ORCA – Firmware V3.x

Revision A | 2024-04-16

Overview

ORCA Level Sensors can be used in IO-Link and non-IO-Link environments.

For non-IO-Link usage, the sensor features up to three digital outputs that switch on at certain fill levels and up to one analog current or voltage output, whose value scales continuously with the fill level.

The related parameters can be configured before/during deployment via IO-Link:

- Container teach-in
- Function of Pins 2, 4, and 5
  - Digital output with individual set and reset point
  - Analog current (4...20mA) or voltage (0...10V) output on Pin 2 (not available on "Lite" variant)
  - Digital input to signal a special system state via the sensor's LED
- Display of fill level by LED as a color gradient, or dedicated color for the three output set points

IO-Link Communication

If the sensor detects IO-Link communication, it automatically switches to the IO-Link communication mode. The IO-Link standard offers different communication mechanisms:

- **Acyclic Data** (Indexed Service Data Units): Used to configure basic settings during commissioning.
- **Cyclic Process Data**: Used to receive the sensor's state and influence its behavior during runtime.
- **Events**: The sensor will report events in case of error.

In IO-Link applications the fill level is provided via cyclic Process Data for processing by a PLC. Additionally, the sensor's LED can be controlled via Process Data – either by choosing a pre-configured scene or sending RGB values directly.

> **INFO**
>
> Process Data, ISDUs and events of the sensor, their respective numeric indices, offsets, and values, are described in the IODD file of the sensor. It is highly recommended to use this file when integrating the sensor in an application.

Device Variants

Product ID	Name	Description
CLP-G5A2N2	ORCA	Level Sensor with 1 Analog and 2 Digital Outputs / 3 Digital Outputs (configurable)
CLP-G5A2K3	ORCA Lite	Level Sensor with 3 Digital Outputs

Container Teach-In

"One-Click" Teach-In

1. Set the **Dielectric Constant** (εR) of the substance in your container via the respective IO-Link parameter.

> **NOTE**
>
> You can also order ORCA Level Sensors with the desired Dielectric Constant pre-configured.

2. Mount the sensor in the empty container.
3. Trigger the IO-Link System Command **"Perform One-Click Teach-In"**.

Low and high reference fill levels will be set to 0% (empty) and 100% (full), respectively, and the currently measured capacitance is applied as low (empty) reference value. The high (full) reference value is calculated using the configured dielectric constant.

Two-Point Teach-In

Two-Point Teach-In offers you to use "low" and "high" reference fill levels of your choice for container teach-in.

1. Configure the desired reference "low" and "high" fill levels by setting the respective IO-Link Parameters.
2. Fill the container to the percentage given as **Container Low Fill Level**.
3. Issue the IO-Link System Command **"Container Teach In 'Empty'"**.
    - The currently measured capacitance will be saved in the sensor as "low" level reference.
    - The sensor's LED may start to blink yellow. This indication of an invalid parameter set will cease after high level teach-in.
4. Fill the container to the percentage given as **Container High Fill Level**.
5. Issue the IO-Link System Command **"Container Teach In 'Full'"**.
    - The currently measured capacitance will be saved in the sensor as "high" level reference.

Additional Reference Points

Optionally, up to four more reference points for fill level calculation can be set in addition to the low (empty) and high (full) references. They allow to adjust the fill level calculation for special container shapes, like funnels.

The additional reference points can be configured via their IO-Link parameters:

1. Set the desired fill level percentage of the additional reference point X (X = 1...4).

> **NOTE**
>
> When its fill level is set to -1, the reference point is disabled.

2. Fill the container to that percentage.
3. Issue the IO-Link System Command **"Set Additional Reference X"**.

Dielectric Constant

Being a capacitive sensor, ORCA Level Sensor makes use of the dielectric constant of the substance to be measured for "One-Click" Teach-In. For conductive substances, a "magic" value of 653.55 is applied.

