IO-Link System Description
Technology and Application
IO-Link Benefits
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1. Preface

IO-Link is a standardised worldwide I/O technology (IEC 61131-9) for the communication with sensors and also actuators. The IO-Link association of companies has the aim of developing and marketing IO-Link as a technology.

To benefit more from the performance of modern sensors and actuators, i.e. being able to operate machines and systems more productively, consistent communication down to the lowest field level is required. Leading automation manufacturers have created a standard with IO-Link that now solves the problem of the "last mile".

In all industrial areas machines and systems are continuously optimised to improve their productivity throughout the whole life cycle. Besides a reduction of the total cost of ownership (TCO) the increase in output and uptime contributes to an increase in competitiveness. Due to the more flexible adaptation to different requirements and ambient temperatures and faster retrofitting in spite of comprehensive configuration data the machines are becoming more and more complex. The more functionality they provide, the more information has to be exchanged across all company levels. Against this background the demand for communication with sensors and actuators is also increasing since they constitute a direct process interface.

It is not possible to exchange any other data than the actual process value via the standard interfaces used so far on the sensor/actuator level. Sensor and actuators provide more and more complex functions with integrated intelligence. Simple switching status or measured value interfaces restrict communication and lead to information congestion. To have an overall picture of the machine for optimisation purposes, networking at all levels must be transparent. It must be possible to map each component with the required depth of information in the complete system pool. In detail this means for sensors and actuators that not only process data has to be exchanged but also parameter and diagnostic data.

In existing sensor/actuator installations a specialised and therefore expensive module had to be used for each signal type. The heterogeneous wiring with screened cables is costly and even then analogue signals were usually transferred with poor quality. Networking of mechatronic units that are used more and more frequently in mechanical engineering proved to be quite complex due to the manifold interfaces. During each machine retrofit, all relevant parameters had to be set manually or via a separate tool directly on each sensor or actuator which led to inconsistent data storage and long downtimes. Besides the complex saving and documentation mechanisms the fear of manipulation remained because the parameters were often directly stored in the sensor or actuator without any additional backup.

Since there was no continuous communication with the superposed levels, the diagnostic data of the sensors and actuators was not available in the engineering tool. Due to their exposed position in the process more errors occur with these components than for example with I/O devices, drives or controllers. If, however, diagnostic information is missing, troubleshooting and error elimination is often difficult and time consuming. Moreover no preventive maintenance can be made with the aim to increase machine uptime.
To eliminate the described weaknesses leading automation manufacturers have defined an open interface between sensors and actuators as well as IO/modules, namely IO-Link. Taking into consideration the current standard of I/O networking via a point-to-point connection a communication channel for continuous transfer of process, parameter and diagnostic data has been created.

"Use" stands for "universal", "smart", "easy"

- **Universal** expresses that IO-Link can be universally used, cooperates with all bus systems and fits into any system environment.

- **Smart** stands for continuous and intelligent communication solutions because IO-Link enables access down to the process level.

- **Easy** reveals that IO-Link makes processes, procedures and consequently life easier. This applies to installation, parameter setting and diagnostics and is of use to everyone who has to do with the manufacture, operation and maintenance of a system.

1.1. **IO-Link consortium**

ifm electronic gmbh is a founder member of the IO-Link consortium and is represented in the following committees:

- Steering
- Marketing
- IODD
- AS-i work group
- Core team
- “Master” work group
- “Test master” work group
- “Test device” work group
- “Technology” work group
- “Data storage” work group
- IEC support

ifm electronic has been decisively involved in the implementation of the specification of IO-Link 1.1. The standardisation of the master was initiated by ifm electronic gmbh.

Further details can be found on the ifm electronic website:

[http://www.ifm.com/ifmde/web/io-link_0.htm](http://www.ifm.com/ifmde/web/io-link_0.htm)
1.2. IO-Link consortium members

At present there are more than 150 member companies in the IO-Link consortium.

All important manufacturers of automation controllers support IO-Link.

Additional information about IO-Link:

For further information about IO-Link please visit:
2. System overview

2.1. Overview IO-Link

Components
An IO-Link system consists of the following components:

- IO-Link master
- IO-Link device
  (for example: sensors, RFID readers, valves, motor starters, I/O modules)
- Unscreened 3, 4 or 5-wire standard cables
- Engineering tool for projection and parameter setting of IO-Link

Figure 1 shows an example of a system architecture using IO-Link.

Figure 1: Example system architecture using IO-Link
The IO-Link master establishes the connection between the IO-Link devices and the automation system. The IO-Link master is a component of a peripheral system and is installed either in the control cabinet or as remote I/O with protection rating IP 65/67 directly in the field. The IO-Link master communicates with the controller via various fieldbuses or product-specific backplane buses. An IO-Link master can have several IO-Link ports (channels). It is possible to connect an IO-Link device to each port. That means that IO-Link is a point-to-point communication and not a fieldbus.

