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Industrial Summit 2021
Shenzhen, China
POWERING YOUR INNOVATION

IO-Link Demonstration and Design Consideration

Allen KE

Automation Competence Center

STMicroelectronics, AP Region

Automation Competence Center

Agenda

1. IO-Link technology introduction
2. Transceivers for IO-Link masters & devices
3. IO-Link evaluation ecosystem
4. Automation competence center system reference design

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IO-Link technology introduction

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IO-Link connecting smart sensors & actuators

1st choice communication standard for next generation industries

Programmable Controller

Smart Sensors & Actuators

IO-Link

IEC 61131-9

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Next generation factory

Connecting smart digital sensors & actuators

IO-Link inside

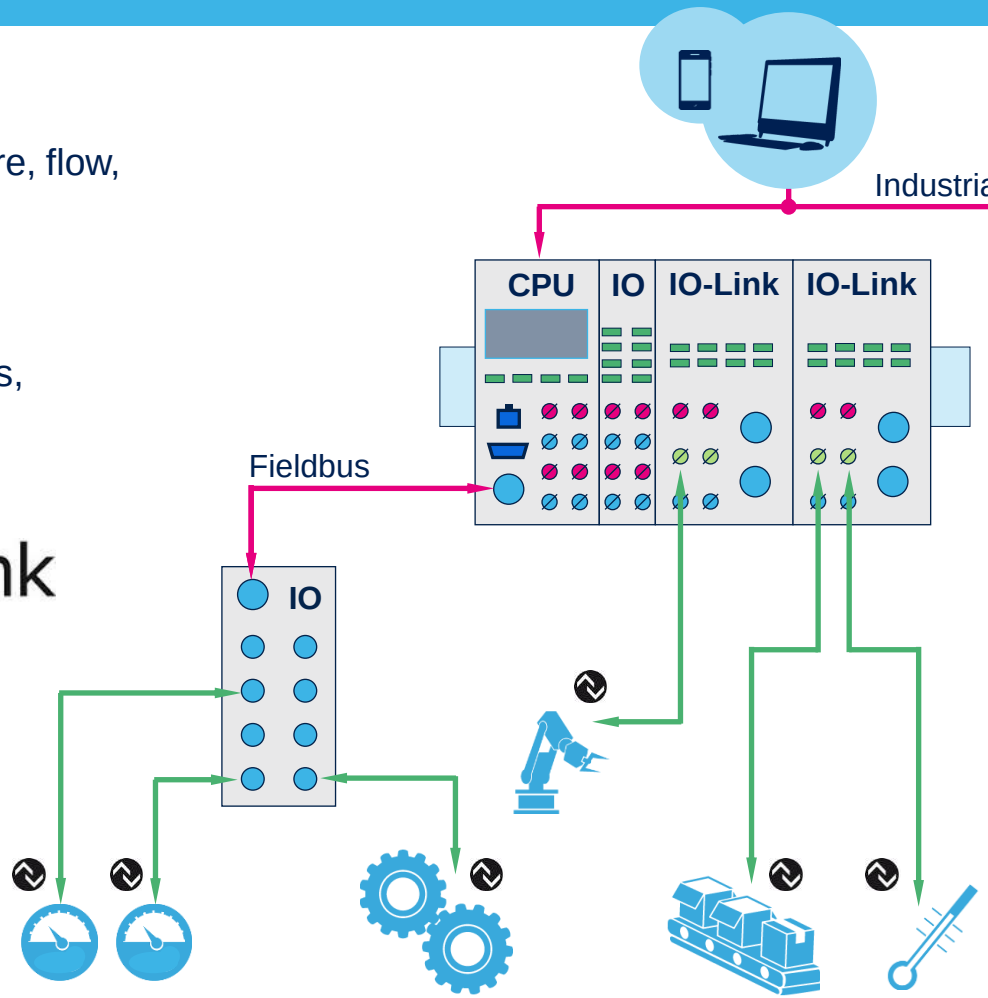
Sensing

- Temperature, pressure, flow, proximity…

Actuation

- Valves, pumps, lamps, relays, contactors…

IO-Link



- Reliable digital communication
- Diagnostics and configurability
- Easy commissioning & modularity

