Baumer

Passion for Sensors

IO-Link

Instruction Manual

Radar Sensor RR30

Sensor Solutions
Motion Control
Vision Technologies
Process Instrumentation

Instruction Manual for Radar Sensor RR30 with IO-Link

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1 Sensors covered by this manual

These instruction apply to the following sensor versions:

Version	Distance range
RR30.DAF0	0.2 m - 6 m
RR30.DAJ2	0.3 m - 12 m
RR30.DAO0	0.5 m - 60 m

The limits and default values in terms of distance can be different for each type of sensor.

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.

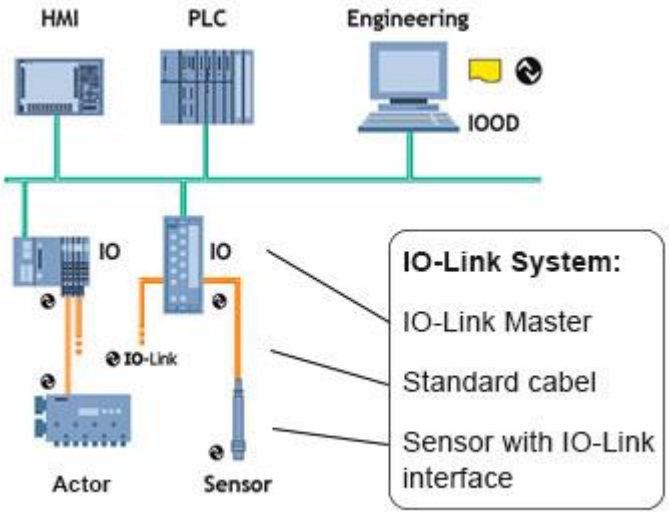

Figure 1 Example of a system architecture using IO-Link

2.1 SIO / DI Mode

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.

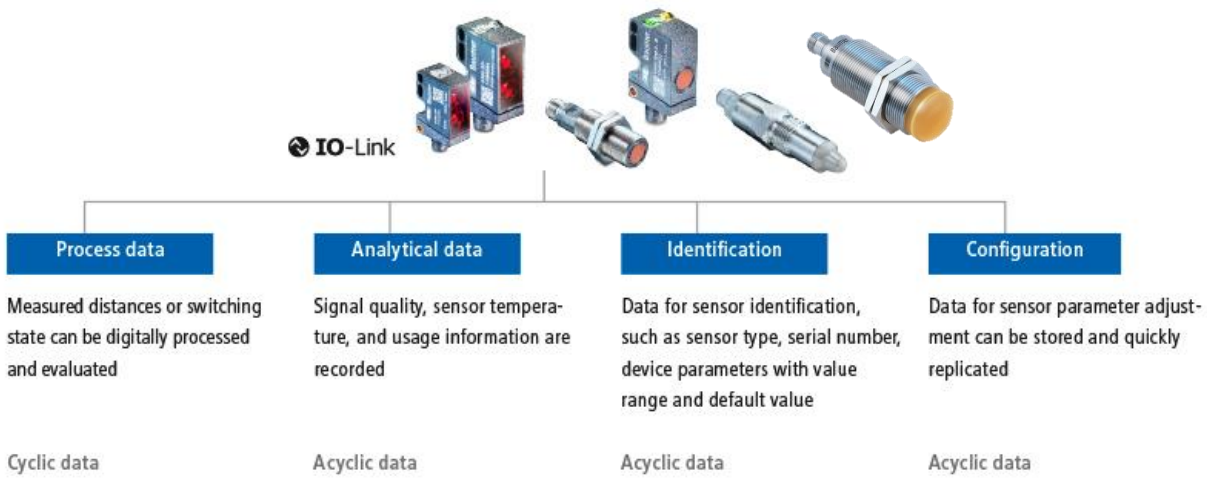

Figure 2 Different IO Link data streams

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.

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).

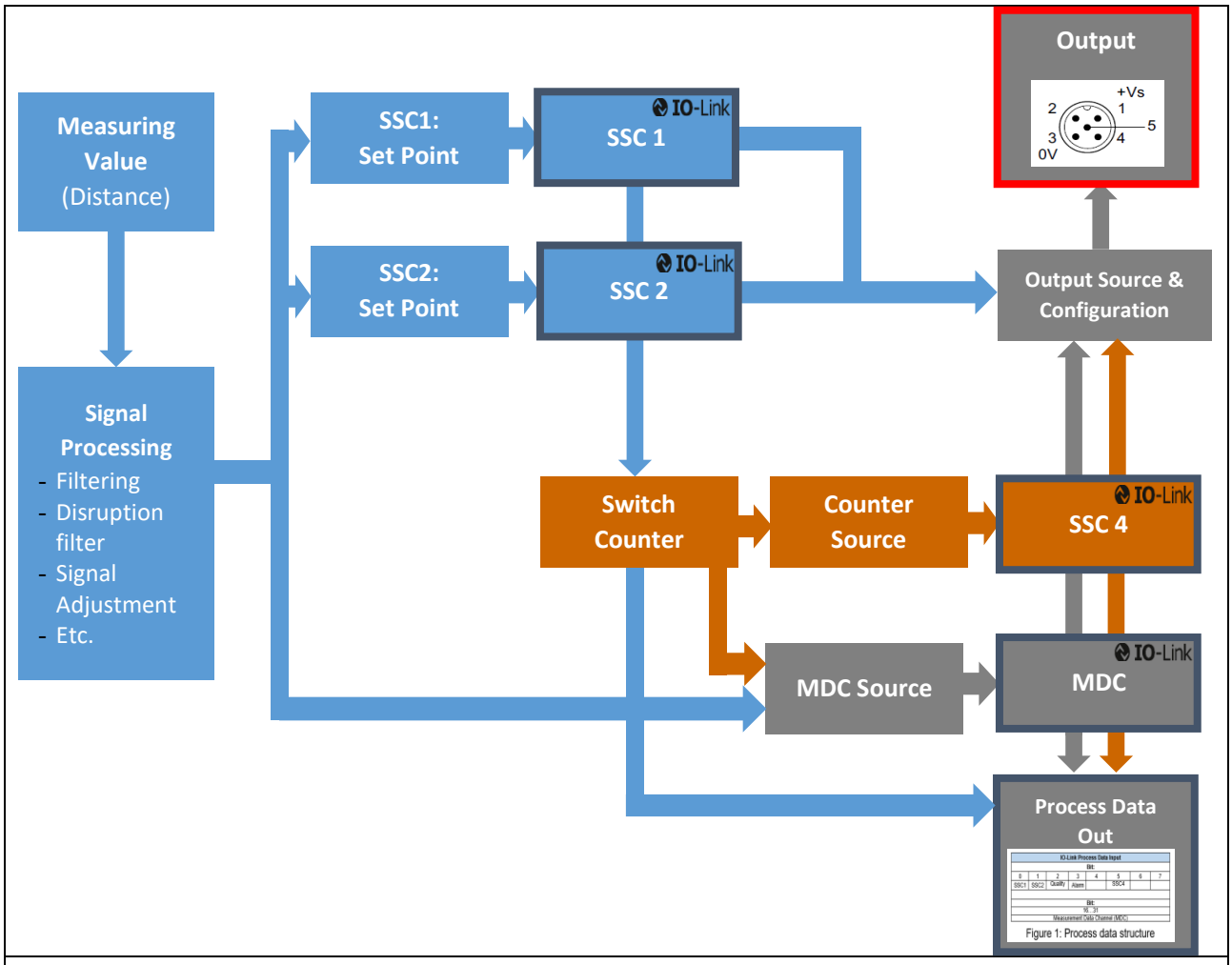

Figure 3 Illustrates the signal path from raw data to an output either through a physical pin (top right) or as output via the process data (bottom right)

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 explicitly to request these data.

