenance Monitor Measurement

Index	Sub	Parameter	Access	Data Type	Length
218 (0xDA)	0	Maintenance Monitor Measurement	r	Record	112 bits
	1	Maintenance Monitor Measurement: Actual Value Rs	-	UInteger	16 bits
	2	Maintenance Monitor Measurement: Actual Value Ls	-	UInteger	16 bits
	3	Maintenance Monitor Measurement: Actual Value Signal Strength	-	UInteger	16 bits
	4	Maintenance Monitor Measurement: Signal Strength Last Min	-	UInteger	16 bits
	5	Maintenance Monitor Measurement: Signal Strength (rated) Last Min	-	Integer	16 bits
	6	Maintenance Monitor Measurement: Signal Strength Last Max	-	UInteger	16 bits
	7	Maintenance Monitor Measurement: Signal Strength (rated) Last Max	-	Integer	16 bits

The "Maintenance Monitor Measurement" parameter can be used to read current function and quality measurement data on the status of the sensor head acyclically in the form of diagnostic information.

By monitoring the series resistance Rs and inductance Ls of the coil system + cable, you can draw conclusions about the condition of the sensor head and its service life. If the user observes a significant change or sporadic fluctuations of Rs and Ls compared to the new condition, this indicates irreversible aging processes.

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Note

The function and quality measurement data that can be recorded during sensor operation enable you to create an individual monitoring scenario. The processing and interpretation of this data is therefore your responsibility, so that you can tailor monitoring and any measures precisely to your application. The use of our "IO-Link Offline Parameterization Tool" with its PACTware user interface can be very helpful for a quick overview of the diagnostic information during the configuration phase. You can find the function and quality measurement data for the inductive sensor set in the "Diagnostics" PACTware menu item.

In the following sections, the relevant technical relationships with the function and quality measurement data of the "Maintenance Monitor Measurement" parameter are explained in more detail.

The following data is provided by a 14 byte data packet:

- Impedance values of the sensor head coil system + cables such as series resistance Rs and inductance Ls
- Signal strength values: The sensor amplifier continuously evaluates the inductive interference of the sensor coil using a nearby metal object and derives a switching signal from this measured variable by means of a threshold value comparison. The inductive interference is output in the form of various signal strength specifications for an extended customer evaluation

Note

If you would like to make use of the options for monitoring the coil system, you must record and save current reference values promptly after commissioning.

By executing the "Teach actual Ls and Rs" command, you can save the current Ls and Rs values as comparison values in the amplifier ("Comparative Value Rs" and "Comparative Value Ls" parameters). Alternatively, you can enter comparison values yourself.

Subindex "Maintenance Monitor Measurement: Actual Value Rs/Ls"

The sensor part (sensor head + cable) is designed for extreme operating temperatures of up to 250 °C. However, it has a finite service life due to aging processes. An innovative method has therefore been developed, which in many cases can be used to detect the approaching end of life of the sensor part at an early stage so that it can be replaced before the sensor finally fails.

Unintentional changes in the switching distance are usually caused by a significant change in the electrical properties of the sensor head's coil system. These properties are determined by the impedance, in other words the resistance Rs and inductance Ls of the sensor head coil system. The sensor amplifier can measure the R and Ls of the connected sensor head in continuous operation and provide diagnostic data via IO-Link in addition to the switching signal ("Actual Value Rs" and "Actual Value Ls"). If the user observes a significant change or sporadic fluctuations of Rs and Ls compared to the new condition, this indicates irreversible aging processes. In this case, the sensor head should be replaced before the switching distance is significantly changed as the sensor ages.

8.4.1 Detecting Critical Series Impedance Changes

Typical Series Impedance in a New State at Room Temperature

- The coil system of a sensor head of type *F135* with an operating distance of 25 mm has a series resistance of Rs = 11.0 ± 0.5 Ω
- The coil system of a sensor head type *F135L* with an operating distance of 50 mm has a series resistance of Rs=11.6 ± 0.5 Ω
- The sensor cable also increases the series resistance Rs by approx. 0.1 Ω/m depending on the cable length
- The inductance of the sensor head is largely independent of the sensor cable length and is as follows:
  - For sensor head type *F135* Ls =3.6 ± 0.2 mH
  - For sensor head type *F135L* Ls= 4.6 ± 0.2 mH

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Normal Series Impedance Change Due to Temperature Change

The series resistance Rs of the sensor part (sensor head + cable) changes due to temperature as per the temperature coefficient of the specific resistance of copper at a rate of approx. 0.39 %/K. If only part of the sensor cable is heated, the total resistance therefore changes less.

The inductance changes at most slightly due to the temperature in the new state (< ± 15 ppm/K). A typical impedance curve of a sensor head at a temperature cycle of 25 °C to 250 °C and back to 25 °C is shown in the following figure. While the resistance is essentially proportional to the temperature of the head, the coil inductance remains largely constant. This allows at least qualitative conclusions to be drawn about any temperature fluctuations at the location of the sensor head as long as aging processes can be excluded in the period under consideration.

