MODERN SENSOR NETWORKS

Industrial communication **protocols** in brief

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ÓBUDA UNIVERSITY

BALLUFF
innovating automation

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BALLUFF

AT A GLANCE

More than 30000 customers and partners worldwide

Comprehensive portfolio of sensor, identification and image processing solutions including network technology and software

On site in over 60 countries: with own subsidiaries and numerous representatives 37

More than 100 years Balluff: since 1921

experienced manufacturer with production sites worldwide 6

4. generation family-owned company

504 million EUR in group sales 2021

about 3600 employees worldwide

1921: THE BALLUFF STORY BEGAN

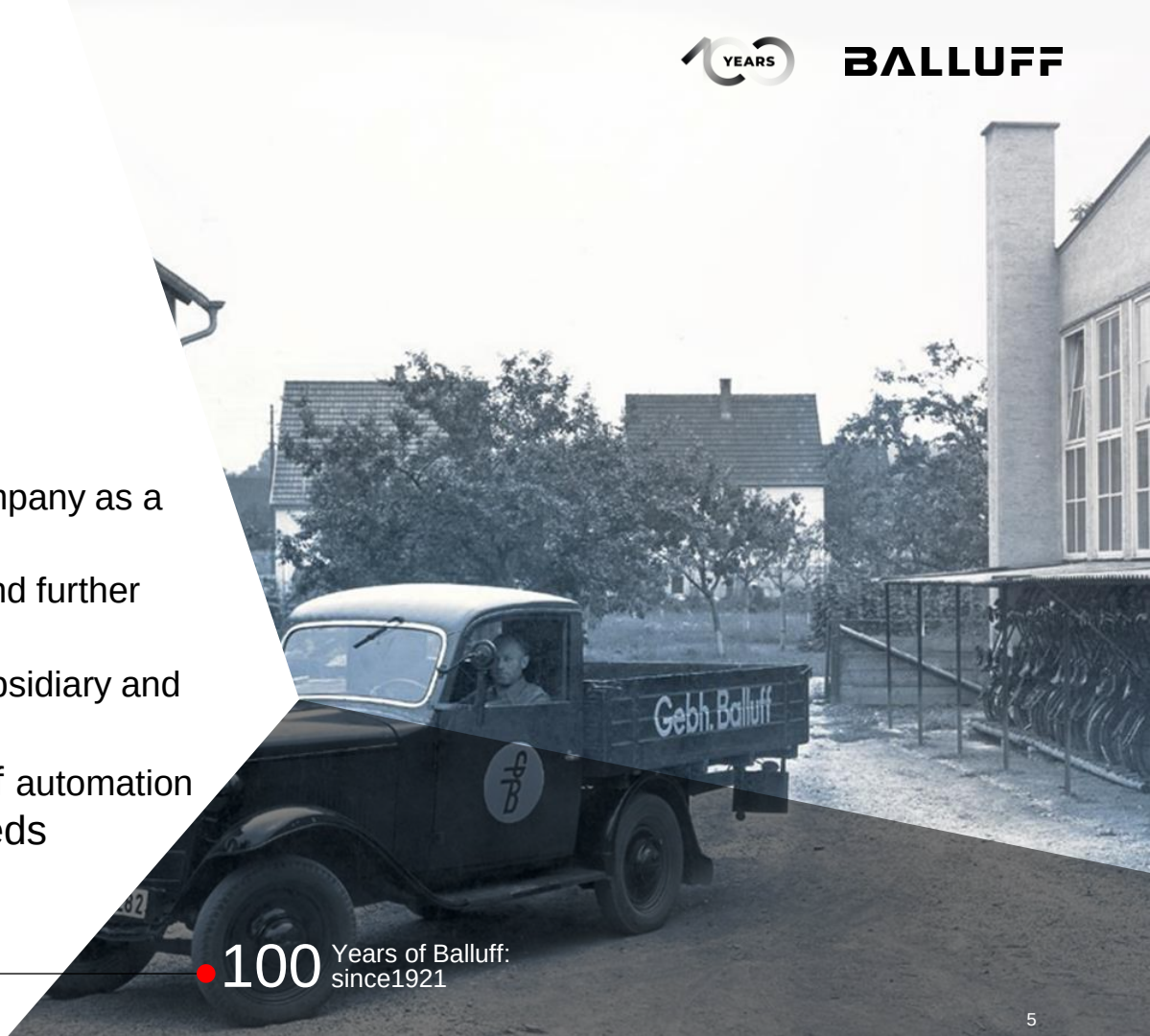
Automate, innovate, celebrate!
One century of Balluff

1921 Gebhard Balluff founds the company as a mechanical repair workshop

1956 Entry into sensor technology and further development of the portfolio

1971 Founding of the first foreign subsidiary and start of internationalization

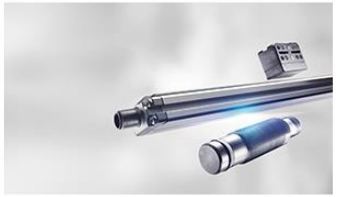
2021 Continuous development of automation innovations to meet customer needs



AT A GLANCE

100 Years of Balluff: since1921

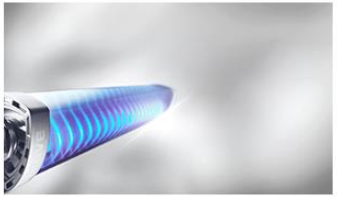
OUR PORTFOLIO



Sensors

Industrial Networking

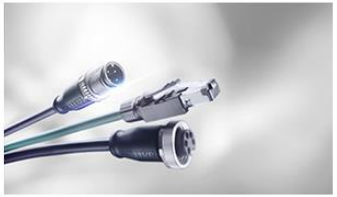
RFID



Human Machine Interfaces

Machine Vision
and Optical Identification

Power Supplies



Connectivity

Accessories

Software

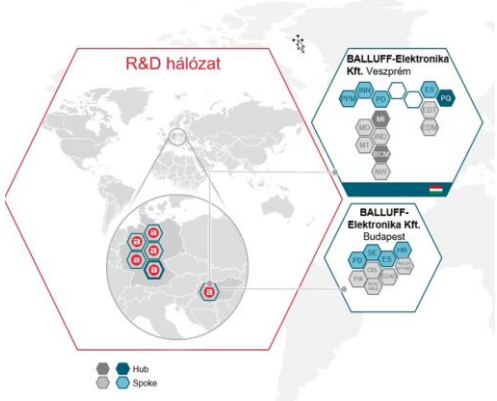
System solutions

… SINCE 33 YEARS IN VESZPRÉM

We are

The largest production site

Second largest R&D site



Development office in Budapest since 2022

WHERE IS VESZPRÉM?

Veszprém-Balaton 2023
European Capital of Culture

Visit us in 2023

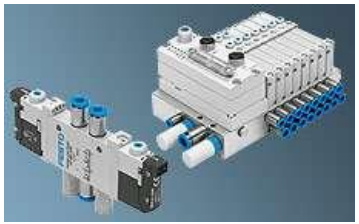
VEB 2023 EUROPEAN CAPITAL OF CULTURE

SENSOR NETWORKS - INTRO

Control theory – Basic terms

Sensor: is a device which detects or measures a physical property and records, indicates, or otherwise responds to it.

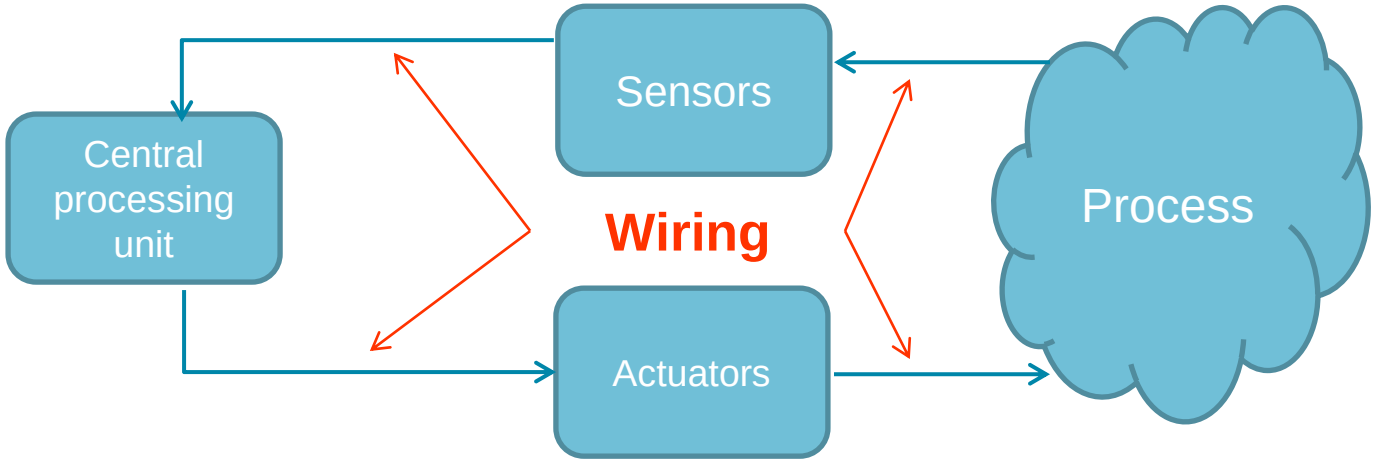
Actuator: An actuator is a device that moves or controls some mechanism. An actuator turns a control signal into mechanical action such as an electric motor..



Control: an operation that intervenes in a technical process in order to start, maintain, ensure its course according to plan, change or stop it.

SENSOR NETWORKS - INTRO

Control loop

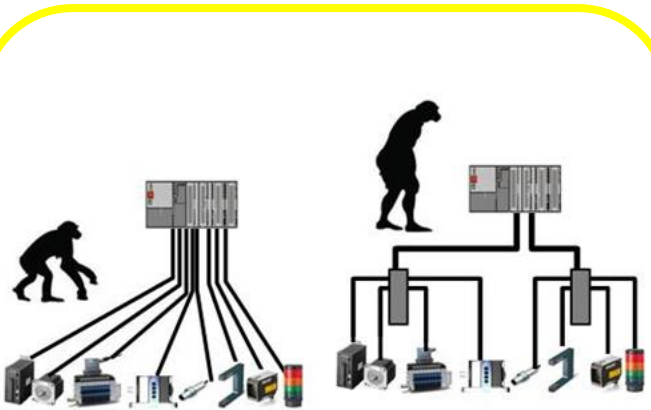


Become important if:

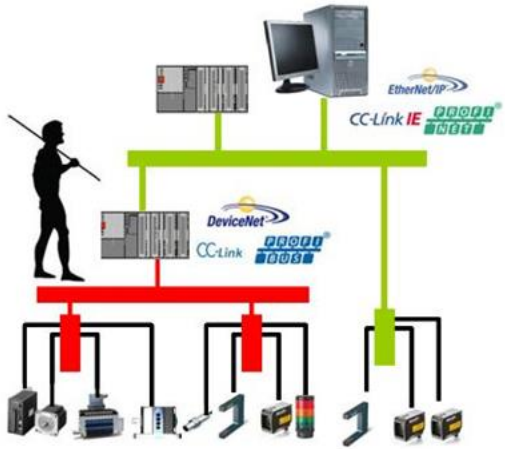
- The system contains numerous sensors and actuators
- Distance between control unit and process is large
- Harsh environment of the process (temperature, pressure, liquids etc.)