3.2.1 Process Data-In

Process Data-In is sent from the sensor to the master (Sensor → Master). As shown in Figure 4 IO Link Process data Input" and the peak data of 5 peaks Figure 5 Process data Input of 5 peaks", the Process Data Input is an 208 bit string.

IO-Link Process Data Input									
47 16	15 8	7 0							
IntegerT(32)	IntegerT (8)	8 bit							
Measurement value (MDC)	Scale	Baumer specific							
		7	6	5	4	3	2	1	0
				SSC4		Alarm	Quality	SSC2	SSC1

Figure 4 IO Link Process data Input

IO-Link Process Data Input (peak data)									
207 192	191 176	175 160	159 144	143 128	127 112	111 96	95 80	79 64	63 48
16 bit	16 bit	16 bit	16 bit	16 bit	16 bit	16 bit	16 bit	16 bit	16 bit
Peak 4 Amplitude	Peak 4 Distance	Peak 3 Amplitude	Peak 3 Distance	Peak 2 Amplitude	Peak 2 Distance	Peak 1 Amplitude	Peak 1 Distance	Peak 0 Amplitude	Peak 0 Distance

Figure 5 Process data Input of 5 peaks

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 configure

Bit 2: Quality
This bit provides information about the quality of the received signal coming from the object.
Bit2 = 0 → Sensor has enough signal to detect an object reliable
Bit2 = 1 → The signal detected from the sensor is critical.

Bit 3: Alarm
The alarm bit indicates that there is a 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 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 switch counts of SSC1 or SSC2. An auto-reset and time filter 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 0 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
- Measured value $1000*10^{-6}$ m or 1000 µm

Bit 16 to 47: MDC

MDC stands for measurement data channel. It contains the already filtered date arising from SSC1 to SSC4 as an 32 bit integer value. See section 4.2 to learn how to configure the MDC.

Bit 48 to 207 : Peak Data

Peak data is the main measurement data. The values are the first 5 peaks from the defined *Region of Interest* (all further peaks are ignored) transmitted as two 16 bit values: 16 bit for the amplitude and 16 bit for the distance. The Amplitude in dB shows the relative strength of the signal and the distance is displayed in mm.

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
						Find Me (Localization: green and yellow LED flashing)	Disable Radar antenna

Bit 0: Disable Radar antenna (Transducer)

By changing this bit the antenna is disabled. This switches off the sensing (receiving) element without switching off the whole electronic of the sensor. The sensor output will be frozen for all distance and amplitude values. This can be used to reduce the heating of the sensor itself.

Bit 0 = 0 → Radar antenna is enabled

Bit 0 = 1 → Radar antenna is disabled

Bit 1: Find Me Function

Signaling e.g. by flashing LEDs (green and yellow) on the sensor to locate or physically identify a sensor in a machine or system.

Bit 1 = 0 → Find Me Function is deactivated

Bit 1 = 1 → Find Me Function is activated, LEDs are flashing.

4 Parameter

RR30 Radar sensor are available in three different distance versions (6, 12 and 60 m). Therefore all allowed or default values in list of this chapter will have three different values according to one of the versions.

wo= write only, ro= read only, rw= read and write

4.1 System Commands

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

Parameter name	Short Description	Rights	Unit / Allowed values
Standard command	Restore Factory Settings	wo	

4.2 Measurement Data Channel (MDC)

4.2.1 Measurement Value Distance

Parameter name	Short Description	Rights	Unit / Allowed values
Measurement Value. Distance	Process value for distance	ro	mm

4.2.2 Switch Counts

For each individual SSCx a switching counter is implemented. The number of counts of each channel can also be mapped to the measurement data channel MDC by adjusting the MDC source. The Trigger of the counter is on the positive slope of the elated SSC.

Parameter name	Short Description	Rights	Unit / Allowed values
- SSC1 Switch Counts Reset - SSC2 Switch Counts Reset - SSC4 Switch Counts Reset	Command to set the counter value of the SSC to zero	wo	
- Switch Counts.SSC1 Resettable - Switch Counts.SSC2 Resettable - Switch Counts.SSC4 Resettable	Total number of switch counts on SSC1 (resettable by user command-> SSC1 Switch Counts Reset) Available for SSC1,2 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 Selection.Source	Select the process value that is shown on the MDC channel	ro	- Distance (Default) - Velocity - Amplitude - Switch Counter SSC1 - Switch Counter SSC2 - Switch Counter SSC4

4.2.4 MDC Unit Code

Parameter name	Short Description	Rights	Unit / Allowed values
MDC Descriptor.Unit code	Indicates the unit of the selected MDC source	ro	- Distance mm - Velocity mm/s - Amplitude dB - SSC1, SSC2, SSC4 none

4.2.5 MDC Setpoint limit

This parameter allows to read out the limits of the measuring range of the sensor.

Parameter name	Short Description	Rights	Unit / Allowed values
MDC Descriptor.Lower limit	Lower value of measuring range, if value is below out of range is shown	ro	A0: 200 mm; 300 mm; 500 mm; depends on version of sensor
MDC Descriptor.Upper limit	Upper value of measuring range, if value is above out of range is shown	ro	A0: 6000 mm; 12000 mm; 60000 mm; depends on version of sensor

4.3 Switching Signal Channel (SSC)

The sensor features three different switching channels. Switching Signal Channels SSC1 and SSC2 are reserved for distance measurements, whereas Switching Channel 4 has a counter function with an auto-reset. All switching channels can be adjusted via IO-Link. All switching channels can be mapped to the MDC as well.

For more information about how to set-up the Counter/SSC4 channel and its behavior, please see section 0.

4.3.1 Setpoint SP

Using this parameter the user can modify the switching point of the sensor by entering the distance value at which the sensor should switch (teach-by-value function), change the value For Single point mode only SP1 is relevant, SP2 is not active. For the Window mode SP1 & SP2 are active. The switching modes are explained in section 4.3.4

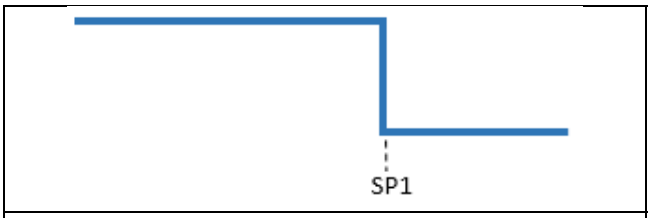

Figure 6 Single Point Mode
SP1: Switch point 1
SP2: is not active

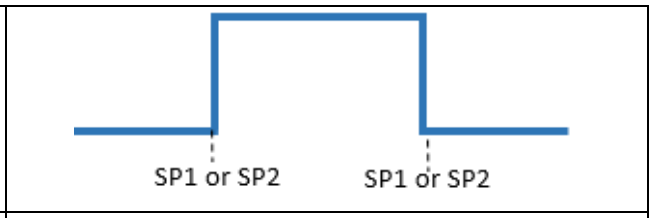

Figure 7 Window Mode
SP1: Switch point 1
SP2: Switch point 2

Parameter name	Short Description	Rights	Unit / Allowed values
SSC1 Param.SP 1	Set the distance at which the related SSC is set to active (or inactive if inverted)	rw	Limits: - 200 - 8000 mm; - 300 - 15000 mm; - 400 - 80000 mm; Default: 1000 mm
SSC1 Param.SP 2	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	rw	Limits: - 200 - 8000 mm; - 300 - 15000 mm; - 400 - 80000 mm; Default: 2000 mm; 5000 mm; 20000 mm

4.3.2 SSC Configuration

All SSC1 setting can be applied also in the same way to SSC2.