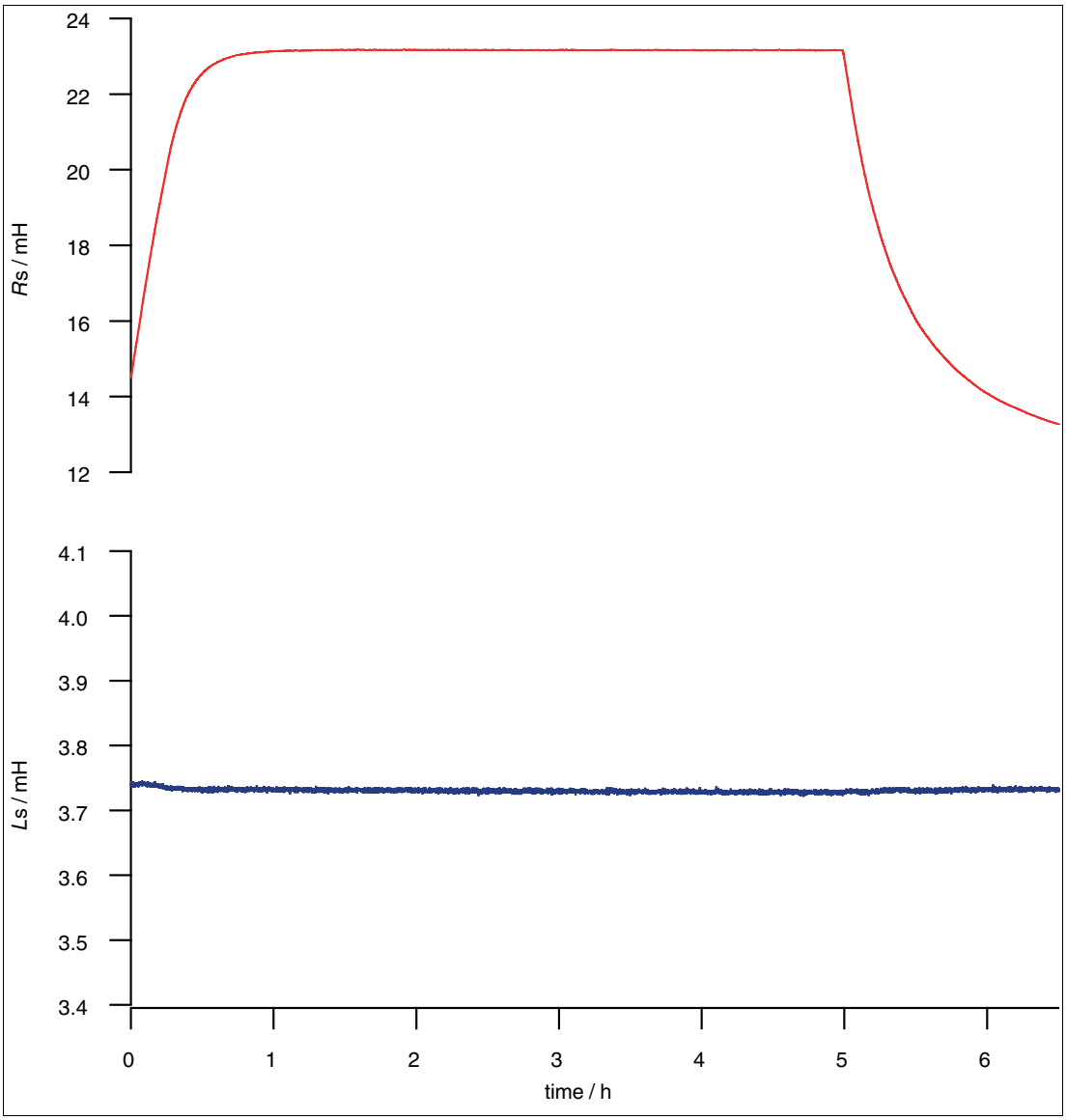


Figure 8.3

Unwanted Series Impedance Change Due to Aging Processes

When the sensor is in a new state, the coil impedance is constant if the temperature remains the same. However, aging processes can lead to slow continuous or sudden changes in coil impedance at the end of its service life. These may, for example, be caused by progressive copper oxidation ("scaling") or the degradation of coil wire insulation. A change in coil impedance can also occur due to improper handling of the sensor part, for example due to mechanical damage to the sensor head (ferrite core breakage) or cable breakage.

The following figure shows a typical change in the impedance of the sensor coil for storage at 250 °C for several thousand hours.

Time course of the relative change in the series resistor Rs and the coil inductance Ls