SENSOR NETWORKS - INTRO

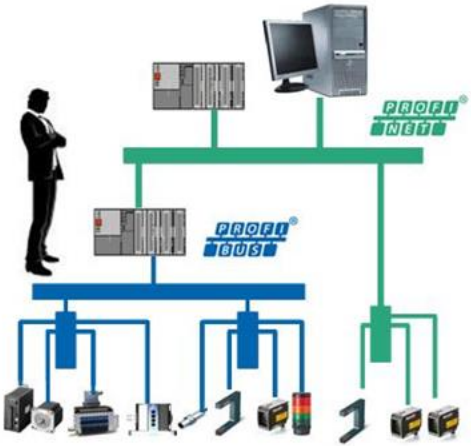
Development of wiring systems



Direct wiring



Bus systems



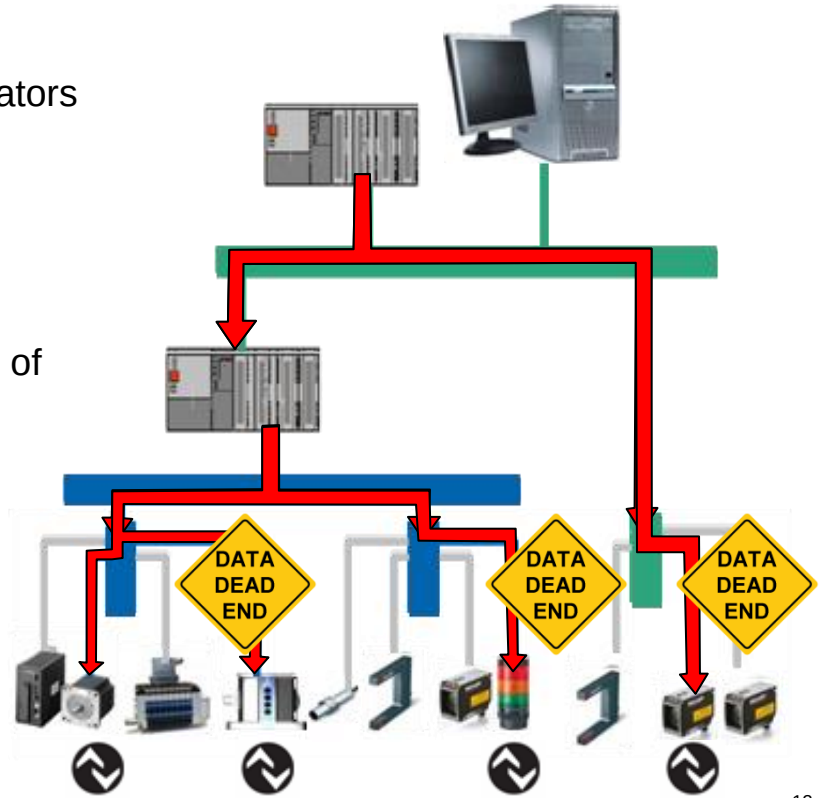
Distributed I/O

SENSOR NETWORKS - INTRO

Distributed I/O

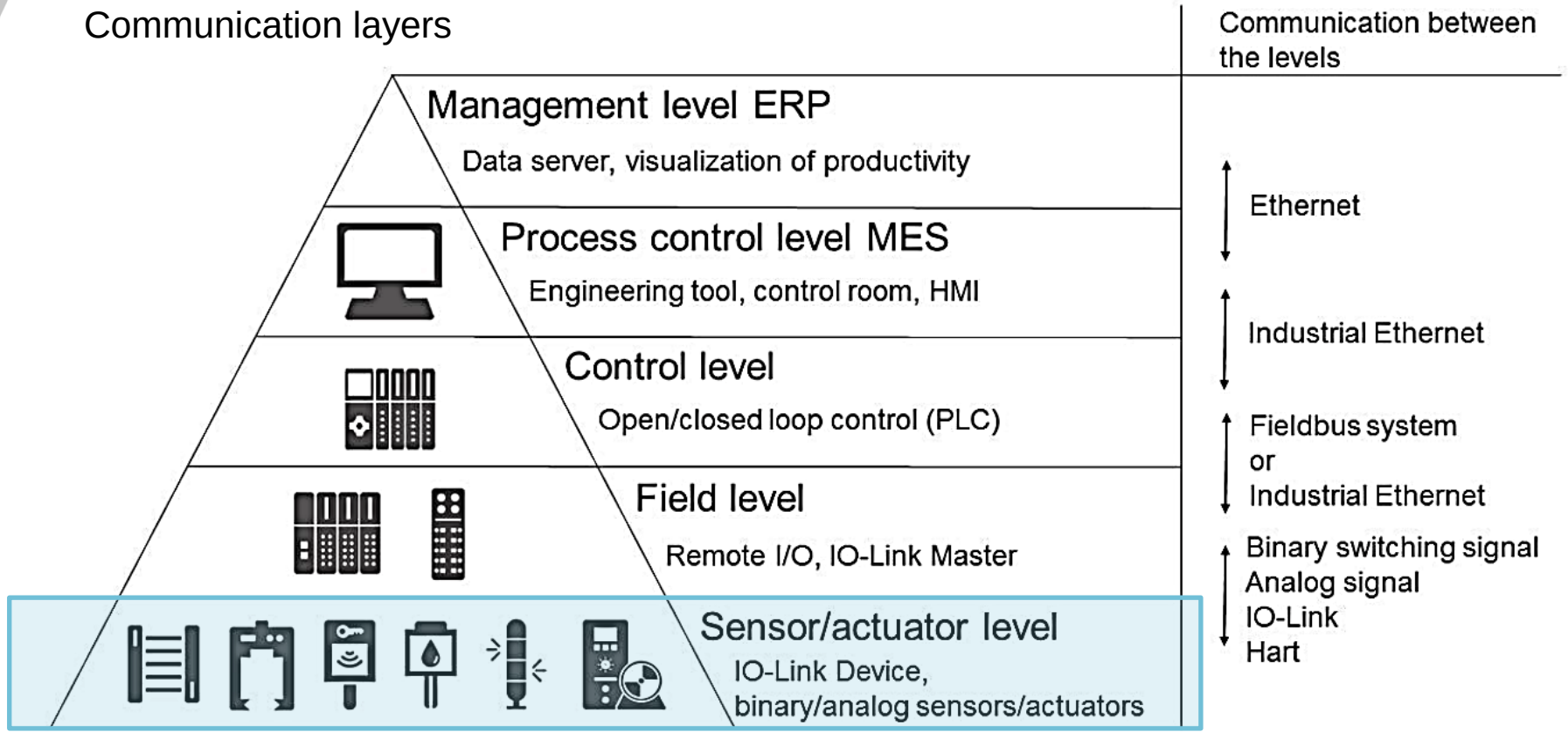
- Direct digital communication with sensors and actuators
- Digital, disturbance tolerant communication
- Access to the intelligence of sensors and actuators
- Easy up- and download of parameters
- Central, online access to the diagnostic information of field devices
- Uniform communication

IO-Link



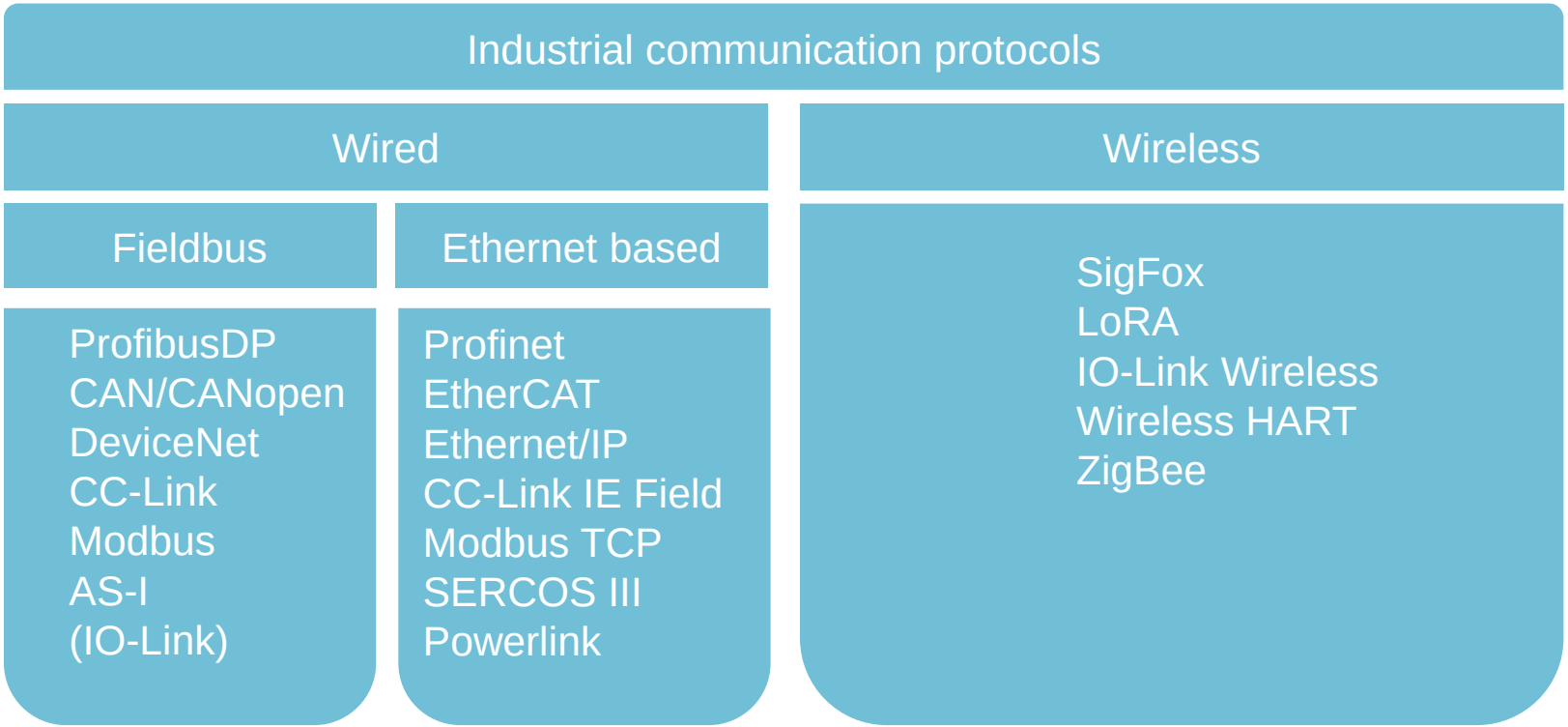
SENSOR NETWORKS - INTRO

Communication layers



SENSOR NETWORKS - INTRO

Industrial communication protocols



SENSOR NETWORKS - INTRO

Protocol

The term protocol comes from **Byzantine Greek**. "*protos*" means "first"; "*kolla*" means "one", from which the term "protocol" was formed, which is the **front sheet** glued to the papyrus rolls, on which the **roll's data** (official approval, date of creation, etc.) were written.

Since in the original sense it actually meant **order in the archive**, in this spirit it could be transferred to the field of high-ranking secular relations - in its classical form diplomacy - **indicating the order** to be **followed**.

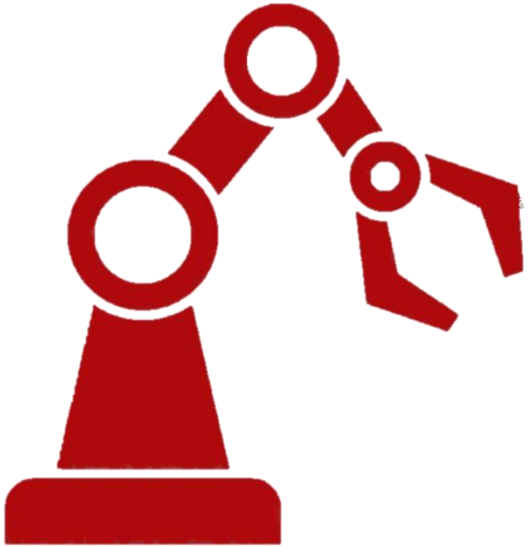
Apart from its primary meaning (protocol = **meeting minutes**) in most languages, the concept of protocol is increasingly used in areas other than diplomacy in its second meaning.