4.3.3 Channel Logic

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

Figure 8 «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

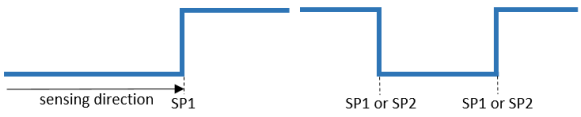

Figure 9 «Inverted» or NC setting

- 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	Selects the SSC logic. It can be changed between "active if object is present (normal)" or "inactive if object is present (inverted)"	rw	- Normal (NO) (Default) - Inverted (NC)

4.3.4 Switching Mode

Figure 10 Single point

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

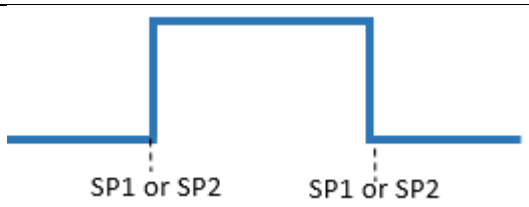

Figure 11 Window Mode

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

Parameter name	Short Description	Rights	Unit / Allowed values
SSC1 Config.Mode	Selects the SSC switch mode	rw	- Disabled - Single Point (Default) - Window

4.3.5 Hysteresis Alignment Mode

In case of axial detection tasks like stop trigger or level detection, an accurate switching 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.

Parameter name	Short Description	Rights	Unit / Allowed values
SSC1 Config.Hyst	Selects the hysteresis alignment mode	rw	- Left Aligned - Center Aligned - Right Aligned (Default)

4.3.5.1 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
  - Example: Detection of the low level of a tank to avoid a dry-run

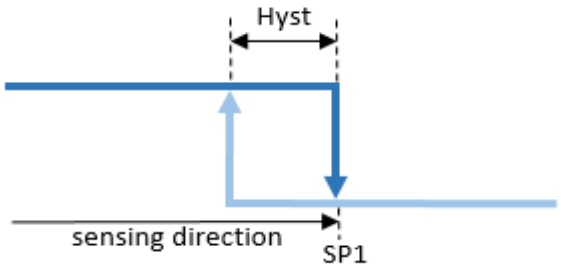

Figure 12 Left Aligned, Single Point Mode

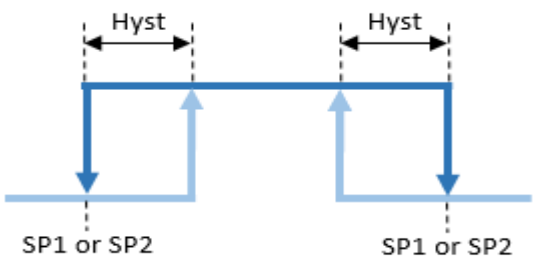

Figure 13 Left Aligned, Window Mode

4.3.5.2 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.

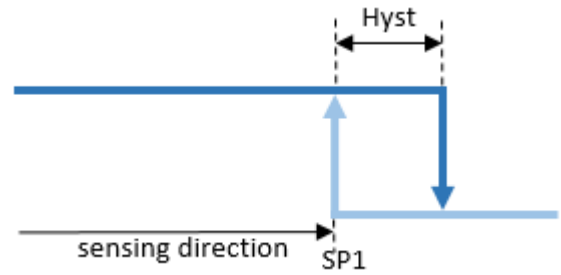

Figure 14 Right Aligned, Single Point Mode

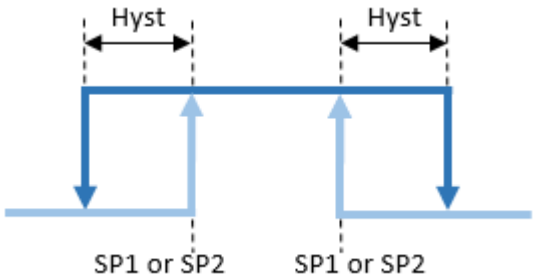

Figure 15 Right Aligned, Window Mode

4.3.5.3 Center Aligned

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

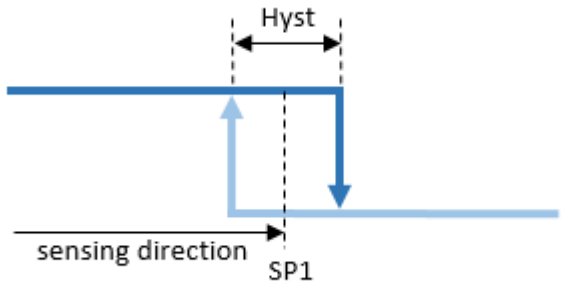

Figure 16 Center Aligned, Single Point Mode

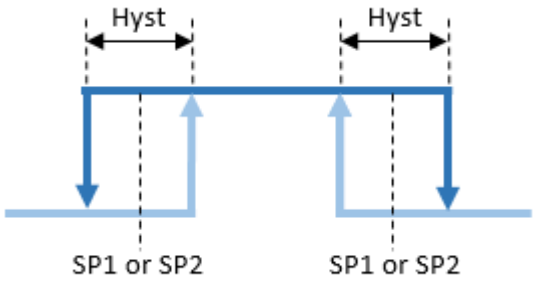

Figure 17 Center Aligned, Window Mode

4.3.6 Hysteresis Width

The hysteresis is configured in percent of the switch point distance. It is the difference between switch point and reset point. This parameter can be beneficial to smoothen out signals when samples have quickly changing positions.

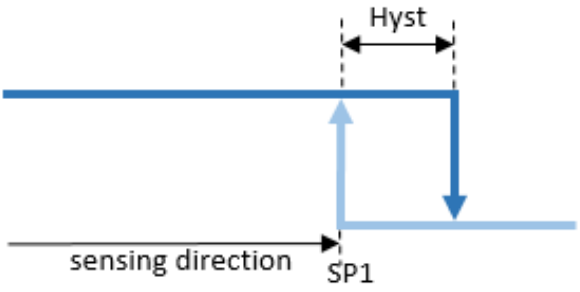

Figure 18 Hysteresis is the difference between switch point and reset point

- Bright blue: object moving from far to close distance (in this case switch point)
- Dark 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 distance	rw	Limits 0 … 99 %, Default 5%

4.3.7 Time filter

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.

4.3.7.1 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 switch points of the related SSC until its status changes to active (or inactive, if the logic is inverted as described in section 4.3.4)

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 output of the sensor.

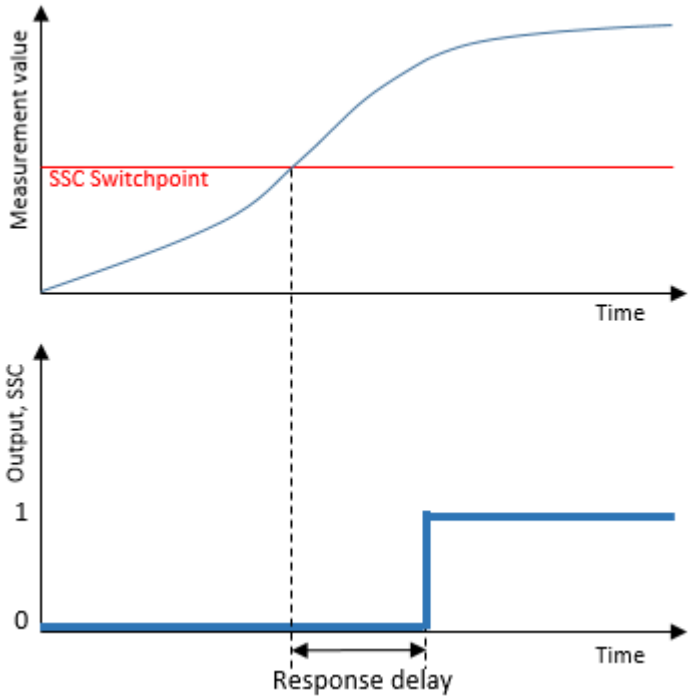

Figure 19: Response Delay

Parameter name	Short Description	Rights	Unit / Allowed values
Response Delay.SSC1 Time	Sets / indicates the response delay time in milliseconds for the respective switching signal channel (SSC).	rw	0 to 60000 ms Default: 0 ms

4.3.7.2 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 switch points of the related SSC, until its status is changed to inactive (or active, if the logic is inverted as described in section 4.3.4)

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 suppress 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 an unwanted gap size within a continuous flow of products.

