Safety shutdown of IO-Link Devices

SIMATIC S7-1500 / IO-Link / SIRIUS 3SK1

https://support.industry.siemens.com/cs/ww/en/view/109806975

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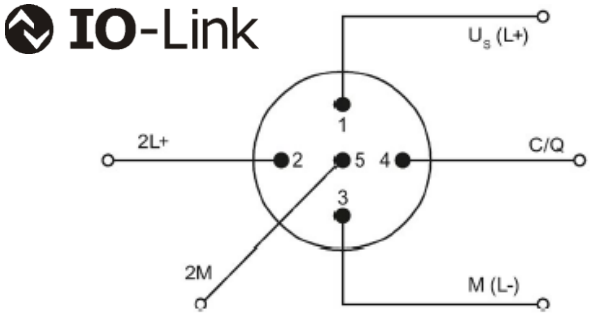
1 Introduction

1.1 Overview

Aim of this application example

In contrast to port class A, port class B allows an IO-Link master to supply an IO-Link device with an additional load voltage (2L+).

Figure 1-1 Additional load voltage 2L+ with IO-Link port class B



Switching off 2L+ removes the load voltage from an IO-Link device. This results in the (standard) digital outputs of the IO-Link device, which are supplied via IO-Link port class B, being switched off. The digital inputs are not affected.

This application example demonstrates this possibility with an IO-Link Device ET 200AL. PROFINET and IO-Link communication remain active after switch-off. In principle, all IO-Link devices (including those from other manufacturers) that support IO-Link Port Class B can be used for this purpose.

Structure of this application example

Via a 3SK1 safety relay, an emergency stop safely switches off the additional 2L+ load voltage of the IO-Link device. This load voltage is provided by port B of the IO-Link master.

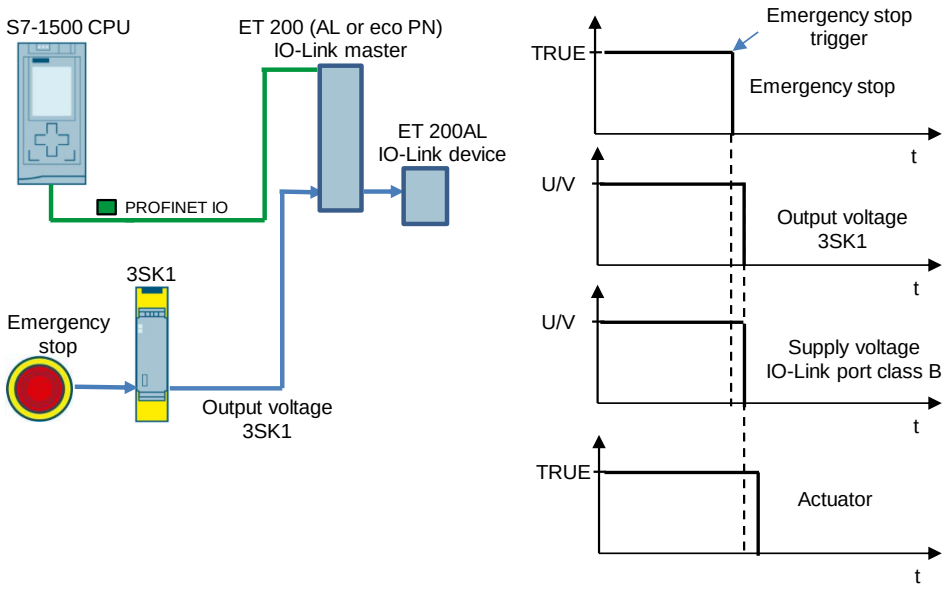
The application example consists of two STEP 7 projects for TIA Portal V17:

- Project A shows the solution with the ET 200AL (IO-Link master and IO-Link device).
- Project B shows the additional solution with the ET 200eco PN as IO-Link master and ET 200AL as IO-Link device.

An S7-1500 standard CPU thereby communicates with the corresponding ET 200 via PROFINET.

