



# IO-Link

## At a Glance

### Specification in Brief

Breakthrough on communication



## Prepared, approved, and released by IO-Link

We welcome any comments, suggestions, and questions regarding this document. Please send these to [www.io-link-projects.com](http://www.io-link-projects.com) and include your name and e-mail address.

### Important notes:

NOTE 1      For every IO-Link device there is an associated IODD file. The file and any updates must be readily available at any time. The IO-Link manufacturer is responsible for ensuring that the IODD file has been tested using the IODD Checker and is available for download at [www.io-link.com](http://www.io-link.com)

NOTE 2      For every IO-Link device the following documents are available for download from [www.io-link.com](http://www.io-link.com): manufacturer's declaration of conformity to this specification, the released IODD, and test documents.

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**Notations:**

The following key words are used in this specification:

**Can** means that a choice is available and no preference is implied.

**Should** means that a choice is available, but a preferred implementation exists.

**Must** indicates a mandatory requirement. Designers **must** implement these mandatory requirements in order to ensure interoperability and to claim conformity with this specification.

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## 2 Overview of IO-Link system

An IO-Link system consists of:

- IO-Link master
- IO-Link devices - mostly sensors, actuators, or combinations thereof
- Standard 3-conductor sensor/actuator cable

The master can be implemented as a device of any type of construction and degree of protection.

The following system architecture is possible:

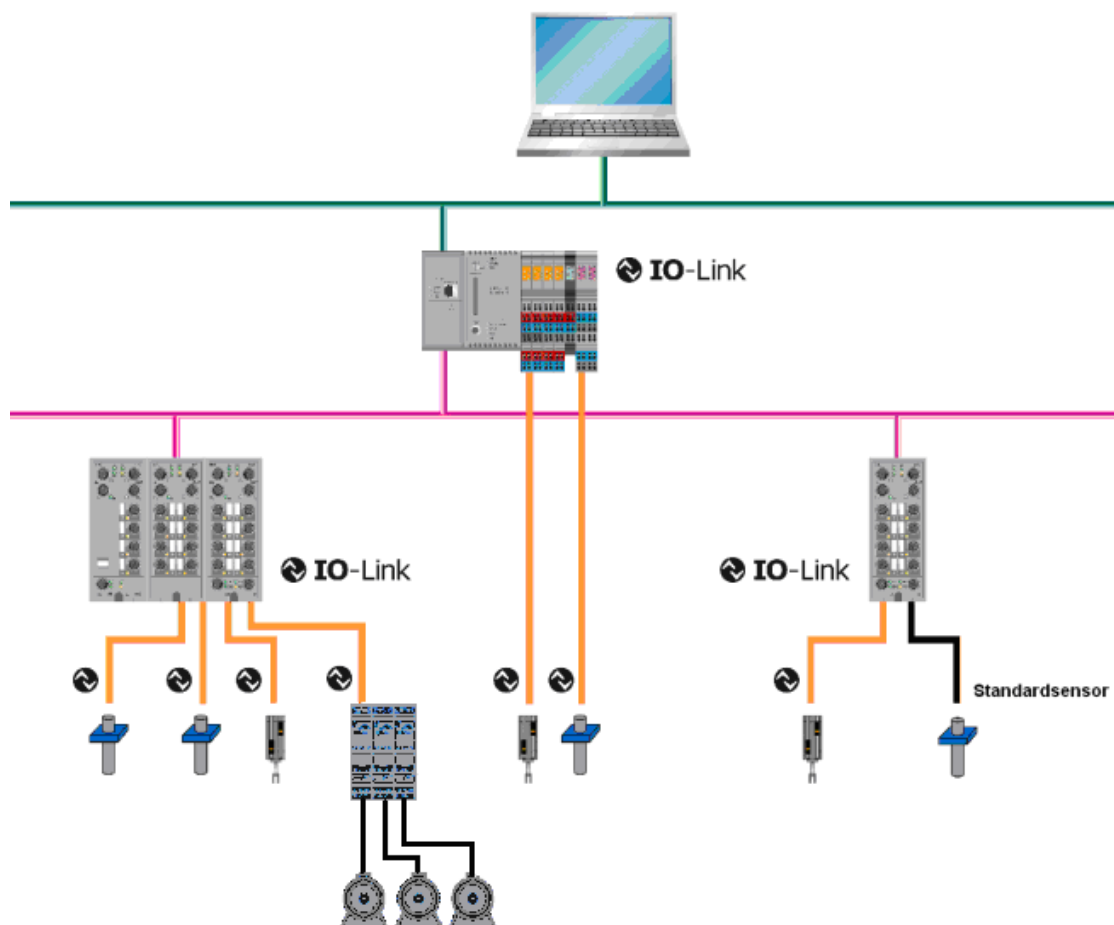


Figure 1: Example of system architecture

An IO-Link master has one or more ports. Only one IO-Link device or one standard sensor/actuator at a time can be connected to each port. Thus, IO-Link is a point-to-point communication system and not a fieldbus.