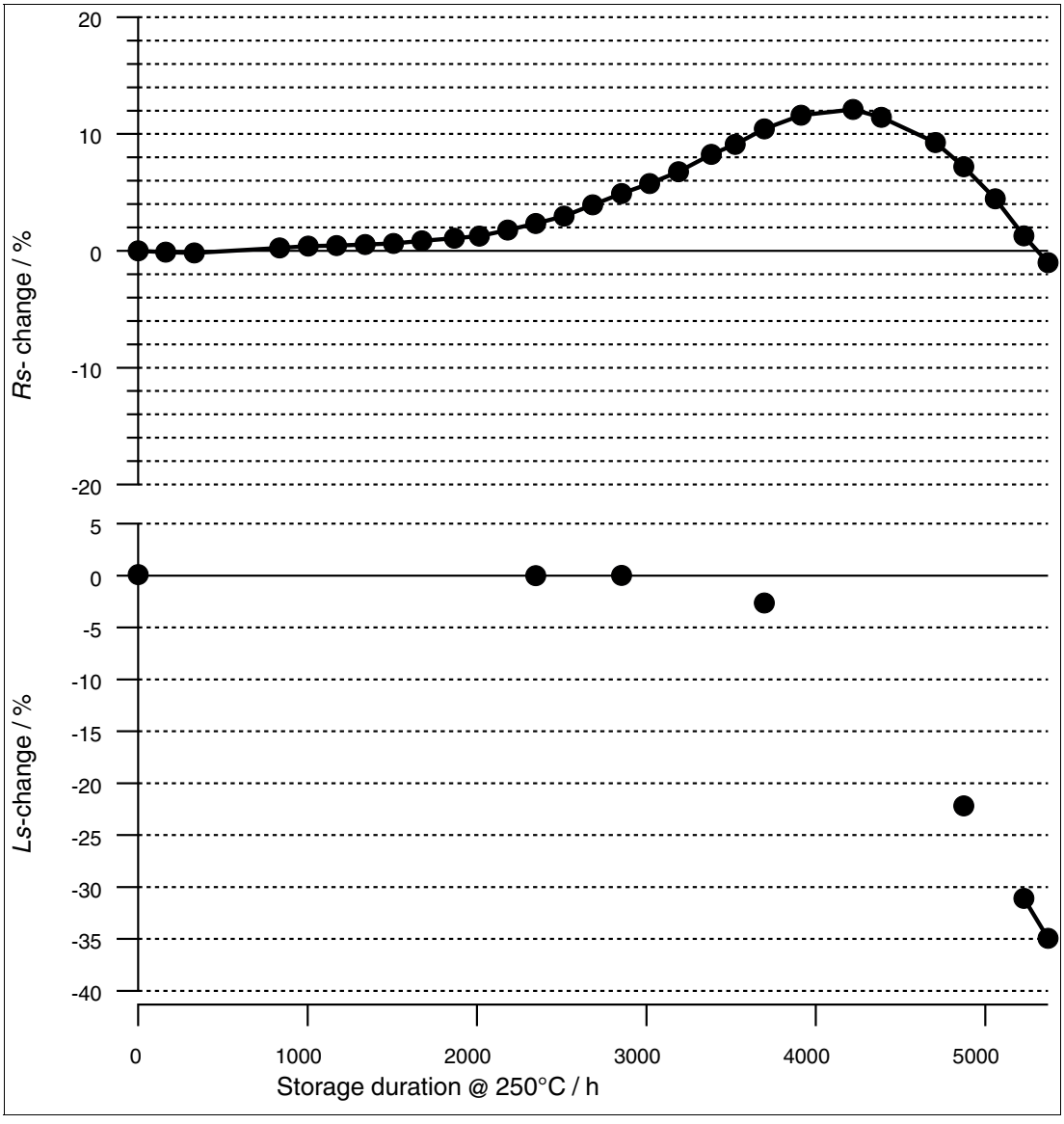


Figure 8.4

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The following figure shows a locus, which results from the application of the relative changes of impedance Rs against inductance Ls. It can be seen that the series resistance typically changes before significant changes in inductance can be detected.

Locus curve of the relative change of Rs against coil inductance Ls

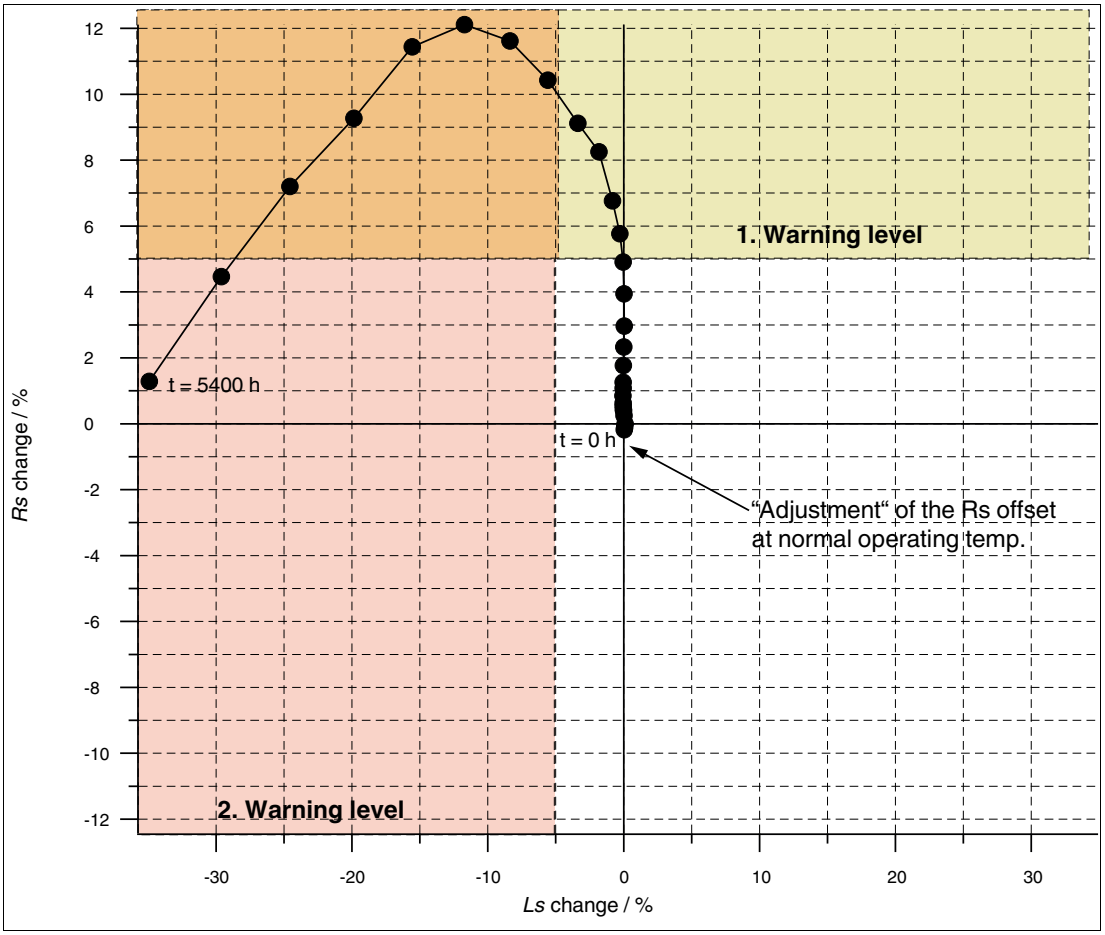


Figure 8.5

Two thresholds are indicated as "warning levels" in this example. If these are configured and are exceeded or undershot, a "DSC - Maintenance Warning" is triggered. The 1st warning level is triggered as soon as the series resistance Rs has exceeded an "Upper Threshold Rs" of +5 %. The 2nd warning level is triggered as soon as the coil inductance Ls has fallen below a "Lower Threshold Ls" of -5 %. To evaluate the 1st warning level (Rs) meaningfully, the values for Rs must be compared at the normal operating temperature due to the temperature dependence of Rs (temperature coefficient approx. 0.39 %/K). If the operating temperature is not sufficiently constant, we recommend that you only configure one threshold for Ls.

8.4.2 Saving Series Impedance Reference Values Immediately After Commissioning

Note

If you would like to make use of the options for monitoring the coil system, you must record and save current reference values promptly after commissioning.