Overview of the automation solution

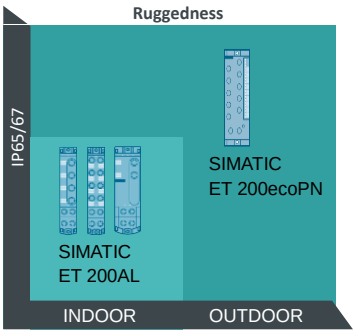
Figure 1-2 Operating principle of the safety function



ET 200 in IP65/67

The ET 200AL and ET 200eco PN are suitable distributed I/Os available with the IP65/IP67 degree of protection.

Figure 1-3 ET 200AL and ET 200eco PN in the IP65/67 degree of protection



IO-Link

ET 200AL and ET 200eco PN offer the IO-Link master version (used here). The advantages as well as some basics about IO-Link can be found in Section 3.1.

Advantages of IO-Link

The following benefits are achieved by using the IO-Link:

- Safe shutdown is possible due to the additional load voltage 2L+.
- In the event of a safe shutdown, the load voltage 1L+ remains available and ensures that
  - PROFINET and IO-Link communication is maintained
  - Messages and diagnostics are still possible

PL d/SIL 2 with 3SK1 and IO-Link I/O modules

For many safety applications, a PL d according to ISO 13849-1 or a SIL 2 according to ISO 62061 is sufficient to implement a safety function. In such cases, the 3SK1 safety relay offers a way to implement safety functions simply and cost-effectively:

- It is **simple** because the safety function can be implemented without creating a safety program.
- It is **cost-effective** because the safe shutdown can be set up using standard modules (in this case, IO-Link I/O modules).

Figure 1-4 3SK1 safety relay

Note

Standard modules that can be used for safe shutdown are described in the following entry:

https://support.industry.siemens.com/cs/ww/en/view/39198632

1.2 Operating principle

At this point, we explain the use of the IO-Link I/O modules and the mode of operation of the safety function. An overview of the hardware configuration used in this application example is given in Section 2.1.

Safe shutdown

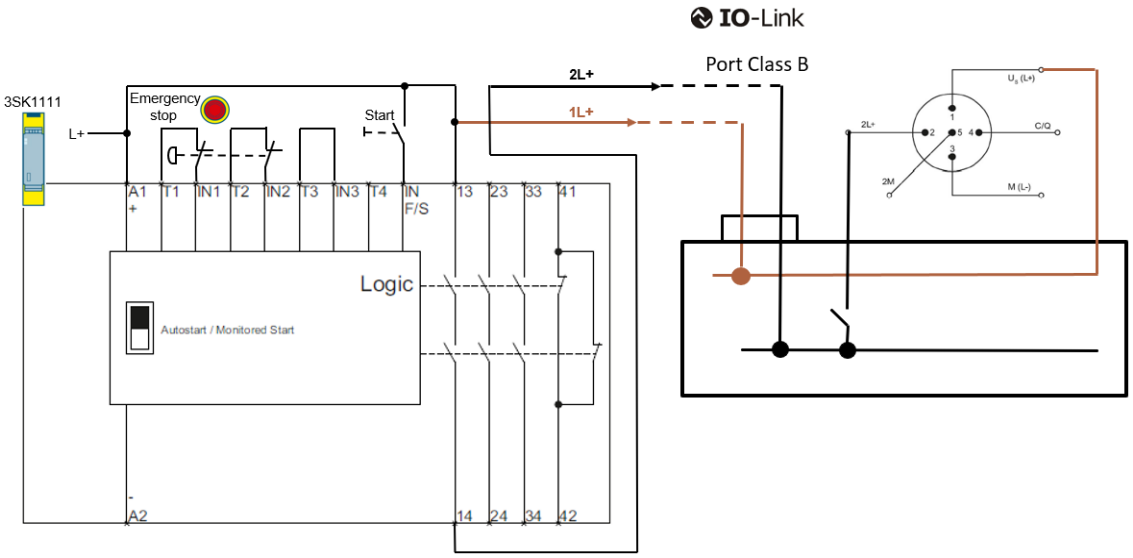
In this application example, the output voltage of the 3SK1 safely switches off the power supply 2L+ of an IO-Link master once the emergency stop has been actuated. IO-Link Devices that are supplied via the additional load voltage are set to the safe state.