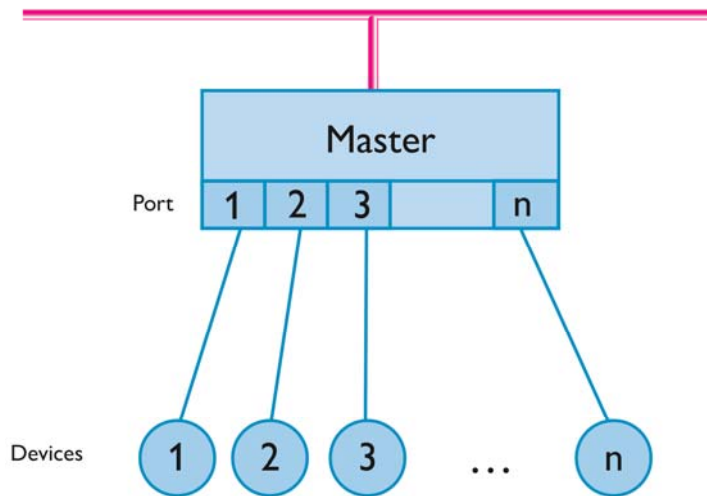


Figure 2: IO-Link point-to-point connection

## 2.1 After switching on

Following switch-on, the device is always in SIO mode (standard I/O mode).

The ports of the master can be configured differently. If a port is set to SIO mode, the master behaves like a normal digital input at this port. If the port is set to IO-Link mode (communication mode), the master attempts to find the connected IO-Link device. This action is called "wake up".

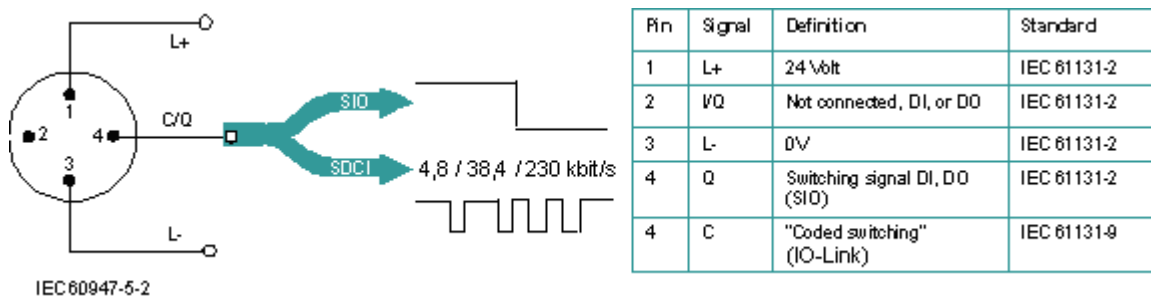


Figure 3: SIO- and IO-Link mode

During "wake-up" the master sends a defined signal and waits for the device to respond. The master first attempts this at the maximum defined baud rate. If this fails, the attempt is repeated at the next lower baud rate. The master makes three attempts at each baud rate to access the device. The device always supports only one defined baud rate. If the master receives a response, both devices start to communicate. They start out by exchanging communication parameters and then initiate cyclic data exchange of process data.

If the device is removed during operation, the master detects the communication break. It signals the communication break to the controller on a fieldbus-specific basis and attempts cyclically to wake up the device again. After another successful wake-up, the communication parameters are read out again and a validation may be performed. Afterwards, cyclic data exchange (cyclic communication channel) starts up again.

### 3 IO-Link protocol

In general, three types of data are exchanged:

- Cyclic process data (process data inputs, output) → cyclic data
- Device parameters (on-request data objects) → acyclic data
- Events → acyclic data

The IO-Link device sends data only when requested to do so by the IO-Link master. Sending of process data follows the IDLE frame of the master. Device parameter data and events are explicitly requested by the master.