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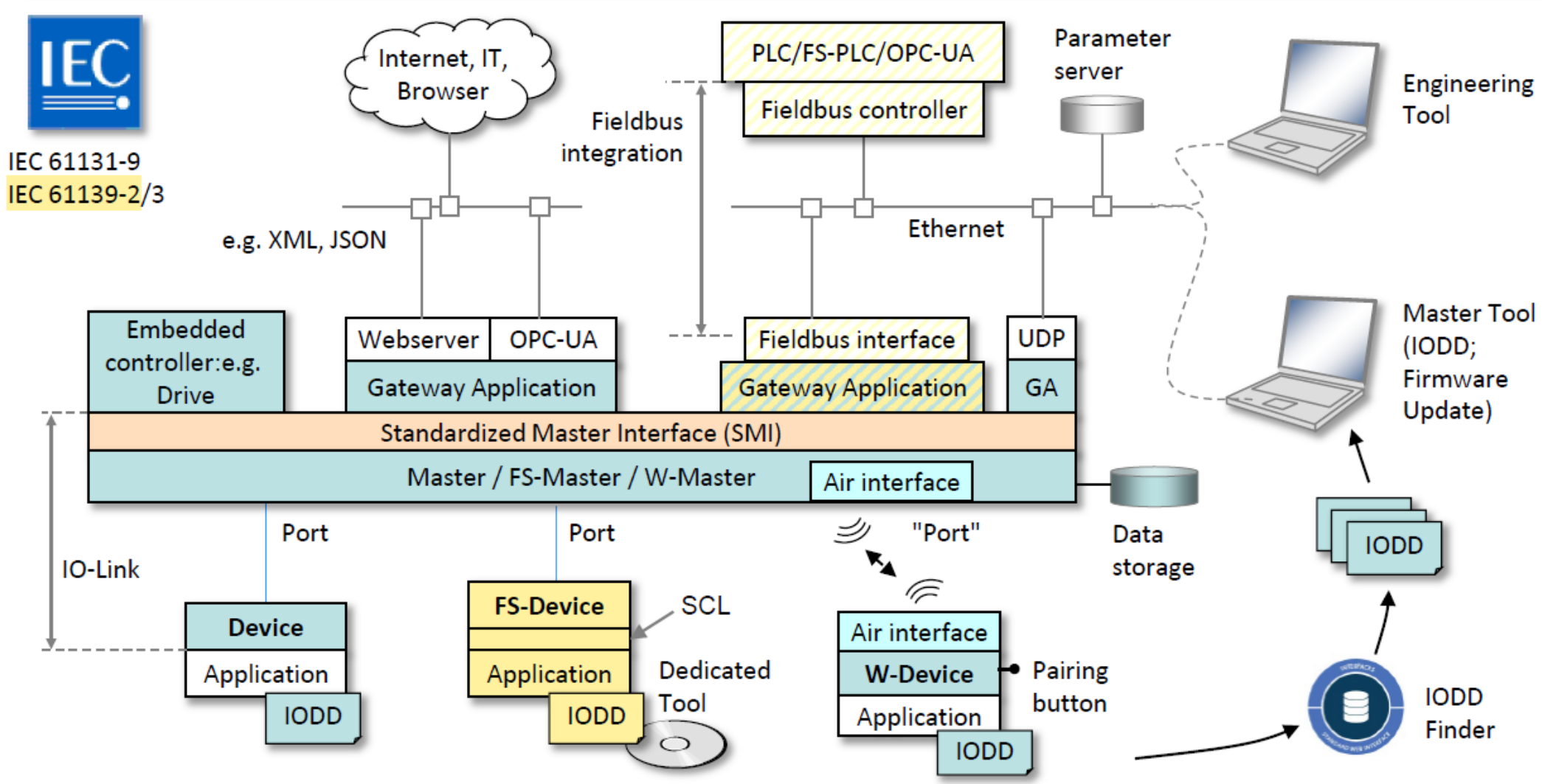
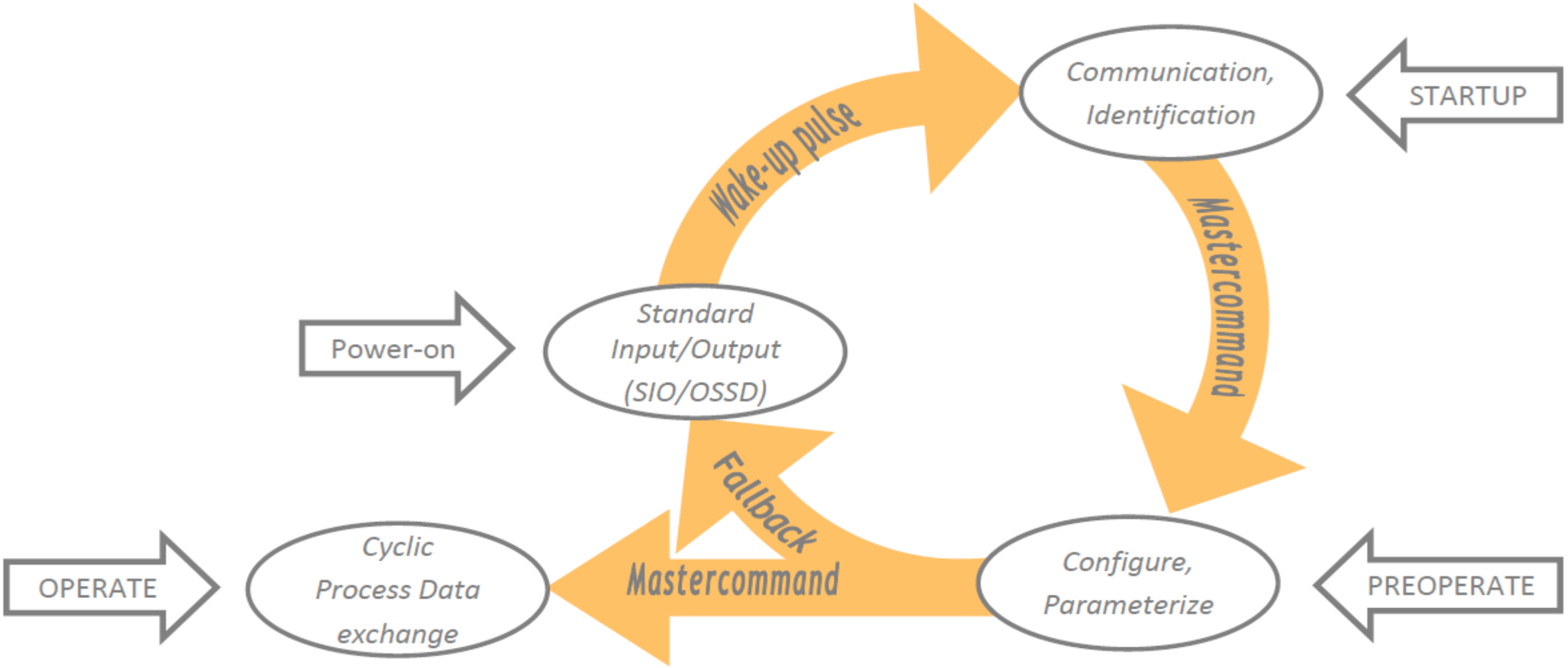
21 million IO-Link nodes by end of 2020

Worldwide more than 350 member companies

The IO-Link Story (Version 1.1.3 or Package 2020)



