Baumer Passion for Sensors

IO-Link

Instruction Manual

Inductive Sensors with IO-Link

Sensor Solutions
Motion Control
Vision Technologies
Process Instrumentation

Instruction Manual for Inductive Sensors with IO-Link

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1 Sensors covered by this manual

These instruction apply to the following sensor versions:

IRxx.DxxL.-xxx.GPxx.xxx
IFxx.DxxL.-xxx.GPxx.xxx

2 IO-Link Introduction

IO-Link is an IO technology standardized worldwide according to IEC 61131-9. It permits manufacturer-independent digital, bidirectional point-to-point communication. For this purpose, sensors are connected to the IO-Link master via standardized 3-wire plug-in cables. IO-Link is available for various sensor technologies and can also be integrated into small miniature sensors. See also here for more information.

With the IO-Link master, which bundles several sensors, the connection to the controller is made via the respective fieldbus system. In addition, an Ethernet-based connection (with OPC UA) from the master allows direct communication from the sensor to IT systems. IO-Link masters are available as field devices for decentralized mounting or as versions for mounting in control cabinets. Many control suppliers also offer IO-Link input terminals and thus an IO-Link master implemented directly on the control. The maximum cable length between sensor and master is 20 m. However, significantly longer connections from the sensor to the controller can be realized by connecting a field master to a field bus system. This gives them maximum flexibility in the connection solution.

As a member of the IO-Link Consortium, Baumer is involved in developing the standard and is one of the first manufacturers to feature the new Smart Sensor Profile 1.1. in its sensors.

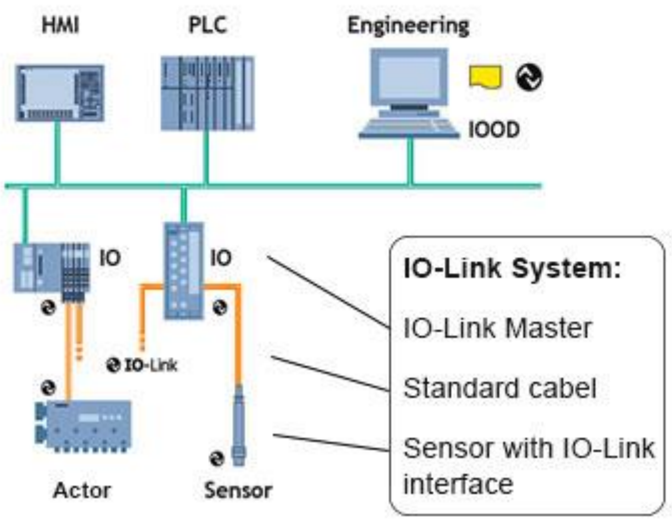


Figure 1 Example of a system architecture using IO-Link

2.1 SIO / DI Mode Mode

Each port of the IO-Link master can be operated either in SIO mode (standard in-out mode: according to the latest specification DI mode for sensors and DQ mode for actuators) or in IO-Link mode and thus process the information of all sensors. In SIO mode, the binary switching output (NPN, PNP or push-pull) of the sensor is used. In IO-Link mode, the output of the sensor (pin 4) is used as a bidirectional, digital interface to exchange measurement and diagnostic information.

2.2 IO-Link Communication Mode

The IO link communication mode is initiated by the master (PLC) with a standardized command sequence, this sequence is called “wake-up”. After successful completion of the wake-up sequence the IO link communication starts.

Data is the most important basis for process and product optimization. With the help of IO-Link, valuable additional data can be made accessible. Sensor and Master can exchange two different types of data (cyclic and acyclic data).
More information can also be found here.

2.2.1 Cyclic data

Transmitted in real time. They are used for process control in the automation system. These can also be transferred to other IT systems via IO-Link.

2.2.2 Acyclic data

Through this data stream, sensors (IO devices) can be parameterized. Additionally this data stream also allows to transmit data for identification and analyzation. The figure below shows the different types of data and their value for the application.

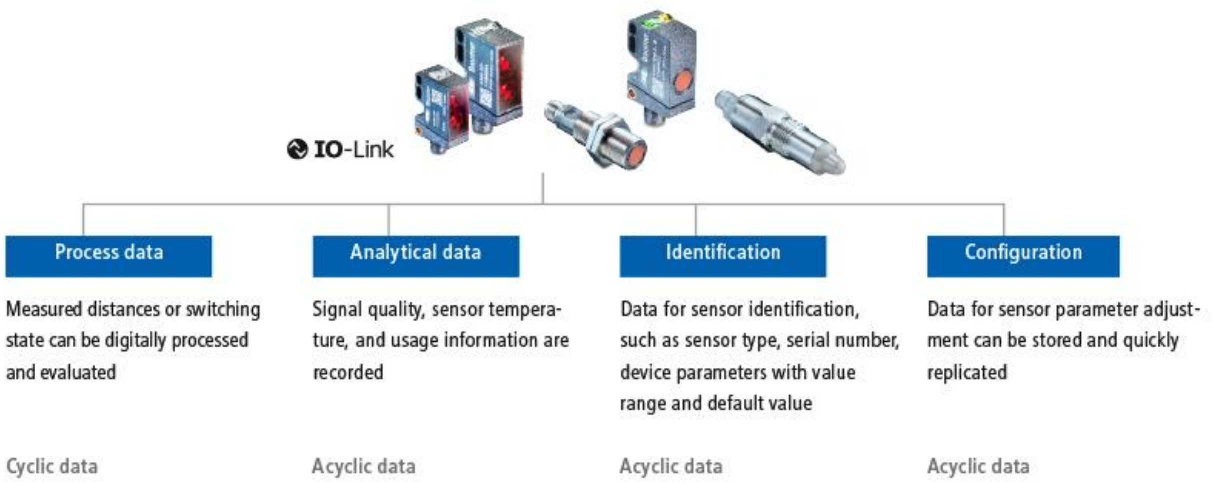


Figure 2 Different IO Link data streams

2.3 IO-Link Device Description (IODD)

Each IO-Link Device has a device description file, the so-called IODD (IO Device Description). This contains data about the manufacturer, article number, functionality, software version etc., which can be easily read out and further processed by the automation system. Each device, i.e. each sensor, can be uniquely identified both via the IODD and via an internal device ID. The identification data of the sensor also includes device or application descriptions that can be freely assigned by the user. The IODD consists of several files: a main file and optional external language files (both in XML format), as well as image files (in PNG format).

2.4 Off-Line Parametrization

Off-line sensor parameter adjustment via convenient user interfaces in the PC (via USB Master) or via Wireless App (via Wireless Master). Sensors can be conveniently configured at the desk and installed without further teach-in.

Even if IO-Link is not implemented in the machine control, sensors can be operated in SIO mode and use this advantage

2.5 Adjustable switching sensor (AdSS)

Additionally, the sensors described in this manual can be operated as “adjustable switching sensors (AdSS)” according to the Smart Sensor Profile. When treated as AdSS the sensors-Master communications happens via a fully standardized command set. Thus operation without IODD file is possible.

3 Sensor in the IO-Link Communication Mode

3.1 Signal Path

The signal path describes the rough position of a parameter in the signal processing chain. The path starts with the measuring value in the top left corner and finishes either with a physical pin (top right) or as output via the process data (bottom right).