M2M **communication** is everywhere

communication
Kommunication
kommunikáció
コミュニケーション
comunicación
溝通
комуникација
ukuxhumana
επικοινωνία

Source: https://studyonline.ecu.edu.au/blog/securing-iot-unique-challenge-machine-machine-communication

M2M **communication** in **automation**



Source: https://studyonline.ecu.edu.au/blog/securing-iot-unique-challenge-machine-machine-communication
Source: https://www.dreamstime.com/automation-icon-robotic-arm-icon-simple-vector-icon-automation-icon-robotic-arm-icon-white-background-image142304714

SENSOR NETWORKS - INTRO

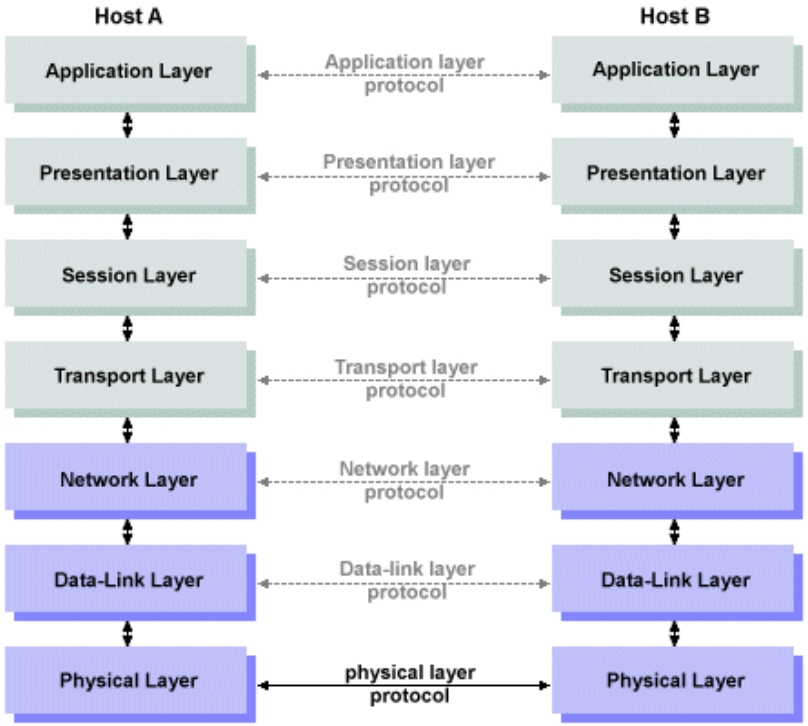
The description of (industrial) communication protocols

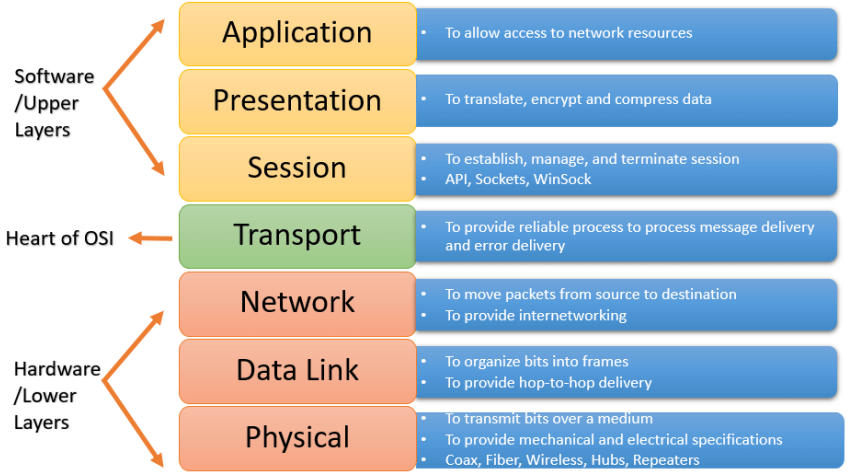
„Ogres are like onions.…*Onions have layers. Ogres have layers. We both have layers.”*

Communication protocols are like ogres and onions. **They have layers**.

SENSOR NETWORKS - INTRO

The description of (industrial) communication protocols





SENSOR NETWORKS - INTRO

Distributed I/O

service,
maintenance,
settings

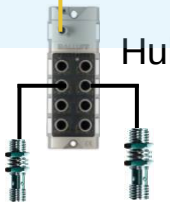
PLC

Industrial Ethernet

Fieldbus

Gateway

IO-Link



Hubs

Sensors and actuators

Process

SHORT **LIVE DEMO**

with a PLC, Gateway and IO-Link Devices

Quiz Game

are these **protocols?**

CAN

CC-Link

ppt

UTP

https

FTP

Dress Code

XML

PHP

UART

VEB

SPI

OLED

IP

Gateway

Ethernet

LAN

C++

Wi-Fi

Bluetooth

Profinet

JPG

WWW

PLC

QUIZ GAME

BALLUFF

Protocols

https
IP
FTP
Ethernet
UTP
UART
Wi-Fi
Bluetooth
Profinet
CAN
CC-Link

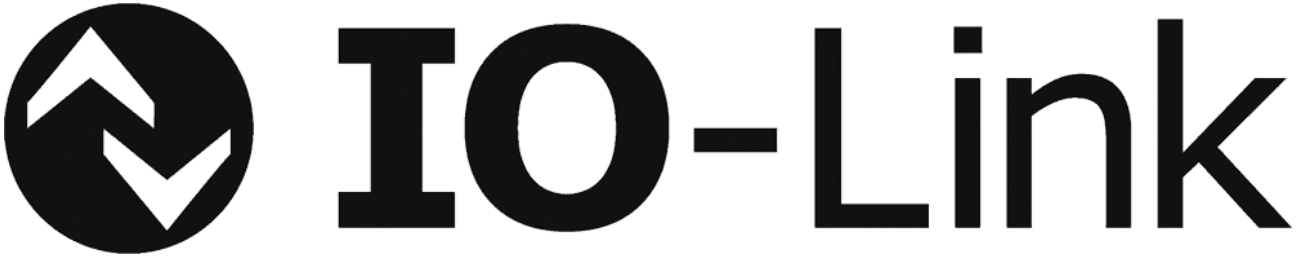
Protocol converter

Gateway

Something else

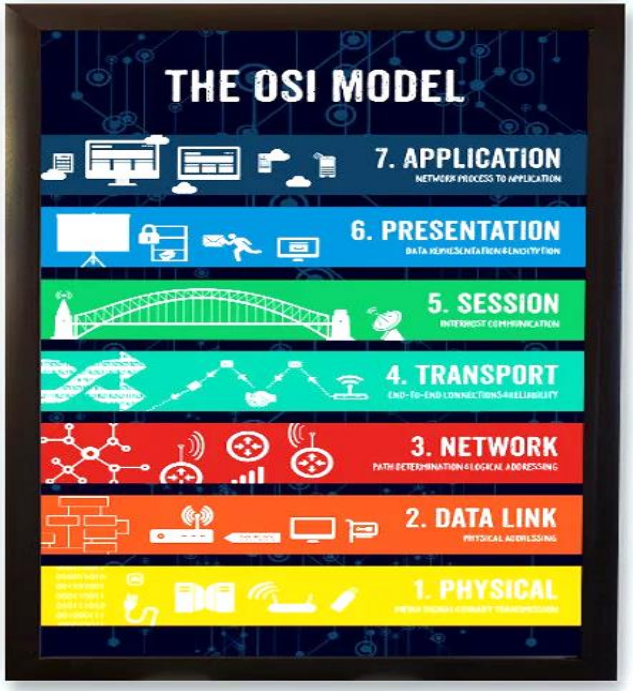
PLC
XML
PHP
ppt
VEB
Dress Code
UTP
JPG
LAN
SPI
C++
OLED
WWW

Please welcome on the stage…



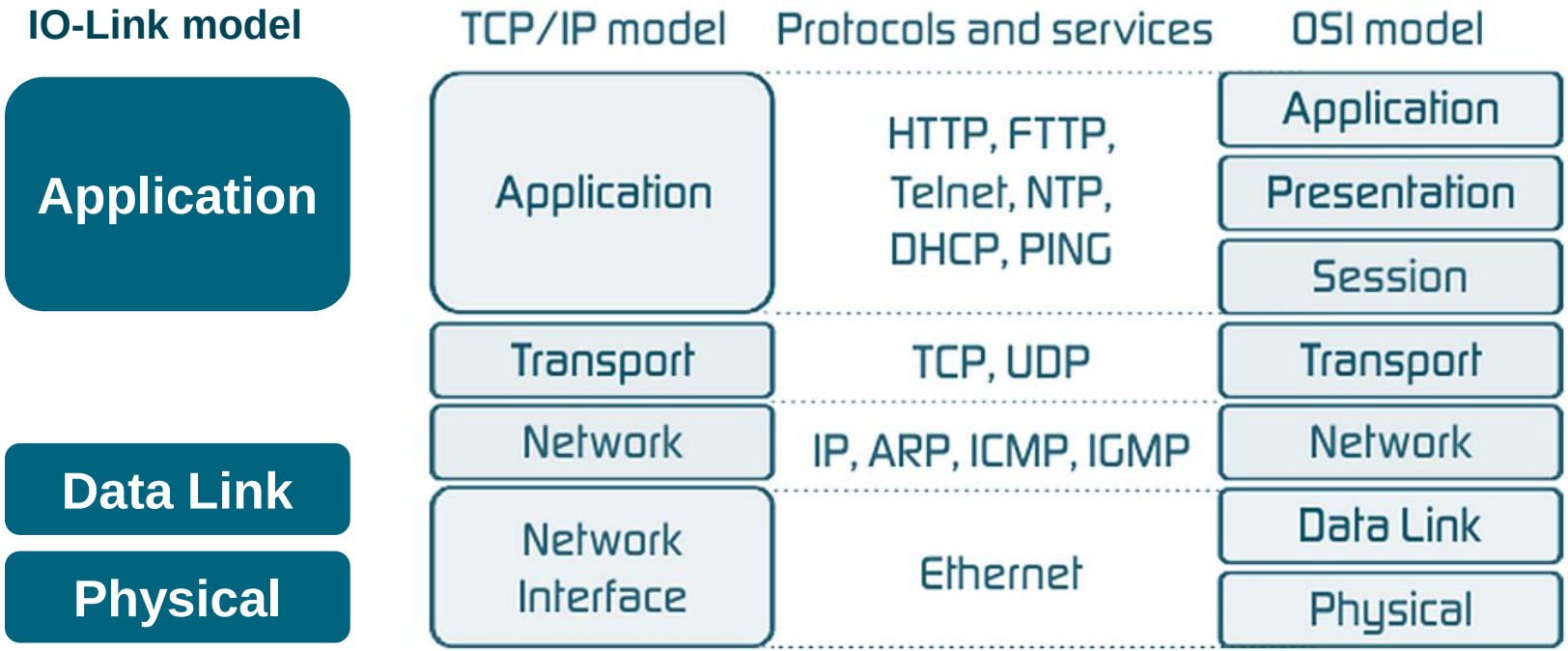
IO-Link is the first standardised IO technology worldwide IEC 61131-9(2013) for the **communication with sensors and also actuators.**
It is an open standard.

