Manual

EtherNet/IP - CIP Safety™

LioN-Safety 8/4-F-DI, 4-F-DO, 2-IOLM M12 (EtherNet/IP™ / CIP Safety™)
0980 SSL 3131-121-007D-202

LioN-Safety 16/8-F-DI M12 (EtherNet/IP™ / CIP Safety™)
0980 SSL 3130-121-007D-202

Technical Support
https://lumberg-automation-support.belden.com

Contents

1 About this manual

This present language version of the manual contains the 'Original Instructions' according to the Machinery Directive (Directive 2006/42/EC).

1.1 General information

Read the assembly and operating instructions on the following pages carefully before starting up the modules. Keep this information where it is accessible to all users.

The texts, figures, diagrams, and examples used in this document are exclusively used to explain how to operate and apply the modules.

Please contact us if you have any detailed questions on installing and starting up the devices:

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1.2 Explanation of symbols

1.2.1 Use of danger information

Danger information is denoted as follows:

Danger: Means that death, serious physical injury or substantial damage to property will occur if the required safety measures are not taken.

Warning: Means that death, serious physical injury or substantial damage to property can occur if the required safety measures are not taken.

Caution: Means that minor physical injury or damage to property can occur if the required safety measures are not taken.

1.2.2 Use of general information

General information is denoted as follows:

Attention: Contains important information on the product, on how to manage the product, or on the respective section of the documentation to which your special attention is being drawn.

1.2.3 Use of the CIP Safety symbol

The CIP Safety symbol means that important information is provided which is required to be considered for proper usage of the described devices in this manual in a Functional Safety environment.

1.3 Version information

Version	Created	Changes
1.0, Draft01	08/2024	
1.0, Draft02	10/2024	
1.0, Pre-Final	11/2024	
1.0	01/2025	Declarations of conformity on page 309

Table 1: Overview of manual revisions

2 Safety instructions

2.1 Intended use

The products described in this manual are decentralized IO-Link Masters on an Industrial Ethernet Network.

We adhere to all safety standards when developing, producing, testing, and documenting our products. When you adhere to the handling specifications and safety instructions described for the configuration, assembly, and correct operation, there should not normally be any risks for people or equipment.

The modules fulfill the requirements of the EMC guidelines (2014/30/EU) and the low voltage guideline (2014/35/EU).

The IO-Link Masters are designed to be used in the industrial sector. The industrial environment is distinguished by the fact that the consumer is not connected directly to the public low voltage network. Additional measures are required for use in residential areas or in business and commercial sectors.

Attention: This equipment may cause radio interference in residential areas. In this case the operator may be requested to carry out appropriate measures.

The proper and safe operation of this product depends on proper transportation, storage, assembly, and installation, and careful operation.

A completely assembled device housing is required for the proper operation of the IO-Link Masters. Only connect devices that fulfill the requirements of EN 61558-2-4 and EN 61558-2-6 to the IO-Link Masters.

During the configuration, installation, start-up, maintenance, and testing of the devices, adhere to the safety and accident-prevention guidelines for the specific application.

Only install cables and accessories that fulfill the requirements and regulations for safety, electromagnetic compatibility, and, where applicable, telecommunication end devices, as well as the specification information. Information on which cables and accessories are permitted for the installation can be obtained from Belden Deutschland GmbH– Lumberg Automation™ or is contained in this manual.

2.2 Qualified personnel

The configuration, installation, start-up, maintenance, and testing of the devices may only be performed by a qualified electrician who is familiar with the safety standards of the automation technology.

The personnel requirements are based on the requirement profiles described by ZVEI, VDMA, or equivalent organizations.

Only electricians who are familiar with the content of all provided device documentation are authorized to install and maintain the devices described. These are persons who

- based on their technical training, knowledge, and experience, and their knowledge of the pertinent standards, can evaluate the work to be carried out and identify any potential risks or
- based on working for several years in a related sector, have the same level of knowledge as they would have from the relevant technical training.

Only Belden Deutschland GmbH– Lumberg Automation™ - is permitted to make changes to the hardware or software of the products that go beyond the scope of this manual.

Warning: Making unqualified changes to the hardware or software, or non-adherence to the warning information contained in this document, can result in serious personal injury or damage to equipment.

Attention: Belden Deutschland GmbH accepts no liability for any damage caused by unqualified personnel or improper use. This automatically voids the warranty.

2.3 FS certifications

The Functional Safety articles 0980 SSL 3131-121-007D-202 and 0980 SSL 3130-121-007D-202 are tested and certified by:

TÜV Rheinland Industrie Service GmbH

Am Grauen Stein

51105 Köln

Germany

The articles are certified according to the standards listed below:

Standard	Titel
IEC 61508, Parts 1-7:2010	Functional safety of electrical/electronic/ programmable electronic safety-related systems
EN ISO 13849-1:2015 EN ISO 13849-1:2023 (PL e, Category 4)	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design

2.4 Underlying technical standards

Standard	Titel
IEC 61131-2:2017	Programmable Controllers - Environmental requirements and tests
IEC 61010-2-201:2017	Safety requirements for electrical equipment for measurement, control and laboratory use
IEC 61131-9	IO-Link Interface and System V1.1.3

3 Designations and synonyms

AOI	Add-On Instruction
API	Application Programming Interface
BF	Bus Fault LED
Big Endian	Data format with High-B on first place (PROFINET and IO-Link)
BUI	Back-Up Inconsistency (EIP diagnostics)
CC	CC-Link IE Field
C/Q	I/O port pin 4 mode, IO-Link communication/switching signal
Ch. A	Channel A (Pin 4) of I/O port
Ch. B	Channel B (Pin 2) of I/O port
CIP	Common Industrial Protocol (media independent protocol)
CIP Safety™	Common Industrial Protocol for Safety applications, CIP Safety™ is a registered trademark of ODVA
Class A	IO-Link port specification (Class A)
Class B	IO-Link port specification (Class B)
CoAP	Constrained Application Protocol
CSP+	Control & Communication System Profile Plus
DAT	Device Acknowledgement Time
DCP	Discovery and Configuration Protocol
DevCom	Device Comunicating (EIP diagnostics)
DevErr	Device Error (EIP diagnostics)
DI	Digital Input
DIA	Diagnostic LED
DO	Digital Output
DIO	Digital Input/Output
DTO	Device Temperature Overrun (EIP diagnostics)
DUT	Device under test

EIP	EtherNet/IP™ is a registered trademark of ODVA
ERP	Enterprise Resource Planning system
ETH	ETHERNET
FE	Functional Earth
FME	Force Mode Enabled (EIP diagnostics)
FS	Functional Safety
FSU	Fast Start-Up
GSDML	General Station Description Markup Language
High-B	High-Byte
HTTPS	Hyper Text Transfer Protocol Secure
ICE	IO-Link port COM Error (EIP diagnostics)
ICT	Invalid Cycle Time (EIP diagnostics)
IDE	IO-Link port Device Error (EIP diagnostics)
IDN	IO-Link port Device Notification (EIP diagnostics)
IDW	IO-Link port Device Warning (EIP diagnostics)
IIoT	Industrial Internet of Things
ILE	Input process data Length Error (EIP diagnostics)
IME	Internal Module Error (EIP diagnostics)
I/O	Input / Output
I/O port	X1 .. X8
I/O port pin 2	Channel B of I/O ports
I/O port pin 4 (C/Q)	Channel A of I/O ports
IODD	I/O Device Description
IOL or IO-L	IO-Link
I/Q	I/O port pin 2 mode, Digital Input/switching signal
ISDU	Indexed Service Data Unit
IVE	IO-Link port Validation Error (EIP diagnostics)
I&M	Identification & Maintenance
JSON	JavaScript Object Notation (platform independent data format)
L+	I/O port pin 1, sensor power supply

LioN-X 60	LioN-X variants with a width of 60mm
Little Endian	Data format with Low-B on first place (EtherNet/IP)
LLDP	Link Layer Discovery Protocol
Low-B	Low-Byte
LSB	Least Significant Bit
LVA	Low Voltage Actuator Supply (EIP diagnostics)
LVS	Low Voltage System/Sensor Supply (EIP diagnostics)
MIB	Management Information Base
MP	Multi-protocol: PROFINET + EtherNet/IP + EtherCAT® + Modbus TCP (+ CC-Link IE Field Basic)
MQTT	Message Queuing Telemetry Transport (open networking protocol)
MSB	Most Significant Bit
M12	Metric thread according to DIN 13-1 with 12 mm diameter
NTP	Network Time Protocol
OFDT	One Fault Delay Time
OLE	Output process data Length Error (EIP diagnostics)
OPC UA	Open Platform Communications Unified Architecture (platform independent, service-oriented architecture)
PFH	Probability of dangerous Failure per Hour [h -1]
PD	Process Data
PDCT	Port and Device Configuration Tool
PLC	Programmable Logic Controller
PN	PROFINET
PWR	Power
Qualifier	Validity on a process value. Valid = "1"
REST	REpresentational State Transfer
RFC	Request for Comments
RPI	Requested Packet Interval
RWr	Word data input as seen from the master station (CC-Link)
RWw	Word data output as seen from the master station (CC-Link)
RX	Bit data input as seen from the master station (CC-Link)

RY	Bit data output as seen from the master station (CC-Link)
SCA	Short Circuit Actuator/U_L/U_{AUX} (EIP diagnostics)
SCS	Short Circuit Sensor (EIP diagnostics)
SFRT	Safety Function Response Time
SIO mode	Standard Input Output mode
SLMP	Seamless Message Protocol
SNMP	Simple Network Management Protocol
SP	Single Protocol (PROFINET, EtherNet/IP, EtherCAT®, Modbus TCP or CC-Link IE Field Basic)
SPE	Startup Parameterization Error (EIP diagnostics)
T-B	Test Channel B
T-A	Test Channel A
U_{AUX}	$U_{Auxiliary}$, supply voltage for the load circuit (Actuator supply on Class B ports of Class A/B IO-Link Master)
UDP	User Datagram Protocol
UDT	User-Defined Data Types
UINT8	Byte in PLC (IB, QB)
UINT16	Unsigned integer with 16 bits or word in PLC (IW, QW)
U_L	U_{Load}, supply voltage for the load circuit (Actuator supply on Class A IO-Link-Master)
UL	Underwriters Laboratories Inc. (certification company)
UTC	Coordinated Universal Time (Temps Universel Coordonné)
WCDT	Worst Case Delay Time

Table 2: Designations and synonyms

4 System description

The LioN modules (Lumberg Automation™ Input Output Network) function as the interface in an industrial Ethernet system: A central controller on the management level is able to communicate with the decentralized sensors and actuators on the field level. The line or ring topologies for which LioN modules can be used ensure not only reliable data communication but also significantly reduce the number of cables required and thus also the costs for installation and maintenance. They additionally enable easy and quick extension.

4.1 About LioN-Safety

LioN variants with Functional Safety (FS) communicate via

- PROFIsafe: a certified protocol for safe PROFINET communication according to IEC 61784-3.
- CIP Safety: a certified protocol for safe EtherNet/IP communication according to IEC 61784-3.

4.2 Device variants

The following CIP Safety variants are available within the LioN-Safety family:

Article number	Product designation	Description	I/O port functionality
935023001	0980 SSL 3131-121-007D-202	LioN-Safety M12-60 mm, FS Mixmodule EtherNet/IP / CIP Safety Safety function up to SIL3, PL e, Cat 4	8/4 x F-DI + 4 x F-DO, 2 x IO-Link Class A
935023005	0980 SSL 3130-121-007D-202	LioN-Safety M12-60 mm, FS 16DI Module EtherNet/IP / CIP Safety Safety function up to SIL3, PL e, Cat 4	16/8 x F-DI

Table 3: Overview of LioN-Safety variants

4.3 I/O port overview

The following tables show the main I/O port differences of the LioN-Safety family. Pin 4 and Pin 2 of the I/O ports can be configured partly to IO-Link, Digital Input or Digital Output. The Functional Safety I/O ports in the following tables are highlighted in red:

LioN-Safety Mixmodule

Device variant	Port	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5
0980 SSL 3131...	**X8:**	U_S (4 A by U_S)	DI/DO (2 A)	GND U_S	IO-Link/DI/DO (2 A by U_S)	n.c.
	X7:	U_S (4 A by U_S)	DI/DO (2 A by U_S)	GND U_S	IO-Link/DI/DO (2 A by U_S)	n.c.
	X6:	GND-U_L-T-A	DO-B (2 A by U_L)	GND U_L	DO-A (2 A by U_L)	GND-U_L-T-B
	X5:	GND-U_L-T-A	DO-B (2 A by U_L)	GND U_L	DO-A (2 A by U_L)	GND-U_L-T-B
	X4:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X3:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X2:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X1:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*

Table 4: Port configuration of 0980 SSL 3131... variant

*) Permissible max. current per each port is 1.5 A in total after summed up U_S-T-A and U_S-T-B.

LioN-Safety 16DI Module

Device variant	Port	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5
0980 SSL 3130...	**X8:**	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X7:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X6:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X5:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X4:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X3:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X2:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*
	X1:	U_S-T-A (1.5 A by U_S)*	DI-B	GND U_S	DI-A	U_S-T-B (1.5 A by U_S)*

Table 5: Port configuration of 0980 SSL 3130... variant

*) Permissible max. current per each port is 1.5 A in total after summed up U_S-T-A and U_S-T-B.

5 Overview of product features

5.1 EtherNet/IP / CIP Safety product features

Data connection

The connection option provided by LioN-Safety is the widely-used M12 connector with D-coding for the EtherNet/IP network.

The connectors are also color-coded to prevent the ports from being mixed up.

Data transmission rates

Featuring a transmission rate of up to 10/100 MBit/s, the EtherNet/IP devices can handle both fast transmission of I/O data and transmission of larger volumes of data.

EtherNet/IP Adapter Device

The LioN-Safety family supports the EtherNet/IP protocol. This allows the transmission of time sensitive process data between network components in real-time communication.

ODVA CIP specification V3.34

The LioN-Safety family complies with ODVA CIP specification V3.34.

ODVA CIP Safety™ specification V2.25

The LioN-Safety family complies with ODVA CIP Safety™ specification V2.25.

Integrated switch

The integrated Ethernet switch has two EtherNet/IP ports and thus supports the establishment of a line or ring topology for the EtherNet/IP network.

DHCP/BOOTP

The supported Dynamic Host Configuration Protocol (DHCP) and the Bootstrap Protocol (BOOTP) provide mechanisms for automatic obtaining of an IP address from a server managing the devices.

Device Level Ring

The additionally implemented Device Level Ring (DLR) enables the design of a highly available network infrastructure of up to 50 DLR ring nodes. If a connection is interrupted, the LioN-Safety devices immediately switch to an alternative ring segment and thus ensure interruption-free operation. These DLR ring nodes are “beacon-based” according to the EtherNet/IP specification.

SNMP

The SNMPv1 protocol handles network component monitoring and communication between the master and device.

Diagnostic data

The devices support diagnosis flags and extended diagnostic data that can be appended to the I/O data.

EDS-based configuration and parameterization of the I/O ports

The EDS offers the option of configuring and parameterizing the I/O ports on the master devices.

5.2 I/O port features

IO-Link specification.

LioN-Safety variants with 2 IO-Link ports support IO-Link specification v1.1.3.

2 x IO-Link Master ports

For the LioN-Safety Mixmodule variant (0980 SSL 3031-...), there are 2 IO-Link Class A ports with additional digital inputs and outputs available. For detailed information see chapter I/O port overview on page 23.

Warning: If devices with electric isolation and devices without electric isolation are used within the same system, the electric isolation of all connected devices is annulled.

IO-Link port connections

The IO-Link port connection option provided by the device series is the 5-pin M12 connector (Pin 5 not used at IO-Link Class A ports).

Validation & Backup

The Validation & Backup function checks if the right device is connected and stores the parameters of the IO-Link Device. The function thus gives you an easy option for replacing the IO-Link Device.

This is possible as of IO-Link specification V1.1 and only if the IO-Link Device **and** the IO-Link Master support the function.

IO-Link Device parameterization

IO-Link Device parameterization in EtherNet/IP via vendor specific IO-Link Device parameter object class and Read/Write ISDU services.

LED

You can see the status of a port by the color of the matching LEDs and their flash pattern. For details on the meanings of the LED colors, please see section LEDs on page 302.

5.3 Integrated Web server

Network parameter display

Get an overview of network parameters such as the IP address, subnet mask and gateway.

Displaying diagnostics

View diagnostics via the integrated Web server.

User management

Use the integrated Web server for convenient management of all users.

IO-Link Device parameters

You can read the parameters of the IO-Link Device and write new parameters to the IO-Link Device in single-write mode (single-write mode does not activate the automatic mechanism of the *Validation and Backup* function).

5.4 Security features

Firmware signature

The official firmware update packages contain a signature which helps prevent the system against manipulated firmware updates.

Syslog

The LioN-Safety variants support the traceability of messages centrally managed and logged via Syslog.

User manager

The Web server provides a user manager to help protect the Web interface against unauthorized access. You can manage the allowed users by the different access levels “Admin” or “Write”.

Default user settings:

User: admin

Password: private

Attention: Change the default settings to help protect the device against unauthorized access.

5.5 Other features

Interface protection

The devices have reverse polarity, short-circuit and overload protection for all interfaces.

For more details, see section Port assignments on page 35.

Failsafe

The devices support a failsafe function for non-safe I/Os of the 2-port IO-Link Master of module 0980 SSL 3131-121-007D-202. This allows you to define the behavior of every single channel configured as an output in the case of invalid PLC data (e.g. PLC in STOP) or of lost PLC communication.

Industrial Internet of Things

LioN-Safety is industry 4.0 ready and supports the integration in IIoT networks via REST API and the IIoT-relevant protocols MQTT, OPC UA and CoAP for module 0980 SSL 3131-121-007D-202.

Color-coded connectors

The colored connectors help you avoid confusion in your cabling.

IP protection classes: IP65 / IP67 / IP69K

The IP protection class describes environmental influences that the devices can be exposed to without risk and without suffering damage or causing a risk for the user.

The whole LioN-Safety family offers IP65, IP67 and IP69K.

6 Assembly and wiring

6.1 General information

Mount the device on a flat surface using 2 screws (M4x 25/30). The torque required here is 1 Nm. Use washers for all fastening methods as per DIN 125.

Attention: The devices have a ground connection with an M4 thread for the conduction of interference currents and the EMC immunity. This is labeled with the symbol for the ground and the designation "FE".

Attention: Use a low-impedance connection to connect the device to the reference ground. When using a grounded mounting surface, you can make the connection directly via the fixing screws.

Attention: If the mounting surface is ground-free, use a ground strap or a suitable FE line (FE = Functional Earth). Use an M4 screw to connect the ground strap or the FE line to the ground point and if possible put a washer and a toothed washer below the fixing screw.

6.2 Outer dimensions

6.2.1 LioN-Safety Mixmodule

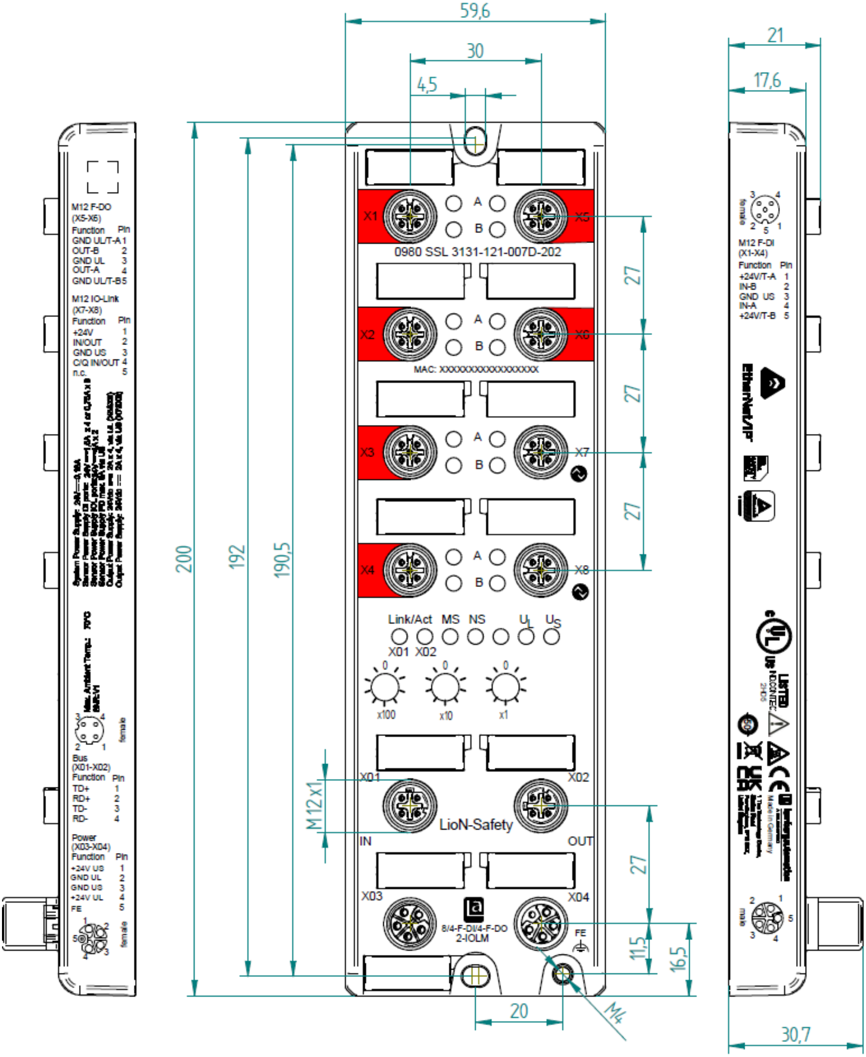


Figure 1: 0980 SSL 3131-121-007D-202

6.2.2 LioN-Safety 16DI variant

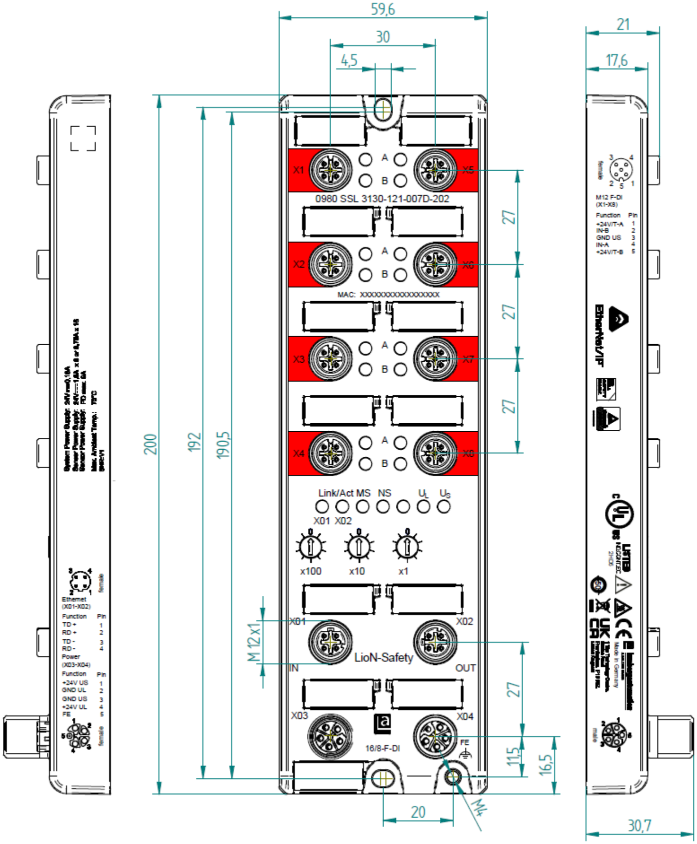


Figure 2: 0980 SSL 3130-121-007D-202

6.2.3 Notifications

Attention:

For **UL applications**: Exclusively use a UL-certified cable with a suitable evaluation to connect the devices (CYJV or PVVA). To program the control, please refer to the OEM information, and only use suitable accessories.

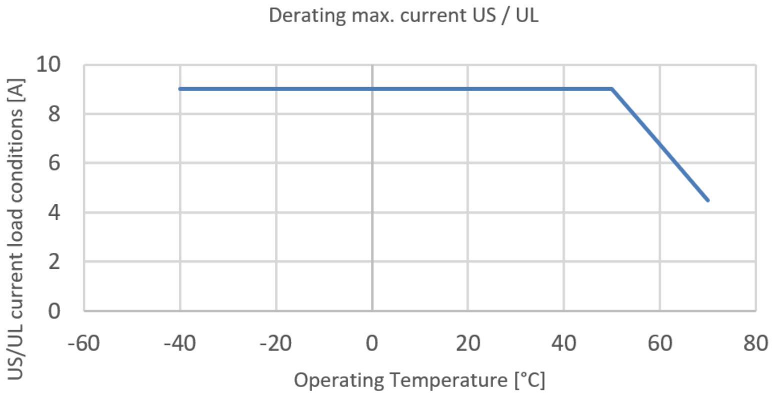
Only approved for interior use. Please note the maximum elevation of +3000 m ASL (+9842 ft ASL) (with derating). Approved up to a maximum soiling level of 2.

Warning: Terminals, housings field-wired terminal boxes or components can exceed temperatures of +60 °C (140 °F).

Warning: For **UL applications**: Use temperature-resistant cables with heat resistance up to at least +125 °C (257 °F) for every LioN-Safety variant.

Warning: Observe the following maximum output power for the sensor supply of the devices:

Max. 4.0 A per port; for **UL applications** max. 5.0 A in total for port pair X7/X8 and max. 9.0 A in total (with derating) for the whole port group X1 .. X8.



6.3 Port assignments

All the contact arrangements shown in this chapter show the frontal view of the connection area for the connectors.

6.3.1 Ethernet ports, M12 socket, 4-pin, D-coded

Color coding: green

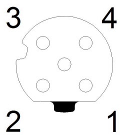


Figure 3: Schematic drawing, ports X01, X02

Port	Pin	Signal	Function
Ethernet Ports X01, X02	1	TD+	Transmit data plus
	2	RD+	Receive data plus
	3	TD-	Transmit data minus
	4	RD-	Receive data minus

Table 6: Assignment of ports X01, X02

Caution: Risk of destruction! Never connect the power supply to the data cables.

6.3.2 Power supply with M12 power L-coded

Color coding: gray

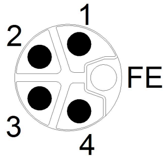


Figure 4: Schematic diagram of the M12 L-coding (connector X03 for Power In)

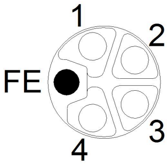


Figure 5: Schematic diagram of the M12 L-coding (socket X04 for Power Out)

Power supply	Pin	Signal	Function
	1	U_S (+24 V)	Sensor/system power supply
	2	GND_U_L	Ground/reference potential U_L
	3	GND_U_S	Ground/reference potential U_S
	4	U_L (+24 V)	Actuator power supply
	5	FE	Functional ground

Table 7: Power supply with M12 L-coding

Attention: Only use power supply units for the system/sensor and actuator supply that correspond to PELV (Protective Extra Low Voltage) or SELV (Safety Extra Low Voltage). Power supplies according to EN 61558-2-6 (transformers) or EN 60950-1 (switching power supply units) fulfill these requirements.

6.3.3 I/O ports as M12 sockets

Color	Port
Black	Non-Functional-Safety-Ports
Red	Functional-Safety-Ports

Table 8: Color coding I/O ports M12

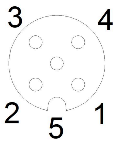


Figure 6: Schematic drawing I/O port as M12 socket IO-Link

0980 XSL 3131-121...	Pin	Signal	Function
FS DI ports X1 .. X4	1	+24 V T-A	Sensor power supply +24 V (A)
	2	IN-B	Ch. B: Digital input
	3	GND U_S	Ground/reference potential U_S
	4	IN-A	Ch. A: Digital input
	5	+24 V T-B	Sensor power supply +24 V (B)
FS DO ports X5 .. X6	1	GND U_L T-A	Reference potential U_L with test function (A)
	2	OUT-B	Ch. B: Digital output
	3	GND U_L	Ground/reference potential U_L
	4	OUT-A	Ch. A: Digital output
	5	GND U_L T-B	Reference potential U_L with test function (B)
IO-Link Class A ports X7 .. X8	1	+24 V	Sensor power supply +24 V
	2	IN/OUT	Ch. B: Digital input or digital output
	3	GND U_S	Ground/reference potential U_S
	4	C/Q IN/OUT	Ch. A: IO-Link data communication, digital input or digital output
	5	n.c.	not connected

0980 XSL 3130-121...	Pin	Signal	Function
FS DI ports X1 .. X8	1	+24 V T-A	Sensor power supply +24 V (A)
	2	IN-B	Ch. B: Digital input
	3	GND U_S	Ground/reference potential U_S
	4	IN-A	Ch. A: Digital input
	5	+24 V T-B	Sensor power supply +24 V (B)

Table 9: I/O port assignment

7 Starting operation

7.1 EDS file

An EDS file describes the EtherNet/IP device and can be installed in the engineering tool for the configuration of the LioN-Safety device. Each of the LioN-Safety variants requires its own EDS file. The file can be downloaded from the product pages on our online catalog: https://catalog.belden.com

On request, the EDS file is also sent to you by the support team.

The EDS files are grouped together in an archive file named **EDS-V3.34.1-BeldenDeutschland-LioN-Safety-yyyymmdd.eds**.

yyyymmdd stands for the date on which the file was issued.

Download this file and unpack it.

Install the EDS file for the respective device variant by using the hardware or network configuration tool of your controller manufacturer.

In Rockwell Automation Studio 5000®, install the files with the *EDS Hardware Installation Tool*.

The LioN-Safety variants are then available in the hardware catalog as *Communications Adapter*.

7.2 MAC addresses

Every device has three unique assigned MAC addresses that cannot be changed by the user. The first assigned MAC address is printed onto the device.

7.3 State on delivery

EtherNet/IP / CIP Safety parameters in state on delivery or after a factory reset:

Network mode:	DHCP
Static IP address:	192.168.1.XXX (XXX = rotary switch position or last stored data)
Subnet mask:	255.255.255.0
Gateway address	0.0.0.0
Device designations:	0980 SSL 3131-121-007D-202 0980 SSL 3130-121-007D-202
Vendor code:	21
Product type:	35 (Safety Discrete I/O Device)

7.4 Setting network parameters

There are multiple ways to configure the network parameters. By default, DHCP is enabled and the network parameters are requested by DHCP requests to a server. If you want to request the network parameters with BOOTP requests, you must activate the BOOTP function through the Web interface or the TCP/IP interface object (CIP Class ID 0xF5, attribute 3 (0x03)). It is also possible to set static network parameters via this CIP object.

7.4.1 IP address for LioN-Safety variants

The LioN-Safety variants support IP address configuration via the three rotary encoding switches on the front of the device (see chapter Setting the rotary encoding switches on page 41). The network parameters are also settable via the Web interface or the IIoT protocols.

Attention: If the TUNID is already set in the LioN-Safety module, the IP address must match the NodeID of the stored TUNID. Otherwise, safety communication cannot be established and the device is in an aborted state. In the event of a mismatch, a factory reset must be performed and a new TUNID must be set.

7.5 Setting the rotary encoding switches

Using rotary encoding switches at the lower front of the devices, you can easily and conveniently set the address of the device.

The LioN-Safety devices have a total of three rotary encoding switches. With the first rotary encoding switch (x100) you set the third last digit of the IP address for EIP.

With the other rotary encoding switches (x10 / x1), you set the last two digits of the IP address when you are using EtherNet/IP.

Protocol	x100	x10	x1
EtherNet/IP	0-2	0-9	0-9

Table 10: Assignment of the rotary encoding switches for EtherNet/IP

In delivery state no IP address settings are stored in the device. In this case a DHCP client is activated. To take over a changed rotary encoding switch setting (IP setting), a “Reset” from the Web interface is necessary.

Once you have set the IP address using the rotary encoding switches, the device stores this setting when it starts in cyclic communication. Changing the IP address using the rotary encoding switch is no longer possible after this point. The device will always start using the stored address from that point on.

To change the user defined IP address, carry out a factory reset. In this way you restore the factory settings of the respective device. How you perform the factory reset for your device is described in chapter Factory reset on page 44.

If you position the rotary encoding switch in a manner that is invalid, the device signals this to you with a blink code (the MS and NS LEDs blink in red three times).

7.5.1 EtherNet/IP selection and IP configuration via rotary encoding switches

The EtherNet/IP protocol can be selected by the first rotary encoding switch (x100) with a value between 0 – 2.

Use all three rotary encoding switches on the front of the device to set the last octet of the static IP address. The first three octets of the IP address are set by default to 192.168.1.

Each rotary encoding switch in the EtherNet/IP setting is assigned to one decimal digit, so that you can configure a number between 0 – 299. During start-up, the position of the rotary encoding switches is typically read within one time cycle.

For example, the rotary encoding switch setting 2 (x100), 1 (x10) and 0 (x1) is interpreted by default as the IP address 192.168.1.210.

Rotary encoding switch setting	Function
000 (state on delivery, default setting)	On delivery, the DHCP function is enabled. The network parameters are requested by DHCP requests to a server. If you want to request the network parameters with BOOTP requests, you must activate the BOOTP function through the Web server or the TCP/IP interface object (CIP Class ID 0xF5, attribute 3 (0x03)). The network parameters are not saved automatically, but the integrated Web server can be used to save them.
000 (network parameters already saved)	The network parameters last saved are used (IP address, subnet mask, gateway address, DHCP on/off, BOOTP on/off).
001 .. 254	The last 3 digits of the saved or preset IP address are overwritten by the setting of the rotary encoding switches. DHCP or BOOTP are disabled if necessary, and the device will start up with a static IP address.
255	Not usable (reserved)
256 .. 299	The factory default setting of the IP address (192.168.001.001) is used.
979	The device performs a reset to the factory settings. The network parameters are also reset to the default values. Communication is not possible in this operation mode.

Table 11: Setting options of the rotary encoding switches for EtherNet/IP

7.5.2 Factory reset

A factory reset restores the original factory settings and thus resets the changes and settings you have made up to that point. It also resets the protocol selection. To perform a factory reset, set the first rotary encoding switch (x100) to 9, the second (x10) to 7, and the third (x1) also to 9.

Afterwards perform a power cycle and wait 10 seconds due to internal memory write processes.

During the factory reset, the U_S LED is blinking red. After the internal memory write processes have finished, the U_S LED returns to display static green or red light, in dependency of the actual U_S voltage.

	x100	x10	x1
Factory Reset	9	7	9

Follow the steps from section Setting the rotary encoding switches on page 41 again to select a new protocol.

For performing a factory reset via software configuration, see chapter OPC UA configuration on page 241 and the configuration section.

8 Configuration EtherNet/IP

The devices support *Implicit Messaging* and *Explicit Messaging* for the EthetNet/IP communication. I/O process data is transferred cyclically via the assembly object connection using *Implicit Messaging*.

Non-critical low priority data, configuration settings and diagnostic data can be exchanged via acyclic messages using *Explicit Messaging*. The exchange is done via EtherNet/IP and vendor specific object classes. For more details on object classes, see chapter CIP object classes on page 168.

8.1 Non-safe assembly types

The LioN-Safety devices support different non-safe assembly types which are defined as follows:

Assembly ID	Assembly Name	Size	Payload
130	IO-Link Output Connection Point Assembly (for Mixmodule only)	0 .. 68 Byte	Consuming IO-Link Data Image
131	IO-Link Input Connection Point Assembly (for Mixmodule only)	0 .. 122 Byte	Producing IO-Link Data Image
132	Safety Input and Diagnostic	18 Byte	Producing Input and Diagnostic Image of safety submodule
145	IO-Link Configuration Assembly (for Mixmodule only)	0 or 400 Byte	Module Configuration IO-Link Data
146	IO-Link Configuration Assembly (for Mixmodule only)	0 or 300 Byte	Module Configuration IO-Link Data (Omron)
147	IO-Link Configuration Assembly (for Mixmodule only)	0 or 210 Byte	Module Configuration Data (Min)

The *Consuming Data Image* and the *Producing Data Image* have dynamic sizes which depend on the complete input and output data size of all connected IO-Link devices and on additional input status information. The general input and output process data sizes of each connection can be configured in the engineering tool. Each IO-Link Device process data size can be configured by the *Module Configuration Data*.

The contents of the *Consuming Data Image* and the *Producing Data Image* are specified in chapter Non-Safe Process data assignment on page 88.

The *Module Configuration Data* is defined in chapter IO-Link Configuration parameters on page 53.

8.2 Safety assembly types

The LioN-Safety devices support different Safety assembly types which are defined as follows:

Assembly ID	Assembly Name	Size	Payload
134	Safety Output Connection Point Assembly (for Mixmodule only)	2 Byte	Consuming Safety Data Image
135	Safety Input Connection Point Assembly	4 Byte	Producing Safety Data Image
150	Safety Configuration Assembly	32 Byte	Safety Configuration Data
194	Safety Null Connection Point	0 Byte	No payload Data

The *Consuming Safety Data Image* and the *Producing Safety Data Image* have fixed sizes. The contents of these images are specified in chapter Safety Process data assignment on page 107. The *Safety Null Connection Point* has to be used for the opposite direction of each safety connection and supports "no payload data".

The *Safety Configuration Data* is defined in chapter Safety Configuration parameters on page 81.

8.3 Non-safe connections

The LioN-Safety devices support three different non-safe connection types which are defined as follows:

Connect-ion name	Connect-ion type	Output connect-ion point assembly	Output data size	Input connect-ion point assembly	Input data size	Configu-ration assembly	Configu-ration data size
IO-Link (Exclusive Owner)	Exclusive Owner	130	0..68 Byte	131	0..122 Byte	145	0 or 400 Byte
IO-Link (Listen Only)	Listen Only	192	0 Byte	131	0..122 Byte	n/a	0 Byte
IO-Link Omron (Exclusive Owner)	Exclusive Owner	130	0..68 Byte	131	0..122 Byte	146	0 or 300 Byte
IO-Link Min (Exclusive Owner)	Exclusive Owner	130	0..68 Byte	131	0..122 Byte	147	0 or 210 Byte
Input and Diagnostic (Input Only)	Input Only	193	0 Byte	131	18 Byte	n/a	0 Byte

The dynamic data sizes depend on the complete input and output data size of all connected IO-Link devices and additional input status information. The general input and output process data sizes of each connection can be configured in the engineering tool. Each IO-Link device process data size can be configured by the *Module Configuration Data*.

Some engineering tools require the immediate configuration of the connection parameters. For the configuration use the parameters listed in the following chapters.

8.3.1 IO-Link parameters (Exclusive Owner)

Connection properties	
Connection name	IO-Link (Exclusive Owner)
Application type	Exclusive Owner
Trigger mode	Cyclic
RPI	min. 1 ms

Connection parameters (O->T)	
Real time transfer format	32 Bit Run/Idle Header
Connection type	POINT2POINT
Assembly ID	130
Data size	0..68 Byte
Data type	INT (2 Byte)

Connection parameters (T->O)	
Real time transfer format	Pure data and modeless
Connection type	MULTICAST, POINT2POINT
Assembly ID	131
Data size	0..122 Byte
Data type	INT (2 Byte)

8.3.2 IO-Link parameters (Listen Only)

Connection properties	
Connection name	IO-Link (Listen Only)
Application type	Listen Only
Trigger mode	Cyclic
RPI	min. 1 ms

Connection parameters (O->T)	
Real time transfer format	Heartbeat
Connection type	POINT2POINT
Assembly ID	192
Data size	0 Byte
Data type	INT (2 Byte)

Connection parameters (T->O)	
Real time transfer format	Pure data and modeless
Connection type	MULTICAST
Assembly ID	131
Data size	0..122 Byte
Data type	INT (2 Byte)

8.3.3 Input and diagnostic parameters (Input Only)

Connection properties	
Connection name	Input and Diagnostic (Input Only)
Application type	Input Only
Trigger mode	Cyclic
RPI	min. 1 ms

Connection parameters (O->T)	
Real time transfer format	Heartbeat
Connection type	POINT2POINT
Assembly ID	193
Data size	0 Byte
Data type	INT (2 Byte)

Connection parameters (T->O)	
Real time transfer format	Pure data and modeless
Connection type	MULTICAST, POINT2POINT
Assembly ID	132
Data size	18 Byte
Data type	INT (2 Byte)

8.4 Safety connections

The LioN-Safety devices support two different Safety connection types which are defined as follows:

Connect-ion name	Connect-ion type	Output connect-ion point assembly	Output data size	Input connect-ion point assembly	Input data size	Configu-ration assembly	Configu-ration data size
Safety Output (for Mixmodule only)	Consumer (Server)	134	2 Byte	194	0 Byte	150	32 Byte
Safety Input	Producer (Client)	194	0	135	4 Byte	150	32 Byte

8.4.1 Safety Output connection parameters

Connection properties	
Connection name	Safety Output
Application type	Consumer (Server)
Trigger mode	Application
RPI	min. 16 ms

Connection parameters (O->T)	
Real time transfer format	Safety
Connection type	POINT2POINT
Assembly ID	134
Data size	2 Byte
Data type	INT (2 Byte)

Connection parameters (T->O)	
Real time transfer format	Safety
Connection type	POINT2POINT
Assembly ID	194
Data size	0 Byte
Data type	No data

8.4.2 Safety Input connection parameters

Connection properties	
Connection name	Safety Input
Application type	Producer (Client)
Trigger mode	Application
RPI	min. 16 ms

Connection parameters (O->T)	
Real time transfer format	Safety
Connection type	POINT2POINT
Assembly ID	194
Data size	0 Byte
Data type	No data

Connection parameters (T->O)	
Real time transfer format	Safety
Connection type	POINT2POINT
Assembly ID	135
Data size	4 Byte
Data type	INT (2 Byte)

9 IO-Link Configuration parameters

Parameters of the LioN-Safety device can be configured via the configuration assembly, CIP object classes, Web server or IIoT protocols. A configuration assembly is sent when an *Exclusive Owner* connection is established. They are optional in this assembly. However, when sending, all existing parameters will be overwritten by this data. Therefore, the content of the configuration assembly has the highest valence.

To avoid parameter overwriting by CIP object classes, Web server or IIoT protocols during operation, some lock parameters can be enabled in the PLC configuration respectively configuration assembly.

The following chapters represent different setting groups with its configuration parameters. They are ingredients of the configuration assembly and can be set via *Explicit Messaging* by the specified CIP object classes. The **default values** are highlighted.

9.1 General settings

Configuration parameter	Byte offset config. assembly			Data type	Valid values	CIP object class 0xA0, Instance 1
	145	**146**	**147**			
Force Mode Lock	1	0	–	SINT	**0: Disable** 1: Enable	Attribute 2
Web Interface Lock	2	1	–	SINT	**0: Disable** 1: Enable	Attribute 3
Report U_L/ U_{AUX} Supply Voltage Fault	4	3	–	SINT	0: Disable **1: Enable**	Attribute 5
Report DO Fault without U_S	5	4	–	SINT	0: Disable **1: Enable**	Attribute 6
CIP object configuration lock	24	5	–	SINT	**0: Disable** 1: Enable	Attribute 25
External configuration lock	25	6	–	SINT	0: Disable **1: Enable**	Attribute 26
IO Mapping Mode	31	7	–	SINT	**0: Default Assignment** 1: Byte Swap 2: LSB Ch.A - MSB Ch.B 3: LSB Ch.B - MSB Ch.A 4: Free I/O Mapping	Attribute 32
General Settings	–	–	4	SINT	-128 .. 127 **(0)**	–

9.1.1 Force mode lock

The input and output process data can be forced via different interfaces (e.g. Web interface, REST, OPC UA, MQTT). The support of interfaces depends on the available software features. If the *Force mode lock* is enabled, it is no longer possible to force input and output process data through these interfaces.

Danger: Risk of physical injury or death! Unattended forcing can lead to unexpected signals and uncontrolled machine movements.

9.1.2 Web interface lock

The Web interface access can be configured. If *Web interface lock* is enabled, the Web pages are no longer reachable.

9.1.3 Report U_L/U_{AUX} supply voltage fault

During commissioning, it is possible that no power supply is connected to the U_L/U_{AUX} pins. Therefore it can be helpful to suppress and disable the *U_L/U_{AUX} supply voltage fault* diagnosis.

9.1.4 Report DO Fault without U_S

With this parameter you suppress the actuator diagnosis message that is sent if the U_S supply is not in range while the output data of a digital channel is controlled.

9.1.5 CIP object configuration lock

When there is no *Exclusive Owner* connection established, all configuration parameters can be set by vendor specific CIP object classes. To exclude parameter changes the setting function of these objects can be blocked.

