# Integrating IO-Link Devices into CIP Networks

Frank Moritz
Product Manager Sensors & Connectivity
SICK AG

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## Abstract

IO-Link was introduced in factory automation in year 2009 as a new communication interface for small sensors and actuators. By now more than 50 companies are using IO-Link in their products and are supporting IO-Link technology. This communication technology allows integration of small devices from different vendors into any field buses or PLCs. The actual IO-Link Version is V1.1 and is being standardized in IEC 61131-9. Because of the interest of user, ODVA has formed an IO-Link Integration SIG to consider the specifications for integration of IO-Link devices into a CIP Network.

## Keywords

IO-Link, Industrial Communication, IODD, IEC 61131-9, SDCI, process data transmission, device description

## Definition of terms

**Device**
IO-Link sensor or actuator.

**Direct Parameters**
directly (page) addressed parameters transferred acyclically via the page communication channel without acknowledgement.

**IO-Link Master**
active peer connected through ports to one up to n Devices and which provides an interface to the gateway to the upper level communication systems or PLCs.

**IODD**
XML based document describing the data objects of an IO-Link device.

**SDCI**
IO-Link specification in IEC 61131-9.

# IO-Link at a Glance

## End user requirements

Today microcontroller based intelligent small sensors and actuators (devices) have a lot of different built-in parameters. End users need to optimize these parameters specific to an application like presence sensing of targets. To allow changing these parameters, devices need a communication interface for data transmission. A field bus connection is often not feasible to implement due to space or cost restrictions.

End users are requesting an easy-to use low cost communication interface for factory automation which can be implemented even into the smallest sensors like magnetic cylinder sensors.

Users are asking for functionality like:

Expanded diagnostics
- Diagnostics including remote diagnostics down to the field device level
- Cable break detection
- Device-specific diagnostics

Simplified installation
- Replace parallel wiring by one simple cable
- Replace analog signal types by digital transmission
- Standardize interfaces and cables with a single type
- Modular machine concepts shall be inherently supported

Automated parameter setting
- Function modules for automated parameter setting
- Tool-assisted parameter setting

Other key requirements include:

- The communication interface shall have the functionality of transmitting cyclic process data as well as acyclic data.
- Cycle times for process data shall meet the requirements for typical factory automation applications.
- The cycle time shall be scalable, providing process data transmission within 2ms.
- The communication interface shall be suitable for sensors and actuators as well and work reliably in a factory automation environment, therefore meeting all EMC requirements.

Users want to have a more robust high resolution transmission of analog 16 bit process data. For transmission of the beam status of a light grid a maximum of 256 bits shall also be transmitted via process data.

Each device shall have a unique ID for the identification of sensor / actuators in remote application.

Users are also asking for a fast setup and integration of devices into their specific control equipment (like PLCs or HMIs). Due to the fact that today sensors are connected to PLCs via various field buses, users want to have an easy integration of their preferred sensors into all of these different field buses.

Easy integration into different field buses requirement
- The communication interface standard should have no restrictions and have to be open to any vendor or supplier for masters and devices.
- Users want to have an accepted technology all over the world, fitting into all PLCs and field buses.
- All devices shall to be integrated into specific engineering tools in an easy way.
- Managing overhead using addresses, switches and bus administration should be avoided.

Users as well as suppliers request to have much lower additional costs than for a direct field bus connection.

Extended features like easy and fast device exchange shall be supported by downloading device parameters and configuration data in an automatic fast and reliable way.

Users want to have backward compatibility to switching sensors and have the advantage of not to make a system decision when they use this communication interface.