The pin assignment is specified according to IEC 60974-5-2 as follows:
- Pin 1: 24 V
- Pin 3: 0 V
- Pin 4: Switching and communication line (C/Q)

These 3 pins are used for the IO-Link communication as well as for supplying the device with max. 200 mA (see Figure 3)
2.2. IO-Link interface

**Port types**
Two types of port are distinguished in the specification for the IO-Link master:

**Port class A (type A)**
For this type the functions of pins 2 and 5 are not specified. These functions are defined by the manufacturer. Usually an additional digital channel is assigned to pin 2.

**Port class B (type B)**
This type provides additional supply voltage and is suitable for the connection of devices with a higher current requirement. Additional (electrically separated) supply voltage is provided via pins 2 and 5. To use this additional supply voltage a 5-wire standard cable is required.

**Connection cable**
The devices are connected to the master via unscreened 3, 4 or 5-wire standard cables with a max. length of 20 m. Screening or observance of specific guidelines for laying the cables are not necessary.
Connecting of sensors to Port Class B

In general it’s possible to connect sensors to ports Class B.
The IO-Link-part is the same for Class A and Class B.

Please consider the different power supply.

For sensors = Class A Pin5 is not in use during Pin 2 can be used as an additional digital output.

For actuators = Class B Pin 2 and Pin 5 are used to transfer the load-voltage to the IO-Link actuator device.

By connecting a Sensor to a Masterport Class B control- and load-voltage will be connected if the digital out-put Out 2 is closed.

This may cause short-circuits and misbehaviors in safety.

To connect sensors with two digital out-puts please use a three-wired cable.
3. Advantages of IO-Link

3.1. Cost advantages

- Manufacturer-independent standard: IO-Link devices from other manufacturers can be connected in the same way.
- Twenty metre cables are no problem
- Only one type of port for all kinds of terminal equipment; → cost savings for storage
- Not only sensors, but also actuators can be connected. One fieldbus node on the machine for sensors, valve islands, frequency converters, etc. → cost savings for hardware.
- Binary inputs, e.g. feedbacks from valves, can be collected locally on input modules and transmitted via an IO-Link port.
- Simultaneous availability of binary and analogue signals
- Transfer of several signals via one cable (e.g. flow sensor: three process values and two switch points).
- Cost savings thanks to prewired cables and reduced storage space requirements
- Existing infrastructure can be used; existing cables can be further used.

3.2. Advantage commissioning

- Prevention and discovery of wiring faults
- Mounting location can be optimised, remote parameter setting from the workplace
- Saving of the settings and providing them to the end user in electronic format. No labelling of the devices since the settings are available in electronic format.
- Parameter setting of all devices with only a few mouse clicks
- Commissioning with tools from the master manufacturers, e.g. Siemens PCT, Beckhoff TwinCat
- Point-to-point parameter setting

3.3. Quality advantage

- Availability of the software and hardware status in the system documentation
- Identification of all IO-Link devices in the system by means of a serial number
- Higher process data precision thanks to digital transfer. This reduces D/A and A/D conversion losses to a minimum. It is ensured, for example, that the controller can process the high accuracy of a pressure measuring cell almost without any loss (see 4.3).
- Signal is not influenced by EMC as in the case of analogue signals (see 4.4)
- Laying the cables is uncritical; even close to FC motor cables
• Logging of parameter changes: MES systems log how a parameter was changed and who did it.
• Parameter storage in the database of MES
• Recipe changeover: inclusion of sensor parameters in orders. The parameters of the sensor will be set according to the product requirements.
• Parameter setting on the device can be locked by remote access (parameter S-Loc). Nevertheless, all parameters can be read on the device.

3.4. Advantage maintenance
• Parameters are stored automatically
• Usability: Inclusion of the terminal equipment in the HMI; these will be created according to the plant standard. Operators and maintenance staff work in their familiar environment.
• HMI and MES can record trend curves; recorded process values make troubleshooting easier.
• Preventive maintenance is supported by diagnostic information of the IO-Link device.
• Remote access to the IO-Link devices via the PLC. The machine manufacturer can access the complete information, even about the individual sensors, via the internet.
• Easy replacement of the device and damaged cables without further wiring.
4. IO-Link basics

4.1. IO-Link protocol

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

- **IO-Link**
  In the "IO-Link" operating mode the port is in the IO-Link communication.

- **DI**
  In the "DI" operating mode the port acts like a digital input.

- **DQ**
  In the "DQ" operating mode the port acts like a digital output.