Simplification



Simplification

Simplification

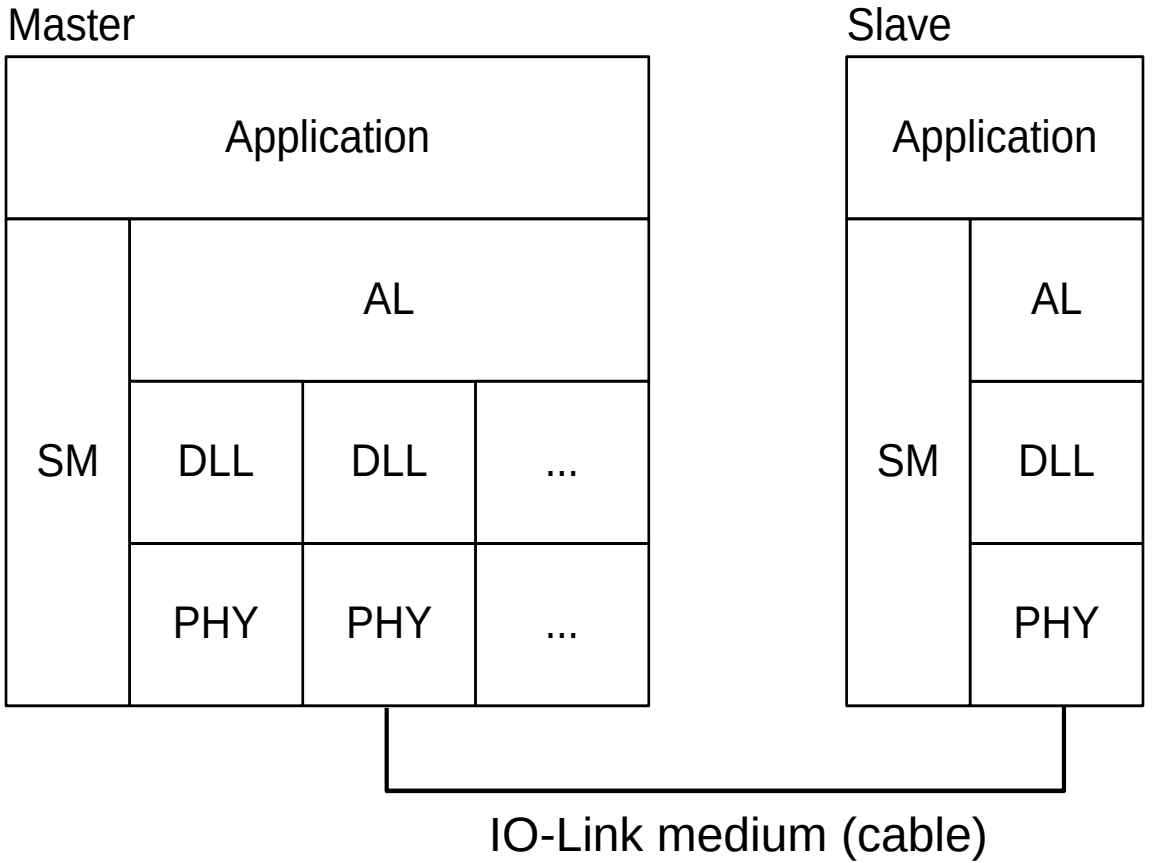


Layers

Three layers implemented from ISO/OSI reference model

AL – Application layer
DLL – Data Link Layer
PHY – Physical Layer

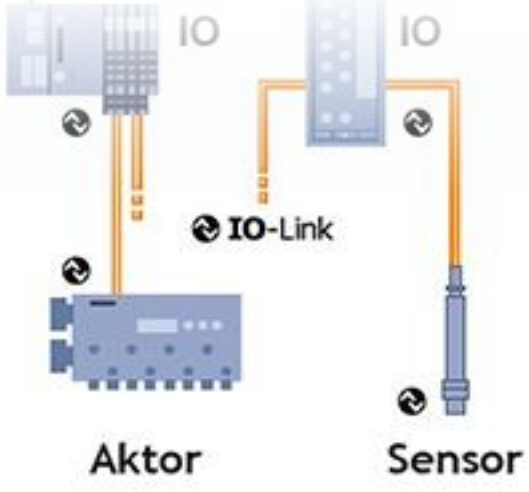
SM – System Management



IO-Link

IO-Link provides for digitalization of the "last metre" of the communication **link to the sensors and actuators**.

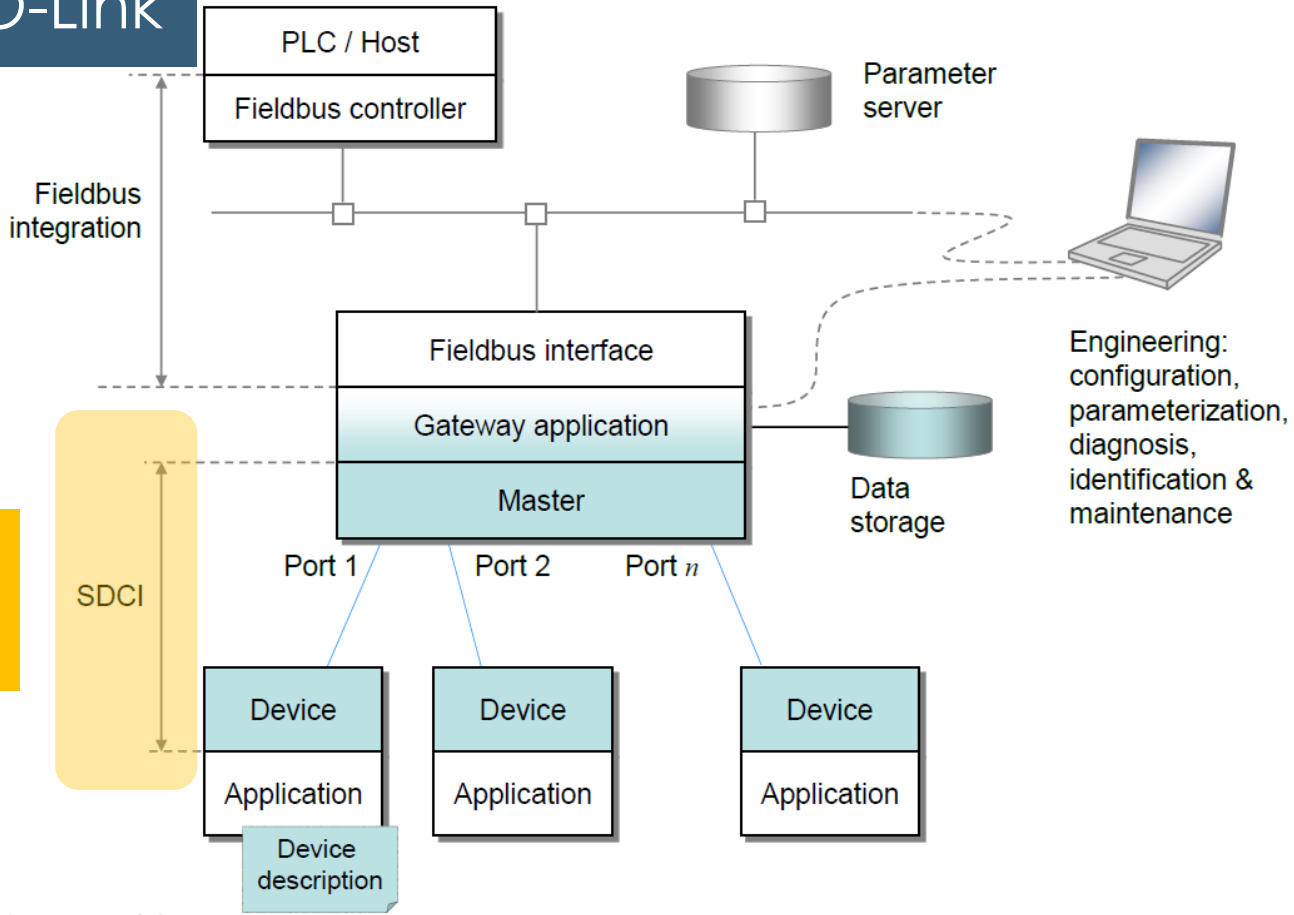
IO-Link is the Industry's USB



SDCI = Single-drop digital communication interface = IO-Link

Placement of IO-Link

Protocol for the last meters



SDCI = Single-drop digital communication interface = IO-Link

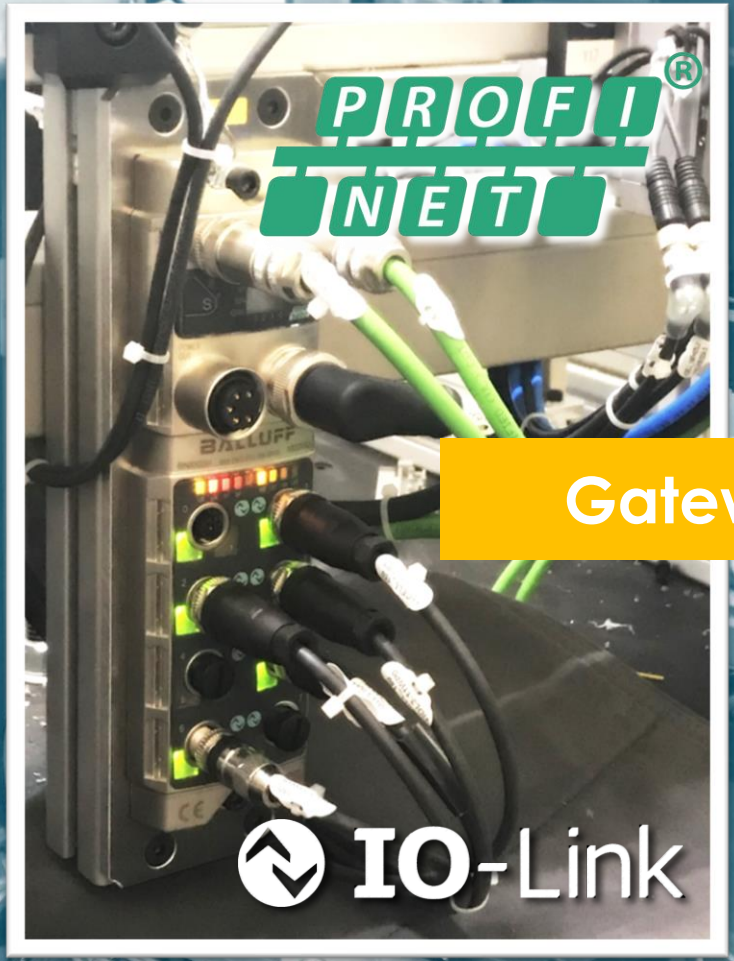
Realization #1

Opto-sensor

Realization #2

Pressure sensor

Realization #3



Gateway

„I communicate, therefore I exist"

IO-Link Master ⟷ IO-Link Device

Main characteristics

Point-point access

For sensors and actuators

Cyclic communication

Fixed Baudrates (4.8, 38.4, 230.4 kbps)

Half-duplex communication

Diagnostics

Field-bus independent (pl: CC-Link, Profinet, Ethernet…)