## Technical overview

The IO-Link technology defines a generic interface for connecting sensors and actuators to a master unit, which may be combined with gateway capabilities to become a fieldbus remote I/O node. The domain of this technology is shown in Figure 1:

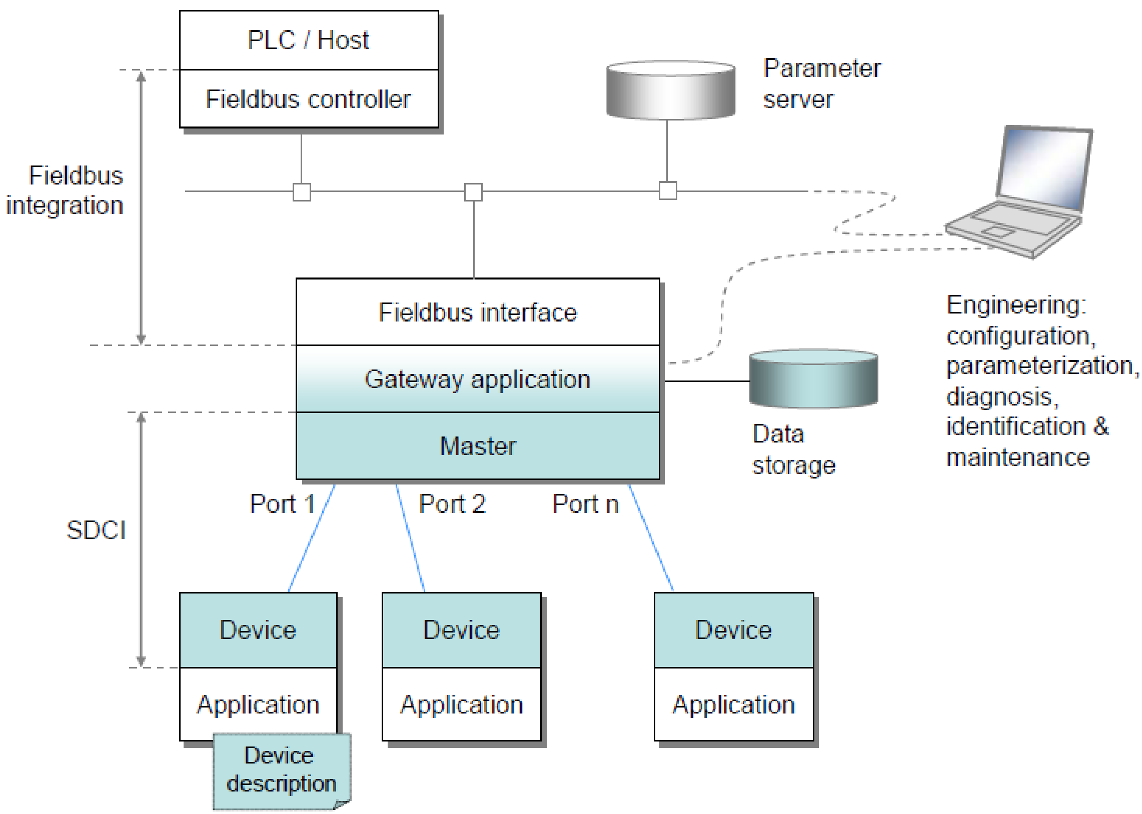



**Figure 1: Domain of the IO-Link technology within the automation hierarchy**

The IO-Link technology covers a number of topics. The domain of devices is the sensors and actuators in the factory automation field. These devices are near or direct in the process of a machine application.
The masters typically have a gateway application and are connected to a field bus. Therefore masters are connecting IO-Link devices to a fieldbus or a PLC. IO-Link is closing the communication gap of the so called “last mile” to small devices (Figure 2).