The IO-Link IODD files contain a short list of Dielectric Constants. For extended lists, please refer to a listing of relative permittivity values, e.g. in CAPTRON's level sensor catalog, pages 51ff.

Once the sensor was taught for a certain container, the level measurement can be adjusted to a different substance by changing the Dielectric Constant and then triggering the IO-Link command **"Adjust to changed medium"**.

Determine Dielectric Constant using ORCA

ORCA Level Sensors can determine the Dielectric Constant of a substance in a container using IO-Link controls:

1. Ensure that the parameters **Container High/Low Fill Level** are set to 100% and 0%, respectively.
2. In an empty container, trigger the **"Container Teach In 'Empty'"** command.
3. Fill the container with the medium to 100%.
4. Trigger the **"Container Teach In 'Full'"** command.
5. Trigger the **"Calculate Dielectric Constant"** command.
6. Read the calculated value from the parameter **"Medium Calculated Constant"**.

Output Configuration

The function of Pins 2, 4, and 5 can be configured via the respective IO-Link parameters.

For a standard ORCA level sensor (but not for the "Lite" variant) Pin 2 can be used as an analog current or voltage output.

For the digital output functions PNP, NPN, and PushPull, a set and a reset point and the output function (Normally Open or Closed) can be set. Digital outputs will switch on when the current fill level is above the respective set point and switch off when the fill level is below the set point minus the given hysteresis value.

For an output switch to be closed when the current fill level is **below** a certain fill level, configure its output function to **Normally Closed**. The set point must be set to the desired level plus the given hysteresis value.

Example: The output switch shall be closed if the fill level is below 10%, with an open/close hysteresis of 3% — configure set point to 13%.

LED

Indication of Fill Level

The LED can indicate the fill level in two ways. This behavior can be set via IO-Link Parameter **Level Display Mode**.

- **Color Gradient** – The color changes continuously depending on the fill level.
- **Output Switch Points** – The LED behavior changes in four steps defined by the set points of the digital outputs (Pins 2, 4, 5). This method is working regardless which Pin Function is configured for the three pins.

For both modes, special "empty" and "full" states can be signaled additionally. These states have dedicated trigger fill levels, which can be configured via IO-Link Parameters **LED Set Point 'Empty'** and **LED Set Point 'Full'**.

If Pin 2 or 5 is configured to be an input, it can trigger another LED state by a high signal level to indicate a special system state.

The actual LED behavior for those states is managed by Scene settings, which can be configured via dedicated IO-Link Parameters.

Scene Assignment

Scene	Color Gradient Mode	Output Switch Points Mode	Example
0	Fill level lower than "LED Set Point Empty"	Fill level lower than "LED Set Point Empty"	Red, flashing
1	Reference color 0%	Fill level lower than all output set points	Red
2	n/a	Fill level higher than one output set point	Orange
3	n/a	Fill level higher than two output set points	Yellow
4	Reference color 100%	Fill level higher than all output set points	Green
5	Fill level higher than "LED Set Point Full"	Fill level higher than "LED Set Point Full"	Green, flashing
6	High signal on any input pin	High signal on any input pin	Blue, flashing

Control Options via IO-Link

In an IO-Link application, the LED can be controlled via cyclic Process Data. This feature can be enabled and configured via IO-Link Parameter **LED Control Mode**.

Three options are available:

- **Control by device** – The LED is not controlled by Process Data, but by the sensor itself as described above.
- **Scene control** – Process Data sets the active Scene (0...6) of the LED or asks the sensor to indicate the fill level with the configured Level Display Mode.
- **Advanced control** – Process Data directly controls the RGB color components, brightness, and effects of the LED.