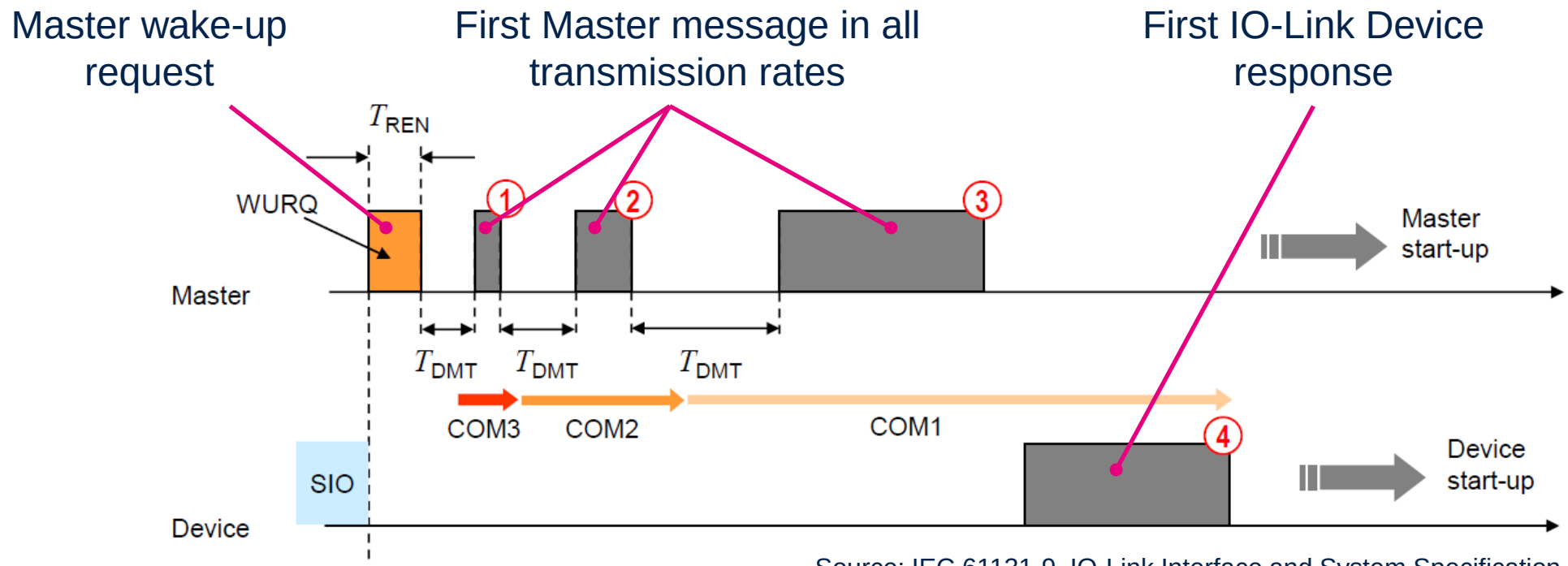
Start-up procedure of basic IO-Link



IO-Link wake-up request

Physical layer interface

- WURQ: IO-Link Master drives the C/Q line to the opposite logic level than Device for 75 to 85µs
- IO-Link Device releases the bus and enables Master to send its first message



Source: IEC 61131-9, IO-Link Interface and System Specification

Transceivers for IO-Link Masters & Devices

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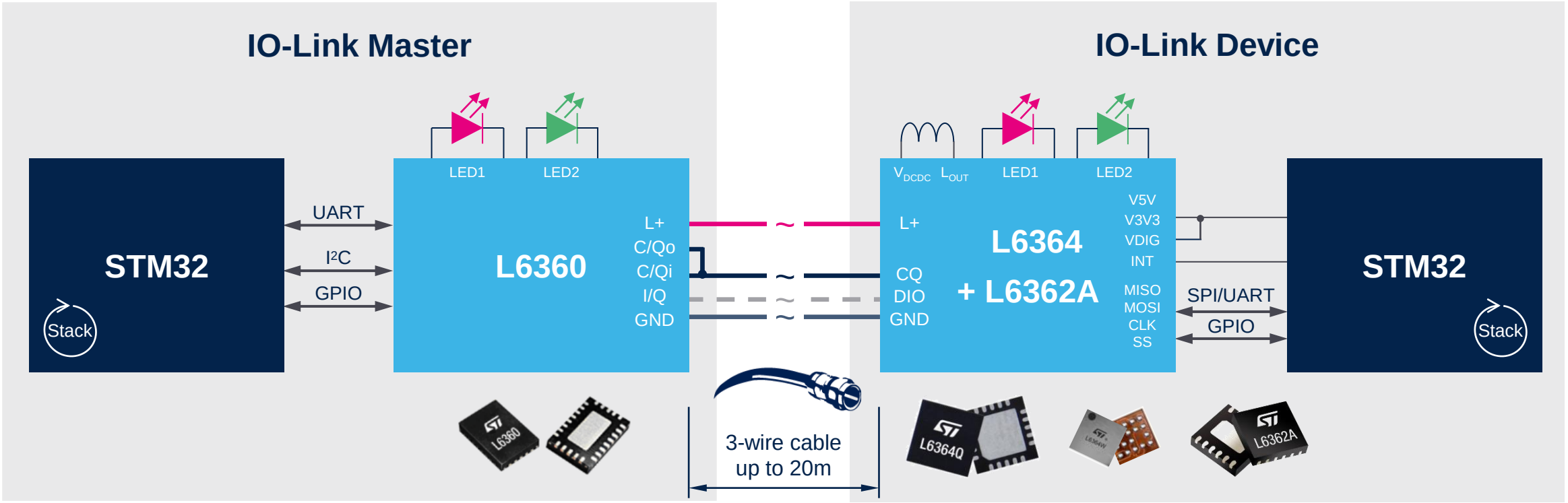
Driven by STMicroelectronics

Point-to-point communication built on ST components



Stack IO-Link Stacks available at our partner www.teconcept.de

TEConcept

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New Dual Channel IO-Link Device

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L6364Q / L6364W

Dual channels IO-Link Device

QFN

4 × 4 mm

CSP

2.5 × 2.5 mm

Two configurable I/Os
up to 500 mA / 2.5Ω

Integrated M-sequence
management with CRC

DC/DC converter
+ two 50mA linear regulators

Wide operating range
4.5 – 35 V

Configuration and diagnostics
over SPI bus

Full set of protections
incl. reverse polarity & surge

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Package Comparison CSP vs. QFN

Dual channel IO-Link Device L6364

16 mm²

QFN

4 × 4 mm

6.25 mm²

CSP

2.5 × 2.5 mm

> 60 % Board space saved!