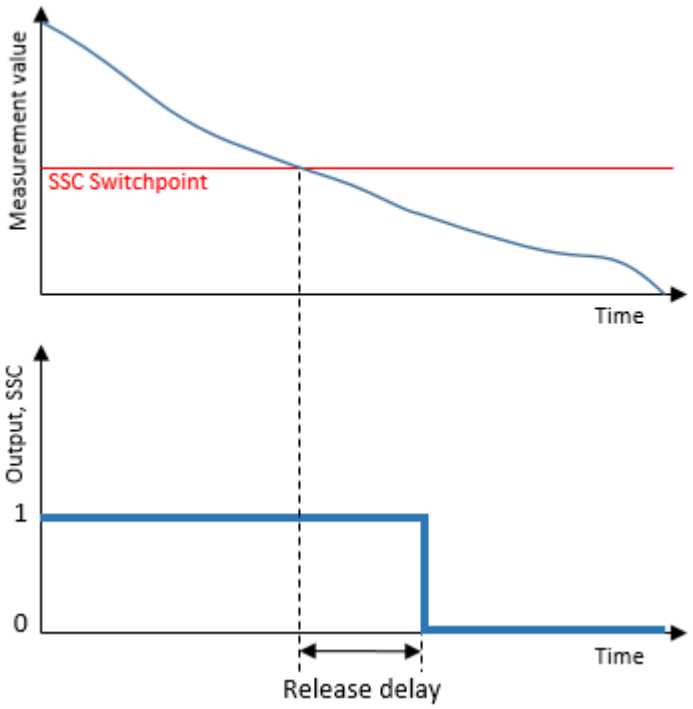

Figure 20: Release Delay

Parameter name	Short Description	Rights	Unit / Allowed values
Release Delay.SSC1 Time	Sets / indicates the release delay time in milliseconds for the respective switching signal channel (SSC).	rw	0 to 60000 ms Default: 0 ms

4.3.7.3 Minimal Pulse Duration

The minimal 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 4.3.4)
- negative slope / inactive (or active, if the logic is inverted as described in section 4.3.4)

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

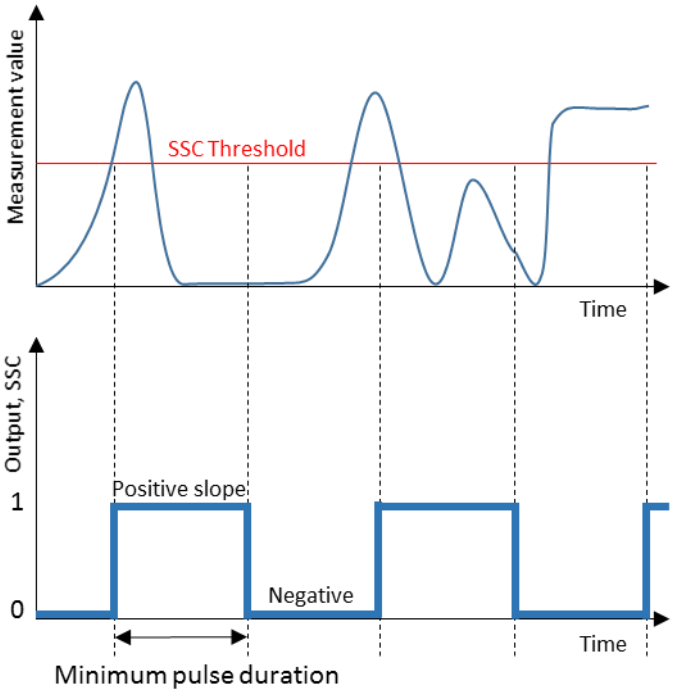

Figure 21 Minimum Pulse Duration

Parameter name	Short Description	Rights	Unit / Allowed values
Minimal Pulse Duration.SSC1 Time	Sets / indicates the minimal pulse length in milliseconds for the respective switching signal channel (SSC).	rw	0 to 60000 ms Default: 0 ms
Minimal Pulse Duration.SSC1 Mode	0: Both Pulses: positive and negative pulses are prolonged; 1: Positive Pulse: only positive pulses are prolonged; 2: Negative Pulse: only negative pulses are prolonged	rw	- Both Pulses (Default) - Positive Pulse - Negative Pulse

4.3.8 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 0).
Trigger of counter is on positive slope of related SSC.

By configuring SSC4, it is also possible to set up a binary signal related to the number of switch counts of SSC1 or SSC2. An auto-reset and time filters 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 described more detailed, to illustrate how the counter module is implemented. In section 4.3.8.2 the behavior is explained.

4.3.8.1 SSC4 Configuration

In general the SSC4 offers the same features as the SSC1 and SSC2 based on distance (See 4.3.2), including also time filters.
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 Param.SP1	Set the number of counts at which the SSC is set to active (or inactive if inverted)	rw	0 … max = 2147483639 Counts, default 20
SSC4 Param.SP2	Set the number of counts at which the SSC is set to inactive (or active if inverted). only active if SSC is set to window mode	rw	0 … max = 2147483639 Counts, default 0

Parameter name	Short Description	Rights	Unit / Allowed values
SSC4 Config.Logic	Selects the SSC logic. It can be changed between active if object is present (normal) or inactive if object is present (inverted)	rw	- Normal (Default) - Inverted
SSC4 Config.Mode	Selection of the switching mode	rw	- Disabled (Default) - Single Point - Window
SSC Source Settings.SSC4 Selection	Select the switch counter that is used as input of SSC4	rw	- SSC1 Switch Counter (Default) - SSC2 Switch Counter
SSC Source Settings.SSC4 Auto Reset	Auto Reset of switch counter if value in SSC4 Param.SP1 is reached	rw	- Enabled (Default) - Disabled

Parameter name	Short Description	Rights	Unit / Allowed values
Release Delay.SSC4 Time	Sets / indicates the release delay time in milliseconds for the respective switching signal channel (SSC).	rw	0 to 60000 ms Default: 0 ms
Response Delay.SSC4 Time	Sets / indicates the response delay time in milliseconds for the respective switching signal channel (SSC).	rw	0 to 60000 ms Default: 0 ms
Minimal Pulse Duration.SSC4 Time	Sets / indicates the minimal pulse length in milliseconds for the respective switching signal channel (SSC).	rw	0 to 60000 ms Default: 0 ms
Minimal Pulse Duration.SSC4 Mode	0: Both Pulses: positive and negative pulses are prolonged; 1: Positive Pulse: only positive pulses are prolonged; 2: Negative	rw	- Both Slopes (Default) - Positive Slope - Negative Slope

	Pulse: only negative pulses are prolonged		

4.3.8.2 SSC4 Behavior

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

Figure 22 illustrates the behavior of SSC4 using different setting. SSC4 source is hereby the switch counter of SSC1.