Other aspects

Easy integration

Bővíthetőség

Maintenanceability

Low installation cost

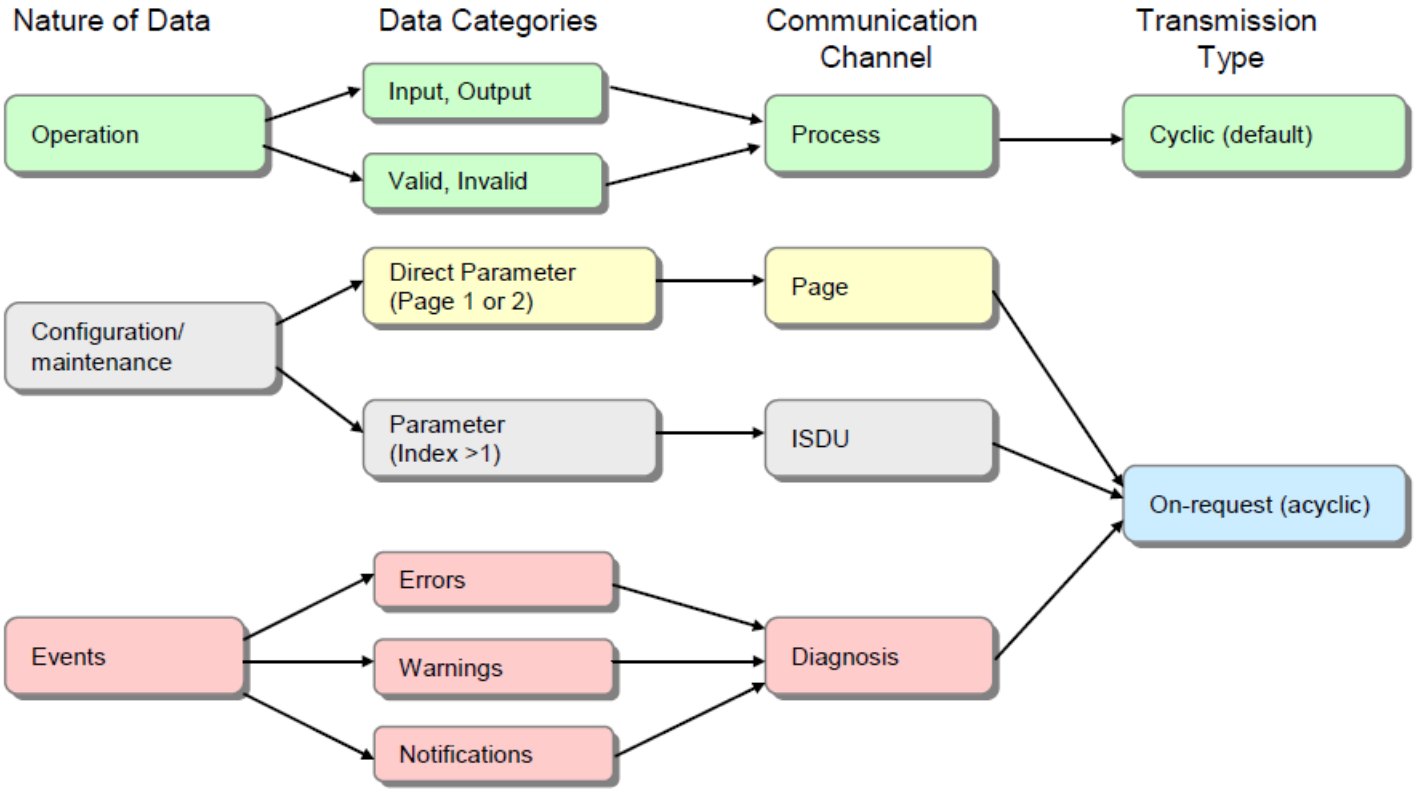
Easy to use

Compatibilty

No special cables required

24 Volt compatible

Logical channels



Three levels of the communication

- **Application**
- **Data Link**
- **Physical**

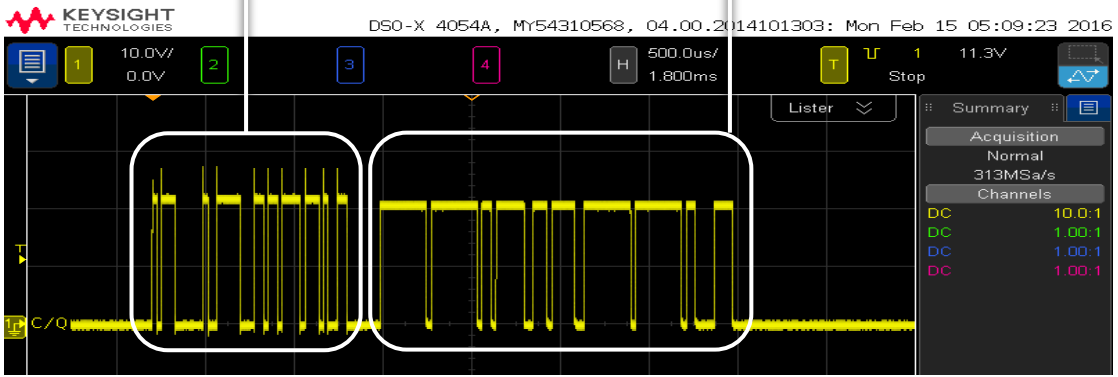
Three levels of the communication

Application

Data Link

Physical

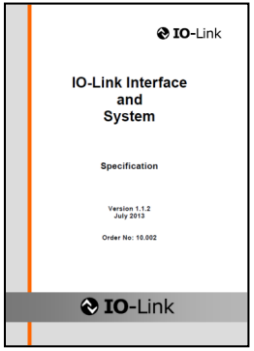
IO-Link Master ⟷ IO-Link Device



UART characters

1110001 10000011 00010010 (0/24 Volt)

Three levels of the communication

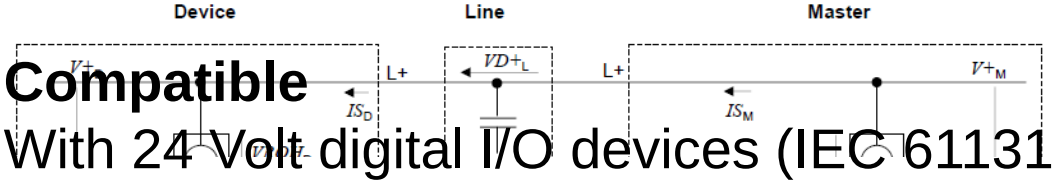


Application

Data Link

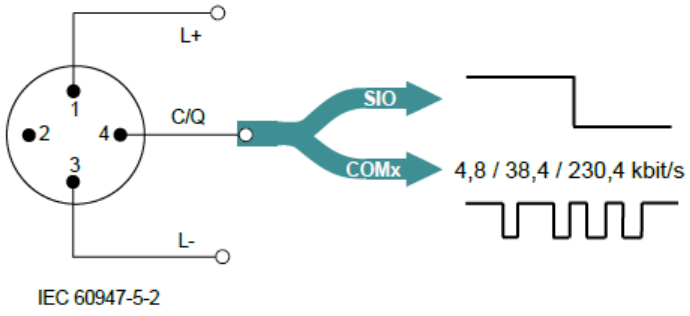
Physical

Physical line driver



Compatible

With 24 Volt digital I/O devices (IEC 61131-2)



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 (SIO)	IEC 61131-2
	C	"Coded switching" (COM1, COM2, COM3)	IEC 61131-9

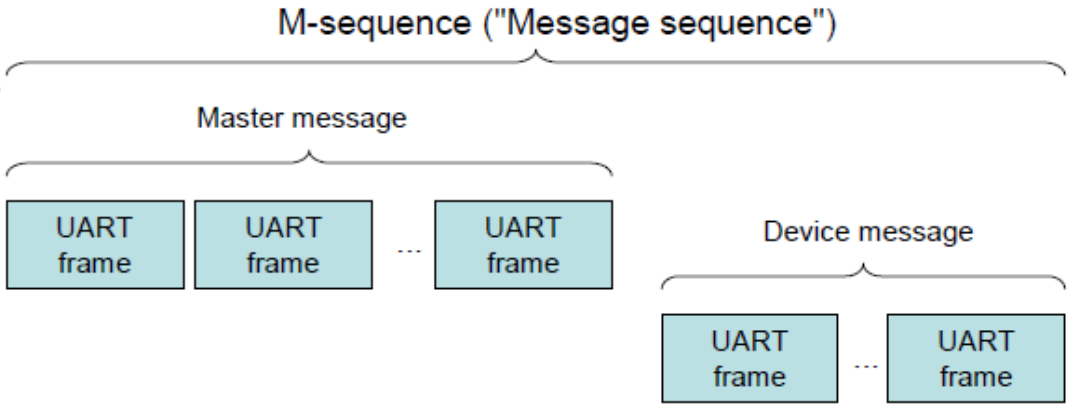
Telegrams

Sent by the Master:

- MC: M-sequence control byte
- CKT: CHECK and TYPE byte
- PD: Output Process Data
- OD: On-request adat

Sent by the Device:

- OD: On-request data
- PD: Input Process Data
- CKS: Checksgup and Status

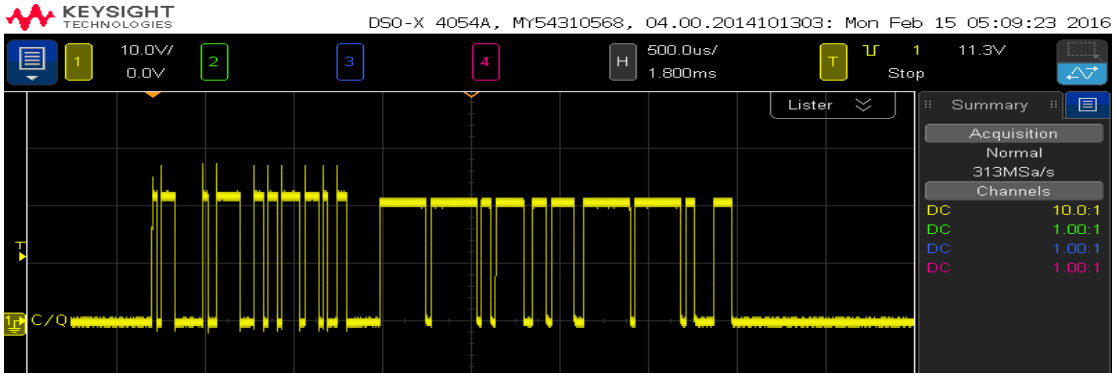


Telegrams

Application

Data Link

Physical



Scope measurement

- One UART
- One Frame
- Cyclic Messaging

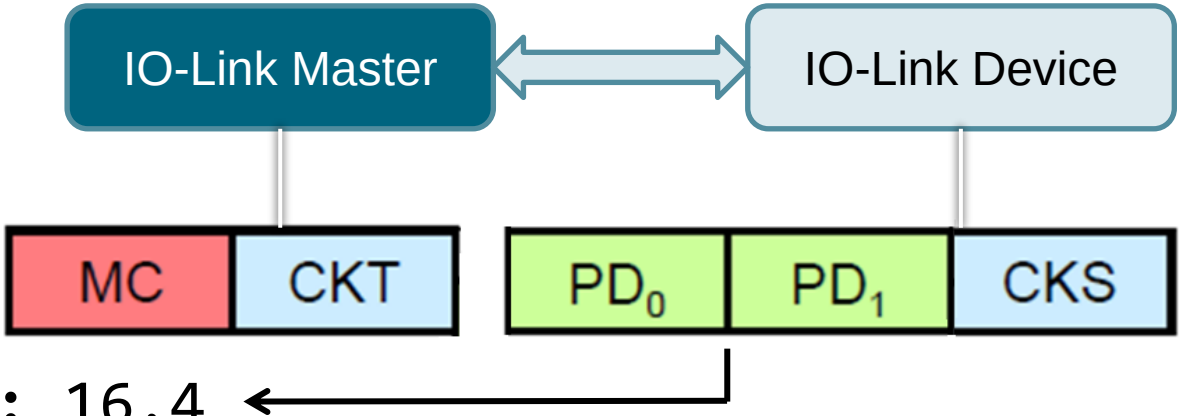
Three levels of the communication

Hogyan?

Application

Data Link

Physical



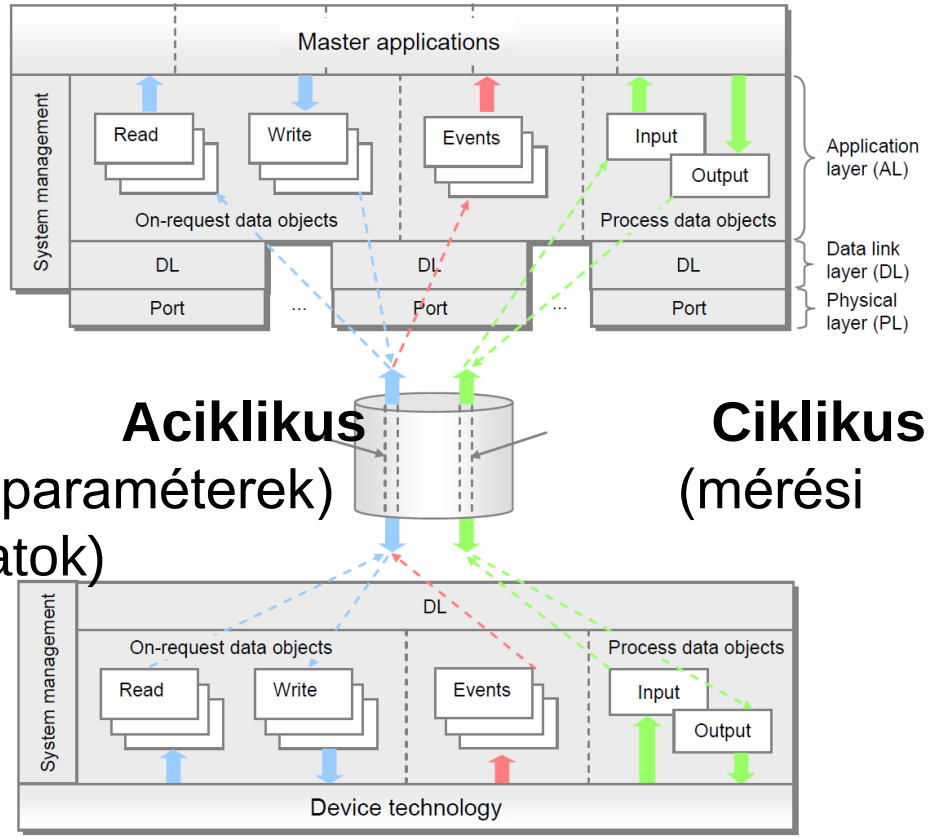
MC: M-sequence control bájt
CKT: CHECK/TYPE bájt
OD: On-request adat
CKS: Checksum, státusz