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IO-Link Device IC positioning

Best applications for each device

L6362A

- ✓ Lowest R_{DSON} → Lowest dissipation
- ✓ Strong EMC immunity
- ✓ Can drive high capacitive loads
- ✓ General purpose 24V line interface
- ✓ Simple to use
- ✓ Cost-effective

L6364W / Q

- ✓ High integration → lower MCU requirements
- ✓ Automatic clock extraction saves oscillator circuits & gives flexibility
- ✓ Wide configurability
- ✓ Two channels with paralleling for high output currents
- ✓ Smallest space per channel

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Evaluation ecosystem

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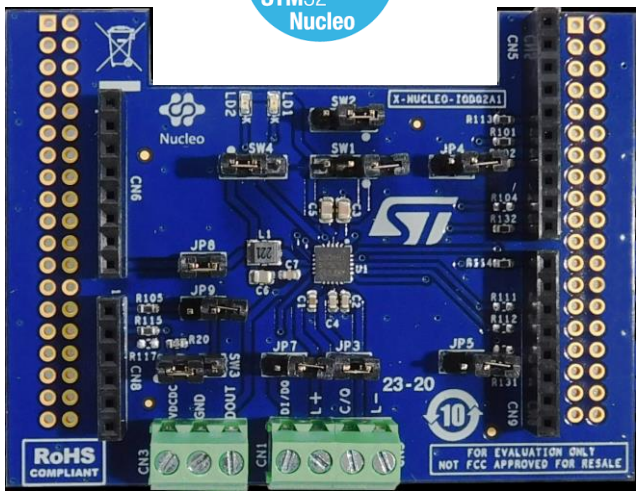
X-NUCLEO-IOD02A1

Nucleo board for IO-Link platform based on L6364

- Process Stage Reverse Polarity
- SPI with Selectable Transmission mode
- Two user LEDs for status & diagnostics
- Process Stage EMC Compliancy

X-CUBE-IOD02

- IODD XML file
- Stack Libraries (IAR, KEIL, GCC)



X-NUCLEO-IOD02A1

Compatible with
NUCLEO-L073, NUCLEO-G071

IO-Link mini stack
and IODD file included

All available in X-CUBE-IOD02

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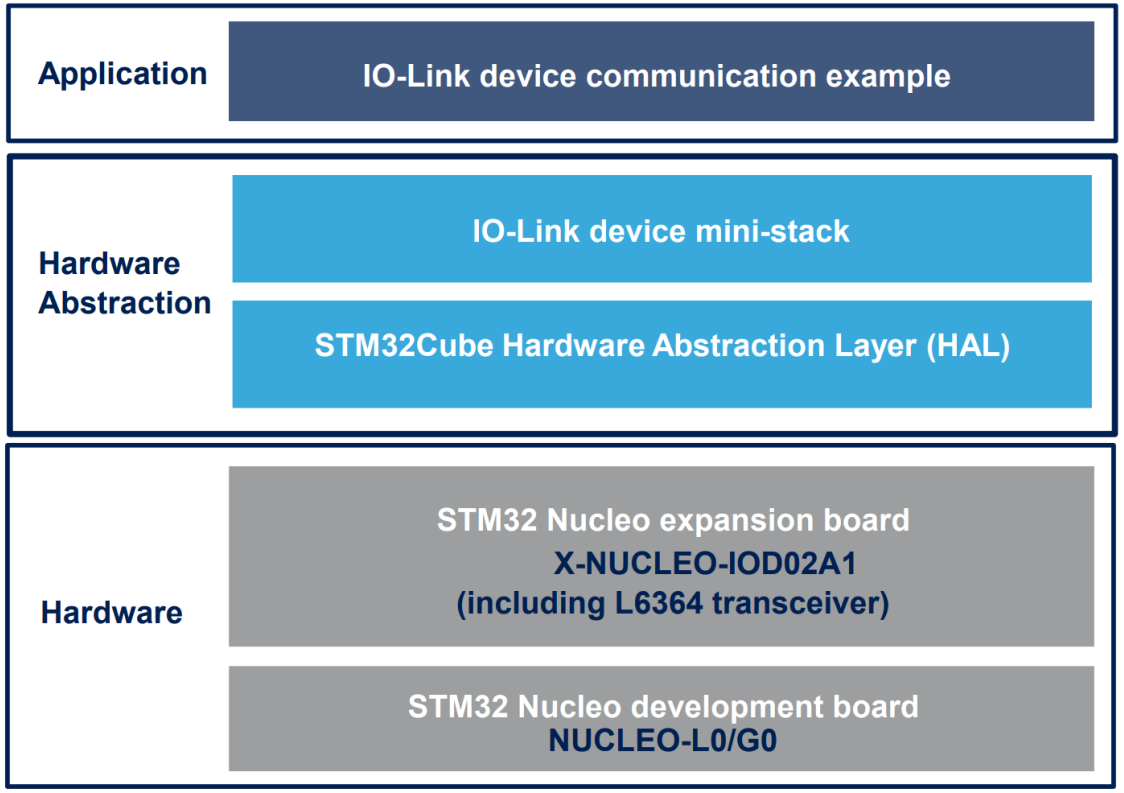
X-CUBE-IOD02: Software for L6364

Industrial IO-Link Device software expansion for STM32Cube

- Complete software to build applications on L6364
- Includes IO-Link Device mini-stack library supporting
  - Single octet, Multi octet IO-Link mode and transparent UART mode
  - COM2 (32.4kbit/s), COM3 (230.4kbit/s)
- GPIOs, SPI, UART and IRQs configuration
- Easy portability to different STM32 microcontrollers (STM32CubeHAL)
- Including sample application for X-NUCLEO-IOD02A1
- Free user-friendly license

Software architecture:



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Multisensor function pack with L6364

