I 4.0 IN MACHINERY AND EQUIPMENT
INTEGRATION OF COMPLEX SENSORS
WITH PROFINET AND IO-LINK

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Wolfgang Wiedemann
55 years old(young)
GLOBAL AVAILABILITY AND TRANSPARENCY
OF ALL DATA AND INFORMATION
.....AT ANY TIME
.....AT ANY PLACE
14.0 BENEFITS FOR THE CUSTOMERS – USE CASES

„Cockpit Integration“

Connectivity of Smart Sensor

Cockpit of the IO-Link sensor is integrated into the „Webserver“ of the MVK modul, and it includes

- Parameterization
- IO-Operation
- Condition Monitoring

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What is IO-Link?
The new standard in the lower field level of the leading automation manufacturers is no standard, as the data profiles of the sensors and actuators are different. BECAUSE?

IO-Link
THE TECHNIQUE

IO-Link is not a new bus system
GE FANUC – IO-LINK

FS30i/31i/32i

I/O-Link

Servo Verstärker  Servomotor

Interface modul  Linear Encoder eines Fremdherstellers

EA Module  Periferiesteuerung

EA Module

IO-Link Verstärker  Servomotor

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STATE OF THE ART
PERIPHERALS - SENSORS

+ **Binary sensors**
  - capacitive and inductive sensors
  - no parameters

+ **Standardized M12 connectors, binary**
  - upto 2 channels per port
  - if needed diagnostics (Pin 2)

 90…95%

+ **Analog and complex sensors / actuators**
  - Pressure / distance / temperature / level / ...
  - Parameter settings

+ **Standardized M12 connectors, analog**
  - typically 1 channel per port
  - no standardized pin assignment
  - sensitive signals

 5…10%
IO-LINK - PORT - PIN 4 - DATEN

SDCI - Kommunikation

SIO - binär

oder

Binäres Device

IO-Link - Device

SDCI:
- Single-drop digital communication interface for sensors and actuators.
COMMUNICATION DOWN TO THE SENSOR / ACTUATOR

Industrial Ethernet

Information

Feldbus/Sensor-/Aktorbus

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WHAT IS IO-LINK

Is a point to point interface for communication (not a fieldbus)
Between one IO-Link-Master with IO-Link-Ports
and one field device.
For sensor and actors.
Is only a 24 V DC-Physic.
Transmit and saves
♦ Device-Parameter.
♦ Process data.
   Binary switching signals.
   Analogue signals.
♦ Diagnostic data.
A parallel wired connection with standard cables
Serial Communication.
FUTURE TASKS FOR THE USE OF SENSORS AND ACTUATORS

Connect and share sensors and actuators universal and flexible. Create standardized by all.

These requirements can be resolved through IO-Link.

System diagnostics down to the sensor / actuator easily integrated (state and events).
Reduce costs.
CLASSIFICATION OF IO-LINK IN THE AUTOMATION PYRAMID

- Field level
  - Input/output
  - Prozess

- Production level
  - Processing

- Plant Operations Level
  - Control

Kommunikation

LAN, WAN, Ethernet TCP/IP, XML

Controlnet, Ethernet/IP, H1
Profibus FMS, Profinet CBA

Devicenet, Interbus, CANopen,
Profibus DP, Profinet IO, CC-Link

The last step...

IO-Link, binär, analog (4…20 mA)
WHAT DOES IO-LINK

It closes the communication gap in the field level
It makes machines and plants validatable down to the single Sensor or actor in the field level
It minimized the variances of interfaces only IO-Link instead of: PNP, 4 - 20 mA, 0-10 V, RS232 und RS422).

validatable:
- Evidence that a system complies with the requirements in practice.
- Evidence that a process or system meets the requirements in practical use.
SUMMARY AND TECHNICAL POINTS

Standard I/O connection methods M12, M8 e.g.
Up to 20 m cable length unshielded
Cyclical, deterministic, process data typ.
2 ms
Data volume:
♦ 1 ... 32 Byte (process-/parameter data)
♦ e.g. 1 Bit (SIO).
With parallel maintenance data transmission
Device replacement with automatic parameter transfer
Lossless Analog data transmission
  Integrated, differentiated Diagnostic messages.
Communication through 24 V puls modulation.
Standard UART - Protocol.
fieldbus neutral.
World wide standardized, IEC 61131-9
REPLACING A PARAMETERIZED DEVICES
YOU HAVE A CUSTOMER AND HE ASKS YOU ABOUT IO-LINK…
DON’T PANIC!
IO-LINK IS EASY!