When the *CIP object* configuration lock is enabled, the vendor specific configuration parameters cannot be set via the CIP services. This relates also to the *CIP object* configuration lock itself. A reset of this parameter can be done by a configuration assembly when an *Exclusive Owner* connection is established.

9.1.6 External configuration lock

Configuration parameters can be set via different alternative interfaces (e.g. Web interface, REST, OPC UA, MQTT). An external configuration can only be done, if no cyclic PLC connection is active. Every new PLC configuration overwrites the external configuration settings.

9.1.7 IO Mapping Mode

The LioN-Safety devices support 5 different I/O mapping modes for the *Digital Output Channel Control* and the *Input Channel Status*. Modes 0 to 3 are pre-defined bit mappings. Mode 4 is a free user defined mapping which can be used in conjunction with the I/O mapping of channel 1 .. 16 in the channel settings.

Default Assignment (Mode 0):

DO Ch. Control / DI Ch. Status	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0 (LSB)	X4B	X4A	X3B	X3A	X2B	X2A	X1B	X1A
Byte 1 (MSB)	X8B	X8A	X7B	X7A	X6B	X6A	X5B	X5A

Byte Swap (Mode 1):

DO Ch. Control / DI Ch. Status	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0 (LSB)	X8B	X8A	X7B	X7A	X6B	X6A	X5B	X5A
Byte 1 (MSB)	X4B	X4A	X3B	X3A	X2B	X2A	X1B	X1A

LSB Ch.A - MSB Ch.B (Mode 2):

DO Ch. Control / DI Ch. Status	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0 (LSB)	X8A	X7A	X6A	X5A	X4A	X3A	X2A	X1A
Byte 1 (MSB)	X8B	X7B	X6B	X5B	X4B	X3B	X2B	X1B

LSB Ch.B - MSB Ch.A (Mode 3):

DO Ch. Control / DI Ch. Status	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0 (LSB)	X8B	X7B	X6B	X5B	X4B	X3B	X2B	X1B
Byte 1 (MSB)	X8A	X7A	X6A	X5A	X4A	X3A	X2A	X1A

Free IO Mapping (Mode 4):

IO Mapping Channel 1 .. 16 is used (see chapter Channel settings on page 58).

9.2 Channel settings

Configuration parameter	Byte offset config. assembly			Data type	Valid values	CIP object class 0xA1, Instance 1 .. 16
	145	146	147			
IO Mapping (Ch1 .. 16)	32	8	–	SINT[16]	**0 .. 15**: Bit number of 16 channel process data 16: Inactive	Attribute 1
DO Surveillance Timeout (Ch13 .. 16)	72	–	–	INT[4]	0 .. 255 **(80)**	Attribute 2
DO Surveillance Timeout Omron (Ch13 .. 16)	–	24	–	USINT[4]	0 .. 255 **(80)**	–
DO Failsafe (Ch13 .. 16)	92	40	–	SINT[4]	**0: Set Low** 1: Set High 2: Hold Last	Attribute 3
DO Restart Mode (Ch13 .. 16)	108	56	–	SINT[4]	0: Disable **1: Enable**	Attribute 4
DO Switch Mode (Ch13 .. 16)	124	72	–	SINT[4]	0: Push-Pull (U_S, 0.5 A) 1: High-Side (U_S, 0.5 A) 2: High-Side (U_S, 1.0 A) 3: High-Side (U_S, 1.5 A) 4: High-Side (U_S, 2.0 A) **5: High-Side (U_S, 2.0 A max)**	Attribute 5
DI Logic (Ch13 .. 16)	140	88	–	SINT[4]	**0: Normally Open** 1: Normally Close	Attribute 6
DI Filter (Ch13 .. 16)	156	104	–	SINT[4]	0: Disabled 1: 1 ms 2: 2 ms **3: 3 ms** 4: 6 ms 5: 10 ms 6: 15 ms	Attribute 7
DI Latch	160	–	–	INT	-32768 .. 32767 **(0)**	–

Configuration parameter	Byte offset config. assembly			Data type	Valid values	CIP object class 0xA1, Instance 1 .. 16
	145	146	147			
DI Extension	176	–	–	DINT	-2147483648 .. 2147483647 **(0)**	–
Channel Mode (Ch13 .. 16)	204	120	–	SINT[4]	0: Inactive 1: Digital Output 2: Digital Input 3: IO-Link **The supported Channel Mode and the default value depend on the device variant.**	Attribute 10
Port mode for Channel A (Pin 4)	–	–	0	INT	-32768 .. 32767 **(0)**	–
Port mode for Channel B (Pin 2)	–	–	2	INT	-32768 .. 32767 **(0)**	–

Assignment of channels:

Channel 1	Port X1.ChA	CIP object instance 1
Channel 2	Port X1.ChB	CIP object instance 2
[…]	[…]	[…]
Channel 15	Port X8.ChA	CIP object instance 15
Channel 16	Port X8.ChB	CIP object instance 16

9.2.1 IO Mapping (Ch1 .. 16)

These configuration parameters can be used to set a user defined IO mapping. It is valid for the input and output data direction. Duplicated assignment are not allowed. In case of an inconsistent mapping, the complete assembly configuration is rejected with an error code.

To use these parameters, it is required to configure the IO mapping mode of the *General settings* to *Free IO Mapping (Mode 4)*. The default value for each parameter is its own channel number.

9.2.2 DO Surveillance Timeout (Ch13 .. 16)

The digital output channels are monitored during runtime. The error states are detected and reported as a diagnosis. To avoid error states during the switching of output channels, the surveillance timeout can be configured as a delay with deactivated monitoring.

The delay time begins with a rising edge of the output control bit. After delay time has elapsed, the output is monitored and error states are reported by diagnosis. When the channel is permanently switched on or off, the typical filter value (not changeable) is 5 ms.

9.2.3 DO Failsafe (Ch13 .. 16)

The LioN-Safety devices support a failsafe function for the channels used as digital outputs. In case of an internal device error, the PLC is in STOP state and cannot provide valid process data. The connection is interrupted or the communication is lost. The outputs are controlled according to the configured failsafe values.

Set Low:

If failsafe is active, the physical output pin of the channel is set to low ("0").

Set High:

If failsafe is active, the physical output pin of the channel is set to high ("1").

Hold Last:

If failsafe is active, the physical output pin of the channel holds the last valid process data state ("0" or "1").

9.2.4 DO Restart Mode (Ch13 .. 16)

In case of a short circuit or overload at an output channel, a diagnosis is reported and the output is switched to "off".

If the *DO Restart Mode* for this channel is enabled, the output will automatically be turned on again after a fix time delay for checking if the overload or short circuit condition is still active. When it is active, the channel is switched off again.

If the *DO Restart Mode* is disabled, the output channel is not automatically turned on again. It can be turned on after a logical reset of the process output data of the channel.

9.2.5 DO Switch Mode (Ch13 .. 16)

With this parameter you can configure the current limitations for the digital outputs by selecting a DO Switch Mode. You can choose between two different output switch modes:

- Push-Pull (U_S,0.5 A):

  If a channel is set to "Push-Pull", the output will be switched active to high or low. In low state, the output can be a current sink. The digital output is supplied by U_S with a maximum current of *0.5 A*. This option is not available for the channel B of any port.

- High-Side (U_S, 0.5 A..2.0 A max):

  If a channel is set to "High-Side", the output will be switched active to high but not to low. In low state, the output has a high impedance. The digital output is supplied by U_S. Depending on the device variant, and has a selectable current limit. This means that the actuator channel error diagnosis is reported when this limit is exceeded. If the you set the level to *2.0 A Max.*, the current limitation is not active and the maximum output current is available.

Refer to chapter I/O port overview on page 23 to get the available voltage supply for the digital outputs of every LioN-Safety variant.

9.2.6 DI Logic (Ch13 .. 16)

The logical state of an input channel can be configured via these parameters. If a channel is set to "Normally Open", a low signal ("0") is transferred to the process input data (e.g. if a non-damped sensor has an open switching output).

If a channel is set to "Normally Close", a high signal ("0") is transferred to the process input data (e.g. if a non-damped sensor has a closed switching output).

The channel LED shows, independent of these settings, the physical input state of the port pin.

9.2.7 DI Filter (Ch13 .. 16)

A filter time for every digital input channel can be configured by these parameters. When there is no need for a filter it can be disabled.

9.2.8 DI Latch

Note: Only applicable for firmware version 11.2 or higher in combination with the latest device description file.

This parameter is used to configure the DI Latch for all 16 channels with a single parameter.

It is a 16bit signed integer used as a bit-field, with each channel occupying 1 bit. Starting with Port 1 Channel A at bit 0 (LSB), Port 1 Channel B at bit 1, Port 2 Channel A at bit 2, …, Port 8 Channel B at bit 15 (MSB).

For each channel, the DI Latch is encoded as follows:

- 0: Disabled
- 1: Enabled

For example, to enable the DI Latch for Port 1 Channel B and Port 6 Channel A while keep it disabled for all other channels, the corresponding bit-field would be '0000010000000010', so the parameter would have to be configured to '1026'.

With the latch for a given DI channel enabled, a rising edge at the digital input is held high in the input status data (latched) as this is acknowledged by the PLC.

In detail:

• If the DI channel is in a low state and a high input of any duration is detected, the channel will report a high input indefinitely, regardless of the actual physical input. In other words, the latch will be triggered.

• If the channel is in a high state, a transition is required at first to 'low' and then to 'high' in order for the latch to be triggered.

The latch is triggered only when a rising edge occurs on the channel.

The latch can be reset by setting the appropriate output channel to 'true'. The input status will not be changed, it will only deactivate the latch.

This setting only works for channels that have been set to 'digital input mode'.

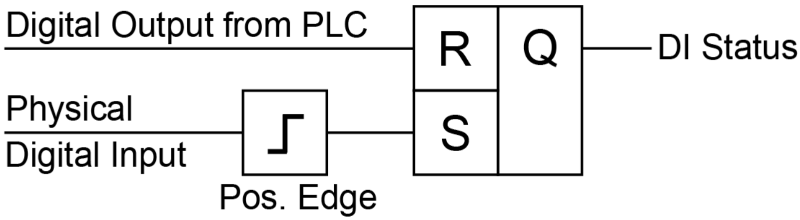


Figure 7: Input latch

Default: 0 (Disabled)

9.2.9 DI Extension

This parameter is used to configure the DI Extension for all 16 Channels with a single parameter.

It is a 32bit signed integer used as a bit-field, with each channel occupying 2 bits. Starting with Port 1 Channel A at bit 0 (LSB), Port 1 Channel B at bit 2, Port 2 Channel A at bit 4, …, Port 8 Channel B at bit 30 (MSB).

For each channel, the DI Extension is encoded as follows:

- (00)0: Disabled
- (01)1: 8 ms
- (10)2: 16 ms
- (11)3: 64 ms

For example, to configure the DI Extension for Port 1 Channel B to '6 ms' and for Port 6 Channel A to '255 ms' while keeping it disabled for all other channels, the corresponding bit-field would be '0000000000000000000011110000000000000000000000000000000010000000', so the parameter would have to be configured to '16492674416768'.

Note: Only applicable for firmware version 11.2 or higher in combination with the latest device description file.

This parameter extends the duration of the digital input status after a state change at the physical input, when the input state change is faster than the extension time set.

The extension time will be applied on 'high' to 'low' and 'low' to 'high' input transitions. This setting only works for channels that have been set to 'digital input'.

Example:

The DI extension parameter is set to 16 ms, the physical input signal has low status => a high signal is detected for 8 ms.

In this case, the DI channel reports a high-status signal for 16 ms, regardless of other physical input signal transitions during this time.

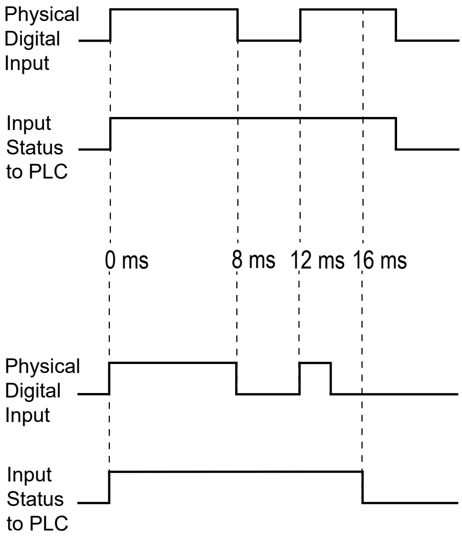


Figure 8: DI Extension

Available values: Off; 8 ms; 16 ms; 64 ms

Default: Off

9.2.10 Channel Mode (Ch13 .. 16)

The operation mode of every channel can be configured by these parameters. The usability of this setting depends on the hardware variant and can be figured out in the description (e.g. for a 8 IO-Link Class A Master, an IO-Link mode can only be configured for channel A and not for channel B).

Inactive:

This mode should be selected when the channel is not in use.

Attention: If channel A of a port is set to inactive, the corresponding channel B is also set to inactive regardless of its configuration. In this case, the entire port is therefore deactivated.

Digital Output:

In this mode, the channel operates as digital output. The channel can be controlled by the *Digital Output Channel Control* (first two bytes of the output data) or by the *IO-Link Output Data* (first byte of each IO-Link Device output data) of the cyclic process data. This depends on the *Digital Output Control* parameter of the *General Settings*.

Digital Input:

In this mode, the channel operates as digital input. The channel state can be seen in the *Digital Input Channel Status* of the cyclic process data.

IO-Link:

In this mode, the channel tries to establish a communication with an IO-Link Device. IO-Link process data can be exchanged via a communication link between the IO-Link Master and the IO-Link Device. The size of the IO-Link input and output data as well as the port mode depend on the IO-Link port settings.

Attention: Not all channels support this configuration.

9.2.11 Port mode for Channel A (Pin 4)

This parameter is used in the *Min Configuration Assembly* to configure the port modes for all 8 A Channels (Pin 4) with a single parameter.

It is a 16bit signed integer used as bit-field, with each channel occupying 2 bits. Starting with port 1 at bit 0 (LSB), port 2 at bit 2, …, port 8 at bit 14 (MSB).

For each channel, the *Port Mode* is encoded as follows:

(00)0: IO-Link (mapped to Digital Input for channels not supporting IO-Link)

(01)1: Digital Output

(10)2: Digital Input

(11)3: Inactive

See chapter Channel Mode (Ch13 .. 16) on page 65 for a detailed description of those different channel modes.

For example, to configure ports 1 .. 4 Channel A to "IO-Link" and ports 5 .. 8 Channel A to "Digital Output'", the corresponding bit-field would be '0101010100000000', so the parameter would have to be configured to '21760'.

9.2.12 Port mode for Channel B (Pin 2)

This parameter is used in the *Min Configuration Assembly* to configure the port modes for all 8 B Channels (Pin 2) with a single parameter.

It is a 16bit signed integer used as bit-field, with each channel occupying 2 bits. Starting with port 1 at bit 0 (LSB), port 2 at bit 2, …, port 8 at bit 14 (MSB).

For each channel, the *Port Mode* is encoded as follows:

(00)0: Digital Input (mapped to Auxiliary Power for IO-Link Type B channels not supporting Digital Input)

(01)1: Digital Output

(10)2: Auxiliary Power (only IO-Link Type B)

(11)3: Inactive

See chapter Channel Mode (Ch13 .. 16) on page 65 for a detailed description of those different channel modes.

For example, to configure ports 1 .. 4 Channel B to "Digital Output" and ports 5 .. 8 Channel B to "Inactive'", the corresponding bit-field would be '1111111101010101', so the parameter would have to be configured to '-171'.

9.3 IO-Link diagnosis settings

Configuration parameter	Byte offset config. assembly	Data type	Valid values	CIP object class 0xA2, Instance 1
IO-Link Master Diagnosis	208	SINT	0: Disable **1: Enable**	Attribute 1
IO-Link Device Error	209	SINT	0: Disable **1: Enable**	Attribute 2
IO-Link Device Warning	210	SINT	0: Disable **1: Enable**	Attribute 3
IO-Link Device Notification	211	SINT	0: Disable **1: Enable**	Attribute 4
IO-Link Device Diagnosis Port 7 .. 8	218 .. 219	SINT[2]	0: Disable **1: Enable**	Attribute 11 .. 12

9.3.1 IO-Link Master Diagnosis

If this parameter is enabled, the *IO-Link Master Diagnosis* is transferred to the IO-Link diagnoses of the input process data. If configured, additional diagnoses and information are transferred in the *IO-Link Extended Status* and in the *IO-Link events*.

If this parameter is disabled, no *IO-Link Master Diagnosis* is reported.

9.3.2 IO-Link Device Error

If this parameter is enabled, the *IO-Link Device Errors* are transferred in the IO-Link diagnoses of the input process data. If configured, additional diagnoses and information are transferred in the *IO-Link Extended Status* and the *IO-Link events*.

If this parameter is disabled, no *IO-Link Device Error* is reported.

9.3.3 IO-Link Device Warning

If this parameter is enabled, the *IO-Link Device Warnings* are transferred in the IO-Link diagnoses of the input process data. If configured, additional diagnoses and information are transferred in the *IO-Link Extended Status* and the *IO-Link events*.

If this parameter is disabled, no *IO-Link Device Warning* is reported.

9.3.4 IO-Link Device Notification

If this parameter is enabled, the *IO-Link Device Notifications* are transferred in the IO-Link diagnoses of the input process data. If configured, additional diagnoses and information are transferred in the *IO-Link Extended Status* and the *IO-Link events*.

If this parameter is disabled, no *IO-Link Device Notification* is reported.

9.3.5 IO-Link Device Diagnosis Port 7 .. 8

If this parameter is enabled for an IO-Link port, the respective diagnoses are transferred in the IO-Link diagnoses of the input process data. If configured, additional diagnoses and information are transferred in the *IO-Link Extended Status* and the *IO-Link events*.

If this parameter is disabled for an IO-Link port, no respective diagnosis is reported.

9.4 IO-Link Port 7 .. 8 settings

Configuration parameter	**Byte offset config. assembly**			**Data type**	**Valid values**	**CIP object class 0xA3, Instance 1 .. 8**
	145	**146**	**147**			
Output Data Size	356, 378	262, 281	–	SINT	0: No data 1: 2 Byte 2: 4 Byte 3: 8 Byte 4: 16 Byte **5: 32 Byte**	Attribute 1
Input Data Size	357, 379	263, 282	–	SINT	0: No data 1: 2 Byte 2: 4 Byte 3: 8 Byte 4: 16 Byte **5: 32 Byte**	Attribute 2
Input Data Extension	358, 380	264, 283	–	SINT	0: No Data 1: Extended Status 2: Events **3: Extended Status + Events**	Attribute 3
Output Data Swapping Mode	359, 381	265, 284	–	SINT	**0: Raw IO-Link Data** 1 .. 16: 1 .. 16 WORD 17 .. 24: 1 .. 8 DWORD	Attribute 4
Output Data Swapping Offset	360, 382	266, 285	–	SINT	0 .. 30 Byte **("0")**	Attribute 5
Input Data Swapping Mode	361, 383	267, 286	–	SINT	**0: Raw IO-Link Data** 1 .. 16: 1 .. 16 WORD 17 .. 24: 1 .. 8 DWORD	Attribute 6

Configuration parameter	**Byte offset config. assembly**			**Data type**	**Valid values**	**CIP object class 0xA3, Instance 1 .. 8**
	145	**146**	**147**			
Input Data Swapping Offset	362, 384	268, 287	–	SINT	0 .. 30 Byte **("0")**	Attribute 7
IOL Failsafe	363, 385	269, 288	–	SINT	**0: Set Low** 1: Set High 2: Hold Last 3: Replacement Value (transferred via IO-Link Failsafe Parameter Object) 4: IO-Link Master Command	Attribute 8
Port Mode	364, 386	270, 289	–	SINT	0: Deactivated 1: Manual (with validation and backup config) **2: Autostart (no validation and backup config)**	Attribute 9
IO-Link Mode	–	–	5	SINT	-128 .. 127 **(0)**	–

Configuration parameter	Byte offset config. assembly			Data type	Valid values	CIP object class 0xA3, Instance 1 .. 8
	145	146	147			
Validation and Backup	365, 387	271, 290	157, 182	SINT	**0: No device check and clear (no data storage)** 1: Type compatible V1.0 device (no data storage) 2: Type compatible V1.1 device (no data storage) 3: Type compatible V1.1 device with Backup + Restore (download + upload) 4 Type compatible V1.1 device with Restore (download master to device)	Attribute 10
Vendor ID	366, 388	272, 291	158, 183	DINT	0 .. 65535 **("0")**	Attribute 11
Device ID	370, 392	276, 295	162, 187	DINT	0 .. 16777215 **("0")**	Attribute 12
Cycle Time	374, 396	–	156, 181	SINT	**0: As fast as possible** 1: 1.6 ms 2: 3.2 ms 3: 4.8 ms 4: 8.0 ms 5: 20.8 ms 6: 40.0 ms 7: 80.0 ms 8: 120.0 ms	Attribute 13

Assignment of the IO-Link ports:

IO-Link port 7	Port X7.ChA	CIP object instance 7
IO-Link port 8	Port X8.ChA	CIP object instance 8

The number of IO-Link ports depends on the IO-Link Master variant. IO-Link Masters with less than 8 IO-Link ports only provide configuration parameters for their own count. Unused configuration data bytes are sent as "zero bytes" inside the configuration assembly.

Configuration parameters of an IO-Link port are only taken into account by the application when the corresponding Channel Mode of the Channel Settings is set to *IO-Link*.

9.4.1 Output Data Size

The *Output Data Size* of the respective IO-Link device can be configured by this parameter. There can be up to 32 Bytes of IO-Link output data per port.

The *Output Data Size* of every IO-Link device has influence on the total *Output Data Size* of the connection. It has to be taken into account that all IO-Link output data fits into the total size.

This parameter is only settable when no connection is active.

9.4.2 Input Data Size

The *Input Data Size* of the respective IO-Link device can be configured by this parameter. There can be up to 32 Bytes of IO-Link input data.

The *Input Data Size* of every IO-Link device has influence on the total *Input Data Size* of the connection. It has to be taken into account that all IO-Link input data fits into the total size.

This parameter is only settable when no connection is active.

9.4.3 Input Data Extension

The *Input Data Extension* can be selected to extend each IO-Link input data with extended status information and/or IO-Link events.

The *Input Data Extension* of every IO-Link device has influence on the total input data size of the connection. It has to be taken into account that all IO-Link output data including the extension fits into the total size.

This parameter is only settable when no connection is active.

9.4.4 Output Data Swapping Mode

The byte order of IO-Link is big endian which is not compatible to EtherNet/IP's little endian format. For setting output data in the correct format, the parameters *Output Data Swapping Mode* and *Output Data Swapping Offset* support the user. There can be selected up to 16 words or up to 8 double words for converting the output data.

Raw IO-Link Data:

No byte swap

Data type WORD:

Data byte order: Byte 0, Byte 1

Order after Swap: Byte 1, Byte 0

Data type DWORD:

Data byte order: Byte 0, Byte 1, Byte 2, Byte 3

Order after Swap: Byte 3, Byte 2, Byte 1, Byte 0

9.4.5 Output Data Swapping Offset

The *Output Data Swapping Offset* describes the start point in the process data for using the configured *Output Data Swapping Mode*. Both parameters are dependent on the configured output data size.

9.4.6 Input Data Swapping Mode

The byte order of IO-Link is big endian which is not compatible to EtherNet/IP's little endian format. For receiving input data in the correct format, the parameters *Input Data Swapping Mode* and *Input Data Swapping Offset* support the user. There can be selected up to 16 words or up to 8 double words for converting the input data.

Raw IO-Link Data:

No byte swap

Data type WORD:

Data byte order: Byte 0, Byte 1

Order after Swap: Byte 1, Byte 0

Data type DWORD:

Data byte order: Byte 0, Byte 1, Byte 2, Byte 3

Order after Swap: Byte 3, Byte 2, Byte 1, Byte 0

9.4.7 Input Data Swapping Offset

The *Input Data Swapping Offset* describes the start point in the process data for using the configured *Input Data Swapping Mode*. Both parameters are dependent on the configured input data size and the optional input data extension.

9.4.8 IOL Failsafe

The LioN-Safety devices support a failsafe function for the output data of the IO-Link channels. In case of an internal device error, the PLC is in STOP state and cannot provide valid process data, the connection is interrupted or the communication is lost: The output data of the IO-Link channels is controlled by the configured failsafe values.

Set Low:

If failsafe is active, all bits of the IO-Link output data are set to low ("0").

Set High:

If failsafe is active, all bits of the IO-Link output data are set to high ("1").

Hold Last:

If failsafe is active, all bits of the IO-Link output data arel hold the last valid process data state ("0" or "1").

Replacement Value:

A replacement value can be set via the *IO-Link Failsafe* parameter object for every IO-Link device. If failsafe is active, these replacement values are transmitted to the IO-Link device. Take into account that in the case of an error the replacement values are sent instead of the output process data so that a configured *Swapping Mode* has influence on the byte order.

IO-Link Master Command:

If failsafe is active, an IO-Link-specific mechanism for valid/invalid output process data is used and the IO-Link device determines the behavior itself.

9.4.9 Port Mode

The *Port Mode* describes how the IO-Link master handles the presence of an IO-Link device at the port.

Deactivated:

The IO-Link port is deactivated but can be configured for later use. No diagnostics are generated if the IO-Link device is not connected.

IO-Link Autostart:

The IO-Link port is activated and no explicit port configuration is needed. Configurations such as *Validation and Backup* (Inspection Level), *Vendor ID*, *Device ID* and *Cycle Time* are not required.

IO-Link Manual:

The IO-Link port is activated and explicit port configuration can be done for the parameters *Validation and Backup* (Inspection Level), *Vendor ID*, *Device ID* and *Cycle Time*.

9.4.10 Validation and Backup

With this parameter, the user can set the behavior of the IO-Link ports regarding the type compatibility and data storage mechanism of the connected IO-Link Device.

The precondition for using *Validation and Backup* is that you configure the *Port Mode* to "IO-Link Manual".

The IO-Link Master has a backup memory which can be used for storing the device parameters and for restoring them on the device. This backup memory can be deleted by the following events:

- IO-Link Master factory reset
- *Channel Mode* reconfiguration, e.g. from “Digital-Input” to “IO-Link”
- *Validation and Backup* reconfiguration, e.g. from “No device check” to “Type compatible V1.1 device with Backup & Restore”

For further information refer to the ‘IO-Link Interface and System Specification’ version 1.1.3 which can be downloaded from https://io-link.com/

No device check (no data storage):

No check of connected Vendor ID or Device ID and no "Backup and Restore" support of the IO-Link Master parameter server.

Type compatible V1.0 device (no data storage):

Type compatible according IO-Link specification V1.0 which includes validation of Vendor ID and Device ID. The IO-Link specification V1.0 does not support IO-Link Master parameter server.

Type compatible V1.1 device (no data storage):

Type compatible according IO-Link specification V1.1 which includes validation of Vendor ID and Device ID. "Backup and Restore" is disabled.

Type compatible V1.1 device with Backup + Restore

(upload + download):

Type compatible according IO-Link specification V1.1 which includes validation of Vendor ID and Device ID. "Backup and Restore" is enabled.

Pay attention to the following explanations regarding *Backup and Restore* conditions:

- Backup (Device to Master):

  A Backup (upload from IOL-Device to IOL-Master) is performed when an IO-Link Device is connected and the Master does not have any valid parameter data. The read parameter data are permanently stored on the IO-Link Master.

  An upload will also be performed, when the IO-Link Device has set the DS_UPLOAD_FLAG (Data Storage Upload Flag). This IOL-Device flag can be set in two ways:

  – Parameters written to IOL-Device in *Block Parameter* mode: An IO-Link Device sets the DS_UPLOAD_FLAG self-dependent, if the parameters were written in block parameter mode to the IO-Link Device with the last system command ParamDownloadStore (e.g. by a third party USB IO-Link Master for commissioning).
  – Parameters written to IOL-Device in *Single Parameter* mode: If single parameter data is changed on the IOL-Device during runtime, the stored device parameters on the IOL-Master can be updated using the ParamDownloadStore (index 0x0002, subindex 0x00, value 0x05) command. This command sets the DS_UPLOAD_REQ flag on the IOL-Device and thus the IO-Link Master executes an upload procedure from the IO-Link Device.

- Restore (Master to Device):

  A Restore (download from IOL-Master to IOL-Device) is performed when an IO-Link Device is connected and the IO-Link Master has valid parameter data stored which are usable for the IOL-Device and not equal compared to the device parameters.

  The restore procedure can be blocked by the IO-Link Device via the *Device Access Locks* parameter when supported by the IO-Link Device (Index 0x000C, refer to vendor specific IO-Link Device documentation).

Type compatible V1.1 device with Restore (download Master to Device):

Type compatible according IO-Link specification V1.1 which includes validation of Vendor ID and Device ID. Only "Restore" is enabled.

Pay attention to the following explanations regarding *Restore* conditions:

- Restore (Download / IOL-Master to IOL-Device):

  A Restore (download from IOL-Master to IOL-Device) is performed when an IO-Link Device is connected and the IO-Link Master has valid parameter data stored which are usable for the IOL-Device and not equal compared to the device parameters.

  In the *Restore* mode no change of the IOL-Device parameters will be stored permanently on the IOL-Master. When the IOL-Device sets the DS_UPLOAD_FLAG in this mode, the device parameters will be restored by the IOL-Master.

  The restore procedure can be blocked by the IO-Link Device via the *Device Access Locks* parameter when supported by the IO-Link Device (Index 0x000C, refer to vendor specific IO-Link Device documentation).

9.4.11 Vendor ID

The *Vendor ID* is needed for the validation of the IO-Link device and can be configured with this parameter.

Precondition for using the *Vendor ID* is that you configure *Port Mode* to "IO-Link Manual". *Validation and Backup* must be set to a type compatible V1.X device.

9.4.12 Device ID

The *Device ID* is needed for the validation of the IO-Link device and can be configured with this parameter.

Precondition for using the *Device ID* is that you configure *Port Mode* to "IO-Link Manual". *Validation and Backup* must be set to a type compatible V1.X device.

9.4.13 Cycle Time

The IO-Link cycle time can be configured by this parameter.

The precondition for using *Cycle Time* is that you configure *Port Mode* to "IO-Link Manual".

As fast as possible:

The IO-Link port uses the max. supported IO-Link Device and Master update cycle time for the cyclic I/O data update between IO-Link Master and IO-Link Device.

1.6 ms, 3.2 ms, 4.8 ms, 8.0 ms, 20.8 ms, 40.0 ms, 80.0 ms, 120.0 ms:

The cycle time can be set manually to the provided options. This option can be used e.g. for IO-Link devices which are connected over inductive couplers. Inductive couplers are normally the bottleneck in the update cycle time between IO-Link Master and IO-Link Device. In this case, please refer to the data sheet of the inductive coupler.

10 Safety Configuration parameters

Parameters of the LioN-Safety device can be configured via the Safety configuration assembly and CIP object classes. A Safety configuration assembly is sent by the PLC when a Safety connection is established and the device was not configured before. Alternatively, a configuration can be send via the Belden CIP Safety Configurator (see Belden CIP Safety Configurator on page 149). However, when sending, all existing parameters will be overwritten by this data. Therefore, the content of the configuration assembly has the highest valence.

Every configuration on the device is validated by the configuration signature which always has to be updated on the device after a configuration change by the PLC or the Belden CIP Safety Configurator.

The following chapters represent different setting groups with its configuration parameters. They are ingredients of the safety configuration assembly and can be get via *Explicit Messaging* by the specified CIP object classes. The **default values** are highlighted.

10.1 General settings

Configuration parameter	Byte offset config. assembly	Data type	Valid values	CIP object class 0xA6, Instance 1
Input Sensor Analysis	1	SINT	**0: 1oo1 without clock signal** 1: 1oo1 with clock signal 2: 1oo2 without clock signal 3: 1oo2 with clock signal	Attribute 1
Output Test Pulses (for Mixmodule only)	2	SINT	**0: Test Pulse Length 0.75 ms, Repetition Rate 300 ms** 1: Test Pulse Length 50 ms, Repetition Rate 5 s 2: Test Pulse Length 100 ms, Repetition Rate 10 s	Attribute 2

10.1.1 Input Sensor Analysis

The requirements of the safety control architecture determines the configuration of the Input Sensor Analysis. The 1oo1 architecture is the simplest safety system and is typically used in lower-level SIL 2, PL d and Cat. 2 systems. The 1oo2 architecture consists of two channels throughout the system which provides high safety integrity to a rating of SIL 3, PL d and Cat. 3.

This parameter only affects safety ports which are set as 'Safe' in the Input Port Config. It has no influence on ports configured as 'Non-Safe'.

Attention:

This is a general parameter. It applies to all safety input ports of the module and not only to a single safety input port. With this parameter, the user determines the safety input port architecture and the integrity level of the entire module.

- 1oo1 without clock signal:

  This mode is used for single channel sensors and supplies no clock signal for functional safety hardware tests.

  Both input channels A and B can be used independently.

  In this mode, the configuration of the *Input Port Sensor Valence* of each port is not evaluated and therefore has no effect on the input process data of the channels.
- 1oo1 with clock signal:

  This mode is used for single channel sensors and supplies a clock signal for functional safety hardware tests each on pin 1 and pin 5.

  Both input channels A and B can be used independently.

  In this mode, the configuration of the *Input Port Sensor Valence* of each port is not evaluated and therefore has no effect on the input process data of the channels.

- 1oo2 without clock signal:

  This mode is used for two 1-channel sensors or one 2-channel sensor and supplies no clock signal for functional safety hardware tests.

  Both physical input channels A and B will be used for one-bit information of the digital input represented in the channel A bit and mirrored in the channel B bit.

  In this mode, the configuration of the *Input Port Sensor Valence* of each port is evaluated and therefore effects the input process data of the channels. If the parameter *Input Port Sensor Valence* is set the 'Equivalence', both input channels must be equal for getting a valid input status on the channels. If the parameter Input Port Sensor Valence is set the 'Antivalence', both input channels must be unequal for getting a valid input status on the channels.
- 1oo2 with clock signal:

  This mode is used for two 1-channel sensors or one 2-channel sensor and supplies a clock signal for functional safety hardware tests each on pin 1 and pin 5.

  Both physical input channels A and B will be used for one-bit information of the digital input represented in the channel A bit and mirrored in the channel B bit.

  In this mode, the configuration of the *Input Port Sensor Valence* of each port is evaluated and therefore effects the input process data of the channels. If the parameter Input Port Sensor Valence is set the 'Equivalence', both input channels must be equal for getting a valid input status on the channels. If the parameter Input Port Sensor Valence is set the 'Antivalence', both input channels must be unequal for getting a valid input status on the channels.

10.1.2 Output Test Pulses

Safety output ports supply a test pulse for functional safety hardware tests where the output is switched off for a configured time. This event is cyclic done and the frequency is determined by the repetition rate.

Only the Mixmodule supports 2 safety output ports (X5..X6). Unsupported configuration data is not evaluated by the device.

Attention:

This is a general parameter. It applies to all safety output ports of the module and not only to a single safety output port. It must be configured with regards to the used actuators to avoid switching of e.g. a fast-responsive valve.

- Test Pulse Length 0.75 ms, Repetition Rate 300 ms:

  This mode sets the safety output test pulse length to 0.75 ms with a repetition rate of 300 ms.
- Test Pulse Length 50 ms, Repetition Rate 5 s:

  This mode sets the safety output test pulse length to 50 ms with a repetition rate of 5 s.
- Test Pulse Length 100 ms, Repetition Rate 10 s:

  This mode sets the safety output test pulse length to 100 ms with a repetition rate of 10 s.

10.2 Safety input port settings

Configuration parameter	Byte offset config. assembly	Data type	Valid values	CIP object class 0xA7, Instance 1 .. n
Input Port Config	9	SINT[8]	**0: Safe** 1: Non-Safe	Attribute 1
Input Port Sensor Valence	17	SINT[8]	**0: Equivalence** 1: Antivalence	Attribute 2

10.2.1 Input Port Config

The *Input Port Config* determines if the port is used as a safety or as a non-safe port. This parameter applies to both channels of the corresponding digital input port.

The 16DI module supports 8 safety input ports (X1..X8) and the Mixmodule supports 4 safety input ports (X1..X4). Unsupported configuration data is not evaluated by the device.

- Safe:

  This mode is used for safety ports. The safety input data is mapped to the safety process data (see Safety digital input channel status on page 109) and the physical input data is mapped to the non-safe process data of the safety submodule (see Digital input channel status on page 96).

  This mode is a pre-condition for using safety architectures such as 1oo1 or 1oo2 which can be configured by the *Input Sensor Analysis*.
- Non-Safe:

  This mode is used for non-safe ports. There is no safety input data mapped and only the physical input data is mapped to the non-safe process data of the safety submodule (see Digital input channel status on page 96).

  In this mode, the configuration of the *Input Sensor Analysis* and of the *Input Port Sensor Valence* of the corresponding port is not evaluated and therefore has no effect on the input process data of the channels.

10.2.2 Input Port Sensor Valence

The *Input Port Sensor Valence* determines if the expected physical input data of the two channels have to be equivalent or antivalent to receive valid safety process input data for the corresponding port. If the states do not match this configuration parameter, the status and validity of the channels in the safety process input data is set to 'false'.

The 16DI module supports 8 safety input ports (X1..X8) and the Mix module supports 4 safety input ports (X1..X4). Unsupported configuration data is not evaluated by the device.

This mode has no influence on non-safe ports where only the physical input data is mapped to the non-safe process data of the safety submodule (see Digital input channel status on page 96).

Pre-condition for using this parameter is that the Input Port Config of the corresponding port is set to 'Safe' and the Input Sensor Analysis is set to '1oo2 without clock signal' or '1oo2 with clock signal'.

- Equivalence:

  This mode is used for two 1-channel equivalent sensors or one 2-channel equivalent sensor. Both input channels must be equal for getting a valid input status on the channels.
- Antivalence:

  This mode is used for two 1-channel non-equivalent sensors or one 2-channel non-equivalent sensor. Both input channels must be unequal for getting a valid input status on the channels.

11 Non-Safe Process data assignment

The LioN-Safety devices in general support process data communication in both directions. The consuming data in this context is defined as the process output data which controls physical outputs and IO-Link output data. The producing data in this context is defined as the process input data which contains the physical inputs, diagnostics and IO-Link input data with optional extended status and event data.

The following chapters describe the data images for the consuming and producing data direction which are assigned to the output and input assemblies.

Assignment of channels	
Channel 1	Port X1.ChA
Channel 2	Port X1.ChB
[…]	[…]
Channel 15	Port X8.ChA
Channel 16	Port X8.ChB

11.1 Consuming IO-Link data image (output)

Output data frame	Digital output channel control	Reserved (e.g. feature control)	IO-Link output data
Consuming data size	2 Byte, INT	2 Byte, INT	0..64 Byte, INT

The complete *Output data frame* has a variable size of up to 68 Bytes. In general, a 4 Byte Run/Idle Header precedes, resulting in up to 72 Bytes in total.

The following chapters describe the bit assignment.

11.1.1 Digital output channel control

Digital output channel control	Bit	7	6	5	4	3	2	1	0
Channel number (default mapping)	Byte 0	–	–	–	–	–	–	–	–
	Byte 1	16	15	14	13	–	–	–	–

The control values are effective if the respective channels are configured as outputs and the *Digital Output Control* is set to *DO Channel Control*.

11.1.2 IO-Link output data

IO-Link output data	IO-Link port 7 control	IO-Link port 8 control
IO-Link port output size	0 Byte 2 Byte 4 Byte 8 Byte 16 Byte 32 Byte	0 Byte 2 Byte 4 Byte 8 Byte 16 Byte 32 Byte

The IO-Link port output size is independent of the configured Channel Mode. It is always considered in the IO-Link output data and therefore the offsets do **not** need to be calculated again by the user in case of a channel mode reconfiguration. Every IO-Link port can be set to its required size. The control data is transferred to the device. However, the content depends on the IO-Link *Output Data Swapping Mode* and *Output Data Swapping Offset*.

If there is no IO-Link port configured, the *Consuming data image* has no IO-Link output data.

11.2 Producing IO-Link data image (input)

Input data frame	Digital input channel status	General diagnostics	Sensor diagnostics	Actuator/ U_{Aux} diagnostics	IO-Link diagnostics	IO-Link input data
Producing data size	2 Byte, INT	2 Byte, INT	2 Byte, INT	2 Byte, INT	0 Byte 6 Byte, INT	0..108 Byte, INT

The complete *Input data frame* has a variable size of up to 122 Bytes.

The following chapters describe the bit assignment.

11.2.1 Digital input channel status

Digital input channel status	Bit	7	6	5	4	3	2	1	0
Channel number (default mapping)	Byte 0	–	–	–	–	–	–	–	–
	Byte 1	16	15	14	13	–	–	–	–

Each status value is effective if the channel is configured as Input.

11.2.2 General diagnostics

General diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	IME	FME	0	0	SCA	SCS	LVA	LVS
	Byte 1	0	0	0	0	IDN	IDW	IDE	IVE

LVS Low Voltage System/Sensor Supply

LVA Low Voltage Actuator Supply

SCS Short Circuit Sensor

SCA Short Circuit Actuator/U_L/U_{Aux}

FME Force Mode Enabled

IME Internal Module Error

IVE IO-Link Validation Error (collective error)

IDE IO-Link Device Error (collective error)

IDW IO-Link Device Warning (collective error)

IDN IO-Link Device Notification (collective error)

0 Reserved

11.2.3 Sensor diagnostics

Sensor diagnostics	Bit	7	6	5	4	3	2	1	0
Port number	Bvte 0	X8	X7	0	0	0	0	0	0
	Byte 1	0	0	0	0	0	0	0	0

X7 .. 8 Sensor Short Circuit on Port X7 .. X8

0 Reserved

11.2.4 Actuator/U_S diagnostics

Actuator/U_S diagnostics	Bit	7	6	5	4	3	2	1	0
Channel number (fix)	Byte 0	–	–	–	–	–	–	–	–
	Byte 1	16	15	14	13	–	–	–	–

13 .. 16

Actuator/U_S channel error detection on channel 13 .. 16

11.2.5 IO-Link diagnostics

IO-Link diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	ICE8	ICE7	0	0	0	0	0	0
	Byte 1	0	0	0	0	0	0	0	0
	Byte 2	IVE8	IVE7	0	0	0	0	0	0
	Byte 3	IDE8	IDE7	0	0	0	0	0	0
	Byte 4	IDW8	IDW7	0	0	0	0	0	0
	Byte 5	IDN8	IDN7	0	0	0	0	0	0

ICE7..8

IO-Link Port COM Error (device missing, broken wire, short circuit)

IVE7..8

IO-Link Port Validation Error

IDE7..8

IO-Link Port Device Error

IDW7..8

IO-Link Port Device Warning

IDN7..8

IO-Link Port Device Notification

0

Reserved

If there is no IO-Link port configured, the input data image doesn't show IO-Link diagnostics.

11.2.6 IO-Link input data

IO-Link input data	IO-Link port 7				[…]	IO-Link port 8			
	Status	PQI	Extended status	Events	[…]	Status	PQI	Extended status	Events
IO-Link port input size	0 Byte 2 Byte 4 Byte 8 Byte 16 Byte 32 Byte	2 Byte	0 Byte 8 Byte	0 Byte 12 Byte	[…]	0 Byte 2 Byte 4 Byte 8 Byte 16 Byte 32 Byte	2 Byte	0 Byte 8 Byte	0 Byte 12 Byte

The IO-Link port input size is independent of the configured Channel Mode. It is always considered in the IO-Link input data and therefore the offsets do **not** need to be calculated again by the user in case of a channel mode reconfiguration. Every IO-Link port can be set to its required size. The device input data is mapped to the **Status** field and the content depends on the IO-Link *Input Data Swapping Mode* and *Input Data Swapping Offset*.

An IO-Link port can be configured via the Channel Mode. The PQI provides some IO-Link information, is always available and is independent of the Status size. The Extended Status and Events can be enabled by the IO-Link port configuration.