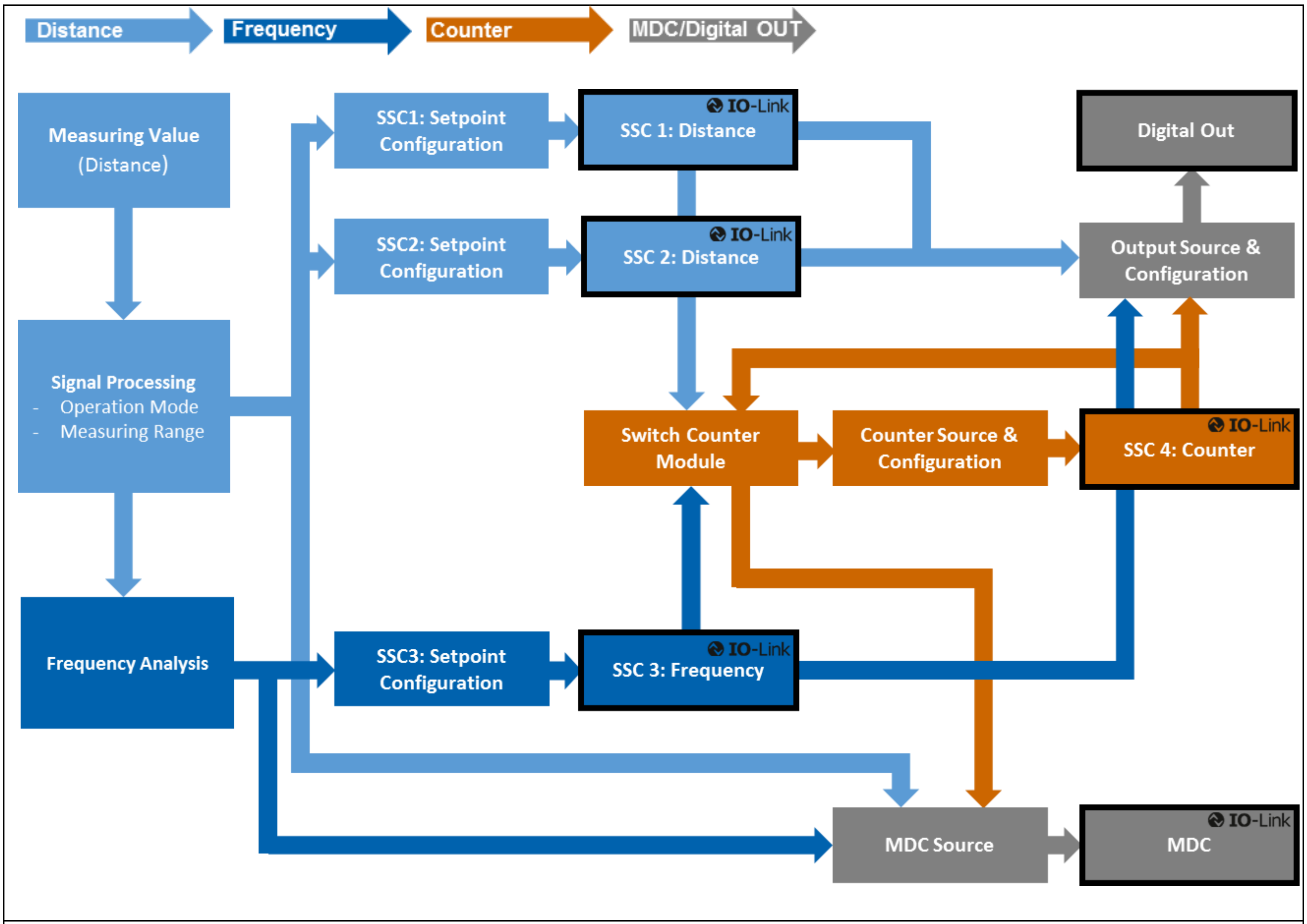


Figure 3 Illustrates the signal path from raw data to an output either through a physical pin (top right) or as output via the process data (bottom right)

3.2 Process Data

With the sensor in the IO-Link communication mode, process data is cyclically exchanged between the IO-Link master and the device. Process data is exchanged to and from the sensor (Sensor←→Master). The master does not need to explicitly request these process data.

3.2.1 Process Data-In

Process Data-In is sent from the sensor to the master (Sensor → Master). As shown in

IO-Link Process Data Input							
Bit:							
0	1	2	3	4	5	6	7
SSC1	SSC2		Alarm	SSC3	SSC4		
Bit:							
16…31							
Measurement Data Channel (MDC)							

Figure 4 Process data Input

The Process Data Input is an 32bit string and structured according to the Smart Sensor Profile definition PDI32.INT16_INT8.

Bit 0/Bit 1: SSC1/SSC2 (Switching Signal Channel 1 & Channel 2)
These bits are the digital representation of the switching outputs.
Bit1 = 0 → There is no object within the switching range (Logic: Normal)
Bit1 = 1 → An object lies within the switching range (Logic: Normal)
See section 4.3 to learn how to configure this bit

Bit 3: Alarm
The alarm bit indicates that there is a detectable problem with the configuration or function of the sensor.
Bit3 = 0 → Sensor operates properly.
Bit3 = 1 → A problem with either the sensor configuration or function was detected.

Bit 4: Switching Signal Channel 3 (SSC3), Frequency Function
By configuring SSC3, it is possible to set up a binary signal related to the frequency measurement.
See section 4.3 to learn how to configure this bit.

Bit 5: Switching Signal Channel 4 (SSC4), Switch Counter Function
By configuring SSC4, it is possible to set up a binary signal related to the number of switchcounts of SSC1 or SSC2. An auto-reset and timefilters are included, to be able to create a full-featured counter being able to count lot sizes without any need to code software on the PLC.
See section 4.3.4 to learn how to configure this bit.

Bit 8 to 15: Scale
Value is the exponent to the power of ten, applicable to the value of the Measurement Data Channel (MDC)
Example:

- Value of MDC 1000
- Unit m
- Scale -6
- Means $1000*10^{-6}$ m or 1000 µm

As inductive IO-Link sensors only providing measuring values where no scale factor is required, the scale factor is set fixed to 0 (zero).

Bit 16 to 31: MDC
MDC stands for measurement data channel. Via this channel the distance value or the switch counts of SSC1, 2, 3 or 4 can be read out as 16 bit integer value. See section 4.2 to learn how to configure the MDC.

3.2.2 Process Data-Out

This data is cyclically sent from the master to the sensor (Master→Sensor).

IO-Link Process Data Output							
Bit:							
7	6	5	4	3	2	1	0
					Synchronisation	Find Me (Localization: LEDs flashing)	Disable Oscillator

Bit 0: Disable Oscillator
By changing this bit the oscillator is disabled. This switches off the oscillator without switching off the electronics. The sensor will not deliver a measurement or switching value. This can be useful to measure neighbouring sensors sequentially.

Note:
This command could create a short communication interrupt.

Bit 1: Find Me Function
Signalling e.g. by flashing LEDs on the sensor to locate and physically identify a sensor in a machine or system. The signalling can be triggered, for example, from the engineering tool of the controller.

4 Parameter

4.1 System Commands

A factory reset of the sensor activates the default parameters as programmed in the factory. All parameters changed by the user will be lost.

Parameter name	Short Description	Rights	Unit / Allowed values
Standard Command	Sets all parameters back to factory configuration	wo	Restore Factory Settings
Baumer Command	Resets all statistic data	wo	All Resetable Statistics Data Reset
Baumer Command	Manually store statistic data prior to disconnecting the sensor. Otherwise counts which occurred since last automatic write interval get lost. Standard automatic write interval is 5 minutes.	wo	Store Statistics

4.2 Measurement Data Channel (MDC)

4.2.1 Measurement Values

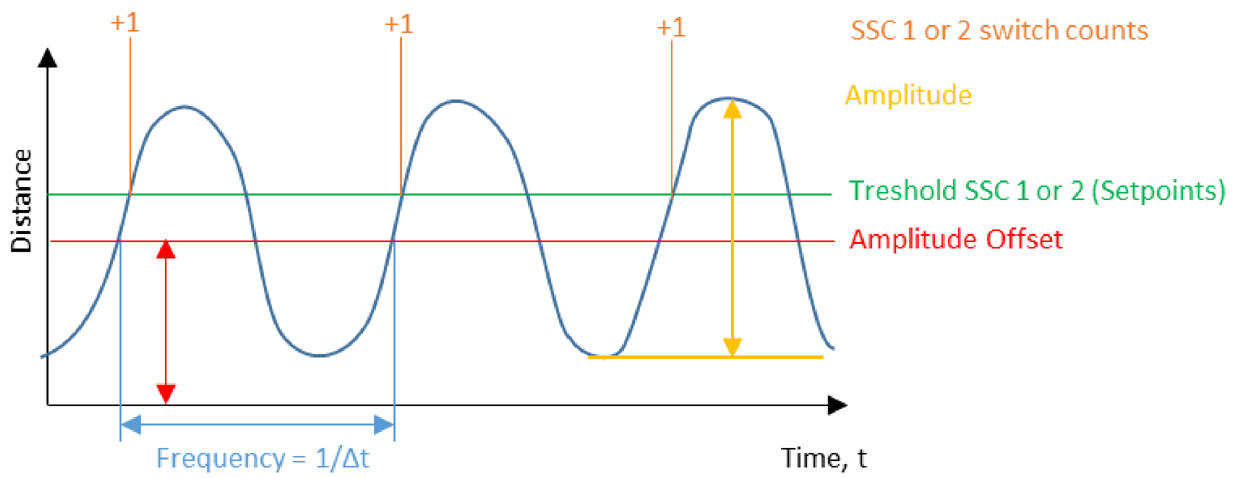


Figure 5 Measurement values

Parameter name	Short Description	Rights	Unit / Allowed values
Measurement Value.Distance	Distance measuring value	ro	
Measurement Value.Frequency	Frequency measuring value which is created by analyzing the distance. Measurement is independent of SSC settings.	ro	
Measurement Value.Amplitude	For diagnostics or for evaluating the application/set up for frequency measurements	ro	

Measurement Value.Amplitude Offset	For diagnostics or for evaluating the application/set up for frequency measurements	ro	

4.2.2 Switch Counts

For each individual SSC a switching counter is implemented, which can be used as diagnosis data or also as measurement value. The number of counts of each channel can also be mapped to the measurement data channel MDC by adjusting the MDC source. Trigger of counter is on positive slope of related SSC.

Note:
Each power up, the switch counts are being reset/start from 0 either for SSC1 or SSC2.

SSC1 and SSC2 are the signal channels for distance measurement, SSC3 is for frequency measurement, SSC4 is for switch counts.
For SSC4 a source has to be set. This source captures the number of switch counts and provides the value to SSC4. This source has to be either SSC1 or SSC2.
The counter which is mapped as source of SSC4 is the one that gets set to zero on power up.
This cannot be disabled, meaning that either SSC1 or SSC2 gets set to zero every time a power up is done on the sensor.

Parameter name	Short Description	Rights	Unit / Allowed values
- SSC1 Switch Counts Reset - SSC2 Switch Counts Reset - SSC3 Switch Counts Reset - SSC4 Switch Counts Reset	Command to set the counter value of SSCn to zero. Available for SSC1,2,3 and 4.	wo	
- Switch Counts.SSC1 Resetable - Switch Counts.SSC2 Resetable - Switch Counts.SSC3 Resetable - Switch Counts.SSC4 Resetable	Number of switching operations. Available for SSC1,2,3 and 4.	ro	32 Bit value

4.2.3 MDC Source

Selects which measuring value is mapped to the MDC channel and is then available via the process data-IN path. When SSC1, SSC2 or SSC4 is selected the number of switches detected by the channel is shown.