Evaluation kit with Industrial Sensors P-NUCLEO-IOD02A1

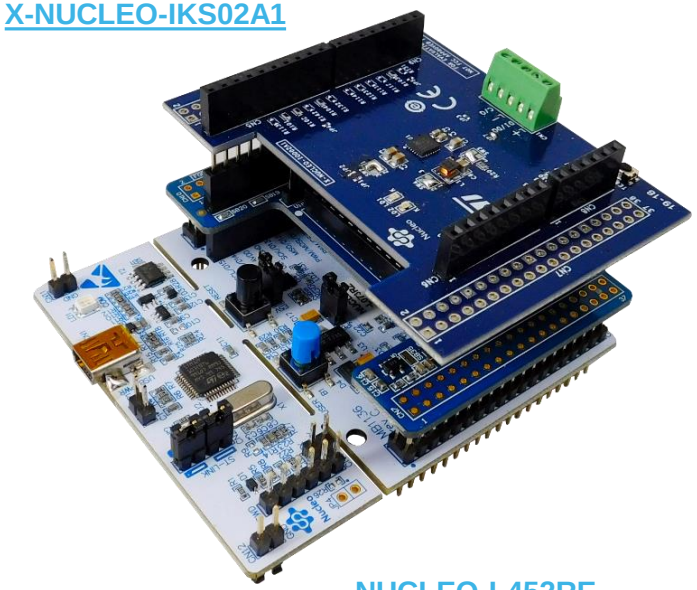
- Process Stage Reverse Polarity
- SPI with Selectable Transmission mode
- Two user LEDs for status & diagnostics
- Process Stage EMC Compliancy

FP-IND-IODSNS1

- X-CUBE-MEMS1
- X-CUBE-IOD02
  - IODD XML file
  - Stack Library (IAR, KEIL, GCC)

X-NUCLEO-IOD02A1

X-NUCLEO-IKS02A1



NUCLEO-L452RE

Pre-programmed Nucleo + L6364 + Sensor board in the kit

IO-Link mini stack and IODD file included

Function pack FP-IND-IODSNS1 contains all needed firmware

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IQInterface - IO-Link test emulation tool

Laboratory tool for IO-Link system testing

IO-Link development & debugging tool

Emulation of Master & Device

GUI & DLLs allowing communication & EMC tests

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IQ² Development
IO-Link Intelligent Components

IQInterface - IO-Link commissioning

IO-Link production & development tool

- Development tool both for
  - IO-Link Master
  - IO-Link Device
- Allows to evaluate and test IO-Link communication during the development and system commissioning
- RS232, USB, Ethernet connection interface
- Provided with GUI applications for
  - IO-Link system commissioning
  - EMC tests
- Includes communication DLLs and Python test automation library

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IQ 2 Development
IO-Link Intelligent Components

IO-Link EMC requirements

IO-Link specifies EMC immunity requirements

Table H.2 – EMC test levels

Phenomena	Test Level	Performance Criterion	Constraints
Electrostatic discharges (ESD) IEC 61000-4-2	Air discharge: ± 8 kV Contact discharge: ± 4 kV	B	See H.1.4, a)
Radiofrequency electromagnetic field. Amplitude modulated IEC 61000-4-3	80 MHz – 1 000 MHz 10 V/m 1 400 MHz – 2 000 MHz 3 V/m 2 000 MHz – 2 700 MHz 1 V/m	A	See H.1.4, a), H.1.4, b), H.1.4, e).
Fast transients (Burst) IEC 61000-4-4	± 1 kV	A	5 kHz only. The number of M-sequences in Table H.1 shall be increased by a factor of 20 due to the burst/cycle ratio 15 ms/300 ms. See H.1.4, c)
	± 2 kV	B	
Surge IEC 61000-4-5	Not required for an SDCI link (SDCI link is limited to 20 m)		-
Radio-frequency common mode IEC 61000-4-6	0,15 MHz – 80 MHz 10 VEMF	A	See H.1.4, b) and H.1.4, d)
Voltage dips and interruptions IEC 61000-4-11	Not required for an SDCI link		

Defined number of M-sequences and maximum error rate during the test

Surge immunity not specified but often requested by customers

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IO-Link EMC requirements

IO-Link specifies EMC immunity requirements

Transmission rate	Master		Device		Maximum of M-sequence errors
	t_{CYC}	Number of M-sequences of TYPE_2_5 (read) (6 octets)	t_{CYC}	Number of M-sequences of TYPE_0 (read) (4 octets)	
4,8 kbit/s	18,0 ms	300 (6 000)	100 T_{BIT} (20,84 ms)	350 (7 000)	6
38,4 kbit/s	2,3 ms	450 (9 000)	100 T_{BIT} (2,61 ms)	500 (10 000)	6
230,4 kbit/s	0,4 ms	700 (14 000)	100 T_{BIT} (0,44 ms)	800 (16 000)	6

Fast transients (Burst) IEC 61000-4-4	± 1 kV	A	5 kHz only. The number of M-sequences in Table H.1 shall be increased by a factor of 20 due to the burst/cycle ratio 15 ms/300 ms. See H.1.4, c)
	± 2 kV	B	