For this purpose, the ET 200 is supplied with voltage at two points and behaves as follows after the safety function (emergency stop) has been triggered:

- **1L+** remains available and maintains the PROFINET and IO-Link communication of the ET 200 I/O devices.
- **2L+** drops out and results in the safe shutdown of the actuator.

Figure 1-5 shows 1L+ and 2L+ on the 3SK1 and the IO-Link (power supply and connection to the channel). 1L+ and 2L+ are galvanically isolated on the IO-Link side.

Figure 1-5 1L+ and 2L+ on the 3SK1 and the IO-Link port class B



If the emergency-stop command device is unlatched and the feedback circuit is closed, the Start button can be used to switch on again.

Operating principle of IO-Link

The note in Section 1.1 links an entry that names standard modules that can be used for safe shutdown. Some of these modules support IO-Link. The application example described here uses IO-Link master with port class B and IO-Link I/O modules.

The IO-Link system offers crucial advantages as a digital interface when connecting sensors/actuators. 3.1 lists these advantages. It also offers a small introduction to the topic.

Operating principle of 3SK1

The 3SK1 safety relay monitors a command device. In this case, it is an emergency stop. When the emergency stop command device is actuated, the 3SK1 opens the release circuits, whereby an output voltage is switched off at the 3SK1. This safely switches off the actuator(s). Such actuators can be:

- Power contactors
- Fail-safe motor starters

3SK1 is suitable for applications up to PL e/SIL 3.

1.3 Components used

The following hardware and software components were used to create this application example:

Table 1-1 Hardware components

Component	Quantity	Article number	Note
CPU 1515-2 PN	1	6ES7515-2AM01-0AB0	FW 2.9
Safety relay Basic unit, standard	1	3SK1111-2AB30	
ET 200AL, IM 157-1 PN	1	6ES7157-1AB00-0AB0	
ET 200AL, CM 4x IO-Link	1	6ES7147-5JD00-0BA0	IO-Link master
ET 200eco PN, CM 8x IO-Link	1	6ES7148-6JG00-0BB0	IO-Link master
ET 200AL, DIQ 4+DQ 4x24VDC/0,5A	1	6ES7143-5BF00-0BL0	IO-Link device
Emergency stop	1	3SU1851-0NB00-2AA2	

Table 1-2 Software components

Component	Quantity	Article number	Note
STEP 7 Professional V17	1	6ES7822-1AA07-0YA5	
Safety Advanced V17	1	6ES7833-1FA17-0YA5	

This application example consists of the following components:

Table 1-3 Components of the application example

Component	File name	Note
Documentation	109806975_F_Shutdown_IO_Link_3SK1_DOC_V1_0_TIAP_V17.pdf	This document
STEP 7 project	109806975_F_Shutdown_IO_Link_3SK1_PROJ_V1_0_TIAP_V17_ET200AL.zip	STEP 7 sample project
STEP 7 project	109806975_F_Shutdown_IO_Link_3SK1_PROJ_V1_0_TIAP_V17_ET200eco PN.zip	STEP 7 sample project