Parameter name	Short Description	Rights	Unit / Allowed values
MDC.Source	Defines the measuring value which is mapped to the MDC channel for availability via the process data-IN path.	ro	- Distance - Frequency - Switch Counter SSC1 - Switch Counter SSC2 - Switch Counter SSC3 - Switch Counter SSC4

4.2.4 MDC Descriptor

This parameter allows to read out the limits of the measuring range of the sensor and unit. When the sensor detects values outside of this range, it will report an out of range value (32760).

Parameter name	Short Description	Rights	Unit / Allowed values
MDC.Unit Code	Shows the unit of the selected MDC source	ro	
MDC.Lower Limit	lower limit of the measuring range	ro	
MDC.Upper Limit	upper limit of the measuring range	ro	

4.3 Switching Signal Channel (SSC)

The sensor features three different switching channels. Switching Signal Channels SSC1 and SSC2 are reserved for distance measurements and SSC3 for frequency measurments
Switching Channel 4 includes a counter function with an auto-reset. All switching channels can be adjusted individually via IO-Link. All switching channels can be mapped to the MDC as well. Then they will show the counts detected by the channel.

For more information about how to set-up the Counter/SSC4 channel and its behavior, please see section 4.3.4.

4.3.1 Setpoints SP

Using this parameter the user can modify the switchpoint of the sensor by entering the distance or frequency value at which the sensor should switch (teach-by-value function). **Figure 6** shows the illustration of the switch point. For Single point mode only SP1 is relevant, SP2 is not active.
For the Window and Two Point modes SP1 & SP2 are active. The switching modes are explained in section

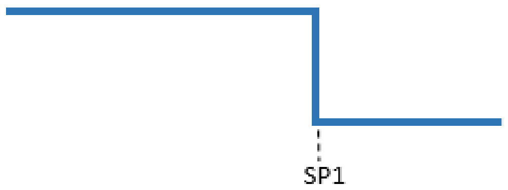


Figure 6 Single Point Mode
SP1: Switch point 1
SP2: is not active

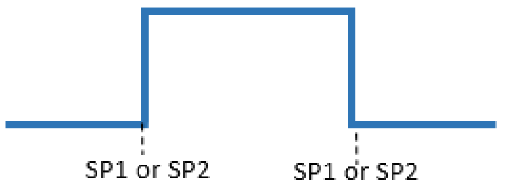


Figure 7 Window Mode
SP1: Switch point 1
SP2: Switch point 2

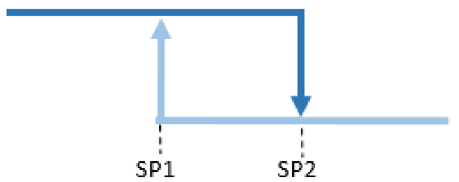


Figure 8 Two Point
SP1: Switch point in close distance
SP2: Switch point in far distance

Parameter name	Short Description	Rights	Unit / Allowed values
SSC1 Setpoints.SP1	Set the distance at which the related	rw	

	SSC is set to active (or inactive if inverted)		
SSC1 Setpoints.SP2	Set the distance at which the related SSC is set to inactive (or active if inverted) - only active if SSC is set to window mode or two point mode	rw	

4.3.2 SSC Configuration

4.3.2.1 Switching Mode

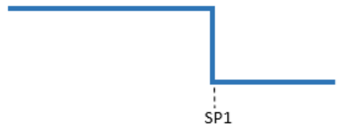


Figure 9 Single point

A single switchpoint (SP1) is defined at which the sensor switches.

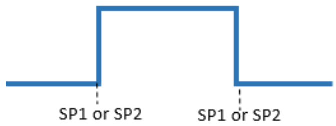


Figure 10 Window Mode

The sensor switches withing a range defined by two different setpoints (SP1 and SP2)

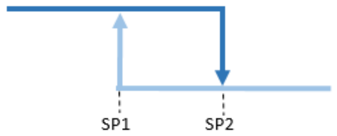


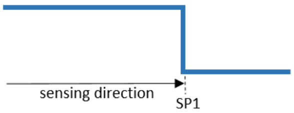
Figure 11 Two Point

SP1 and SP2 define the on and off switching positions/Hysteresis.

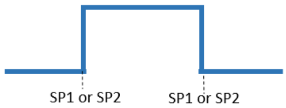
Parameter name	Short Description	Rights	Unit / Allowed values
SSC1 Config.Mode	Selection of the switching mode	rw	- Deactivated - Single Point - Two Point - Window

4.3.2.2 Channel Logic

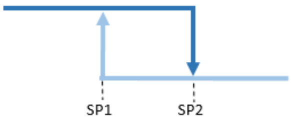
Allows to change the output logic from Normally Open (NO, Normal) to Normally closed (NC, Inverted).



Single Point Mode



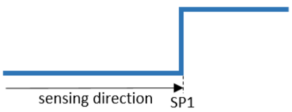
Window Mode



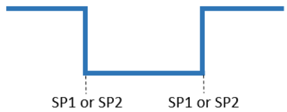
Two Point Mode

Figure 12 «Normal» or NO setting

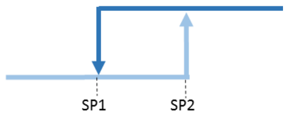
- The **output is high**, when the object is within the range defined by the setpoints.
- The **output is low** when the object is not present our outside of the range defined by the setpoints



Single Point Mode



Window Mode



Two Point Mode

Figure 13 «Inverted» or NC setting

- The **output is high** when the object is not present our outside of the range defined by the setpoints

the **output is low**, when the object is within the range defined by the setpoints

Parameter name	Short Description	Rights	Unit / Allowed values
SSC1 Config.Logic	Changes the Logic from NO to NC	rw	- Normal (NO) - Inverted (NC)

4.3.2.3 Hysteresis Width

The hysteresis is configured relative value of the switch point value. It is the difference between switch point and reset point (see Figure 14). This parameter can be beneficial to smoothen out signals when samples/objects have quickly changing positions.

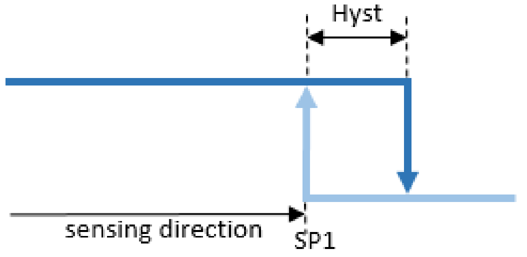


Figure 14 Hysteresis is the difference between switch point and reset point

- Bright blue: object moving from far to close distance (in this case switch point)
- Bark blue: moving from close to far distance (in this case reset point)

Parameter name	Short Description	Rights	Unit / Allowed values
Hysteresis.SSC1 Width	Adjust hysteresis width as percent of the switch point value	rw	%

4.3.2.4 Hysteresis Alignment Mode

In case of axial detection tasks like stop trigger or level detection, an accurate switching distance is required. To adapt the switching behavior and the hysteresis to the movement direction of the object, the alignment of the hysteresis can be changed.
Only active in Sinlge Point or Window mode.

Parameter name	Short Description	Rights	Unit / Allowed values
Hysteresis.SSC1 Alignment	Selection of the alignment modes Available for SSC1, SSC2 and SSC3	rw	- Left Aligned - Center Aligned - Right Aligned

4.3.2.4.1 Left Aligned

Left Aligned defines the hysteresis to be aligned towards the sensor / against the sensing direction.

When to apply?

- For an accurate switching distance in case the object is moving away from the sensor

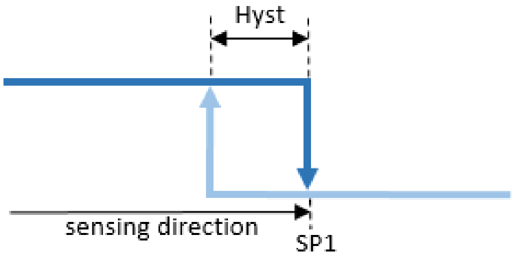


Figure 15 Left Aligned, Single Point Mode

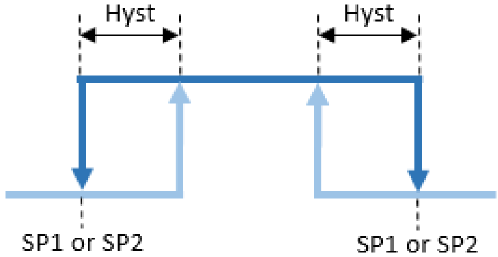


Figure 16 Left Aligned, Window Mode

4.3.2.4.2 Right Aligned

Right Aligned defines the hysteresis to be aligned away from the sensor / in sensing direction.

When to apply?

- For an accurate switching distance in case the object is moving towards the sensor.
  - Example: Stop trigger application, usual detection tasks.

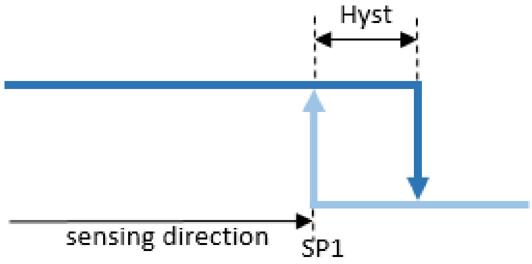
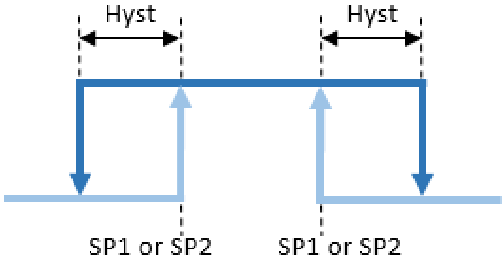
	

Figure 17 Right Aligned, Single Point Mode	**Figure 18** Right Aligned, Window Mode

4.3.2.4.3 Center Aligned

A compromise between left and right aligned. The hysteresis is aligned symmetrical around the individual setpoints.