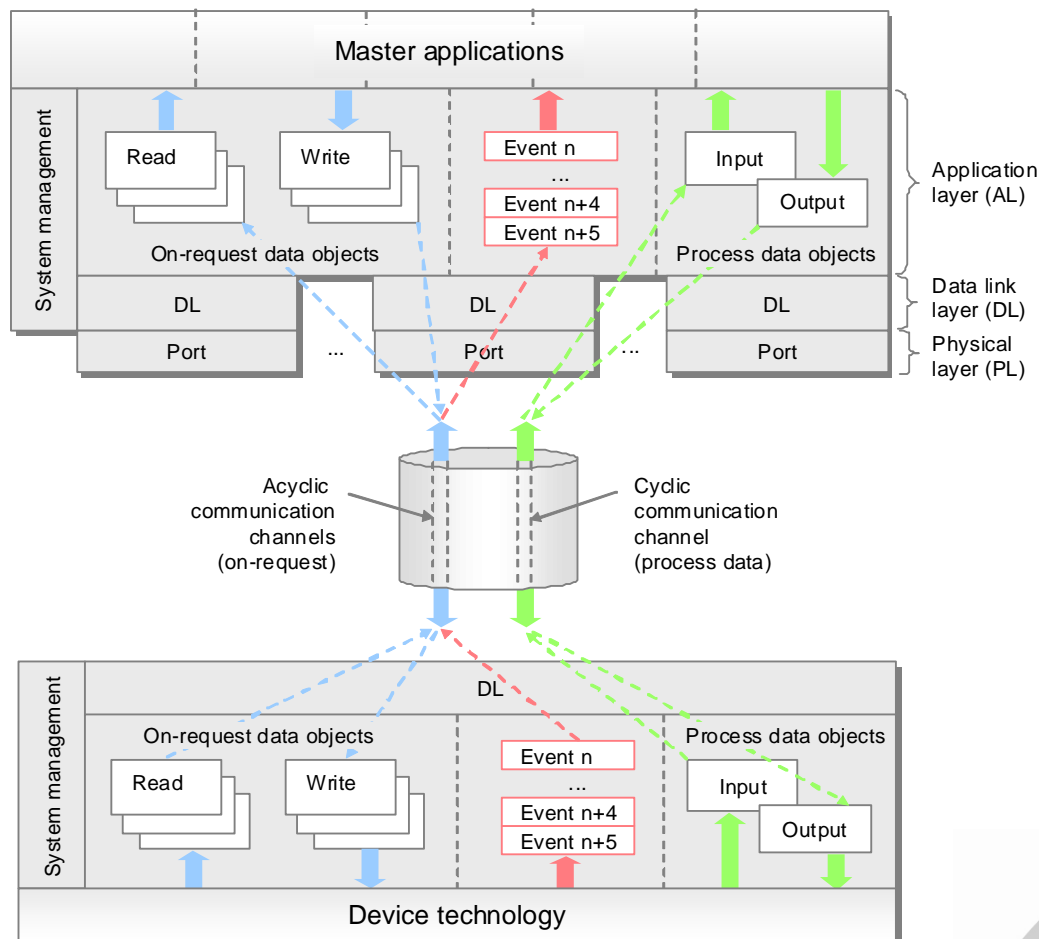


Figure 4: Cyclic and acyclic data exchange



### 3.1 Process data (process data objects)

The process data of a device are transferred cyclically in an F-sequence (data frame). The size of the process data is specified by the device. A range of 0 to 32 bytes of process data per device can be transferred (input and output, respectively). The validity of the process data is signaled by PD Valid.

### 3.2 Device parameters (on-request data objects)

Device parameters are exchanged acyclically and when requested by the IO-Link master. The IO-Link master always sends a prompt to the device first, and then the device answers. This applies when writing data to the device and when reading data from the device. Parameter values can be written to the device (Write) and device statuses can be read out from the device (Read) with the help of "on-request data objects".

### 3.3 Events

When an event occurs, the device sets the event flag, which is sent in the device reply message. The master detects the event flag and reads out the signaled event. While an event is being read out, no parameter data can be exchanged because the transfer of event data uses the time block of the on-request data.

Three categories of events are defined:

- Error messages (errors)
- Maintenance data (warnings)
- Device functions (notifications)

In this way it is possible to transfer events or device statuses, such as contamination, overheating, short-circuit, etc., from the device through the IO-Link master to the PLC or display devices.

The IO-Link master can also generate its own events and statuses and transfer these over the respective fieldbus. These events may include wire break, communication break, overload, etc.