IO-Link Interface

IO-Link Specification: V1.1.2 (July 2013)

Property	ORCA	ORCA Lite
Vendor ID	1239	1239
Device Family	Level Sensors	Level Sensors
Device Name	ORCA	ORCA Lite
Device ID	1542	1543
IODD	IODDfinder	IODDfinder

Communication Interface

Property	Value
IO-Link Version	V1.1
Bitrate	COM2
Minimum Cycle Time	14800 µs
Process Data Input Bits	128
Process Data Output Bits	64
SIO Supported	Yes
ISDU Supported	Yes
Data Storage	Yes
Block Parameter	No
Supported Profiles	FW-Update (49)

Process Data

> **NOTE**
> IO-Link bit offset counts from the last byte of the data array.

Process Data Input

128 bit / 16 bytes

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bit Offset					96				64	48	32	24	16	8	0	
Data					Capacitance				reserved	reserved		res.	Pin 5	Pin 4	Pin 2	

Field Reference

Bit Offset	Name	Datatype	Values	Info
0	Pin 2	8-bit UIntegerT	0 - Output OFF, 1 - Output ON, 2 - Output Analog, 4 - Input OFF, 5 - Input ON	Pin 2 state. Value 2 (Analog) not available on Lite variant.
8	Pin 4	8-bit UIntegerT	0 - Output OFF, 1 - Output ON	Pin 4 state.
16	Pin 5	8-bit UIntegerT	0 - Output OFF, 1 - Output ON, 4 - Input OFF, 5 - Input ON	Pin 5 state.
24	reserved	8-bit IntegerT		
32	Fill Level	16-bit IntegerT	-32767...32767 [0.01 %], -32768 - not available	Fill level in 0.01%. Value -32768 means fill level not available (during device start-up or due to parameter error).
48	reserved	16-bit IntegerT		
64	reserved	32-bit UIntegerT		
96	Capacitance	32-bit UIntegerT	0 ... 4294967295 [0.01 pF]	Measured electric capacitance in 0.01 pF.

Process Data Output

64 bit / 8 bytes

LED Control Mode "By Device" (0)

Process Data Output is **unused**.

LED Control Mode "Scene controlled by IO-Link Process Data" (1)

Byte	0	1	2	3	4	5	6	7
Data	unused							LED Scene

Bit Offset	Name	Datatype	Values	Info
0	LED Scene	8-bit UIntegerT	0...6, 255 - control by device	Switch between LED scenes 0 to 6. For control by the device (fill level visualization), set 255.

LED Control Mode "Advanced control by IO-Link Process Data" (2)

Byte	0	1	2	3	4	5	6	7
Bit Offset	56	48	40	32	24	16		0
Data	LED Frequency	LED Effect	LED Color B	LED Color G	LED Color R	LED Brightness		Active LEDs

Bit Offset	Name	Datatype	Values	Info
0	Active LEDs	16-bit UIntegerT	0...1	Bitmask defining which LEDs are active.
16	LED Brightness	8-bit UIntegerT	0...100 [%]	Brightness of LED in percent.
24	LED Color R	8-bit UIntegerT	0 ... 255	Red component of LED color.
32	LED Color G	8-bit UIntegerT	0 ... 255	Green component of LED color.
40	LED Color B	8-bit UIntegerT	0 ... 255	Blue component of LED color.
48	LED Effect	8-bit UIntegerT	0 - Static, 1 - Flash, 2 - Pulse	
56	Effect Frequency	8-bit UIntegerT	1...60 [0.1 Hz], 0 - Default Frequency	Frequency of LED effect in 0.1 Hz, range: 0.1 ... 6 Hz.