To make statements about the aging status of the sensor head based on the relative impedance change of the sensor head, you should record the series impedance values for Ls and Rs (sensor head coil + cable) immediately after commissioning and save or record them as reference values for comparison purposes. Ideally, this is done at the standard operating temperature, especially when relative changes in the temperature-dependent series resistance Rs should be evaluated.

The comparison values of the new sensor head must be recorded again when the inductive sensor head is replaced. By executing the "Teach actual Ls and Rs" command, you can save the current Ls and Rs values as comparison values in the amplifier ("Comparative Value Rs" and "Comparative Value Ls" parameters). Alternatively, you can enter comparison values manually.

Note the following aspects for measuring and saving reference values:

- The series impedance of the connected sensor head (head + cable) is only evaluated if the distance from the metal object to the sensor end face exceeds at least 65 % of the effective operating distance.
- If no sensor head is connected (Sensor Head Status = Sensor not OK), no impedance readings are displayed (Ls, Rs, and signal strength = 0).
- The measuring range of the Rs measurement is 4000 to 45,000 mΩ and the measuring range of the Ls measurement is 2000 to 5500 µH.
- Due to component tolerances, different amplifiers for the same sensor head can easily supply different impedance readings with the typical variations being ΔRs,rel. <±4 %, and ΔLs,rel. <±1 %. This should be taken into account when evaluating relative impedance changes if the amplifier is replaced.
- The repeat accuracy (measurement noise) of the Rs measurement and Ls measurement is typically well below 1 %.

8.4.3 Series Impedance Monitoring for Predictive Maintenance

There are various indicators that you can monitor and evaluate yourself to assess when it makes sense to replace the inductive sensor head. To do this, you can create a monitoring scenario immediately after commissioning by saving reference values and limit values for the series impedance (sensor head coil + cable) Rs and Ls.

- **Resistance Criterion**
  We recommend that you replace the sensor head as soon as the resistance has changed by more than $\Delta Rs,rel \approx \pm 5$ % on average over time compared to the new state at the same temperature.
  As described above, however, it should be noted that temperature changes also lead to a change in coil resistance of approx. 0.39 %/K. The temperature of the sensor (sensor head + cable) must therefore be known and as constant as possible on average over time for the evaluation of the pre-failure criterion!
- **Inductance Criterion**
  We recommend replacing the sensor head as soon as the inductance has increased by more than $\Delta Ls \approx -5$ % compared to the new state.
  Since the inductance hardly depends on the temperature of the sensor head, the inductance criterion is usually easier to apply than the resistance criterion set out above.
  However, the inductance criterion does not allow for the early detection of aging processes that only affect the resistance of the sensor (e.g., progressive copper oxidation).

You can evaluate any Ls and Rs changes yourself, e.g. by reading out the current Ls and Rs values and comparing these values with the recorded/stored reference values.

Alternatively, a simple evaluation based on upper and lower percentage threshold values is already implemented in the amplifier. You can define limits for this. By setting "Lower Threshold Ls" to a value of -5 %, the user receives a "DSC - Maintenance Warning" in addition to the switching signal information, e.g., using the process data, if the inductance Ls has fallen below this value due to aging.

The "Maintenance Warning" information is transferred cyclically in the process data and also as an event. The event is only sent if it is activated in the "Event Config" parameter.

8.4.4 Signal Strength and Operating Reserve

The amplifier continuously evaluates the inductive interference of an approaching metal object on the sensor coil in the sensor head. The amplifier derives a switching signal from this measured variable using a threshold value comparison. For an extended evaluation, inductive interference in the form of "signal strength" is also provided via IO-Link.

The "operating reserve", which indicates how significantly the operating distance of the inductive sensor set is exceeded or undershot, serves as an additional adjustment aid for the user.

Signal Strength

The following figure shows an example of how the signal strength, the switching signal, and the operating reserve change when a standard measuring plate, acting as a damping element, is moved closer/further away to/from the sensor head. The standard measuring plate is made of ferromagnetic St37 steel with the following dimensions:

- 75 mm x 75 mm x 1 mm for the small sensor head
- 150 mm x 150 mm x 1 mm for the small sensor head