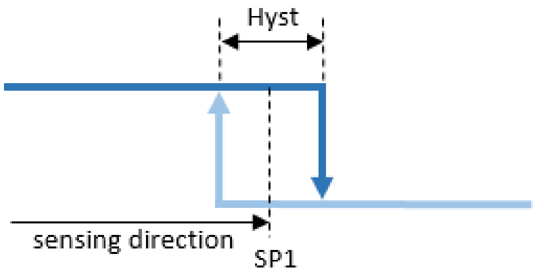
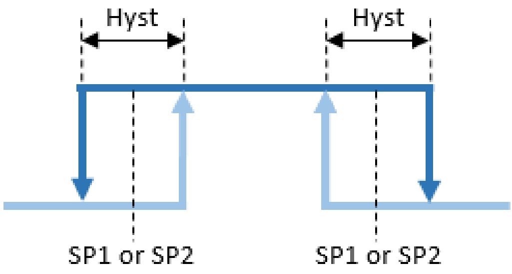
	

Figure 19 Center Aligned, Single Point Mode	**Figure 20** Center Aligned, Window Mode

4.3.3 Timefilter

This changes the timing of the switching signals, for example to avoid bouncing/suppress false switching operation. The ability to directly parametrize and configure the timing on the sensor itself, removes the need to have additional coding on the PLC or to use pulse stretching adapters.

The described time filters can be configured and applied to each SSC individually.

4.3.3.1 Response Delay Time

The response delay time defines the time, the measurement value needs to be above (single point mode) or inside (window mode) the switchpoints of the related SSC until its status changes to active (or inactive, if the logic is inverted as described in section 4.3.2.1)

When to apply?

- To avoid the detection of small peaks/false switching operations due to structure changes of the background or similar.
- To avoid wrong switching of known disturbances such as the wheel of a mixer
- To avoid bouncing.
- To optimize the timing of the execution of a subsequent actor triggered by the outssput of the sensor.

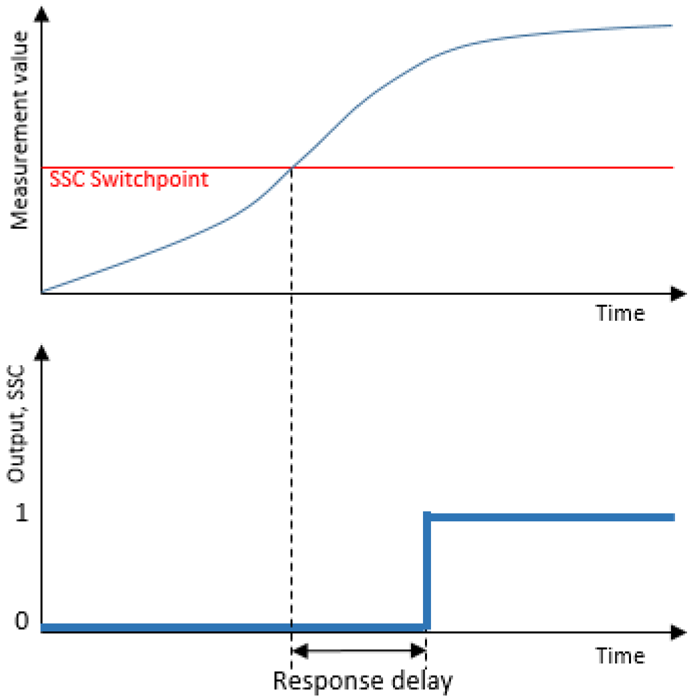


Figure 21 Response Delay

Parameter name	Short Description	Rights	Unit / Allowed values
Response Delay.SSC1 Time	Sets the response delay time, Available for SSC1, SSC2, SSC3 and SSC4	rw	0 to 60.000 ms

4.3.3.2 Release Delay Time

The release delay time defines the time, where the measurement value needs to be below (single point) or outside (window mode) of the switchpioints of the related SSC, until its status is changed to inactive (or active, if the logic is inverted as described in section 4.3.2.1)

When to apply?

- To avoid false switching operations in case of an object which is not 100% stable to detect over the whole length
- To supress short losses of a proper signal due to known disturbances such as the wheel of a mixer.
- To avoid bouncing.
- To optimize the timing of the execution of a subsequent actor triggered by the output of the sensor.
- To detect a unwanted gap size within a continuous flow of products.

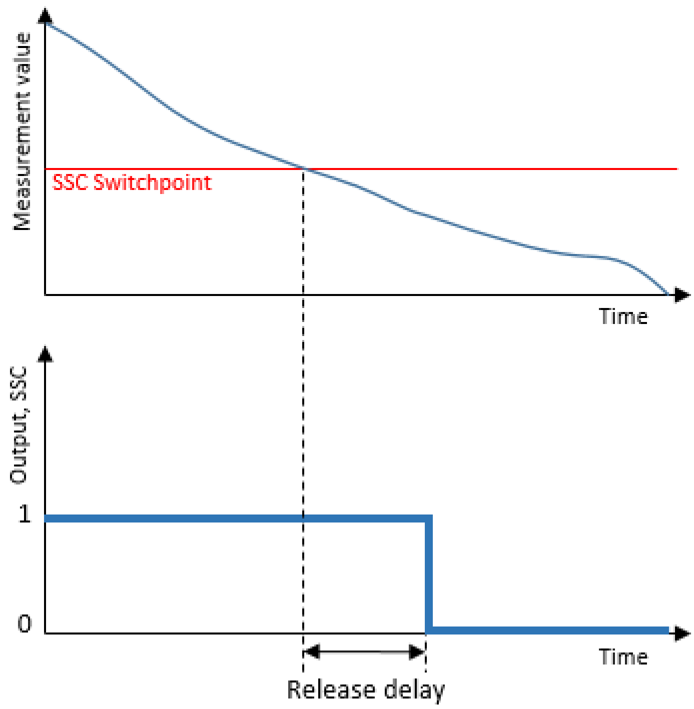


Figure 22 Release Delay

Parameter name	Short Description	Rights	Unit / Allowed values
Release Delay.SSC1 Time	Sets the release delay time, Available for SSC1, SSC2, SSC3 and SSC4	rw	0 to 60.000 ms

4.3.3.3 Minimum Pulse Duration

The minimum pulse duration defines the minimum time, the switching signal of the related SSC stays active or inactive after the change of its status.

This parameter can be applied on

- both slopes / active and inactive
- positive slope / active (or inactive, if the logic is inverted as described in section 4.3.2.1)
- negative slope / inactive (or active, if the logic is inverted as described in section 4.3.2.1)

When to apply?

- To align the timing of the sensor to a slower PLC.
- To avoid bouncing.
- To avoid false pulses due to short losses of a proper signal.
- To straighten the clock / pace

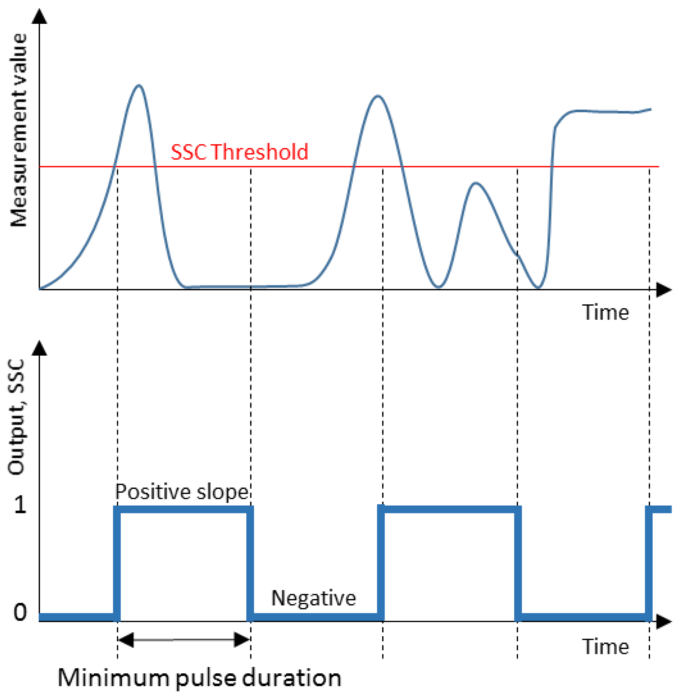


Figure 23 Minimum Pulse Duration

Parameter name	Short Description	Rights	Unit / Allowed values
Minimum Pulse Duration.SSC1 Time	Sets the response delay time, Available for SSC1, SSC2, SSC3 and SSC4	rw	0 to 60.000 ms
Min Pulse Duration.SSC1 Mode	Sets the mode as described in , Available for SSC1, SSC2 SSC3 and SSC4	rw	Both Slopes / Positive Slope / Negative Slope

4.3.4 Counter / SSC4

For each individual SSC a switching counter is implemented, which can be used as diagnosis data or also as measurement value. The number of counts of each channel can also be mapped to the measurement data channel MDC by adjusting the MDC source (See section 4.2.3).
Trigger of counter is on positive slope of related SSC. When the sensor is powered up, the counter assigned to SSC 4 (Index 85.31) is automatically set to zero, even if SSC4 is disabled (Index 85.32).

By configuring SSC4, it is also possible to set up a binary signal related to the number of switchcounts of SSC1 or SSC2. An auto-reset and timefilters are included, to be able to create a full-featured counter being able to count lot sizes without any need to code software on the PLC.