2 Engineering

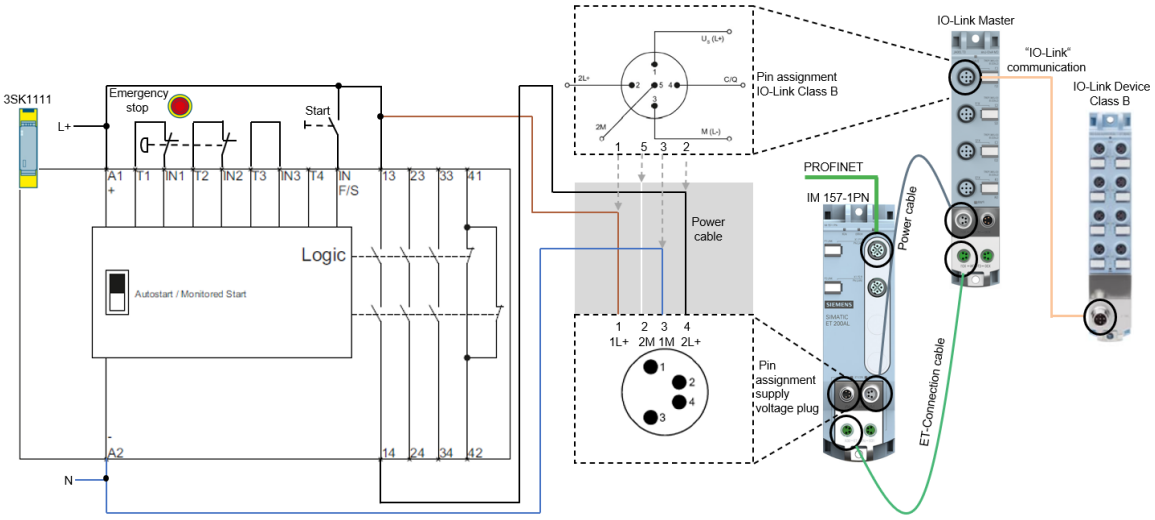
2.1 Hardware configuration and wiring

The following applies to Figure 2-1 and Figure 2-2:

- The S7-1500 CPU is not listed for the sake of clarity. This is connected via PROFINET to the IM 157-1PN of the ET 200AL or the ET 200eco PN.
- The dashed arrows at (1, 5, 3, 2) of the "IO-Link pin assignment" serve to clarify the common signals with the pin assignment to the "Supply voltage connector pin assignment" (1, 2, 3, 4).

Project A (solution with ET 200AL)

Figure 2-1 Project A: Hardware configuration and wiring



The figure above shows a possible solution configuration with ET 200AL.
As an alternative solution, instead of using the power line, the lines could be connected directly to X80 (POWER Input) as a separate supply. In this regard, observe the following note:

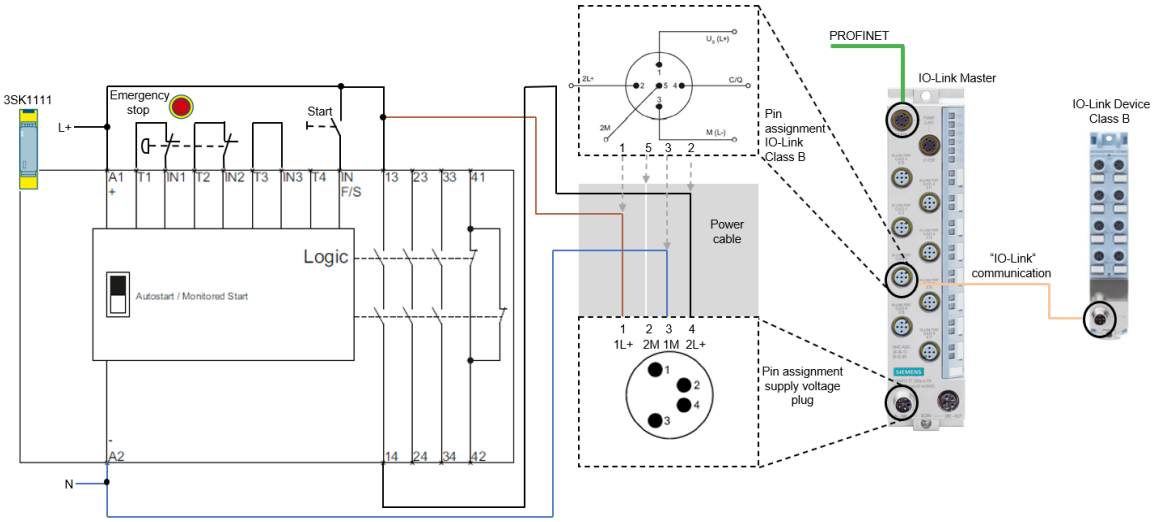
CAUTION

With a separate supply at X80 (no power line), the 2L+ supply must be applied there. This can be safely switched off by the 3SK1.