Port Qualifier Information (PQI):

PQI (Port Qualifier Information)	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	PQ	DevErr	DevCom	PortActive	SubstDev	NewPar	0	0
	Byte 1	0	0	0	0	0	0	0	0

NewPar	Update of Device parameter detected

SubstDev	Substitute device detected (different SerialNumber)
PortActive	Port activated
DevCom	Device detected and is in PREOPERATE or OPERATE state
DevErr	Error/warning assigned to Device or Port occurred
PQ	Valid I/O Process Data from Device
0	Reserved

Extended status:

IO-Link Extended status	Bit	7	6	5	4	3	2	1	0
Extended diagnostics	Byte 0	0	0	0	ICT	BUI	SPE	ILE	OLE
	Byte 1	0							
Vendor ID	Byte 2	Vendor ID (LSB)							
	Byte 3	Vendor ID (MSB)							
Device ID	Byte 4	Device ID (LSB)							
	Byte 5	Device ID							
	Byte 6	Device ID (MSB)							
	Byte 7	0							

OLE	Output process data length error (device mismatch)
ILE	Input process data length error (device mismatch)

SPE	Startup parameterization error (direct parameter error)
BUI	Backup inconsistency (parameter storage error)
ICT	Invalid Cycle Time
0	Reserved

Events:

IO-Link events	Bit	7	6	5	4	3	2	1	0
Event Qualifier 1	Byte 0	Mode		Type		0	0	Instance	
	Byte 1	0	0	0	0	0	0	0	0
Event Code 1	Byte 2	Event Code							
	Byte 3								
Event Qualifier 2	Byte 4	Mode		Type		0	0	Instance	
	Byte 5	0	0	0	0	0	0	0	0
Event Code 2	Byte 6	Event Code							
	Byte 7								
Event Qualifier 3	Byte 8	Mode		Type		0	0	Instance	
	Byte 9	0	0	0	0	0	0	0	0
Event Code 3	Byte 10	Event Code							
	Byte 11								

Instance	Unknown ("0"), Reserved (Physical Layer PL ("1"), Data Link Layer DL ("2"), Application Layer AL ("3")), Application ("4")
Type	Notification ("1"), Warning ("2"), Error ("3")

Mode	Event single shot ("1"), Event disappears ("2"), Event appears ("3")
Event Code	Diagnostic code reported by the IO-Link device
0	Reserved

11.3 Producing Input and Diagnostic image of safety submodule

Input and diagnostic data frame	Digital input channel status	Digital input diagnostics	Digital output diagnostics	Device diagnostics
Producing data size	2 Byte, INT	8 Byte, INT	6 Byte, INT	2 Byte, INT

The complete *Input and diagnostic data frame* has a fix size of 18 Bytes.

The following chapters describe the bit assignment.

11.3.1 Digital input channel status

Digital input channel status	Bit	7	6	5	4	3	2	1	0
Channel number (default mapping)	Byte 0	8	7	6	5	4	3	2	1
	Byte 1	16	15	14	13	12	11	10	9

- 16DI module

  Channel 1 .. 16: physical digital input status

- Mixmodule

  Channel 1 .. 8: physical digital input status

  Channel 9 .. 16: reserved

11.3.2 Digital input diagnostics

Digital input diagnostics	Bit	7	6	5	4	3	2	1	0
Internal error	Byte 0	8	7	6	5	4	3	2	1
	Byte 1	16	15	14	13	12	11	10	9
Cross circuit	Byte 2	8	7	6	5	4	3	2	1
	Byte 3	16	15	14	13	12	11	10	9
Overload	Byte 4	8	7	6	5	4	3	2	1
	Byte 5	16	15	14	13	12	11	10	9
Discrepancy	Byte 6	X4	X4	X3	X3	X2	X2	X1	X1
	Byte 7	X8	X8	X7	X7	X6	X6	X5	X5

- 16DI module

  Channel 1 .. 16: safety digital input diagnosis

  Port X1 .. X8: safety digital input diagnosis

- Mixmodule

  Channel 1 .. 8: safety digital input diagnosis

  Channel 9 .. 16: reserved

  Port X1 .. X4: safety digital input diagnosis

  Port X5 .. X8: reserved

Internal error

Internal module error state of each channel (e.g. internal abnormal state).

Cross circuit

Discrepancy errors can only be shown if the *Input Sensor Analysis* is configured to "1oo1 with test pulse" or "1oo2 with test pulse". An error is shown if an input channel is connected to the wrong sensor supply, e.g. pin 4 is supplied by pin

	5, pin 2 is supplied by pin 1 or an external sensor supply is used.
Overload	Internal test pulse error, short circuit or overload between pin 1 (sensor supply channel A) or pin 5 (sensor supply channel B) and pin 3 (GND).
Discrepancy	Discrepancy errors can only be shown if the *Input Sensor Analysis* is configured to "1oo2 without test pulse" or "1oo2 with test pulse". An error is shown depending on the result of the equivalence or antivalence comparison. It is always shown as a port error with two identical status flags.

Attention: If a detected discrepancy error is present for at least 24 hours, the error can no longer be cancelled and the affected inputs remain invalid until the module is restarted.

11.3.3 Digital output diagnostics

Digital output diagnostics	Bit	7	6	5	4	3	2	1	0
Cross circuit readback	Byte 0	–	–	–	–	–	–	–	–
	Byte 1	–	–	–	–	12	11	10	9
Cross circuit test pulse	Byte 2	–	–	–	–	–	–	–	–
	Byte 3	–	–	–	–	12	11	10	9
Overload	Byte 4	–	–	–	–	–	–	–	–
	Byte 5	–	–	–	–	12	11	10	9

- 16DI module

  All bytes reserved since no safety digital outputs available

- Mixmodule

  Channel 1 .. 8: reserved

  Channel 9 .. 12: safety digital output diagnosis

  Channel 13 .. 16: reserved

The digital outputs on pin 4 and pin 2 are protected against short circuits and overloads. In case of a detected fault, the output is automatically switched to "inactive". If an error is detected, the dedicated channel LED lights up in red.

Attention: X5 .. X6 outputs are supplied by the U_L power.

Cross circuit readback	If a short circuit is detected, a channel error is shown in this field when the actuator **is connected** to its associated GND, e.g. the actuator is connected to pin 4 and pin 1 or to pin 2 and pin 5.
Cross circuit test pulse	If a short circuit is detected, a channel error is shown in this field when the actuator **is not connected** to its associated GND, e.g. the actuator **is not connected** to pin 4 and pin 1 or to pin 2 and pin 5.
Overload	If an overload is detected, a channel error is shown in this field.

11.3.4 Device diagnostics

Device diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	DST		SAL	SWA	IME	OVS	UVS	DTO
	Byte 1	EST							

DTO	Device Temperature Overrun

UVS	Undervoltage System/Sensor Supply
OVS	Overvoltage System/Sensor Supply
IME	Internal Module Error
SWA	Safety Warning
SAL	Safety Alarm
DST	Device State
EST	Extended Status

Extended Status – Error codes:

EXT_STATUS_NO_ERROR = 0x00

/* warnings (b6 = 0) */

EXT_STATUS_WARN_RCV_IO_CONFIG_INVALID = 0x05

EXT_STATUS_WARN_DPRAM_WRITE_NO_SLOT = 0x06

EXT_STATUS_WARN_DPRAM_GENERIC = 0x0F

EXT_STATUS_WARN_SEND_SYSTEM_INFO = 0x12

/* alarms (b6 = 1) */

EXT_STATUS_ALARM_SSO_ATTR_ID_INIT_NVM_CRC = 0x41

EXT_STATUS_ALARM_IO_CONFIG_INIT_NVM_CRC = 0x42

EXT_STATUS_ALARM_IO_CONFIG_WRONG_LENGTH = 0x4B

EXT_STATUS_ALARM_READ_NVM = 0x4C

EXT_STATUS_ALARM_SSO_ATTR_CRC_READBACK_NVM = 0x4D

EXT_STATUS_ALARM_IO_CONFIG_CRC_READBACK_NVM = 0x4E

EXT_STATUS_ALARM_IO_CONFIG_SSO_ATTR_READ_NVM = 0x50

EXT_STATUS_ALARM_IO_CONFIG_SSO_ATTR_READ_NVM = 0x50

11.4 Sample applications

The connection and configuration parameters of the device with its variable data sizes provides you an individual approach for realizing your application. The size of each IO-Link port can be determined which also has influence on the process data offsets.

The following application samples describe the process data assignments for the input and output data including the byte offsets. When there is no need to configure the data sizes, use the first sample to get the default byte offsets for your application. When you decide to reduce the data sizes to set them for example to the required IO-Link data lengths or you when do not need the extended status, have a look at the second sample to understand how the data mapping works.

For Rockwell Automation/Allen Bradley PLC customer, it is recommended to use an Add-On Instruction in Studio 5000® as an interface to the process data as described in chapter Add-On Instruction (AOI) on page 158.

11.4.1 Process data images – default configuration

The default configuration of the IO-Link port input and output data sizes is set to the maximum sizes in the EDS files. This means the user gets all data of each IO-Link port. The following tables provide you an overview of the data structures and the byte offsets for input and output data:

Connection parameters

Output data size	260
Input data size	446

Byte offset	Output data
0	Digital output channel control (2 bytes)
2	Reserved (2 bytes)
4	IO-Link port1 data (control, 32 bytes)
36	IO-Link port2 data (control, 32 bytes)
68	IO-Link port3 data (control, 32 bytes)
100	IO-Link port4 data (control, 32 bytes)
132	IO-Link port5 data (control, 32 bytes)
164	IO-Link port6 data (control, 32 bytes)
196	IO-Link port7 data (control, 32 bytes)
228	IO-Link port8 data (control, 32 bytes)

Table 12: Default output process data

Byte offset	Input data
0	Digital input channel status (2 bytes)
2	General diagnostics (2 bytes)
4	Sensor diagnostics (2 bytes)
6	Actuator diagnostics (2 bytes)
8	IO-Link diagnostics (6 bytes)
14	IO-Link port1 data (status, 32 bytes)
46	IO-Link port1 PQI (2 bytes)
48	IO-Link port1 extended status (8 bytes)
56	IO-Link port1 events (12 bytes)
68	IO-Link port2 data (status, 32 bytes)
100	IO-Link port2 PQI (2 bytes)
102	IO-Link port2 extended status (8 bytes)
110	IO-Link port2 events (12 bytes)
122	IO-Link port3 data (status, 32 bytes)
154	IO-Link port3 PQI (2 bytes)
156	IO-Link port3 extended status (8 bytes)

Byte offset	Input data
164	IO-Link port3 events (12 bytes)
176	IO-Link port4 data (status, 32 bytes)
208	IO-Link port4 PQI (2 bytes)
210	IO-Link port4 extended status (8 bytes)
218	IO-Link port4 events (12 bytes)
230	IO-Link port5 data (status, 32 bytes)
262	IO-Link port5 PQI (2 bytes)
264	IO-Link port5 extended status (8 bytes)
272	IO-Link port5 events (12 bytes)
284	IO-Link port6 data (status, 32 bytes)
316	IO-Link port6 PQI (2 bytes)
318	IO-Link port6 extended status (8 bytes)
326	IO-Link port6 events (12 bytes)
338	IO-Link port7 data (status, 32 bytes)
370	IO-Link port7 PQI (2 bytes)
372	IO-Link port7 extended status (8 bytes)
380	IO-Link port7 events (12 bytes)
392	IO-Link port8 data (status, 32 bytes)
424	IO-Link port8 PQI (2 bytes)
426	IO-Link port8 extended status (8 bytes)
434	IO-Link port8 events (12 bytes)

Table 13: Default input process data

11.4.2 Process data images with modified data sizes

The IO-Link port input and output data sizes and the existence of the extended status can be modified by the configuration assembly. This means the user can decide about which data is mapped to the process data. The following configuration tables provide you a sample and an overview of possible data structures and the byte offsets for input and output data:

Connection parameters

Output data size	62
Input data size	66

IO-Link Port1

Output data size	2 Byte
Input data size	2 Byte
Input data extension	No Data

IO-Link Port2

Output data size	32 Byte
Input data size	0 Byte
Input data extension	Extended Status

IO-Link Port3

Output data size	16 Byte
Input data size	4 Byte
Input data extension	Extended Status + Events

IO-Link Port4

Output data size	8 Byte
Input data size	2 Byte
Input data extension	No Data

IO-Link Port5 .. 8

Output data size	0 Byte
Input data size	0 Byte
Input data extension	No Data

Byte offset	Output data	Input data
0	Digital output channel control (2 bytes)	Digital input channel status (2 bytes)
2	Reserved (2 bytes)	General diagnostics (2 bytes)
4	IO-Link port1 data (control, 2 bytes)	Sensor diagnostics (2 bytes)
6	IO-Link port2 data (control, 32 bytes)	Actuator diagnostics (2 bytes)
8		IO-Link diagnostics (6 bytes)
10		
12		
14		IO-Link port1 data (status, 2 bytes)
16		IO-Link port1 PQI (2 bytes)
18		IO-Link port2 PQI (2 bytes)
20		IO-Link port2 extended status (8 bytes)
22		
24		
26		
28		IO-Link port3 data (status, 4 bytes)
30		
32		IO-Link port3 PQI (2 bytes)
34		IO-Link port3 extended status (8 bytes)
36		
38	IO-Link port3 data (control, 16 bytes)	
40		
42		IO-Link port3 events (12 bytes)
44		
46		
48		
50		
52		
54	IO-Link port4 data (control, 8 bytes)	IO-Link port4 data (status, 2 bytes)
56		IO-Link port4 PQI (2 bytes)

Byte offset	Output data	Input data
58		IO-Link port5 PQI (2 bytes)
60		IO-Link port6 PQI (2 bytes)
62		IO-Link port7 PQI (2 bytes)
64		IO-Link port8 PQI (2 bytes)
66		

Table 14: Modified process data

12 Safety Process data assignment

The LioN-Safety devices in general support safety process data communication, depending on the device variant, even in both directions. The consuming safety data in this context is defined as the process safety output data which controls physical outputs. The producing safety data in this context is defined as the process safety input data which contains the physical inputs and validity data.

The following chapters describe the safety data images for the consuming and producing data direction which are assigned to the safety output and input assemblies.

Assignment of channels	
Channel 1	Port X1.ChA
Channel 2	Port X1.ChB
[…]	[…]
Channel 15	Port X8.ChA
Channel 16	Port X8.ChB

12.1 Consuming Safety data image (output)

Safety output data frame	Safety digital output channel control
Consuming data size	2 Byte, INT

The complete *Safety output data frame* has a fix size of 2 Bytes.

The following chapters describe the bit assignment.

12.1.1 Safety digital output channel control

Digital output channel control	Bit	7	6	5	4	3	2	1	0
Channel number	Byte 0	–	–	–	–	–	–	–	–
	Byte 1	–	–	–	–	12	11	10	9

12.2 Producing Safety data image (input)

Safety input data frame	Safety digital input channel status	Safety digital I/O validity
Producing data size	2 Byte, INT	2 Byte, INT

The complete *Safety input data frame* has a fix size of 4 Bytes.

The following chapters describe the bit assignment.

12.2.1 Safety digital input channel status

Digital input channel status	Bit	7	6	5	4	3	2	1	0
Channel number	Byte 0	8	7	6	5	4	3	2	1
	Byte 1	16	15	14	13	12	11	10	9

- 16DI module

  Channel 1 .. 16: safety digital input status

- Mixmodule

  Channel 1 .. 8: safety digital input status

  Channel 9 .. 16: reserved

12.2.2 Safety digital I/O validity

Digital I/O validity	Bit	7	6	5	4	3	2	1	0
Channel number	Byte 0	8	7	6	5	4	3	2	1
	Byte 1	16	15	14	13	12	11	10	9

- 16DI module

  Channel 1 .. 16: safety digital input validity

- Mixmodule

  Channel 1 .. 8: safety digital input validity

  Channel 9 .. 12: safety digital output validity

  Channel 13 .. 16: reserved

13 Functional Safety I/O modes

13.1 SDI modes overview

The following Safety levels can be reached for the Safety digital input ports of the modules 0980 SSL 3131-121-007D-202 and 0980 SSL 3130-121-007D-202. Refer to the referenced chapters in the table below for detailed information and the requirements for reaching the respective Safety level.

Up to Safety level	Configuration settings			
	Setting options	**Input sensor analysis**	**Input port config**	**Valence**
SIL 2, PL d, Cat. 2 (with external test interval) on page 111	Setting 1	1oo1 without clock signal	'Safe'	NA
	Setting 2	1oo2 without clock signal	'Safe'	'Antivalence'
SIL 2, PL d, Cat. 2 on page 115	Setting 1	1oo2 with clock signal	'Safe'	'Antivalence'
	Setting 2	1oo1 with clock signal	'Safe'	NA
SIL 3, PL d, Cat. 3 (with external test interval) on page 119	–	1oo2 without clock signal	'Safe'	'Equivalence'
SIL 3, PL e, Cat. 4 on page 121	–	1oo2 with clock signal	'Safe'	'Equivalence'

Table 15: SDI modes

- For the SIL (Safety Integration Level) specification, refer to IEC 61508 Parts 1-7:2010.
- For the PL (Performance Level) and Cat. (Category), refer to EN ISO 13849-1:2015 / EN ISO 13849-1:2023.

- Refer also to chapter Safety Configuration parameters on page 81 for parameter settings via an engineering tool or the Belden CIP Safety Configurator.

13.1.1 SIL 2, PL d, Cat. 2 (with external test interval)

For reaching this functional safety level there are **two settings** possible.

For **Setting 1**, the following configuration must be set:

- Input sensor analysis:

  '1oo1 without clock signal' – In this mode, the Pin1 and Pin5 sensor supplies of a digital input port will **not be switched off** for functional hardware tests.

  Both input channels A and B can be used independently.
- Input port config:

  'Safe'
- Input port sensor valence:

  Not applicable (is not evaluated)

Danger: In order to achieve PL d for the application, the machine control must carry out an average diagnostic measure. This can be achieved by testing the safety function inside the application by dynamically switching off the input signals and by checking this procedure based on the transmitted input status in the machine control. The diagnostic test interval must be less than the required response time or at least a 100 times the expected request rate of the application. Without this diagnostic test interval, only PL c will be reached.

With this configuration **no cross-fault detection** is provided!

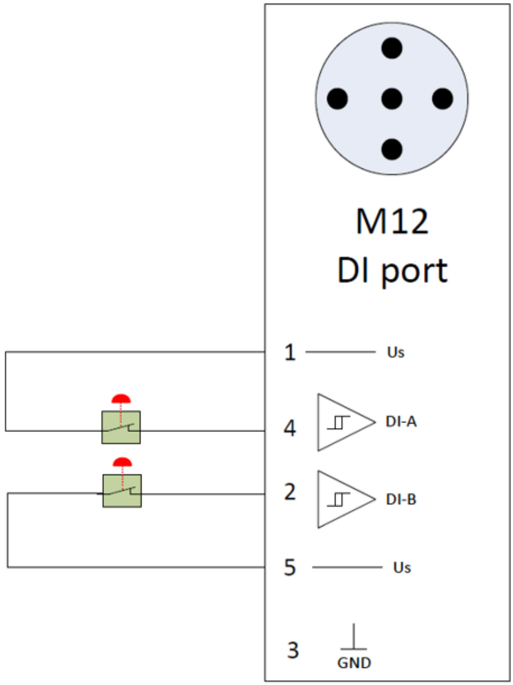


Figure 9: Internal SDI block diagram

Module variant	Available channels in this mode
0980 SSL 3131-121-007D-202	up to 8
0980 SSL 3130-121-007D-202	up to 16

Table 16: Available channels

For **Setting 2**, the following configuration must be set:

- Input sensor analysis:

  '1oo2 without clock signal' – In this mode, the Pin1 and Pin5 sensor supplies of a digital input port will **not be switched off** for functional hardware tests.

  Both input channels A and B will be used for one-bit information of the digital input represented in the channel A bit and mirrored in the channel B bit. Depending on the 'Antivalence' set in *Input port sensor valence*, both input channels must have the opposite status for a valid input status on the channel A bit.
- Input port config:

  'Safe'
- Input port sensor valence:

  'Antivalence'

Danger: In order to achieve PL d for the application, the machine control must carry out an average diagnostic measure. This can be achieved by testing the safety function inside the application by dynamically switching off the input signals and by checking this procedure based on the transmitted input status in the machine control. The diagnostic test interval must be less than the required response time or at least a 100 times the expected request rate of the application. Without this diagnostic test interval, only PL c will be reached.

With this configuration **no cross-fault detection** is provided!

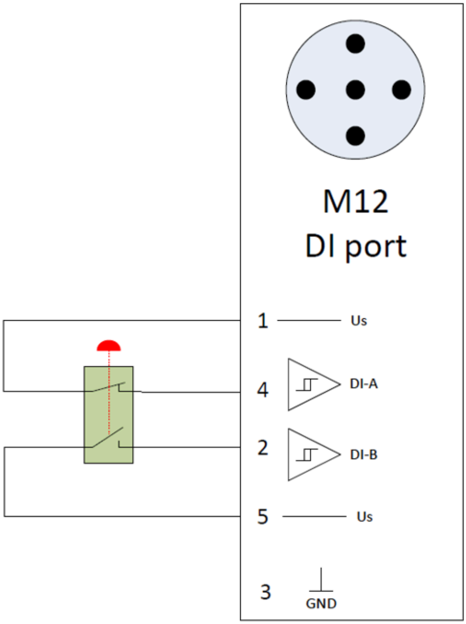


Figure 10: Internal SDI block diagram

Module variant	Available channels in this mode
0980 SSL 3131-121-007D-202	up to 4
0980 SSL 3130-121-007D-202	up to 8

Table 17: Available channels

13.1.2 SIL 2, PL d, Cat. 2

For reaching this functional safety level there are **two settings** possible.

For **Setting 1**, the following configuration must be set:

- Input sensor analysis:

  '1oo2 with clock signal' – In this mode, the Pin1 and Pin5 sensor supplies of a digital input port will **be switched off** for functional hardware tests.

  Both physical input channels A and B will be used for one-bit information of the digital input represented in the channel A bit and mirrored in the channel B bit.
- Input port config:

  'Safe'
- Input port sensor valence:

  'Antivalence' – Both input channels must have the opposite status for a valid input status on the channel A bit.

The diagnostic test interval is 108 ms for module variant 0980 SSL 3x31-121... and 204 ms for module variant 0980 SSL 3x30-121... . The required response time must be equal or higher than T_D, or the expected request rate of the application must be at least a 100 times higher than T_D.

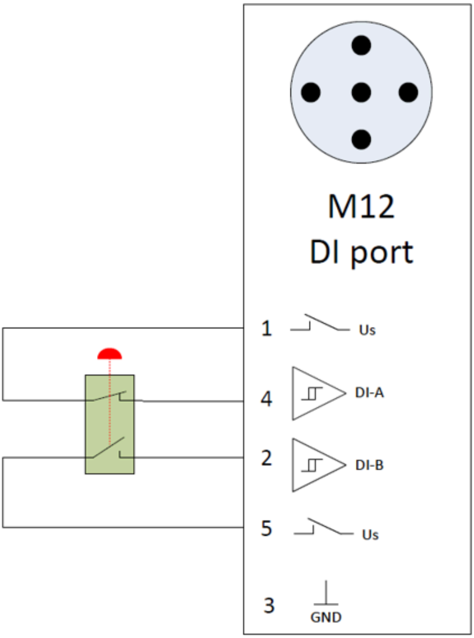


Figure 11: Internal SDI block diagram

Module variant	Available channels in this mode
0980 SSL 3131-121-007D-202	up to 4
0980 SSL 3130-121-007D-202	up to 8

Table 18: Available channels

<u>For **Setting 2**, the following configuration must be set:</u>

- Input sensor analysis:

  '1oo1 with clock signal' – In this mode, the Pin1 and Pin5 sensor supplies of a digital input port will **be switched off** cyclically for functional hardware tests.

  The diagnostic test interval is 108 ms for module variant 0980 SSL 3x31-121... and 204 ms for module variant 0980 SSL 3x30-121... . The required response time must be equal or higher than T_D, or the expected request rate of the application must be at least a 100 times higher than T_D.

  Both input channels A and B can be used independently.
- Input port config:

  'Safe'
- Input port sensor valence:

  Not applicable (is not evaluated)

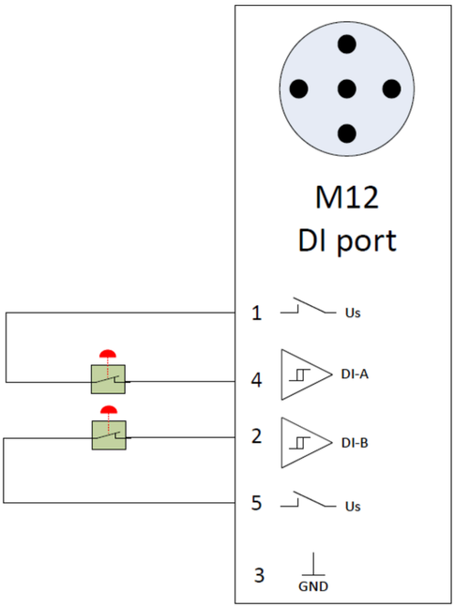


Figure 12: Internal SDI block diagram

Module variant	Available channels in this mode
0980 SSL 3131-121-007D-202	up to 8
0980 SSL 3130-121-007D-202	up to 16

Table 19: Available channels

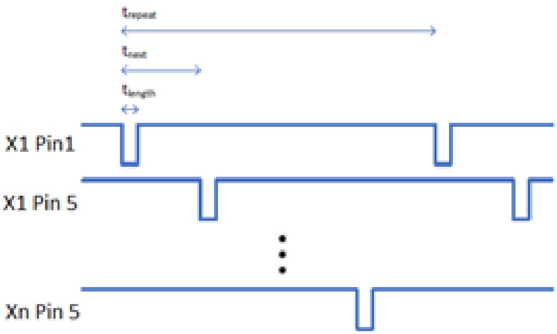


Figure 13: Diagram: SDI test pulse timing

t_{length} = 0.5 ms

t_{next} = 32 ms

t_{repeat} = 256 ms (0980 SSL3131-121-007D-202, n = 8)

t_{repeat} = 512 ms (0980 SSL3130-121-007D-202, n = 16)

13.1.3 SIL 3, PL d, Cat. 3 (with external test interval)

For reaching this functional safety level the following configuration must be set:

- Input sensor analysis:

  '1oo2 without clock signal' – In this mode, the Pin1 and Pin5 sensor supplies of a digital input port will **not be switched off** for functional hardware tests.

  Both physical input channels A and B will be used for one-bit information of the digital input represented in the channel A bit and mirrored in the channel B bit. Depending on the 'Equivalence' set in *Evaluation Configuration*, both input channels must be equal for a valid input status on the channel A bit.
- Input port config:
- 'Safe'
- Input port sensor valence:
- 'Equivalence'

Danger: In order to achieve PL d for the application, the machine control must carry out an average diagnostic measure. This can be achieved by testing the safety function inside the application by dynamically switching off the input signals and by checking this procedure based on the transmitted input status in the machine control. The diagnostic test interval T_D must be < or = 24 h.

With this configuration **no cross-fault detection** is provided!

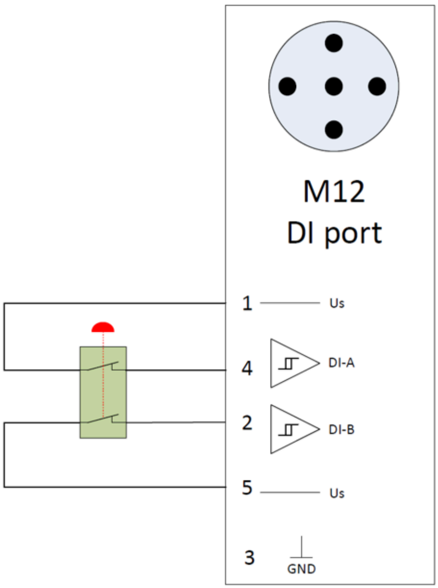


Figure 14: Internal SDI block diagram

Module variant	Available channels in this mode
0980 SSL 3131-121-007D-202	up to 4
0980 SSL 3130-121-007D-202	up to 8

Table 20: Available channels

13.1.4 SIL 3, PL e, Cat. 4

For reaching this functional safety level the following configuration must be set:

- Input sensor analysis:
- '1oo2 with clock signal' – In this mode, the Pin1 and Pin5 sensor supplies of a digital input port will **be switched off** for functional hardware tests.

  Both physical input channels A and B will be used for one-bit information of the digital input represented in the channel A bit and mirrored in the channel B bit.
- Input port config:

  'Safe'
- Input port sensor valence:

  'Equivalence' – Both input channels must have the same status for a valid input status on the channel A bit.

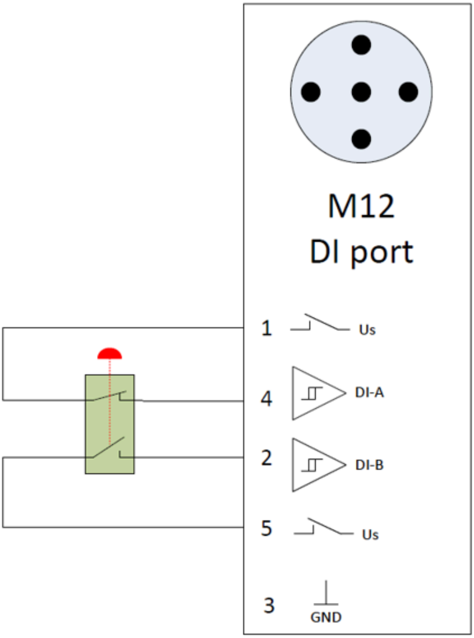


Figure 15: Internal SDI block diagram

Module variant	Available channels in this mode
0980 SSL 3131-121-007D-202	up to 4
0980 SSL 3130-121-007D-202	up to 8

Table 21: Available channels

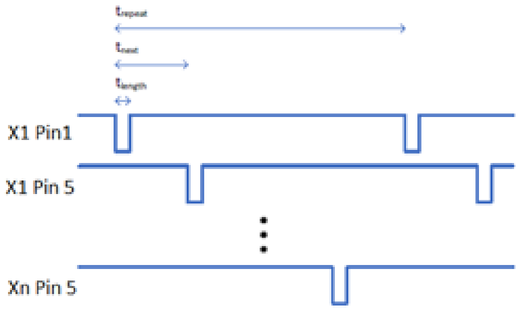


Figure 16: Diagram: SDI test pulse timing

t_{length} = 0.5 ms

t_{next} = 32 ms

t_{repeat} = 256 ms (0980 SSL3131-121-007D-202, n = 8)

t_{repeat} = 512 ms (0980 SSL3130-121-007D-202, n = 16)

13.2 SDO modes overview

Only the module variant 0980 SSL3131-121-007D-202 provides safety digital output ports.

For the safety digital outputs, the mode to select depends on the wiring of the connected actuators.

Safety level	SDO concept (1oo2)	GND UL testing	Chapter
SIL 3, PL e, Cat. 4	Two redundant SDOs	Without	SIL 3, PL e, Cat. 4 with two redundant SDOs on page 125
SIL 3, PL e, Cat. 4	Two redundant actuators	With	SIL 3, PL e, Cat. 4 with two redundant actuators on page 126

Table 22: F-DO modes

The following schematic illustration shows the internal safety relevant testing capabilities:

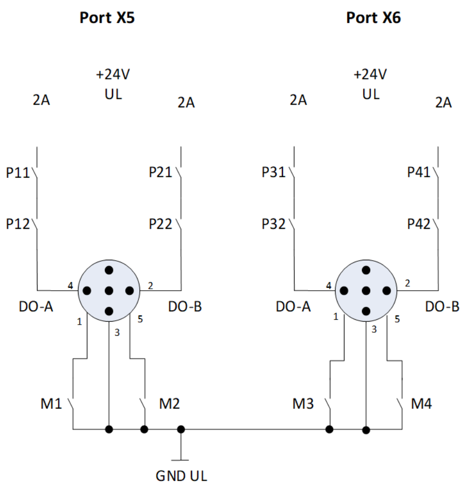


Figure 17: Schematic illustration of the DO functionality

The pulse width for the test switches must be configured in dependency of the used actuators. Refer to chapter Safety Configuration parameters on page 81 for test pulse configuration and the appropriate test pulse timing in dependency of the setting.

13.2.1 SIL 3, PL e, Cat. 4 with two redundant SDOs

In this mode the Safety controller must control two outputs redundantly. The GND connection on Pin 3 must be used. There is no internal testing mechanism on the Pin 3 GND.

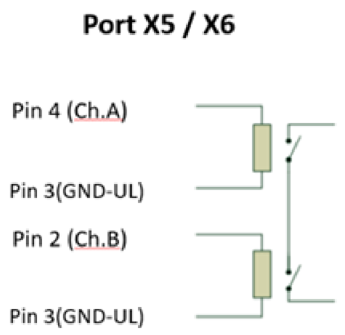


Figure 18: Schematic illustration with two redundant SDOs

Module variant	Available channels in this mode
0980 SSL 3131-121-007D-202	up to 2

Table 23: Available channels in redundant outputs mode

13.2.2 SIL 3, PL e, Cat. 4 with two redundant actuators

In this mode two actuators must be used redundantly on one SDO. The internal tested GND on Pin 1 for the SDO channel A and Pin 5 for the SDO channel B must be used in this mode.

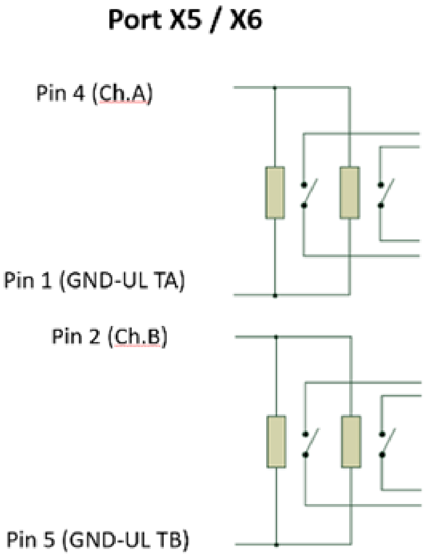


Figure 19: Schematic illustration with two redundant actuators

Module variant	Available channels in this mode
0980 SSL 3131-121-007D-202	up to 4

Table 24: Available channels in redundant actuators mode

Attention: If the switched UL_GND potential (DO_Nx) is disconnected in the event of a detected fault, the connected actuators must assume the safe state. It must be ensured that the actuators do not draw the UL_GND potential from another location.

14 Configuration and operation with Rockwell Automation Studio 5000®

The configuration and start-up of the devices described on the following pages refers to Rockwell Automation Studio 5000®, V33. If you are using an engineering tool from another provider, please consider the related documentation.

14.1 Basic and Safety commissioning

The commissioning of a Safety module can be done via configuration by an EDS file or with the help of the external Belden CIP Safety Configurator tool. Regardless of the approach, a Safety connection can only be established by a PLC when the I/O module has been configured completely.

During this configuration process, the TUNID with its NodeID and time stamp shall be set before transferring the Safety configuration. At the end of this process the Safety configuration is verified by a CRC checksum. If this check is successful, the device goes to the Idle state so that a connected PLC is able to establish a Safety connection.

Attention:

- Before installing on a Safety network, the user must commission all Safety devices with a NodeID (IP address). These can be set using the rotary switches or be received via a DHCP server (SRS53).
- If the TUNID is already set in the LioN-Safety module, the IP address must match the NodeID of the stored TUNID. Otherwise, safety communication cannot be established and the device is in an aborted state. In the event of a mismatch, a factory reset must be performed and a new TUNID must be set.
- Before installing on a Safety network, the user must clear all pre-existing configurations from all Safety devices (SRS52).
- The replacement of Safety devices requires that the replacement device must be configured properly and the operation of the replacement device shall be user verified (FRS112).

- Safety function implementers must carefully consider the implications of mixing different SIL level devices on the network (SRS54).
- LEDs are NOT reliable indicators and cannot be guaranteed to provide accurate information. They should ONLY be used for general diagnostics during commissioning or troubleshooting. Do not attempt to use LEDs as operational indicators (SRS105).

14.1.1 EDS configuration

Perform the following working steps:

1. Create a new project in Studio 5000®.

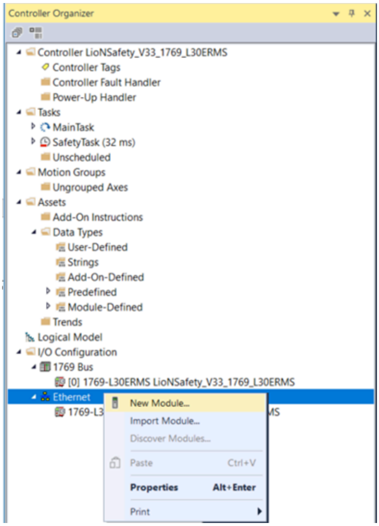
2. Select the correct Safety controller.

3. When no integrated EtherNet/IP interface is available, add the proper communication interface to your backplane under **Controller Organizer** > **I/O-Configuration**.

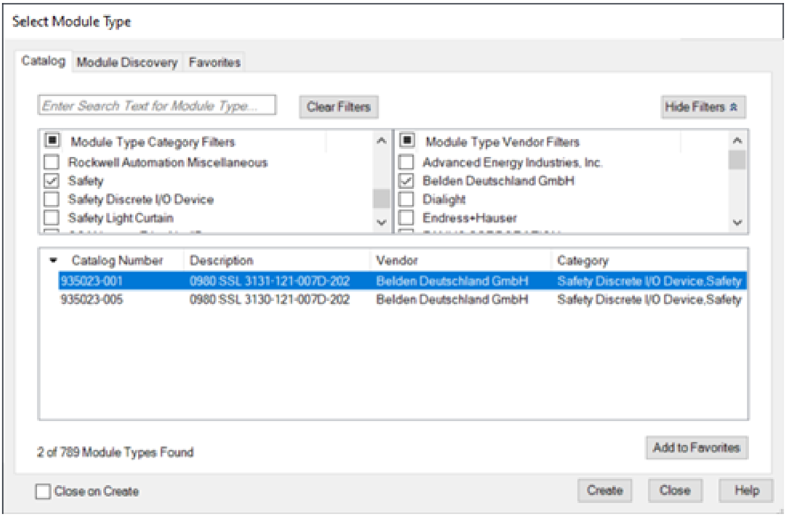
4. Set a communication path to enable the project download.

5. Install the EDS files of the LioN-Safety devices in Studio 5000® with the EDS hardware installation tool.

6. Go to **Controller Organizer** > **I/O-Configuration** and right-click the Ethernet interface.

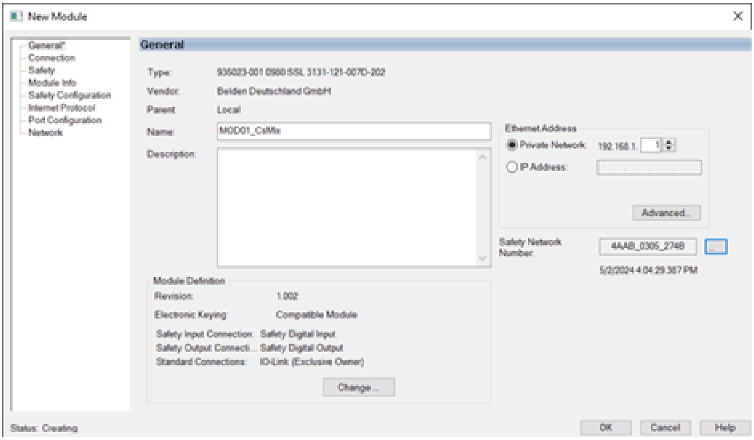


7. Select **New Module** in the menu. The following selection window opens:



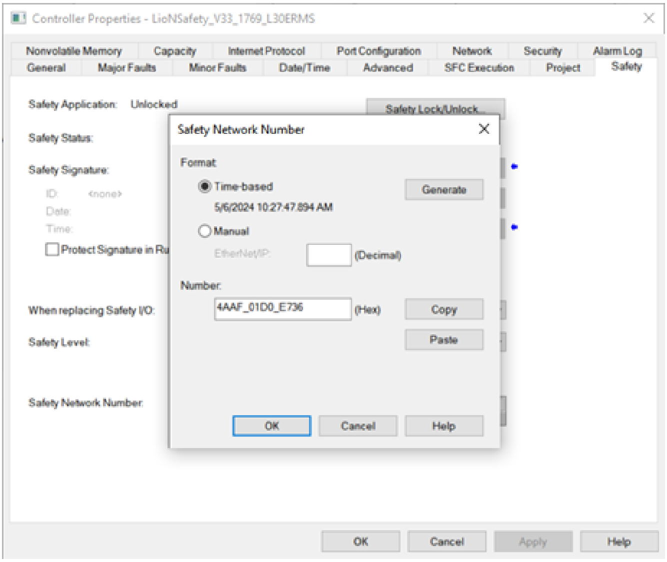
8. Use the **Module Type Category Filter** on the left side to display only Safety devices of Belden Deutschland GmbH.

9. Select the device you wish to add and click on **Create**.



10. Enter a name for the device and set the chosen IP address. In this example, the name is **MOD01_CsMix** and the IP address is **192.168.1.1**.

11. Check if the Safety network number is the same as in the EtherNet/IP controller. For the establishment of a Safety connection it is not mandatory that both numbers match. If needed, the number can be copied from the Safety parameters of the controller properties.

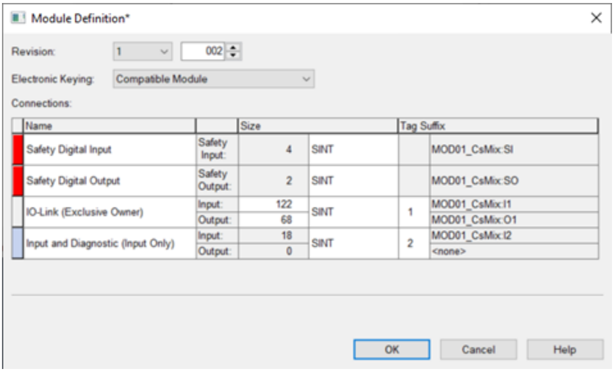


Attention:

- The user should assign SNN numbers for each Safety network or Safety sub-net that are unique across the system (FRS154).
- Originators that have an “automatic” SNN setting feature should only use that feature when the Safety system is not being relied upon (SRS193).

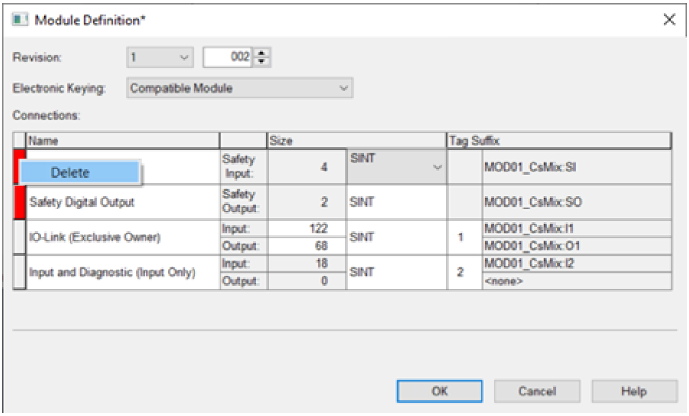
12. Click on **Change** in order to change the settings for the device revision, electronic keying and connection types.

The revision is determined by the EDS file and should not be changed by the user. The *Electronic Keying* should not be disabled to help ensure that only connections are established to modules that match the vendor ID, product code, device type and revision. Therefore, it is recommended to use the settings "Compatible Module" or "Exact Match".

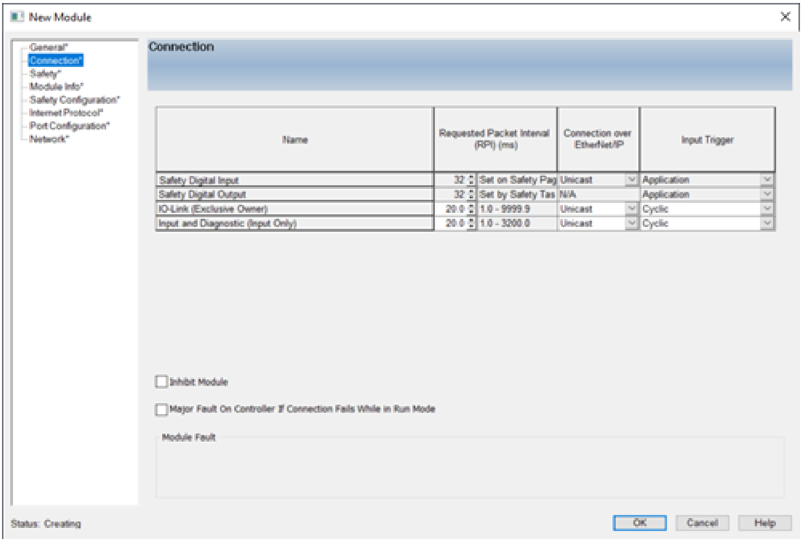


13. Select the needed Safety (red) and non-safe (grey) connections. For the optional IO-Link connection configure the total sizes of the input and outputprocess data. The sizes depend on the number of connected IO-Link devices and their data lengths of both directions. Each device input and output data size must also be set later in the IO-Link port configuration. The selection of the data type refers to the type in which Studio 5000® maps the input and output data. The default data type is SINT. The INT type is selectable when each size is a multiple of 2. The DINT type is selectable when each size is a multiple of 4. Check the Tag Suffixes to get the information in which tags the Safety and non-safe process data is mapped.