As all SSCs, SSC4 can also be mapped to the digital output giving the possibility to create a stand-alone lot-size counter.

In section 3.1, the signal path is decribed more detailed, to illustrate how the counter module is implemented. In section 4.3.4.2 the behavior depending on the configuration is explained.

4.3.4.1 SSC4 Configuration

In general the SSC4 offers the same features as the SSC1 and SSC2 based on distance (See 4.3.2), including also timefilters.
Exceptions:

- No hysteresis settings as there are only incremental counts.
- Additional parameters to adjust like *SSC4 Source* and *SSC4 Auto-Reset.*

Parameter name	Short Description	Rights	Unit / Allowed values
SSC4 Setpoints.SP1	Set the number of counts at which the SSC is set to active (or inactive if inverted)	rw	Counts / 0 to 32759
SSC4 Setpoints.SP2	Set the number of counts at at which the SSC is set to inactive (or active if inverted) - only active if SSC is set to window mode	rw	Counts / 0 to 32759

Parameter name	Short Description	Rights	Unit / Allowed values
SSC4 Config.Logic	Changes the Logic from NO to NC	rw	- Normal - Inverted
SSC4 Config.Mode	Selection of the switching mode	rw	- Single Point - Window
SSC4 Config.Source	Selection of source for counter function	rw	- SSC1 Switch Counter - SSC2 Switch Counter
SSC4 Config.Auto Reset	Autoreset of switch counter if given switch counts are reached. If autoreset is switched from disabled to enabled, the selected switch counter-source is automatically being reset to zero.	rw	- Enabled - Disabled

Parameter name	Short Description	Rights	Unit / Allowed values
Response Delay.SSC4 Time	Sets the response delay time, Available for SSC1, SSC2, SSC3 and SSC4	rw	0 to 60'000 ms
Release Delay.SSC4 Time	Sets the release delay time, Available for SSC1, SSC2, SSC3 and SSC4	rw	0 to 60'000 ms
Minimum Pulse Duration.SSC4 Time	Sets the response delay time, Available for SSC1, SSC2 , SSC3 and SSC4	rw	0 to 60'000 ms
Min Pulse Duration.SSC4 Mode	Sets the mode as described in , Available for SSC1, SSC2, SSC3 and SSC4	rw	Both Slopes / Positive Slope / Negative Slope

4.3.4.2 SSC4 Behavior

By enabling autoreset, a full-featured counter being able to count lot sizes can be created without any need of a manual reset.
Timefilters like *Response Delay* can help to optimize the timing of the execution of a subsequent actor.

Figure 24 illustrates the behavior of SSC4 using different setting. SSC4 source is hereby the switchcounter of SSC1.

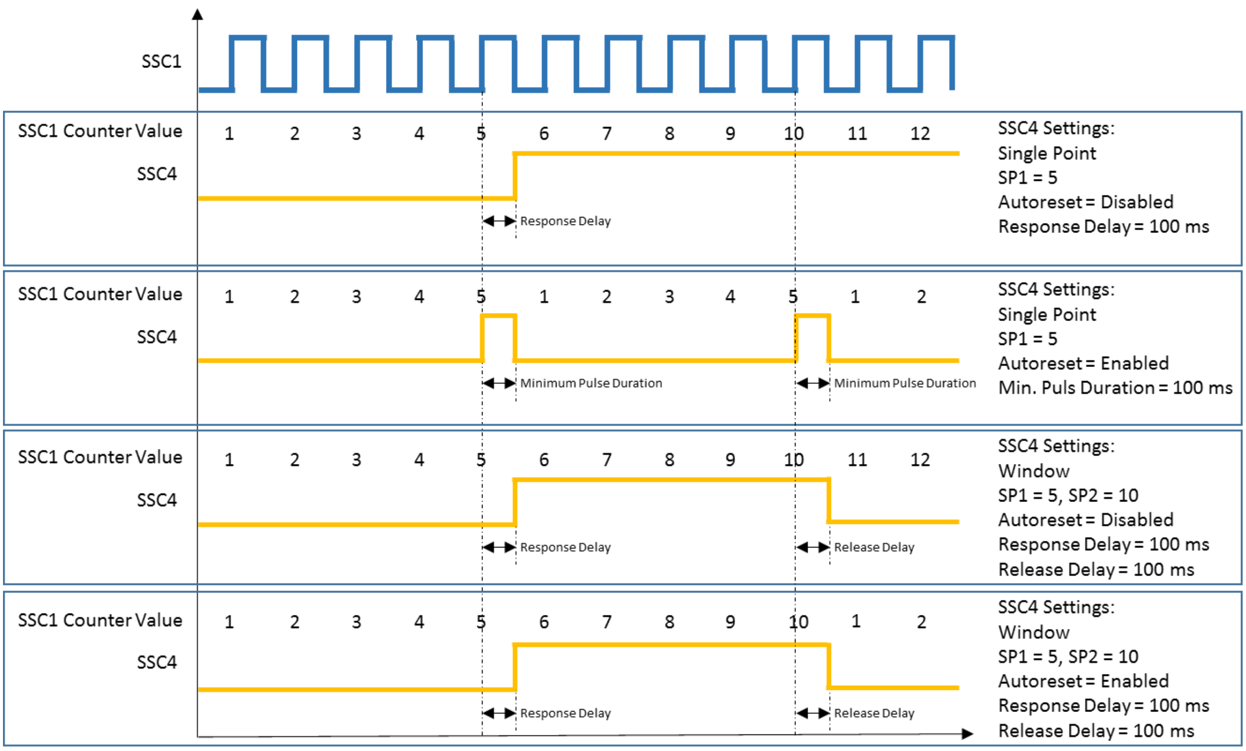


Figure 24 Behavior SSC4/Counter: Single-Point or Window, Autoreset enabled or disabled

4.4 Signal Processing

4.4.1 Measurement Mode

With this parameter pre-defined modes can be selected to achieve optimal results without much trial and error.

Parameter name	Short Description	Rights	Unit / Allowed values
Measurement Mode	Choose measurement mode for different applications	rw	- Highspeed - Standard - Robust - High Accuracy - High Pass Filter

Highspeed, 1.2 kHz:
Ideal for fast moving objects. Sensors is adjusted for fastest response time. The signal to noise ratio is negatively affected.

Standard, 500 Hz:
Optimal compromise between speed and singal-to-ratio. (default setting, all values in the datasheet are referenced with respect to this mode).

Robust, 100 Hz:
More stable than Standard, still fast enough for most applications

High Accuracy, 10 Hz:
To achieve highest signal-to-noise ratio and best accuracy. The measurement speed of the sensor will be reduced.

High Pass Filter, >300 Hz:
Useful for frequency measurements >300 Hz or to analys/detect a dynamic stroke.

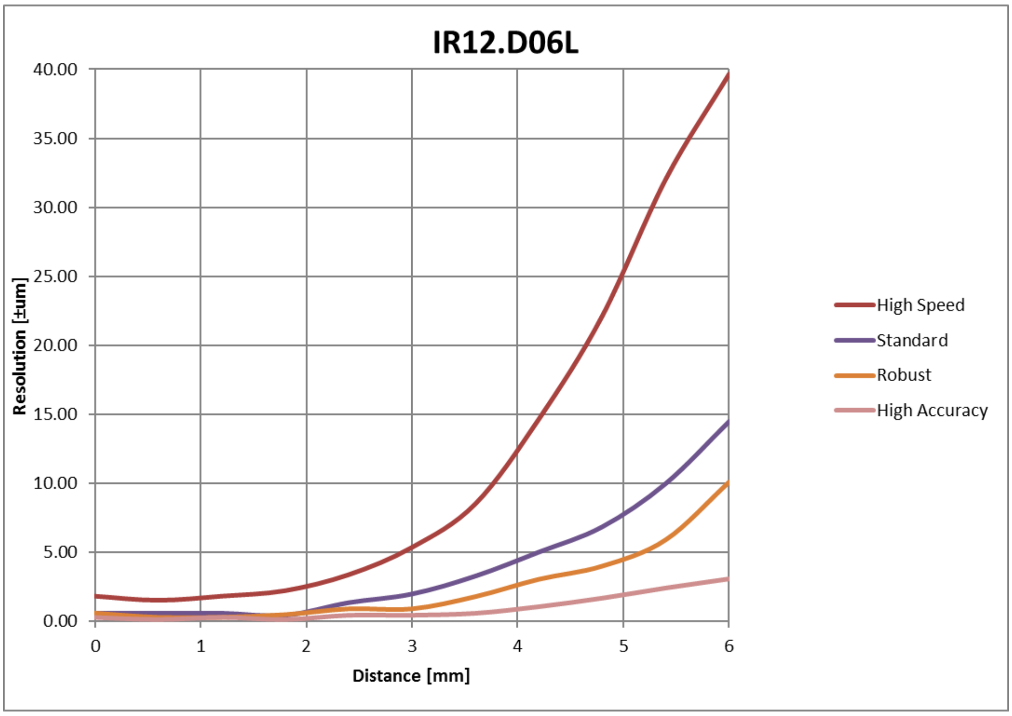


Figure 25 Example on IR12.D06L how the measurement mode influences the resolution.

4.5 Input/Output Settings

4.5.1 Switching Output

Via this parameter it is possible to select the ouput circuit of the physical outputs. If set to PushPull, the circuit type (change from NPN to PNP) can also be modified by changing the external load according to the connection diagram, this can be found in the datasheet or in the Assembly Instruction (MAL) of the resepective article.