Defined number of M-sequences and maximum error rate during the test

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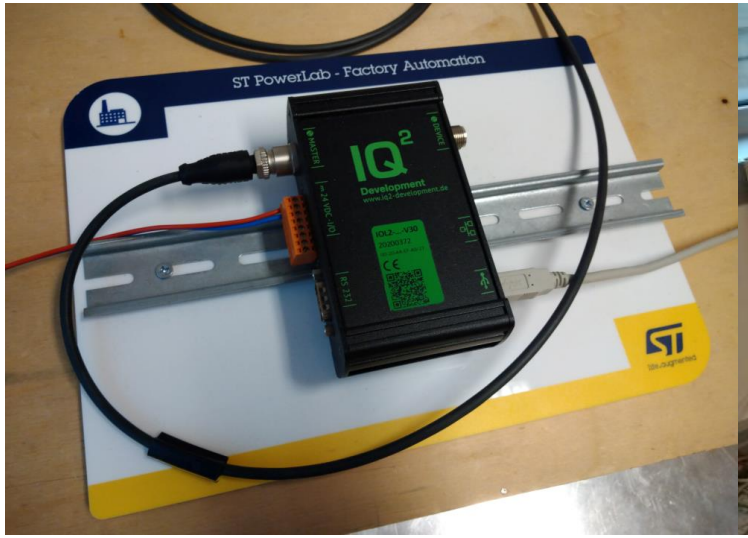
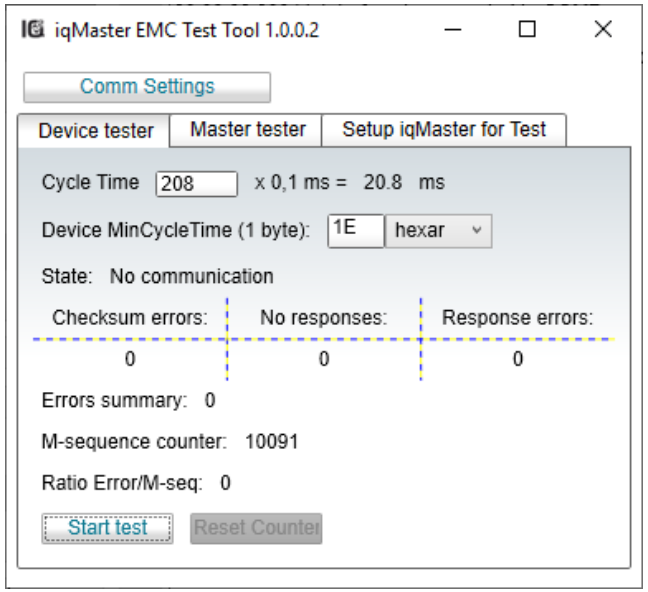
IO-Link EMC requirements

EMC Burst immunity tests





Electrical Fast Transient (EFT)
IEC 61000-4-4

±1kV (5kHz)
applied trough capacitive clamp

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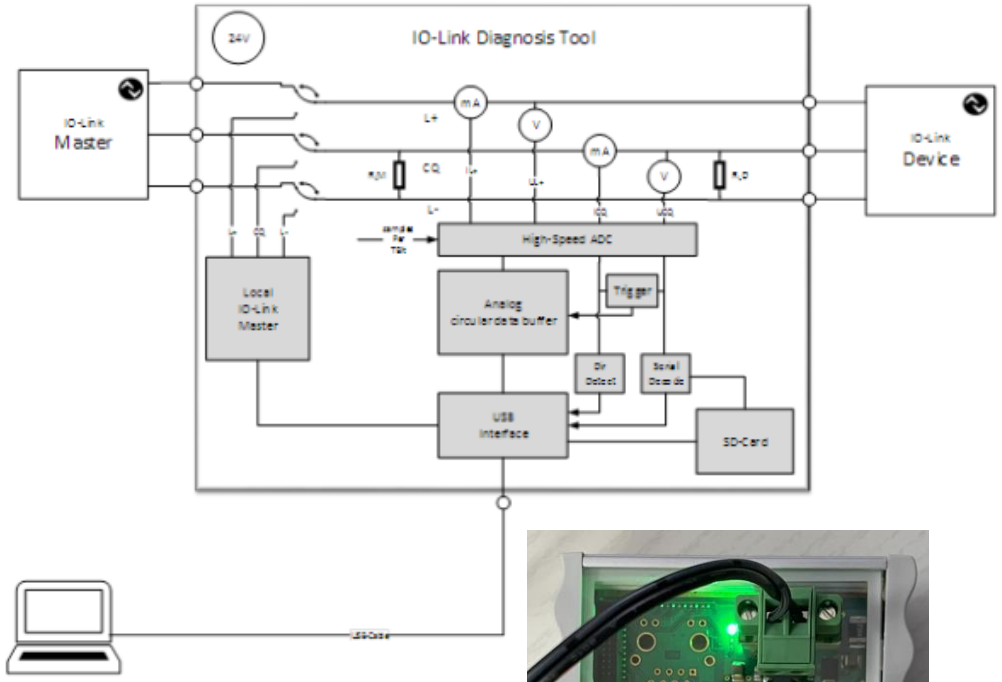
Diagnostic tools



Raw View | Msequence View

Filter | Settings

Timestamp	Cycle Time	Access	Address	Master Request	Response Delay	Device Response	PD validity
00:05.970465	0 µs	R	2	0xA2 0x00	33.8 µs	0x04 0x3F	valid
00:05.971672	1206 µs	R	3	0xA3 0x11	33.8 µs	0x01 0x3C	valid
00:05.972910	1238 µs	R	4	0xA4 0x33	32.9 µs	0x11 0x28	valid
00:05.974147	1237 µs	R	5	0xA5 0x22	32.1 µs	0x48 0x17	valid
00:05.975388	1241 µs	R	6	0xA6 0x12	32.1 µs	0x08 0x0F	valid
00:05.976631	1242 µs	W	0	0x20 0x36 0x95	36.4 µs	0x2D	valid
00:05.977868	1237 µs	R	7	0xA7 0x03	31.2 µs	0x02 0x0C	valid
00:05.979109	1241 µs	R	8	0xA8 0x03	35.5 µs	0x86 0x36	valid
00:05.980346	1237 µs	R	9	0xA9 0x12	34.7 µs	0x02 0x0C	valid
00:05.981589	1242 µs	R	10	0xAA 0x22	34.7 µs	0x00 0x2D	valid
00:05.982826	1237 µs	R	11	0xAB 0x33	33.8 µs	0x03 0x1D	valid
00:05.984063	1237 µs	R	12	0xAC 0x11	33.8 µs	0x00 0x2D	valid
00:05.985561	1497 µs	R	13	0xAD 0x00	33.8 µs	0x00 0x2D	valid
00:05.986799	1238 µs	R	14	0xAE 0x30	32.9 µs	0x00 0x2D	valid
00:05.988036	1237 µs	W	0	0x20 0x36 0x9A	36.4 µs	0x2D	valid
00:05.989282	1245 µs	R	IDLE1	0xF1 0x3C	36.4 µs	0x00 0x2D	valid
⚠ 00:05.990380	1098 µs	W	START	0x70 0x09 0x93	45.0 µs	0x2D	valid
⚠ 00:05.991475	1094 µs	W	COUNT(1)	0x61 0x17 0x15	44.1 µs	0x2D	valid
⚠ 00:05.992573	1098 µs	W	COUNT(2)	0x62 0x2B 0x86	44.1 µs	0x2D	valid