- **Disabled**
  The "Disabled" operating mode can be used for unused ports.

When IO-Link was defined special emphasis was placed on the compatibility of conventional units with a simple binary output stage. In the standard I/O mode (SIO) IO-link sensors can also be operated on conventional input modules. Conversely, sensors with switching output also work on IO-Link ports. In SIO mode the sensor is operated as digital input to the master.
Transfer rate

Three data transfer rates for the IO-Link operation mode are specified in the IO-Link specification V1.1:

- COM 1 = 4.8 kBaud
- COM 2 = 38.4 kBaud
- COM 3 = 230.4 kBaud (optional to specification V1.0)

**Example PN7:**
- COM 2 (38.4 kBaud)
- 2 byte process data
- Refresh rate 2.3 ms

An IO-Link device supports only one of the defined data transfer rates. The IO-Link master supports all data transfer rates and adapts them automatically to the data transfer rate supported by the device.

Response time of the IO-Link system

The response time of the IO-Link system informs about the frequency and speed of the data transfer rate between the device and the master. The response time depends on several factors.

A value for the min. cycle time of the device is defined in the device description file IODD of the device. This value indicates at which time intervals the master may address the device. The value has a great influence on the response time. In addition the master has an internal processing time which is included in the calculation of the response time.

Transfer quality

IO-Link is a very robust communication system. This communication system operates with a 24 V level. If transfers fail, the message is repeated twice. Only after the failure of the third attempt will the IO-Link master detect a communication failure and will signal it to the higher-level controller.

Data types

In general three data types are available:

- Process data → Cyclic data
- Parameters → Acyclic data
- Events → Acyclic data
Process data
The process data of the devices is transferred cyclically. The process data size is defined by the device. Depending on the device process data from 0 to 32 bytes is possible (input and output each).

*Example:*
- PN, PP, LMT, LR = 2 byte process data input
- SM, SD = 8 byte process data input

Value status (process value validity)
Each port has a value status (port qualifier). The value status indicates if the processed data is valid or invalid. The value status can be cyclically transferred.

Device data (parameters)
Device data can be parameters, identification data and diagnostic information. It is exchanged acyclically and on request of the IO-Link master. Device data can both be written to the device or read from the device.

Events
When an event occurs, the device signals the presence of an event to the master. Then the master reads the event. Events can be error messages (e.g. short circuit) and warnings/maintenance data (e.g. soiling, overheating). Error messages are transferred from the device to the controller or the HMI via the IO-Link master. The IO-Link master can also transfer events and conditions. Such events are e.g. wire breaks or communication failures.

Device parameters or events are transferred independently of the cyclic transfer of the process data. The transfers do not influence or impair each other.
4.2. IODD and engineering

IO-Link devices can easily be connected to the IO-Link master via generic modules. To provide the user with easier use and more reliability the possibility was created to implement connection via the IODD file.

Device description IODD
An electronic device description, the IODD file (IO Device Description), is available for each device. The IODD provides a lot of information to the system integration:

- Communication characteristics
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device details
- Text description
- Image of the device
- Manufacturer's logo

The structure of the IODDs is the same for all devices from all manufacturers. The IODD structure is always represented in the same way by the IO-Link configuration tools from the master manufacturers. The same handling of all IO-Link devices irrespective of the manufacturer is thus guaranteed.

For devices which support both V1.0 and V1.1 there are two different IODD versions.

→ IODDs for ifm devices: https://my.ifm.com/web/ifmde/download/iodd

IO-Link configuration tool
The IO-Link configuration tools from the master manufacturers can read IODDs. Among the most important tasks of the IO-Link configuration tools:

- Assignment of the devices to the ports of the master
- Easy parameter setting of the IO-Link devices

In addition the connected devices can be diagnosed.

The IO-Link configuration tool allows transparent visualisation of the IO-Link system down to the field level.
Fast to the IODD In just a few steps

In the browser, open the site [www.ifm.com/de](http://www.ifm.com/de)

Enter the ifm article number in the search box

**PN7094**

Click on "More information"

Download the requested file.

The .zip file contains all parameters and settings that are machine-readable for configuration tools such as the LINERECORDER SENSOR.

The pdf files contain the parameters and settings in plain text in the respective language.
4.3. Differences of the IO-Link specifications V1.0 and V1.1

**Specification**

The technical definition of the IO-Link system is described in a specification of the IO-Link association of companies. In a first step the specification version 1.0 was drawn up. The further development and the function extensions of the IO-Link system led to version 1.1.