14. As default, all available Safety connections and the first non-safe connection of the module are shown. Single connections can be removed by right-clicking on the red or grey rectangle left-hand side of each row.



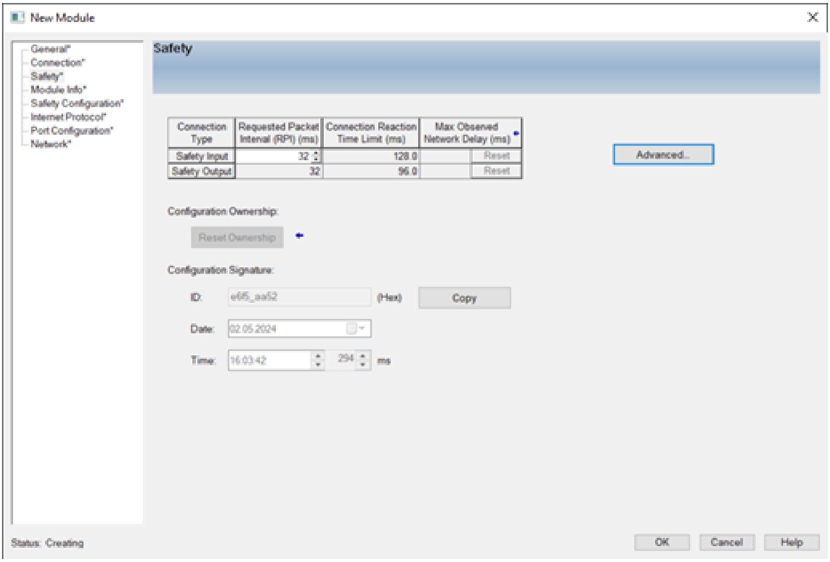
15. Click on **OK**. In the **Connection** section of the **Module Properties**, you see all selected connections. This section also lets you define the **Requested Packet Interval (RPI)** and the EtherNet/IP connection type of the non-safe connections. A value of 1 ms is the minimum for parameter RPI; the connection types *Unicast* or *Multicast* can be chosen. The **Requested Packet Interval (RPI)** of the safety connections can be set depending on the type in the Safety section or via the Safety Task.



16. The Safety section provides the configuration signature (SCID) with CRC checksum and time stamp of the Safety configuration. In Studio 5000®, an EDS configuration requires a Configuration Signature. Other engineering tools may only offer this as optional. Setting the Configuration Signature is not mandatory, but is recommended for Safety reasons.

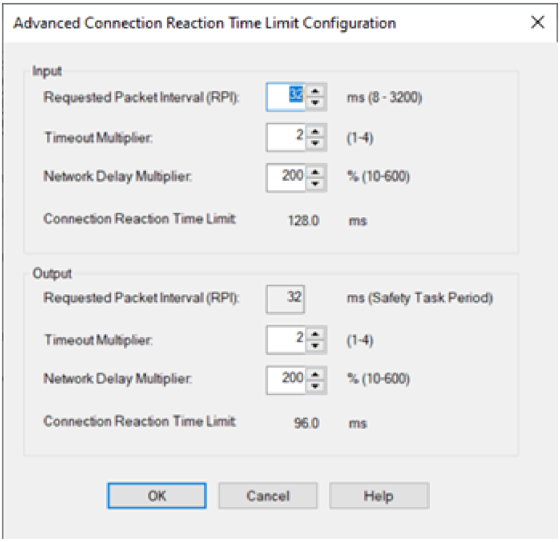
Attention: If you choose to configure Safety connections with an SCID = 0 (Configuration Signature disabled), you are responsible for ensuring that originators and targets have the correct configurations (FRS103).

The **Requested Packet Interval (RPI)** of the Safety input connection can be modified here. The **Requested Packet Interval (RPI)** of the Safety output connection can be directly modified in the properties of the Safety Task. The recommended RPI value for each Safety connection is 32 ms.

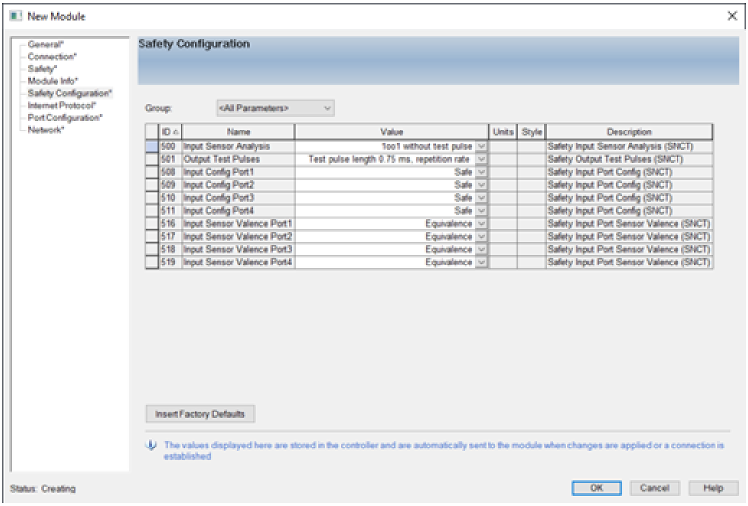


17. Some detailed Safety settings can be done via the *Advanced Connection Reaction Time Limit Configuration* by clicking the **Advanced** button on the right side. Modifying the *Timeout and Network Delay Multiplier* calculates in combination with the RPI the *Connection Reaction Time Limit* of each Safety connection. This value shall not be less than the "Max. Observed Network Delay (ms)" for getting a stable Safety connection without any interruptions. The "Max. Observed Network Delay (ms)" holds the max. data age of the Safety communication packets and is displayed when online in the Safety section.

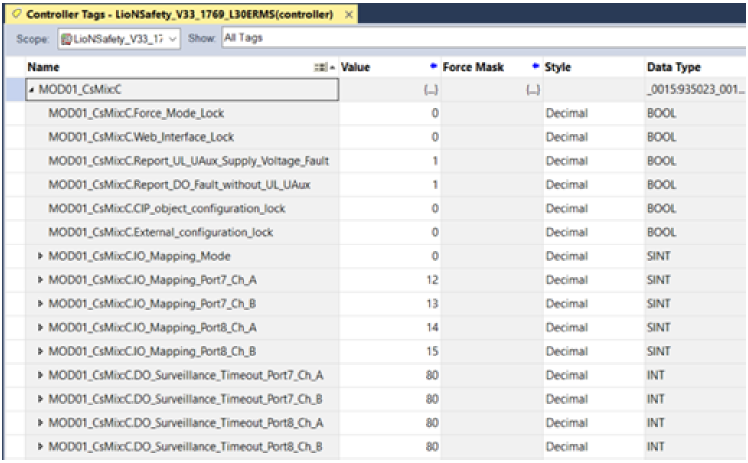
Attention: Changes to the values of the *Advanced Connection Reaction Time Limit Configuration* are not recommended as they will affect the module reaction time and the stablitiy of the Safety connections. You are responsible for helping ensure that the connections are in a stable condition. Further details are described in chapter Safety connection reaction time limits on page 155.



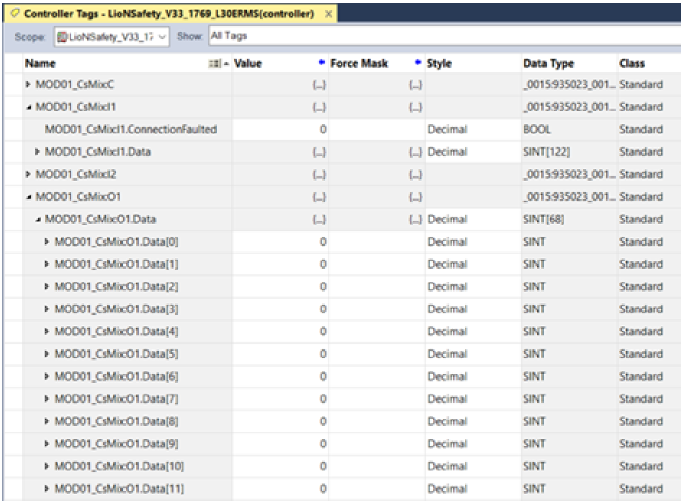
18. The Safety parameters of the I/O module can be changed in the section **Safety Configuration**. These will be stored in the PLC and are automatically sent to the I/O module when changes are applied during the establishment of a Safety connection. Every change of a parameter updates the CRC checksum and the timestamp of the Configuration Signature (SCID) which is shown in the Safety section.



19. Apply the settings and move to **Controller-Tags** in **Controller Organizer**. The controller tags for the non-safe IO-Link configuration parameters contain the name of the device, followed by a "**:C**". The configuration parameters can be set under **Value** and are described in chapter IO-Link Configuration parameters on page 53.

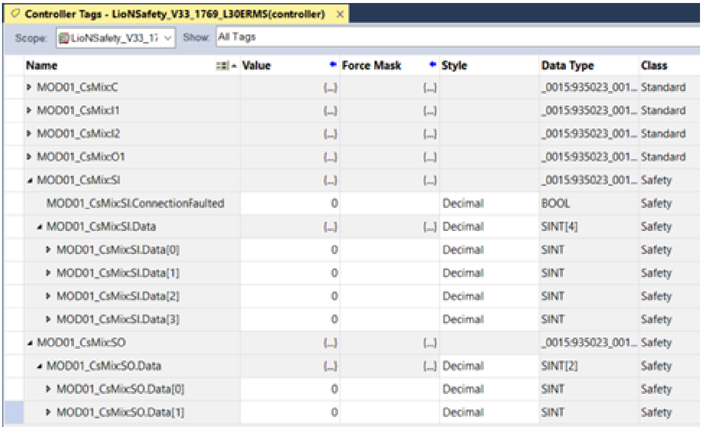


20. The tag of the non-safe IO-Link input process data contains the name of the device, followed by a "**:IX.Data**" (X = Tag Suffix). The output process data has the same name followed by a "**:OX.Data**" (X = Tag Suffix). Both arrays show its configured data sizes. The content of them is described in chapter Non-Safe Process data assignment on page 88.


Controller Tags - LioNSafety_V33_1769_L30ERMS(controller)
Scope: LioNSafety_V33_17 Show: All Tags

Name	Value	Force Mask	Style	Data Type	Class
MOD01_CsMixC	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixI1	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixI1.ConnectionFaulted	0		Decimal	BOOL	Standard
MOD01_CsMixI1.Data	{...}	{...}	Decimal	SINT[122]	Standard
MOD01_CsMixI2	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixO1	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixO1.Data	{...}	{...}	Decimal	SINT[68]	Standard
MOD01_CsMixO1.Data[0]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[1]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[2]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[3]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[4]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[5]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[6]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[7]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[8]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[9]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[10]	0		Decimal	SINT	Standard
MOD01_CsMixO1.Data[11]	0		Decimal	SINT	Standard

21. The tag of the Safety input process data contains the name of the device, followed by a "**:SI.Data**". The output process data has the same name followed by a "**:SO.Data**". The content of them is described in chapter Safety Process data assignment on page 107.

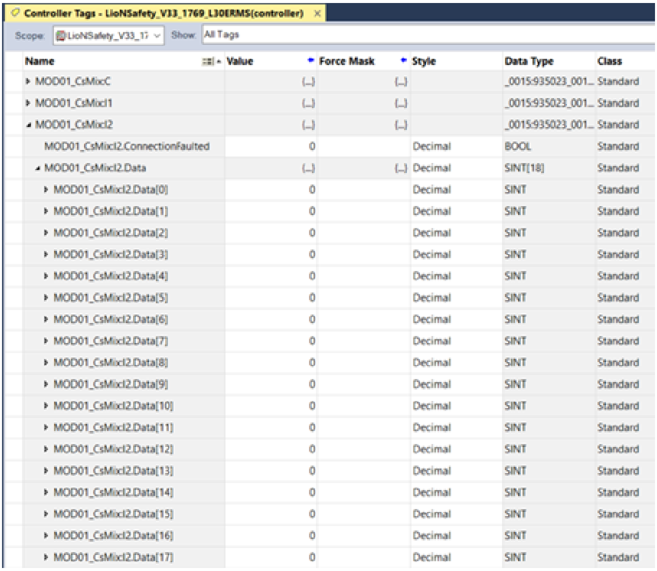


Controller Tags - LioNSafety_V33_1769_L30ERMS(controller)

Scope: LioNSafety_V33_17 Show: All Tags

Name	Value	Force Mask	Style	Data Type	Class
MOD01_CsMixC	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixI1	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixI2	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixO1	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixSI	{...}	{...}		_0015:935023_001...	Safety
MOD01_CsMixSI.ConnectionFaulted	0		Decimal	BOOL	Safety
MOD01_CsMixSI.Data	{...}	{...}	Decimal	SINT[4]	Safety
MOD01_CsMixSI.Data[0]	0		Decimal	SINT	Safety
MOD01_CsMixSI.Data[1]	0		Decimal	SINT	Safety
MOD01_CsMixSI.Data[2]	0		Decimal	SINT	Safety
MOD01_CsMixSI.Data[3]	0		Decimal	SINT	Safety
MOD01_CsMixSO	{...}	{...}		_0015:935023_001...	Safety
MOD01_CsMixSO.Data	{...}	{...}	Decimal	SINT[2]	Safety
MOD01_CsMixSO.Data[0]	0		Decimal	SINT	Safety
MOD01_CsMixSO.Data[1]	0		Decimal	SINT	Safety

22. The tag of the input and diagnostic process data contains the name of the device, followed by a "**:IY.Data**" (Y = Tag Suffix). The content of it is described in chapter Producing Input and Diagnostic image of safety submodule on page 96.



Controller Tags - LioNSafety_V33_1769_L30ERMS(controller)

Scope: LioNSafety_V33_17 Show: All Tags

Name	Value	Force Mask	Style	Data Type	Class
MOD01_CsMixC	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixI1	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixI2	{...}	{...}		_0015:935023_001...	Standard
MOD01_CsMixI2.ConnectionFaulted	0		Decimal	BOOL	Standard
MOD01_CsMixI2.Data	{...}	{...}	Decimal	SINT[18]	Standard
MOD01_CsMixI2.Data[0]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[1]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[2]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[3]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[4]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[5]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[6]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[7]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[8]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[9]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[10]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[11]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[12]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[13]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[14]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[15]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[16]	0		Decimal	SINT	Standard
MOD01_CsMixI2.Data[17]	0		Decimal	SINT	Standard

23. When the configuration is completed, the parameters can be downloaded to the EtherNet/IP controller. During the connection establishment, the EtherNet/IP controller automatically sets the TUNID in the I/O module, transfers the Safety configuration and validates the Configuration Signature before cyclic process data is exchanged.

Attention:

- The Safety configuration parameters must be downloaded to the target so they can be tested and verified. Only then, SCIDs from the target can be confirmed (SRS44).
- To help ensure that all industrial plant parameters are configured as required, all downloads must be validated by user testing (SRS42).
- The Configuration Signature should only be considered as "verified" after user testing (SRS43).
- The user must test the Safety connection configurations after they have been applied in an originator to confirm that the target connection is operating as intended (SRS92).
- The user must visually verify that all configuration data was downloaded correctly (SRS204).
- The user must verify that all originator-configured Safety devices have their ownership assignments as part of the final verification process (SRS203).

If the Safety connection establishment is rejected, the displayed error code can be looked up in Safety error codes on page 304.

14.1.2 Generic configuration

Perform the following working steps:

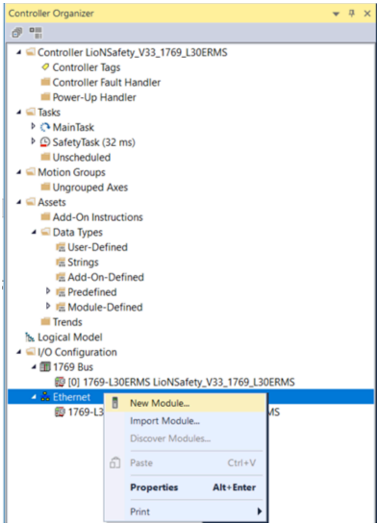
1. Create a new project in Studio 5000®.

2. Select the correct Safety controller.

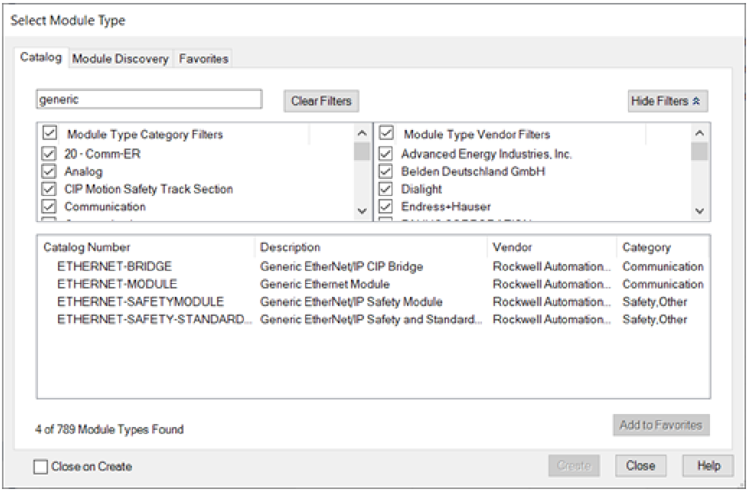
3. When no integrated EtherNet/IP interface is available, add the proper communication interface to your backplane under **Controller Organizer** > **I/O-Configuration**.

4. Set a communication path to enable the project download.

5. Go to **Controller Organizer** > **I/O-Configuration** and right-click the Ethernet interface.

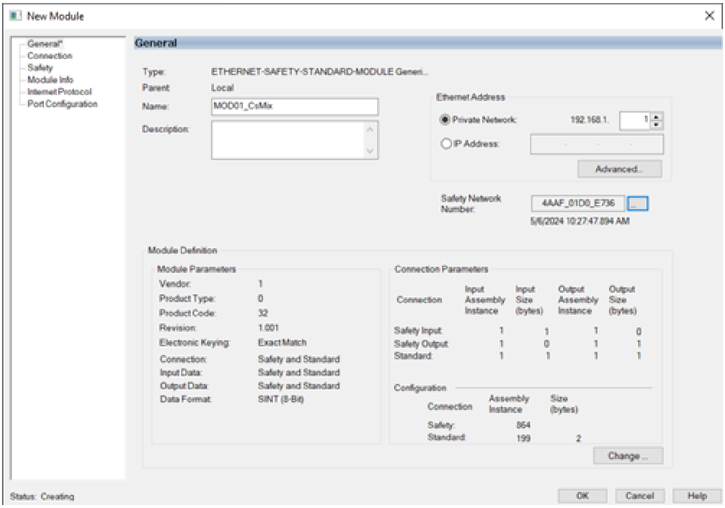


6. Select **New Module** in the menu. The following selection window opens:



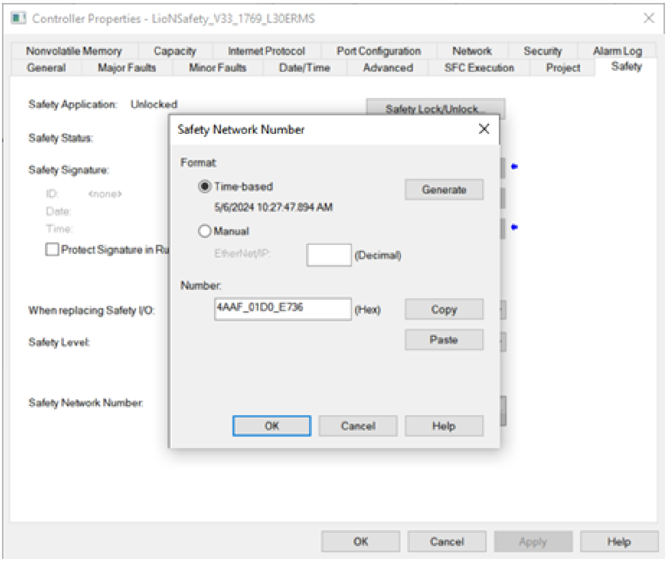
7. Put the term "generic" into the **search field** to filter for generic modules.

8. Select the desired *Generic EtherNet/IP Safety Module* or *Generic EtherNet/IP Safety and Standard Module* from vendor *Rockwell Automation* and click on **Create**.



9. Enter a name for the device and set the chosen IP address. In this example, the name is **MOD01_CsMix** and the IP address is **192.168.1.1**.

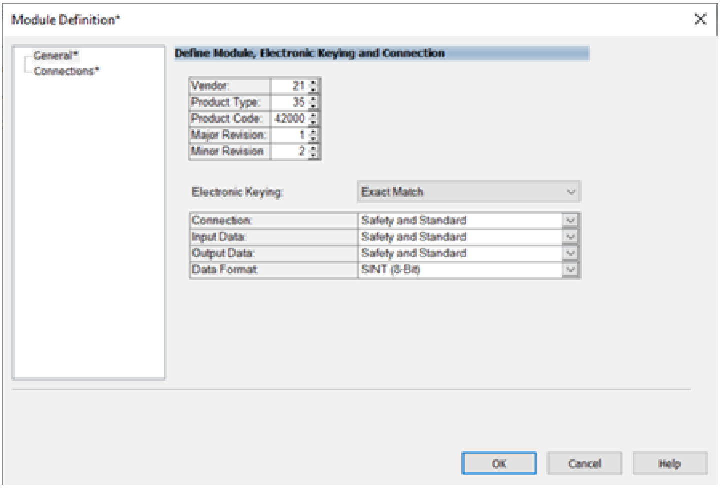
10. Check if the Safety network number is the same as in the EtherNet/IP controller. For the establishment of a Safety connection it is not mandatory that both numbers match. If needed, the number can be copied from the Safety parameters of the controller properties.



Attention:

- The user should assign SNN numbers for each Safety network or Safety sub-net that are unique across the system (FRS154).
- Originators that have an “automatic” SNN setting feature should only use that feature when the Safety system is not being relied upon (SRS193).

11. Click on **Change** in order to change the settings for the module and the connection parameters.

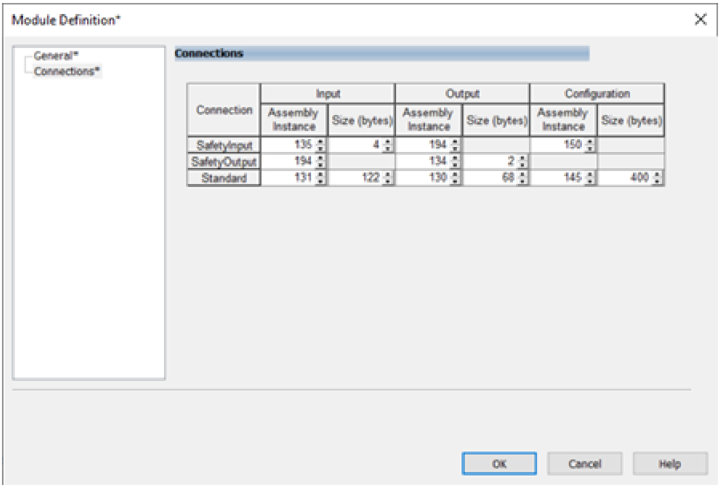


12. Insert the following module parameters:

Parameter	Value
Vendor	`21`
Product Type	`35`
Product Code	`42000` for LioN-Safety 8/4-F-DI, 4-F-DO, 2-IOLM M12 (0980 SSL 3131-121-007D-202), or `42001` for LioN-Safety 16/8-F-DI M12 (0980 SSL 3130-121-007D-202)
Major Revision	`1`
Minor Revision	`2`

The *Electronic Keying* should not be disabled to help ensure that only connections are established to modules that match the vendor ID, product code, device type and revision. Therefore, it is recommended to use the settings "Compatible Module" or "Exact Match".

13. Click on **Connections** in order to change the settings for the connection parameters.



14. Insert the following connection parameters:

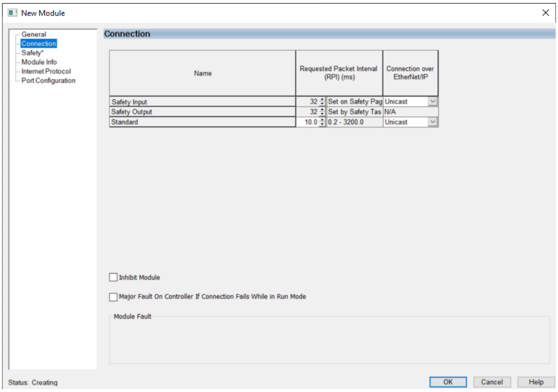
SafetyInput:	Input Assembly 135, Size 4, Output Assembly 194, Configuration Assembly 150
SafetyOutput:	Input Assembly 194, Output Assembly 134, Size 2

The Safety Output Connection is only available for LioN-Safety 8/4-F-DI, 4-F-DO, 2-IOLM M12 (0980 SSL 3131-121-007D-202) and can be deactivated in section **General**.

The Standard Connection is optional and can also be deactivated in section **General**. In the given example the IO-Link (Exclusive Owner) Connection is configured. See chapter Non-safe connections on page 47 for all available Standard Connections.

15. Apply the settings for the module and connection parameters.

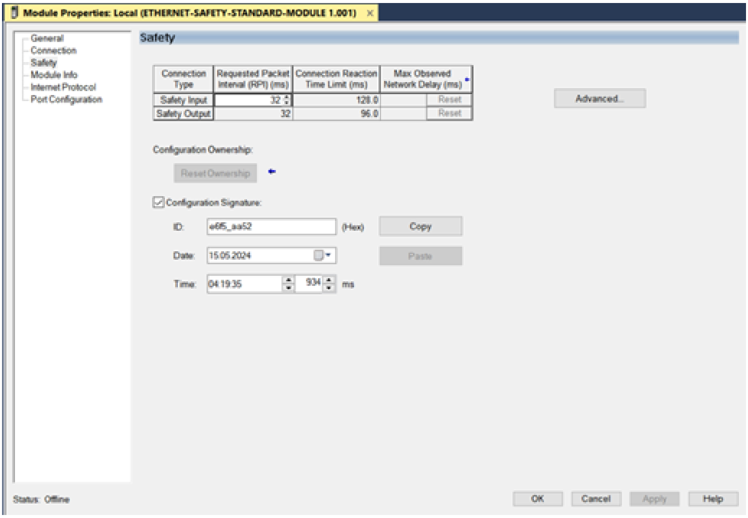
16. Click on **Connection** to see the connection properties. The Safety Input connection only supports a *Unicast* connection. The type for the Standard Connection can be set to *Multicast* and the **Requested Packet Interval (RPI)** to another value.



17. Click on **Safety** to show the Safety properties. The **Requested Packet Interval (RPI)** of the Safety input connection can be modified here. The **Requested Packet Interval (RPI)** of the Safety output connection can be directly modified in the properties of the Safety Task. The recommended RPI value for each Safety connection is 32 ms.

The Safety parameters of the I/O module cannot be configured with a generic module in Rockwell Automation Studio 5000®. This has to be done with the Belden CIP Safety Configurator. Each safety module needs an I/O configuration which is validated during the Safety connection establishment over the Configuration Signature (SCID). This Signature has to be calculated with the Belden CIP Safety Configurator.

See chapter Belden CIP Safety Configurator on page 149 for transferring an I/O configuration to the device and getting the Configuration Signature. This value can directly be copied and pasted into the generic module in Rockwell Automation Studio 5000®.

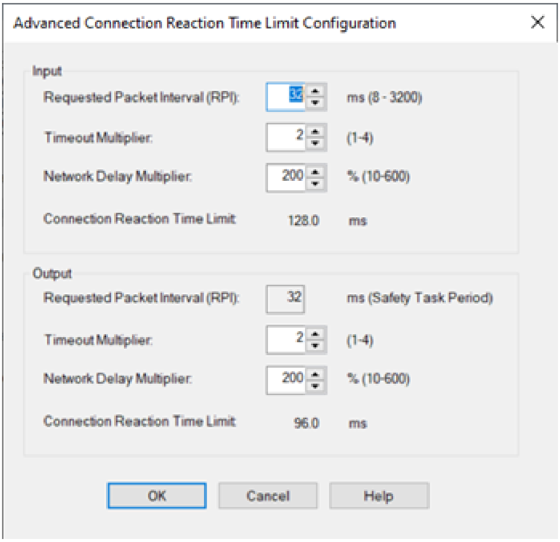


Setting the Configuration Signature (SCID) is only an option and not mandatory. However setting the Configuration Signature (SCID) is recommended for Safety reasons.

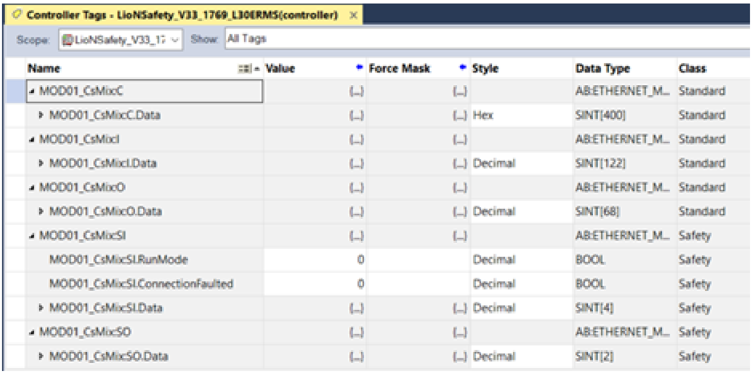
Attention: If you choose to configure Safety connections with an SCID = 0 (Configuration Signature disabled), you are responsible for ensuring that originators and targets have the correct configurations (FRS103).

18. Some detailed Safety settings can be done via the *Advanced Connection Reaction Time Limit Configuration* by clicking the **Advanced** button on the right side. Modifying the *Timeout and Network Delay Multiplier* calculates in combination with the RPI the *Connection Reaction Time Limit* of each Safety connection. This value shall not be less than the "Max. Observed Network Delay (ms)" for getting a stable Safety connection without any interruptions. The "Max. Observed Network Delay (ms)" holds the max. data age of the Safety communication packets and is displayed when online in the Safety section.

Attention: Changes to the values of the *Advanced Connection Reaction Time Limit Configuration* are not recommended as they will affect the module reaction time and the stablitiy of the Safety connections. You are responsible for helping ensure that the connections are in a stable condition. Further details are described in chapter Safety connection reaction time limits on page 155.



19. Apply the settings and move to **Controller-Tags** in **Controller Organizer**. The controller tags for the non-safe IO-Link configuration parameters contain the name of the device, followed by a "**:C**". The configuration parameters can be set under **Value** and are described in chapter IO-Link Configuration parameters on page 53.


Controller Tags - LioNSafety_V33_1769_L30ERMS(controller)
Scope: LioNSafety_V33_1 Show: All Tags

Name	Value	Force Mask	Style	Data Type	Class
MOD01_CsMixC	{...}	{...}		AB:ETHERNET_M...	Standard
MOD01_CsMixC.Data	{...}	{...}	Hex	SINT[400]	Standard
MOD01_CsMixI	{...}	{...}		AB:ETHERNET_M...	Standard
MOD01_CsMixI.Data	{...}	{...}	Decimal	SINT[122]	Standard
MOD01_CsMixO	{...}	{...}		AB:ETHERNET_M...	Standard
MOD01_CsMixO.Data	{...}	{...}	Decimal	SINT[68]	Standard
MOD01_CsMixSI	{...}	{...}		AB:ETHERNET_M...	Safety
MOD01_CsMixSI.RunMode	0		Decimal	BOOL	Safety
MOD01_CsMixSI.ConnectionFaulted	0		Decimal	BOOL	Safety
MOD01_CsMixSI.Data	{...}	{...}	Decimal	SINT[4]	Safety
MOD01_CsMixSO	{...}	{...}		AB:ETHERNET_M...	Safety
MOD01_CsMixSO.Data	{...}	{...}	Decimal	SINT[2]	Safety

It has to be considered that a non-safe connection can reject a connection establishment because of not acceptable zero data in a configuration parameter. In that case at least the default value has to be set in the configuration array. Each offset of a configuration parameter can be seen in IO-Link Configuration parameters on page 53.

20. The tag of the non-safe IO-Link input process data contains the name of the device, followed by a "**:I.Data**". The output process data has the same name followed by a "**:O.Data**". Both arrays show its configured data sizes. The content of them is described in chapter Non-Safe Process data assignment on page 88.

21. The tag of the Safety input process data contains the name of the device, followed by a "**:SI.Data**". The output process data has the same name followed by a "**:SO.Data**". The content of them is described in chapter Safety Process data assignment on page 107.

22. When the configuration is completed, the parameters can be downloaded to the EtherNet/IP controller.

Attention:

- To help ensure that all industrial plant parameters are configured as required, all downloads must be validated by user testing (SRS42).
- The Configuration Signature should only be considered as "verified" after user testing (SRS43).
- The user must test the Safety connection configurations after they have been applied in an originator to confirm that the target connection is operating as intended (SRS92).
- The user must visually verify that all configuration data was downloaded correctly (SRS204).

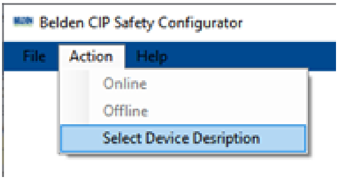
14.1.3 Belden CIP Safety Configurator

Perform the following working steps:

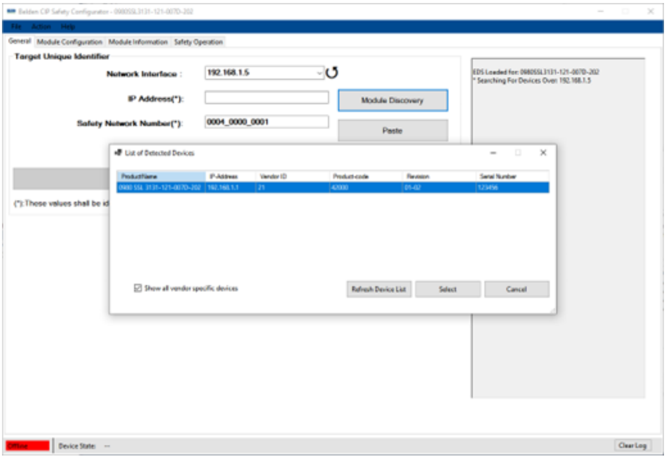
1. Download and install the Belden CIP Safety Configurator from https://www.belden.com/products/i-o-systems.

2. Start the application via the respective desktop symbol.

3. Select the Device Description File as used in the engineering software project.

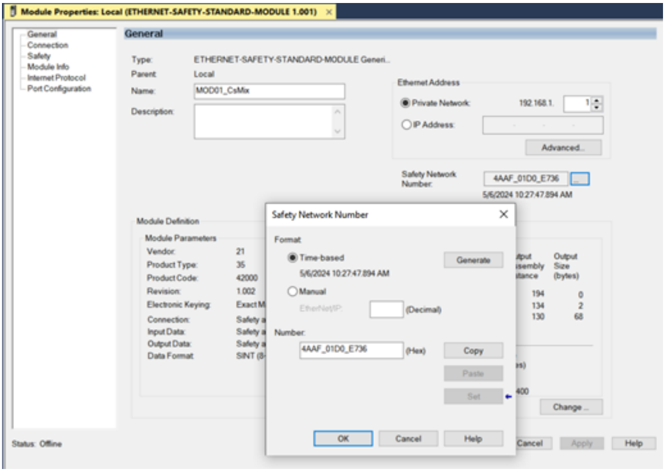


4. When the I/O module is connected, select your network interface in section *General*. Select the I/O module via **Module Discovery**.



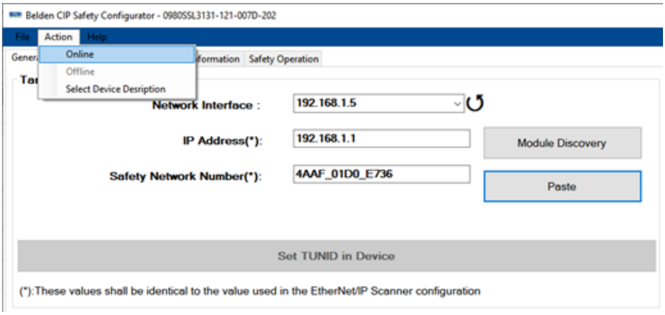
Alternatively, enter the IP address of the I/O module into the respective field.

5. Enter the Safety Network Number (SNN), which is used in the engineering software project, in the respective field. It can also be copied and pasted within the tool. In Studio 5000® you can find the Safety Network Number in each module description.

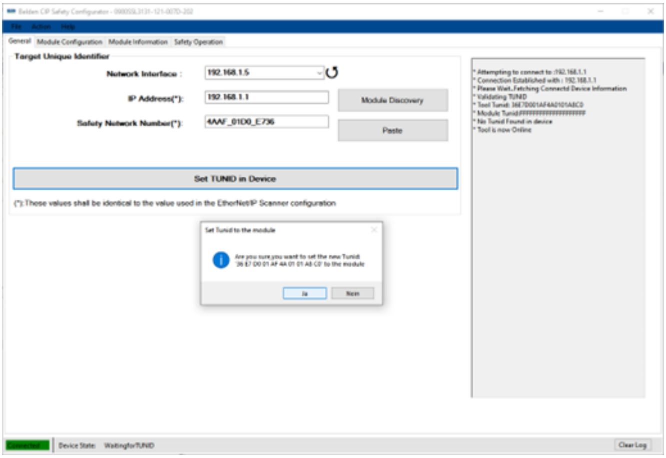


Attention: The user should assign SNN numbers for each Safety network or Safety sub-net that are unique across the system (FRS154).

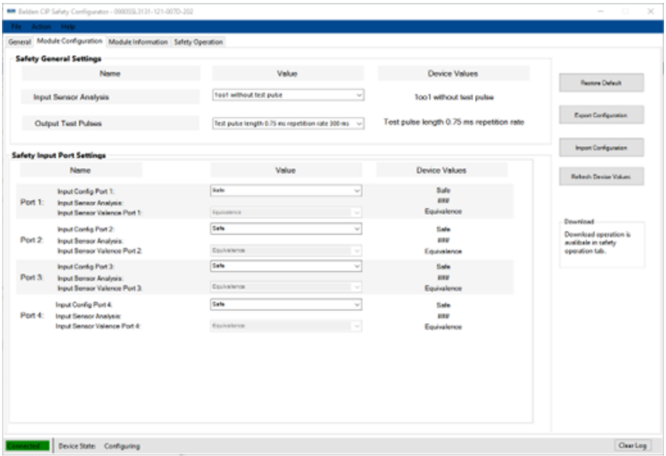
6. Go online with the I/O module.



7. When the device state is "Waiting for TUNID", click **Set TUNID in Device**. When a TUNID mismatch has been detected, the I/O module must be reset to factory default. This can be done in section *Safety Operation*.

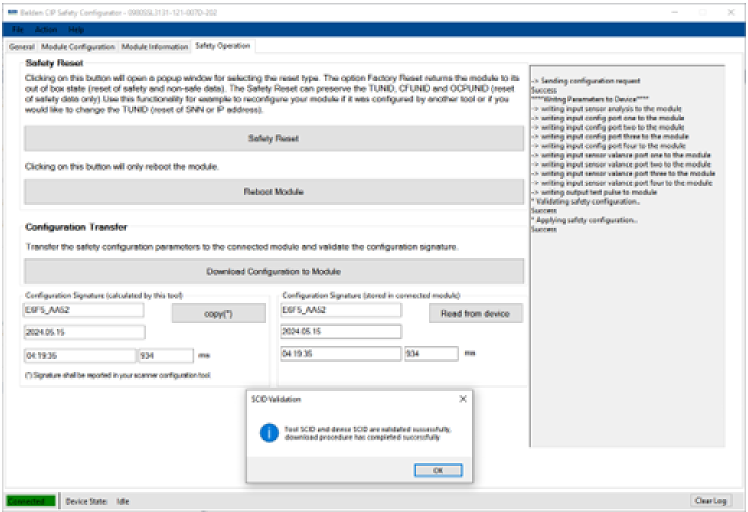


8. Click on **Module Configuration** to configure the Safety configuration parameters. Every change of a parameter updates the CRC checksum and timestamp of the Configuration Signature (SCID) which is shown in section *Safety Operation*.



9. The actual configuration of the module is shown on that screen. A Safety configuration can also be restored to default values, imported into the tool or exported to a certain file via the buttons on the right side.

10. Click on **Safety Operation** to see the configuration signature created by the tool. Check if the device state is in "Configuring or Idle state" and click on **Download Configuration to Module** in order to transfer configuration parameters. If the device state is different, perform a factory or Safety reset and repeat the mentioned steps one more time.

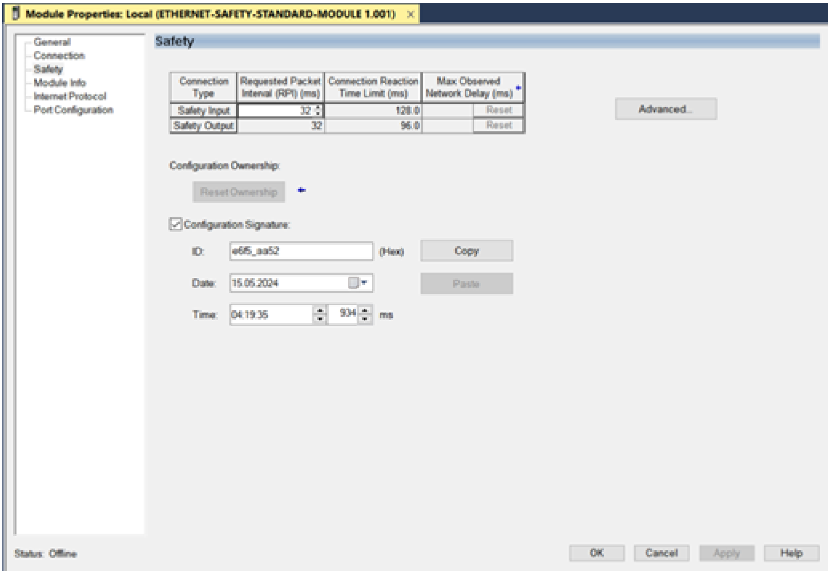


Attention: The Safety configuration parameters must be downloaded to the target so they can be tested and verified. Only then, SCIDs from the target can be confirmed (SRS44).

11. The configuration signature and parameters are permanently stored on the I/O module and can only be changed again within the tool. The configuration signature calculated by the I/O module is shown on the right side and shall match the configuration signature calculated by the tool. A successful SCID validation is also displayed in a pop-up window. After downloading the Safety configuration, the device state shall be in "Idle state" and the module configuration shall match the settings in the tool.

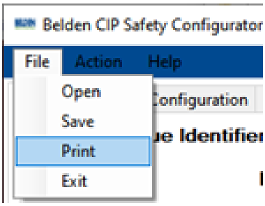
Attention: The user has to compare the transferred SCID and configuration data with the SCID and configuration data originally viewed in the tool (SRS38).

12. Copy the configuration signature and paste it into the engineering software project. In Studio 5000® you can paste the configuration signature in the Safety section of the module properties.

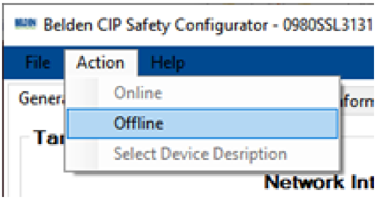


13. Click on **Module Information** to see the alarm and warning configuration and the device status with Safety Configuration Identifier (SCID), Configuration UNID (CFUNID) and Target UNID (TUNID) of the I/O module. The *Module Identification* displays some general module parameter.

14. The downloaded configuration and the identity of the module can be printed in a document for your Safety documentation.



15. Go offline with the I/O module.



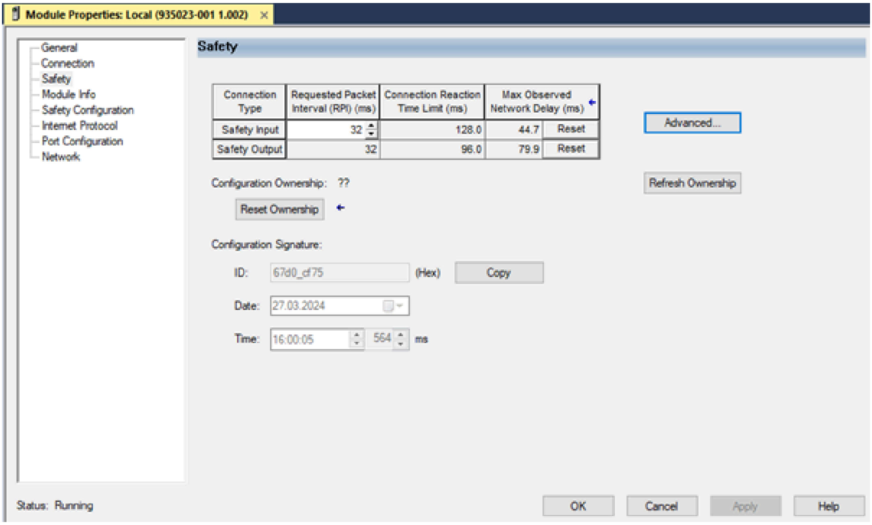
The I/O module is now ready for operation and an EtherNet/IP controller is able to establish a Safety communication when the configuration signature matches the value in the I/O module.