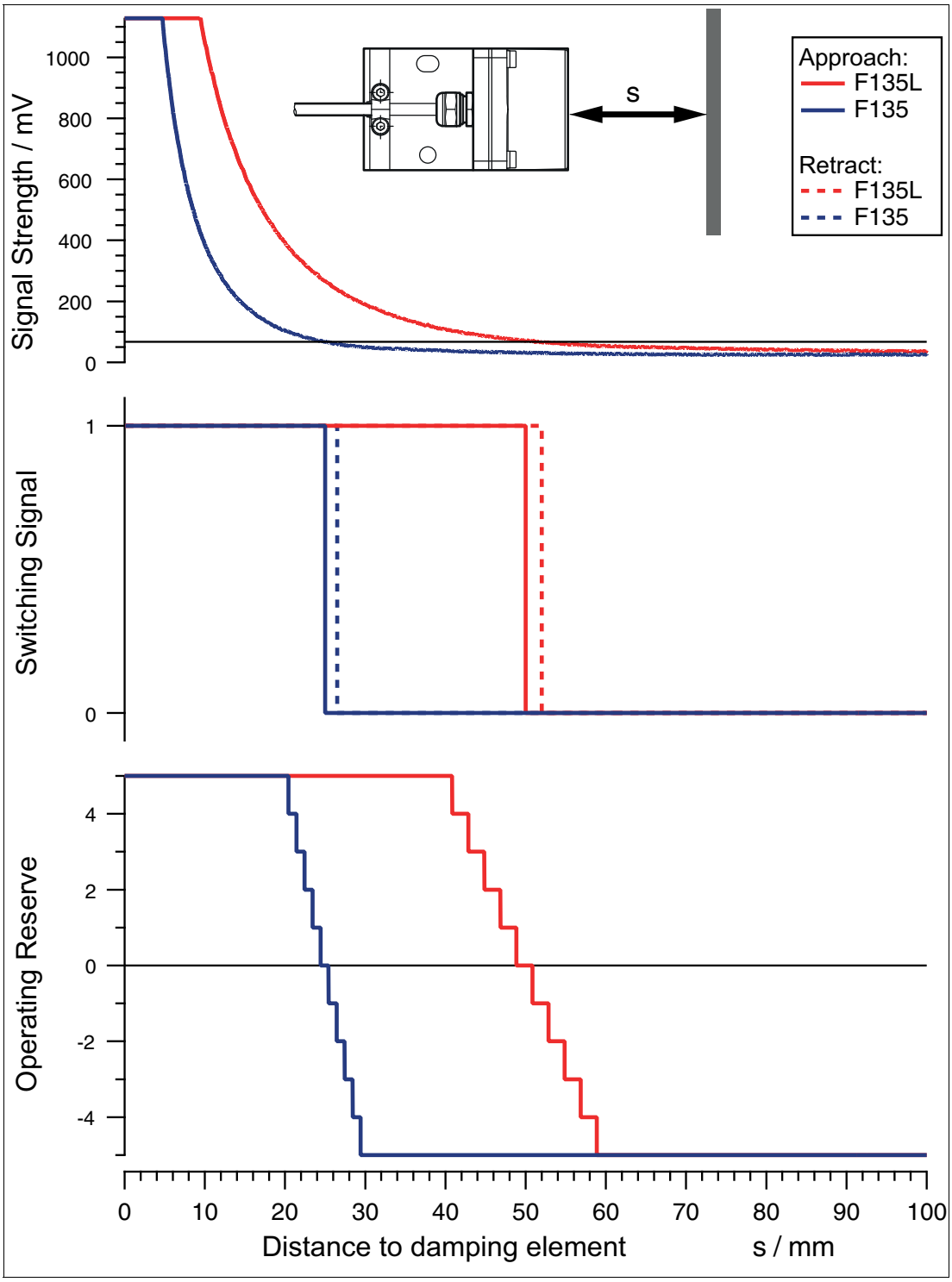


Figure 8.6

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The blue curves show the typical gradients for a sensor head of type *F135* (25 mm operating distance) and the red curves show the typical gradients for a sensor head of type *F135L* (50 mm operating distance).

Without a close damping element (metal object), the inductive interference is only determined by the aluminum angle of the sensor head or any metals present in the environment. The signal strength for large object distances is therefore at a low value of approx. 25–30 mV. As the standard measuring plate approaches , the signal strength increases as the distance decreases.

From a threshold of approx. 65 mV (black line in the "Signal strength" diagram), the switching signal of the sensor changes from low to high. This threshold is typically reached with a standard measuring plate distance of 25 mm for the small sensor head (*F135*) or 50 mm for the large sensor head (*F135L*). As it is moved closer, the signal strength increases until, at approx. 5 mm for the small sensor head (*F135*) or approx. 10 mm for the large sensor head (*F135L*), it reaches a limit value of approx. 1130 mV.

The relationship between inductive interference (signal strength) and object distance is highly non-linear in inductive sensors and depends on the geometry and electromagnetic properties of the detection object. A direct derivation of the object distance from the signal strength therefore requires a prior linearization to the relevant detection object. Nevertheless, even without linearization, a more precise evaluation of the signal strength can be used to make a statement about any varying object distances in the application . This makes it possible to detect mechanical changes in the operation of a system that are due to wear or changed ambient temperatures or an adjustment change, for example.

Operating Reserve

Like the switching signal, the operating reserve is derived directly from the signal strength and serves as an adjustment aid for the user. You can also read the information on the operating reserve acyclically using the "Observation Data" parameter (subindex 1), see chapter 8.9.

The "Operating reserve" diagram in the previous figure shows the measured values of the "Observation Data: Operating Reserve" parameter for moving a standard measuring plate toward or away from the object axially ("Switching signal" dashed lines diagram).

The value range of this parameter ranges from -5 to +5 and represents the distance range of a standard measuring plate distance in as linear a way as possible but also discreetly,

- between 80 % (20 mm for small sensor head *F135* and 40 mm for large sensor head *F135L*)
- and 120 % (30 mm for *F135* and 60 mm for *F135L*)