Always note where you switch off 2L+ using the 3SK1 and whether this also acts on the actuator.

Project B (solution with ET 200eco PN)

Figure 2-2 Project B: Hardware configuration and wiring



2.2 Project engineering and configuration

2.2.1 Configuration

IP addresses

The sample project uses the following IP address for project A and project B:

Table 2-1 IP addresses used

Component	IP address	Subnet mask
S7-1500 CPU	192.168.0.1	255.255.255.0
ET 200AL, IM 157-1 PN or ET 200eco PN, CM 8x IO-Link	192.168.0.2	255.255.255.0

2.2.2 Configuration

The following illustrations of the hardware configuration of STEP 7 are already set up in the sample project. Here, they serve as an overview.

Project A (ET 200AL)

Figure 2-3 Network view

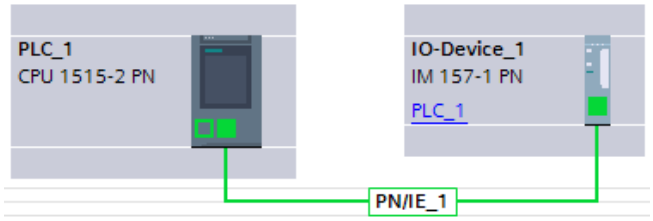
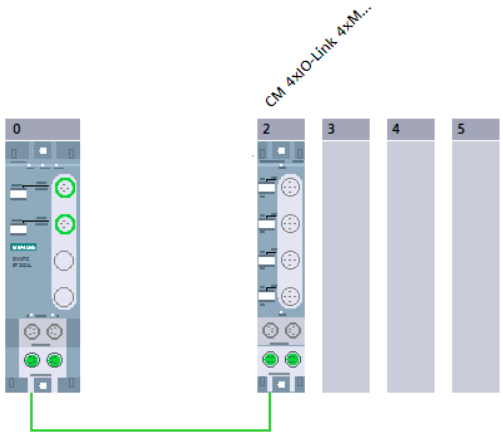
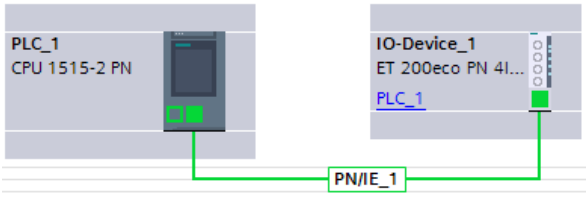


Figure 2-4 Device view



Project B (ET 200eco PN)

Figure 2-5



Connecting the IO-Link device

To connect the IO-Link device to the IO-Link master module, you will need:

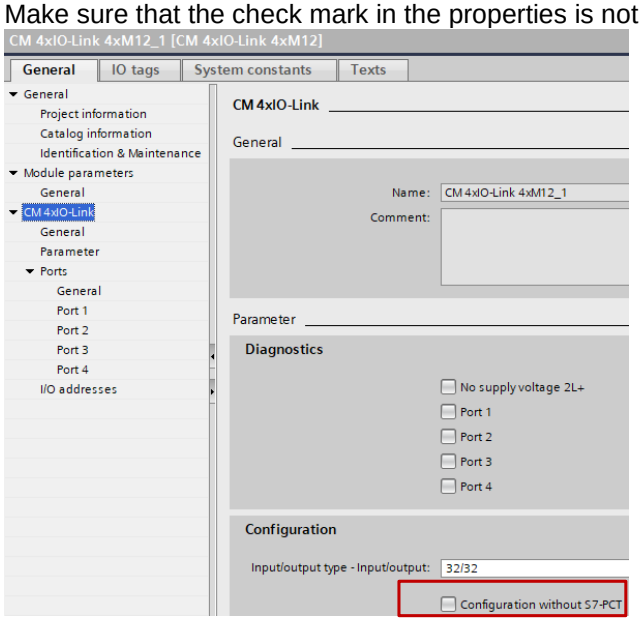
- IODD file
- Port configuration tool S7-PCT.