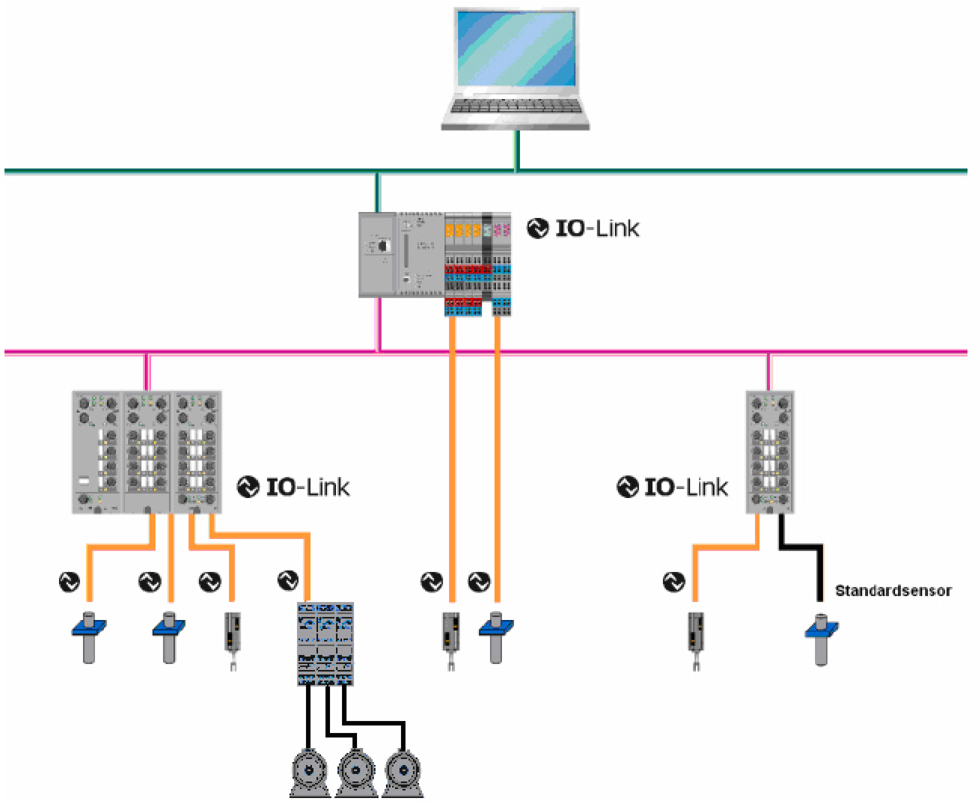



**Figure 2: IO-Link on the last mile**

The physical topology of IO-Link (Figure 3) is point-to-point from each Device to the Master using 3 wires over distances up to 20 m. The IO-Link physical interface is backward compatible with the usual 24 V I/O signalling specified in IEC 61131-2. 3 Transmission rates of 4,8 kbit/s, 38,4 kbit/s and 230,4 kbit/s are supported.

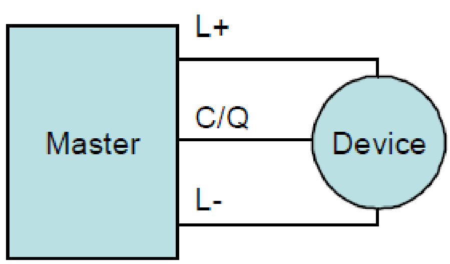
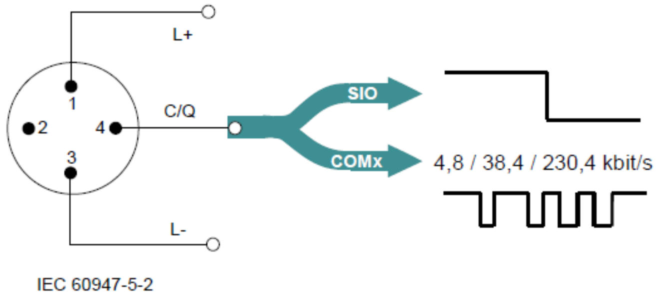