- Cycle time
- Access
- Address
- Request
- Response
- Response delay
- PD Validity

Protocol View | IODD View

Filter | Settings

Timestamp	State	Action	Message	Details
00:05.322096	PREOPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x10] = 0x69, 0x66, 0x6D, 0x20, 0x65, 0x6C, 0x65, 0x63, 0x74, ...
00:06.280385	PREOPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x12] = 0x54, 0x41, 0x44, 0x39, 0x38, 0x31
00:07.017659	PREOPERATE	Write Direct Parameter Page 1	Write page parameter	21200 µs = Master Cycle Time
00:07.181402	PREOPERATE	Master Command	Write master command	Device Operate (0x99)
00:20.847349	OPERATE	Write system command	Positive Response	Param upload start (0x01)
00:21.368164	OPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x10] = 0x69, 0x66, 0x6D, 0x20, 0x65, 0x6C, 0x65, 0x63, 0x74, ...
00:22.062909	OPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x12] = 0x54, 0x41, 0x44, 0x39, 0x38, 0x31
00:22.562273	OPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x14] = 0x54, 0x65, 0x6D, 0x70, 0x65, 0x72, 0x61, 0x74, 0x75, ...
00:23.582431	OPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x15] = 0x74, 0x30, 0x31, 0x31, 0x36, 0x31, 0x31, 0x30, 0x37, 0...
00:24.190335	OPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x16] = 0x41, 0x43
00:24.689471	OPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x17] = 0x33, 0x30, 0x31
00:25.188835	OPERATE	ISDU Read (8bit Index)	Positive Response	Index[0x18] = 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0...
00:25.905259	OPERATE	Write system command	Positive Response	Param upload end (0x02)
00:34.675341	OPERATE	Write system command	Positive Response	0xF0
00:34.762016	OPERATE	Status code	Read event status code	Event with details: activated events: 1

- State
- Action
- Message
- Details

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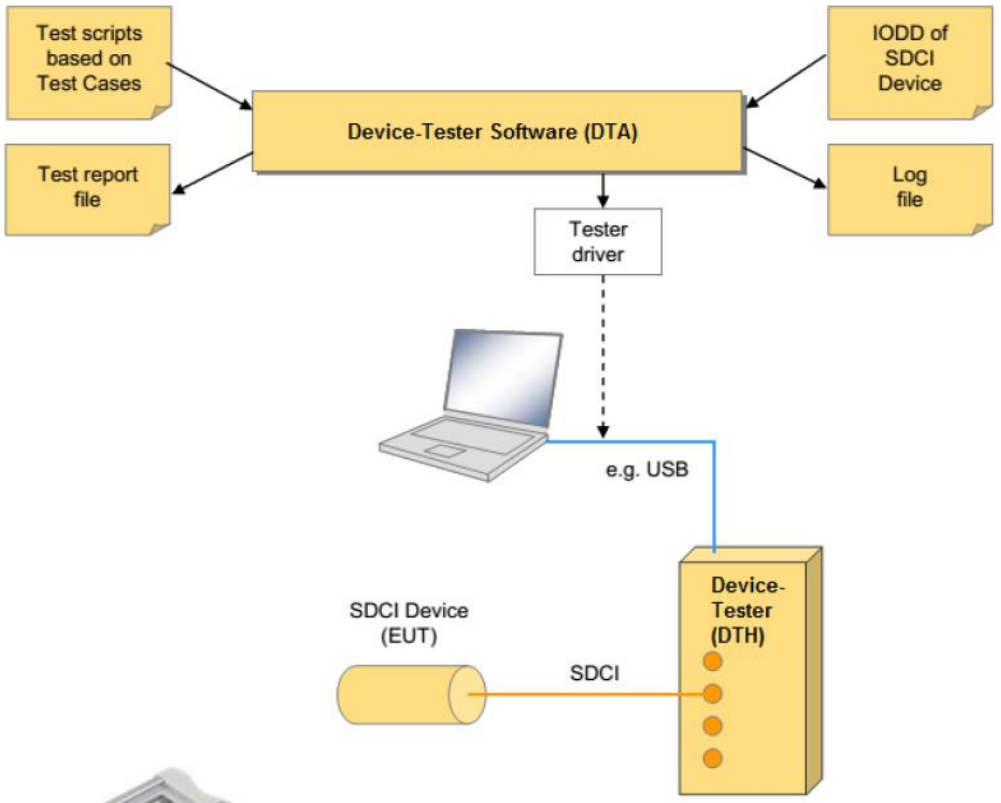
Device tester



Test logs and trace

Test case:

Test ID:	SDCI_TC_0037	EUT:	Device and Legacy-Device, except Devices with zero length process data
Name:	TCD_DLPC_OPER_OPERSTUP1	Spec.:	[9], see 7.2.3.5, 9.3.3.2
Group:	Startup	Initial s.:	Operate
Version:	1.1	Category:	Device protocol test; test to pass (positive testing)
Purpose:	Test correct state transition from OPERATE to STARTUP		

Test Case Steps:

Step Name	COF	EOF
1. Set DTH parameters	☐	☑
2. Start Up Device	☑	☑
3. Send ISDU Command	☑	☑
4. Set DTH parameters	☐	☑

Step infomation:

Set DTH not to disconnect IO-Link communication when the Device doesn't answer for the request. Set DTH message handler's number of retries to 0.

Parameters:
Number of tries: 0
Disconnect IOLink communication on error: No
Next state on error: Startup

Store:
-

Log:

Test: SDCI_TC_0037
Set Deviceinitial state
Wake up device: Success
Start up device: Success
PreOperate: Success
Operate: Success
Initial state is set. Device is ready for the test.

1. step - SDCI_TC_0037: Set DTH not to disconnect IO-Link communication when the Device doesn't answer for the request. Set DTH message handler's number of retries to 0.
✓ DTH is set.

2. step - SDCI_TC_0037: Device is in OPERATE state. Master sends 0x97 DeviceStartup command.