The most important extensions of version 1.1 are:

- Parameter setting server function (data storage)
- Data transfer rate 230.4 kBaud
- Process data width per port up to 32 bytes
- Automatic verification of the compatibility in case of replacement

**Combination of IO-Link devices**

In principle any combination of masters and devices is possible. For the combination of IO-Link devices of different IO-Link specifications the following has to be observed:

- On an IO-Link master to V1.0, IO-Link V1.0 and V1.1 devices with the V1.0 IODD version can be operated.
- On an IO-Link master to V1.1, IO-Link devices to V1.0 and V1.1 can be operated.
- The parameter setting server function (data storage) and the data transfer rate of 230.4 kBaud of the IO-Link master to V1.1 can only be used if these functions are also supported by the IO-Link device.
5. IO-Link in detail

5.1. Communication start-up

5.1.1. Wake-Up

If the port of the master is set to the IO-Link mode, the IO-Link master tries to communicate with the connected IO-Link device. In this respect the IO-Link master sends a defined signal (wake-up impulse) and waits for the reply of the IO-Link device. First of all the IO-Link master tries to communicate with the highest data transfer rate defined. In the event of a failure, the IO-Link master tries to communicate with the next lower data transfer rate. The device always supports only one defined data transfer rate which cannot be set.

When the master receives a reply, communication starts.

The wake-up impulse is a short-circuit current pulse of 500 mA for a duration of 75 to 85 µs. Then the device has 500 µs to start up the communication.
5.1.2. Start-Up

The master checks the device on the basis of the acceptance threshold set for the port.

**Acceptance thresholds:**

No check:
Master accepts all devices.

Compatibility:
Same vendor ID, same/compatible device ID.
A device of the same type or a compatible device has to be installed.

Identical:
Same vendor ID, same device ID, same serial number
Only the device with the respective serial number can be operated at this port.

During start-up the communication speed and the process data width are defined.

IO-Link provides the option to set the port cycle time to flexibly control the process data exchange.

The following settings are possible

**FreeRunning**
The master adapts to the device. There is a process data exchange depending on the minimum cycle time of the device.

**FixedValue**
The port cycle time is set to a defined value. This value must not be lower than the minimum cycle time of the device.

**FrameSyncron**
All IO-Link ports of the master start the process data communication simultaneously. This means that data consistency across the process values of the individual devices is ensured.

The process data width set at the master port must be greater than or equal to the process data width of the device.
5.1.3. Preoperate

In the preoperate mode there is no cyclic process data exchange. During the preoperate mode the same interface width is used for transferring parameters, events and commands. A transfer of the parameters, for example from the master to the device, is therefore much faster.

The preoperate mode was not available for the IO-Link version 1.0; these devices pass from the start-up directly to the operate mode.

5.1.4. Operate

In the operate mode, process data is exchanged cyclically. Process data is transmitted deterministically at equidistant time intervals.

Parameter settings can also be transferred in the operate mode.

When the device signals an event, this event is retrieved by the master and transferred to the higher-level controller.

5.1.5. Fallback

With the fallback command the master deactivates the communication between the master and the device. The master forces the device to change to the SIO mode. The master port is set as a digital input.
5.2. Data access from the automation system

Cyclic data exchange
To exchange the cyclic process data between an IO-Link device and a controller the IO-Link data from the IO-Link master is assigned to the address ranges set before. The user program of the controller accesses the process values via these addresses and processes them. The cyclic data exchange from the controller to the IO-Link device (e.g. IO-Link actuator) is effected in reverse.

Acyclic data exchange
The exchange of acyclic data such as device parameters or events is effected via a defined index and sub-index area. The controller accesses it via system mechanisms (e.g. for online functions such as reading the status). Using the index and the sub-index area device data can be accessed (e.g. for new parameter setting of the device or master during operation).

To support programming of acyclic access, controller and device manufacturers offer IO-Link function blocks.

5.3. Replacement of a device during operation

The replacement of a device during operation is a repeated scenario and must not cause longer downtimes of the installation. It should be possible to replace a device fast and without any errors by operators without any special knowledge and tools.

Parameter setting server function (data storage)
The device parameters set with the configuration tool during engineering are transferred to the device. The device saves these parameters in a non-volatile manner.

Then the parameter data of the device is stored on the master. During replacement the master provides these parameters automatically to the new device. This supports the device replacement since parameter setting of the new device is effected automatically by the IO-Link master.

If at a given time the parameters are changed via the configuration tool or by the controller/HMI, they are stored both in the device and in the master.

The prerequisite for using the parameter setting server function is the implementation of the IO-Link specification V1.1 in the master and in the devices. Masters and devices to IO-Link specification V1.0 cannot perform this function.
5.3.1. **DataStorage Configuration**

The performance of the master and the device in the event of an exchange can be set at the IO-Link master port.