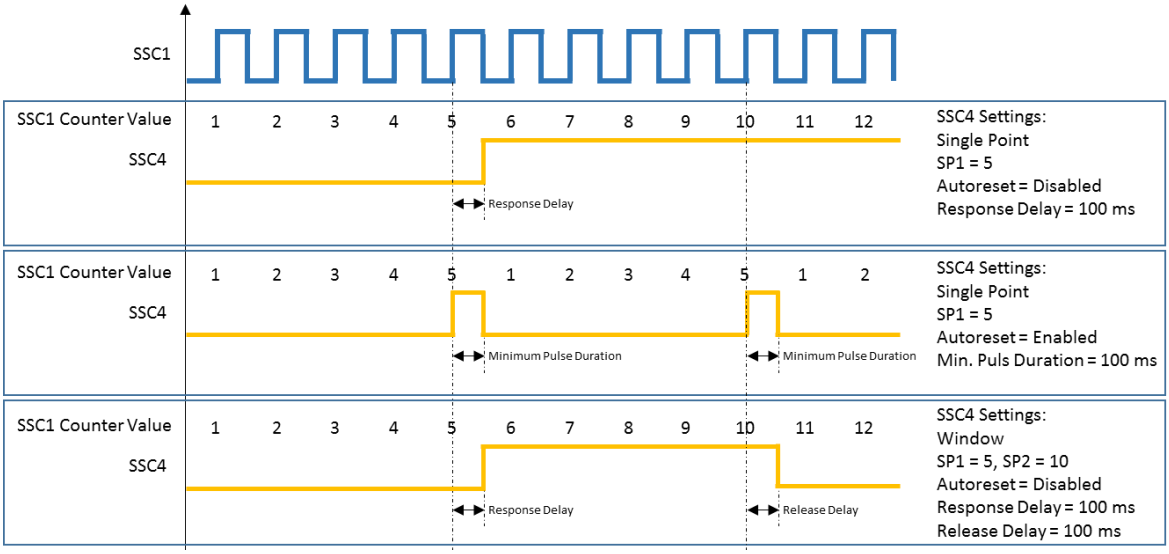

Figure 22: Behavior SSC4/Counter: Single-Point or Window, Auto reset enabled or disabled

auto

4.4 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 **Fehler! Verweisquelle konnte nicht gefunden werden.** and **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Parameter name	Short Description	Rights	Unit / Allowed values
TI Select	Selection of the SSC for which the teach commands are valid (TI Select - Teach-In Select)	rw	- Default (SSC1) / SSC1 / SSC2 - Default: Default
TI Info.Mode of TI Select	Mode of the selected Teach channel	ro	Single Point / Window
TI Result.State	Shows the teach status of the teach-in process	ro	- 0 = Idle - 1 = SP1 Success - 2 = SP2 Success

			- 3 = SP1&2 Success - 4 = Waiting for Command - 6 = Busy - 7 = Error
TI Result. Teach Flag SP1	Shows the teach status of the respective switch point	ro	Not Taught / Taught
TI Result. Teach Flag SP2	Shows the teach status of the respective switch point	ro	Not Taught / Taught
Analogue Output Teach.Status	Status of the Analogue teach output	ro	x (Idle / Successful / Not Successful)

4.5 Static

By using teach commands, set point 1 and set point 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
Standard Command	Teach SP1 TP1	wo	
Standard Command	Teach SP1 TP2	wo	
System Command (Teach Apply)		wo	
System Command (Teach Cancel)		wo	

4.6 Signal Processing

4.6.1 Process Value Exponential

With the help of this function slight fluctuations and outliers of the values are compensated. It must be ensured that the switching signals are displayed with the length of the mean delay.

Parameter name	Short Description	Rights	Unit / Allowed values
Process Value Exponential Filter.Output Filter Time	Time over which the signal is exponentially averaged and is displayed as the value (distance/velocity or amplitude). This time is a multiple of the smallest measurement time.	rw	Limits: 0 to 1000.000 ms Default: 200 ms

4.6.2 Disruption Filter

This filter allows you to ignore interfering objects when passing through the measuring range either cyclic or non-cyclic. This function depends on two parameters

Parameter name	Short Description	Rights	Unit / Allowed values
Process Value Disruption Filter.Maximum perturbation time	Duration (in units of time) until a signal (as defined in the parameter . Distance) becomes visible at the output.	rw	Limits: 0 to 1000.000 ms Default: 200 ms
Process Value Disruption Filter.Distance	Distance deviations from the current measured value which are ignored, if shorter than the period set by the parameter “Process Value Disruption Filter Maximum perturbation time”.	rw	Limits 5 to 10.000 mm Default: 300 mm

4.6.3 Region of Interest (ROI)

The region of interest is the space (in mm) in which the sensor performs. If a signal is detected in this region, the data will be processed and the result displayed. All signals, even if detected by the sensor, being out of this region are not processed and displayed further on. The ROI is not necessary the same as the analog output region. But the analog one has to be inside the bounders of the ROI. See 4.8.2.

Parameter name	Short Description	Rights	Unit / Allowed values
Region of Interest.Start Distance	Defines the Start of the Region of interest within a signal becomes visible at the output.	rw	Limits: - 100 to 8500 mm (Vers.: DAF0) - 100 to 15500 mm (Vers.: DAJ2) - 100 to 82000 mm (Vers.: DAO0) Default = 100 mm
Region of Interest.End Distance	Defines the End of the Region of interest within a signal becomes visible at the output.	rw	Limits: - 100 to 8500 mm (Vers.: DAF0) - 100 to 15500 mm (Vers.: DAJ2) - 100 to 82000 mm (Vers.: DAO0) Default = - 6500 mm (Vers.: DAF0) - 12500 mm (Vers.: DAJ2) - 62000 mm (Vers.: DAO0)

4.7 Expert settings

The following parameters are specific for this type of Radar sensors and are used to optimize the performance of the sensor.

The table gives an overview of all expert settings parameters, while being followed by more detailed explanations. After a profile is chosen the following procedure usually applies:

- Adjust the sensitivity level
- Choose the peak settings depending on respective environment
- Adjust filters (Exponential Output / Disruption)

Parameter name	Short Description	Rights	Unit / Allowed values
Measurement Sensitivity Scale	Select sensitivity level in 5 different scales from Very Low to Very High.	rw	- Very High - High - Medium (Default) - Low - Very Low
Peak Setting Mode	Peak selection for the output value calculation.	rw	- Highest Peak - First Peak (default) - Second Peak - Last Peak
Operation Modes Measurement Modes	Algorithm selection for the peak calculations.	rw	- Fast - Precise (default) - Structured - Precise – all

Process Value Exponential Filter. Peak Filter	Time over which the signal used for the peak calculations (FFT) is exponentially averaged. Used in combination with the “Structured” Measurement Mode.	rw	Limits: 0 to 1000.000ms Default: 4ms
Object Tracking Mode	In Tracking mode the target is followed even if new objects are introduced into the sensor viewing area.	rw	- Off (default) - Mode 1 - Mode 2 - Mode 3 - Mode 4
Object Tracking Hold Time	Time for which a lost signal is retrieved in the same distance.	rw	Limits: 0 to 3600.000ms Default: 0ms

4.7.1 Measurement Sensitivity Scale

This parameter sets an internal threshold for the selection of the peaks to be processed. All peaks above the threshold are considered by the sensor for further calculations. All peaks below are not considered further on.

The sensitivity should be chosen as high as necessary and as low as possible. The sensor signal should be good (>10 dB) over the whole measurement range. If the sensitivity is set too high, many reflections will be visible and might lead to an incorrect sensor behavior. This depends on the application, the target and the environment.

Before adjusting this parameter or if the targets reflection is too weak, make sure the mounting and alignment of the sensor are exact and stable. They are far more important to successfully solve an application. The use of a corner cube can also help obtaining a better measurement result.