### 3.4 Data exchange

Parameter data/events and process data can be transferred in **one** F-Sequence (frame) or in **separate** F-sequences (frames). Parameter data and events are always transferred in reserved time blocks (on-request data) so that the transmission time and deterministic behavior are independent of their transfer.

A more detailed representation of the frame structure can be found in Section "Frame types and their structure".

### 3.5 Transmission quality, retries, QoS

IO-Link is a very robust transmission system. It works at a 24 V level. If F-sequences are missing, the master call is repeated twice. If the first and second repetition attempts also



fail, the master detects a communication break and signals this to the higher-level controller.

### 3.6 Transmission rates and synchronicity

In IO-Link specification V1.1, the transmission rates (baud rates) 4.8 kBaud, 38.4 kBaud, and 230.4 kBaud are defined. An IO-Link device can support only one of the defined baud rates. The IO-Link master supports all baud rates.

The cycle time is made up of the frame length and the delay times in the master and the device. At a baud rate of 38,4 kBaud and a frame length of 2 bytes, the cycle time is typically about 2 ms.

The total time response results from the minimum cycle time that a device can provide and the subsequently negotiated or assigned actual cycle time. The master specifies this (master cycle time).

### 3.7 Frame types and their structure

Parameters/events and process data can be transferred in one F-Sequence (frame) or in separate F-sequences (frames). This transfer takes place over separate cyclic and acyclic communication channels, in which parameter data and events are always transferred in reserved time blocks (on-request data). Thus, the transfer of parameters/events has no effect on the velocity and the deterministic behavior of the process data transfer.

The IO-Link specification defines different F-Sequence types (frame types) that differ by size of the input/output process data (PD) and the number of parameters/event data (OD). In addition, access to the different communication channels (cyclic, acyclic) is specified for the respective frame types.

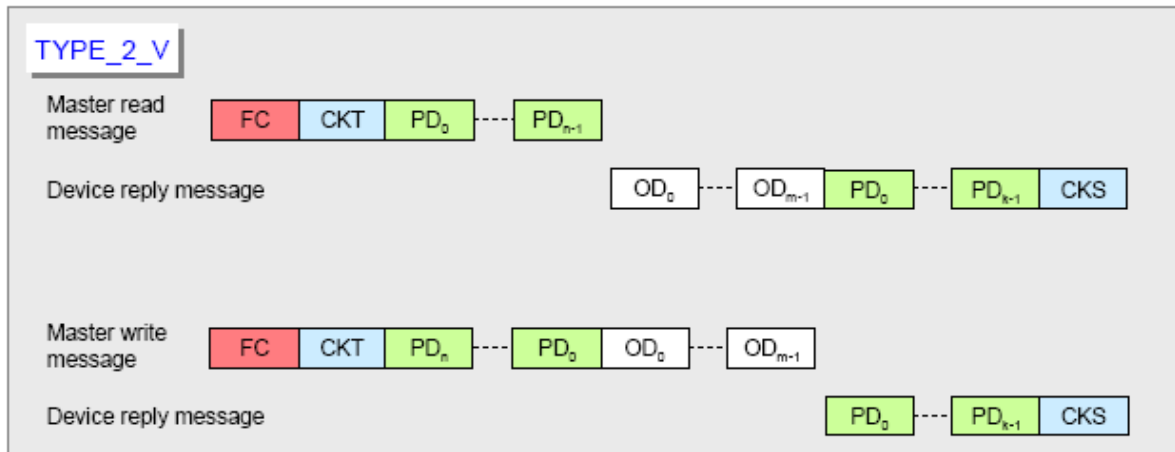


Figure 5: Basic IO-Link frame structure

#### F-Sequence control (FC)

In order to establish communication, the master must determine the communication parameters of the device. The length of the process data is relevant, among other things. Based on this information, the IO-Link master decides which F-sequence type (frame type)

is used for the cyclic data exchange. During the time that the communication is being established, the master uses the F-Sequence type 0 (frame type 0).

Other frame types are always used when the sum of the input and output process data of a device exceeds two bytes or service data are used additionally.

## 4 Integration into higher-level fieldbuses

### 4.1 Data exchange

To exchange data between an IO-Link device and a PLC, the IO-Link data from the IO-Link master are mapped to the utilized fieldbus. This is referred to as IO-Link mapping to the fieldbus. If the IO-Link master is connected directly to a PLC via a proprietary backplane bus (see Figure 1), the IO-Link data are mapped to this bus and transferred to the PLC or from the PLC to the IO-Link master and beyond to the IO-Link device. Specifications already exist for IO-Link mapping for PROFIBUS, PROFINET, INTERBUS, AS-i, EtherCAT, and PowerLink.