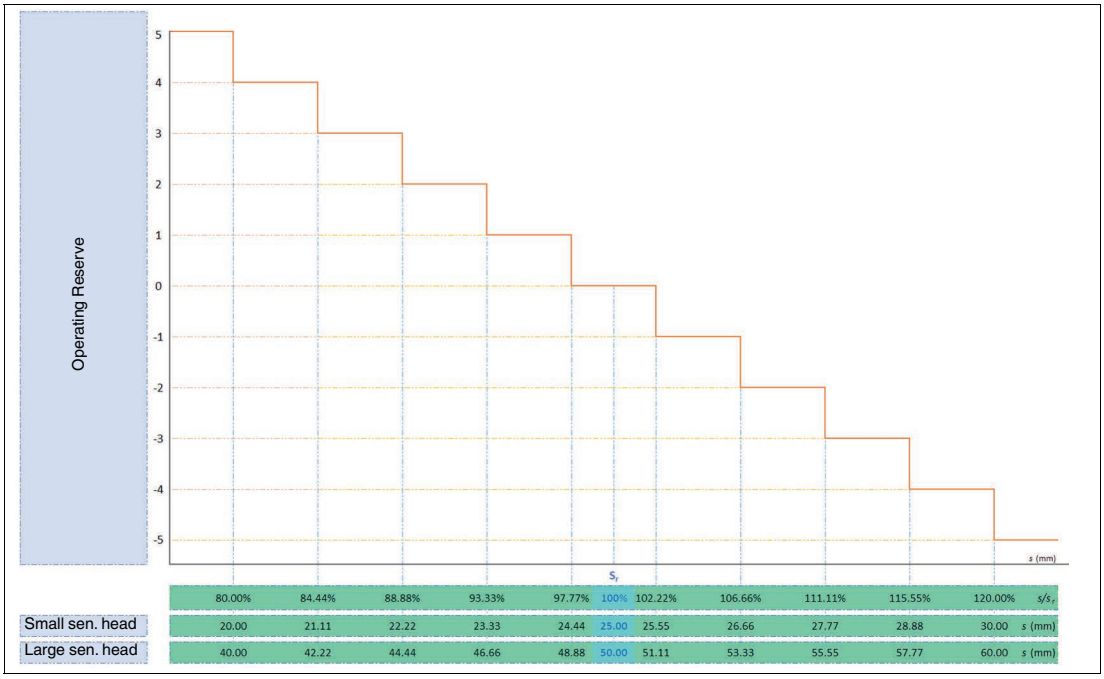


Figure 8.7

If the operating reserve assumes the value -5 or +5, the operating distance of the proximity switch is safely exceeded or undershot, which ensures rugged/reliable functioning of the object detection.

The table below shows the stages of the operating reserve in detail.

Distance s	Operating reserve
0 % ≤ s/s_r < 80.00 %	5
80.00 % ≤ s/s_r ≤ 84.44 %	4
84.44 % < s/s_r ≤ 88.88 %	3
88.88 % < s/s_r ≤ 93.33 %	2
93.33 % < s/s_r ≤ 97.77 %	1
97.77 % < s/s_r ≤ 102.22 %	0
102.22 % < s/s_r ≤ 106.66 %	-1
106.66 % < s/s_r ≤ 111.11 %	-2
111.11 % < s/s_r ≤ 115.55 %	-3
115.55 % < s/s_r ≤ 120.00 %	-4
120.00 % < Y	-5

Table 8.1

Signal Strength of the Last Minimum/Maximum and Weighted Signal Strength of the Last Minimum/Maximum

The four diagrams in the following figure describe the behavior of various sensor measured values in the event of a cyclical change in the axial distance of a standard measuring plate. The standard measuring plate distance was alternately reduced to different values and increased again a total of 12 times (see 1st diagram).

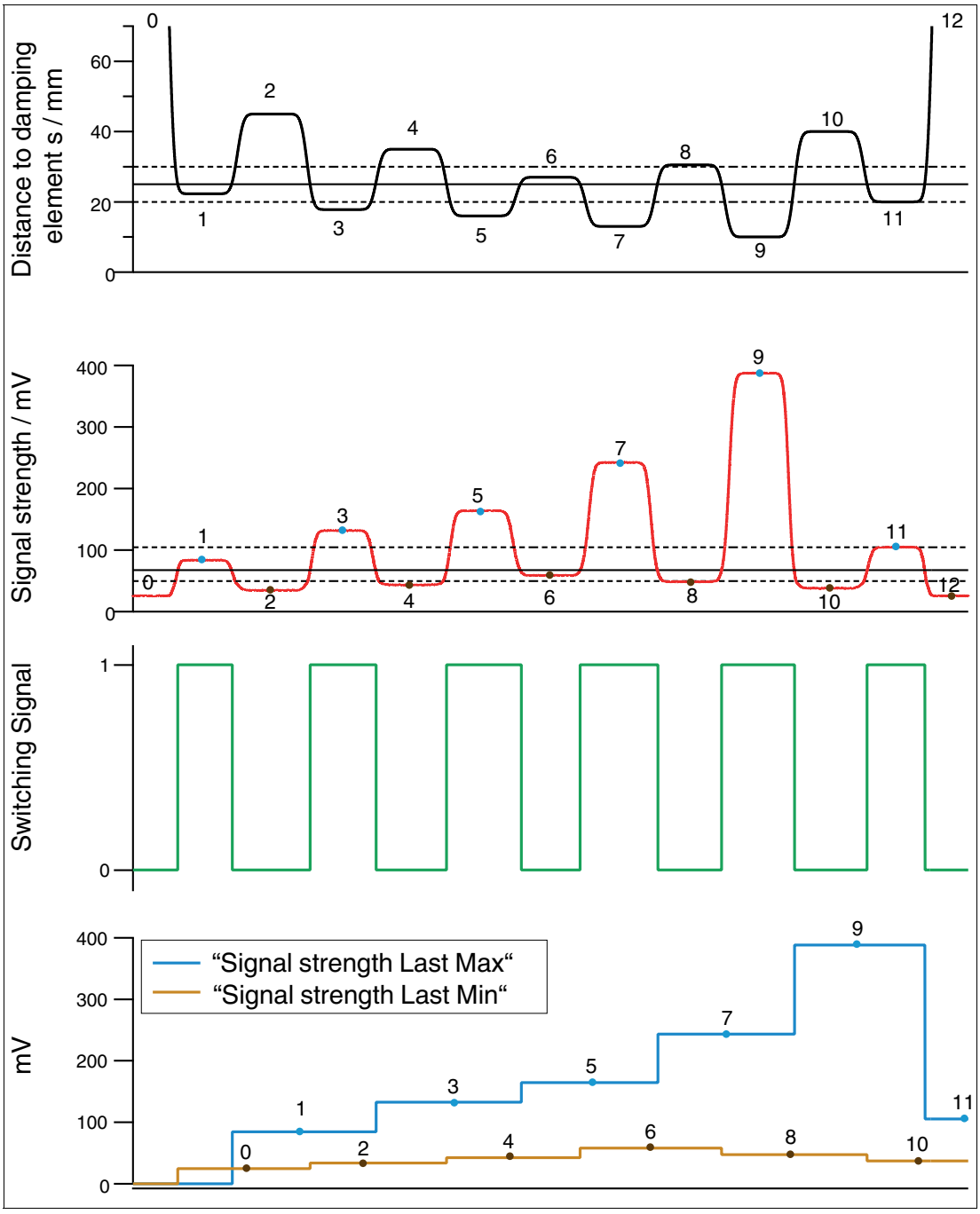


Figure 8.8

The resulting signal strength curve is shown in the 2nd diagram with a red line. With each change of direction in the 1st diagram, the switching threshold, symbolized by the black solid line, is exceeded at a distance of approx. 25 mm, so that the switching signal shown in the 3rd diagram changes from "Low" to "High" with a green curve.