Events & Commands

Events

Event Code	Type	Definition and recommended maintenance action
6144	Error	Output Overload – Output current too high – max. 200 mA
6145	Error	Voltage Output Overload – Current on analog voltage output too high
6146	Warning	Current Output Overload – Resistance on current output too high
16912	Warning	Device temperature over-run (above 90°C) – Clear source of heat
16928	Warning	Device temperature under-run (below -20°C) – Insulate device
20496	Error	Component malfunction – Repair or exchange
20752	Warning	Primary supply voltage over-run (above 30V) – Check tolerance
20753	Warning	Primary supply voltage under-run (below 16.8V) – Check tolerance
25376	Error	Parameter error – Check data sheet and values

Commands

ISDU Index 2 – System Command

General Commands

Value	Name	Description
128	Device Reset	Restart the device
130	Restore Factory Settings	Restore Factory Settings

Calibration Commands

Value	Name	Description
164	Container Teach In 'Low'	Stores the current sensor value as Low Level reference point
165	Container Teach In 'High'	Stores the current sensor value as High Level reference point
166	Calculate Dielectric Constant	Calculate Medium Dielectric Constant from Capacitance of High and Low Level Reference points
167	Set Additional Reference 1	Stores the current sensor value as additional reference point 1
168	Set Additional Reference 2	Stores the current sensor value as additional reference point 2
169	Set Additional Reference 3	Stores the current sensor value as additional reference point 3
170	Set Additional Reference 4	Stores the current sensor value as additional reference point 4
171	Perform One-Click Teach-In	Note: will change Low and High reference points
172	Adjust to changed medium	Note: will change High reference point

ISDU Indices

Access Rights: **ro** – Read Only, **rw** – Read/Write, **wo** – Write Only

System Command

Name	Index	Bytes	Access	Values	Description
System Command	2	1	wo	see Events & Commands	

Identification

Name	Index	Bytes	Access	Values	Description
Vendor Name	16	23	ro	CAPTRON Electronic GmbH	
Product Name	18	4 / 9	ro	ORCA (Lite)	
Product ID	19	10	ro	CLP-xxxxxx	
Product Text	20	20	ro	Order Code	
Rod Length	193	4	ro	[mm]	
Hardware Identification Key	17342	9	ro	A0002001A	
Serial Number	21	13	ro		
Firmware Version	23	4	ro	V3.x	
Application Specific Tag	24	32	rw	***	

Measurement Configuration

Name	Index	Bytes	Access	Values	Description
Averaging Time Constant	327	2	rw	0 - No additional filter, 1...65535 [ms]	
Medium Dielectric Constant	325	2	rw	100...65535	See common values below . 65535 = Conductive Medium.

Dielectric Constant Values

Value	Substance
150	Resin
180	Sugar
200	Benzine, Glue
210	Chlor, fluid
220	Propanol (propyl alcohol)
230	Hot glue
270	Silicone oil
400	Phosphorus salt
420	Phenetole
520	Nitro varnish
740	Phenol resin
800	Phenol
1070	Isoquinoline
1350	Benzyl alcohol
1620	Ethanol (ethyl alcohol)
1830	Cresol resin, Tooth paste
2060	Allyl alcohol
2150	Acetone
2190	Sulfuric acid
2400	Vinegar
2500	Bore oil emulsion
3160	Ammonia solution (25%)
3200	Soft soap
3700	Glycol

Value	Substance
65535	Conductive Medium

Container Teach-In

High Fill Level

Name	Index	Bytes	Access	Values	Description
Container High Fill Level	287	1	rw	0 ... 100 [%]	Fill level in percent of High Level reference point.
Capacitance "High Level"	289	4	rw	1 ... 1000000 [0.01 pF]	Sensor value for High Level reference point. Will be set to current Capacitance value when triggering "Calibrate High Level" or "Perform One-Click Teach-In" command.

Low Fill Level

Name	Index	Bytes	Access	Values	Description
Container Low Fill Level	286	1	rw	0 ... 100 [%]	Fill level in percent of Low Level reference point.
Capacitance "Low Level"	288	4	rw	1 ... 1000000 [0.01 pF]	Sensor value for Low Level reference point. Will be set to current Capacitance value when triggering "Calibrate Low Level" or "Perform One-Click Teach-In" command.