### 4.2 Access to device data

During cyclic data exchange, process data are transferred from and to the IO-Link device over the fieldbus or backplane bus. The parameter data must be explicitly requested by the PLC, or sent designated as such. The iSDU (indexed service data unit) has been defined for this purpose in the IO-Link specification.

Parameter values and statuses can be queried in an IO-Link device using indices and sub-indices. The requests (Read Write Services) are coded to an IO-Link-specific iSDU in the IO-Link master and transmitted via the IO-Link interface to the device.

The iSDU specifies whether the request is for reading or writing. The indices are used to specify the parameters whose values are to be read or written.



The iSDU is structured as follows:

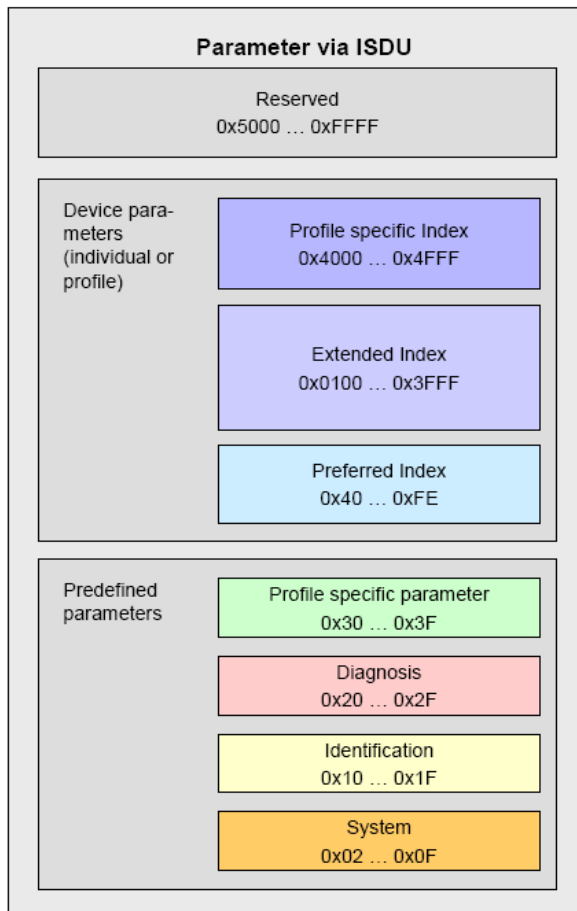


Figure 6: Structure of an iSDU

Up to 65536 indices with a size of up to 232 bytes can be addressed using IO-Link. The IO-Link specification already contains pre-defined indices (predefined parameters). A portion of these indices are stipulated as mandatory. Examples include:

- Vendor Name
- Product Name

The IO-Link devices can be identified explicitly using these indices.

However, the majority of the defined indices are optional, i.e., they can be used but are not required. Examples include:

- Serial Number
- Error Count
- Diagnosis History



### 4.3 Device profiles

Every PLC manufacturer supplies several customized function blocks (FB) for its system. Function blocks are used in the PLC program to program the acyclic communication with the IO-Link device by the IO-Link master. Through the FB it is specified which IO-Link master (i.e., which field bus node) the IO-Link device always communicates with and the ports of the IO-Link master via which data are to be exchanged. The request is also sent to the IO-Link device simultaneously.

To simplify the accesses from the PLC to the devices, device profiles are defined. The device profiles establish the data structure, data contents, and basic functionality. This ensures uniformity from the user's point of view and identical program access to many different devices.

### 4.4 Configuration in the fieldbus

The IO-Link master presents itself like a standard fieldbus node on the fieldbus. It is integrated into the respective network configurator by means of the relevant device description (e.g., GSD, FDCML, GSDML, etc.). These files contain a description of the communication properties and other properties of the IO-Link master, such as the number of ports. Which IO-Link devices are connected cannot be read out here. However, to represent the system architecture completely and transparently as far as the IO-Link device, the IO-Link device description (IODD) has been defined. With the help of the IODD and the IO-Link master manufacturer's IO-Link configuration tool, it is possible to configure which IO-Link device is connected to which port of an IO-Link master.