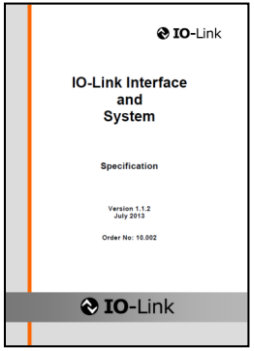
Three levels of the communication

Application

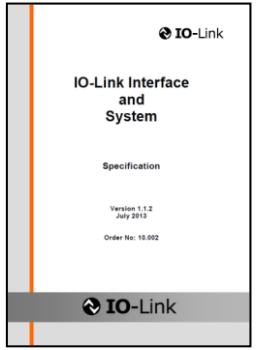
Data Link

Physical

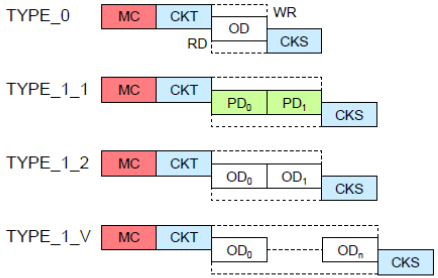




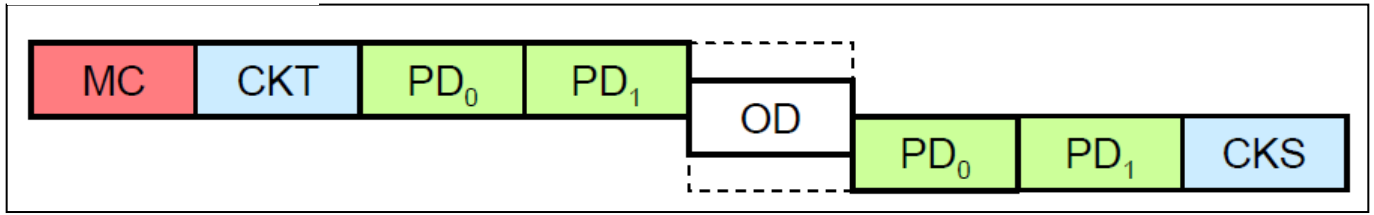
Three levels of the communication

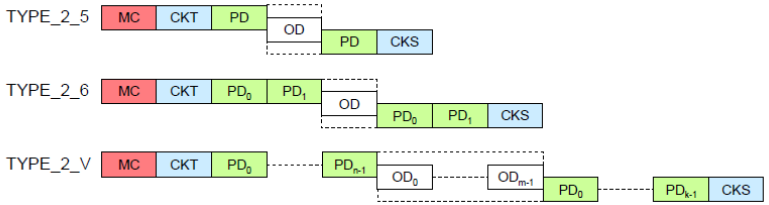


- Application
- Data Link
- Physical



Frame/Message Types





Three levels of the communication

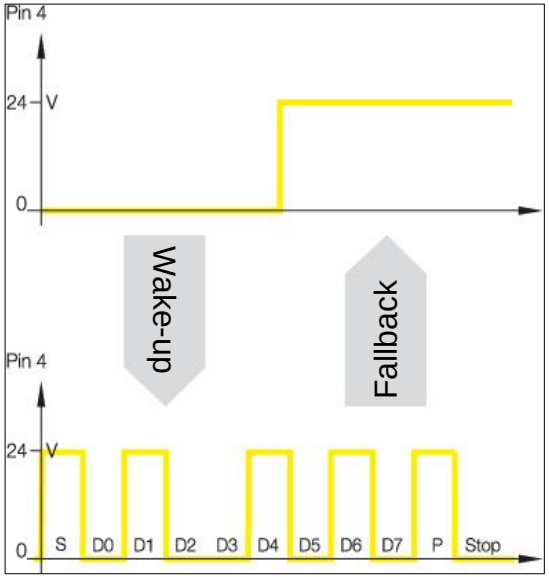
Application

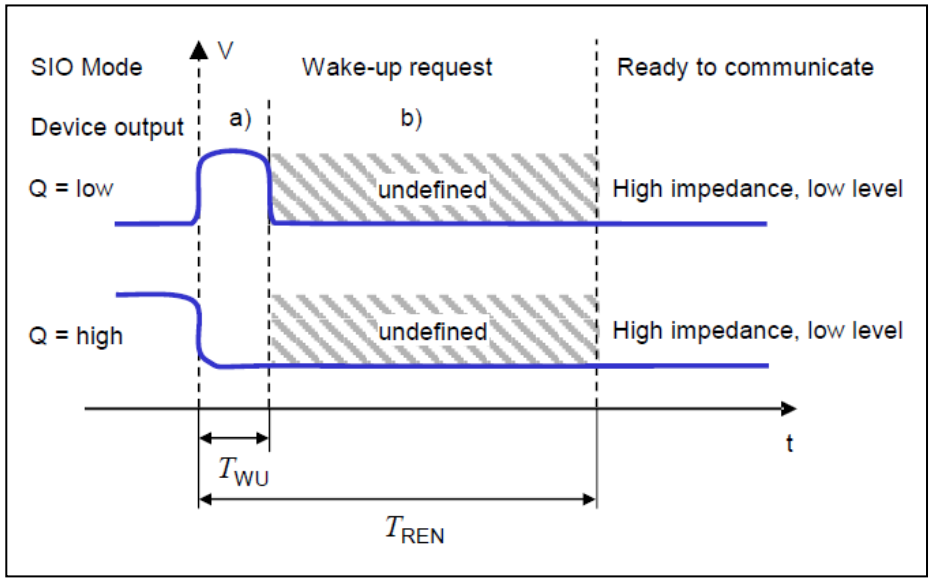
Data Link

Physical

IO-Link States
- Wake-up / Fallback
- Startup
- Preoperate
- Operate

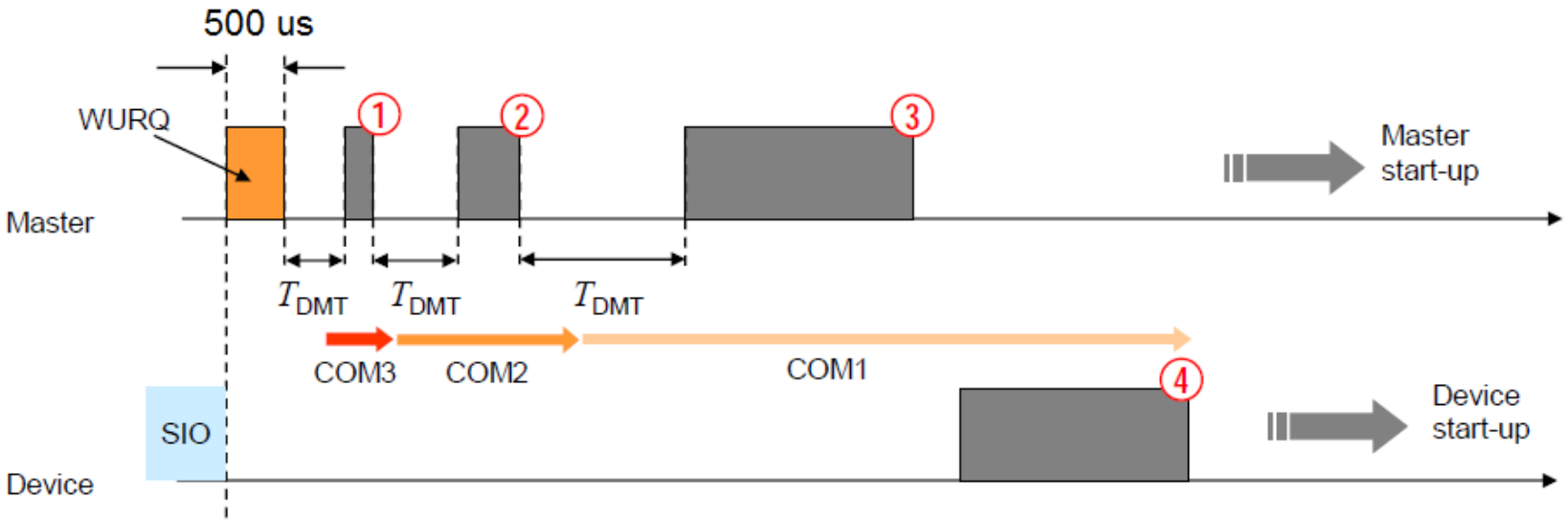
SIO versus IO-Link





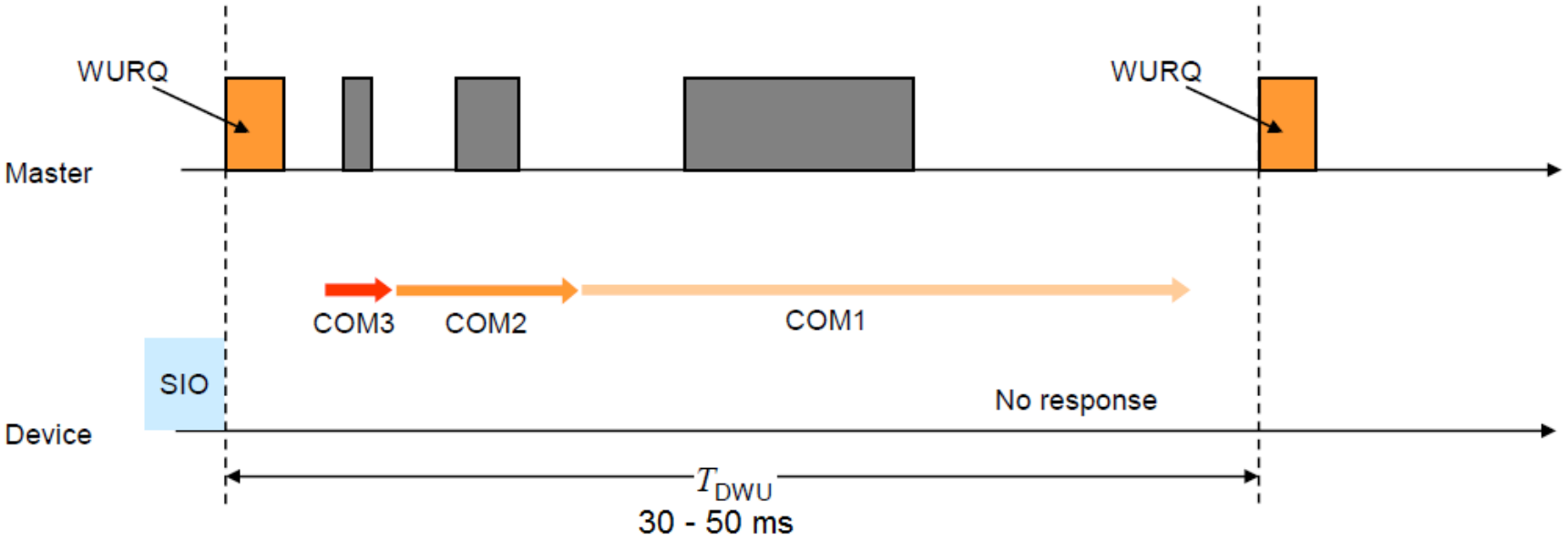
Establish the communication

Wake-up



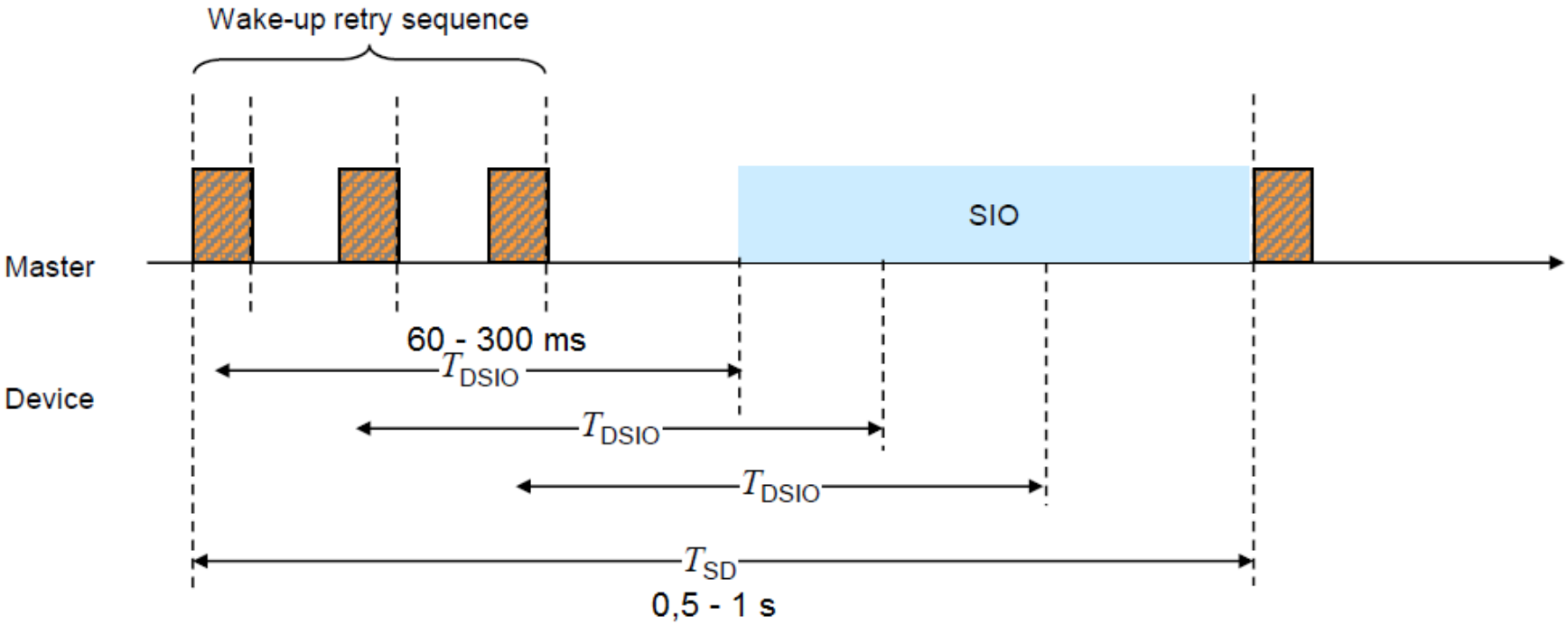
Establish the communication

Wake-up



Establish the communication

Wake-up



Fallback

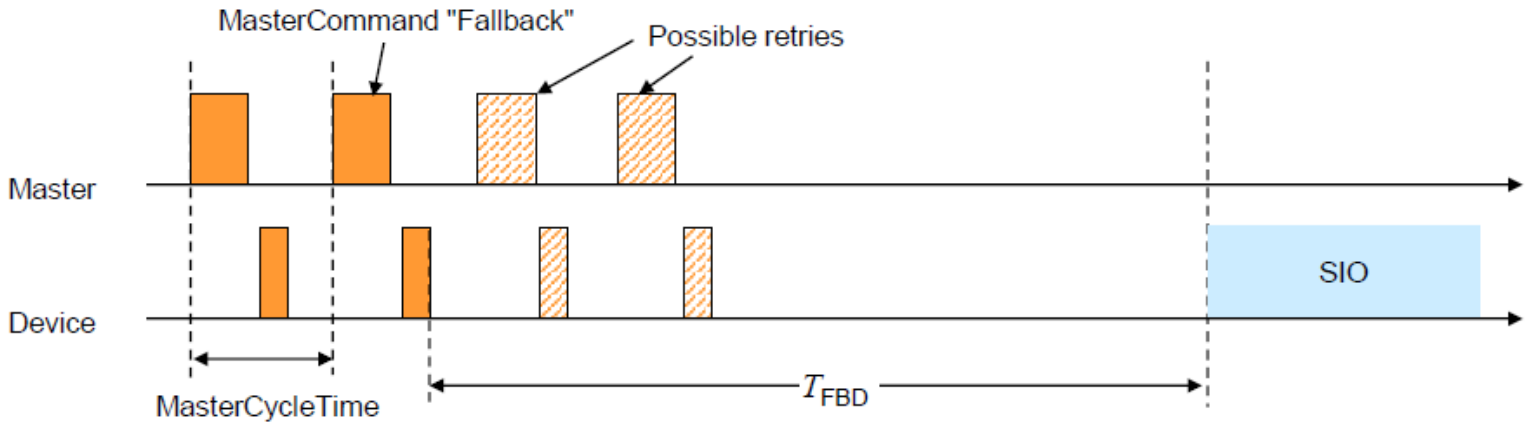


Figure 32 – Fallback procedure

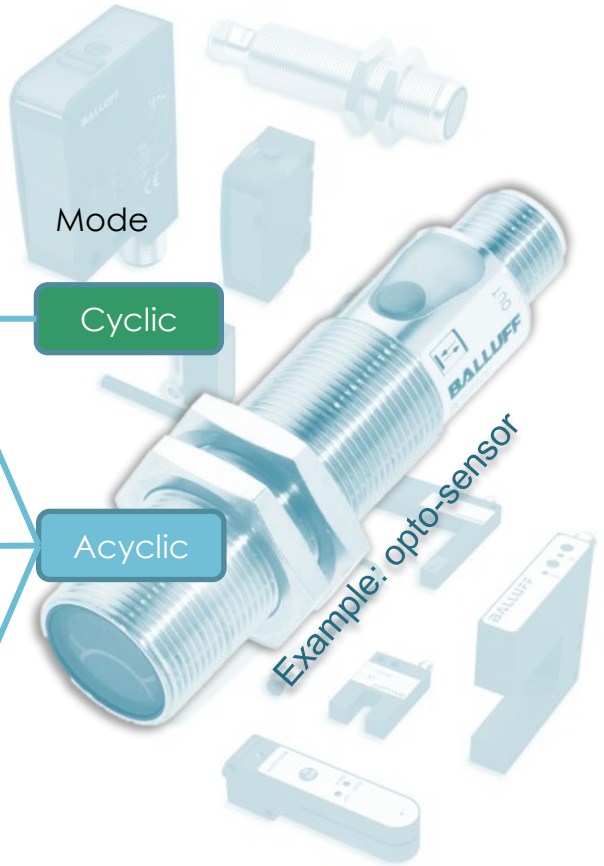
Three levels of the communication

Application

Data Link

Physical