Additional Reference Points

Reference Point 1 (Index 328)

Subindex	Name	Bytes	Access	Values	Description
1	Level	1	rw	-1 - not set, 0...100 [%]	Fill level in percent.
2	Capacitance	4	rw	0 - not set, 1...1000000 [0.01 pF]	Sensor value.

Reference Point 2 (Index 329)

Subindex	Name	Bytes	Access	Values	Description
1	Level	1	rw	-1 - not set, 0...100 [%]	Fill level in percent.
2	Capacitance	4	rw	0 - not set, 1...1000000 [0.01 pF]	Sensor value.

Reference Point 3 (Index 330)

Subindex	Name	Bytes	Access	Values	Description
1	Level	1	rw	-1 - not set, 0...100 [%]	Fill level in percent.
2	Capacitance	4	rw	0 - not set, 1...1000000 [0.01 pF]	Sensor value.

Reference Point 4 (Index 331)

Subindex	Name	Bytes	Access	Values	Description
1	Level	1	rw	-1 - not set, 0...100 [%]	Fill level in percent.
2	Capacitance	4	rw	0 - not set, 1...1000000 [0.01 pF]	Sensor value.

Pin Configuration

Pin 2 – Digital / Analog Output / Input

Name	Index	Bytes	Access	Values	Description
Pin 2 Function	315	1	rw	0 - NPN, 1 - PNP, 2 - PushPull, 3 - Current Output 4...20mA *, 4 - Voltage Output 0...10V *, 5 - Input (active high)	* Not available on Lite variant. Input mode sets LED Scene 6.
Output Function	318 - 1	1	rw	0 - NO (Normally Open), 1 - NC (Normally Closed)	Applies only if Pin function is NPN, PNP, or PushPull.
Output Set Point	318 - 2	1	rw	0 ... 100 [%]	Fill level above which Output will switch ON. 100% = never switch on.
Output Hysteresis	318 - 3	1	rw	0 ... 100 [%]	Output will switch OFF when fill level is below Set Point minus this value.
Output Minimum Impulse Time	318 - 4	4	rw	10 ... 300000 [ms]	Applies only if Pin function is NPN, PNP, or PushPull.

Pin 4 – Digital Output / IO-Link

Name	Index	Bytes	Access	Values	Description
Pin 4 Function	316	1	rw	0 - NPN, 1 - PNP, 2 - PushPull	
Output Function	319 - 1	1	rw	0 - NO (Normally Open), 1 - NC (Normally Closed)	
Output Set Point	319 - 2	1	rw	0 ... 100 [%]	Fill level above which Output will switch ON. 100% = never switch on.
Output Hysteresis	319 - 3	1	rw	0 ... 100 [%]	Output will switch OFF when fill level is below Set Point minus this value.
Output Minimum Impulse Time	319 - 4	4	rw	10 ... 300000 [ms]	

Pin 5 – Digital Output / Input

Name	Index	Bytes	Access	Values	Description
Pin 5 Function	317	1	rw	0 - NPN, 1 - PNP, 2 - PushPull, 5 - Input (active high)	Input mode sets LED Scene 6.
Output Function	320 - 1	1	rw	0 - NO (Normally Open), 1 - NC (Normally Closed)	Applies only if Pin function is NPN, PNP, or PushPull.
Output Set Point	320 - 2	1	rw	0 ... 100 [%]	Fill level above which Output will switch ON. 100% = never switch on.
Output Hysteresis	320 - 3	1	rw	0 ... 100 [%]	Output will switch OFF when fill level is below Set Point minus this value.
Output Minimum Impulse Time	320 - 4	4	rw	10 ... 300000 [ms]	Applies only if Pin function is NPN, PNP, or PushPull.