<table>
<thead>
<tr>
<th>Upload</th>
<th>Download</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>Upload</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>Download</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>Download</td>
</tr>
</tbody>
</table>

**Neither upload nor download selected:**

There is no data exchange even if the configuration in the memory of the master and the device differ.

**Only upload selected:**

With differences in the configurations the data is uploaded from the device to the memory of the master. This function can be used to upload the settings of preconfigured devices to the memory of the master during the set-up.

**Only download selected:**

If the configuration data in the master memory differ from the data in the device, the master transfers the data to the device. 

*Note:* Settings made directly on the device are not uploaded to the memory of the master. They are overwritten by the master during the next start-up of the plant.

**Upload and download selected:**

Master port without stored data + device with data = settings are uploaded from the device to the master.  
Master port with stored data + device at factory settings = settings are downloaded from the master to the device.

**For Downloading Datas from Master to the device, please make sure that the device is on factory-settings.**

Changes made via a parameter tool or the pushbuttons on the device are uploaded to the data storage of the master.
Special function for parameter download from the control program:

The parameters written via the controller are only uploaded to the data storage of the master if the command ParamDownLoadStore (Index 2, Subindex 0, Value 5) is subsequently sent.
5.4. Conversion and EMC influence

For the transfer of the analogue signal to the controller several conversions from analogue to digital and from digital to analogue are necessary. Each of these conversions affects the quality of the process value transferred. In addition there are electromagnetic influences, in particular if the cable is not laid and the connection of the screen is not made professionally.

IO-Link requires only one conversion. The analogue signal from the element detecting the measurand is converted into a digital signal. Then signal processing and transfer are digital. This avoids losses due to conversion. Another advantage is that EMC influences due to the digital transfer can no longer influence the quality of the process value.

Due to the digital transfer the calibration of the distance sensor - controller is no longer necessary. This is a cost advantage since only the sensor has to be calibrated.
5.5. Update of the process value

For certain processes, e.g. control tasks, it is important to receive process values in the controller in short time intervals.

5.5.1. Analogue

**Conversion time:**

The conversion time is the sum of the time the A/D converter needs to record a measured value and the time needed (diagnostics, wire-break monitoring) to process the measured value in the module.

**Cycle time:**

The cycle time is the time that elapses between two conversions on the same channel.

**Example analogue input module:**

Four channels enabled, current measurement, noise voltage suppression 50 Hz, wire-break monitoring activated.

**Calculation:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic conversion time per channel</td>
<td>22 ms</td>
</tr>
<tr>
<td>Wire-break monitoring per channel</td>
<td>10 ms</td>
</tr>
<tr>
<td>Conversion time per channel</td>
<td></td>
</tr>
<tr>
<td>Conversion time</td>
<td>22 ms + 10 ms</td>
</tr>
<tr>
<td>Conversion time</td>
<td>32 ms</td>
</tr>
<tr>
<td>Cycle time</td>
<td>32 ms x 4</td>
</tr>
<tr>
<td>Cycle time</td>
<td>128 ms</td>
</tr>
</tbody>
</table>

A measured signal on the input is converted every 128 ms and provided.
5.5.2. IO-Link

<table>
<thead>
<tr>
<th></th>
<th>COM1</th>
<th>COM2</th>
<th>COM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baudrate</td>
<td>4,8 kBit/s</td>
<td>38,4 kBit/s</td>
<td>230,4 kBit/s</td>
</tr>
<tr>
<td>Typical cycle time</td>
<td>18 ms</td>
<td>2.3 ms</td>
<td>0,4 ms</td>
</tr>
<tr>
<td>Bit time $T_{\text{bit}}$</td>
<td>208,33 µs</td>
<td>26,04 µs</td>
<td>4,34 µs</td>
</tr>
</tbody>
</table>

Typical cycle time for a device with 2 byte process data and 1 byte service data

An IO-Link device gets the data rate that depends on the complexity, data volume and intended use necessary for the application from the manufacturer.

The number of the IO-Link master ports used does not influence the refresh time of the individual process values.

When a typical ifm pressure sensor is connected, a new actual value is provided on the master every 2.3 ms which is retrieved by the controller and can be used for example in a control application.
5.6. **Compatibility for device replacement**

In the IO-Link system to 1.1 replacement of compatible devices without any changes to the machine is possible.

A device manufacturer can design a successor device or another device from the device family in a compatible way. If there is a failure in the system, the operator can install a compatible device in the system without using any tools.

The IO-Link master checks the configuration and discovers an error. Then it is checked if the device can be operated in a compatible mode. If this check is successful, the system is operated in the same way as with the predecessor device. The controller configuration, user program and IODD remain the same.

The manufacturers of IO-Link devices indicate what device types are compatible to other devices.