IODD file and S7-PCT are explained in Section 3.1.3. The possibility of configuration without S7-PCT is not explained in this application example.

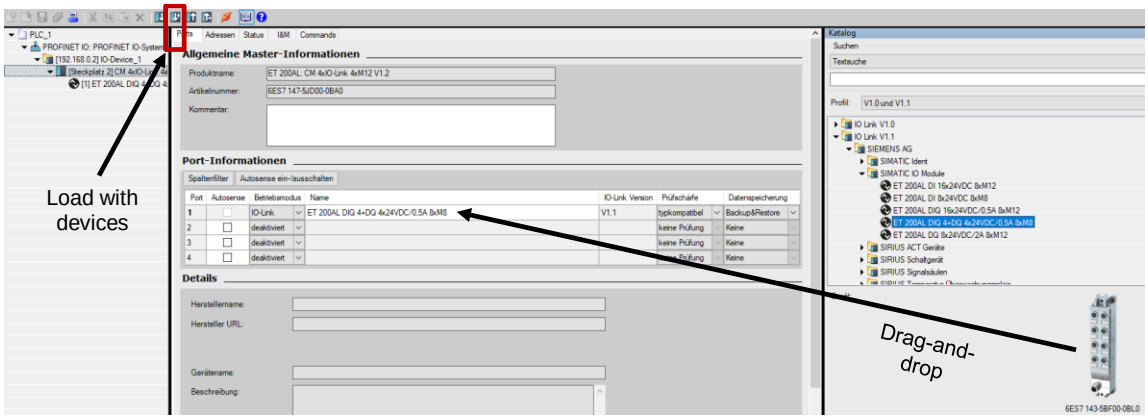
The following instructions show the connection of the IO device using the example of project A (ET 200AL). These instructions also apply correspondingly to project B (ET 200eco PN).

Instructions

1. Open the STEP 7 hardware configuration.
2. Select the communication module (CM) and go to the device view.
3. Make sure that the check mark in the properties is not set.



4. Start the S7-PCT configuration tool as follows:
   Highlight the communication module (CM) > right mouse button > "Start device tool" > "Start".
5. Drag-and-drop the IO-Link device into the table under "Port information" and then click "Load with devices" (icon in the menu bar).



6. Close the S7-PCT by clicking on "X" at the top right of the window. The settings in the S7-PCT are saved in the process.
7. Load the STEP 7 project into the S7-1500 CPU.

2.3 Programming

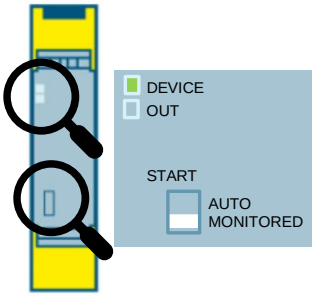
The STEP 7 project contains the hardware configuration, including the configuration in S7-PCT.

A STEP 7 user program is not required to present the safe emergency stop using the 3SK1.

2.4 Operation

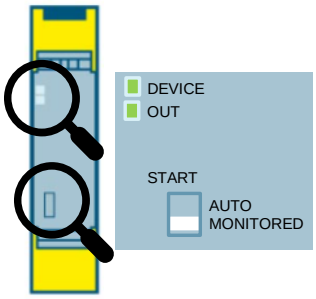
Requirement

- The hardware is structured as shown in Figure 2-1 and Figure 2-2.
- Project A or Project B is available in the S7 CPU.
- The S7-CPU is in RUN operating mode.
- On the 3SK1, the "DEVICE" LED lights up in green and the slide switch is set to "MONITORED":



Instructions

1. Press the start button on the 3SK1 (contact "IN F/S").



2. Press the emergency stop.
   - The IO device is switched off.
   - The "OUT" LED turns off.
   - The "PWR" LED on the CM 4xIO link turns off.
3. Release the emergency stop.
4. Start again with step 1.