Parameter name	Short Description	Rights	Unit / Allowed values
DI/DO Settings.OUT1Circuit	Selection of circuit type	rw	- PNP - PushPull (default)
DI/DO Settings.OUT1 Mode	Selection of output source (Default: SSC1)	rw	- SSC1 (default) - SSC2 - SSC3 - SSC4
DI/DO Settings.OUT2Circuit	Selection of circuit type	rw	- PNP - PushPull (default)
DI/DO Settings.OUT2 Mode	Selection of output source (Default: SSC1)	rw	- SSC1 (default) - SSC2 - SSC3 - SSC4

Note:
Output 2 settings are available on dual channel versions only. Output 2 can be configured in the same way as Output 1. For example teach modes, switching points, time delays etc.

4.6 Local User Interface

Different parameters are available to configure the local user interface which means the indication LEDs in case of inductive IO-Link sensors.

4.6.1 Indication LEDs

While the underlying functionality of the LEDs is in general well defined, it is possible to deactivate or to invert those.

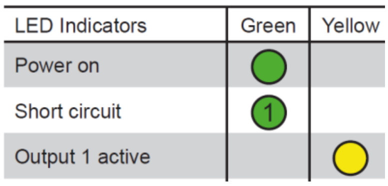


Figure 26 LED Indication - Standard-behavior in operating mode

Parameter name	Short Description	Rights	Unit / Allowed values
LED Settings.Green Mode	Power on/short circuit	rw	On Off
LED Settings.Yellow Mode	Connected to output 1 (LED on if output 1 is active)	rw	On Off Inverted

If the LED mode is set

- *On,* the behaviour of the related LED is as described in Figure 26.
- *Off*, the LED is deactived except if the function Find Me is activated. (See section 3.2.2)
- *Inverted*, the LED behaviour is inverted to the definition in Figure 26.

If the yellow LED is configured to work as alignment aid, the LED indicates the strength of the received signal. The faster the flashing, the stronger the signal.

Note:
LED configuration is available on types with physical LED only. LED output indication available for Output 1 only.

5 Teach Commands

By using teach commands, the setpoints of the switching signal channels SSC1 and can be defined by teach-in the position of the object or reference.
Next to teach-by-value which can be applied as described in section 4.3.1, using teach commands makes it easy to compensate individual variations such as mechanical and mounting tolerances.

There are two different procedures available – static or dynamic – which can be individually chosen independent of the switching mode of the selected SSC

- Static: Defines the setpoints by teach-in the positions of non-moving objects
- Dynamic: For moving and small objects. Analyzes the minimum and maximum distances within a time frame to define the setpoints.

The teach-in procedures are described more detailed in section 5.2 (Static) and 5.3 (Dynamic).

The switching behavior of each switching signal channel depends on the configuration (Switching Mode, Channel Logic, …) described in section 4.3.2.

As additional feature, by seperated commands the range of the measuring values related to the real distance can be scaled (Section 30).

5.1 Teach Channel Selection & Teach Status

The described teach commands can be applied to individual switching signal channels. Before proceeding with the teach-in procedure, make sure to select the SSC that should be addressed.

Furthermore different information are available to indicate the current mode and teach-in state of the selected switching signal channel to help to execute the right commands described in section 5.2 and 5.3.

Parameter name	Short Description	Rights	Unit / Allowed values
Teach Channel Selection	Select the SSC	rw	SSC1 / SSC2
Teach Status.Mode of selected SSC	Indicates the current switching mode of the selected SSC	ro	Single Point / Window
Teach Status.Teach Flag SP1		ro	Not Taught / Taught
Teach Status.Teach Flag SP2		ro	Not Taught / Taught
Teach Status.Teach State		ro	0 = Idle 1 = SP1 Success 2 = SP2 Success 3 = SP1&2 Success 4 = Waiting for Command 6 = Busy 7 = Error

5.2 Static

By using teach commands, setpoint 1 and setpoint 2 (SP1 and SP2) can be set by placing the object at the desired position and triggering the command. Which command is used in which order varies depending on the active switching mode (Single-Point or Window) of the selected-teach channel and is explained below.

Parameter name	Short Description	Rights	Unit / Allowed values
Teach SP1	Set SP1 at the current position of the object which is within the scanning range.	wo	
Teach SP2	Set SP2 at the current position of the object which is within the scanning range.	wo	
Teach Apply		wo	
Teach Cancel		wo	

5.2.1 Single Point / 1-Point Teach

If the selected SSC is configured as Single Point mode (Section 4.3.2.1), following command sequence is required to teach-in SP1:

Command sequence:

- Place object at desired switching distance
- Execute *Teach SP1* to teach-in the distance
- Execute *Teach Apply* to store the setpoint

By executing *Teach Cancel* the teach-in procedure can be canceled at any state, as long *Teach Apply* has not been used before.

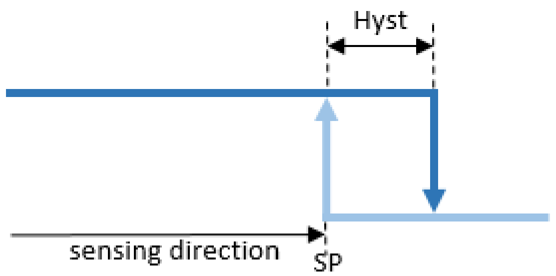


Figure 27 Single Point Teach, switching behavior

Figure 27 shows the switching behavior of the selected SSC if the teach-in was successful.
In this example, the hysteresis is configured to be right aligned (See 4.3.2.4 for more details regarding hysteresis alignment)

5.2.2 Window Teach

If the selected SSC is configured to Window mode (Section 4.3.2.1), following command sequence can be applied to teach-in SP1 and SP2:

Command sequence:

- Place object at desired switching distance
- Execute *Teach SP1* to teach-in the distance related to SP1
- Execute *Teach SP2* to teach-in the distance related to SP2
- Execute *Teach Apply* to store the setpoint

By executing *Teach Cancel* the teach-in procedure can be canceled at any state as long *Teach Apply* has not been used before.

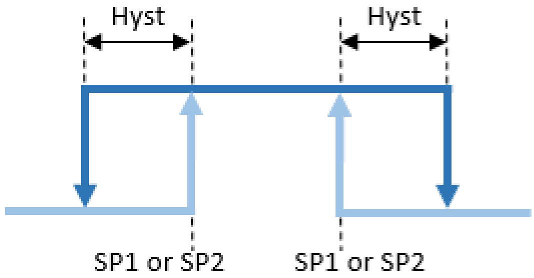


Figure 28 Window Teach, switching behavior

Figure 28 shows the switching behavior of the selected SSC if the teach-in was successful.
In this example, the hysteresis is configured to be right aligned (See 4.3.2.4 for more details regarding hysteresis alignment)
Which SP was teached at a higher distance does not have any influence on the switching behavior (SP1<SP2, SP1>SP2).

5.2.3 Two Point

If the selected SSC is configured to Two Point mode (Section 4.3.2.1), following command sequence can be applied to teach-in SP1 and SP2:

Command sequence:

- Place object at desired switching distance
- Execute *Teach SP1* to teach-in the distance related to SP1
- Execute *Teach SP2* to teach-in the distance related to SP2
- Execute *Teach Apply* to store the setpoint

By executing *Teach Cancel* the teach-in procedure can be canceled at any state as long *Teach Apply* has not been used.

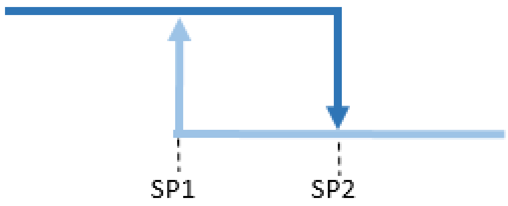
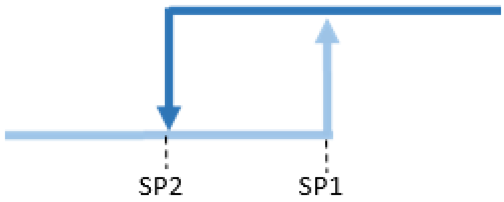
	

Figure 29 Two Point Mode, switching behavior 1 If SP1 < SP2	**Figure 30** Two Point Mode, switching behavior 2 If SP1 > SP2

Figure 29 and Figure 30 show the switching behavior of the selected SSC if the teach-in was successful.

5.3 Dynamic

By using the dynamic teach-in commands, it is possible to define the setpoints by evaluating the minimum and maximum measurement values within a time frame.

When to apply?

- For moving and/or small objects

The command sequence to perform a dynamic teach-in is the same for all switching modes.

Command sequence:

- Execute Dynamic*Teach Start* to start the data acquisition
- Execute Dynamic *Teach Stop* to stop the data acquisition
- Execute *Teach Apply* to store the setpoint

By executing *Teach Cancel* the teach-in procedure can be canceled at any state as long *Teach Apply* has not been used.

Parameter name	Short Description	Rights	Unit / Allowed values
Dynamic Teach SP Start	Starts the data acquisition.	wo	
Dynamic Teach SP Stop	Stops the data acquisition	wo	
Teach Apply		wo	
Teach Cancel		wo	

In all examples, the hysteresis is to be configured to be right aligned (See 4.3.2.4 for more details regarding hysteresis alignment

5.3.1 Dynamic Single Point / 1-Point Teach

If the selected SSC is configured to Single Point mode (Section 4.3.2.1), during the dynamic teach-in the minimum and maximum values are evaluated and the setpoint SP1 set to the middle

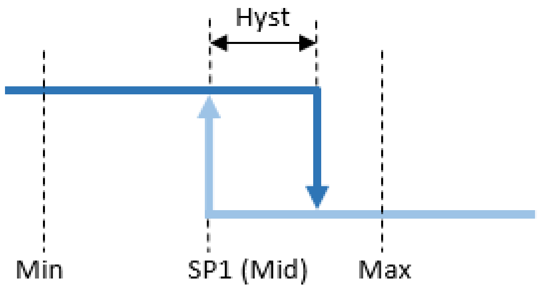


Figure 31 Dynamic Single Point Teach, switching behavior

5.3.2 Dynamic Window Teach

If the selected SSC is configured to Window mode (Section 4.3.2.1) during the dynamic teach-in the minimum and maximum values are evaluated. Setpoint SP1 is set to Min, SP2 is set to Max.