IO-Link is a bi-directional serial communication, point to point, from 1 slave (called “device”) to 1 master

Device and master can exchange not only 1 bit input OR 1 bit output, but up to 32 bytes inputs AND 32 bytes outputs data

And this with a regular 3-pole unshielded cable, of up to 20m long

Using the 24V as signal level, with 4.8, 38.4 or even 230.4 kBaud

This is a LOT more than just a single DI or DO!
IO-LINK IS EASY!

With all this “power”, it is possible to exchange more than just I/O data:

- **Process data**: the real I/O data is exchanged cyclically, of course.
- **Value status**: together with the real I/O data, it is possible to cyclically transmit information about its quality.
- **Device data**: but also device identification and parameters can be exchanged when desired (acyclically).
- **Event data**: and finally, when something important happens, it can be informed to the master.
IO-LINK IS EASY!

Examples of process data

Distance value from a Sick sensor

Outputs to a Festo valve island
ENGINEERING: ACCESSING PROCESS DATA

1. Customer download GSDML file for the IO-Link Master module (e.g. 55532 MVK-MPNIO DIO12 IOL4 IRT 7/8" 5pin)
ENGINEERING: ACCESSING PROCESS DATA

2. And imports GSDML file into the Engineering System (e.g. Siemens TIA Portal)
ENGINEERING: ACCESSING PROCESS DATA

3. Then includes the module into the PROFINET network (e.g. 55532)
ENGINEERING: ACCESSING PROCESS DATA

4. Chooses an IO-Link submodule with the desired data length (according to the IO-Link device to be used) and inserts it at the desired IO-Link port, reserving an I/O area
(e.g. 2 input bytes IO-Link device on port 1 and reserving bytes 2 and 3)
That’s it! I/O data is already available, in this case, at bytes 2 and 3!
IO-LINK IS EASY!

This is *everything* that the customer needs, as long as

He uses IO-Link as installation concept, with

- Digital Hubs
- Valve Islands

Or he uses an IO-Link device, that no parameter needs to be changed

Wait a moment: *Parameters*?!...
DON’T PANIC!
IO-LINK IS EASY!

As told before, the big advantage of IO-Link is that we can exchange not only I/O data, but also other information using the same physical (the same cable) at the same time.

The I/O data is exchanged cyclically.

Other information are exchanged acyclically.
IO-LINK IS EASY!

Cyclic data
is automatically exchanged between master and device
always exchange the same amount of information
   ...10110...
   ...10110...
   ...11100...
   ...11100...
   ...00100...
   ...00100...
   ...00110...
   ...00111...
   ...00000...

Acyclic data
must be triggered by the user to be exchanged
can be used to exchange different amounts of information

Manufacturer?
   ☑ Murrelektronik!

ArtNo?
   ☑ 59407!

Errors?
   ☑ Error 1!
   ☑ Error 2!
IO-LINK IS EASY!

In order to differentiate each acyclic information, they need unique “addresses”.

These addresses are defined with two numbers:

IO-Link Index: this is a number between 0 and 65535

IO-Link Sub-index: this is a number between 0 and 255

The device manufacturer needs to specify which data is available on which address. This is usually done by means of a table.
IO-LINK IS EASY!

Examples of acyclic data

Device Identification: information about the device (typically “read only”). Here the Product Name of an IFM TR7439 Temperature Sensor