**Figure 3: Physical topology of IO-Link**

IO-Link is compatible to IEC 61131-2 (Figure 4) and supports the digital input functionality “SIO” (standard input output) as well as communication on sensor devices and also on masters. A master is able to switch at any time from SIO mode to communication mode with the different transmission rates COM1, COM2 and COM3 and vice versa. While a device supports exactly one transmission rate, the masters have to support all 3 transmission rates




| Pin | Signal | Definition | Standard |
|---|---|---|---|
| 1 | L+ | 24 V | IEC 61131-2 |
| 2 | I/Q | Not connected, DI, or DO | IEC 61131-2 |
| 3 | L- | 0 V | IEC 61131-2 |
| 4 | Q | "Switching signal" DI, DO (SIO) | IEC 61131-2 |
| | C | "Coded switching" (COM1, COM2, COM3) | IEC 61131-9 |

**Figure 4: IO-Link compatibility with IEC 61131-2**

Once activated, the IO-link mode supports parameterization, cyclic data exchange, diagnosis reporting, identification & maintenance information, and external parameter storage for device backup and fast reload of replacement devices.

## Data model of IO-Link devices

The data model of IO-Link devices covers process data, parameters, commands and diagnosis (events) (Figure 5). The address range allows the addressing of 65536 data objects which is restricted for IO-Link to 16364 data objects. The objects are accessible via indices and sub-indices. Each object can obtain simple or structured data types. Structured data types are combinations of simple types like integer, octets, strings or records.