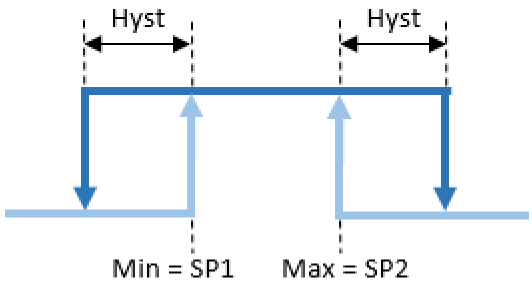


Figure 32 Dynamic Window Teach, switching behavior

5.3.3 Dynamic Two Point Teach

If the selected SSC is configured to Two Point mode (Section 4.3.2.1), during the dynamic teach-in the minimum and maximum values are evaluated. Setpoint SP1 is set to Min, SP2 is set to Max.

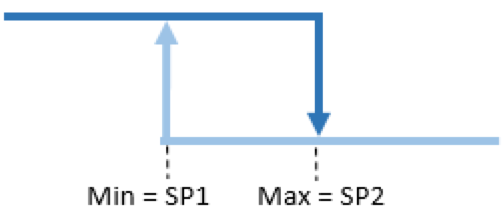


Figure 33 Dynamic Two Point Teach, switching behavior

5.4 Input Scale

Due to the inductive principle, the behavior depends a lot on the material, form and dimensions of the target and also on the surrounding material if mounted flush.

The input scaler makes it is easy to compensate installation tolerances or to scale the distance characteristics (real distance vs. measured value in digits)

Both, the minimum and maximum values can be adjusted individually to fit every customer needs

- Fine adjust the scale manually by defining the concrete values
- Teach-In by using IO-Link commands (Recommended)

5.4.1 Teach Modes

5.4.1.1 Single Point Mode

Teach or set both positions individually (Corner 1, Corner 2)

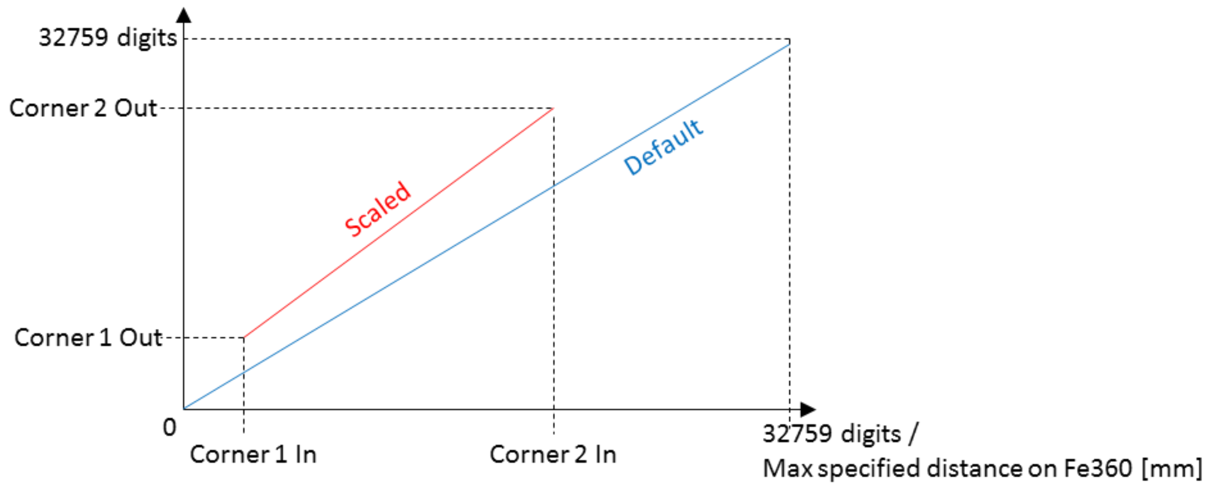


Figure 34 Input Scaler – In vs out

Using this mode, the end and start position can be adjusted indivually to as example to scale the measuring values exactly to a defined measuring range to get a most linear behavior.

By the teach commands Corner 1 In and Corner 2 In are being adjusted. Usually Corner 1 out and Corner 2 out stay at 0 and 32759 digits to get the maximum resolution.
In case it is required, Corner 1 & Corner 2 out can be adjusted manually.

5.4.1.2 Fixed Slope Gradient

5.4.1.2.1 Teach Corner 1 to define the beginning of the measuring range

Teach Corner 1 to define where the measuring range starts considering a fixed slope gradient.
This makes it easy if it's required to just compensate the offset/to make a zero set.

The resulting measurement value will start by 0 digits and ends at 32759 minus Offset/Corner 1 In

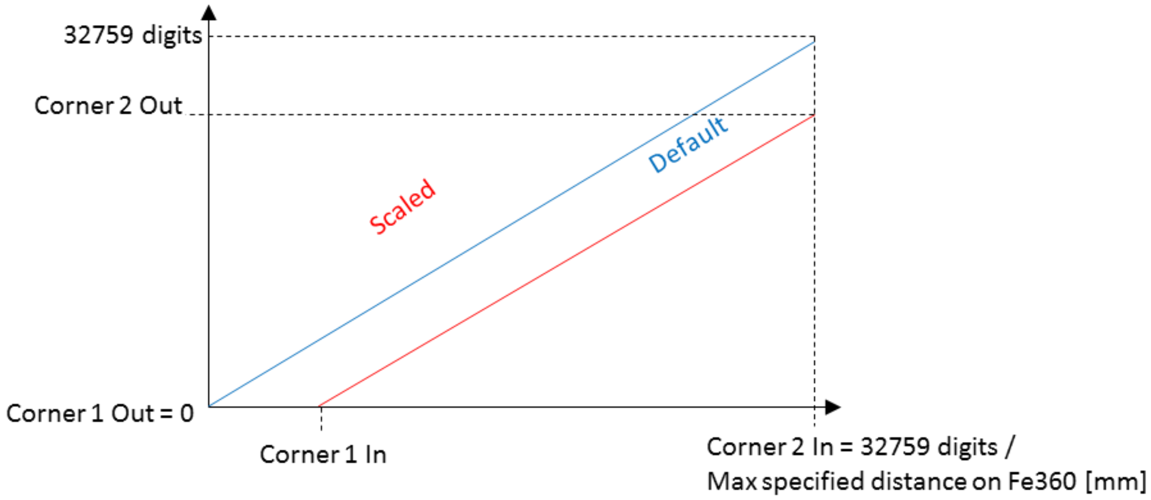


Figure 35 Input Scaler – Fixed Slope Gradient, Teach Corner 1

5.4.1.2.2 Teach Corner 1 to define the end of the measuring range

Teach Corner 2 to define where the measuring range ends considering a fixed slope gradient.
This makes it easy if it's required to just compensate the offset/to make a zero set at the end of the measuring range.

The resulting measurement value will ends at 32759 digits and starts at 32759 minus Offset/Corner 2 In

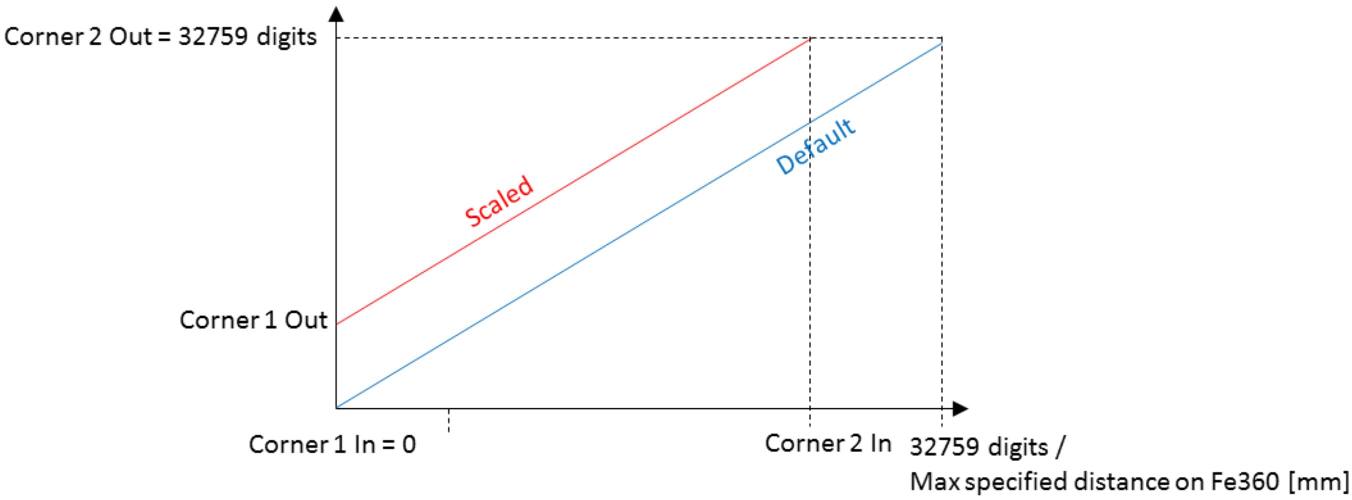


Figure 36 Input Scaler – Fixed Slope Gradient, Teach Corner 2

Parameter name	Short Description	Rights	Unit / Allowed values
Teach Corner 1	Teach Corner 1 Single-Point: Corner 1 In is set to the current measuring value Fixed Slope Gradient: Corner 1 is set to the current measuring value to store it as offset/starting point Corner 2 is calculated accordingly.		
Teach Corner 2	Teach Corner 2 Single-Point: Corner 2 In is set to the current measuring value Fixed Slope Gradient: Corner 2 is set to the current measuring value to store it as end of the measuring range. Corner 1 is calculated accordingly.		
Input Scale.Enable			Enable / Disable
Input Scale.Corner 1 In			0 … 32759 digits
Input Scale.Corner 1 Out			0 … 32759 digits
Input Scale.Corner 2 In			0 … 32759 digits
Input Scale.Corner 2 Out			0 … 32759 digits
Input Scale.Teach Mode	Define the behaviour of the teach commands		Single Point /Fixed Slope Gradient

Note:

- Teach values are only stored if the input scaler is set to Enable.