If the Safety connection establishment is rejected, the displayed error code can be looked up in Safety error codes on page 304.

14.2 Safety connection reaction time limits

The Safety connection reaction time limit is defined by the *Requested Packet Interval (RPI)*, the *Timeout Multiplier* and the *Network Delay Multiplier*. Any change on these parameters has to be done very careful because it adjusts the connection reaction time limit.

If this limit is set to too short a time, not all valid Safety packets can be received in the predetermined time so that the connection times out. As a result, the Safety connection cannot be established in a stable and reliable condition and is interrupted whenever the number of Safety packets defined by the *Timeout Multiplier* is lost. Therefore, it is required that the *Max. Data Age* time of the Safety packets is less than the *Connection Reaction Time Limit*.



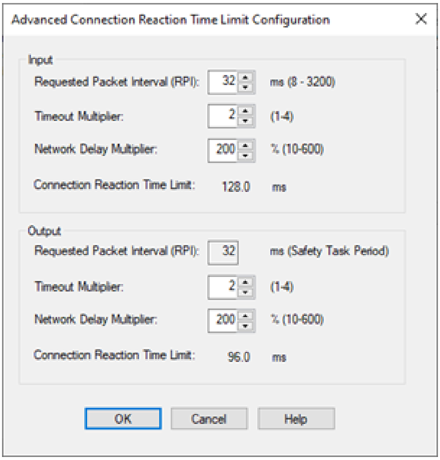
The *Max. Data Age* of a Safety packet can be seen in the *Max. Observed Network Delay* when Studio 5000® is online with the PLC. These values can be reset by clicking the respective buttons or are automatically reset in case of a disconnection.

The example shows the following *Max. Data Age* for both directions:

Safety Input Connection: approx. 45 ms

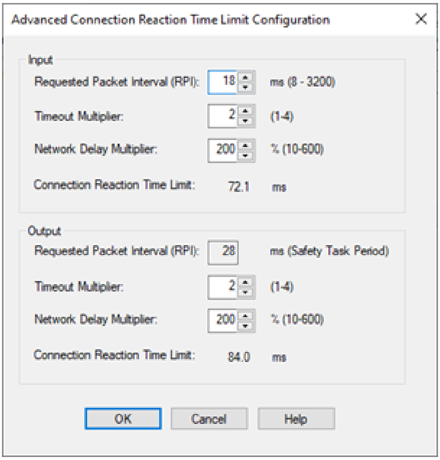
Safety Output Connection: approx. 80 ms

The *Connection Reaction Time Limit* of each Safety connection shall not be set less than these values. The *Advanced Connection Reaction Time Limit Configuration* can be opened by clicking the button **Advanced**. A pop-up window appears which provides the configuration of the *Requested Packet Interval (RPI)*, the *Timeout Multiplier* and the *Network Delay Multiplier* for each connection direction.



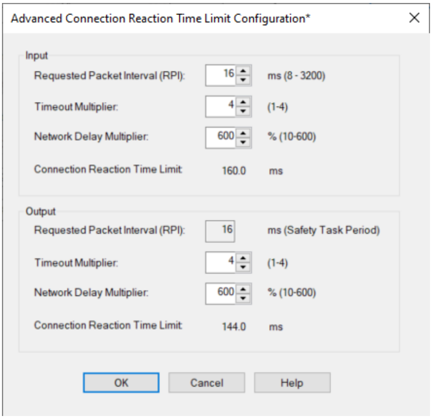
This configuration is the default and recommended configuration for the *Connection Reaction Time Limit*. The recommended RPI value for each Safety connection is 32 ms. Decreasing the *Requested Packet Interval (RPI)*, the *Timeout Multiplier* or *Network Delay Multiplier* of a connection reduces the *Connection Reaction Time Limit*. Any change must be done carefully and the result have to be checked.

The min. *Requested Packet Interval (RPI)* of both directions without changing any multiplier can be seen in this example:



With the default multiplier configuration, the min. *Requested Packet Interval (RPI)* of the Safety input connection is "18 ms" and for the Safety output connection is "28 ms".

When the *Timeout Multiplier* and *Network Delay Multiplier* are set to their max. values, the min. *Requested Packet Interval (RPI)* of both directions can be decreased even further:



With setting the multiplier parameters to their max. values, the min. *Requested Packet Interval (RPI)* for both Safety connections should not be less than "16 ms".

It must be considered that the actual throughput time of the Safety packets depends on the architecture of the network. It cannot be granted that the mentioned times can be reached in every network. If the established connections are not stable without any interruptions, the *Requested Packet Interval (RPI)* of the connections should be increased.

14.3 Add-On Instruction (AOI)

Rockwell Automation Studio 5000® provides the user a mechanism for the optimization and encapsulation of data and logic via an Add-On Instruction. This AOI can be added to a rung as any other pre-defined instruction in the controller and is useful for the preprocessing of the input and output data of a device.

With the help of User-Defined Data Types (UDT), the user gets a comprehensible interface with a clear naming and description for each field of the process data. The advantage is that it is no longer required to calculate byte offsets of the input and output data. Every field of the process data can be directly addressed via a unique name.

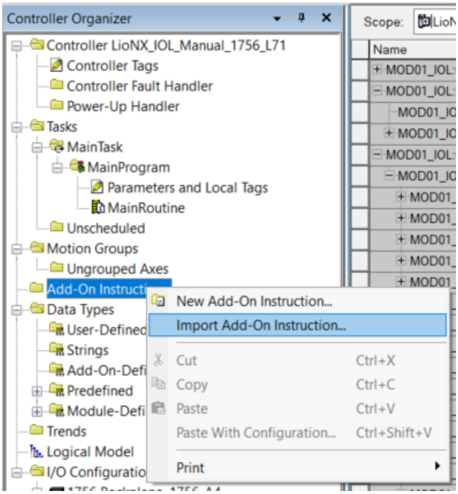
Belden provides AOIs for customers which can be downloaded from the product pages on our online catalog: https://catalog.belden.com.

On request, an AOI is also sent to you by the Belden support team.

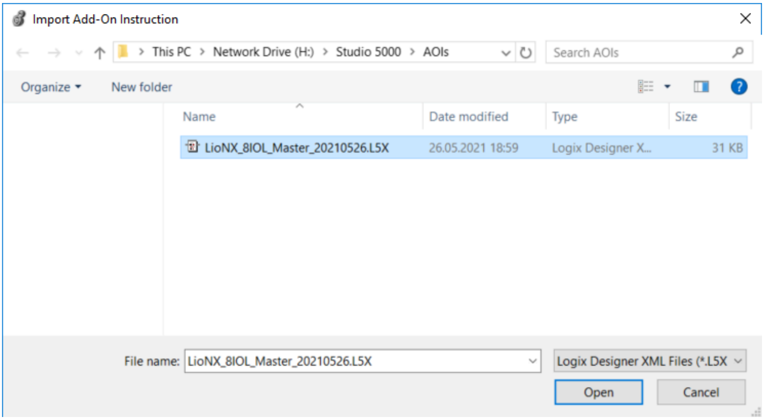
Perform the following working steps for using an AOI:

Attention: For version V36, the edits (steps 5, 6, 7 and 8) should be done directly in the LSX file before starting the import (step 1).

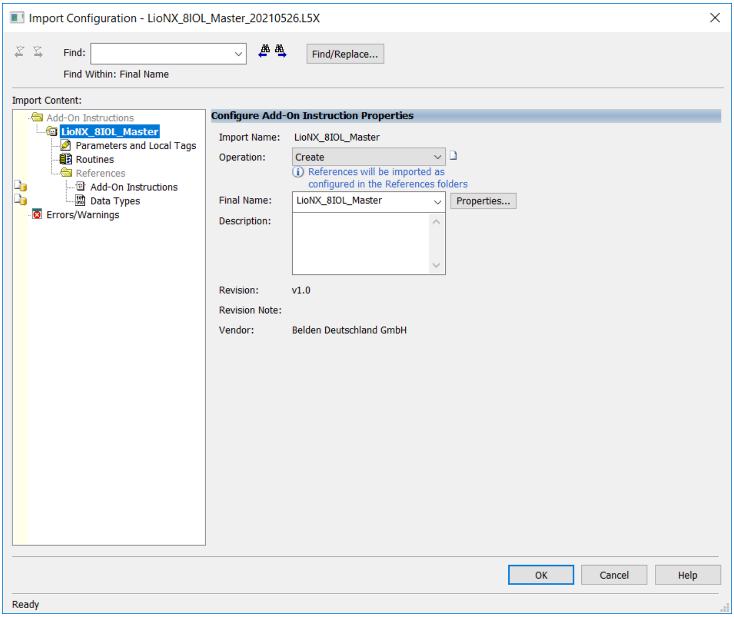
1. In your Studio 5000® project, navigate to **Controller Organizer**, right-click on **Add-On Instructions** and click **Import Add-On Instruction...**:


Controller Organizer
Controller LioNX_IOL_Manual_1756_L71
Controller Tags
Controller Fault Handler
Power-Up Handler
Tasks
MainTask
MainProgram
Parameters and Local Tags
MainRoutine
Unscheduled
Motion Groups
Ungrouped Axes
Add-On Instructi
Data Types
User-Defined
Strings
Add-On-Defi
Predefined
Module-Defi
Trends
Logical Model
I/O Configuratio
Scope:
Name
New Add-On Instruction...
Import Add-On Instruction...
Cut Ctrl+X
Copy Ctrl+C
Paste Ctrl+V
Paste With Configuration... Ctrl+Shift+V
Print

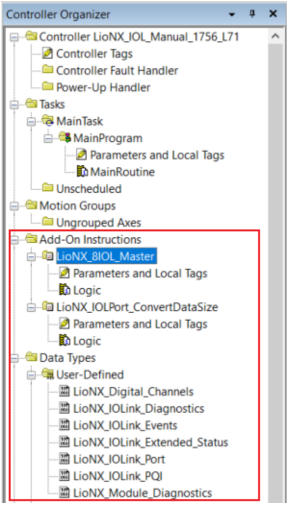
2. Open the *.L5X file:



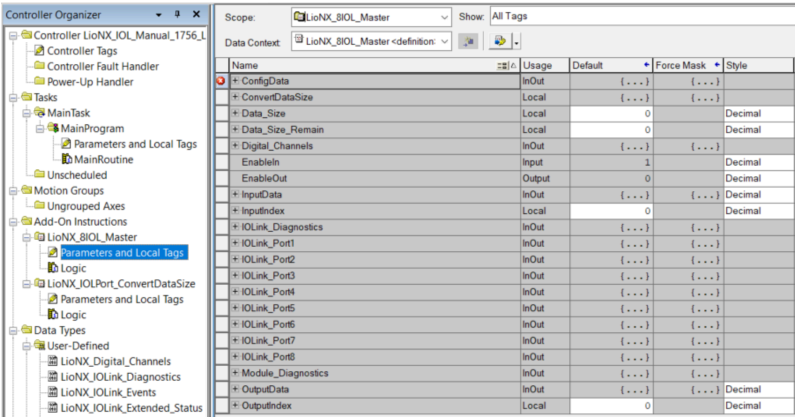
3. Click OK to create the AOI with all necessary User-Defined Data Types:



4. The imported components are now shown in the **Controller Organizer**:

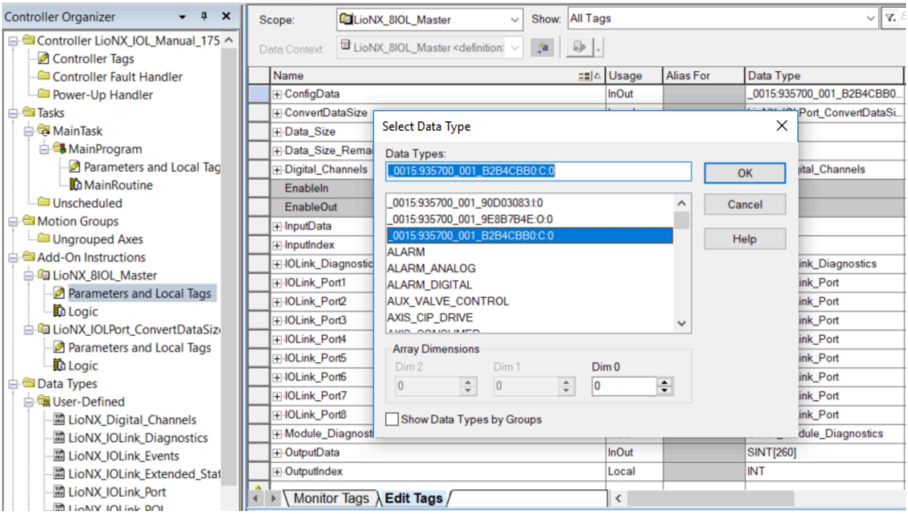


5. Check if an error is shown in the AOI tags (red circle with a white cross). This can happen for the configuration data when you have imported an AOI on your system for the first time:



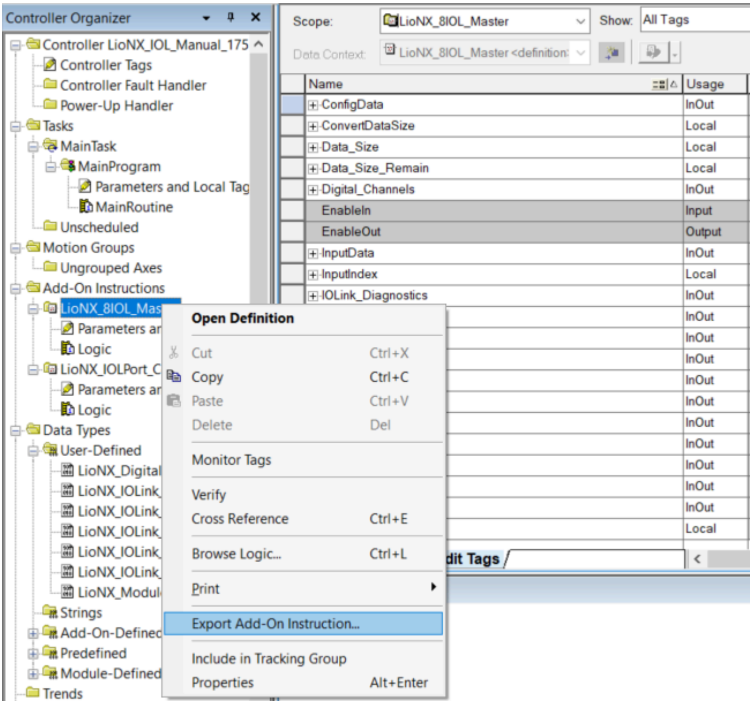
If no error occurred, continue with step **9.**

6. Go to **Edit Tags** and change the data type to the Module-Defined type on your system:

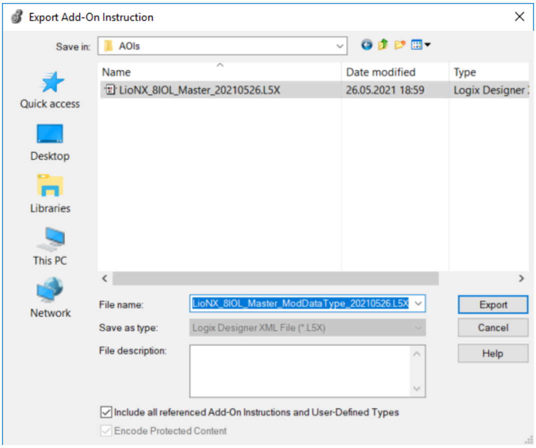


The data type must match the string until the third underscore (_). The CRC32 before **:C:0** is system dependent and does not match the one from the imported AOI. The error is resolved when the red symbol in front of the line is cleared.

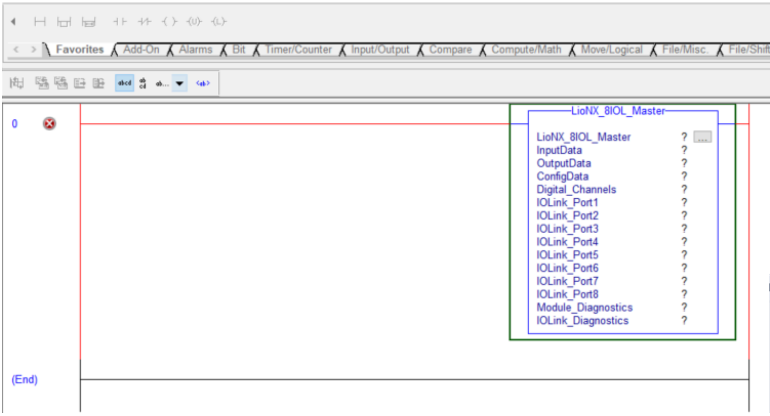
7. When you have changed a data type in the AOI, you should do an export to store this version for future use in other projects on your system. Right-click the AOI and click **Export Add-On Instruction…**:

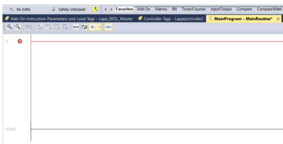


8. Edit the file name and save the AOI:

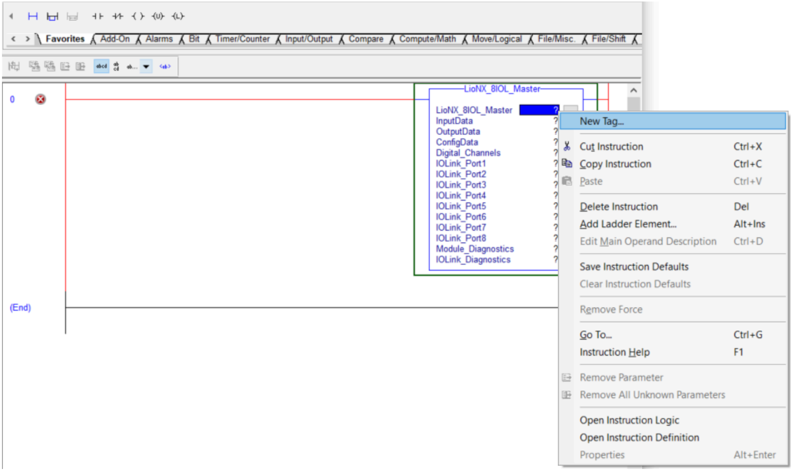


9. For using the AOI go to a logic, e.g. the *MainRoutine*, and add the IO-Link Master AOI via drag and drop to the rung:

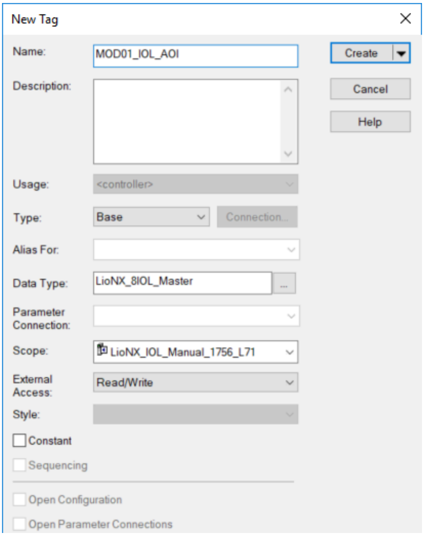




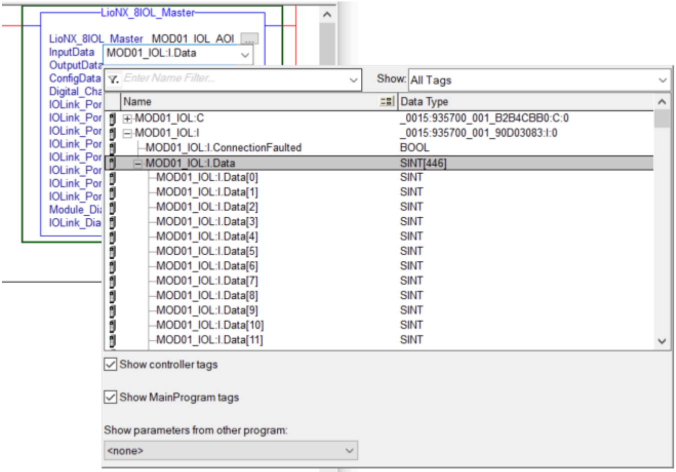
10. Right-Click on the first element of the AOI and click **New Tag...**:



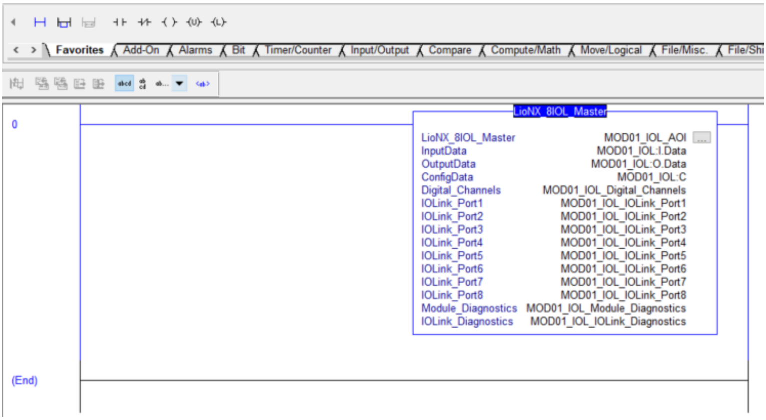
11. Enter a name and create the tag for the AOI:



12. Assign the input, output and configuration data of the module:



13. Create the tags for the remaining elements as shown in steps **10.** and **11.**:



14. From now on, your logic does not need to synchronously copy the input and output data anymore. It just uses the new data tags as the interface for exchanging process data with the module:

Scope: LioNX_IOL_Manual Show: All Tags

Name	Value	Force Mask	Style	Data Type	Description
− MOD01_IOL_Digital_Channels	{...}	{...}		LioNX_Digital_Channels	
+ MOD01_IOL_Digital_Channels.Control	{...}	{...}	Decimal	SINT[2]	Digital Output Data, default mapping: Bit0=PortX1Ch.A ...
+ MOD01_IOL_Digital_Channels.Status	{...}	{...}	Decimal	SINT[2]	Digital Input Channel Status, default mapping: Bit0=PortX...
− MOD01_IOL_IOLink_Diagnostics	{...}	{...}		LioNX_IOLink_Diagnostics	
+ MOD01_IOL_IOLink_Diagnostics.COM_Error	0		Decimal	SINT	Bit0=IOLinkPort1 ... Bit7= IOLinkPort8
+ MOD01_IOL_IOLink_Diagnostics.Reserved	0		Decimal	SINT	not in use
+ MOD01_IOL_IOLink_Diagnostics.Validation_Error	0		Decimal	SINT	Bit0=IOLinkPort1 ... Bit7= IOLinkPort8
+ MOD01_IOL_IOLink_Diagnostics.Device_Error	0		Decimal	SINT	Bit0=IOLinkPort1 ... Bit7= IOLinkPort8
+ MOD01_IOL_IOLink_Diagnostics.Device_Warning	0		Decimal	SINT	Bit0=IOLinkPort1 ... Bit7= IOLinkPort8
+ MOD01_IOL_IOLink_Diagnostics.Device_Notification	0		Decimal	SINT	Bit0=IOLinkPort1 ... Bit7= IOLinkPort8
− MOD01_IOL_IOLink_Port1	{...}	{...}		LioNX_IOLink_Port	
+ MOD01_IOL_IOLink_Port1.Control	{...}	{...}	Decimal	SINT[32]	IO-Link Port Output Data
+ MOD01_IOL_IOLink_Port1.Status	{...}	{...}	Decimal	SINT[32]	IO-Link Port Input Data
− MOD01_IOL_IOLink_Port1.PQI	{...}	{...}		LioNX_IOLink_PQI	IO-Link Port PQI Data
+ MOD01_IOL_IOLink_Port1.PQI.PQI_Byte	0		Decimal	SINT	Bit2=NewPar, Bit3=SubstDev, Bit4=PortActive, Bit5=Dev...
+ MOD01_IOL_IOLink_Port1.PQI.Reserved	0		Decimal	SINT	not in use
− MOD01_IOL_IOLink_Port1.Extended_Status	{...}	{...}		LioNX_IOLink_Extended_Status	IO-Link Port Extended Status
+ MOD01_IOL_IOLink_Port1.Extended_Status.Extended_Diag	0		Decimal	INT	Bit0=OutDataLenErr, Bit1=InDataLenErr, Bit2=StartupPar...
+ MOD01_IOL_IOLink_Port1.Extended_Status.Vendor_ID	0		Decimal	INT	Vendor ID
+ MOD01_IOL_IOLink_Port1.Extended_Status.Device_ID	0		Decimal	DINT	Device ID
− MOD01_IOL_IOLink_Port1.Events	{...}	{...}		LioNX_IOLink_Events	IO-Link Port Events
+ MOD01_IOL_IOLink_Port1.Events.Event_Qualifier1	0		Decimal	INT	Bit0..1=Instance, Bit4..5=Type, Bit6..7=Mode
+ MOD01_IOL_IOLink_Port1.Events.Event_Code1	0		Decimal	INT	Event Code
+ MOD01_IOL_IOLink_Port1.Events.Event_Qualifier2	0		Decimal	INT	Bit0..1=Instance, Bit4..5=Type, Bit6..7=Mode
+ MOD01_IOL_IOLink_Port1.Events.Event_Code2	0		Decimal	INT	Event Code
+ MOD01_IOL_IOLink_Port1.Events.Event_Qualifier3	0		Decimal	INT	Bit0..1=Instance, Bit4..5=Type, Bit6..7=Mode
+ MOD01_IOL_IOLink_Port1.Events.Event_Code3	0		Decimal	INT	Event Code
+ MOD01_IOL_IOLink_Port2	{...}	{...}		LioNX_IOLink_Port	
+ MOD01_IOL_IOLink_Port3	{...}	{...}		LioNX_IOLink_Port	
+ MOD01_IOL_IOLink_Port4	{...}	{...}		LioNX_IOLink_Port	
+ MOD01_IOL_IOLink_Port5	{...}	{...}		LioNX_IOLink_Port	
+ MOD01_IOL_IOLink_Port6	{...}	{...}		LioNX_IOLink_Port	
+ MOD01_IOL_IOLink_Port7	{...}	{...}		LioNX_IOLink_Port	
+ MOD01_IOL_IOLink_Port8	{...}	{...}		LioNX_IOLink_Port	
− MOD01_IOL_Module_Diagnostics	{...}	{...}		LioNX_Module_Diagnostics	
+ MOD01_IOL_Module_Diagnostics.General	0		Decimal	INT	Bit0=LowVoltSys, Bit1=LowVoltAct, Bit2=ShortCircSen, B...
+ MOD01_IOL_Module_Diagnostics.Sensor	0		Decimal	INT	Bit0=PortX1 ... Bit7=PortX8
+ MOD01_IOL_Module_Diagnostics.Actuator	0		Decimal	INT	Bit0=PortX1Ch.A ... Bit15=PortX8Ch.B

Note:

If you decide to reduce the input and output data sizes of the connection, you also must set these new sizes to the SINT arrays of *InputData* and *OutputData* within the AOI. In steps **6.** to **8.** it is described how to modify data types of an AOI and how to store the changes.

15 CIP object classes

15.1 EtherNet/IP object classes

According to the CIP specification, the LioN-Safety variants support the following standard EtherNet/IP object classes:

Object Class	Object ID	Instances
Identity Object	0x01	0, 1
Message Router Object	0x02	0 (only on class level)
Assembly Object	0x04	0, 130, 131, 132, 134, 135, 145, 146, 150
Connection Manager Object	0x06	0 (only on class level)
Discrete Input Point Object	0x08	0, 13 .. 16
Safety Supervisor Object	0x39	0, 1
Safety Validator Object	0x3A	0, 1 .. 2
Safety Discrete Output Point Object	0x3B	0, 9 .. 12
Safety Discrete Input Point Object	0x3D	0, 1 .. 16
DLR Object	0x47	0, 1
QoS Object	0x48	0, 1
TCP/IP Interface Object	0xF5	0, 1
Ethernet Link Object	0xF6	0, 1 .. 2
LLDP Management Object	0x109	0, 1

All objects with instance attributes are described in the following chapters.

15.1.1 Identity Object (0x01)

Supported services:

Get Attributes All (0x01)

Get Attribute Single (0x0E)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device
6	Maximum ID Number Class Attributes	Get	UINT	The attribute ID number of the last class attribute of the class definition implemented in the device
7	Maximum ID Number Instance Attributes	Get	UINT	The attribute ID number of the last instance attribute of the class definition implemented in the device.

Instance attribute (Instance 1)

Attribute	Name	Access	Data Type	Description
1	Vendor ID	Get	UINT	Vendor Identification
2	Device Type	Get	UINT	Indication of general type of product
3	Product Code	Get	UINT	Identification of a particular product of an individual vendor
4	Revision	Get	USINT, USINT	Structure with major and minor revision
5	Status	Get	WORD	Summary status of device: b0: Owned b1: Reserved ("0") b2: Configured b3: Reserved ("0") b4 .. 7: Extended Device Status 0 = Self-Testing or Unknown 1 = Firmware Update in Progress 2 = At least one faulted I/O connection 3 = No I/O connections established 4 = Non-Volatile Configuration bad 5 = Major Fault 6 = At least one I/O connection in RUN mode 7 = At least one I/O connection established, all in IDLE mode 8 = Unused (valid only for instances grater than "1") 9 = Reserved 10 .. 15 = Vendor specific b8: Minor Recoverable Fault b9: Minor Unrecoverable Fault b10: Major Recoverable Fault b11: Major Unrecoverable Fault b12 .. 15: Reserved ("0")
6	Serial Number	Get	UDINT	Serial number of device
7	Product Name	Get	STRING	Human readable identification

Attribute	Name	Access	Data Type	Description
8	State	Get	USINT	Present state of the device: 0 = Nonexistent 1 = Device Self Testing 2 = Standby 3 = Operational 4 = Major Recoverable Fault 5 = Major Unrecoverable Fault 6 .. 254 = Reserved 255 = Default Value
9	Configuration Consistency Value	Get	UINT	Can be a CRC, incrementing count or any other mechanism (vendor specific behavior) to reflect a non-volatile configuration change
19	Protection Mode	Get	WORD	Current protection mode of the device: b0: Implicit Protection enabled b1 .. 2: Reserved b3: Explicit Protection enabled b4 .. 15: Reserved

15.1.2 Assembly Object (0x04)

Supported services:

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device
3	Number of Instances	Get	UINT	Number of Instances currently created in this class level of the device
6	Maximum ID Number Class Attributes	Get	UINT	The attribute ID number of the last class attribute of the class definition implemented in the device
7	Maximum ID Number Instance Attributes	Get	UINT	The attribute ID number of the last instance attribute of the class definition implemented in the device.

Instance attribute (Instance <AssemblyID>)

Attribute	Name	Access	Data Type	Description
3	Data	Get, Set	ARRAY	Assembly Data (Set service only available for consuming assemblies that are not part of an active implicit connection)
4	Size	Get	UINT	Number of bytes in Attribute 3

15.1.3 Discrete Input Point Object (0x08)

Supported services:

Get Attribute Single (0x0E)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object

Instance attribute (Instance 1 .. 16)

Attribute	Name	Access	Data type	Description
3	Value	Get	BOOL	Input Point Value (0 = OFF, 1 = ON)
4	Status	Get	BOOL	Input Point Status (0 = OK, 1 = Alarm)

15.1.4 Safety Supervisor Object (0x39)

Supported services:

Get Attributes All (0x01)

Get Attribute Single (0x0E)

Safety Reset (0x54), only available for Instance 1:

- Request data:

  Reset Type (1 byte) + Password (16 byte) + TUNID (10 byte) + Attribute Bit map (1 byte, only appended for reset type 2)
- Reset Type:

  0= Reset Module (Warmstart)

  1= Reset to Factory Default

  2 = Safety Reset with exception of attribute bit map
- Attribute bit map:

  b0: preserve NodeID (IP address)

  b1: preserve Communication Link Parameters (Ethernet Link Interface Control)

  b2: preserve TUNID

  b4: preserve CFUNID

  b5: preserve OCPUNID (for mixmodule only)

Propose TUNID (0x56), only available for Instance 1:

- Request data: TUNID (10 byte)

Apply TUNID (0x57), only available for Instance 1:

- Request data: TUNID (10 byte)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object

Instance attribute (Instance 1)

Attribute	Name	Access	Data Type	Description
11	Device Status	Get	USINT	0 = Undefined 1 = Self-Testing 2 = Idle 3 = Self-Test Exception 4 = Executing 5 = Abort 6 = Critical Fault 7 = Configuring 8 = Waiting for TUNID
12	Exception Status	Get	BYTE	b0 .. 6: Device specific definition 0x05 = Warning Received I/O Config Invalid 0x06 = Warning DPRAM Write Failed 0x0F = Warning General DPRAM Error 0x12 = Warning System Info Failed 0x41 = Alarm CRC SSO Attribute EEPROM 0x42 = Alarm CRC I/O Config EEPROM 0x4B = Alarm Wrong I/O Config Size 0x4C = Alarm EEPROM Read Failed 0x4D = Alarm Init SSO Attribute Failed CRC 0x4E = Alarm Init I/O Config Failed CRC 0x50 = Alarm SSO I/O Config EEPROM Read Failed 0x53 = Alarm Wrong I/O Config b7: Basic method ("0")
15	Alarm Enable	Get, Set	BOOL	0 = Disable 1 = Enable (default)
16	Warning Enable	Get, Set	BOOL	0 = Disable 1 = Enable (default)

Attribute	Name	Access	Data Type	Description
25	Configuration UNID	Get	STRUCT	CFUNIT : Owner of the device configuration (Time + Date + NodeID, total size 10 byte) Special meanings: All bytes 0x00 = No owner, accept any (default) All bytes 0xFF = Tool-only configuration, the tool is the owner (SNCT)
26	Safety Configuration Identifier	Get	STRUCT	SCID: Signature of the configuration (Safety Config CRC + Time Stamp, total size 10 byte)
27	Target UNID	Get	STRUCT	TUNID: Current UNID of the device (Time + Date + NodeID, total size 10 byte)
28	Output Connection Point Owners	Get	STRUCT	OCPUNID: Number of Array Entries (UINT) + Array of all Output Connection Point Owners (Time + Date + NodeID + EPATH size + EPATH), only 1 entry available
29	Proposed TUNID	Get	STRUCT	UNID that an originator is attempting to set in the device (Time + Date + NodeID, total size 10 byte)

15.1.5 Safety Validator Object (0x3A)

Supported services:

Get Attributes All (0x01)

Get Attribute Single (0x0E)

Reset Error Counters (0x4B), only available for Instance 0

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
8	Safety Connection Fault Count	Get	UINT	Diagnostic Counter that is a running count of Safety Connection Faults

Instance attribute (Instance 1 .. 2)*

Attribute	Name	Access	Data Type	Description
1	Safety Validator State	Get	USINT	0 = Unallocated 1 = Initializing 2 = Established 3 = Connection Failed (no connection established)
2	Safety Validator Type	Get	USINT	b0 .. b6: Safety Connection Type 0 = Unallocated 1 = Singlecast 2 = Multicast b7: Direction 0 = Producer (Client) 1 = Consumer (Server)
3	Ping Interval EPI Multiplier	Get, Set	UINT	Number that defines the Ping_Count_Interval for a particular connection (16 .. 1000)
4	Time Coordination Message Min Multiplier	Get, Set	STRUCT	Time Coordination Message Min. Multiplier array size (USINT) Time Coordination Message Min. Multiplier (ARRAY of UINT)
5	Network Time Expectation Multiplier	Get	STRUCT	Network Time Expectation Multiplier array size (USINT) Network Time Expectation Multiplier (ARRAY of UINT)
6	Timeout Multiplier	Get	STRUCT	Timeout Multiplier array size (USINT) Timeout Multiplier (ARRAY of USINT)
7	Max Consumer Number	Get	USINT	Maximum number of consumers allowed for the connection (1 = Singlecast, 2 .. 15 = Multicast)

Attribute	Name	Access	Data Type	Description
12	Max Data Age	Get, Set	UINT	Diagnostic which holds the largest Data Age detected in 128 μs increments. Only set to "0" is allowed.
13	Application Data Path	Get	EPATH	Points to the application data attached to this Safety connection.
14	Error Code	Get	UINT	Reason for error within this instance (0 = no error)
15	Producer/ Consumer Fault Counters	Get	STRUCT	Producer/Consumer Counter Array Size (USINT) Producer/Consumer Fault Counter (ARRAY of USINT)

* Instance per Safety connection (client/server)

15.1.6 Safety Discrete Output Point Object (0x3B)

Only applicable for mixmodule variants.

Supported services:

Get Attribute Single (0x0E)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device
6	Maximum ID Number Class Attributes	Get	UINT	The attribute ID number of the last class attribute of the class definition implemented in the device
7	Maximum ID Number Instance Attributes	Get	UINT	The attribute ID number of the last instance attribute of the class definition implemented in the device.
8	Latch Output Error Time	Get	UINT	Any Safety Output error will be latched for this minimum time. If the error is no longer present after this time the error condition may be reset by the module (0 .. 65535 ms, default value 1000 ms).

Instance attribute (Instance 9 .. 12)

Attribute	Name	Access	Data Type	Description
3	Safety Output Value	Get	BOOL	Safety Output Point Value (0 = OFF, 1 = ON) This Value is Safety Data with a Safety State of "0". Settable only by Safety I/O connections, not settable by explicit messaging.
4	Output Monitor Value	Get	BOOL	Safety Output Point Monitor (0 = OFF, 1 = ON) This is not Safety data, there is no Safety state (read back value).
5	Safety Status	Get	BOOL	Safety Output Point Status (0 = Alarm, 1 = OK) This Value is Safety Data with a Safety State of "0".

15.1.7 Safety Discrete Input Point Object (0x3D)

Supported services:

Get Attribute Single (0x0E)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device
6	Maximum ID Number Class Attributes	Get	UINT	The attribute ID number of the last class attribute of the class definition implemented in the device
7	Maximum ID Number Instance Attributes	Get	UINT	The attribute ID number of the last instance attribute of the class definition implemented in the device.
8	Latch Input Error Time	Get	UINT	Any Safety Input error will be latched for this minimum time. If the error is no longer present after this time the error condition may be reset by the module (0 .. 65535 ms, default value 1000 ms).

Instance attribute (Instance 1 .. n)*

Attribute	Name	Access	Data Type	Description
3	Input Port Value	Get	BOOL	Input Point Value (0 = OFF, 1 = ON) This is not Safety data, there is no Safety state.
4	Safety Status	Get	BOOL	Input Point Status (0 = Alarm, 1 = OK) This Value is Safety Data with a Safety State of "0".
7	Safety Input Logical Value	Get	BOOL	Input point value after Safety and on/off delay evaluation (0 = OFF, 1 = ON) This Value is Safety Data with a Safety State of "0".

* n = number of safety input ports supported by the device variant

15.1.8 DLR Object (0x47)

Supported services:

Get Attributes All (0x01)

Get Attribute Single (0x0E)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device
6	Maximum ID Number Class Attributes	Get	UINT	The attribute ID number of the last class attribute of the class definition implemented in the device
7	Maximum ID Number Instance Attributes	Get	UINT	The attribute ID number of the last instance attribute of the class definition implemented in the device.

Instance attribute (Instance 1)

Attribute	Name	Access	Data type	Description
1	Network Topology	Get	BOOL	0 = Linear 1 = Ring
2	Network Status	Get	BOOL	0 = Normal operation 1 = Ring Fault 2 = Unexpected Loop Detected 3 = Partial Network Fault 4 = Rapid Fault/Restore Cycle
10	Active Supervisor Address	Get	ARRAY	Supervisor IP Address, Supervisor MAC Address (0 = not configured)
12	Capability Flags	Get	DWORD	Flag description: b0: Announce-based Ring Node ("0") b1: Beacon-based Ring Node ("1") b2 .. 4: Reserved ("0") b5: Supervisor Capable ("0") b6: Redundant Gateway Capable ("0") b7: Flush_Table frame Capable ("1") b8 .. 15: Reserved ("0")

15.1.9 QoS Object (0x48)

Supported services:

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device
6	Maximum ID Number Class Attributes	Get	UINT	The attribute ID number of the last class attribute of the class definition implemented in the device
7	Maximum ID Number Instance Attributes	Get	UINT	The attribute ID number of the last instance attribute of the class definition implemented in the device.