- Very high
  - The most sensitive level selects more or less all the available peaks
  - *the first 5 in peaks starting left in the example diagram are selected (Figure 23)*
- High
  - The level is used for sensitive applications like solid level measurement
- Medium
  - The default setting is set in a way to fulfill most of the applications in the field
  - *Would select the three peaks above the red line from the diagram example*
- Low
  - For applications with strong signals this setting can be chosen
- Very low
  - For very strong signal applications
  - *only the first peak in the example (Figure 23) will be selected*

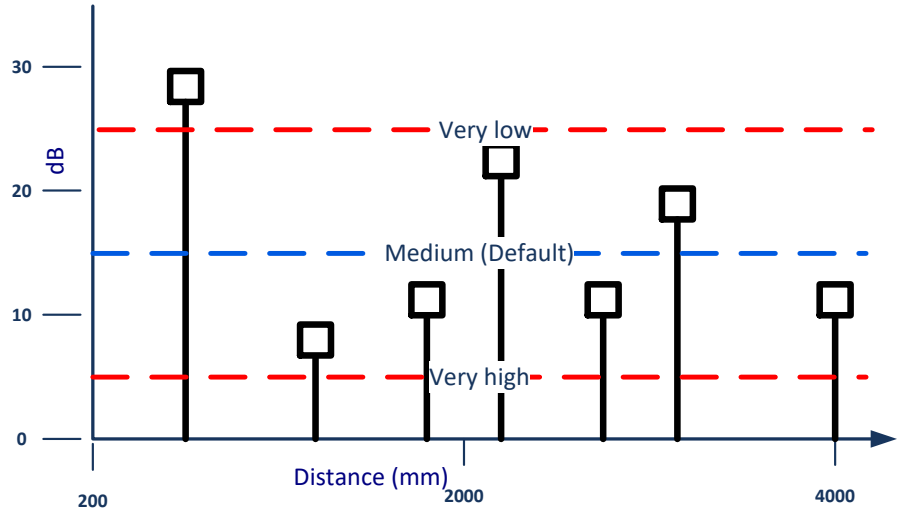

Figure 23: Sensitivity Scale (Example)

4.7.2 Peak Selection Mode

The parameter defines the peak to be chosen for the calculation of the “Measurement Value” in the process data. The selection relies on the 5 available peaks in process data after using the sensitivity filter. As in most application the first peak is the desired, on it is the default setting. Please take care that when not operating the sensor in the Peak Selection mode “First peak” or “Highest Peak“ the risk in receiving a wrong measurement is increased. If the measurement result is insufficient (e.g. wrong or weak signal), check the placement and alignment of the sensors. The use of a corner cube can also help to obtain a better measurement result.

Peak	Value		Unit
Peak4.Amplitude	7.9		dB
Peak4.Distance	3710		mm
Peak3.Amplitude	14		dB
Peak3.Distance	3152		mm
Peak2.Amplitude	10.1		dB
Peak2.Distance	1812		mm
Peak1.Amplitude	6.5		dB
Peak1.Distance	1250		mm
Peak0.Amplitude	10		dB
Peak0.Distance	450		mm

Figure 24: Peak data (Distance and amplitude) as an example from IO-Link Tool

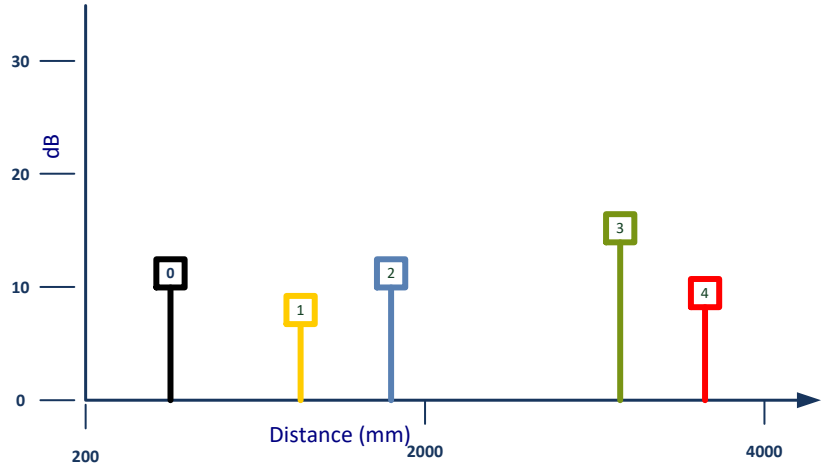

Figure 25: Peak view (example)

There are four selection possible:

- Highest Peak
  - *Would select peak no. 3 from the example (Figure 25) which has the highest amplitude level*
  - If only one peak available this one is selected
  - Use when the target is not always the first but has the strongest signal reflection
- First Peak (default)
  - *Would select peak no. 0 from the example*
  - If only one peak available this one is selected
- Second Peak
  - *Would select peak no. 1 from the example*
  - If only one peak is available none is selected
- Last Peak
  - *Would select peak no. 4 from the example*
  - If only one peak available this one is selected

4.7.3 Operation Modes - Measurement Modes

The Parameter sets the internal operation mode, meaning the way in which the distance value is calculated out of the measured raw data.

This is important to ensure on one hand precise and on the other hand reliable measurement. The measuring results of the different modes may vary by a few millimeters, this is normal and no measuring error.There are four possible modes:

- Fast
  - Setting can be used when the target is only some milliseconds in the view of the sensor
  - This mode is mostly used for time sensitive applications
  - This algorithm will improve the time response while reducing the accuracy of the detected signal.

- Precise (default)
  - Is more exact than the fast mode and should be chosen in most standard applications where the target reflects a clear and strong signal (e.g. flat sample with an ideal alignment to the sensor)
  - Recommended mode when operating with a corner cube

- Structured
  - Recommended mode when fulfilling an application of level detection of solid substances
  - Use for uneven surfaces
  - Should be used when the Exponential Peak Filter is enabled

- Precise – all
  - The same algorithm as in precise gets applied to all found peaks.
  - This mode is used when all Peaks transmitted in the Process Data are used for further evaluation.

4.7.4 Process Value Exponential Filter. Peak Filter

The parameter defines the number of periods over which the signal used for the peak calculations is exponentially averaged. The value of the filter is always a multiple of the minimum measurement time. The sensor automatically uses the next smaller possible value.
This filter is used for targets which do not offer a stable nor strong reflection (e.g. grain, coffee beans, debris, etc.). With the help of this filter a more stable output signal can be achieved and short periods of signal loss get neglected.
This filter should be used with caution and not for fast applications.

4.7.5 Object Tracking Mode

The tracking mode is used to follow (track) an object over a longer distance, especially if the object is moving for- and backwards to or away from the sensor (axially). The main reasons for a wrong measurement are unwanted or unknown object occurring in the sight of the sensor. Goal: keep the measurement on the wanted object all the time. If the tracking mode is enabled, the sensor chooses an object on the basis of the other set parameters (e.g. Peak Selection). Once the track is selected, the sensor keeps this object (distance) as the sensor output, even if other, stronger echoes may occur.

Hence the tracking mode is used, when the target is always visible for the sensor and cannot reliably be selected with the Peak Selection Mode parameter.

When the track is lost, the sensor choses a new track and starts the same procedure again. For the time set in Object Tracking Hold Time, the sensor tries to retrieve the track in the region the track got lost.

There are five given tracking modes:

- Mode 0 Off (default)
  - No tracking is used
- Mode 1
  - Medium (standard), should be used for slow moving objects less than 1 m/s
- Mode 2
  - Slow, should be used for static or slow moving objects less than 0,01 m/s
- Mode 3
  - Fast, should be used for fast moving objects up to 10 m/s
- Mode 4
  - Predictive, can be use instead of the fast or standard mode
  - Calculates the predictive position of the object in the next step
  - Use with caution, can generate errors under certain circumstances

4.7.6 Object Tracking Hold Time

The parameter determines the time a track is held before it being discarded. For the time set in Object Tracking Hold Time, the sensor tries to retrieve the track in the region the track got lost. The sensor output is also retained for the time set.

4.8 Output Settings

4.8.1 Switching Output

The values from the selected internal output are directly set to the physical output layer.

Parameter name	Short Description	Rights	Unit / Allowed values
DI/DO Settings.OUT1 Mode	Select the SSC channel that is set on the output Pin	rw	- SSC1 (default) - SSC2 - SSC4

4.8.2 Analog Output

4.8.2.1 Output Scale

Allows to change the values of the analog output range. For example: the default range is 4 to 20 mA, this can be modified to e.g. 8 to 16mA. In terms of distance values mapped to analog values the modification would mean that the default mapping of 4 mA = 700 mm and 20mA = 3000 mm, is modified to 8 mA = 700mm and 16mA = 3000 mm. The inverting of the analog output can be achieved by setting Analog Max to a lower value as Analog .

When to use: When the master requires a different current range.