**Example: ifm PN pressure sensor**

After 20 years of successful ifm pressure sensor history, the new generation of PN sensors was developed in close coordination with the users. The units have an outstanding modern and user-friendly design. High overload protection, IP 67 and the captive laser labelling make the new PN sensors your perfect partner even in the most harsh environments.

5.7. Parameter setting of IO-Link devices

Using the device:

As previously, the device parameters can be set on the device display.

With activated data storage on the master port the settings made are automatically applied to the parameter storage of the master.

Using point-to-point:

IO-Link devices can be connected to the PC via a suitable interface and the parameters can be set via software. The distinction has to be made between FDT-based tools (ifm Container, PactWare) and IODD-based tools such as the LINERECORDER SENSOR.

FDT-based tools use a DTM for device identification. The device IODD can be converted into a DTM via the IODD DTM configurator tool and integrated into the FDT tool.

More information and download:
https://my.ifm.com/web/ifmde/download/fdt-dtm

The IODDs of all device manufacturers can be imported in IODD-based tools. A tool can be used for all IO-Link devices. The LINERECORDER SENSOR tool from the company ifm electronic already contains the IODDs of the ifm devices at the point of time the software is provided; updates and IODDs from competitors can be easily integrated via the import function. In addition to parameter setting the LINERECORDER SENSOR provides a trend-curve function to record the process values of the connected device and to export them, if required.

More information:
http://www.ifm-datalink.com/ifmde/web/linerecorder-sensor.htm
Using tools from the controller manufacturers:

Controller manufacturers provide tools for parameter setting of IO-Link devices from the PC to the controller.

Examples are Siemens PCT and Beckhoff TwinCat.

Parameter setting and diagnostics are performed by the PC via the interface to the controller, via fieldbus to the IO-Link master and from there via IO-Link to the IO-Link device.

IO-Link devices can be operated from the workstation (control room, maintenance office). This is of particular advantage for devices that are difficult to access such as those on a silo or in a clean room.

Parameters settings can be saved in the project and provided to the customer in electronic format.

Using function blocks:

The controller manufacturers in the IO-Link consortium provide function blocks for the communication to IO-Link devices.

By using these blocks the parameters of the IO-Link devices can be set via the HMI.

It is possible to transfer order-dependent device parameters from the control system to the controller and from there to the device via IO-Link.
It is also possible to read device settings and to transfer them to the control system for the production documentation.

On request, ifm electronic provides examples of programming for ifm IO-Link sensors.

**Block parameter setting:**

IO-Link provides the option to download all parameters as a block and to check them for their plausibility after the transfer was made. IO-Link device tools already work with block parameter setting. For parameter download from the controller the block parameter setting must be activated with the command ParamDownloadStart (Index 2, Subindex 0, Value 3) and completed after the download with the command ParamDownloadEnd (Index 2, Subindex 0, Value 4).
5.8. Protection against manipulation

Checking the connected devices:

Machine builders and the people responsible for the system repeatedly face the problem that devices are replaced by unsuitable substitutes.

Example:

A 10 bar pressure sensor is replaced by a 25 bar pressure sensor which may not provide the accuracy that is required for the operation of the machine.

Using IO-Link each master port can be configured so that only the respective device or a device indicated as compatible by the manufacturer can be connected.

It is controlled via the:

VendorID: manufacturer ID that was assigned to the device manufacturer by the IO-Link consortium, e.g. ifm electronic = 310 dec.

DeviceID: is assigned by the manufacturer according to the company standard.

In addition it is possible to read other identification parameters such as the series number to ensure that only one particular device can be operated on this port.

It is, of course, also possible to disable this verification should the device check prove that it is suboptimal for the application.

The study groups of the IO-Link consortium are working on the development of manufacturer-independent device profiles. This ensures that the suitable device, e.g. pressure sensor 0 - 10 bar, is connected; the selection of the manufacturer remains flexible, however.

Locking parameter change:

Parameters are sometimes changed by non-authorised staff. This may have negative effects on the process and the machine.

With IO-Link there is the function S-Loc. S-Loc locks the change of parameters on the local display. It is still possible to read the parameters. S-Loc can only be unlocked via a parameter setting tool or parameter transfer from the controller program.

Tools for parameter setting of IO-Link devices include a user role. By assigning passwords unauthorised access to parameter settings can be prevented.

IO-Link allows shifting parameter setting to the HMI of the system. Entries on HMIs are usually password-protected. This password protection can also be used for parameter setting of the IO-Link devices. The operating stations partly have a log-in function which records which parameters were changed by which user.