Instance attribute (Instance 1)

Attribute	Name	Access	Data type	Description
2	DSCP PTP Event	Get, Set	USINT	DSCP value for PTP Event frames (default value "59")
3	DSCP PTP General	Get, Set	USINT	DSCP value for PTP General frames (default value "47")
4	DSCP Urgent	Get, Set	USINT	CIP transport class 0/1 messages with Urgent priority (default value "55")
5	DSCP Scheduled	Get, Set	USINT	CIP transport class 0/1 messages with Scheduled priority (default value "47")
6	DSCP High	Get, Set	USINT	CIP transport class 0/1 messages with High priority (default value "43")
7	DSCP Low	Get, Set	USINT	CIP transport class 0/1 messages with Low priority (default value "31")
8	DSCP Explicit	Get, Set	USINT	CIP UCMM, CIP transport class 2/3, All other EtherNet/IP encapsulation messages (default value "27")

15.1.10 TCP/IP Object (0xF5)

Supported services:

Get Attributes All (0x01)

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 1)

Attribute	Name	Access	Data type	Description
1	Status	Get	DWORD	Interface Status description: b0 .. 3: Interface Configuration Status 0 = Not configured 1 = Configuration obtained by BOOTP, DHCP or stored value 2 = Configuration obtained by hardware settings (e.g. rotary switches) 3 .. 15 = Reserved b4: Mcast Pending b5: Interface Configuration Pending b6: Acd Status b7: Acd Fault b8 .. 31: Reserved ("0")

Attribute	Name	Access	Data type	Description
2	Configuration Capability	Get	DWORD	Interface Capability Flags: b0: BOOTP Client ("1") b1: DNS Client ("0") b2: DHCP Client ("1") b3: DHCP-DNS Update ("0") b4: Configuration Settable ("1") b5: Hardware Configurable (0 = no rotary switches; 1 = rotary switches available) b6: Interface Configuration Change Requires Reset ("0") b7: Acd Capable ("1") b8 .. 31: Reserved ("0")
3	Configuration Control	Get, Set	DWORD	Interface Control Flags: b0 .. 3: Configuration Method: 0 = Stored Value 1 = BOOTP 2 = DHCP 3 .. 15 = Reserved b4: DNS Enable ("0") b5 .. 31: Reserved ("0")
4	Physical Link Object	Get	STRUCT	Path to physical link object
5	Interface Configuration	Get, Set	STRUCT	TCP/IP network interface configuration
6	Host Name	Get, Set	STRING	Host name of the device (length of 0 = not configured)
10	Select Acd	Get, Set	BOOL	Enables ("1") or disables ("0") the use of ACD (default value "1")
11	Last Conflict Detected	Get, Set	STRUCT	Structure containing information related to the last conflict detected
13	Encapsulation Inactivity Timeout	Get, Set	UINT	Number of seconds of inactivity before TCP connection is closed: 0 = disable 1 .. 3600 = timeout in seconds 120 = default value

15.1.11 Ethernet Link Object (0xF6)

Supported services:

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Get and Clear (0x4C)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.
3	Number of Instances	Get	UINT	Number of object instances currently created at this class level of the device (in this case number of ethernet ports)

Instance attribute (Instance 1 .. 2)

Attribute	Name	Access	Data type	Description
1	Interface Speed	Get	UDINT	Current Interface speed in Mbps
2	Interface Flags	Get	DWORD	Interface Flags: b0: Link Status b1: Half ("0") or Full ("1") Duplex b2 .. 4: Negotiation Status: 0 = Auto-negotiation in progress 1 = Auto-negotiation and speed detection failed (using default 10Mbps and half duplex) 2 = Auto negotiation failed but detected speed (using default half duplex) 3 = Successfully negotiated speed and duplex 4 = Auto-negotiation not attempted (forced speed and duplex) b5: Manual Setting Requires Reset b6: Local Hardware Fault b7 .. 31: Reserved ("0")
3	Physical Address	Get	ARRAY	MAC address
4	Interface Counters	Get	STRUCT	Interface Counters
5	Media Counters	Get	STRUCT	Media-specific counters
6	Interface Control	Get, Set	STRUCT	Configuration for physical interface Control Bits (WORD): b0: Auto-negotiate b1: Forced Duplex Mode (0 = Half Duplex; 1 = Full Duplex, only valid when Auto-negotiate = 0) b2 .. 15: Reserved ("0") *Forced Interface Speed in Mbps (UINT)*

Attribute	Name	Access	Data type	Description
7	Interface Type	Get	USINT	Type of interface: 0 = Unknown interface type 1 = Internal interface 2 = Twisted-pair 3 = Optical fiber 4 .. 255 = Reserved
8	Interface State	Get	USINT	State of interface: 0 = Unknown 1 = Enabled and ready to send and receive data 2 = Disabled 3 = Testing 4 .. 255 = Reserved
9	Admin State	Get, Set	USINT	Administrative state: 0 = Reserved 1 = Enable interface 2 = Disable interface 3 .. 255 = Reserved
10	Interface Label	Get	STRING	Human readable identification (size max. 64)
11	Interface Capability	Get	STRUCT	Interface Capability Flags (DWORD): b0: Manual Setting Requires Reset ("0") b1: Auto-negotiate ("1") b2: Auto-MDIX ("1") b3: Manual Speed/Duplex ("1") b4 .. 31: Reserved ("0") Speed/Duplex Array Count of following struct (USINT, 4) Interface Speed in Mbps (UINT, 10/100) Interface Duplex Mode (USINT, 0/1): 0 = Half Duplex 1 = Full Duplex 2 .. 255 = Reserved

15.1.12 LLDP Management Object (0x109)

Supported services:

Get Attributes All (0x01)

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.
3	Number of Instances	Get	UINT	Number of object instances currently created at this class level of the device (in this case number of ethernet ports)
6	Maximum ID Number Class Attributes	Get	UINT	Attribute ID number of the last class attribute
7	Maximum ID Number Instance Attributes	Get	UINT	Attribute ID number of the last class attribute

Instance attribute (Instance 1)

Attribute	Name	Access	Data type	Description
1	LLDP Enable	Get/Set	STRUCT	LLDP Enable Array Length (UINT): 1 + Class attribute 2 from the Ethernet Link Object (0xF6) = 3 LLDP Enable Array (BYTE): b0: Global Enable, LLDP Tx & Rx Enabled (1) b1: LLDP Tx Enabled (Intance 1 of Ethernet Link Object) (1) b2: LLDP Tx Enabled (Intance 2 of Ethernet Link Object) (1)
2	msgTxInterval	Get/Set	UINT	From 802.1AB-2016: Interval in seconds for transmitting LLDP frames from this device 0 .. 4 = Reserved 5 .. 32768 = Message Transmission Interval for LLDP frames (30) 32769 .. 65535 = Reserved
3	msgTxHold	Get/Set	USINT	From 802.1AB-2016: Multiplier of msgTxInterval to determine the value of the TTL TLV sent to neighboring devices 0 = Reserved 1 .. 100 = Message Transmission Multiplier for LLDP Frames (4) 101 .. 255 = Reserved
4	LLDP Datastore	Get	WORD	Indication of the retrieval methods for the LLDP database: b0: LLDP Data Table Object (0) b1: SNMP (1) b2: NETCONF YANG (0) b3: RESTCONF YANG (0) b4 .. b15: Reserved (0)
5	Last Change	Get	UDINT	Counter in seconds from the last time any entry in the local LLDP database changed or power up

15.2 Vendor specific object classes

The LioN-Safety EtherNet/IP variants support the following vendor specific object classes:

Object Class	Instances
General Settings Object (0xA0)	0, 1
Channel Settings Object (0xA1)	0, 13 .. 16
IO-Link Diagnosis Settings Object (0xA2)	0, 1
IO-Link Port Settings Object (0xA3)	0, 7 .. 8
IO-Link Failsafe Parameter Object (0xA4)	0, 7 .. 8
IO-Link Device Parameter Object (0xA5)	0, 7 .. 8
Safety General Settings Object (0xA6)	0, 1
Safety Input Port Settings Object (0xA7)	0, 1 .. n*

* n = number of safety input ports supported by the device variant

15.2.1 General Settings Object (0xA0)

Supported services:

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 1)

Attribute	Name	Access	Data type	Description
2	Force Mode Lock	Get, Set	BOOL	0: Disable 1: Enable
3	Web Interface Lock	Get, Set	BOOL	0: Disable 1: Enable
5	Report U_L/U_{Aux} Supply Voltage Fault	Get, Set	BOOL	0: Disable 1: Enable
6	Report DO Fault without U_S	Get, Set	BOOL	0: Disable 1: Enable
7..24	Reserved			
25	CIP object configuration lock	Get, Set	BOOL	0: Disable 1: Enable
26	External configuration lock	Get, Set	BOOL	0: Disable 1: Enable
27..31	Reserved			
32	IO Mapping Mode	Get, Set	SINT	0: Default Assignment 1: Byte Swap 2: LSB Ch.A - MSB Ch.B 3: LSB Ch.B - MSB Ch.A 4: Free IO Mapping

15.2.2 Channel Settings Object (0xA1)

Only applicable for mixmodule variants.

Supported services:

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 13 .. 16)

Attribute	Name	Access	Data type	Description
1	IO Mapping	Get, Set	SINT	0 .. 15: Bit number of 16 channel process data 16: Inactive
2	DO Surveillance Timeout	Get, Set	INT	0 .. 255
3	DO Failsafe	Get, Set	SINT	0: Set Low 1: Set High 2: Hold Last
4	DO Restart Mode	Get, Set	SINT	0: Disable 1: Enable

Attribute	Name	Access	Data type	Description
5	DO Switch Mode	Get, Set	SINT	0: Push-Pull (U_S, 0.5 A) 1: High-Side (U_L, 0.5 A) 2: High-Side (U_L, 1.0 A) 3: High-Side (U_L, 1.5 A) 4: High-Side (U_L, 2.0 A) 5: High-Side (U_L, 2.0 A max)
6	DI Logic	Get, Set	SINT	0: Normally Open 1: Normally Close
7	DI Filter	Get, Set	SINT	0: Disabled 1: 1 ms 2: 2 ms 3: 3 ms 4: 6 ms 5: 10 ms 6: 15 ms
8	DI Latch	Get, Set	SINT	0: Disable 1: Enable
9	DI Extension	Get, Set	SINT	0 .. 127
10	Channel Mode	Get, Set	SINT	0: Inactive 1: Digital Output 2: Digital Input 3: IO-Link 4: Auxiliary Power **The supported Channel Mode depends on the device variant.**

15.2.3 IO-Link Diagnosis Settings Object (0xA2)

Only applicable for mixmodule variants.

Supported services:

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 1)

Attribute	Name	Access	Data type	Description
1	IO-Link Master Diagnosis	Get, Set	BOOL	0: Disable 1: Enable
2	IO-Link Device Error	Get, Set	BOOL	0: Disable 1: Enable
3	IO-Link Device Warning	Get, Set	BOOL	0: Disable 1: Enable
4	IO-Link Device Notification	Get, Set	BOOL	0: Disable 1: Enable
11 .. 12	IO-Link Device Diagnosis Port 7 .. 8	Get, Set	BOOL	0: Disable 1: Enable

15.2.4 IO-Link Port Settings Object (0xA3)

Only applicable for mixmodule variants.

Supported services:

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 7 .. 8)

Attribute	Name	Access	Data type	Description
1	Output Data Size	Get, Set	SINT	0: No data 1: 2 Byte 2: 4 Byte 3: 8 Byte 4: 16 Byte 5: 32 Byte Only settable when no connection is established.
2	Input Data Size	Get, Set	SINT	0: No data 1: 2 Byte 2: 4 Byte 3: 8 Byte 4: 16 Byte 5: 32 Byte Only settable when no connection is established.

Attribute	Name	Access	Data type	Description
3	Input Data Extension	Get, Set	SINT	0: No Data 1: Extended Status 2: Events 3: Extended Status + Events Only settable when no connection is established.
4	Output Data Swapping Mode	Get, Set	SINT	0: Raw IO-Link Data 1 .. 16: 1 .. 16 WORD 17 .. 24: 1 .. 8 DWORD Only settable when no connection is established.
5	Output Data Swapping Offset	Get, Set	SINT	0 .. 30 Byte Only settable when no connection is established.
6	Input Data Swapping Mode	Get, Set	SINT	0: Raw IO-Link Data 1 .. 16: 1 .. 16 WORD 17 .. 24: 1 .. 8 DWORD Only settable when no connection is established.
7	Input Data Swapping Offset	Get, Set	SINT	0 .. 30 Byte Only settable when no connection is established.
8	IOL Failsafe	Get, Set	SINT	0: Set Low 1: Set High 2: Hold Last 3: Replacement Value (transferred via IO-Link Failsafe Parameter Object) 4: IO-Link Master Command
9	Port Mode	Get, Set	SINT	0: Deactivated 1: Manual (with validation and backup config) 2: Autostart (no validation and backup config)

Attribute	Name	Access	Data type	Description
10	Validation and Backup	Get, Set	SINT	0: No device check and clear (no data storage) 1: Type compatible V1.0 device (no data storage) 2: Type compatible V1.1 device (no data storage) 3: Type compatible V1.1 device with Backup + Restore (Download + Upload) 4 Type compatible V1.1 device with Restore (Download Master to Device)
11	Vendor ID	Get, Set	DINT	0 .. 65535
12	Device ID	Get, Set	DINT	0 .. 16777215
13	Cycle Time	Get, Set	SINT	0: As fast as possible 1: 1.6 ms 2: 3.2 ms 3: 4.8 ms 4: 8.0 ms 5: 20.8 ms 6: 40.0 ms 7: 80.0 ms 8: 120.0 ms

15.2.5 IO-Link Failsafe Parameter Object (0xA4)

Only applicable for mixmodule variants.

Supported services:

Get Attribute Single (0x0E)

Set Attribute Single (0x10)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 7 .. 8)

Attribute	Name	Access	Data type	Description
1	Failsafe value of IO-Link port	Get, Set	Array of Bytes	Depends on configured process data lengths, content must consider possible swapping configuration (failsafe value format must match output data format)

15.2.6 IO-Link Device Parameter Object (0xA5)

Only applicable for mixmodule variants.

Supported services:

Instance 0

Get Attribute Single (0x0E)

Instance 7 .. 8

Get ISDU data (0x4B)

Set ISDU data (0x4C)

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 7 .. 8)

Attribute	Name	Access	Data type	Description
1	ISDU data of IO-Link port	Get, Set	Array of Bytes	ISDU data of an IO-Link Device can be read using the Get ISDU data service and written using the Set ISDU data service (see description of these services below).

Get ISDU data

The Index and Subindex shall be set in the source data. The different protocol data formats between EtherNet/IP (little-endian) and IO-Link (big-endian) must be considered. The data length of the response depends on the data type of the IO-Link Device.

Protocol	EtherNet/IP		
Byte	0	1	2
Data type	UINT		USINT
Endianness	LSB	MSB	–
Content	Index		Subindex

Table 25: Source

Protocol	IO-Link		
Byte	0	…	n
Data type	Depends on device data type		
Endianness	MSB	…	LSB
Content	Data or Error occurred (max. 232 Bytes)		

Table 26: Destination

Set ISDU data

The Index, Subindex and IO-Link data shall be set in the source data. The data length of the request depends on the data type of the IO-Link Device. The different protocol data formats between EtherNet/IP (little-endian) and IO-Link (big-endian) must be considered. There is only data in the response of the IO-Link Device available if an Error occurred.

Protocol	EtherNet/IP			IO-Link		
Byte	0	1	2	3	…	n
Data type	UINT		USINT	Depends on device data type		
Endianness	LSB	MSB	–	MSB	…	LSB
Content	Index		Subindex	Data (max. 232 Bytes)		

Table 27: Source

Protocol	IO-Link		
Byte	0	…	n
Data type	Depends on device data type		
Endianness	MSB	…	LSB
Content	Error if occurred (max. 232 Bytes)		

Table 28: Destination

If the read or write request is not successful (CIP response status is unequal "0"), the following response format of 4 bytes is available:

Name	Data type	Error code description	Error code
IO-Link Master Error	UINT	Service not available	1
		Port blocked	2
		Timeout	3
		Invalid index	4
		Invalid sub-index	5
		Wrong port	6
		Wrong port function	7
		Invalid length	8
		ISDU not supported	9
IO-Link Device Error	USINT	Refer to IO-Link specification	–
IO-Link Device Additional Error	USINT	Refer to IO-Link specification	–

In Get/Set ISDU data on page 212, you find an example for Rockwell Automation Studio 5000®.

15.2.7 Safety General Settings Object (0xA6)

Supported services:

- Get Attribute Single (0x0E)
- Set Attribute Single (0x10)*
- Configure Request (0x4D)*

  Request data: Password (16 byte) + TUNID (10 byte)
- Validate Configuration (0x4E)*

  Request data: SCID of tool (SCCRC (4 byte) + SCTS (6 byte))
- Apply Configuration (0x4F)*

* only accepted in "Configuring" state, *Configure Request* also accepted in "Idle" state

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 1)

Attribute	Name	Access	Data type	Description
1	Input Sensor Analysis	Get, Set	SINT	0: 1oo1 without test pulse 1: 1oo1 with test pulse 2: 1oo2 without test pulse 3: 1oo2 with test pulse
2	Output Test Pulses	Get, Set	SINT	0: Test Pulse Length 0.75 ms, Repetition Rate 300 ms 1: Test Pulse Length 50 ms, Repetition Rate 5 s 2: Test Pulse Length 100 ms, Repetition Rate 10 s

15.2.8 Safety Input Port Settings Object (0xA7)

Supported services:

- Get Attribute Single (0x0E)
- Set Attribute Single (0x10)*

* only accepted in "Configuring" state

Class attribute (Instance 0)

Attribute	Name	Access	Data type	Description
1	Revision	Get	UINT	Revision of this object
2	Max. Instance	Get	UINT	Maximum instance number of an object currently created in this class level of the device.

Instance attribute (Instance 1 .. n*)

Attribute	Name	Access	Data type	Description
1	Input Port Config	Get, Set	BOOL	0: Safe 1: Non-Safe
2	Input Port Sensor Valence	Get, Set	BOOL	0: Equivalence 1: Antivalence

* n = number of safety input ports supported by the device variant

15.3 Message configuration in Rockwell Automation Studio 5000®

Attributes of CIP object classes can be handled in Rockwell Automation Studio 5000® by the *Message instruction*. This requires the selection of the proper message and service type with its respective service code.

The channels as in the *Channel Settings Object* are each assigned in ascending order to an instance ID.

Assignment of the channels:

Channel 1	Port X1.ChA	CIP object instance 1
Channel 2	Port X1.ChB	CIP object instance 2
[…]	[…]	[…]
Channel 15	Port X8.ChA	CIP object instance 15
Channel 16	Port X8.ChB	CIP object instance 16

The IO-Link ports as in the *IO-Link Port Settings Object*, *IO-Link Failsafe Parameter Object* and *IO-Link Device Parameter Object* are each assigned in ascending order to an instance ID.

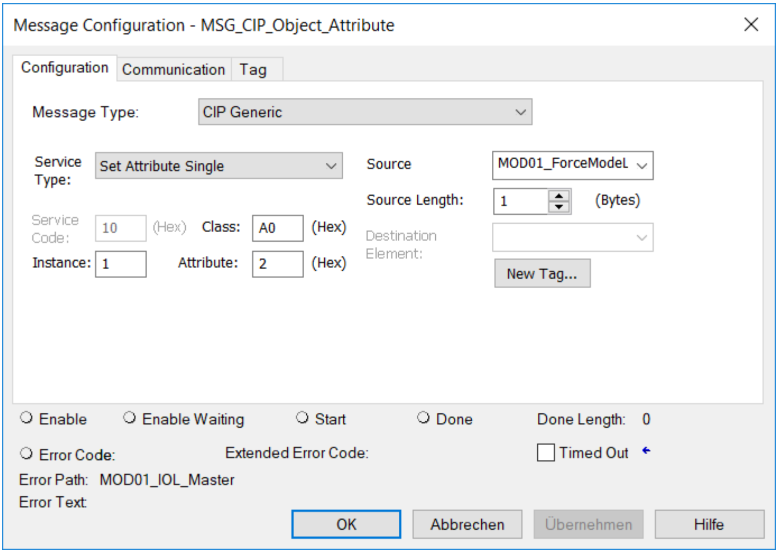
Assignment of the IO-Link ports:

IO-Link port 1	Port X1.ChA	CIP object instance 1
[…]	[…]	[…]
IO-Link port 8	Port X8.ChA	CIP object instance 8

15.3.1 Get/Set attribute single

Every attribute with exception of the IO-Link Device Parameter Object Instance 1..n can be accessed using the *Get/Set attribute single* service by the CIP object class ID, the instance ID and attribute ID. The respective data is described in the previous chapters.

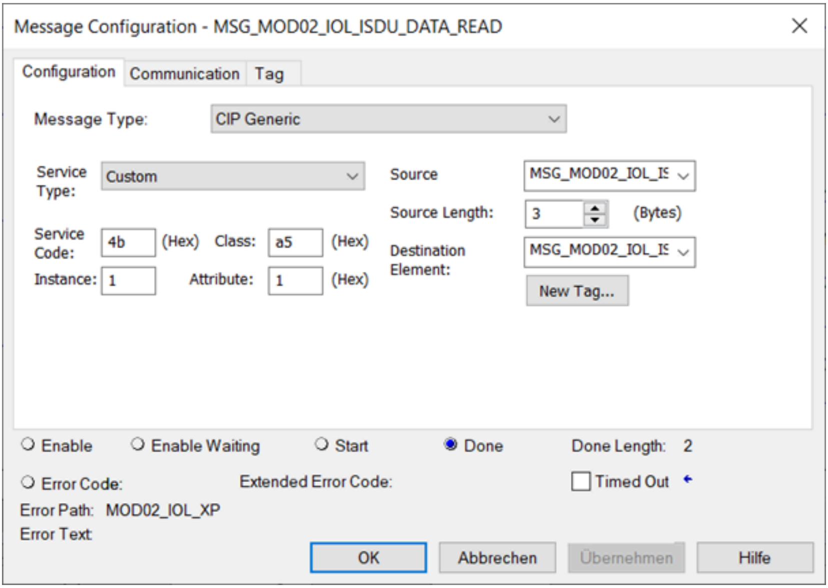
The following image shows an example of how to set *Force Mode Lock* (Attribute 2) of the *General Settings Object (0xA0)* with the *Message instruction*:



15.3.2 Get/Set ISDU data

The IO-Link Device Parameter Object Instance 1..n can be accessed using the vendor specific *Get/Set ISDU data* service by the CIP object class ID, the instance ID and attribute ID. The Index and Subindex shall be set in the source data. For the *Set ISDU data* service, the IO-Link data must be appended. The different protocol data formats between EtherNet/IP (little-endian) and IO-Link (big-endian) must be considered. The respective data is described in the previous chapters.

The following figure shows an example of how to get an IO-Link Device parameter using the *Get ISDU data (0x4B)* service of the *IO-Link Device Parameter Object (0xA5)* with the *Message instruction:*



The Index (0x003C) and Subindex (0x01) of the IO-Link device parameter are set in the little-endian format of EtherNet/IP in the source data:

−MSG_MOD02_IOL_ISDU_SRC_READ	{...}	{...}	Hex	SINT[8]
+MSG_MOD02_IOL_ISDU_SRC_READ[0]	16#3c		Hex	SINT
+MSG_MOD02_IOL_ISDU_SRC_READ[1]	16#00		Hex	SINT
+MSG_MOD02_IOL_ISDU_SRC_READ[2]	16#01		Hex	SINT

The response data of the IO-Link device can be found in the destination element. In the following example, the received value is of the type UINT in the big-endian format of IO-Link (0x0546 = 1350):

− MSG_MOD02_IOL_ISDU_DST_READ	{...}	{...}	Hex	SINT[8]
+ MSG_MOD02_IOL_ISDU_DST_READ[0]	16#05		Hex	SINT
+ MSG_MOD02_IOL_ISDU_DST_READ[1]	16#46		Hex	SINT

16 Diagnostics processing

16.1 Error of the system/sensor power supply

The voltage value for the incoming system/sensor power supply is also monitored globally. If the voltage drops below approx. 18 V, or exceeds approx. 30 V, an error diagnosis is generated. The IO-Link specification requires at least 20 V at the L+ (pin1) output supply of the I/O ports. At least 21 V of U_S supply voltage for the IO-Link Master are required to minimize the risk of internal voltage drops in the IO-Link Master.

The green U_S indicator is off.

The error diagnosis has no effect on the outputs.

Caution: It must definitely be ensured that the supply voltage, measured at the most remote participant is not below 21 V DC from the perspective of the system power supply.

The following diagnostics are generated in the producing data image:

General diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	IME	FME	0	0	SCA	SCS	LVA	**LVS**
	Byte 1	0	0	0	0	IDN	IDW	IDE	IVE

LVS Low Voltage System/Sensor Supply

Attention: If the undervoltage has been detected for longer than 10 minutes, the Safety system switches into safe state.

16.2 Error of the auxiliary/actuator power supply

The voltage value for the incoming auxiliary/actuator power supply is also monitored globally. If *Report U_L/U_{AUX} Supply Voltage Fault* is enabled, an error message is generated when the voltage drops below approx. 18 V or exceeds approx. 30 V. The U_L/U_{AUX} indicator shows red.

The following diagnostics are generated in the *producing data image*:

General diagnostics	**Bit**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
General Bit	Byte 0	IME	FME	0	0	SCA	SCS	**LVA**	LVS
	Byte 1	0	0	0	IDN	IDW	IDE	IVE	0

LVA	Low Voltage Actuator Supply

If output channels are set to *High State* and *Report DO Fault without U_S*, additional error diagnostics, caused by the voltage failure, are generated on the channels

The following diagnostics are generated in the *producing data image*:

Actuator/U_{AUX} diagnostics	**Bit**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Channel number (fix)	Byte 0	0	0	0	0	0	0	0	0
	Byte 1	16	15	14	13	0	0	0	0

13 .. 16	Actuator/U_S channel error on channel 13 .. 16

If *Report U_L/U_{AUX} Supply Voltage Fault* is disabled, no U_L/U_{AUX} or channel diagnostics appear.

16.3 Overload/short-circuit of the I/O port sensor supply outputs

In case of an overload or a short circuit between pin 1 and pin 3 on the ports (X1 .. X8), the following channel-specific diagnostics in the producing data image are generated:

General diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	IME	FME	0	0	SCA	**SCS**	LVA	LVS
	Byte 1	0	0	0	0	IDN	IDW	IDE	IVE

SCS Short Circuit Sensor

Sensor diagnostics	Bit	7	6	5	4	3	2	1	0
Port number	Byte 0	**X8**	**X7**	0	0	0	0	0	0
	Byte 1	0	0	0	0	0	0	0	0

X7 .. 8 Sensor Short Circuit on Port X7 .. X8

16.4 Overload/short circuit of the digital outputs

In case of an overload or a short circuit of an output channel, the following channel-specific diagnostics are generated in the *producing data image*:

General diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	IME	FME	0	0	**SCA**	SCS	LVA	LVS
	Byte 1	0	0	0	0	IDN	IDW	IDE	IVE

SCA

Short Circuit Actuator/U_L/U_{AUX}

Actuator/U_{AUX} diagnostics	Bit	7	6	5	4	3	2	1	0
Channel number (fix)	Byte 0	0	0	0	0	0	0	0	0
	Byte 1	16	15	14	13	0	0	0	0

13 .. 16

Actuator/U_S channel error on channel 13 .. 16

A channel error is determined by comparing the target value set by a controller and the physical value of an output channel.

When an output channel is activated (rising edge of the channel state), the channel errors are filtered for the period that is set by the "Surveillance-Timeout" parameter via the configuration of the device. The value of this parameter can range from 0 to 255 ms; the factory setting is 80 ms.

The filter is used to avoid premature error messages when a capacitive load is activated or an inductive load is deactivated, and during other voltage peaks when a status changes.

In static state of the output channel, that is, while the channel is permanently switched on, the filter time between error detection and the diagnosis is typically 5 ms.

16.5 IO-Link COM error

If an IO-Link Device in COM mode is unplugged, an incorrect IO-Link Device is plugged in, or an electrical fault occurs on the C/Q (Pin 4) line, for example, due to a short circuit, the following diagnostics are generated in the *producing data image*:

IO-Link diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	**ICE8**	**ICE7**	0	0	0	0	0	0
	Byte 1	0	0	0	0	0	0	0	0
	Byte 2	IVE8	IVE7	0	0	0	0	0	0
	Byte 3	IDE8	IDE7	0	0	0	0	0	0
	Byte 4	IDW8	IDW7	0	0	0	0	0	0
	Byte 5	IDN8	IDN7	0	0	0	0	0	0

ICE7 .. 8

IO-Link Port COM Error (device missing, broken wire, short circuit)

16.6 IO-Link validation error

If an IO-Link Device is exchanged by a new device, the validation is configured. The vendor ID and/or device ID do not match the data of the device and the following diagnostics are generated in the *producing data image*:

IO-Link diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	ICE8	ICE7	0	0	0	0	0	0
	Byte 1	0	0	0	0	0	0	0	0
	Byte 2	**IVE8**	**IVE7**	0	0	0	0	0	0
	Byte 3	IDE8	IDE7	0	0	0	0	0	0
	Byte 4	IDW8	IDW7	0	0	0	0	0	0
	Byte 5	IDN8	IDN7	0	0	0	0	0	0

IVE7 .. 8 IO-Link Port Validation Error

If extended status data is enabled by the configuration of an IO-Link port, the vendor ID and device ID are additionally transferred in the *producing data image*.

16.7 IO-Link device diagnostics

The diagnostics of an IO-Link Device come in three different levels: Error, Warning or Notification. The following diagnostics are generated in the *producing data image*:

IO-Link diagnostics	Bit	7	6	5	4	3	2	1	0
General Bit	Byte 0	ICE8	ICE7	0	0	0	0	0	0
	Byte 1	0	0	0	0	0	0	0	0
	Byte 2	IVE8	IVE7	0	0	0	0	0	0
	Byte 3	**IDE8**	**IDE7**	0	0	0	0	0	0
	Byte 4	**IDW8**	**IDW7**	0	0	0	0	0	0
	Byte 5	**IDN8**	**IDN7**	0	0	0	0	0	0

IDE7 .. 8 IO-Link Port Device Error

IDW7 .. 8 IO-Link Port Device Warning

IDN7 .. 8 IO-Link Port Device Notification

If IO-Link event data is enabled by the configuration of an IO-Link port the device additionally reports event codes in the *producing data image*. Use the IO-Link Device documentation to interpret the error message.

17 IIoT functionality

The LioN-Safety variants offer a number of new interfaces and functions for the optimal integration into existing or future IIoT (Industrial Internet of Things) networks. The devices continue to work as field bus devices which communicate with and are controlled by a PLC (Programmable Logic Controller).

In addition, the devices offer common IIoT interfaces, which enable new communication channels besides the PLC. The communication is performed via IIoT-relevant protocols MQTT and OPC UA. With the help of these interfaces not only all information in a device can be read. They also enable its configuration and control, if the user wishes. All interfaces can be configured extensively and offer read-only functionality.

All LioN-Safety variants provide user administration, which is also applicable for accessing and configuring the IIoT protocols. This allows you to manage all modification options for the device settings via personalized user authorizations.

All IIoT protocols can be used and configured independently of the field bus. It is also possible to use the devices completely without the help of a PLC and control them via IIoT protocols.

Attention: When using the IIoT functionality, a protected local network environment without direct access to the Internet is recommended.

17.1 MQTT

The MQTT (Message Queuing Telemetry Transport) protocol is an open network protocol for machine-to-machine communication, which provides the transmission of telemetric data messages between devices. The integrated MQTT client allows the device to publish a specific set of information to an MQTT broker.

The publishing of messages can either occur periodically or be triggered manually.

17.1.1 MQTT configuration

In **delivery state**, MQTT functions are **disabled**. The MQTT client can be configured either using the Web interface or directly via a JSON object sent in an HTTP/HTTPS request. For more information see chapter MQTT configuration - Quick start guide on page 238.

The configuration URL is:

`http://[ip-address]/w/config/mqtt.json`

The configuration can also read back as a JSON file:

`http://[ip-address]/r/config/mqtt.json`

The configuration is a JSON object. Each JSON member is a configuration element. The object must not contain all elements. Only the provided elements will be changed. The configuration changes apply only after a device restart.

The following configuration elements are available (default values in bold):

Element	Data type	Description	Example data
mqtt-enable	boolean	Master switch for the MQTT client.	true / **false**
broker	string	IP address of the MQTT Broker	**"192.168.1.1"**
login	string	Username for MQTT Broker	"admin" (Default: **null**)
password	string	Password for MQTT Broker	"private" (Default: **null**)
port	number	Broker port	**1883**
base-topic	string	Base topic	"iomodule_[mac]" (Default: **"lionsafety"**)
will-enable	boolean	If true, the device provides a last will message to the broker	true / **false**
will-topic	string	The topic for the last will message.	(Default: **null**)
auto-publish	boolean	If true, all enabled domains will be published automatically in the specified interval.	**true** / false
publish-interval	number	The publish interval in ms if auto-publish is enabled. Minimum is 250 ms.	**2000**
publish-identity	boolean	If true, all identity domain data will be published	**true** / false
publish-config	boolean	If true, all config domain data will be published	**true** / false
publish-status	boolean	If true, all status domain data will be published	**true** / false
publish-process	boolean	If true, all process domain data will be published	**true** / false
publish-devices	boolean	If true, all IO-Link Device domain data will be published	true / **false**
commands-allowed	boolean	Master switch for MQTT commands. If false, the device will not subscribe to any command topic, even if specific command topics are activated below.	true / **false**
force-allowed	boolean	If true, the device accepts force commands via MQTT.	true / **false**
reset-allowed	boolean	If true, the device accepts restart and factory reset commands via MQTT.	true / **false**
config-allowed	boolean	If true, the device accepts configuration changes via MQTT.	true / **false**

Element	Data type	Description	Example data
qos	number	Selects the "Quality of Service" status for all published messages.	**0 = At most once** 1 = At least once 2 = Exactly once

Table 29: MQTT configuration

MQTT response:

The resulting response is a JSON object with a "status" field. Status should be "0" if no error occurred and "-1" if there is an error.

In case of an error, the response contains an error array.

The error array contains an error object for each error occurred. The object consists of a field "Element" which names the config element which caused the error, and a field "Message" for the error message.

- A malformed JSON object produces an error.
- Not existing parameters produce an error.
- Parameters with a wrong data type produce an error.

It is not allowed to write all available parameters at once. You may write only one or a limited number of parameters.

Examples:

```
{"status": -1, "error": [{"Element": "publish-interval", "Message": "Integer expected"}]}

{"status": 0}

{"status": -1, "error": [{"Element": "root", "Message": "Not a JSON object"}]}
```

For more information see chapter MQTT topics on page 226.

17.1.2 MQTT topics

MQTT mainly relates to topics. All messages are attached to a topic which adds context to the message itself. Topics may consist of any string and they are allowed to contain slashes (`/`) as well as wildcard symbols (`*, #`).

17.1.2.1 Base topic

For all LioN-Safety variants there is a configurable Base topic which is the prefix for all topics. The Base topic can be chosen freely by the user. The Base topic can also contain selected variables as shown in Table 30: Base topic variables on page 226.

Variables in the Base topic have to be written in brackets ("[ ]"). The following variables are possible:

Variable	Description
mac	The MAC address of the device
name	The name of the device
order	The ordering number of the device
serial	The serial number of the device

Table 30: Base topic variables

Example:

The Base topic `"io_[mac]"` translates to `"io_A3B6F3F0F2F1"`.

All data is organized in domains. The domain name is the first level in the topic after the Base topic. Note the following notation:

`Base-Topic/domain/.….`

There are the following domains:

Domain name	Definition	Example content
identity	All fixed data which is defined by the used hardware and which cannot be changed by configuration or at runtime.	Device name, ordering number, MAC address, port types, port capabilites and more.
config	Configuration data which is commonly loaded once at startup, mostly by a PLC.	IP address, port modes, input logic, failsafe values and more.
status	All (non-process) data which changes quite often in normal operation.	Bus state, diagnostic information, IO-Link Device status and data.
process	All process data which is produced and consumed by the device itself or by attached devices.	Digital inputs, digital outputs, cyclic IO-Link data.
iold	IO-Link Device parameters according to the IO-Link specification.	Vendor name, product name, serial number, hardware revision, software revision and more.

Table 31: Data domains

There is often one topic used for all gateway related information and topics for each port. All identity topics are published just once at start-up, because this information should never change. All other topics are published either in a fixed interval or just triggered manually, according to the configuration.

Topic	Content examples	Total publish count	Publish interval
[base-topic]/identity/gateway	Name, ordering number, MAC, vendor, I&M etc.	1	Startup
[base-topic]/identity/port/n	Port name, port type	8	Startup
[base-topic]/config/gateway	Configuration parameters, ip address etc.	1	Interval
[base-topic]/config/port/n	Port mode, data storage, mapping, direction	8	Interval
[base-topic]/status/gateway	Bus state, device diagnosis, master events	1	Interval
[base-topic]/status/port/n	Port or channel diagnosis, IO-Link state, IO-Link Device events	8	Interval
[base-topic]/process/gateway	All Digital IN/OUT	1	Interval
[base-topic]/process/port/n	Digital IN/OUT per port, IOL-data, pdValid	8	Interval
[base-topic]/iold/port/n	IO-Link Device parameter	8	Interval

Table 32: Data model

An MQTT client which wants to subscribe to one or more of these topics can also use wildcards.

Full topic	Description
[base-topic]/identity/gateway	Receive only indentity objects for the gateway
[base-topic]/identity/#	Receive all data related to the identity domain
[base-topic]/status/port/5	Receive only status information for port number 5
[base-topic]/+/port/2	Receive information of all domains for port number 2
[base-topic]/process/port/#	Receive only process data for all ports
[base-topic]/config/#	Receive config data for the gateway and all ports.

Table 33: Use case examples

17.1.2.2 Publish topic

Overview of all publish JSON data for the defined topics:

Key	Data type
product_name	json_string
ordering_number	json_string
device_type	json_string
serial_number	json_string
mac_address	json_string
production_date	json_string
fw_name	json_string
fw_date	json_string
fw_version	json_string
hw_version	json_string
vendor_name	json_string
vendor_address	json_string
vendor_phone	json_string
vendor_email	json_string
vendor_techn_support	json_string
vendor_url	json_string
vendor_id	json_integer
device_id	json_integer

Table 34: Identity/gateway

Key	Data type	Range	Default value	Remarks
fieldbus_protocol	json_string	PROFINET, EtherNet/IP, EtherCAT®		
ip_address	json_string		192.168.1.1	
subnet_mask	json_string		255.255.255.0	
report_alarms	json_boolean		0.0.0.0	
report_ul_alarm	json_boolean	true / false	true	
report_do_fault_without_ul	json_boolean	true / false	false	
force_mode_lock	json_boolean	true / false	false	
web_interface_lock	json_boolean	true / false	false	
do_auto_restart	json_boolean	true / false	true	
fast_startup	json_boolean	true / false	false	PROFINET and EIP only

Table 35: Config/gateway

Key	Data type	Range	Default value	Remarks
protocol	json_string	wait_for_io_system wait_for_io_Connection failsafe connected error		
ethernet_port1	json_string	100_mbit/s_full 100_mbit/s 10_mbit/s_full 100_mbit/s		
ethernet_port2	json_string	100_mbit/s_full 100_mbit/s 10_mbit/s_full 100_mbit/s		
module_restarts	json_integer	0 .. 4294967295		
channel_diagnosis	json_boolean	true / false		
failsafe_active	json_boolean	true / false		
system_voltage_fault	json_boolean	true / false		
actuator_voltage_fault	json_boolean	true / false		
internal_module_error	json_boolean	true / false		
simulation_active_diag	json_boolean	true / false		
us_voltage	json_integer	0 .. 32		in Volts
ul_voltage	json_integer	0 .. 32		in Volts
forcemode_enabled	json_boolean	true / false		

Table 36: Status/gateway

Key	Data type	Range	Default value	Remarks
Input_data	json_integer[]			
output_data	json_integer[]			

Table 37: Process/gateway

Key	Data type	Range	Default value	Remarks
port	json_integer	1 .. 8		
type	json_string	digital_universal digital_input digital_Output io_link		
max_output_power_cha	json_string	2.0_mA 0.5_mA		
max_output_power_chb	json_string	2.0_mA 0.5_mA		
channel_cha	json_string	input/output input output io_link aux		
channel_chb	json_string	input/output input output io_link aux		

Table 38: Identity/port/1 .. 8

Key	Data type	Range	Default value	Remarks
port	json_integer	1 .. 8		
direction_cha	json_string	input/output input output		
restart_mode_cha	json_string	Manual Auto		
restart_mode_chb	json_string	Manual Auto		
input_polarity_cha	json_string	NO NC		
input_polarity_chb	json_string	NO NC		
input_filter_cha	json_integer			ms
input_filter_chb	json_integer			ms
do_auto_restart_cha	json_boolean	true / false		
do_auto_restart_chb	json_boolean	true / false		

Table 39: Config/port/1 .. 8

Key	Data type	Range	Default value	Remarks
port	json_integer	1 .. 8		
physical_state_cha	json_integer	0 .. 1		
physical_state_chb	json_integer	0 .. 1		
actuator_short_circuit_cha	json_boolean	true / false		
actuator_short_circuit_chb	json_boolean	true / false		
sensor_short_circuit	json_boolean	true / false		
current_cha	json_integer			mA
current_chb	json_integer			mA
current_pin1	json_integer			mA

Table 40: Status/port/1 .. 8

17.1.2.3 Command topic (MQTT Subscribe)

The main purpose of MQTT is to publish data from the device to a broker. This data can then be received by any subscriber who is interested in this data. But also the other way round is possible. The device can subscribe to a topic on the broker and is then able to receive data. This data can contain configuration or forcing data. This allows the user to fully control a device via MQTT only, without using other ways of communication like Web or REST.

If the configuration allows commands in general, the device subscribes to special Command topics on which it can receive commands from other MQTT clients. The Command topic is based upon the Base topic. It always has the following form:

```
[base-topic]/command
```

After the Command topic, there are fixed topics for different writeable objects. The data format of the MQTT payload is always JSON. It is possible to set only a subset of the possible objects and fields.

[...]/forcing

Use the Command topic `[base-topic]/command/forcing` for *Force object* data. The *Force object* can contain any of the following properties:

Property	Data type	Example values	Remarks
forcemode	boolean	true / false	Forcing Authority: on/off
digital	array (Table 42: Force object: Digital on page 235)		
iol	array (Table 43: Force object: IOL (IO-Link devices only) on page 235)		

Table 41: Force object properties

For the *Force object* properties `digital` and `iol`, there are several value specifications arrayed:

Property	Data type	Example values	Remarks
port	integer	1, 2, 5	
channel	string	"a", "b"	
force_dir	string	"out", "in", "clear"	
force_value	integer	0, 1	

Table 42: Force object: Digital

Property	Data type	Example values	Remarks
port	integer	0, 1, 5	
output	array[integer]	[55, 88, 120]	
input	array[integer]		Input-Simulation

Table 43: Force object: IOL (IO-Link devices only)

[…]/config

Use the Command topic `[base-topic]/command/config` for *Config object* data. The *Config object* can contain any of the following properties:

Property	Data type	Example values	Remarks
portmode	array (Table 45: Config object: Portmode on page 236)		
ip_address	string	"192.168.1.5"	
subnet_mask	string	"255.255.255.0"	
gateway	string	"192.168.1.100"	

Table 44: Config object properties

For the *Config object* property `portmode`, there are several value specifications arrayed:

Property	Data type	Example values	Remarks
port	integer	2	
channelA*	string	"dio", "di", "do", "iol", "off"	
channelB*	string	"dio", "di", "do", "iol", "off", "aux"	
inlogicA	string	"no", "nc"	
inlogicB	string	"no", "nc"	
filterA	integer	3	input filter in ms
filterB	integer	3	input filter in ms
autorestartA	boolean		
autorestartB	boolean		
iolValidation	integer	0 = NoCheck 1 = Type 1.0 2 = Type 1.1 3 = Type 1.1 BR 4 = Type 1.1 RES	
iolDeviceID	integer		for validation
iolVendorID	integer		for validation

Table 45: Config object: Portmode

*channelA = Pin 4, channelB = Pin 2

[…]/reset

Use the Command topic `[base-topic]/command/reset` for *Reset object* data about restart and factory reset issues. The *Reset object* can contain any of the following properties:

Property	Data type	Example values	Remarks
factory_reset	boolean	true / false	
system_reset	boolean	true / false	

Table 46: Reset object properties

[…]/publish

Use the Command topic `[base-topic]/command/publish` for *Publish object* data.

Trigger publish of all topics manually (can be used when auto publish is off or long interval is set).

17.1.3 MQTT configuration - Quick start guide

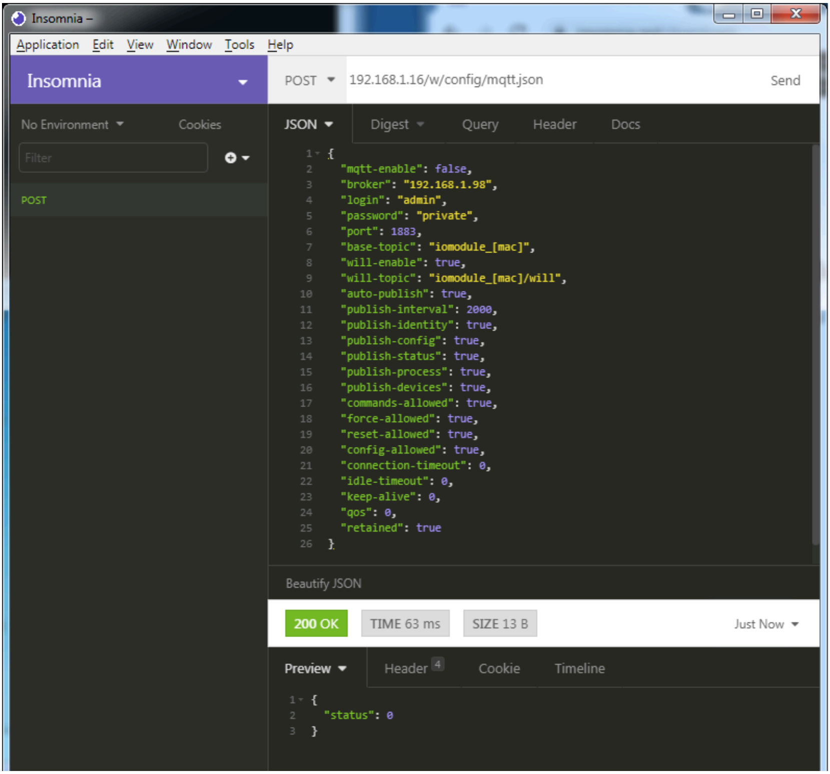
Attention: Lumberg Automation™ is not responsible for any content of the referenced Web pages and provides no warranty for any functionality of the named third party software.