Data	Channel	Mode
Distance = 14.7 mm	PD	Cyclic
Cycletime (data excange rate) = 6 ms	DPP	Acyclic
Threshold = 10.0 mm	ISDU	Acyclic
Dirty glasses!	Diagnosis	Acyclic



Three levels of the communication

Data + Description = Information

Application

Data Link

Physical

16,4 means
Object distance = 16,4 mm

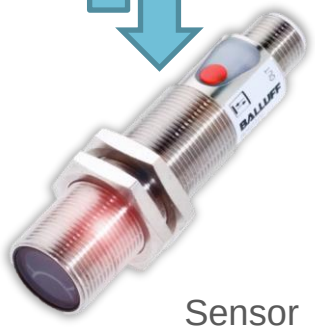
PLC

Description

Data

Milyen jellemzőt mér a szenzor?
Mi a mértékegység?
Milyen paraméterei vannak?
Milyen diagnosztikával rendelkezik?
Milyen funkciókat tud?

IODD
IO Device Description



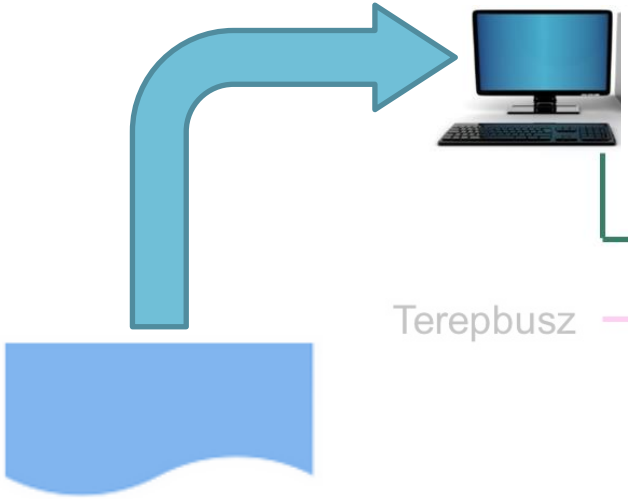
Sensor

Three levels of the communication

Application

Data Link

Physical

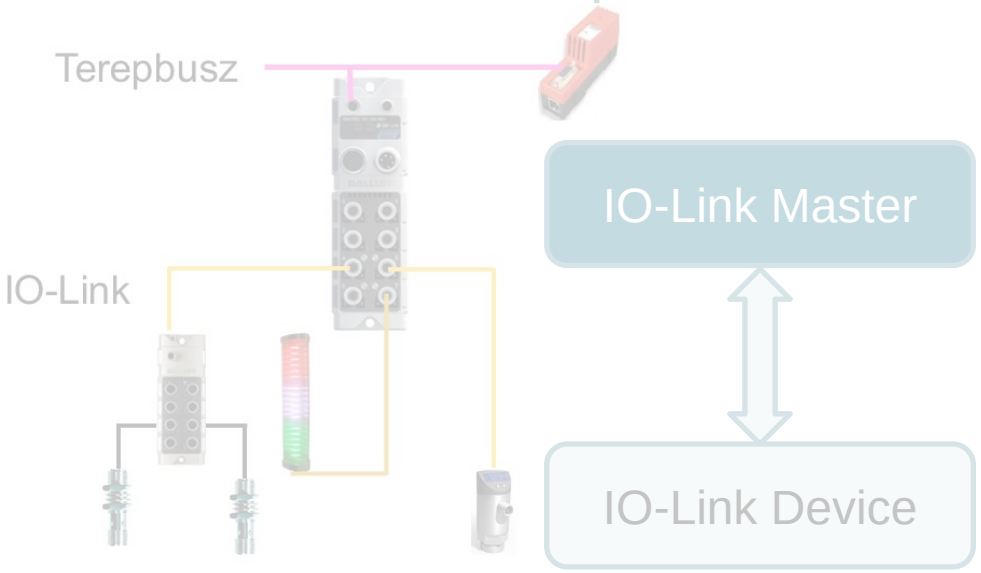


IODD

IO Device Description

Service
Maintenance
Parameterization

PLC



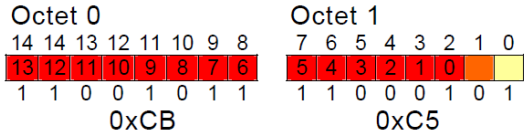
Three levels of the communication

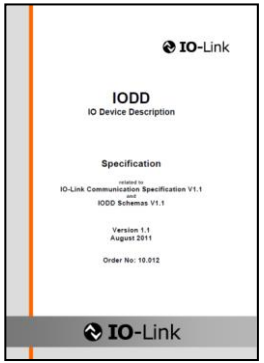
Application

Data Link

Physical

RecordItem	Subindex	Datentyp	bitLength	bitOffset	Value
1	1	UIntegerT	14	2	0x32F1
2	2	BooleanT	–	1	false
3	3	BooleanT	–	0	true