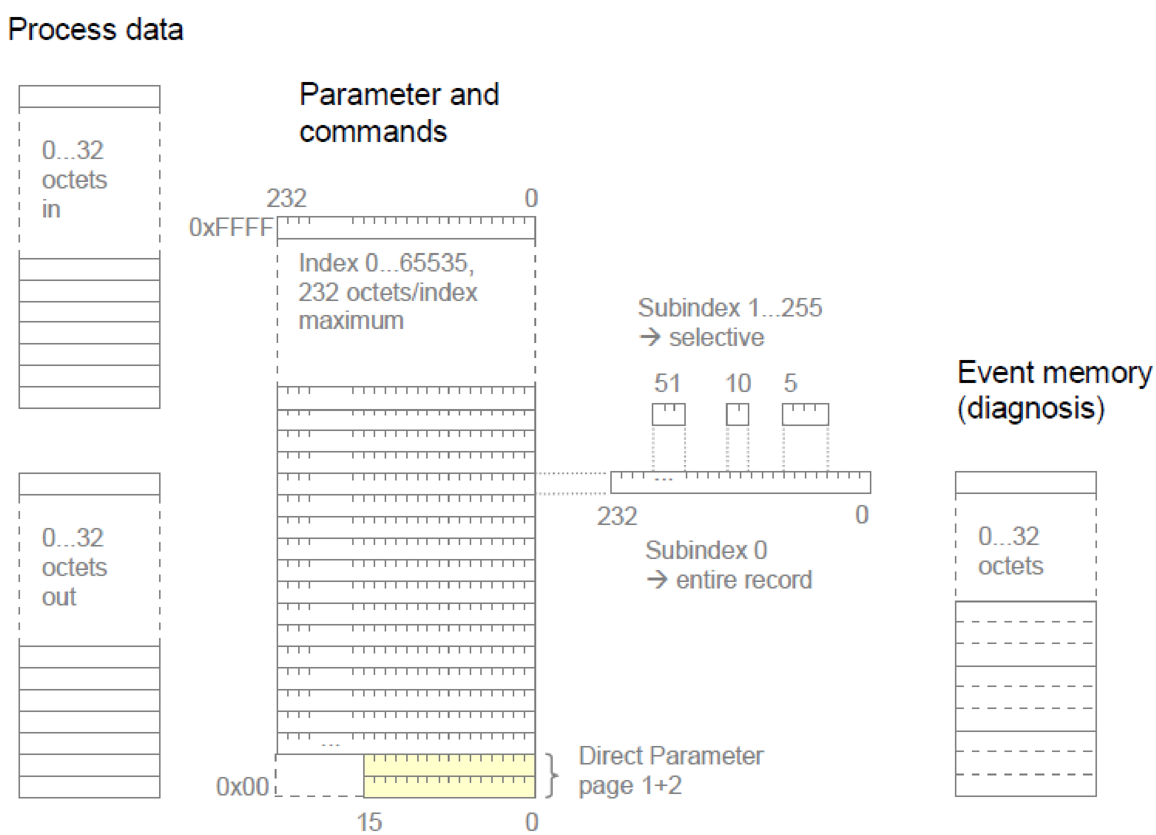



**Figure 5: Data model of IO-Link**

## Device Description IODD

All user accessible data objects, the content as well as their structure are described in the IODD. The IODD is a XML based device description file which is mandatory for all devices.
Inside the IODD, the content as well as the structure of data objects is described. Importing and interpreting this IODD enables tools to have an automatic access to parameters and also the right representation of data supported. This enables user-friendly integration into PLC-engineering tools or into an FDT container environment.
In Figure 6 a part on an IODD is shown as an example. A representation of an IODD on a PC based graphical user interface is shown in Figure 7.


```xml
  <?xml version="1.0" encoding="UTF-8" ?>
- <IODevice xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://www.io-link.com/IODD/2009/11" xsi:schemaLocation="http://www.io-link.com/IODD/2009/11
    IODD1.0.1.xsd">
    <DocumentInfo copyright="Copyright 2009, SICK AG." releaseDate="2010-04-29" version="V1.870" />
  - <ProfileHeader>
      <ProfileIdentification>IO-Link Device Profile</ProfileIdentification>
      <ProfileRevision>1.00</ProfileRevision>
      <ProfileName>Device Profile for IO-Link Devices</ProfileName>
      <ProfileSource>IO-Link Consortium</ProfileSource>
      <ProfileClassID>Device</ProfileClassID>
    - <ISO15745Reference>
        <ISO15745Part>1</ISO15745Part>
        <ISO15745Edition>1</ISO15745Edition>
        <ProfileTechnology>IODD</ProfileTechnology>
      </ISO15745Reference>
    </ProfileHeader>
  - <ProfileBody>
    - <DeviceIdentity deviceId="1040119" vendorId="26" vendorName="SICK AG">
        <VendorText textId="TI_VendorText" />
        <VendorUrl textId="TI_VendorUrl" />
        <VendorLogo name="SICKAG-logo.png" />
        <DeviceFamily textId="TI_DeviceFamily" />
      - <DeviceVariantCollection>
        - <DeviceVariant deviceIcon="SICKAG-WTB4C-3P3464-icon.png" deviceSymbol="SICKAG-WTB4C-3P3464-pic.png" firmwareRevision="1.47" hardwareRevision="1.40"
            productId="WTB4C-3P3464">
            <ProductName textId="TI_3P3464_Name" />
            <ProductText textId="TI_3P3464_Text" />
          </DeviceVariant>
```


**Figure 6: part of an IODD**

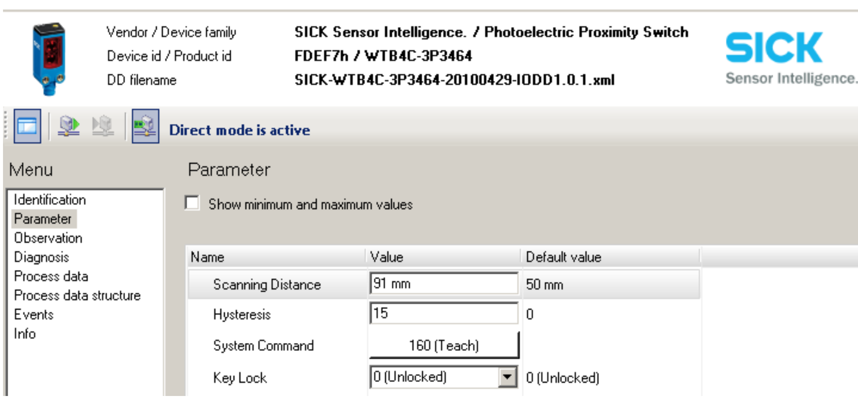



**Figure 7: IODD representation inside a FDT container**

All acyclic and cyclic data are transmitted through the IO-Link communication channel and split via the System Management to the different Application Layer services. In Figure 8 the object transfer at the application layer level is shown.