17.1.3.1 MQTT configuration via JSON

1. Depending on your application case, download and install *Insomnia* or a comparable application: https://insomnia.rest/download/

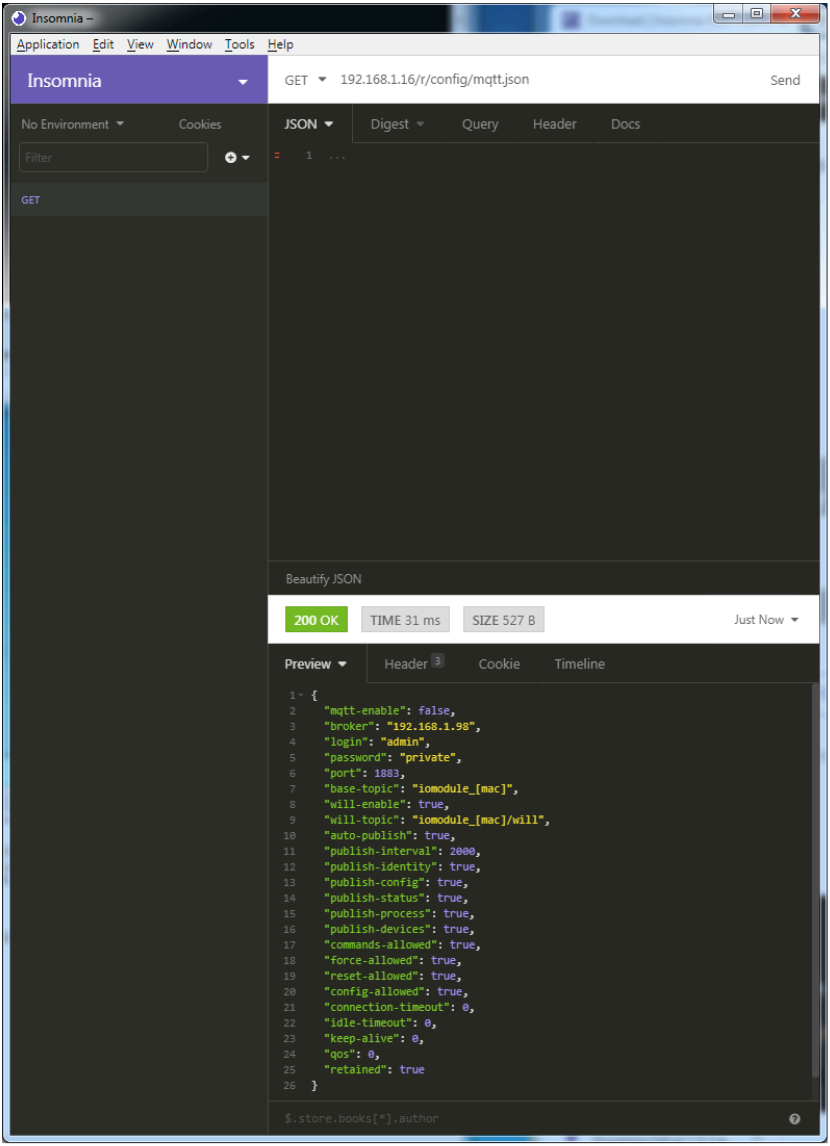
2. Configure MQTT:

POST: `[IP-address]/w/config/mqtt.json`



3. Read MQTT:

GET: `[IP-address]/r/config/mqtt.json`



17.2 OPC UA

OPC Unified Architecture (OPC UA) is a platform-independent standard with a service-oriented architecture for communication in and with industrial automation systems.

The OPC UA standard is based on the client-server principle and lets machines and devices, regardless of any preferred field bus, communicate horizontally among each other as well as vertically to the ERP system or the cloud. LioN-Safety provides an OPC UA server on field device level, with which an OPC UA client can connect for information exchange secure in transmission.

For OPC UA, we comply (apart from the exceptions listed below) with the IO-Link Companion Specification, which can be downloaded from https://catalog.belden.com or directly from io-link.com.

Feature	Support
Managing IODDs (chapter 6.1.6 in the specification)	Not supported
Mapping IODD information to OPC UA ObjectTypes (chapter 6.3 in the specification)	Not supported
IOLinkIODDDeviceType (chapters 7.2 ff. in the specification)	Not supported
ObjectTypes generated based on IODDs (chapters 7.3 ff. in the specification)	Not supported
Creation of Instances based on ObjectTypes generated out of IODDs (chapter 7.4 in the specification)	Not supported
IODDManagement Object (chapter 8.2 in the specification)	Not supported
RemoveIODD Method (chapter 8.3 in the specification)	Not supported

Table 47: Non-supported OPC UA features according to the IO-Link Companion Specification

17.2.1 OPC UA configuration

In **delivery state**, OPC UA functions are **disabled**. The OPC UA Server can be configured either using the Web interface or directly via a JSON Object sent in an HTTP/HTTPS request. For more information see OPC UA configuration - Quick start guide on page 244.

The configuration URL is:

`http://[ip-address]/w/config/opcua.json`

The configuration can also read back as a JSON file:

`http://[ip-address]/r/config/opcua.json`

The configuration is a JSON object. Each JSON member is a configuration element. The object must not contain all elements. Only the provided elements will be changed. All configuration changed applies only after a device restart.

There are the following configuration elements (default values in bold):

Element	Data type	Description	Example data
port	integer	Server port for the OPC UA server.	0, **4840**, 0xFFFF
opcua-enable	boolean	Master switch for the OPC UA server.	true / **false**
anon-allowed	boolean	If true, anonymous login is allowed.	**true** / false
commands-allowed	boolean	Master switch for OPC UA commands. If false there will be no writeable OPC UA objects.	true / **false**
force-allowed	boolean	If true, the device accepts force commands via OPC UA.	true / **false**
reset-allowed	boolean	If true, the device accepts restart and factory reset commands via OPC UA.	true / **false**
config-allowed	boolean	If true, the device accepts configuration changes via OPC UA.	true / **false**

Table 48: OPC UA Configuration

All configuration elements are optional and do not need a specific order. Not every element is required to be sent. This means that only configuration changes will be taken over.

Optional: The configuration parameters of OPC UA can be set directly via the Web interface. It is possible to download the Web interface for sharing with other devices.

Response:

The resulting response is a JSON object with a status field. Status should be "0" if no error occurred and "-1" if there is an error.

In case of an error, the response contains an error array.

The error array contains an error object for each error occurred. The object consists of a field "Element" which names the config element which caused the error, and a field "Message" for the error message.

Examples:


```
{"status": -1, "error": [{"Element": "upcua-enable", "Message": "Boolean
 expected"}]}

{"status": 0}

{"status": -1, "error": [{"Element": "root", "Message": "Not a JSON
 object"}]}
```


17.2.2 OPC UA address space

OPC UA provides different services on the LioN-Safety devices with which a client can navigate through the hierarchy of the address space and read or write variables. In addition, the client can monitor up to 10 attributes from the address space for value changes.

A connection to an OPC UA server is established via the endpoint URL:

```
opc.tcp://[ip-address]:[port]
```

Various device data such as MAC address, device settings, diagnostics or status information can be read via *Identity objects*, *Config objects*, *Status objects* and *Process objects*.

Command objects can be read and written. This makes it possible, for example, to transfer new network parameters to the device, to use Force Mode or to reset the entire device to its factory settings.

The following figures illustrate the OPC UA address space of the LioN-Safety devices. The objects and information displayed depend on the device variant used.

17.2.3 OPC UA configuration - Quick start guide

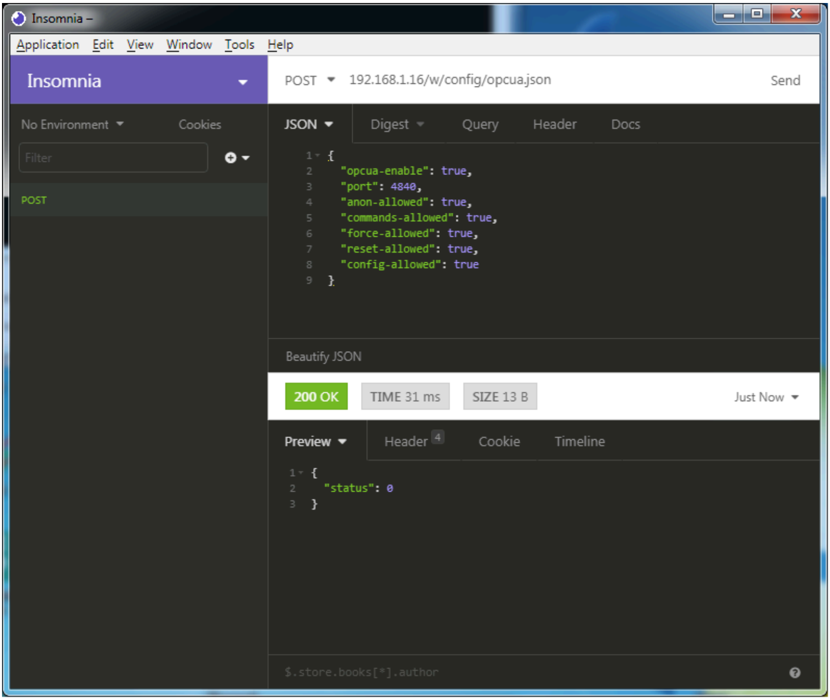
Attention: Lumberg Automation™ is not responsible for any content of the referenced Web pages and provides no warranty for any functionality of the named third party software.

17.2.3.1 OPC UA configuration via JSON

1. Depending on your application case, download and install *Insomnia* or a comparable application: https://insomnia.rest/download/

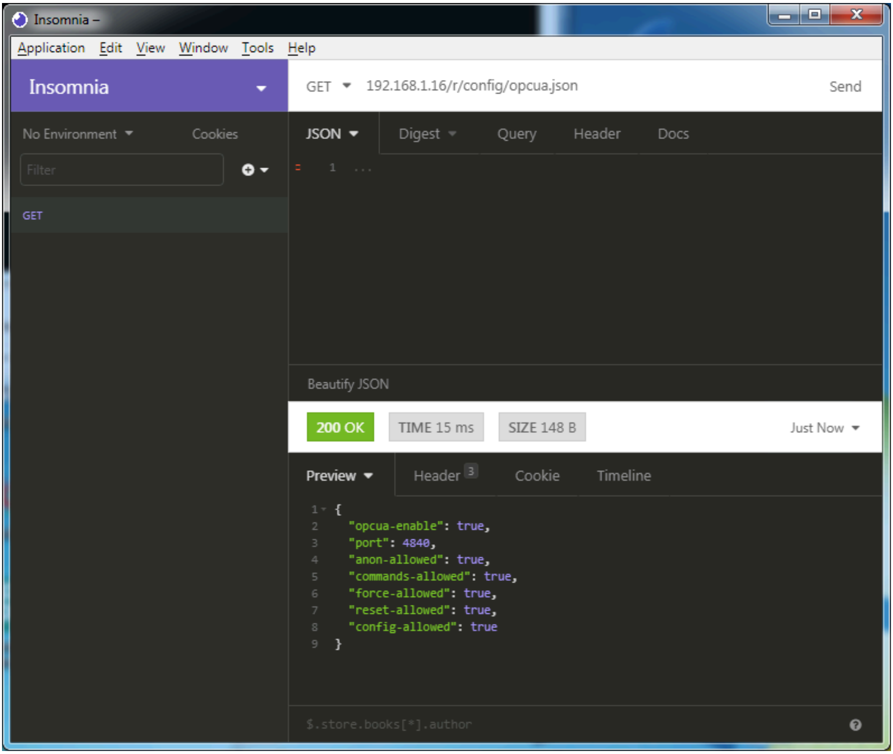
2. Configure OPC UA:

POST: `[IP-address]/w/config/opcua.json`



3. Read OPC UA:

GET: `[IP-address]/r/config/opcua.json`



17.3 REST API

The Representational State Transfer – Application Programming Interface (REST API) is a programmable interface which uses HTTP requests to GET and POST data. This enables the access to detailed device information.

The REST API can be used to read the device status and to write configuration and forcing data.

There are two different REST API standards you can use for the requests:

1. A standardized REST API that has been specified by the IO-Link Community and is described separately:

   `JSON_Integration_10222_V100_Mar20.pdf`

   Please download the file from https://catalog.belden.com or directly from io-link.com.

Attention: Consider the following table to get an overview of the supported features of the IO-Link specification:

Feature		Supported
Gateway	GET /identification	Yes
	GET /capabilities	Yes
	GET /configuration	Yes
	POST /configuration	Yes
	POST /reset	Yes
	POST /reboot	Yes
	GET /events	Yes
Master	GET /masters	Yes
	GET /capabilities	Yes
	GET /identification	Yes
	POST /identification	Yes

Feature		Supported
Port	GET /ports	Yes
	GET /capabilities	Yes
	GET /status	Yes
	GET /configuration	Yes
	POST /configuration	Yes
	GET /datastorage	Not supported
	POST /datastorage	Not supported
Devices	GET /devices	Yes
	GET /capabilities	Yes
	GET /identification	Yes
	POST /identification	Yes
	GET /processdata/value	Yes
	GET /processdata/getdata/value	Yes
	GET /processdata/setdata/value	Yes
	POST /processdata/value	Yes
	GET /parameters	Not supported
	GET /parameters/{index}/subindices	Not supported
	GET /parameters/{parameterName}/subindices	Not supported
	GET /parameters/{index}/value	Not supported
	GET /parameters/{index}/subindices/{subindex}/value	Not supported
	GET /parameters/{parameterName}/value	Not supported
	GET /parameters/{parameterName}/subindices/{subParameterName}/value	Not supported
	POST /parameters/{index}/value	Not supported
	POST /parameters/{parameterName}/value	Not supported
	POST /parameters/{index}/subindices/{subindex}/value	Not supported
	POST /parameters/{parameterName}/subindices/{subParameterName}/value	Not supported
	POST /blockparametrization	Not supported
	GET /events	Yes

Feature		Supported
IODD	GET /iodds	Not supported
	POST /iodds/file	Not supported
	DELETE /iodds	Not supported
	GET /iodds/file	Not supported

Table 49: Support of REST API features according to the IO-Link specification

2. A customized Belden REST API that is described in the following chapters.

17.3.1 Standard device information

Request method:	http GET
Request URL:	`<ip>/info.json`
Parameters	n.a.
Response format	JSON

The goal of the "Standard device information" request is to get a complete snapshot of the current device status. The format is JSON. For IO-Link devices, all ports with connected IO-Link device information are included.

17.3.2 Structure

Name	Data type	Description	Example
name	string	Device name	"0980 XSL 3912-121-007D-0 "
order-id	string	Ordering number	"935700002"
fw-version	string	Firmware version	"V.11.2.0.0 - 08.08.2024"
hw-version	string	Hardware version	"V.1.00"
mac	string	MAC address of the device	"3C B9 A6 F3 F6 05"
bus	number	0 = No connection 1 = Connection with PLC	1
failsafe	number	0 = Normal operation 1 = Outputs are in failsafe	0
ip	string	IP address of the device	
snMask	string	Subnet Mask	
gw	string	Default gateway	
rotarys	array of numbers (3)	Current position of the rotary switches: Array element 0 = x1 Array element 1 = x10 Array element 2 = x100	
ulPresent	boolean	True, if there is a UL voltage supply detected within valid range	
usVoltage_mv	number	US voltage supply in mV	
ulVoltage_mv	number	UL voltage supply in mV (only available for devices with UL supply)	
inputs	array of numbers (2)	Real state of digital inputs. **Element 0 = 1 Byte:** Port X1 Channel A to Port X4 Channel B **Element 0 = 1 Byte:** Port X5 Channel A to Port X8 Channel B	\[128,3\]
output	array of numbers (2)	Real State of digital outputs. **Element 0 =1 Byte:** Port X1 Channel A to port X4 Channel B **Element 0 = 1 Byte:** Port X5 Channel A to port X8 Channel B	\[55,8\]

Name	Data type	Description	Example
consuming	array of numbers (2)	Cyclic data from PLC to device	
producing	array of numbers (2)	Cyclic data from device to PLC	
diag	array of numbers (4)	Diagnostic information **Element 0 = 1 Byte:** Bit 7: Internal module error (IME) Bit 6: Forcemode active Bit 3: Actuator short Bit 2: Sensor short Bit 1: U_L fault Bit 0: U_S fault **Element 1 = 1 Byte:** Sensor short circuit ports X1 .. X8. **Element 2 =1 Byte:** Actuator short circuit ports X1 Channel A to X4 Channel B **Element 3 = 1 Byte:** Actuator short circuit ports X5 Channel A to X8 Channel B	
fieldbus	FIELDBUS Object		
FIELDBUS Object			
fieldbus_name	string	Currently used fieldbus	
state	number	Fieldbus state	
state_text	number	Textual representation of fieldbus state: 0 = Unknown 1 = Bus disconnected 2 = Preop 3 = Connected 4 = Error 5 = Stateless	
forcing	FORCING Object	Information about the forcing state of the device	
channels	Array of CHANNEL (16)	Basic information about all input/output channels	

Name	Data type	Description	Example
iol	IOL Object	Contains all IO-Link related information such as events, port states, device parameters.	
iol/diagGateway	array of DIAG	Array of currently active device/ gateway related events	
iol/diagMaster	array of DIAG	Array of currently active IOL-Master related events	
iol/ports	array of PORT (8)	Contains one element for each IO-Link port	
CHANNEL Object			
name	string	Name of channel	
type	number	Hardware channel type as number: 0 = DIO 1 = Input 2 = Output 3 = Input/Output 4 = IO-Link 5 = IOL AUX 6 = IOL AUX with DO 7 = IOL AUX with DO. Can be deactivated. 8 = Channel not available	
type_text	string	Textual representation of the channel type	
config	number	Current configuration of the channel: 0 = DIO 1 = Input 2 = Output 3 = IO-Link 4 = Deactivated 5 = IOL AUX	
config_text	string	Textual representation of the current config	
inputState	boolean	Input data (producing data) bit to the PLC	
outputState	boolean	Output data bit to the physical output pin	

Name	Data type	Description	Example
forced	boolean	True, if the output pin of this channel is forced	
simulated	boolean	True, if the input value to the PLC of this channel is simulated	
actuatorDiag	boolean	True, if the output is in short circuit / overload condition	
sensorDiag	boolean	True, if the sensor supply (Pin 1) is in short circuit / overload condition	
maxOutputCurrent_mA	number	Maximum output current of the output in mA	
current_mA	number	Measured current of the output in mA (if current measurement is available)	
voltage_mV	number	Measured voltage of this output in mV (if voltage measurement is available)	
PORT Object			
port_type	string	Textual representation of the IO-Link port type	
iolink_mode	number	**Current port mode:** 0 = Inactive 1 = Digital output 2= Digital input 3 = SIO 4 = IO-Link	
iolink_text	string	Textual representation of the current port mode	"Digital Input"
aux_mode	number	Indicates the configured mode for the Pin 2: 0 = No AUX 1 = AUX output (always on) 2 = Digital output (can be controlled by cyclic data) 3 = Digital input	
aux_text	string	Textual representation of the current aux mode	"AUX Output"
cq_mode	number	Port mode according to IOL specification	
iq_mode	number	Pin2 mode according to IOL specification	

Name	Data type	Description	Example
port_status	number	Port status according to IOL specification	
ds_fault	number	Data storage error number	
ds_fault_text	string	Textual data storage error.	
device	DEVICE Object	IO-Link device parameters. → Null if no IO-Link communication active	
diag	array of DIAG (n)	Array of port related events	
DIAG Object			
error	number	Error code	
source	string	Source of the current error.	"device" "master"
eventcode	number	Event code according to IO-Link specification	
eventqualifier	number	Event qualifier according to IO-Link specification	
message	string	Error message	"Supply Voltage fault"
DEVICE Object		Standard parameters of the IOL-Device	
device_id	number		
vendor_id	number		
serial	string		
baudrate	string	Baudrate (COM1,2,3)	
cycle_time	number	Cycle time in microseconds	
input_len	array of numbers (n)	IOL input length in bytes	
output_len	array of numbers (n)	IOL output length in bytes	
input_data	array of numbers (n)	IOL input data	
output_data	array of numbers (n)	IOL output data	
pd_valid	number	"1", if IOL input data is valid	
pdout_valid	number	"1", if IOL output data is valid	
FORCING Object		Forcing information of the device	
forcingActive	boolean	Force mode is currently active	

Name	Data type	Description	Example
forcingPossible	boolean	True, if forcing is possible and force mode can be activated	
ownForcing	boolean	True, if forcing is performed by REST API at the moment	
forcingClient	string	Current forcing client identifier	
digitalOutForced	array of numbers (2)	The force values of all 16 digital output channels.	
digitalOutMask	array of numbers (2)	The forcing mask of all 16 digital output channels.	
digitalInForced	array of numbers (2)	The force values of all 16 digital input channels.	
digitalInMask	array of numbers (2)	The forcing mask of all 16 digital input channels.	

17.3.3 Configuration and forcing

Method:	POST
URL:	`<ip>/w/force.json`
Parameters:	None
Post-Body:	JSON Object

Property	Data type	Example values	Description
forcemode	boolean	true / false	Forcing authority on/off
portmode	array (Port mode object)		
digital	array (Digital object)		
iol	array (IOL object)		

Table 50: Root object

Property	Data type	Example values	Remarks
port	integer	0..7	
channel	string	"a","b"	optional default is "a"
direction	string	"dio","di","do","iol", "off", "aux"	
aux	string	"dio","di","do","iol", "off", "aux"	IOL only, but optional
inlogica	string	"no","nc"	
inlogicb	string	"no","nc"	
inputlatch	bool	true / false	enable/disable input latch, optional
inputext	integer	Depends on the fieldbus: ▶ eip: 0 (off) - 255 (ms) ▶ ethercat: 0 (off) - 255 (ms) ▶ pns: 0 (off) - 255 (ms) ▶ cclink: 0 (off) - 255 (ms) ▶ mbtcp: 0 (off) - 255 (ms)	set input extension, optional
inputfilter	integer	0 .. 255	set input filter, optional

Table 51: Port mode object

Property	Data type	Example values	Remarks
port	integer	0..7	
channel	string	"a","b"	
force_dir	string	"phys_out","plc_in","clear"	optional default is "phys_out"
force_value	integer	0,1	

Table 52: Digital object

Property	Data type	Example values	Remarks
port	integer	0..7	
output	array[integer] or null to clear forcing	[55,88,120]	Output forcing
input	array[integer] or null to clear forcing	[20,0,88]	Input simulation to PLC

Table 53: IOL object

17.3.4 Reading and writing ISDU parameters

The *Indexed Service Data Unit* (ISDU) provides a highly flexible message format, which can contain single or multiple commands.

LioN-Safety IOL-Masters with IIoT support reading and writing ISDU parameters from connected IOL-Devices. It is possible to do this as a bulk transfer by reading and writing of multiple ISDU parameters via a single request.

17.3.4.1 Reading ISDU

Method:	POST
URL:	`<ip>/r/isdu.json`
Parameters:	port (6 .. 7)
Example:	`192.168.1.20/r/isdu.json?port=5`
Post-Body:	JSON array of read ISDU object

Property	Data type	Example values	Remarks
ix	integer	0-INT16	Index to be read
subix	integer	0-INT8	Subindex to be read

Table 54: Read ISDU object

Property	Data type	Example values	Remarks
status	integer	0, -1	0 = no error, -1= an error occured
message	string		Error Message if error occured
data	array (Read ISDU data object)		data, if no error occured. otherweise null

Table 55: Read ISDU response object

Property	Data type	Example values	Remarks
ix	integer	0-INT16	Index that was read
subix	integer	0-INT8	Subindex that was read
status	integer	0, -1	0 = no error, -1= an error occured
eventcode	integer		IOL eventcode if status is -1
data	array[integer]		data, if no error occured. otherweise null

Table 56: Read ISDU data object

17.3.4.2 Writing ISDU

Method:	POST
URL:	`<ip>/w/isdu.json`
Parameters:	port (6 .. 7)
Post-Body:	JSON array of write ISDU object

Property	Data type	Example values	Remarks
ix	integer	0-INT16	Index to be read
subix	integer	0-INT8	Subindex to be read
data	array[integer]		Data to be written

Table 57: Write ISDU object

Response: Write ISDU response object

Property	Data type	Example values	Remarks
status	integer	0, -1	0 = no error, -1= an error occured
message	string		Error Message if error occured
data	array (Write ISDU data object)		data, if no error occured. otherweise null

Table 58: Write ISDU response object

Property	Data type	Example values	Remarks
ix	integer	0-INT16	Index that was written
subix	integer	0-INT8	Subindex that was written
status	integer	0, -1	0 = no error, -1= an error occured
eventcode	integer		IOL eventcode if status is -1

Table 59: Write ISDU data object

17.3.5 Example: Reading ISDU

ISDU read request

```
[
 {"ix":5,"subix":0},
 {"ix":18,"subix":0},
 {"ix":19,"subix":0},
 {"ix":20,"subix":0}
]
```

Response

```
{
 "message":"OK",
 "data":
[
 {"ix":5,"subix":0,"status":-1,"eventcode":32785},
 {"ix":18,"subix":0,"data":[79,68,83,49,48,76,49,46,56,47,76,65,54,44,50,
        48,48,45,77,49,50],"status":0},
 {"ix":19,"subix":0,"data":[53,48,49,50,57,53,51,53],"status":0},
 {"ix":20,"subix":0,"data":[100,105,115,116,97,110,99,101,32,115,101,110,
        115,111,114],"status":0}
],
"status":0}
```

17.3.6 Example: Writing ISDU

ISDU write request

```
[
 {"ix":24,"subix":0,"data":[97,98,99,100,101,102]},
 {"ix":9,"subix":0,"data":[97,97,97,97,97,98]}
]
```

Response

```
{
 "message":"OK",
 "data":[
 {"ix":24,"subix":0,"status":0},
 {"ix":9,"subix":0,"eventcode":32785,"status":-1}
],
"status":0}
```

17.4 CoAP server

The **Co**nstrained **A**pplication **P**rotocol (CoAP) is a specialized **I**nternet application protocol for constrained networks such as lossy or low power networks. CoAP is useful especially in M2M (Machine to Machine) communication and can be used to translate simplified HTTP requests of low speed networks.

CoAP is based on the Server-Client principle and a service layer protocol that lets nodes and machines communicate with each other. The LioN-Safety variants provide CoAP server functionalities via a REST API interface over UDP.

17.4.1 CoAP configuration

In delivery state, CoAP functions are *disabled*. The CoAP server can be configured either using the Web interface or directly via a JSON object sent in an HTTP/HTTPS request. For more information see chapter CoAP configuration - Quick start guide on page 267.

The configuration URL is:

```
http://[ip-address]/w/config/coapd.json
```

The configuration can also read back as a JSON file:

```
http://[ip-address]/r/config/coapd.json
```

The configuration is a JSON object. Each JSON member is a configuration element. The object must not contain all elements. Only the provided elements will be changed. The configuration changes apply only after a device restart.

The following configuration elements are available (default values in bold):

Element	Data type	Description	Example data
enable	boolean	Master switch for the CoAP server	true / **false**
port	integer (0 to 65535)	Port of the CoAP server	**5683**

Table 60: CoAP configuration

CoAP response:

The resulting response is a JSON object with a "status" field. Status should be "0" if no error occurred, and "-1" if there is an error.

In case of an error, the response contains an error array.

The error array contains an error object for each error occurred. The object consists of a field "Element" which names the config element that caused the error, and of a field "Message" for the error message.

Examples:

```
{"status": -1, "error": [{"Element": "upcua-enable", "Message": "Boolean expected"}]}

{"status": 0}

{"status": -1, "error": [{"Element": "root", "Message": "Not a JSON object"}]}
```

17.4.2 REST API access via CoAP

A connection to the CoAP server running on the LioN-Safety variants can be established via the following URL:

`coap://[ip-address]:[port]/[api]`

For LioN-Safety, the following REST API Requests (JSON format) can be accessed via a CoAP endpoint:

Type	API	Note
GET	/r/status.lr	
GET	/r/system.lr	
GET	/info.json"	
GET	/r/config/net.json	
GET	/r/config/mqtt.json	
GET	/r/config/opcua.json	
GET	/r/config/coapd.json	
GET	/r/config/syslog.json	
GET	/contact.json	
GET	/fwup_status	
GET	/iolink/v1/gateway/identification	
GET	/iolink/v1/gateway/capabilities	
GET	/iolink/v1/gateway/configuration	
GET	/iolink/v1/gateway/events	
GET	/iolink/v1/masters	
GET	/iolink/v1/masters/1/capabilities	
GET	/iolink/v1/masters/1/identification	
GET	/iolink/v1/masters/1/ports	
GET	/iolink/v1/masters/1/ports/{port_number}/capabilities	This API is available for all 8 ports. {port_number} should be between "1" and "8".
GET	/iolink/v1/masters/1/ports/{port_number}/status	This API is available for all 8 ports. {port_number} should be between "1" and "8".
GET	/iolink/v1/masters/1/ports/{port_number}/configuration	This API is available for all 8 ports. {port_number} should be between "1" and "8".
GET	/iolink/v1/devices/master1port{port_number}/identification	This API is available for all 8 ports. {port_number} should be between "1" and "8".

Type	API	Note
GET	/iolink/v1/devices/master1port{port_number}/capabilities	This API is available for all 8 ports. {port_number} should be between "1" and "8".
GET	/iolink/v1/devices/master1port{port_number}/processdata/getdata/value	This API is available for all 8 ports. {port_number} should be between "1" and "8".
GET	/iolink/v1/devices/master1port{port_number}/events	This API is available for all 8 ports. {port_number} should be between "1" and "8".

Table 61: REST API access via CoAP

17.4.3 CoAP configuration - Quick start guide

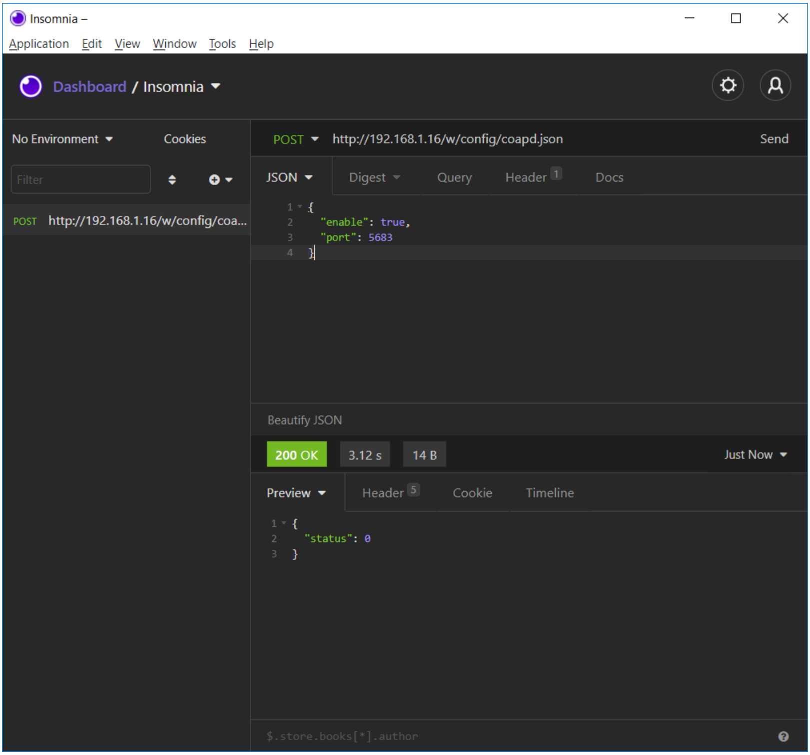
Attention: Lumberg Automation™ is not responsible for any content of the referenced Web pages and provides no warranty for any functionality of the named third party software.

17.4.3.1 CoAP configuration via JSON

1. Depending on your application case, download and install *Insomnia* or a comparable application: https://insomnia.rest/download/

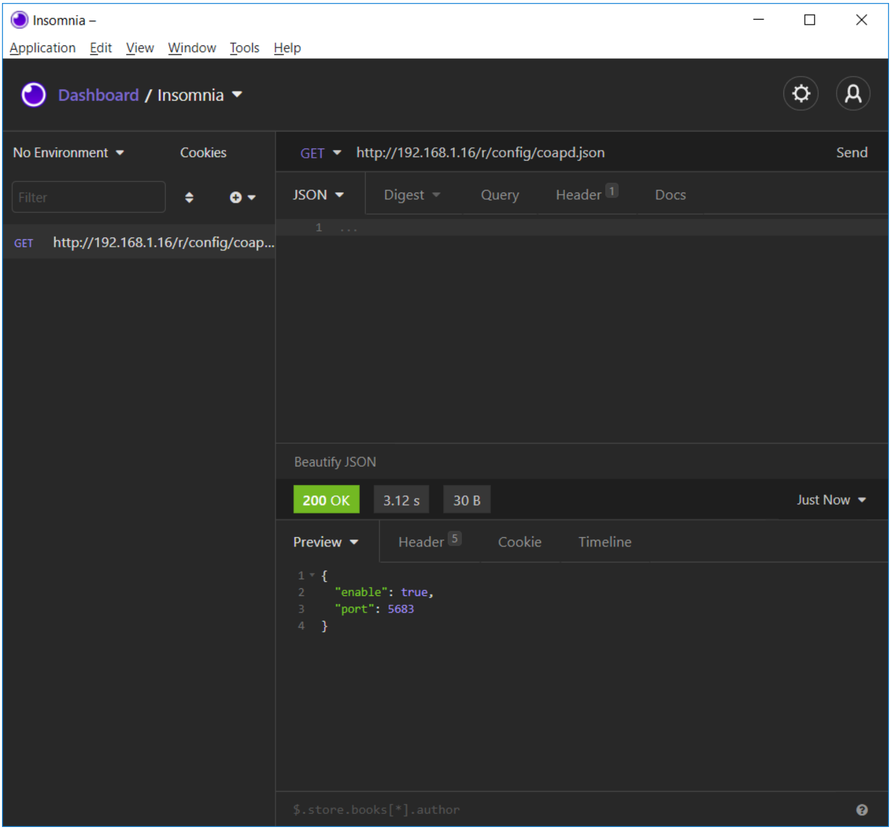
2. Configure CoAP:

POST: `[IP-address]/w/config/coapd.json`



3. Read CoAP configuration:

GET: `[IP-address]/r/config/coapd.json`



17.5 Syslog

The LioN-Safety variants provide a Syslog client which can connect with a configured Syslog server and is able to log messages.

Syslog is a platform-independent standard for logging messages. Each message contains a timestamp as well as information about the severity level and the subsystem. The Syslog protocol RFC5424 is based on the Server-Client principle and lets machines and devices send messages in the network and collect them centrally. (For more details on the used syslog standard, please refer to https://datatracker.ietf.org/doc/html/rfc5424.)

LioN-Safety supports the storage of 256 messages in a ring buffer which are sent to the configured Syslog server. When the ring is full with 256 messages, the oldest message is always replaced by the newly arriving messages. All messages can be saved on the Syslog server. The Syslog client of the IO-Link Master will not store any message permanently.

17.5.1 Syslog configuration

In **delivery state**, Syslog functions are **disabled**. The Syslog client can be configured either using the Web interface or directly via a JSON object sent in an HTTP/HTTPS request. For more information see chapter Syslog configuration - Quick start guide on page 272.

The configuration URL is:

```
http://[ip-address]/w/config/syslog.json
```

The configuration can also read back as a JSON file:

```
http://[ip-address]/r/config/syslog.json
```

The configuration is a JSON object. Each JSON member is a configuration element. The object must not contain all elements. Only the provided elements will be changed. The configuration changes apply only after a device restart.

The following configuration elements are available (default values in bold):

Element	Data type	Description	Example data
syslog-enable	boolean	Master switch for the Syslog client	true / **false**
global-severity	integer	<u>Severity level of Syslog client</u> 0 – Emergency 1 – Alert 2 – Critical **3 – Error** 4 – Warning 5 – Notice 6 – Info 7 – Debug The client will log all messages of severity according to the setting, including all below levels.	0/1/2/**3**/4/5/6/7
server-address	string (IP address)	IP address of the Syslog server	192.168.0.51 (Default: **null**)
server-port	integer (0 to 65535)	Server port of the Syslog server	**514**
server-severity	integer (0 to 7)	<u>Severity level of Syslog server</u> 0 – Emergency 1 – Alert 2 – Critical **3 – Error** 4 – Warning 5 – Notice 6 – Info 7 – Debug	0/1/2/**3**/4/5/6/7

Table 62: Syslog configuration

Syslog response:

The resulting response is a JSON object with a "status" field. Status should be "0" if no error occurred, and "-1" if there is an error.

In case of an error, the response contains an error array.

The error array contains an error object for each error occurred. The object consists of a field "Element" which names the config element that caused the error, and of a field "Message" for the error message.

Examples:

```
{"status": -1, "error": [{"Element": "upcua-enable", "Message": "Boolean expected"}]}

{"status": 0}

{"status": -1, "error": [{"Element": "root", "Message": "Not a JSON object"}]}
```

17.5.2 Syslog configuration - Quick start guide

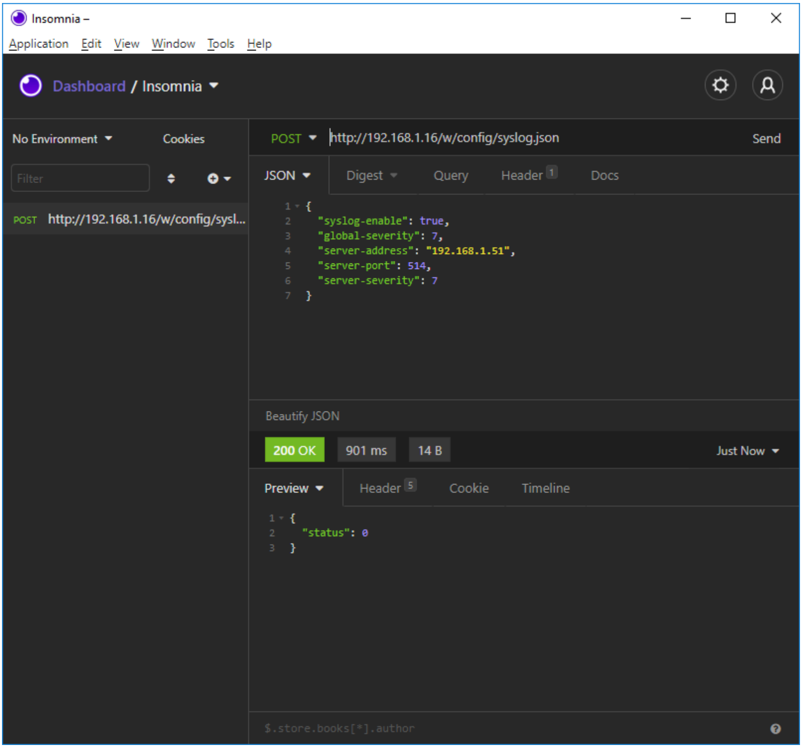
Attention: Lumberg Automation™ is not responsible for any content of the referenced Web pages and provides no warranty for any functionality of the named third party software.

17.5.2.1 Syslog configuration via JSON

1. Depending on your application case, download and install *Insomnia* or a comparable application: https://insomnia.rest/download/

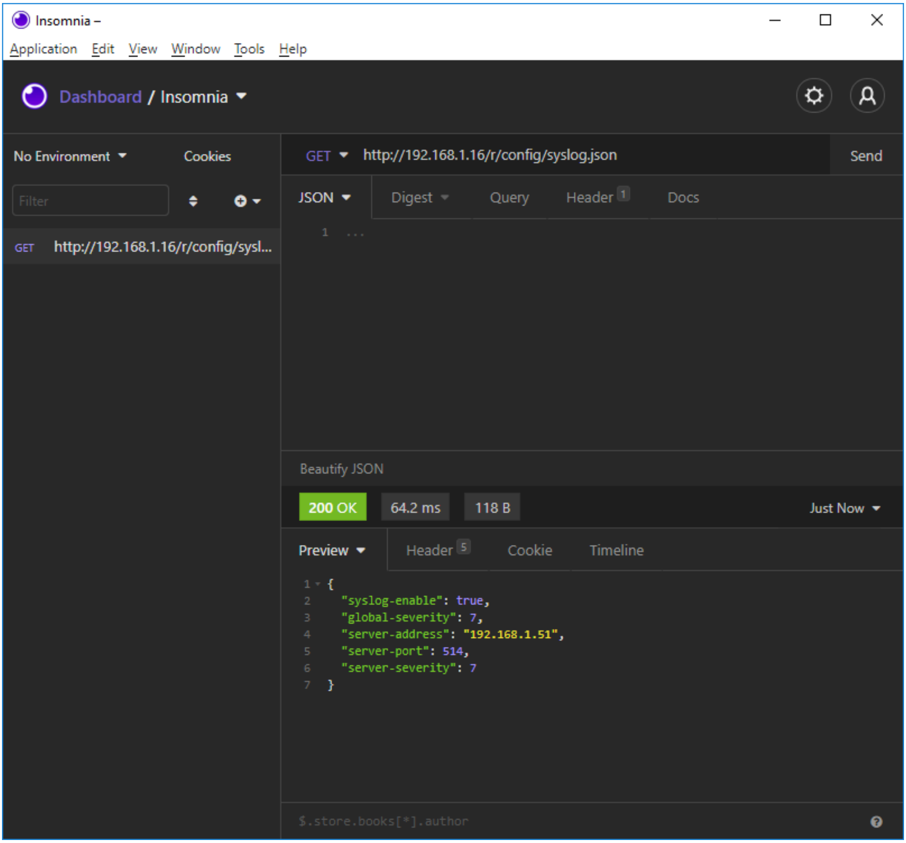
2. Configure Syslog:

POST: `[IP-address]/w/config/syslog.json`



3. Read Syslog configuration:

GET: `[IP-address]/r/config/syslog.json`



17.6 Network Time Protocol (NTP)

The LioN-Safety variants provide an NTP client (version 3) which can connect with a configured NTP server and is able to synchronize the network time at a configurable interval.

NTP is a network protocol which uses UDP datagrams to send and receive timestamps in order to synchronize with a local clock. The NTP protocol RFC1305 is based on the Server-Client principle and exclusively supplies the synchronization with Coordinated Universal Time (UTC). (For more details on the used NTP standard, please refer to https://datatracker.ietf.org/doc/html/rfc1305.)

17.6.1 NTP configuration

In **delivery state**, the NTP client is **disabled**. The NTP client can be configured either using the Web interface or directly via a JSON object sent in an HTTP/HTTPS request. For more information see chapter NTP configuration - Quick start guide on page 276.

The configuration URL is:

```
http://[ip-address]/w/config/ntpc.json
```

The configuration can also read back as a JSON file:

```
http://[ip-address]/r/config/ntpc.json
```

The configuration is a JSON object. Each JSON member is a configuration element. The object must not contain all elements. Only the provided elements will be changed. The configuration changes apply only after a device restart.

The following configuration elements are available (default values in bold):

Element	Data type	Description	Example data
NTP client state	boolean	Master switch for the NTP client	true / **false**
Server address	string	IP address of the NTP server	192.168.1.50
Server port	integer	Port of the NTP server	**123**
Update interval	integer	Interval at which the client will connect with the configured NTP server (see table row "Server address"). **Note: This value is in seconds.**	1/2/10/**60**

Table 63: NTP configuration

NTP response:

The resulting response is a JSON object with a "status" field. Status should be "0" if no error occurred, and "-1" if there is an error.

In case of an error, the response contains an error array.

The error array contains an error object for each error occurred. The object consists of a field "Element" which names the configuration element that caused the error, and of a field "Message" for the error message.

Examples:

```
{"status": -1, "error": [{"Element": "ntpc-enable", "Message": "Boolean expected"}]}

{"status": 0}

{"status": -1, "error": [{"Element": "root", "Message": "Not a JSON object"}]}
```

17.6.2 NTP configuration - Quick start guide

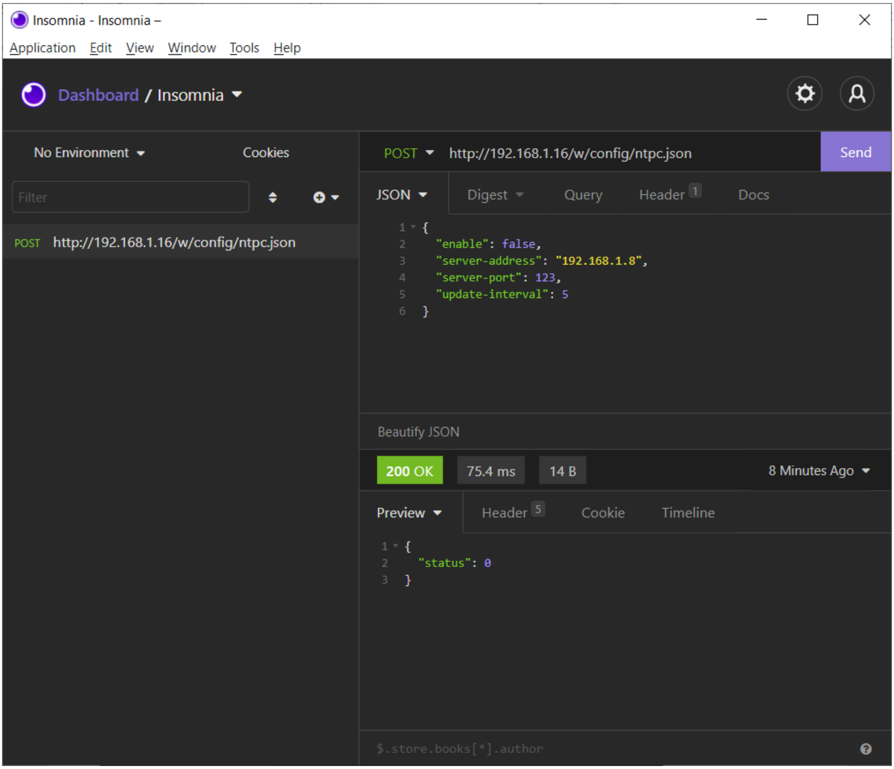
Attention: Lumberg Automation™ is not responsible for any content of the referenced Web pages and provides no warranty for any functionality of the named third party software.