3 Useful information

3.1 IO-Link basics

3.1.1 Advantages of IO-Link

- Open standard in accordance with IEC 61131-9
- Tool-supported parameter setting and central data management
- Simple, uniform wiring and significantly reduced variety of interfaces on the sensors/actuators
- Consistent communication between sensors/actuators and the CPU
- Consistent diagnostic information down to the sensor/actuator level
- Dynamic change of sensor/actuator parameters by the controller or the operator on the HMI
- Automatic reparameterization in the case of device replacement during operation
- Consistent device identification
- Additional galvanically separated power supply for actuators (Class B)

3.1.2 Components and connection system

Components

An IO-Link consists of the following components:

- IO-Link master
- IO-Link device, e.g.:
  - Sensors/actuators
  - RFID reader
  - I/O modules
  - Valves
- Unshielded 3- or 5-wire standard cables
- An engineering tool for the configuration and parameterization of the IO-Link

IO-Link master

The IO-Link master establishes the connection between the IO-Link devices and the automation system. As part of an I/O system, the IO-Link master is installed either in the control cabinet or directly in the field as a remote I/O, with IP65/67 degree of protection. The IO-Link master communicates via various fieldbuses or product-specific backplane buses. An IO-Link master can have several IO-Link ports (channels). One IO-Link device can be connected to each port (point-to-point communication).

Engineering

The IO-Link system is engineered in parallel with the overall automation system, and it can be embedded and interlocked with it.

IP65/67 connection system

For the connection technology in IP65/67, M12 connectors, among others, have been specified. Sensors should have a 4-pin connector and actuators a 5-pin connector. IO-Link master generally has a 5-pin M12 socket.

The connector assignment is as follows in accordance with IEC 60974-5-2:

- Pin 1: 24 V
- Pin 3: 0 V
- Pin 4: Switching and communication line (C/Q)

In addition to providing the IO-Link communication, these three pins also supply the devices with energy. You can find more information on this energy supply in the documentation of the IO-Link master used.

Figure 3-1 IO-Link device pin assignment

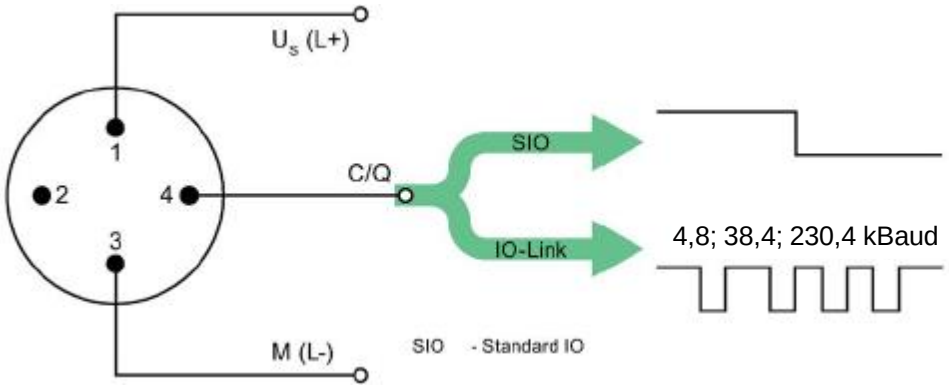


Table 3-1 Pin assignment Figure 3-1

Pin	Signal	Definition	Standard
1	U_S (L+)	24 V	IEC 61131-2
2	-	Not defined	-
3	M (L-)	0 V	IEC 61131-2
4	Q	Switching signal DI, DQ (SIO)	IEC 61131-2
4	C	"Coded switching signal" (IO-Link)	IEC 61131-9

Operating modes

The IO-Link ports of the master can be operated in the following modes:

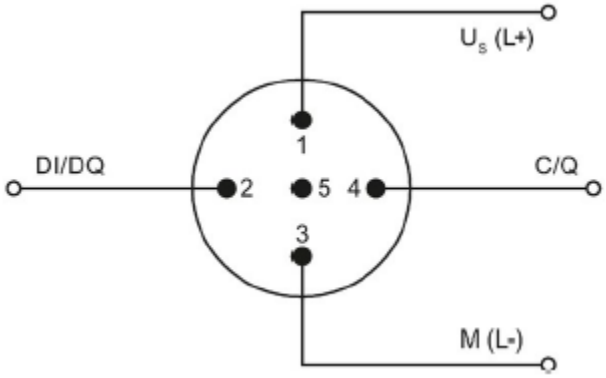
- IO-Link: The port is located in the IO-Link communication.
- DI: The port behaves like a digital input.
- DQ: The port behaves like a digital output.
- Deactivated: The port is deactivated.

Specification for IO-Link master

The specification for IO-Link master distinguishes between two types of ports:

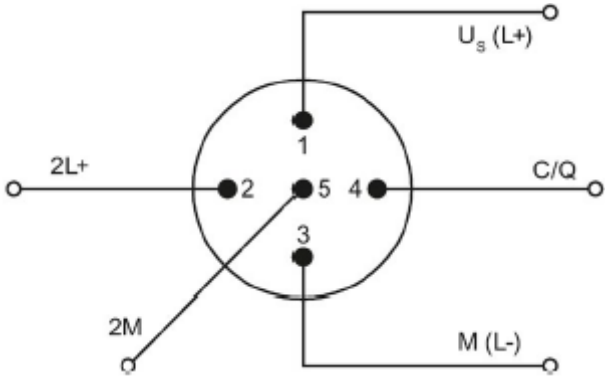
Port class A (type A)
With this type, the functions of pins 2 and 5 are not specified. The manufacturer specifies these functions. Generally, pin 2 is used with an additional digital channel.

Figure 3-2 Port class A pin assignment



Port class B (type B)
This type offers an additional supply voltage suitable for connecting devices with increased power consumption. Thereby, an additional (galvanically isolated) supply voltage is provided via pins 2 and 5. A 5-wire standard cable is required to use this additional supply voltage.

Figure 3-3 Port class B pin assignment



3.1.3 IODD and S7-PCT Port Configuration Tool

IODD device description

For each device, an electronic device description is available in the form of the IODD file (IO device description). The IODD holds a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostics data
- Device data
- Text description
- Image of the device
- Logo of the manufacturer

The structure of the IODD is the same for all devices of all manufacturers. The IO-Link configuration tools of master manufacturers (S7-PCT at Siemens) always display the structure of the IODD in the same way. This ensures that the handling is the same for all IO-Link devices, whatever the manufacturer.

IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database. This database provides the current IODDs of the device manufacturers and offers an information and download platform. You can find the IODDfinder on the internet (https://ioddfinder.io-link.com/).

IO-Link configuration tool

Configuration tools are required to configure the entire IO-Link system. The IO-Link configuration tools of master manufacturers can read IODDs.

The key tasks of the IO-Link configuration tool include:

- Assigning the devices to the ports of the master
- Assigning the addresses of the ports within the address range of the master
- Parameterizing IO-Link devices

Moreover, the connected devices can be diagnosed.

The IO-Link configuration tool thus allows a transparent representation of the IO-Link system down to the field level.

Siemens provides S7-PCT for the engineering of the IO-Link system.

Configuring the IO-Link master

The configuration of the IO-Link master and the devices connected to it (up to four) is performed in an independent tool, the S7-PCT (Port Configuration Tool). The S7-PCT specifies:

- Which IO-Link device (e.g., a sensor) is connected to which port of the IO-Link master module
- Which addresses are occupied by the IO-Link devices in the I/O area of the SIMATIC S7 CPU
- What the parameterization for the IO-Link devices looks like

4 Appendix

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4.3 Links and literature

Table 4-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/109806975
\3\	How can safety related shutdown of standard modules be achieved? https://support.industry.siemens.com/cs/ww/en/view/39198632

4.4 Change documentation

Table 4-2

Version	Date	Modifications
V1.0.0	05/2022	First version
V1.0.1	06/2022	Title and one sentence changed
V1.0.2	11/2023	Correction of the circuit diagram