Parameter name	Short Description	Rights	Unit / Allowed Values
Analog Output.AnalogMax	Set the maximum value of the analog output	rw	Limits: 4 - 20 mA, Default: 20mA
Analogue Output.AnalogMin	Set the minimum value of the analog output	rw	Limits: 4 20 mA, Default: 4 mA

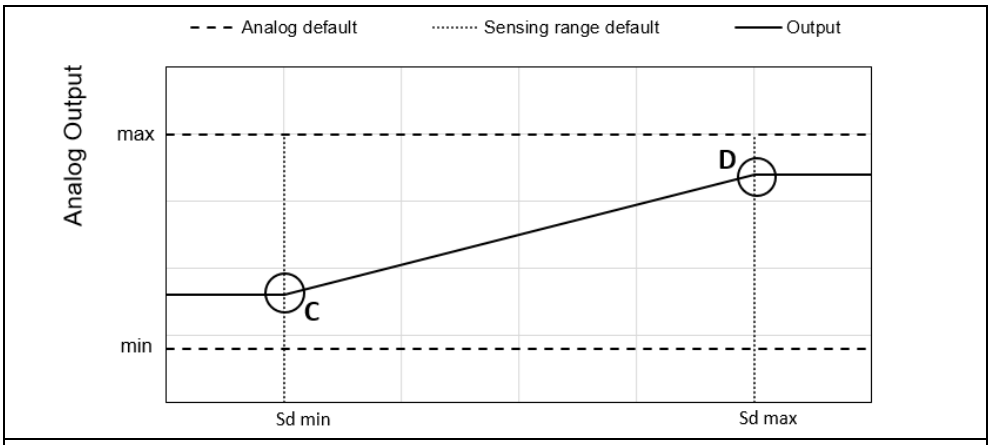

Figure 26 Modified analog Output range

4.8.2.2 Distance at Analog Min/Max

With this parameters the analog output characteristic is set. By reducing the range the resolution of the analogue output is changed, improved.
When to use: When the resolution of the analog output range should be improved.

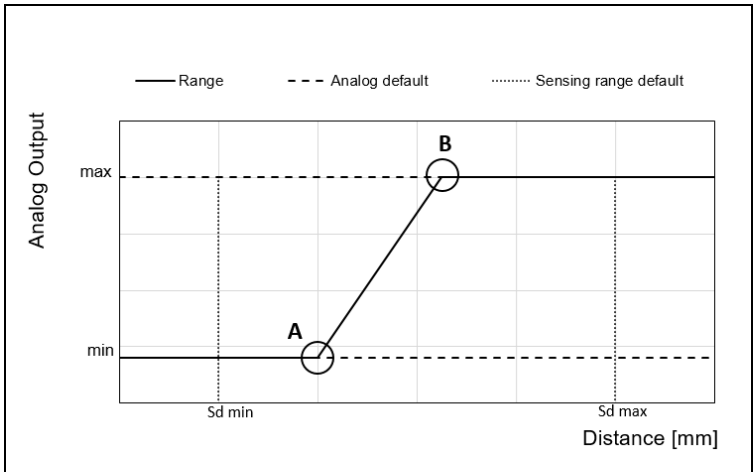

Figure 27 Reduced sensing range for improved accuracy

Parameter name	Short Description	Rights	Unit / Allowed values
Analog Output.Distance@AnalogMin	Set the distance value in mm at the minimum value of the Analog Output	rw	Limits: - 200 to 8000 mm (Vers.: DAF0) - 300 to 15000 mm (Vers.: DAJ2) - 400 to 80000 mm (Vers.: DAO0) Default = - 200 mm - 300 mm - 500 mm
Analog Output.Distance@AnalogMax	Set the distance value in mm at the maximum value of the Analog Output	rw	Limits: - 200 to 8000 mm (Vers.: DAF0) - 300 to 15000 mm (Vers.: DAJ2) - 400 to 80000 mm (Vers.: DAO0) Default = - 6000 mm - 12000 mm - 60000 mm

4.9 Local User Interface

Different parameters are available to configure the local user interface which means the indication LEDs and the local-teach-in (teach by wire)

4.9.1 Indication LEDs

Parameter name	Short Description	Rights	Unit / Allowed values
LED Settings.Green.Mode	Switches the LED off, no change of other function	rw	On / Off Default: On
LED Settings.Yellow.Mode	Switches the LED off, no change of other function, Inverted: Pin high, LED off On: Pin high, LED on	rw	On / Off / Inverted Default: On

4.10 Quality Parameters

4.10.1 Quality Parameters

This parameter indicates the signal strength from the received reflection relative to the set threshold. It is useful to be monitored by the PLC to detect weak signals which may be caused by misalignment or by dirt on the sensor surface. By setting the quality threshold to a value above 6 dB an alarm can be generated if the quality value gets below this number. This might be useful for critical applications to define a minimum signal strength.

Parameter name	Short Description	Rights	Unit / Allowed values
Quality.Value	Quality value indicates the quality of the reflected signal	ro	units dB
Quality Bit.Threshold	Selects the Quality Threshold, if the quality value is below the threshold the LEDs start to blink and the quality bit in the process data is set to 1	rw	Limits: 6 to 80 dB; Default: 6 dB

4.11 Device Access Lock

4.11.1 Device Access Lock

This parameter limits the possibility to erase historical data in the sensor.

Parameter name	Short Description	Rights	Unit / Allowed values
Device Access Locks	Lock the possibility to erase the collected historical data	rw	false (default) / true

4.12 Application Specific Profiles

The RR30 IO Link sensor has implemented predefined application profiles. The function allows the user to get the first entry parameter setting for the chosen application. As not all application are similar this parameter setting can be a first approach to find the correct settings. In the most application cases the user has to modify the parameters to the specific application and the environmental conditions.
For the RR30 sensor 8 different profiles are available:

- Standard (default setting)
- Fill level fluid: slow
- Fill level fluid: fast
- Fill level solid
- Fast detection
- Tracking: slow
- Tracking: standard
- Tracking: fast

When switching between different profiles the modified parameters are stored inside the sensor.
All parameters can be reset by choosing the function “Restore Factory Settings“ (Chapter 4.1)

4.12.1 Standard

The standard profile sets the parameters in a way that many common applications (e.g. a clear defined target without other without disturbing effects) can be solved. The sensor should deliver reasonable results when operating with good targets (material / surface structure / size / angel / etc.). This profile is the default setting.

4.12.2 Fill level fluid: slow

The Profile “Fill level fluid slow” can be used for a detection of fill level in e.g. liquid tanks. If the level in the tank is not changing slowly and the fluids have high viscosity (e.g. glues / pasty goods / etc.) the this profile should be selected. The profile works well inside a tank where no barriers or disturbing elements are present (mixer, stirrer, bars, pipes). If a stirrer is present please use the fast profile 4.12.3. Take care when operating inside a tank where reflections (e.g. side reflections) can influence the measurement. Foam in general might have a negative effect on the measurement of the liquid level. The profile can also be used for solid materials that have a high percentage of humidity.

4.12.3 Fill level fluid: fast

Use this profile if the changes of the level are fast. if e.g. the filling or emptying of tanks requires a stable measurement. Also when disturbing object like mixer are interfering with the radar beam we recommend fast profile. Rotations of the stirrer between 20 and 60 rot/min are covered by the original settings. For faster or slower movement parameters like disruption filter should be adjusted. Use this profile also for level with waves or out sticking objects.

4.12.4 Fill level solid

Compared to the fluid substance the handling and detection of solid substance is more difficult. As the structure of the substances is mostly not flat (compared to the surfaces inside liquid tanks) this has a strong influence of the measurement accuracy. The predefined profile is parametrized in a way to obtain adequate results when detecting e.g. a level of granular substances inside a silo. Due to the physically detection capability of radar radiation a grain size of <1 mm and >5 mm can be detected easier the objects with size within 1 and 5 mm. As mentioned a lot of different parameter of the tank / reservoir / vessel environment and the physical characteristic of the substance might have an impact on the signal so the sensor parameters must be adjusted accordingly. Use this profile also when the material forms a pile.