17.6.2.1 NTP configuration via JSON

1. Depending on your application case, download and install *Insomnia* or a comparable application: https://insomnia.rest/download/

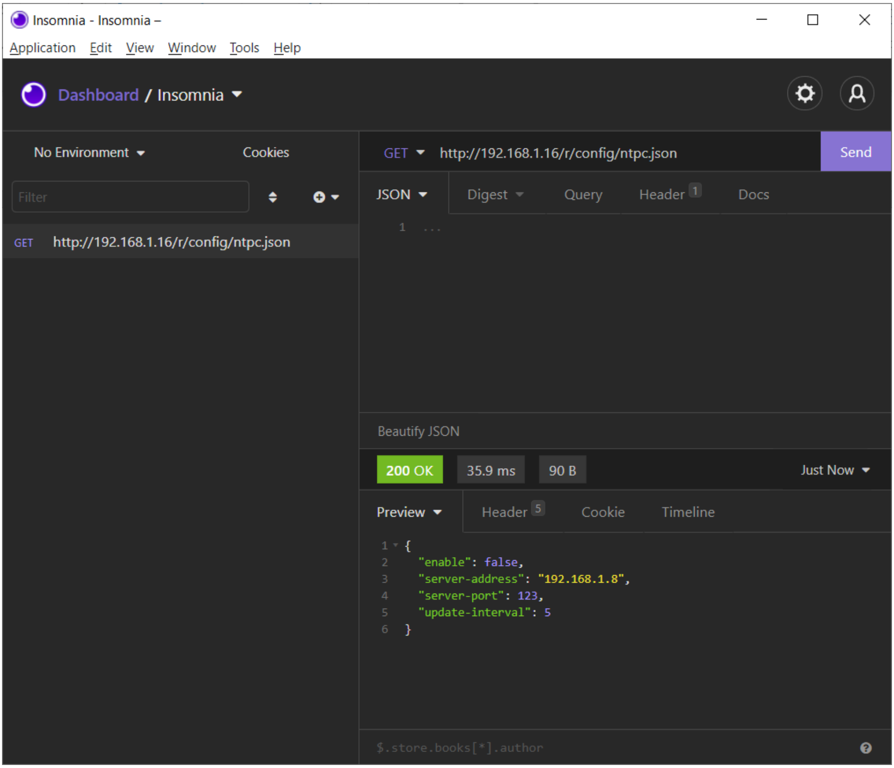
2. Configure NTP:

POST: `[IP-address]/w/config/ntpc.json`



3. Read NTP configuration:

GET: `[IP-address]/r/config/ntpc.json`



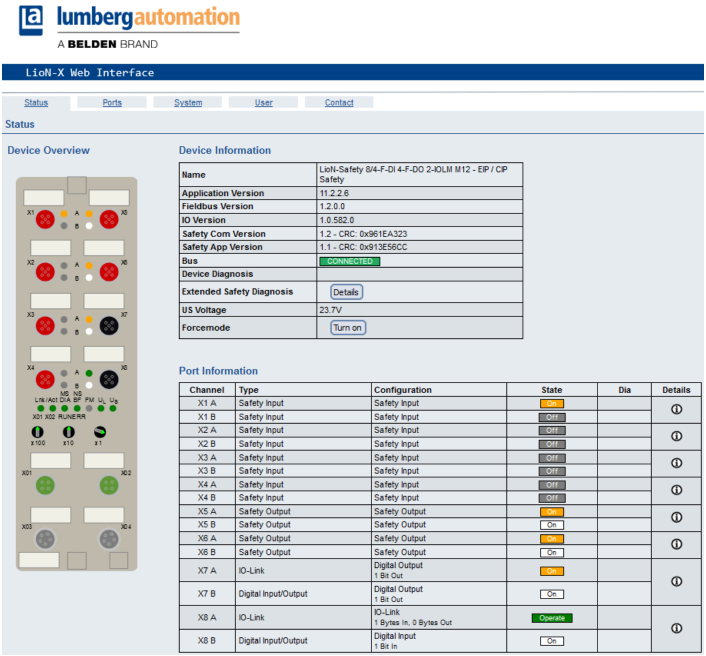
18 The integrated Web server

All device variants are equipped with an integrated Web server which makes functions for the device configuration and the display of status and diagnostic information available via a Web interface.

The Web interface provides an overview of the configuration and status of the device. It is also possible to use the Web interface to trigger a reboot, reset to the factory defaults, or perform a firmware update.

Enter "http://" or "https://" followed by the IP address, such as "http://192.168.1.5", in your Web browser’s address bar. If the status page of the device is not displayed, check your browser and firewall settings.

18.1 The Status page



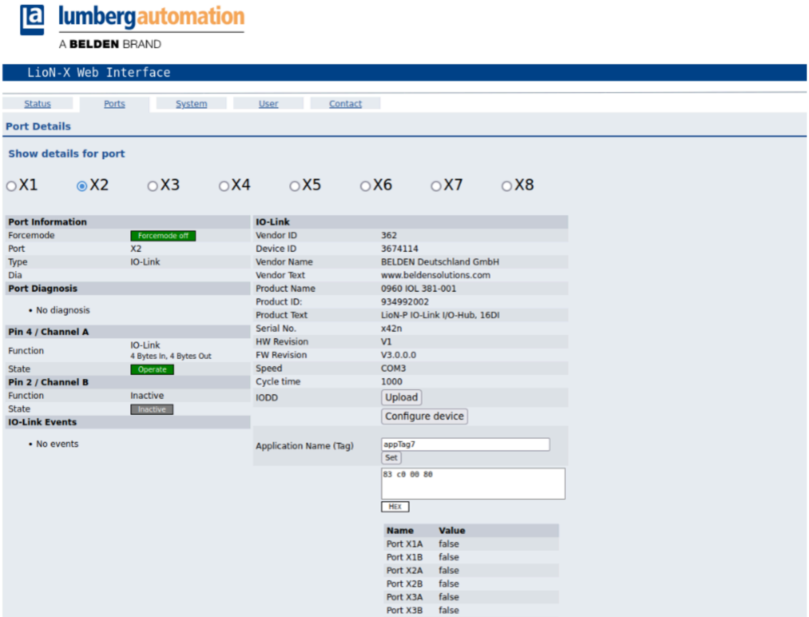
The status page provides a quick overview of the current state of the device.

The left side shows a graphical representation of the module with all its LEDs and the positions of the rotary encoding switches.

The right side shows the "Device Information" table with some basic data for the module; for example, the variant, the cyclic communication status and a diagnostic indicator. The indicator shows whether diagnostics for the module exist.

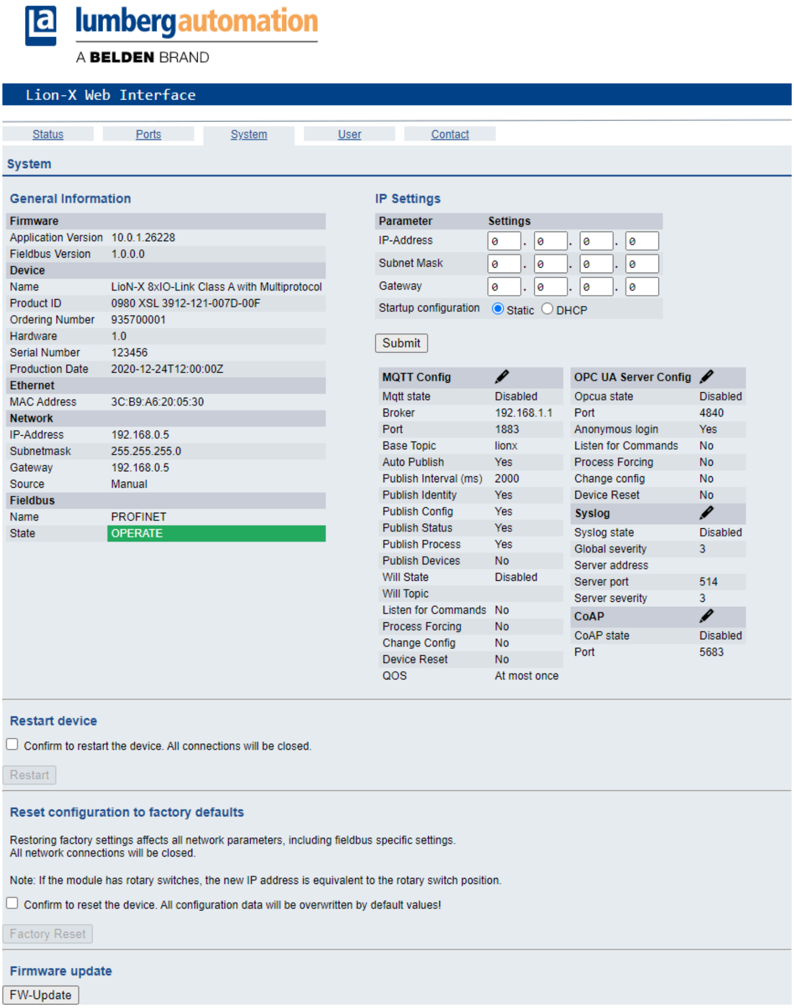
The "Port Information" table shows the configuration and state of the I/O ports.

18.2 The Ports page



The page shows detailed port information. In the field **Port Diagnosis**, incoming and outgoing diagnostics are displayed as clear text. **Pin 2** and **Pin 4** contain information about the configuration and state of the port. For IO-Link ports, additional information relating to the connected sensor and the process data is displayed.

18.3 The System page



The System page shows the basic information for the module like Firmware version, Device information, Ethernet, Network and Fieldbus information.

Restart Device

The module initializes a software reset.

Reset to Factory Settings

The module restores to the default factory settings.

IP Settings

Use this parameter to change the current IP address of the module.

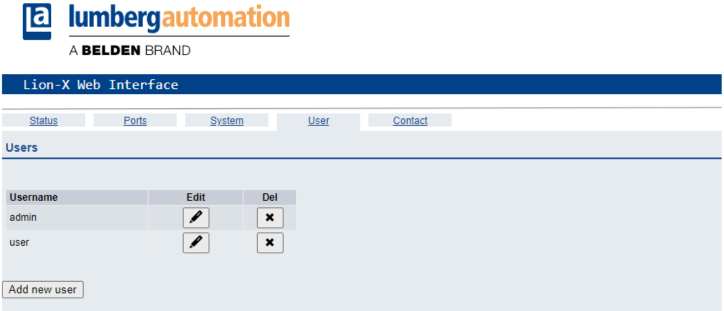
For PROFINET, this is only useful during commissioning. Normally, the PLC sets the IP address at start-up by detecting the PROFINET module via its device name.

Firmware Update

A firmware update by the user is not intended for functionally safe I/O modules. If this should nevertheless be necessary, the following steps must be observed:

1. For the update, remove the module from all security functions.
2. Exclusively download the firmware currently released for the module.
3. Before the update, make sure that the upload file is unchanged (by verifying the hash value).
4. After the update, use the displayed values for version and CRC to verify whether the new firmware is on the module.
5. Document the (user-performed) verifications of the firmware update.

18.4 The User page



The User page provides the user management of the Web interface. New users with access rights "Admin" or "Write" can be added here. For security reasons please change the default admin password immediately after configuring the device.

Default user login data:

- User: admin
- Password: private

19 IODD

IODD functions are **only** applicable for the following device variant:

- 0980 SSL 3131-121-007D-202

The **IO D**evice **D**escription (IODD) is a set of files formally describing an IO-Link Device. The IODD is created by the vendor and is mandatory for each IO-Link Device.

Belden IO-Link Masters with the "IODD on Module" functionality are ready to use IODDs in order to make the IO-Link Device configuration much more easier and the process data human readable in a better way. IODDs can be uploaded via the Web Interface and remanently stored on the IO-Link Master afterwards.

If a corresponding IO-Link Device is connected, the stored IODD is used to provide a user friendly configuration page, where all parameters of the device can be viewed and edited. Additionally, according to the IODD, the process data will also be formatted and displayed to the user.

19.1 IO-Link Device parameters and ISDU requests

Every IO-Link Device provides parameters that can be read and written via the special IO-Link service ISDU (**I**ndexed **S**ervice **D**ata **U**nit).

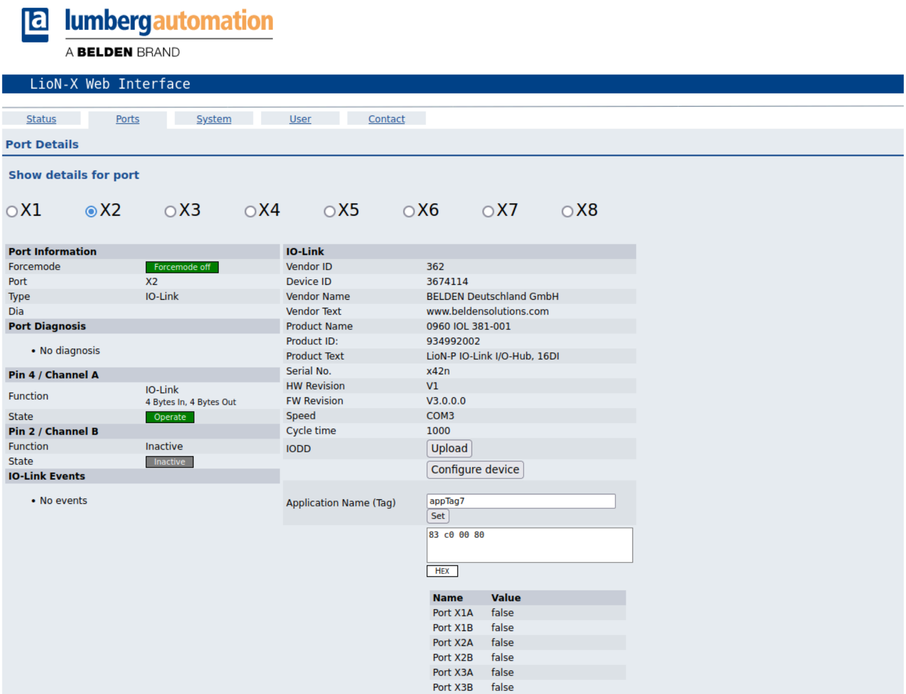
Every parameter is addressed by an index. Sub-indices are possible but optional. Some parameters (most of them read-only) are mandatory for IO-Link devices an can be found always on the same indices (See *Table B.8* in the *IO-Link Interface and System Specification*: https://io-link.com/share/Downloads/Package-2020/IOL-Interface-Spec_10002_V113_Jun19.pdf).

A vendor can use additional parameters and therefore more indices for their devices in order to provide additional configuration options. These vendor specific parameters can be described in an IODD. The "IODD on Module" feature of a LioN-Safety IO-Link Master can read and parse this information out of an IODD and use it to provide the user viewing and editing options for vendor specific parameters without any additional knowledge about the vendor specific device features.

19.2 Web GUI functionality

All of the "IODD on Module" features are accessible via the LioN-Safety Web interface.

19.2.1 Port Details page



The Port Details Page shows all information about the selected port. In the left column, all port and channel specific information is displayed. If the port is configured as IO-Link and there is an IO-Link Device connected, all IO-Link information for the connected device is displayed in the right column.

IODD buttons

The row called *IODD* provides access to the "IODD on Module" features. The button *UPLOAD* will let the user upload an IODD file into the module, regardless of the original device the IODD has been designed for.

The maximum number of IODDs is limited due to storage space. If there is no more space left for new IODDs, there will be an error message. In this case, navigate to the IODD Management page to delete IODDs which are no longer used.

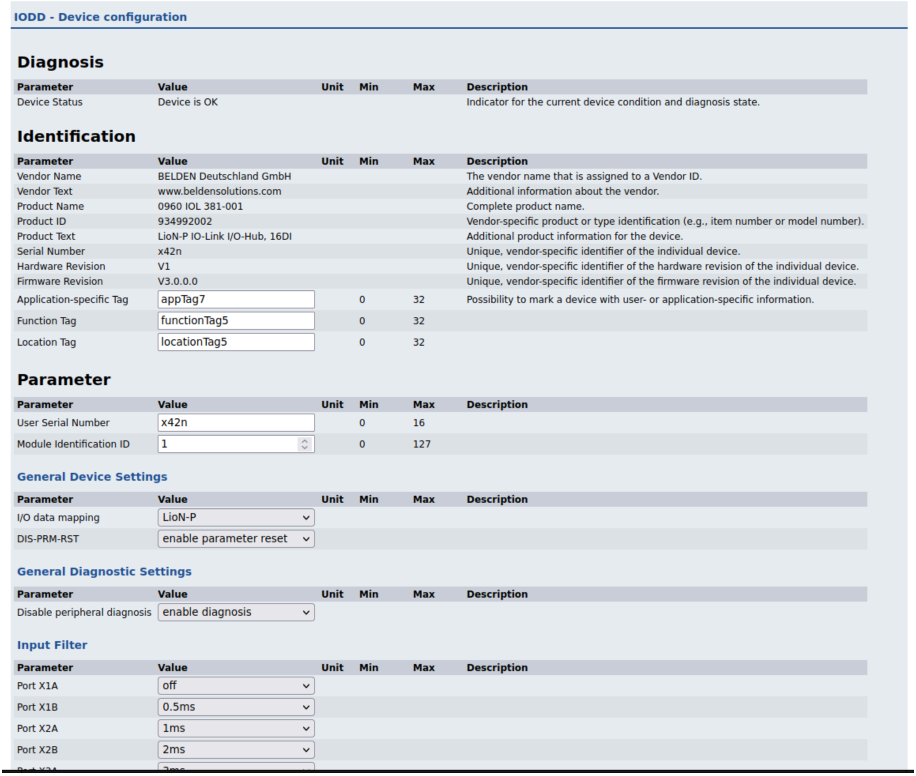
If there is a matching IODD for the currently connected device already stored in the system, the button *CONFIGURE* is shown in the interface. By clicking this button, the Parameter Page will open to configure the device.

Process data

For every connected IO-Link Device, raw process data for input and output direction (set of bytes) is on display.

If a matching IODD providing information about process data is already stored in the system, this data will also be displayed in a user-friendly format according to the IODD.

19.2.2 Parameters page



The parameters page "IODD – Device configuration" shows all parameters which are provided by the IODD of the device. That means the parameter set is variable and depends on the connected IO-Link Device.

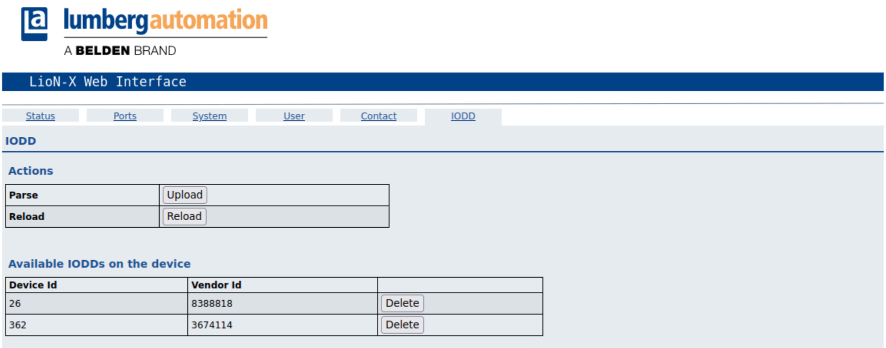
The stored IODD reads the parameter meta data, such as names, units, min/max values, descriptions etc. The values will be obtained directly from the connected device. For that reason it may take several seconds until the page is updated.

If not already saved into the browser, you will be asked for your credentials to continue. A valid user access with Web Interface group membership is needed in order to edit the device parameters. After the registration, enabled values can be changed. Disabled values cannot be changed and may be marked as "read-only" in the IODD. All values are directly written back to the device after any change.

Limitations

- Editing parameter values will directly change them inside the connected device. No parameter server action is triggered by that.
- There is a maximum size of the IODD in order to be uploaded into the system. This depends on several values, such as file size, parameter count, nesting levels etc.

19.2.3 IODD Management page



The IODD Management Page can be accessed via the System page displaying all IODDs that are currently stored in the system. All IODDs matching connected devices are marked. On the IODD Management page, you can manually delete any IODD in the system.

20 Technical data

The following sections give an overview of the most important functional data needed to operate the device. For further information and detailed technical data, see the respective **Data Sheet** of your required product in the product specific download area on https://catalog.belden.com.

20.1 Safety codes

Conditions:

The values are calculated for an average ambient temperature of +40 °C (+104 °F) and an installation altitude of up to 3000 m (9842 ft) and apply to a safety function consisting of one input/input pair and one output pair.

Mix modules 0980 SSL 3x31-121...		
Feature	**Code**	**Standard**
Performance Level (PL)	Up to e	EN ISO 13849-1
Category	Up to 4	EN ISO 13849-1
Safety Integration Level (SIL)	Up to 3	IEC 61508
MTTF	84 years	not standardized
PFH (T_1 = 20 years) (Communication PFH not included)	1.43 E-9 1/h	IEC 61508
$MTTF_d$	227 years	EN ISO 13849-1
DC_{avg}	99.37 %	EN ISO 13849-1
MTTR	24 h	EN ISO 13849-1

Table 64: Safety codes for mix modules 0980 SSL 3x31-121...

DI modules 0980 SSL 3x30-121...		
Feature	**Code**	**Standard**
Performance Level (PL)	Up to e	EN ISO 13849-1
Category	Up to 4	EN ISO 13849-1
Safety Integration Level (SIL)	Up to 3	IEC 61508
MTTF	107 years	not standardized
PFH (T_1 = 20 years) (Communication PFH not included)	1.32 E-9 1/h	IEC 61508
$MTTF_d$	255 years	EN ISO 13849-1
DC_{avg}	99.41 %	EN ISO 13849-1
MTTR	24 h	EN ISO 13849-1

Table 65: Safety codes for DI modules 0980 SSL 3x30-121...

Attention: The safety devices are designed for a lifetime (mission time) of 20 years (from a safety point of view). No proof test is required within the mission time. At the end of the mission time, the safety device must be taken out of service.

20.2 General

Protection class (Only applies if the connectors are screwed together or if protective caps are used.)[1]	IP65 IP67 IP69K	
Ambient temperature (during operation and storage)[2]	0980 SSL 3x31-121...	-40 °C .. +70 °C (-40 °F .. +158 °F)
	0980 SSL 3x30-121...	
Installation height (during operation and storage)	Up to +3000 m ASL (+9842 ft ASL)	
Weight	LioN-Safety 60 mm	approx. 500 gr. (17.6 oz)
Ambient moisture	Max. 98% RH (For UL applications: Max. 80% RH)	
Housing material	Die-cast zinc	
Surface finish	Frosted nickel	
Flammability class	UL 94 (IEC 61010)	
Vibration resistance (oscillation) DIN EN 60068-2-6 (2008-11)	15 g / 5-500 Hz	
Shock resistance DIN EN 60068-2-27 (2010-02)	50 g / 11 ms +/- X,Y,Z	
Fastening torques	M4 fixing screws	1 Nm
	M4 ground connection	1 Nm
	M12 connector	0.5 Nm
Permitted cables	Ethernet cables according to IEEE 802.3, min. CAT 5 (shielded) Max. length of 100 m, not routed out of facility (= local network)	

Table 66: General information

1 Not under UL investigation.

2 Restricted to -40 °C .. +63 °C (-40 °F .. +145 °F) at a level higher than +2000 m ASL (+6562 ft).

20.3 EtherNet/IP protocol

Protocol	EtherNet/IP, CIP V3.34
Update cycle	1 ms (non-safe), 32 ms (safety)
EDS file	EDS-V3.34.1-BeldenDeutschland-XXX-yyyymmdd.eds
Transmission rate	10/100 Mbit/s, half/full duplex
Transmission procedure Autonegotiation	10BASE-T/100BASE-TX supported
RPI min.	1 ms (non-safe), 16 ms (safety)
Vendor ID	21
Product type	35 (Safety Discrete I/O Device)
Product code	42000 (Mixmodule, 0980 SSL 3131-121-007D-202) 42001 (16DI module, 0980 SSL 3130-121-007D-202)
Supported Ethernet protocols	Ping ARP- HTTP TCP/IP DHCP/BOOTP
Switch functionality	Integrated
EtherNet/IP interface Connections Autocrossing	2 M12 sockets, 4-pin, D-coded (see pin assignments) 2 M12 Hybrid male/female, 8-pin supported
Electrically isolated Ethernet ports -> FE	2000 V DC

Table 67: EtherNet/IP protocol

20.4 Power supply of the module electronics/ sensors

Port X03, X04	M12-L-coded Power, connector/socket, 5-pole Pin 1 / Pin 3		
Nominal voltage U_S	24 V DC (SELV/PELV)		
Current U_S (X03/X04)	Max. 16 A		
Voltage range	18 .. 30 V DC		
Potential difference between power supply and FE	+24 V DC <-> FE		+32 V DC
	GND <-> FE		-32 V DC
Voltage range for IO-Link applications	21 .. 30 V DC		
Power consumption of module electronics	Typically 180 mA (+/-20 % at U_S nominal voltage)		
Power supply interruption internal	Max. 10 ms		
Voltage ripple U_S	Max. 5 %		
Current consumption sensor system (Pin 1 + Pin 5)	0980 SSL 3x31-121...	Port X1 .. X4 (Pin 1 + Pin 5)	max. 1.5 A per port, max. 9 A per device at $T_{ambient}$ = +30 °C (+86 °F)
		Port X7 .. X8 (L+ / Pin 1)	max. 4 A per port, max. 9 A per device at $T_{ambient}$ = +30 °C (+86 °F)
	0980 SSL 3x30-121...	Port X1 .. X8 (Pin 1 + Pin 5)	max. 1.5 A per port, max. 9 A per device at $T_{ambient}$ = +30 °C (+86 °F)
Voltage level of the sensor power supply	Min. (U_S – 1.5 V)		
Short circuit/overload protection of sensor supply	Yes, per port		

Reverse polarity protection	Yes	
Operational indicator (U_S)	LED green:	18 V (+/- 1 V) < U_S
	LED red:	U_S < 18 V (+/- 1 V)

Table 68: Information on the power supply of the module electronics/ sensors

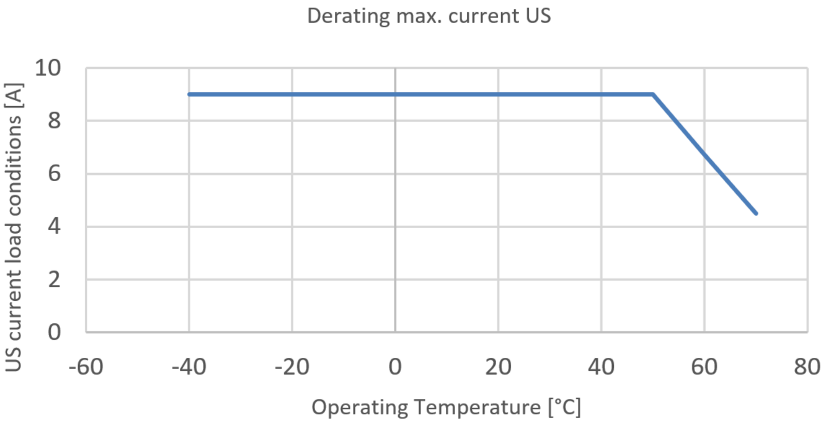


Figure 20: Derating of U_S

Attention:

For F-DI changes caused by U_S power supply interrupts, the safety input data can be switched from '1' to '0'. The input change caused by the power interrupts will not be detected by an internal safety diagnostic circuit. This input change can result in an unwanted reaction in the safety application. A suitable power supply with buffering must be used to avoid power interrupts on U_S supply.

Caution: In case of a faulty SELV/PELV power supply unit, a maximum operating voltage of +60 V DC is possible at the U_S voltage supply (Pin1/Pin5) on the F-DI ports. The device variants 0980 SSL 303x-121… do not limit these maximum possible output voltages.

Confirm that the external connected sensors or actuators are designed for voltages up to +60 V DC.

20.5 Power supply of the actuators

Nominal voltage U_L	24 V DC (SELV/PELV)	
Voltage range	18 .. 30 V DC	
Potential difference between power supply and FE	+24 V DC <-> FE	+32 V DC
	GND <-> FE	-32 V DC
Current U_L (X03/X04)	Max. 16 A	
Voltage ripple U_L	Max. 5 %	
Reverse polarity protection	Yes	
Operational indicator (U_L)	LED green: 18 V (+/- 1 V) < U_L LED red: U_L < 18 V (+/- 1 V) or U_L > 30 V (+/- 1 V) * if "Report U_L supply voltage fault" is enabled.	
Port X03, X04	M12_L-coded Power, connector/socket, 5-pole Pin 2 / Pin 4	

Table 69: Information on the power supply of the actuators

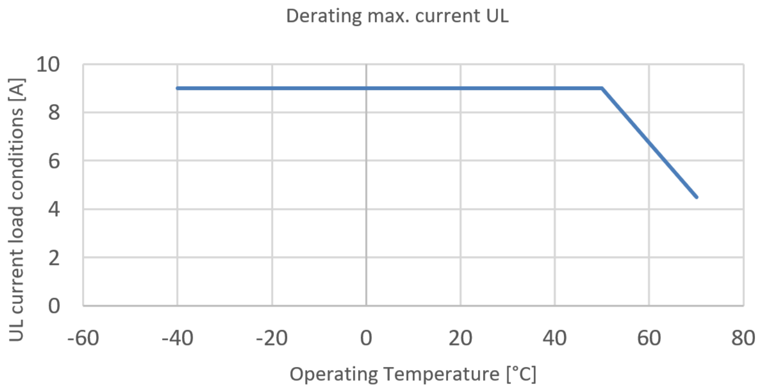


Figure 21: Derating of U_L

Caution: In case of a faulty SELV/PELV power supply unit, a maximum operating voltage of +60 V DC is possible at the U_L voltage supply (Pin 4/Pin2) on the F-DO ports. The device variants 0980 SSL 303x-121… do not limit these maximum possible output voltages. Confirm that the external connected sensors or actuators are designed for voltages up to +60 V DC.

20.6 FS DI ports

FS DI ports	0980 SSL 3x31-121...	Port X1 .. X4	M12 socket, 5-pin
	0980 SSL 3x30-121...	Port X1 .. X8	
Input connection	Type 3 as per IEC 61131-2		
Nominal input voltage	24 V DC		
Input current with 24 V DC	Typically 4 mA		
Short-circuit proof	Yes		
Channel type	Normally open, p-switching		
Safety state	Safe shut down → low Signal		
Number of digital inputs	0980 SSL 3x31-121...	4 (SIL 3,1oo2) 8 (SIL 2, 1oo1)	
	0980 SSL 3x30-121...	8 (SIL 3, 1oo2) 16 (SIL 2, 1oo1)	
Status indicator	Yellow LED for channel A / White LED for channel B		
Diagnostic indicator	Red LED per channel		
Input filter	≤ 1 ms (only switch-off pulses)		
	32 ms (± 1 ms; only switch-off pulses)		

Table 70: FS DI ports (Digital Input): Functional overview

Attention: In the event of an unwanted reverse supply from a connected actuator with an external power supply, the maximum reverse voltage must be less than +60 V DC.

20.7 FS DO ports

Attention: For ports X5 and X6 the outputs are supplied by the U_L power supply.

FS DO ports	0980 SSL 3x31-121...	Port X5 .. X6	M12 socket, 5-pin
Output type	Normally open, pp-switching or ppm-switching		
Nominal output voltage per channel Signal status “1” Signal status “0”	min. (U_L -1 V) max. 2 V		
Max. output current	0980 SSL 3x31-121...	per device:	max. 8.0 A per device at $T_{ambient}$ = +30 °C (+86 °F)
		per channel:	2.0 A
Short-circuit protection	Yes		
Overload protection	Yes		
FS-DO loads	In general:	Resistive, inductive and capacitive loads	
	For UL applications:	DC general use, DC resistance, DC Pilot duty according to UL/CSA/IEC 61010-2-201	
Behavior in case of short circuit or overload	Deactivation with automatic power-on		
Safe state	Safe shut down → high impedance		
Number of digital outputs	0980 SSL 3x31-121...	4 (SIL 3,1oo2)	
Status indicator	Yellow LED for channel A / White LED for channel B		
Diagnostic indicator	Red LED per channel		

Table 71: FS DO ports (Digital Output): Functional overview

Attention: In the event of an unwanted reverse supply from a connected actuator with an external power supply, the maximum reverse voltage must be less than +60 V DC.

20.8 IO-Link Master ports Class A

0980 XSL 3x31-121...	Port X7 .. X8	M12 socket, 5-pin

Table 72: IO-Link Master ports Class A

20.8.1 Configured as digital input (Pin 4 + Pin 2)

Input connection	0980 SSL 3x31-121...	Type 1 as per IEC 61131-2
Nominal input voltage	24 V DC	
Input current	Typically 3 mA	
Channel type	Normally open, p-switching	
Number of digital inputs	0980 SSL 3x31-121...	4
Status indicator	Yellow LED	
Diagnostic indicator	Red LED per channel	

Table 73: IO-Link Master Class A ports, configured as digital input

20.8.2 Configured as digital output (Pin 4 + Pin 2)

Attention: For ports X7 and X8 the outputs are supplied by the U_S power supply.

Output type	Normally open, p-switching		
Nominal output voltage per channel Signal status “1” Signal status “0”	min. (U_L -1 V) max. 2 V		
Max. output current	0980 SSL 3x31-121...	per device:	max. 8.0 A per device at $T_{ambient}$ = +30° C (+86° F)
		per channel:	2.0 A
Short-circuit protection	Yes		
Overload protection	Yes		
Non-Safety DO loads	In general:	Resistive, inductive and capacitive loads	
	For UL applications:	DC general use, DC resistance, DC Pilot duty according to UL/CSA/IEC 61010-2-201	
Behavior in case of short circuit or overload	deactivation with automatic power-on		
Number of digital outputs	0980 XSL 3x31-121...		4
Status indicator	Yellow LED per output		
Diagnostic indicator	Red LED per channel		

Table 74: IO-Link Master ports, configured as digital output

20.8.3 Configured as IO-Link port in COM mode (Pin 4)

IO-Link Master specification	v1.1.3 ready, IEC 61131-9	
Communication rates	4.8 kbaud (COM 1) 38.4 kbaud (COM 2) 230.4 kbaud (COM 3)	
Line lengths in the IO-Link Device	max. 20 m	
Number of IO-Link ports	0980 SSL 3x31-121...	2
Min. IO-Link cycle time	400 µs	

Table 75: Configured as IO-Link port in COM mode

20.9 LEDs

LED	Color	Description
U_L/U_{AUX}	Green	Auxiliary sensor/actuator voltage OK 18 V (+/- 1 V) < U_L/U_{AUX} < 30 V (+/- 1 V)
	Red*	Auxiliary sensor/actuator voltage LOW U_L/U_{AUX} < 18 V (+/- 1 V) or U_L/U_{AUX} > 30 V (+/- 1 V) * if "Report U_L/U_{AUX} supply voltage fault" is enabled.
	OFF	None of the above conditions.
U_S	Green	System/sensor voltage OK 18 V (+/- 1 V) < U_S < 30 V (+/- 1 V)
	Red	System/sensor voltage LOW U_S < 18 V (+/- 1 V) or U_S > 30 V (+/- 1 V)
	Red flashing	Device performs a factory reset (position of rotary encoding switches: 9-7-9)
	OFF	None of the above conditions.
X1 .. X8 A	Green	IO-Link COM Mode: IO-Link communication exists.
	Green flashing	IO-Link COM Mode: No IO-Link communication.
	Yellow	Standard I/O Mode: Status of digital input or output on C/Q (pin 4) line "on".
	OFF	None of the above conditions.
X1 .. X8 B	White	Status of digital input or digital output on pin 2 line "on".
	Red	Short circuit on C/Q (pin 4) line / All modes: Overload or short circuit on L+ (pin 1) line / communication error
	OFF	None of the above conditions.
P1 Lnk/Act P2 Lnk/Act	Green	Ethernet connection to another subscriber exists. Link detected.
	Yellow flashing	Data exchange with another subscriber.
	OFF	No connection to another subscriber. No link, no data exchange.

LED	Color		Description
MS	Green		The device is operating in a normal condition. Safety Supervisor State: Executing.
	Green flashing		The deviceis ready and configured. Safety Supervisor State: Idle.
	Red		Serious detected error that cannot be resolved (Unrecoverable Fault). Safety Supervisor State: Critical Fault.
	Red flashing		Minor detected error that can be resolved (Recoverable Fault) Examples: The IP address of the module does not match the already stored NodeID of the TUNID / The module has an incorrect or contradictory configuration Safety Supervisor State: Self-Test Exception or Abort.
	Flashing alternately at 1 Hz:		The device is in Self-Test or the device needs commissioning due to configuration or UNID missing, incomplete or incorrect. Safety Supervisor State : Self-Testing, Waiting for TUNID or Configuring.
	Red	Green	
	OFF		The device is switched off.
NS	Green		The device is on-line and has at least one connection established.
	Green flashing		The device is on-line, has an IP address but no connection established.
	Red		The device has detected that the assigned IP address is already being used by another device (duplicate IP address).
	Red flashing		One or more I/O connections are in the Timed–Out state.
	Flashing alternately at 1 Hz:		The device has detected a Network Access error and is in the Communication Faulted state.
	Red	Green	
	Flashing alternately at 2 Hz:		The device received Propose TUNID service and waits for the Apply TUNID service. Safety Supervisor State: Waiting for TUNID
	Red	Green	
	OFF		The device is switched off, is in Self-Test or has not been assigned an IP address.

Table 76: Information on the LED colors

20.10 Safety error codes

Error Code	Description
0x0100	Connection in Use or Duplicate Forward_Open
0x0105	Ownership Conflict or OUNID Mismatch. The configuration is already owned by another originator.
0x0106	Ownership Conflict or OUNID Mismatch. The output connection was already owned by another originator.
0x0110	Device not configured
0x0111	RPI not supported
0x0113	Connection Manager or connection object cannot support any more connections.
0x0205	Parameter Error in Unconnected Send Service or Parameter Error in SafetyOpen or SafetyClose
0x0315	Invalid Connection Type
0x0320	Configuration Inconsistency
0x0801	Incompatible Multicast Time Correction RPI. An existing connection has been established at a different Time Correction RPI.
0x0802	Invalid Safety Connection Size
0x0803	Invalid Safety Connection Format
0x0804	Invalid Time Correction Connection Parameters
0x0805	Invalid Ping Interval EPI Multiplier
0x0806	Time Coordination Msg Min Multiplier
0x0807	Network Time Expectation Multiplier
0x0808	Timeout Multiplier
0x0809	Invalid Max Consumer Number
0x080A	Invalid CPCRC
0x080B	Time Correction Connection Id Invalid
0x080C	SCID Mismatch. The SCID was non-zero and did not match the value in the target
0x080D	TUNID not set. Device is out-of-box and TUNID has not been set, so connections are not allowed.
0x080E	TUNID Mismatch. The TUNID provided does not match. The message was likely routed to this node in error

Error Code	Description
0x080F	Configuration operation not allowed
0x0815	Incompatible Multicast Ping Interval EPI Multiplier. An existing connection has been established with a different Ping Interval EPI Multiplier.
0x0816	Incompatible Multicast Max Consumer Number. An existing connection has been established with a different Max Consumer Number.
0x0817	Incompatible Multicast Safety Network Segment Type. An existing connection has been established with a different Safety Network Segment Type.

20.11 Data transfer times for non-Safety I/O

The following tables give an overview of the internal data transfer times of the LioN-Safety IO-Link Master with a connected IO-Link Device as digital I/O extension (Belden article 0960 IOL 380-021 16DIO Hub with a minimum cycle time of 1 ms).

There are three measured data direction values for each use case:

- **PLC to DO:** Transfer of a changed PLC output data to IO-Link Device digital output.
- **DI to PLC:** Transfer of a changed digital input signal on IO-Link Device to PLC.
- **Round-trip time (RTT):** Transfer of a changed PLC output data to IO-Link Device digital output. The digital output is connected to an IO-Link Device digital input. Transfer of the changed digital input signal on IO-Link Device to PLC. RTT = [PLC to DO] + [DI to PLC].

The measured values are taken from the ethernet data transmission line. The values are therefore without PLC processing times and PLC cycle time.

The configurable digital input filter value on 0960 IOL 380-021 was set to "off" (0 ms).

For calculation of user specific data transfer and round-trip times of possible input filters, PLC processing and cycles times must be taken into calculation.

The measured values are valid for a maximum of 48 bytes of IO-Link data for the IO-Link Master in each direction (Input/Output).

Use case 1:

IO-Link Master configuration with enabled Web interface and *disabled* IIoT protocols

Data direction	Data transfer time in ms		
	Minimum	Average	Maximum
PLC to DO	3.7	6.0	7.7
DI to PLC	1.1	3.0	4.3
RTT	6.1	8.9	11.1

Use case 2:

IO-Link Master configuration with enabled Web interface and *enabled* IIoT protocols

Data direction	Data transfer time in ms		
	Minimum	Average	Maximum
PLC to DO	7.7	10.0	13.4
DI to PLC	3.3	4.4	5.6
RTT	12.1	14.3	17.0

21 Accessories

In order to get access to various types of accessories, please visit our Web page:

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22 Declarations of conformity

Lumberg Automation™ and Hirschmann™ Products

EC Declaration of Conformity

Manufacturer Belden Deutschland GmbH **Doc-Nr.:** CE_0441V00_
Hersteller **File:** CE_0441V00_.pdf

Adress Im Gewerbepark 2
Adresse 58579 Schalksmühle

declares in sole responsibility, that the product(s):
erklärt in alleiniger Verantwortung, dass das/die Produkt(e):

Type Remote IO Module - Functional Safety - CIP Safety
Typ

Product(s) 0980 SSL 3131-121-007D-202
Produkt(e)

comply with the requirements of the following European directive(s):
übereinstimmen mit den Vorschriften folgender/folgenden Europäischer Richtlinie(n):

2014/30/EU,
2011/65/EU,
2006/42/EG

The following standard(s) was(were) applied:
Folgende Normen wurden angewandt:

EN IEC 63000: 2018
IEC 61131-2: 2017
EN 61131-2: 2007
EN ISO 13849-1: 2023

Notified Body for certification (EC type-examination) in accordance with Annes IX of 2006/42/EG

Benannte Stelle für die Zertifizierung (EG Baumusterprüfung) in Übereinstimmung mit Anhang IX, 2006/42/EG:

TÜV Rheinland Industrie Service GmbH
Am grauen Stein
D-51105 Köln
Germany
Kenn-Nr. 0035
EC type-examination No.: 01/205/6012.00/24
EG-Baumusterprüfung Reg.-Nr.: 01/205/6012.00/24

Neckartenzlingen, den 20.12.2024

i.V. Jochen Dolezal	i.V. Sercan Suoelmez	i.A. Gerald Lieb
Director R&D	Manager Quality	R&D Engineer

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Lumberg Automation™ and Hirschmann™ Products

EC Declaration of Conformity

Manufacturer Belden Deutschland GmbH **Doc-Nr.:** CE_0442V00_
Hersteller **File:** CE_0442V00_.pdf

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Adresse 58579 Schalksmühle

declares in sole responsibility, that the product(s):
erklärt in alleiniger Verantwortung, dass das/die Produkt(e):

Type Remote IO Module - Functional Safety - CIP Safety
Typ

Product(s) 0980 SSL 3130-121-007D-202
Produkt(e)

comply with the requirements of the following European directive(s):
übereinstimmen mit den Vorschriften folgender/folgenden Europäischer Richtlinie(n):

2014/30/EU,
2011/65/EU,
2006/42/EG

The following standard(s) was(were) applied:
Folgende Normen wurden angewandt:
EN IEC 63000: 2018
IEC 61131-2: 2017
EN 61131-2: 2007
EN ISO 13849-1: 2023

Notified Body for certification (EC type-examination) in accordance with Annes IX of 2006/42/EG

Benannte Stelle für die Zertifizierung (EG Baumusterprüfung) in Übereinstimmung mit Anhang IX, 2006/42/EG:

TÜV Rheinland Industrie Service GmbH
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EC type-examination No.: 01/205/6012.00/24
EG-Baumusterprüfung Reg.-Nr.: 01/205/6012.00/24

Neckartenzlingen, den 20.12.2024

i.V. Jochen Dolezal	i.V. Sercan Suoelmez	i.A. Gerald Lieb
Director R&D	Manager Quality	R&D Engineer

CE_0442V00_.pdf - Page 1 of 1