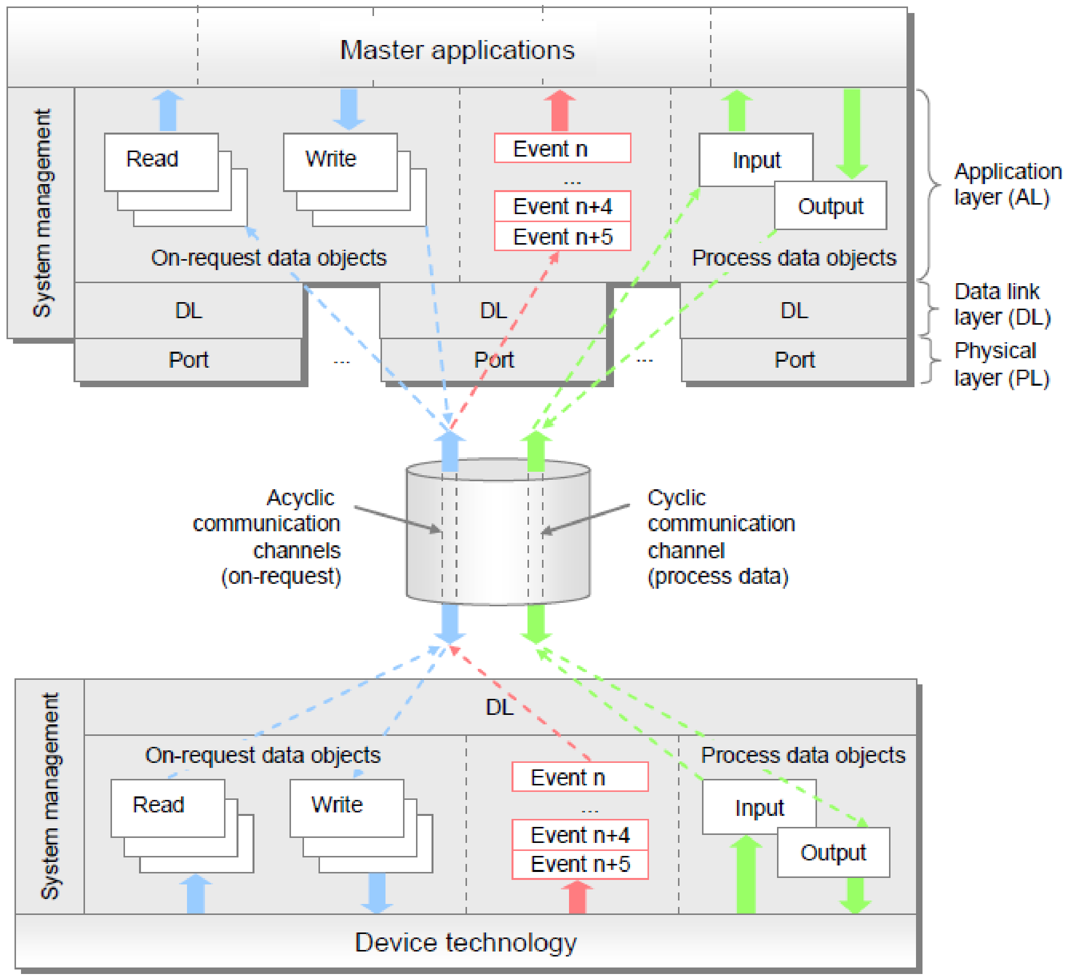



**Figure 8: Object transfer at the application layer level**

For an optimized data transmission different frame types are supported the data link layer (Figure 9). Each frame is transmitting one or more bytes of acylic (OD on-request data) and cyclic data (PD process data). Each frame contains the master request (started by MC) and device response. The master request, as well as the device response, is secured by an additional checksum (CKT and CKS).