4.12.5 Fast detection

If using the “Fast detection-Profile“ the sensor will try to find as fast as possible any target. The Sensor will be adjusted to find also the fastest and smallest target. The profile can be use e.g. for environmental scan or collision avoiding application, generally if the sensor has no object in its field of view most of the time. As the sensor is set very sensitive the risk in finding wrong and not desired targets is given, therefore use only if necessary. The profile uses no filtering.

The tracking profiles are needed if the goal is to follow a detected target over a longer distance. Once the target is detected (set) the sensor will try to stick with this object as far as this one is detected. The sensor will search a new target by a defined peak selection only if the “old” one is completely lost.
Tracking is needed if disturbing objects in the view of the sensor have higher or stronger reflections than the wanted target and this one is in move. Due to the nature of the profile a categorization to a specific speed level of the targets is needed. See also 4.7.5

4.12.6 Tracking: slow

The “Tracking: slow - Profile” can be used for very slow or a not moving target. For good result the speed of the target should be less < 0,01 m/s.

4.12.7 Tracking: standard

The Tracking “Tracking: Standard “-Profile should be selected when the objects are moving with a speed up to a maximum speed of 1 m/s. In cases the profile will not work proper please select the slower or faster version to test if an improvement can be achieved.

4.12.8 Tracking: fast

The Tracking “Tracking : Fast“-Profile should be selected when the object is moving with a speed of > 1 m/s up to a maximum speed of 10 m/s. The maximum speed range depends on the characteristic of the objective surface. For faster objects no tracking can be chosen. A good trackable surface can be detected at a higher speed compared to a bad detectable target. In case the profile will not work proper please select the slower version to test if an improvement can be achieved.

5 Diagnosis

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

5.1 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	

5.2 Device Temperature

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

Parameter name	Short Description	Rights	Unit / Allowed values
Device Temperature Reset	Resets the device temperature statistic	wo	
Device Temperature.Current	Internal temperature of the sensor	ro	
Device Temperature.Resettable Min	Minimal measured internal temperature of the sensor (Resettable)	ro	
Device Temperature.Resettable Max	Maximal measured internal temperature of the sensor (Resettable)	ro	

Device Temperature.Lifetime Min	Minimal measured internal temperature of the sensor (Lifetime)	ro	
Device Temperature.Lifetime Max	Maximal measured internal temperature of the sensor (Lifetime)	ro	
Unit Selection.Temperature	Choice of temperature unit (Default: °C)	ro	°C, °F, K

5.3 Power Supply Voltage

Parameter name	Short Description	Rights	Unit / Allowed values
Power Supply Voltage Reset	Resets the device power supply [V] statistic	wo	
Power Supply Voltage.Current	Current power supply voltage	ro	V
Power Supply Voltage.Resettable Min	Minimal measured power supply voltage (Resettable by user command)	ro	V
Power Supply Voltage.Resettable Max	Maximal measured power supply voltage (Resettable by user command)	ro	V
Power Supply Voltage.Lifetime Min	Minimal measured power supply voltage over the complete lifetime	ro	V
Power Supply Voltage.Lifetime Max	Maximal measured power supply voltage over the complete lifetime	ro	V

5.4 Bootcyles

Parameter name	Short Description	Rights	Unit / Allowed values
Bootcyles.Lifetime	Total number of bootcycles over the complete lifetime	ro	Bootcycles

5.5 Operation Time

Parameter name	Short Description	Rights	Unit / Allowed values
Operation Time Reset	Resets the operation time statistic	wo	
Operation Time.Powerup	Operation time on power-up	ro	
Operation Time.Resettable	Operation time (Resettable by user command)	ro	
Operation Time.Lifetime	Lifetime operation time	ro	
Unit Selection.Time	Choice of time unit	ro	Second

5.6 Histograms

Several diagnosis and process values are continuously tracked to allow predictive maintenance or trouble shooting. Instead of storing each value, the values are stored in a histogram. Therefore the values are divided into several intervals (bins). This allows a much more efficient way to store the values for analyzes.

Example based on Device Temperature:

- Range: -40 … +120°C
- Number of Bins: 16 Bin
- Size of a Bin: 160°C / 16 = 10 °C
- Range of Bin 1: -40 …. -30.00 °C
- Range of Bin 2: -20.00 … -10.00 °C
- …
- Range of Bin 16: +110.00 °C ... +120 °C

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

Histograms are available for

- Device Temperature, Lifetime
- Power Supply Voltage, Lifetime
- Process Value 1: Distance, Resettable

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

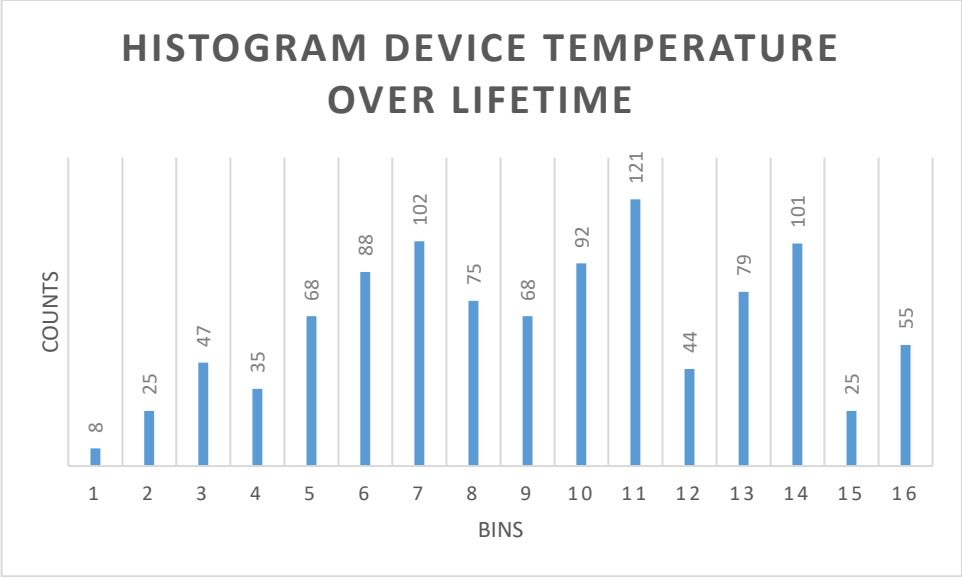

Figure 28: Histogram Device Temperature over Lifetime, Example

The counts of each bin are stored as 32 bit value (up to 4’294’967’296 counts).

5.6.1 Device Temperature

Parameter name	Short Description	Rights	Unit / Allowed values
Device 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
Device Temperature Lifetime Histogram.RangeStart	Defines, where the range starts.	ro	-40
Device Temperature Lifetime Histogram.RangeEnd	Defines, where the range ends.	ro	+120
Device Temperature Lifetime Histogram.Nbr of Bins	Number of bins	ro	16
Device Temperature Lifetime Histogram Bin1 … 16	Number of counts of each bin	ro	32 Bit for each bin

5.6.2 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	+48
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

5.6.3 Process Value 1: Distance

Parameter name	Short Description	Rights	Unit / Allowed values
Distance Resettable Histogram Reset	Command to reset the histogram of process value 1	ro	
Distance Resettable Histogram.Mode	Standard means: Linear partition of the range into bins.	ro	Standard
Distance Resettable Histogram.Unit	Indicates the unit	ro	Millimeter
Distance Resettable Histogram.RangeStart	Defines, where the range starts.	ro	0
Distance Resettable Histogram.RangeEnd	Defines, where the range ends.	ro	6000; 12000; 60000
Distance Resettable Histogram.Nbr of Bins	Number of bins	ro	16
Distance Resettable Histogram.Bin1 … 16	Number of counts of each bin	ro	32 Bit for each bin

6 Glossary

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

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