Additional protection is the possibility to regularly compare the parameters in the devices with the parameters in the memory area of the controller. Should this comparison reveal any deviations in settings, the intended settings can be transferred from the controller to the devices using IO-Link.
5.9. Remote maintenance up to the device

Remote maintenance connections via modem or internet are state-of-the-art technology. They provide the machine manufacturer with the possibility to eliminate errors and to make uploads. The end user has the advantage that downtimes are minimised and expensive travels by the service engineer can be saved.

So far the connection has ended in the field bus devices. Whether a sensor is faulty or parameters were changed could only be found out by statements made by the operators and maintenance staff.

Using IO-Link there is a connection up to the terminal equipment. The tool (e.g. Siemens PCT) on the service PC at the manufacturer's location can communicate directly with the terminal equipment. It is easy to make a comparison of the device status and the parameter setting. Using this same method it is possible to read and evaluate events provided by the IO-Link device.

The advantage of remote access can also be used for internal company purposes. The maintenance staff can diagnose the device from his workstation PC before going to the system and pick up the suitable replacement from the warehouse. Cost-intensive production downtime can thus be minimised.
5.10. Characteristic IO-Link data

- Cable length from the IO-Link master to the IO-Link device up to 20 metres
- Medium: standard sensor cable, unscreened round cable
- Connection technology: M12, M8, M5, terminals
- Physical transfer layer: 24 V pulse modulation
- Data volume: from one bit to 32-byte process data in both directions (input / output); sufficient address space for parameter addressing.
- Process data cycle time: depending on the process data volume and the transfer rate of the device, min. 2.3 ms (2 bytes process data - 1 byte service data) - independent of parameter setting and events, independent of the number of the used IO-Link master ports

5.11. Physical definitions

- Communication via the switching output or input
- Voltage level defined with limit values
- Half duplex
- Speeds 4.8k, 38.4k and 230k baud
- Automated speed detection
- Enabling of the output (SIO mode) via short circuit (wake-up call)
- Voltage supply of the outputs with via e-stop function
5.12. **IO-Link default parameters**

- **MinCycleTime**
  → Shortest time interval between 2 messages

- **IO-Link revision**
  → Revision ID to recognise compatibility or skills

- **ProcessDataIn**
  → Number of the sensor process data

- **ProcessDataOut**
  → Number of the actuator process data

- **Manufacturer ID**
  → Unique identification of the manufacturer, IO-Link specific, ifm ® 310, 0x136

- **Device ID**
  → Unique identification of the device, manufacturer-specific

- **Function ID**
  → Identification of the compatibility with predecessor devices

5.13. **Default parameters extended by IO-Link**

- **Manufacturer name, manufacturer text**
  → Readable name, URL ...

- **Product name, product ID**
  → Readable name of the device, order designation

- **Serial number**
  → Hardware, firmware revision

- **User-specific name**
  → Plain text clearly identifying the device
6. ifm electronic software tool portfolio

LINE RECORDER MES (Manufacturing Execution System)

LINE RECORDER standard software module, customer-specific use, for production optimisation from the receiving area to the dispatch area. Standardised function modules, individual use for optimisation and quality assurance of the production and process chains. Consistent internal and external traceability to ZVEI guideline, order planning and control modules.

Machine connections are implemented quickly and without complex programming only via configuration by means of a specifically developed intelligent interface concept.

- Process optimisation
- Quality assurance
- Traceability
- OEE level down to the level of the individual machine
- Material logistics
- Monitoring and organising material and tools
- Applying order data to the machine controller
- ERP connectivity

LINE RECORDER SENSOR

Uniform parameter setting and visualisation for all I/O-Link sensors

- Easy selection of different IO-Link sensors
- Consistent parameter setting
- Consistent framework
- Automatic sensor detection
- Fast representation of the sensor values in table or graphical format
- Integration into product and process traceability
- Transparency of the sensor signals to SAP
SMARTOBSERVER

Condition monitoring and energy efficiency

- Continuous condition monitoring of machines and systems
- Trend analyses
- Limit value representation
- Representation and evaluation of all process parameters
- Process data recording of all parameters available
- Evaluation to DIN ISO 50001
- Visualisation and evaluation with trend display for pressure, flow, temperature, current, rotational speed
- Possibly change of the operating conditions of the machines
- Organisation and planning of maintenance tasks
- Data provision for higher-level systems (ERP, SAP, HANA, MII; ME)
- Alarm escalation chains

Customer benefits

- Energy-efficient, ecological production
- Quality assurance
- Preventive maintenance management
- Reduction of manufacturing costs
- Increase of uptime
- Remote maintenance and notification

Further information please visit:
7. Technical literature on IO-Link

The authors Peter Wienzek and Joachim Uffelmann work for ifm electronic gmbh and ifm ecomatic gmbh. They have been active in the study groups of the IO-Link consortium right from the start.