## 5 IO-Link system structure

### 5.1 The IO-Link device

The IO-Link device uses the IO-Link protocol to provide access to process data and variables of the devices. Certain variables specify things like the identification. The manufacturer puts the device-specific variables in defined index spaces. All of this information is described in the IODD.

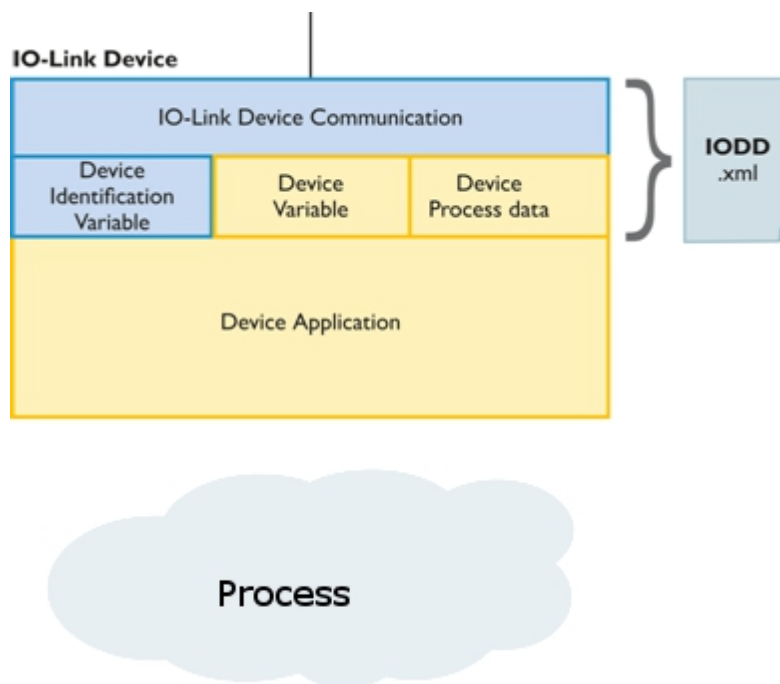


Figure 7: IO-Link device structure



## 5.2 IODD and IO-Link configuration tool

The IODD contains:

- Information regarding communication properties
- Information regarding device parameters
- Identification, process, and diagnostic data
- Image of the device
- Manufacturer's logo

The structure of the IODD is identical for all devices of all manufacturers. It is always represented in the same way by the master manufacturer's IO-Link configuration tool. This guarantees identical handling for all IO-Link devices regardless of the manufacturer. The IODD consists of one or more xml files that describe the device and image files in png format.

"IODD-StandardDefinitions1.0.xml" describes all the generally valid and mandatory properties of the device. A single instance of this file in every supported language must be present in the IODD directory. The manufacturer-specific properties of a device are described in other xml files.