IODD

IO Device Description

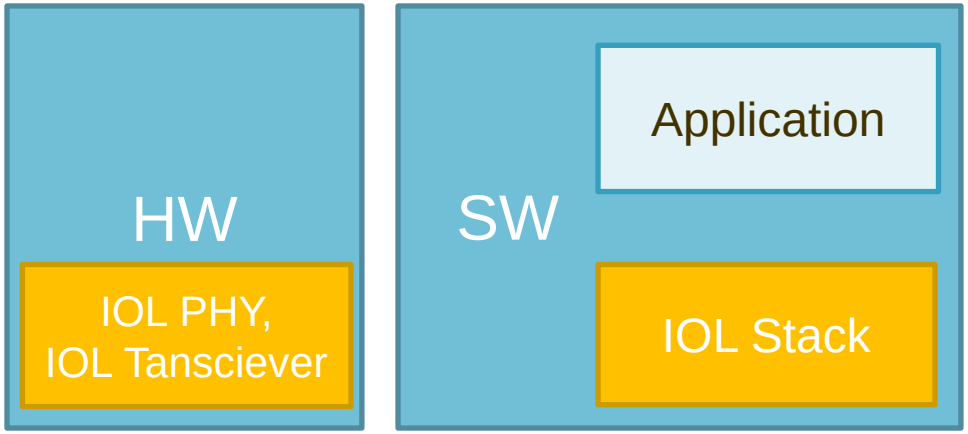
Formal description

(data type, name, length)

```
<Datatype xsi:type="RecordT" bitLength="16">
        <Name textId="TI_ProcessData"/>
        <RecordItem subindex="1" bitOffset="2">
                <SimpleDatatype xsi:type="UIntegerT" bitLength="14"/>
                <Name textId="TI_AnalogValue"/>
        </RecordItem>
        <RecordItem subindex="2" bitOffset="1">
                <SimpleDatatype xsi:type="BooleanT"/>
                <Name textId="TI_Signal2"/>
        </RecordItem>
```

Schematic view of an IO-Link Device

What is in the box?



by HW supplyer

by SW developers or
from IO-Link Competence Center

The **hardware**

Source: https://datasheets.maximintegrated.com/en/ds/MAX14824.pdf

HW

IOL PHY,
IOL Tansciever

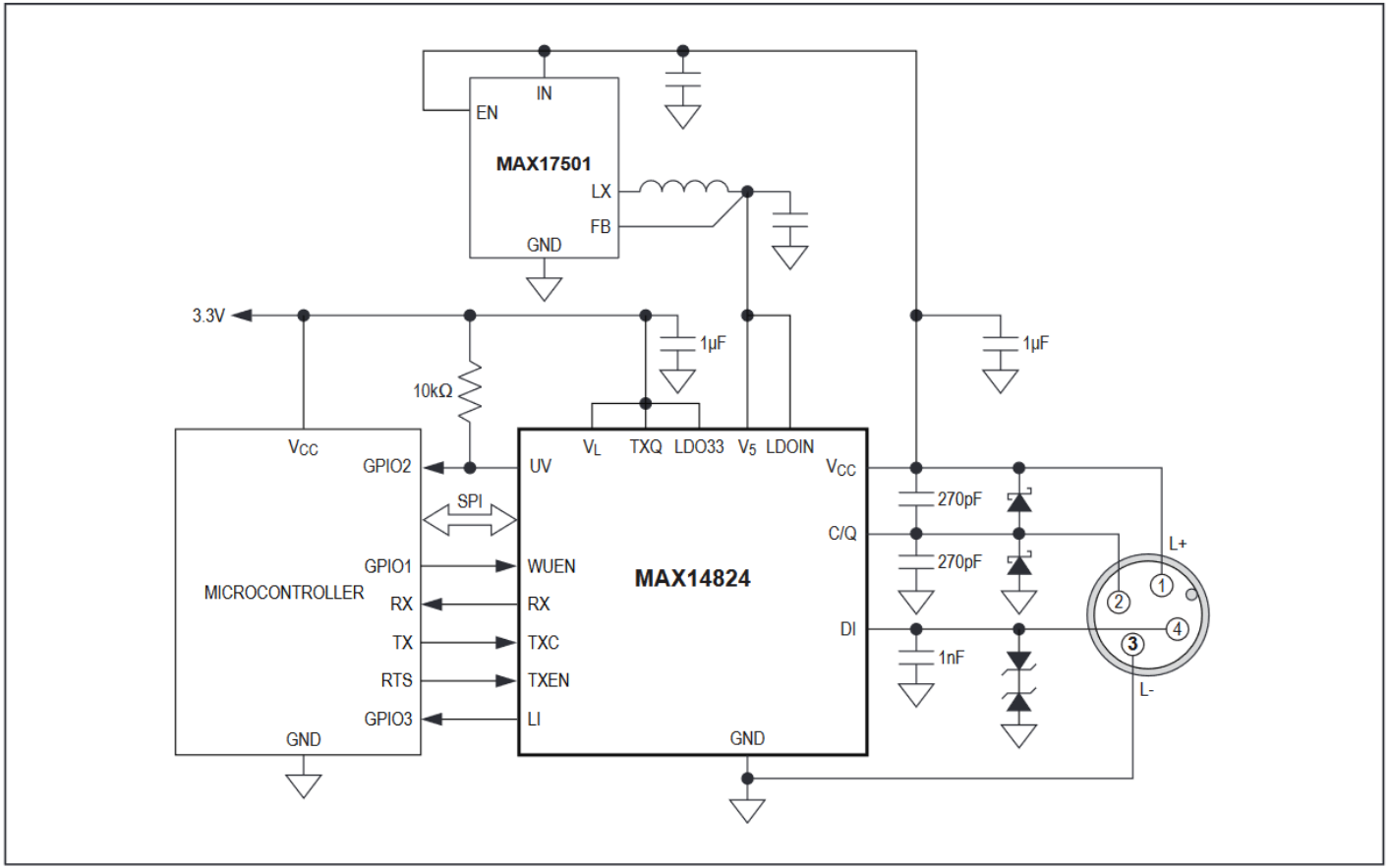
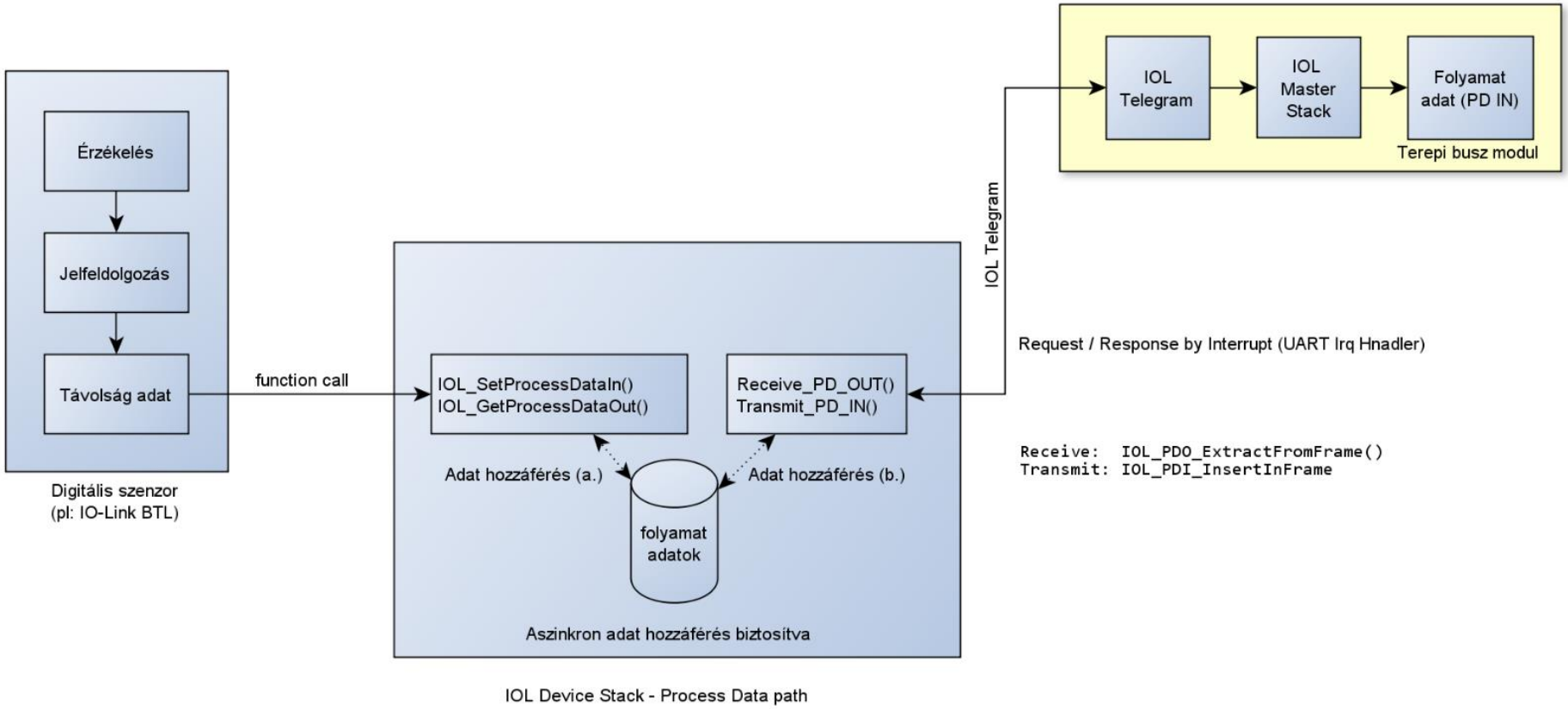


Figure 12. Use an External Supply to Power the MAX14824

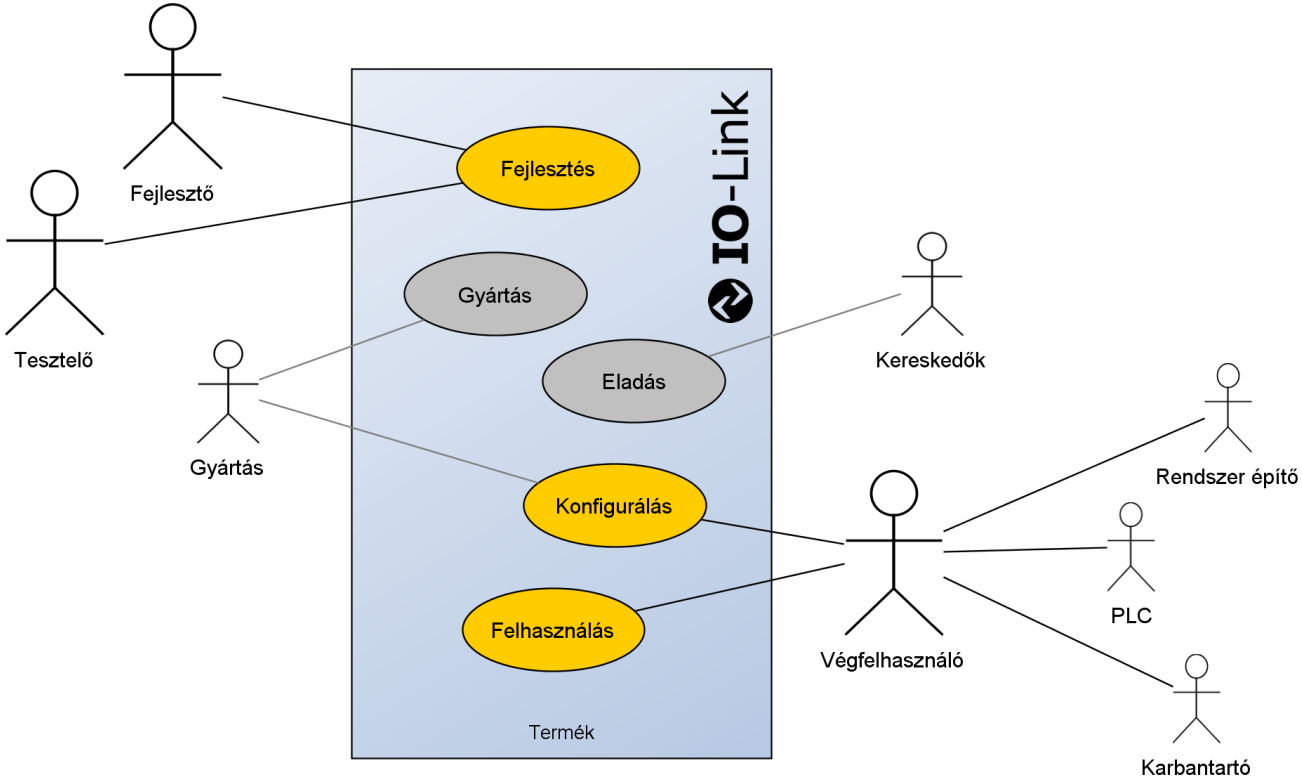
The **software** **firmware**



overview_of_iol.png

IO-Link (device) Use Cases

Users of the protocol



Behind the scene

EMC