LED

Name	Index	Bytes	Access	Values	Description
LED Control Mode	293	1	rw	0 - By Device, 1 - Scene controlled by IO-Link Process Data, 2 - Advanced control by IO-Link Process Data	See LED for details on each mode.
Level Display Mode	290 - 1	1	rw	0 - Color Gradient, 1 - Output Switch Points	**Color Gradient** : LED color changes continuously with fill level between color of Scene 1 (0%) and 4 (100%). **Output Switch Points** : LED settings chosen from Scenes 1 to 4 depending on number of outputs switched on.
LED Set Point 'Empty' (Scene 0)	290 - 2	1	rw	0 ... 100 [%]	Fill level below which LED Scene 0 is set. A value of 0% disables the "Empty" state.
LED Set Point 'Full' (Scene 5)	290 - 3	1	rw	0 ... 100 [%]	Fill level above which LED Scene 5 is set. A value of 100% disables the "Full" state.
LED Brightness	285	1	rw	0 ... 100 [%]	Brightness of LED in percent.

Observation & Diagnosis

Name	Index	Bytes	Access	Values	Description
Sensor Temperature	257	2	ro	-32768 ... 32767 [0.1 °C]	
Supply Voltage	256	2	ro	0 ... 65535 [0.001 V]	
Voltage on Analog Output	281	2	ro	0 ... 65535 [0.001 V]	
Intermediate voltage	326	2	ro	0 ... 65535 [0.001 V]	
MCU Voltage	279	2	ro	0 ... 65535 [0.001 V]	
Charge Code	280	4	ro	0 ... 4294967295	
Error Code	282	2	ro	0 ... 65535	
Flash Erase Count	259	2	ro	0 ... 65535	
Device Access Locks	12		rw		

LED Scenes

ORCA has 7 LED scenes (0–6), each configured with:

- **LED Color** – The color of the LED
- **LED Effect** – The behavior (Static, Flash, Pulse)
- **Effect Frequency** – Frequency of animated effects in 0.1 Hz (range: 0.1 ... 6 Hz)

Available LED Colors

Value	Color
1	Red
2	Green
3	Blue
4	Yellow
5	Magenta
6	Cyan
10	Orange
11	Violet
12	Turquoise
13	Off
14	Clean Blue
128	Custom Color 1
129	Custom Color 2

Scene ISDU Indices

Scene	Condition	LED Color	LED Effect	Effect Frequency
Scene 0	Empty	295 - 1	295 - 2	295 - 3
Scene 1	0% / Step 1	296 - 1	296 - 2	296 - 3
Scene 2	Step 2	297 - 1	297 - 2	297 - 3
Scene 3	Step 3	298 - 1	298 - 2	298 - 3
Scene 4	100% / Step 4	299 - 1	299 - 2	299 - 3
Scene 5	Full	300 - 1	300 - 2	300 - 3
Scene 6	Input active	301 - 1	301 - 2	301 - 3

Custom Scene Colors

Custom Color 1 (Index 306)

Subindex	Component	Values
1	R	0 ... 255
2	G	0 ... 255
3	B	0 ... 255

Custom Color 2 (Index 307)

Subindex	Component	Values
1	R	0 ... 255
2	G	0 ... 255
3	B	0 ... 255

Self-Diagnosis and Error Codes

ORCA Level Sensors include the following diagnosis features:

- **Self-Test**: When triggered by the respective IO-Link System Command, the RGB LED is checked electrically.
- **Monitoring** of Supply and internal Voltages and MCU Temperature
- **Overload Detection** on digital and analog outputs

Detected errors are indicated via IO-Link Events and/or in the **Error Code** IO-Link Parameter, as well as by blinking patterns of the LED.

Error Codes

Blink Code	IO-Link Error Code	Description
1	0x0001	Internal error
2	0x0002	Error with intermediate voltage
4	0x0008	Supply voltage overrun / underrun
8	0x0080	Parameter memory error
9	0x0100	Parameter error
12	0x0800	LED error
13	0x1000	Overload on digital output
–	0x2000	Overload on analog output
15	0x4000	Temperature overrun

Revision History

Rev. A – 2024-04-16

- Initial release