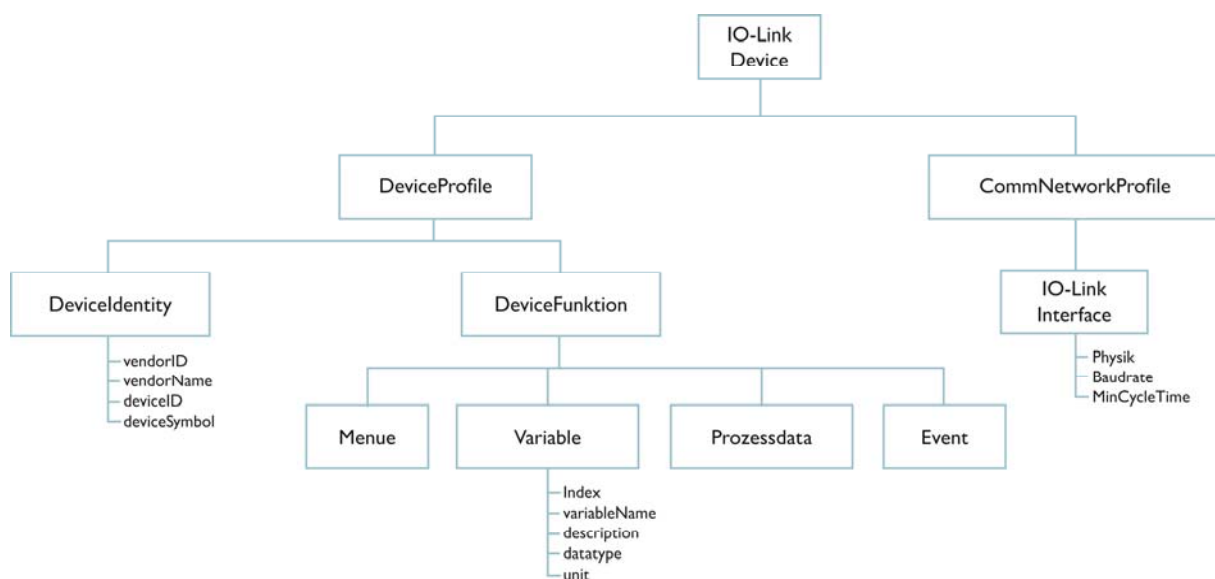


Figure 8: Structure of IODD

The master manufacturer's IO-Link configuration tools are able to read an IODD and display the device described therein graphically (only possible to a limited extent). It can be used to assign parameters for or diagnose IO-Link devices of all manufacturers. At the same time an IO-Link configuration tool allows transparent representation of the system architecture down to the field level.

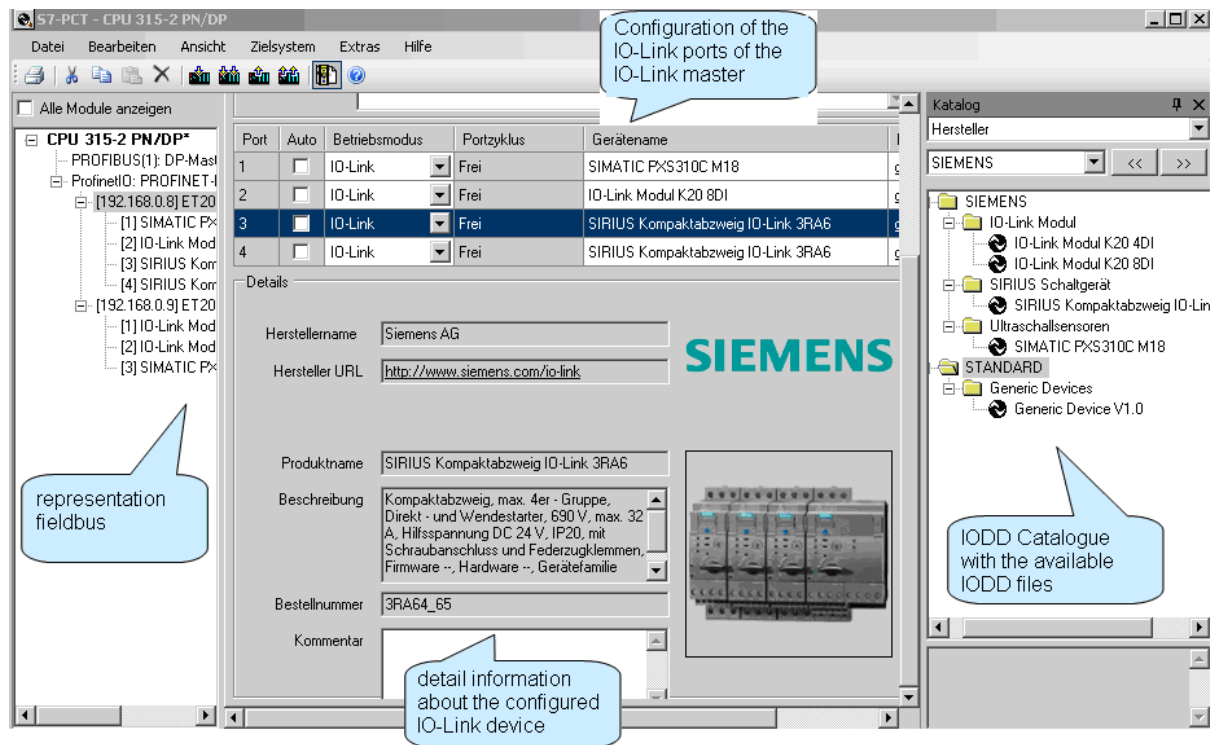


Figure 9: IO-Link configuration tool of a master manufacturer

The IODD checker has been developed for validating an IODD. All IODDs must be tested with the IODD checker. In so doing, the checker enters a checksum into the IODD. IO-Link configuration tools that read in an IODD also create a checksum on their part. This checksum must match the checksum entered in the IODD.

### 5.3 The parameter assignment serverfunction

The device parameters set using the configuration tool and IODD are transferred to the device. These are stored in non-volatile memory. These parameters can be changed from the PLC or by means of the configuration tool at any time and are stored in the device.