6 Diagnosis

In addition to solving the primary application, the simple evaluation of secondary data, such as temperature, supply voltage or operating time, allows for predictive maintenance and thus optimum machine availability.

6.1 Device Status

Parameter name	Short Description	Rights	Unit / Allowed values
Device Status	Indicates if the sensor is working properly	ro	0=Device is OK 2=Out of Specification 4=Failure
Detailed Device Status		ro	

6.2 Device Temperature

An integrated temperature sensor allows to track the internal temperature of the sensor.
Please be aware that compared to the ambient temperature the indicated values are higher due to the internal heating of the sensor.
The temperature may also vary due to mounting conditions and due to the electric load connected to the output.

Parameter name	Short Description	Rights	Unit / Allowed values
Device Temperature Reset	Command to reset the resetable temperature data	wo	
Device Temperature.Current		ro	
Device Temperature.Min Resetable		ro	
Device Temperature.Max Resetable		ro	
Device Temperature.Min Lifetime		ro	
Device Temperature.Max Lifetime		ro	
Unit Selection.Temperature	Choice of temperature unit (Default: °C)	rw	°C, °F, K

6.3 Power Supply Voltage

Parameter name	Short Description	Rights	Unit / Allowed values
Power Supply Voltage Reset	Command to reset the resetable power supply data	wo	
Power Supply Voltage.Current		ro	V
Power Supply Voltage.Min Resetable	Minimum power supply voltage since first start up	ro	V
Power Supply Voltage.Max Resetable	Maximum power supply voltage since last reset	ro	V
Power Supply Voltage.Min Lifetime	Minimum power supply voltage since first start up	ro	V
Power Supply Voltage.Max Lifetime	Maximum power supply voltage since first start up	ro	V

6.4 Bootcyles

Parameter name	Short Description	Rights	Unit / Allowed values
Bootcycles.Lifetime	Count number of bootcycles since first start up	ro	

6.5 Operation Time

Parameter name	Short Description	Rights	Unit / Allowed values
Operation Time Reset	Command to reset the resetable operation time data	wo	
Operation Time.Powerup	Operation time since last start up	ro	
Operation Time.Resetable	Operation time since last reset	ro	
Operation Time.Lifetime	Operation time since first start up	ro	
Unit Selection.Time	Choice of time unit	rw	S, min, h

6.6 Histogram

Several diagnosis and process values are continuously tracked to allow predictive maintenance or trouble shooting tasks. Instead of storing each value by itself, the values are stored in a histogram. Therefore the range of possible values is divided into several intervals (bins), then the number of occasions are counted that a new values falls into a interval (bin). This allows to store the values in a much more efficient way and ready for analysation.

Example based on Device Temperature:

- Range: -40 … +125°C
- Number of Bins: 16 Bin
- Size of a Bin: 165°C / 16 = 10.31 °C
- Range of Bin 1: -40 …. -20.69 °C
- Range of Bin 2: -20.68 … -10.37 °C
- …
- Range of Bin 16: +114.69 °C ... +120 °C

By extracting the related bins and information via IO-Link, it is possible to plot a histogram to get easily the distribution of the values illustrated.

Such histograms are available for

- Device Temperature, Lifetime
- Power Supply Voltage, Lifetime
- Process Value 1: Distance, Resetable
- Process Value 2: Frequency, Resetable

Regarding Device Temperature and Power Supply Voltage, every 10 seconds a measurement is tracked. For the process values, every single measurement is tracked.

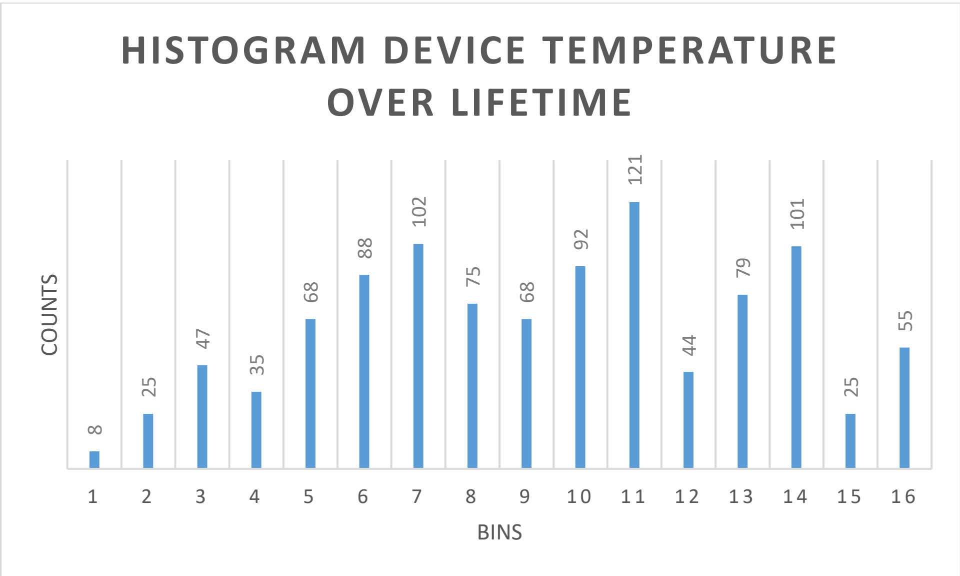


Figure 37: Histogram Device Temperature over Lifetime, Example

The counts of each bin are stored as 32 bit value.

6.6.1 Device Temperature

Parameter name	Short Description	Rights	Unit / Allowed values
Temperature Lifetime Histogram.Mode	Standard means: Linear partition of the range into bins.	ro	Standard
Device Temperature Lifetime Histogram Unit	Indicates the unit	ro	°C, K, F
Temperature Lifetime Histogram RangeStart	Defines, where the range starts.	ro	-25
Temperature Lifetime Histogram RangeEnd	Defines, where the range ends.	ro	+125
Temperature Lifetime Histogram Nbr of Bins	Number of bins	ro	16
Temperature Lifetime Histogram Bin1 … 16	Number of counts of each bin	ro	32 Bit for each bin

6.6.2 Power Supply

Parameter name	Short Description	Rights	Unit / Allowed values
Power Supply Voltage Lifetime Histogram.Mode	Standard means: Linear partition of the range into bins.	ro	Standard
Power Supply Voltage Lifetime Histogram Unit	Indicates the unit	ro	Volts
Power Supply Voltage Lifetime Histogram RangeStart	Defines, where the range starts.	ro	0
Power Supply Voltage Lifetime Histogram RangeEnd	Defines, where the range ends.	ro	+40
Power Supply Voltage Lifetime Histogram Nbr of Bins	Number of bins	ro	16
Power Supply Voltage Lifetime Histogram Bin1 … 16	Number of counts of each bin	ro	32 Bit for each bin

6.6.3 Process Value 1: Distance

Parameter name	Short Description	Rights	Unit / Allowed values
Resetable Histogram.Reset	Command to reset the histogram of process value 1	ro	
PV1 Resetable Histogram.Mode	Standard means: Linear partition of the range into bins.	ro	Standard
PV1 Resetable Histogram.Unit	Indicates the unit	ro	digits
PV1 Resetable Histogram.RangeStart	Defines, where the range starts.	ro	0
PV1 Resetable Histogram.RangeEnd	Defines, where the range ends.	ro	32'768
PV1 Resetable Histogram.Nbr of Bins	Number of bins	ro	16
PV1 Resetable Histogram.Bin1 … 16	Number of counts of each bin	ro	32 Bit for each bin

6.6.4 Process Value 2: Frequency

Parameter name	Short Description	Rights	Unit / Allowed values
PV2 Resetable Histogram.Reset	Command to reset the histogram of process value 2	ro	
PV2 Resetable Histogram.Mode	Standard means: Linear partition of the range into bins.	ro	Standard
PV2 Resetable Histogram.Unit	Indicates the unit	ro	Hertz
PV2 Resetable Histogram.RangeStart	Defines, where the range starts.	ro	0
PV2 Resetable Histogram.RangeEnd	Defines, where the range ends.	ro	1000
PV2 Resetable Histogram.Nbr of Bins	Number of bins	ro	16
PV2 Resetable Histogram.Bin 2 to 16	Number of counts of each bin	ro	32 Bit for each bin

7 Glossar

wo	Write only access
rw	Read and write access
ro	Read only access
SSC	Switching Signal Channel
MDC	Measurement Data Channel
SP	Switching Point
AdSS	Adjustable switching sensor

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