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Index</th>
<th>Subindex</th>
<th>Data type</th>
<th>Length</th>
<th>Access rights</th>
<th>Default</th>
<th>Value range</th>
<th>Gradient</th>
<th>Offset</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Access Lock</td>
<td></td>
<td>12</td>
<td>Sub 0</td>
<td>RecordT</td>
<td>16 Bit</td>
<td>rw</td>
<td></td>
<td>(not) Locked</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendor Name</td>
<td></td>
<td>16</td>
<td>Sub 0</td>
<td>StringT</td>
<td>max 19 Byte</td>
<td>ro</td>
<td>Imf electronic gmbh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendor Text</td>
<td></td>
<td>17</td>
<td>Sub 0</td>
<td>StringT</td>
<td>max 11 Byte</td>
<td>ro</td>
<td><a href="http://www.ifm.com">www.ifm.com</a></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Product Name</strong></td>
<td></td>
<td>18</td>
<td>Sub 0</td>
<td>StringT</td>
<td>max 6 Byte</td>
<td>ro</td>
<td>TR7439</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product ID</td>
<td></td>
<td>19</td>
<td>Sub 0</td>
<td>StringT</td>
<td>max 6 Byte</td>
<td>ro</td>
<td>TR7439</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Text</td>
<td></td>
<td>20</td>
<td>Sub 0</td>
<td>StringT</td>
<td>max 34 Byte</td>
<td>ro</td>
<td>Temperature sensor evaluation unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serial Number</td>
<td></td>
<td>21</td>
<td>Sub 0</td>
<td>StringT</td>
<td>max 12 Byte</td>
<td>ro</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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IO-LINK IS EASY!

Examples of acyclic data

Device Parameter: setting of the device (typically “read/write”). Here the Unit for the temperature, °C or °F, to be shown on the sensor display.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Index</th>
<th>Subindex</th>
<th>Data type</th>
<th>Length</th>
<th>Access rights</th>
<th>Default</th>
<th>Value range</th>
<th>Gradient</th>
<th>Offset</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOU2</td>
<td>[OUT 2] behaviour in case of fault</td>
<td>532</td>
<td>Sub 0</td>
<td>IntegerT</td>
<td>8 Bit</td>
<td>rw</td>
<td>(4) OFF</td>
<td></td>
<td>(2) On</td>
<td>(4) OFF</td>
<td></td>
</tr>
<tr>
<td>Loc</td>
<td>[Loc] locks the local user interface to prevent unintentional changes, [Loc] is resettable at the device</td>
<td>550</td>
<td>Sub 0</td>
<td>IntegerT</td>
<td>8 Bit</td>
<td>rw</td>
<td>(1) uLoc</td>
<td></td>
<td>(0) Loc</td>
<td>(1) uLoc</td>
<td></td>
</tr>
<tr>
<td>unit</td>
<td>Selection of unit on the sensor display</td>
<td>551</td>
<td>Sub 0</td>
<td>IntegerT</td>
<td>8 Bit</td>
<td>rw</td>
<td>(0) °C</td>
<td>(0) °C</td>
<td>(1) °F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IO-LINK IS EASY!

Now you know that, besides I/O data, the customer can read Device Information, as well as read and write Device Parameters when needed. And that this is done using acyclic communication to addresses documented in a table. Written data (parameter) are automatically saved in the IO-Link Device.

In case the customer replaces the device, he needs to parametrize it again, because this information is only available inside the device. Not in the PLC.

If both IO-Link Master and IO-Link Device are V1.1, a copy of the parameters can be stored in the IO-Link Master. This is called Data Storage.

In case of replacement, the new device can receive the parameters directly from the master.
IO-LINK IS EASY!

But how can the customer read and write this data to the device for the first time? Or when he wants to change something?

There are two ways to exchange acyclic information:

Acyclic Access directly from the PLC application program

IO-Link Tool + IODD

We will now explain both ways!
ENGINEERING: ACCESSING ACYCLIC DATA FROM THE PLC

Usually a PLC have instructions to allow the user to access acyclic data from his application program.

Knowing the IO-Link address, the user can write a routine in the application to read or write from/to an Index/Sub-index (e.g.):

- Read Manufacturer and Product names from the device, when the machine is turned on
- Write device parameters, when a device is replaced
You already know that the device manufacturer specifies all Index/Sub-index that the device supports. The manufacturer can also deliver this “table” in an electronic form, a file. This file is called “IO-Link Device Description”, or “IODD”.

The IODD describes the IO-Link device to the IO-Link Master, exactly like a GSDML describes the Profinet device to the Profinet Controller.
ENGINEERING: ACCESSING ACYCLIC DATA WITH TOOL + IODD

Like a GSDML is imported into the Engineering Station, delivered by the Profinet Controller manufacturer, an IODD is imported into the called “IO-Link Tool”, which is delivered by the IO-Link Master manufacturer.
ENGINEERING: ACCESSING ACYCLIC DATA WITH TOOL + IODD

With this tool and the IODD the customer can comfortably read and write data to any Index/Sub-index of the IO-Link device.
## COMPARING BOTH ACCESS METHODS