In their book the authors describe the start, technology and possible use of IO-Link.

The book is interesting and informative both for beginners and people with advanced knowledge.

- **Soft cover:** 297 pages
- **Publisher:** Oldenbourg Industrieverlag (20 November 2010)
- **Language:** German
- **ISBN-10:** 3835631152
- **ISBN-13:** 978-3835631151
# 8. Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Actuator</td>
<td>Device to convert electrical signals into kinetic energy</td>
</tr>
<tr>
<td>Acyclic data</td>
<td>Data that is only transferred from the controller after a request (e.g. parameter data, diagnostic data).</td>
</tr>
<tr>
<td>COM1-3</td>
<td>IO-Link data transfer rates</td>
</tr>
<tr>
<td>Device</td>
<td>A device can be a sensor, an actuator or a hybrid device. It is a passive participant and only replies at the master's request.</td>
</tr>
<tr>
<td>DI</td>
<td>Digital input</td>
</tr>
<tr>
<td>DQ</td>
<td>Digital output</td>
</tr>
<tr>
<td>DTM</td>
<td>Device Type Manager (manufacturer-specific driver)</td>
</tr>
<tr>
<td>Event</td>
<td>The device can signal an incorrect operating status to the master per event. This is done by setting a bit in the interface. The master reads this event with a classifying error code.</td>
</tr>
<tr>
<td>FDT</td>
<td>Field Device Tool (e.g. ifm Container)</td>
</tr>
<tr>
<td>GSD file</td>
<td>Device master file - describes an interface to the device which is to be connected to the fieldbus. GSD files are available as files and provided by the device manufacturer.</td>
</tr>
<tr>
<td>HMI</td>
<td>Operating and observation device of the automation system (Human Machine Interface)</td>
</tr>
<tr>
<td>Hub</td>
<td>In contrast to the gateways hubs establish connections between two identical interfaces; known are USB hubs.</td>
</tr>
<tr>
<td>Hybrid device</td>
<td>A device combining both sensor and actuator functions.</td>
</tr>
<tr>
<td>IEC 61131-9</td>
<td>The international standard IEC 61131 deals with the basics of the programmable logic controllers. Part 9 describes IO-Link under the designation Single-drop digital communication interface for small sensors and actuators (SDCI).</td>
</tr>
<tr>
<td>IODD</td>
<td>Electronic device description (IO device description)</td>
</tr>
<tr>
<td>IO-Link device</td>
<td>Field device that is monitored and controlled by an IO-Link master.</td>
</tr>
<tr>
<td>IO-Link master</td>
<td>Establishes the connection between a higher-level fieldbus and the IO-Link device. The IO-Link master monitors and controls the IO-Link devices.</td>
</tr>
<tr>
<td>MES</td>
<td>Manufacturing Execution System</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Port</td>
<td>An IO-Link communication channel</td>
</tr>
<tr>
<td>Parameter setting server</td>
<td>An IO-Link master to IO-Link specification 1.1 can act as parameter setting server for the IO-Link device.</td>
</tr>
<tr>
<td>Point-to-point connection</td>
<td>A point-to-point connection is a direct, immediate connection between two points, places or devices.</td>
</tr>
<tr>
<td>Cyclic data</td>
<td>Data that is transferred automatically and at regular intervals (process data, value status)</td>
</tr>
<tr>
<td>Sensor</td>
<td>Device to detect and convert physical values into electrical quantities</td>
</tr>
<tr>
<td>PLC</td>
<td>A PLC is an industrial computer used to control a machine or system and programmed on a digital basis. The user programs a PLC according to the requirements of his system. The peripheral signals are read or provided via input/output modules or fieldbus masters and decentralised fieldbus slaves.</td>
</tr>
<tr>
<td>SIO</td>
<td>Standard Input Output mode: Connection of conventional, digital devices on IO-Link master ports</td>
</tr>
<tr>
<td>Slave</td>
<td>Bus participant that does not communicate independently but only replies to requests from the master</td>
</tr>
<tr>
<td>Conversion time</td>
<td>The conversion time is the sum of the time the A/D converter needs to record a measured value and the time needed (diagnostics, wire-break monitoring) to process the measured value in the module.</td>
</tr>
<tr>
<td>Cyclic data</td>
<td>Data that is transferred automatically and at regular intervals (process data, value status)</td>
</tr>
<tr>
<td>Cycle time</td>
<td>In the context of controllers, the cycle time means the processing of the program from reading of the inputs to the provision at the outputs. In the context of communication systems, the cycle time is the time until all data has been exchanged with all participants and the cycle starts again.</td>
</tr>
</tbody>
</table>