The device signals any parameter changes to the master. Then the master retrieves the current parameters from the device. The master, or a higher-level system of the master, stores these data and makes them available again automatically when the device is replaced by a new device.

This aids in convenient device replacement, since the IO-Link master carries out the parameter assignment for the new device automatically.

## 5.4 The IO-Link master

The IO-Link master can be connected to the PLC in different ways (see Figure 1) and has one or more ports.

The IO-Link specification distinguishes between two types of ports.

In the case of Port Class A (Type A), the functions of Pin 2 and Pin 5 are not described in more detail and can thus be defined by the manufacturer as desired.

Port Class B (Type B) is defined for devices that require a special voltage supply.

### Port Class A

Pin 4 can be configured as a digital input (DI) or IO-Link for this port type. Optionally, manufacturers can offer pin 4 as a digital output (DO) with a limited output current, as well. In addition, pin 2 can be used as desired. Manufacturers could implement pin 2 as a DI or DO, for example.

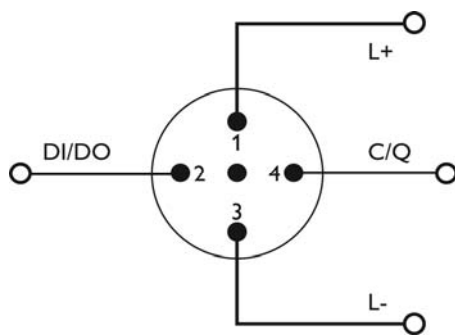


Figure 10: IO-Link master Port Class A

### Port Class B

Port type B is defined for actuators or sensors, for example, having an electrically isolated voltage supply. An additional voltage supply is provided here for pins 2 and 5.

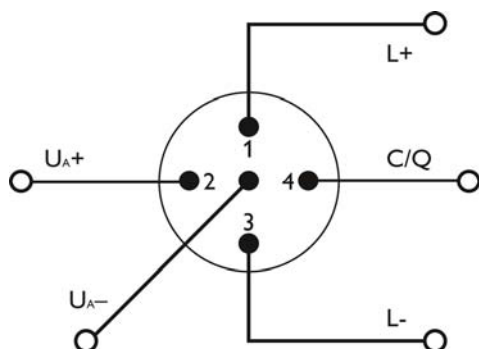


Figure 11: IO-Link master Port Class





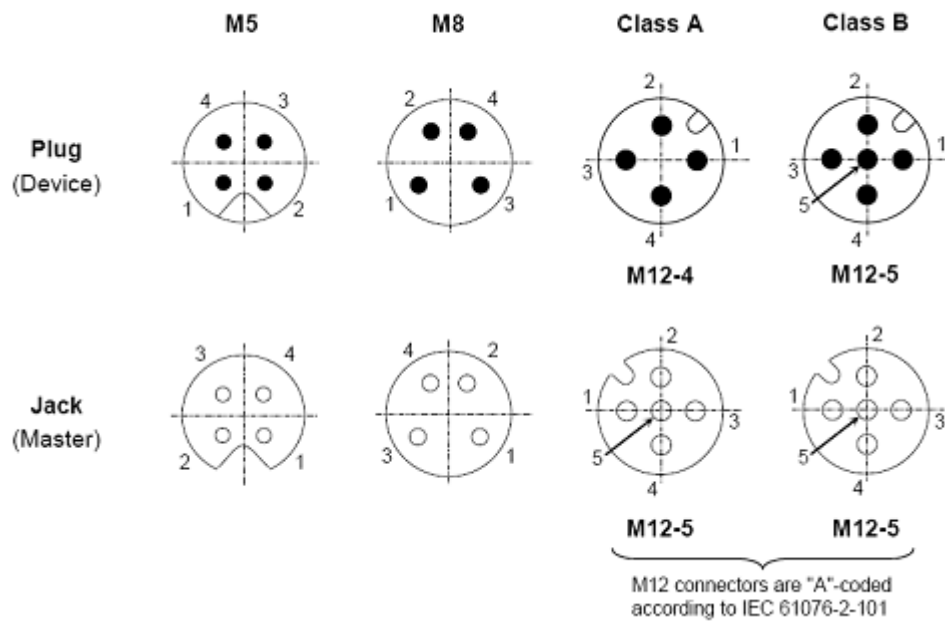


Figure: 12: Defined connector technology for devices with high degree of protection

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