<table>
<thead>
<tr>
<th></th>
<th>Pro</th>
<th>Contra</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLC program</td>
<td>Data is centralized in the PLC</td>
<td>High programming effort</td>
</tr>
<tr>
<td></td>
<td>No tool needed</td>
<td>Uncomfortable IO-Link handling</td>
</tr>
<tr>
<td></td>
<td>No IODD needed</td>
<td>(decoding/encoding of physical values to bits)</td>
</tr>
<tr>
<td></td>
<td>All devices are parametrized in one step</td>
<td></td>
</tr>
<tr>
<td>IO-Link Tool + IODD</td>
<td>No programming</td>
<td>Data is distributed: IO-Link device &amp; IO-Link Master -&gt; Consistency?</td>
</tr>
<tr>
<td></td>
<td>Comfortable IO-Link handling</td>
<td>Tool needed IODD needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Each device needs to be parametrized individually</td>
</tr>
</tbody>
</table>
IODD ON BOARD

Well, this is now past, because Murrelektronik developed “IODD on Board”.

The idea is quite simple, but revolutionary: we take from the IO-Link Device IODD file the needed parameters and include them into the original IO-Link Master GSDML file, generating a Customer Specific GSDML.

In this way, the Device is now integrated into our Master, as it would be “part” or our module!
IODD ON BOARD

Or, showing in a very easy way:

- Data length is already correct
- IO-Link Devices are integrated
- Parameters are integrated
IODD ON BOARD

Data is centralized in the PLC
No tool needed
No IODD needed
No programming needed
All devices are parametrized in one step
Comfortable handling from IO-Link parameters
Automatic projecting possible (Copy & Paste, either from Device and from the complete project from one machine to next one)
And you are still flexible: the parameters are fixed in the project, but can be overwritten via acyclic communication in case you want to change someone
IODD ON BOARD
CUSTOMIZED “IODD ON BOARD” GSDML FILES

Murrelektronik will NOT include all possible IODDs from all possible IO-Link devices available on the market.

We will do this in a customer base. This means, we will generate a single GSDML file for a customer including all IODDs that this customer wants to use.

This file will be backwards compatible: it will always maintain the “old devices” and receive “new devices”. The file name will have a new date, to identify it.

The GSDML will be managed by Murrelektronik. No other customer will have access to this file. The customer can always download the latest file from us.

It was confirmed with the PI Organization (Profinet Test Lab Certification) that no certification relevant part of the file will be changed!
HOW TO HAVE A CUSTOMIZED GSDML FOR CUSTOMER

You explained to your customer, in a few words, what “IODD on Board” is. Your customer is convinced that he wants to have his own GSDML file.

1. Ask your customer following data about his IO-Link Device(s):
   a. See the separate Page
2. Forward these information to Application & Sales Support Department
3. E-Mail: sales-support-bu-automation@murrelektronik.de
4. If not tested before, we will buy and test the device(s)
5. The GSDML file will be implemented and tested with the device(s)
6. File and tests will be documented
7. File will be archived and released to download
8. Subsequent requests will follow the same procedure, starting with the last available file
The perfect machine installation!

### General

<table>
<thead>
<tr>
<th>Company:</th>
<th>Street:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact:</td>
<td>Code/loc:</td>
</tr>
<tr>
<td>E-Mail:</td>
<td>Phone</td>
</tr>
<tr>
<td>Website:</td>
<td>Client No.</td>
</tr>
</tbody>
</table>

**Type of machine:**
- Standard machines
- Tool machines
- Pharmacy & Conveyors
- Paper industry
- Assembly & Handling
- Plant construction
- Rail
- Packaging
- Automotive
- Robot
- Other: 

### Questions to IO-Link

1. Which Receptor?
   - Profinet
   - Profinet
   - Ethernet IP
   - Other

2. Which product?
   - M/VC
   - Impact
   - Cubis7
   - Other

3. Usage of IO-Link?
   - Sensor/Actuator
   - Installation concept
   - Process data
   - Parameters: Online
   - Parameters: Offline
   - Other

4. Which device should be included to the CEDM/IP? (only possible with Impact and M/VC)

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Order No.</th>
<th>Type/Version</th>
<th>Quantity</th>
<th>Commissioning date</th>
<th>Other</th>
</tr>
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</table>

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IODED ON BOARD

For further information please contact:

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