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In the 2nd diagram, the local signal minima ("Signal Strength Min") and signal maxima ("Signal Strength Max") are numbered and marked with blue and brown markers. As soon as the inductive sensor set changes its switch state, these extremes (4th diagram) are saved in the amplifier in the form of the variables "Signal Strength Last Min" and "Signal Strength Last Max" and can be called up via IO-Link. This simple evaluation of the signal strength makes it possible to detect significant variations in cyclic "attenuations" and to draw conclusions about any changes in plant operation, for example aging, measuring objects of different sizes, different adjustments, etc.

Cyclic damping can be caused by a cyclic change in the axial distance of the measured object (see 1st diagram) or through a lateral pass of various measuring objects with potentially different sizes, properties, or distances.

Weighted Signal Strength of the Last Minimum/Maximum and Process Data "Option - Uncertainty Indication"

As further monitoring information in the "Maintenance Monitor Measurement" parameter, the amplifier provides the values "Signal Strength (rated) Last Min" and "Signal Strength (rated) Last Max". These are the extremes of the signal strength (1st diagram), which has been converted to the form of the operating reserve (3rd diagram).

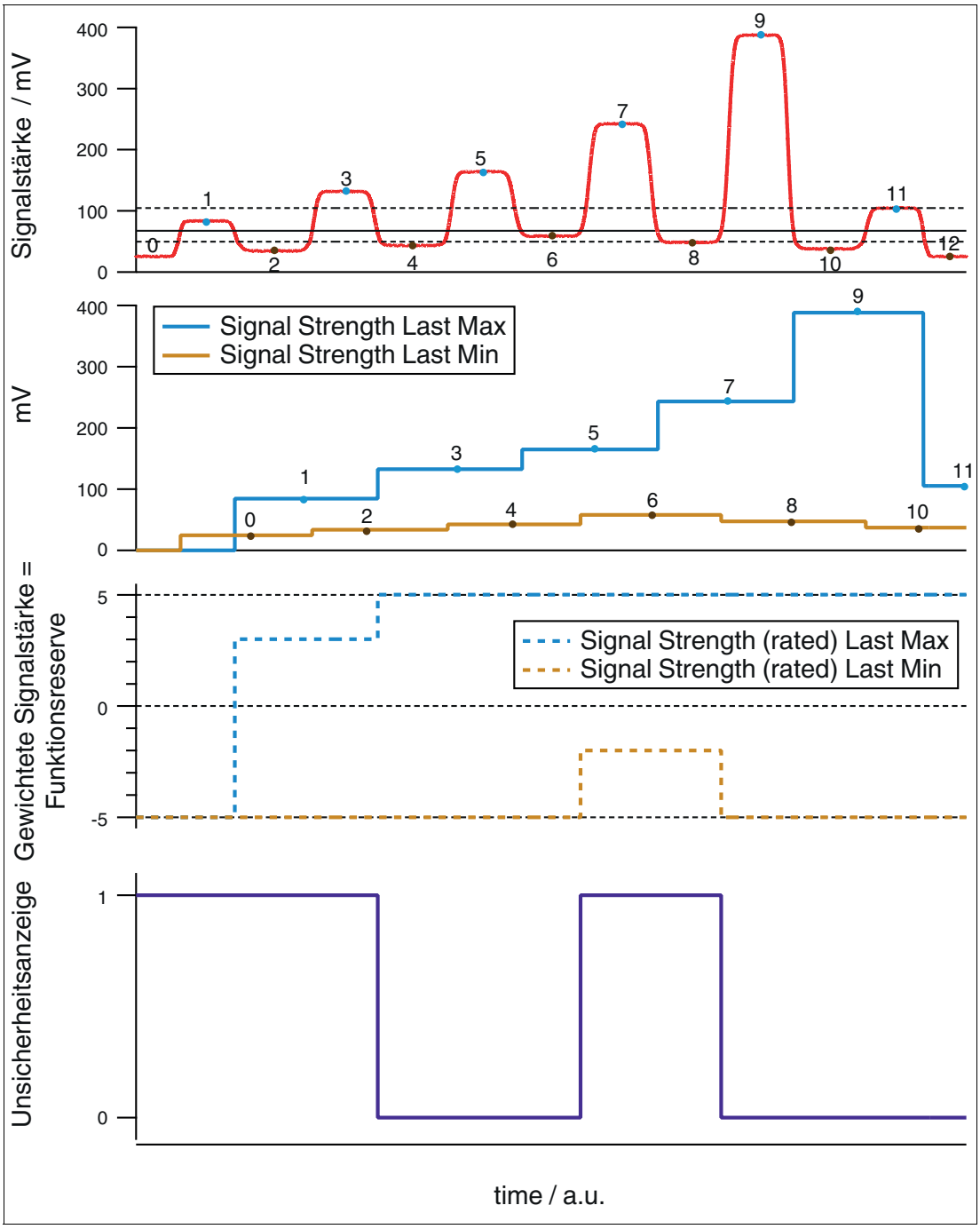


Figure 8.9

If the maximum and minimum of the weighted signal strength (3rd diagram) exceeds or falls below a value of +4 or -4, the effective operating distance of the sensor has been undershot or exceeded by at least 20 % during the last attenuation or de-attenuation by an object to be detected.

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If this is not the case, the sensor set outputs an uncertainty indication using the "Option - Uncertainty Indication" process data (4th diagram) and optionally as an event. This simple evaluation serves to inform the user of any critical detection distances at an early stage when setting up the system. If, for example, large mechanical tolerances should be expected during continuous plant operation, reliable object detection may no longer be guaranteed.

8.5 Maintenance Reset Count

Maintenance Reset Count

Index	Sub	Parameter	Access	Data Type	Length
223 (0xDF)	0	Maintenance Reset Count	r	UInteger	16 bits

Displays the number of maintenance cycles that have been reset using the "Maintenance Reset" command.