A typical frame for transmitting 8 bits of process data of a sensor is TYPE_2_1 which takes 2.3 ms at a transmission rate of 38.4 KBaud.


**Figure 9: IO-Link transmission frames**

# Why IO-Link

## The Target use cases

The main target use is to give connectivity to devices which are not able to get a field bus connection and giving these sensors and actuators enhancements and additional functionality like:

- Precise analog value transmission in harsh environment
- Replacement of analog 4..20mA interfaces
- Parameterization of small devices (sensors and actuators)
- Getting detailed diagnostic data
- Monitoring of device conditions

For the handling of devices in automation systems the use cases are

- Remote access to devices for diagnosis
- Fast and reliable device exchange without any tooling
- Monitoring device data remotely

## IO-Link functions to be supported

An integration of IO-Link into CIP shall support all main features and functionalities of IO-Link. This includes the mapping and access to all supported data objects and services.

- Process data transmission (1 Bit to 32 Byte)
- Service Data transmission (16 Bit index range)
- Event handling
- Direct parameter page support
- System commands

- Transmission of block parameters
- Easy device exchange based on the identification of devices
- Automatic device data exchange without tooling
- Change from communication into SIO mode and vice versa.
- Hot plug functionality

## Tool integration (optional)

For a tool-based integration the interpretation of the device IODD shall be supported.

## Specifications

IO-Link is a complete specification suite including "interface & system" as well as "test" and "device description." The specifications are divided into 3 documents (Figure 11).

- Interface and System
- IODD (Schema, data representation in tools, parameter description
- Test specification for masters as well as for devices for both Versions V1.0 and V1.1

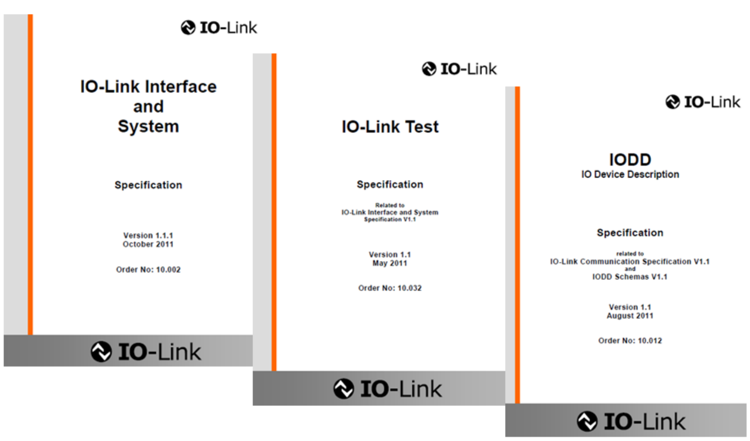



**Figure 11: IO-Link specifications**

The IO-Link technology is currently being standarized at IEC. The standardization process has reached the level FDIS (Final Draft International Standard). The publication is expected in Q2 2013. IO-Link will become an IEC 61131 standard. It is also integrated with PROFINET, EtherCAT, PROFIBUS, Interbus, and AS-Interface.

All specifications are fully publicly available via www.IO-link.com.

## Summary

IO-Link technology is field bus independent and supports extended functionality improving machine performance. The integration of IO-Link will enable user benefits for machine performance. IO-Link today is an approved technology already integrated into a number of field buses. Many PLC suppliers are also supporting IO-Link in their PLC modules and the appropriate engineering tools.

## References

IEC 61131-9
IO-Link.com

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