8.6 Operating Hours

Operating Hours

Index	Sub	Parameter	Access	Data Type	Length
224 (0xE0)	0	Operating Hours	r	UInteger	32 bits

The "Operating Hours" parameter indicates the operating time since the inductive sensor set was first commissioned. The resolution is 1 hour. You can read the parameter acyclically.

The value is permanently stored every 15 minutes. Each time the sensor set is switched on, the counter is incremented by 15 minutes. The counter has an accuracy of +/- 3 % over the entire temperature range.

8.7 Synchronization Status

Synchronization Status

Index	Sub	Parameter	Access	Data Type	Length
230 (0xE6)	0	Synchronization Status	r	UInteger	8 bits

The "Synchronization Status" parameter indicates the current status of the synchronization via the SYNC line.

The following synchronization statuses can be displayed:

- 0 (Line Sync off) = Synchronization using pin 2 has been deactivated. Pin 2 is pulled to "high" with high resistance (L+ potential)
- 1 (Neighbour detected) = Synchronization using pin 2 is activated. Sensor communicates via pin 2 and has detected another connected sensor.
- 2 (Line is low) = Synchronization using pin 2 is activated, but communication is not possible because the potential of pin 2 is permanently kept at "low".
- 3 (Line is high) = Synchronization using pin 2 is activated, but communication is not possible because the potential of pin 2 is permanently kept at "high".
- 4 (No connection) Synchronization using pin 2 is activated, but no other synchronization partner is connected to pin 2.

8.8 Maintenance Diag

Maintenance Diagnosis

Index	Sub	Parameter	Access	Data Type	Length
235 (0xEB)	0	Maintenance Diag	r	Record	16 bits
	1	Maintenance Diag: Operating Conditions Warning	-	Bool	1 bit
	2	Maintenance Diag: SSC Limits Value Warning	-	Bool	1 bit
	3	Maintenance Diag: Measurement Limit Values Warning	-	Bool	1 bit

The "Maintenance Diag" parameter provides recorded limit/measured value overranges and underranges that have been defined via the relevant maintenance parameters (see chapter 7). You can read the parameter acyclically.

Note

During ongoing operation, the current SSC count values can be read from a volatile buffer. The counters are written to a persistent memory every five minutes. If the operating voltage is lost, values that have not yet been written to the persistent memory may be lost. The counter value most recently written to the persistent memory is always output during a restart.

- **Operating Conditions Warning**
  Indicates whether the configured limit value for the "operating time" has been reached. The warning is reset by executing the "Maintenance-Reset", "Application-Reset", or "Back to Box" commands.
- **SSC Limit Value Warning**
  Indicates whether the limit value configured for SSC has been reached. The warning is reset by executing the "Maintenance-Reset", "Application-Reset", or "Back to Box" commands.
- **Measurement Limit Values Warning**
  Indicates whether one of the limit values configured for measurement conditions has been reached. The warning disappears again when the measured values are within the limit values.

8.9 Observation Data

Observation Data

Index	Sub	Parameter	Access	Data Type	Length
236 (0xEC)	0	Observation Data	r	Record	48 bits
	1	Observation Data: Operating Reserve	-	UInteger	16 bits
	2	Observation Data: SSC - Switching Signal	-	UInteger	8 bits
	3	Observation Data: OPTION - Uncertainty indication	-	UInteger	8 bits
	4	STAT - Sensor Head Status	-	UInteger	8 bits
	5	DSC - Maintenance Warning	-	UInteger	8 bits

This is a collection of measurement data that is relevant for monitoring the operational state of the device.

The following information is provided here:

- **Operating Reserve**
  For details, see chapter 8.4.4 section "Operating reserve".
- **SSC - Switching Signal**
  See process data description for SSC - Switching Signal.
- **OPTION - Uncertainty Indication**
  See process data description for OPTION – Uncertainty Indication
- **STAT - Sensor Head Status**
  See process data description for STAT - Sensor Head Status.
- **DSC - Maintenance Warning**
  See process data description for DSC - Maintenance Warning.

9 Maintenance and Repair

9.1 Maintenance Work

In general, maintenance on the sensor head itself is not required. However, check that the sensor head, actuator, and connector are secure as part of routine maintenance intervals. Use the maintenance functions of the inductive sensor set to monitor the sensor head and the application. You may also want to check that the connection cable is installed and intact.

9.2 Resetting the Output Functions to the Factory Setting

The sensor can be reset via IO-Link only. If you operate the device using the PACTware interface, you can perform a factory reset in the "Parameters" menu area, "General settings" function using the "Reset application" key.

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10 Troubleshooting

10.1 What to Do in Case of Fault

In case of fault, use the following checklist to determine whether a fault in the sensor can be remedied.

If none of the information provided in the checklist solves the problem, contact Pepperl+Fuchs via your sales office with any queries. If possible, have the model number and firmware version of the sensor ready.

Checklist

Error	Cause	Remedy
No IO-Link connection to device	The C/Q communication port on the sensor is not connected to the IO-Link master	Make sure that the C/Q communication port is connected to the IO-Link master.
	No power supply	Check whether there is a reason for the absence of the voltage supply (installation or maintenance work, etc.). Switch on the voltage supply.
	The IO-Link master (if used) is not ready for IO-Link operation.	If used, check the IO-Link master.
No sensor head detected	The connector of the sensor head connection cable is not correctly connected to the amplifier.	Ensure that the connection between the sensor head connection cable and the amplifier is correct and that the union nuts are hand-tight. Check the "Synchronization Mode" parameter. If a sync line is not to be used, option "0" or "2" must be set.
	The "Synchronization Mode" parameter may have an incorrect setting (1 = Line Sync on), although no synchronization is actually planned using the sync line. If, in this case, a low potential is permanently applied to the sync line, the measuring sequence remains stopped.	
Damping element not detected	The distance between the sensor and the damping element is too great.	Check the mounting and establish the correct distance between the sensor and the damping element.

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