Parameters:
Cycletime: 100 Tbit

Answer:
Minimum cycle time: 0x62
M-sequence capability: 0x01
Revision ID: 0x11
Data In: 0x50
Data Out: 0x00

✓ DeviceStartup command is sent.

3. step - SDCI_TC_0037: Master sends ISDU idle message with the OPERATE M-sequence type. The Device shouldn't answer for the request because it has fallen to STARTUP state .

Parameters:
ISDU command: IDLE
M-sequence: M-Sequence type which is used in state OPERATE

Answer:
Device answers for the request: No

✓ Device doesn't answer for the request with illegal M-sequence type.

4. step - SDCI_TC_0037: Set DTH to disconnect IO-Link communication when the Device doesn't answer for the request. Set DTH message handler's number of retries to 2.
✓ DTH is set.

✓ Test has been passed.
Device has gone to the initial state. [Devicestate: E_DEVICESTATE_SIO]

Trace:

Test case: SDCI_TC_0037

Set initial state:

A2 00 ->
A2 00 -> 62 30
A3 11 -> 01 3C
A4 33 -> 11 28
A5 22 -> 50 21
A6 12 -> 00 2D
20 36 95 -> 2D
A7 03 -> 02 0C
A8 03 -> 86 36
A9 12 -> 01 3C
AA 22 -> 00 2D
AB 33 -> 02 0C
AC 11 -> 00 2D
AD 00 -> 00 2D
20 36 9A -> 2D
21 05 62 -> 2D
20 06 99 -> 2D
F1 94 -> 00 01 1C 18
(Repeated 6 times)
F1 94 -> 00 01 1B 3A
(Repeated 3 times)
F1 94 -> 00 01 1B 3A
(Repeated 4 times)
F1 94 -> 00 01 1C 18
(Repeated 2 times)

1. step - SDCI_TC_0037
(Set DTH parameters)

F1 94 -> 00 01 1C 18
(Repeated 20 times)
F1 94 -> 00 01 1C 18
(Repeated 6 times)

2. step - SDCI_TC_0037
(Start Up Device)

F1 94 -> 00 01 1C 18
(Repeated 5 times)
20 BF 97 -> 00 1C 09

3. step - SDCI_TC_0037
(Send ISDU Command)

F1 94 ->

4. step - SDCI_TC_0037
(Set DTH parameters)

STEVAL-IOD004KT1

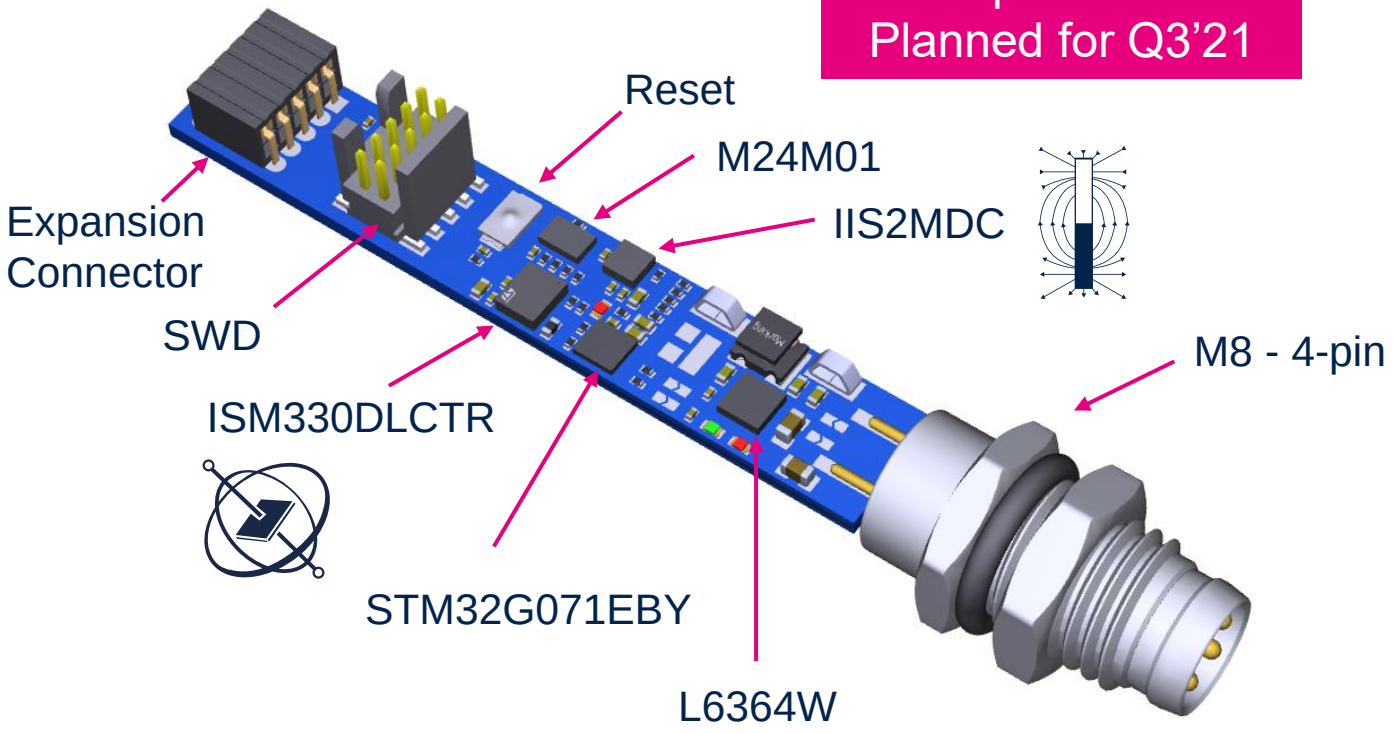
Reference design kit for IO-Link industrial sensors based on L6364W

- Multi-sensor board based on L6364W
- Compatible with IO-Link v.1.1/COM3
- Smallest form factor PCB 45×7.5mm
- SWD programming interface and Industrial field-side connector M8

Will be available in a kit with all needed accessories including:

- STLINKV3-MINI programmer
- M8-M12 adapter cable
- IO-Link firmware package

Development status: Planned for Q3'21



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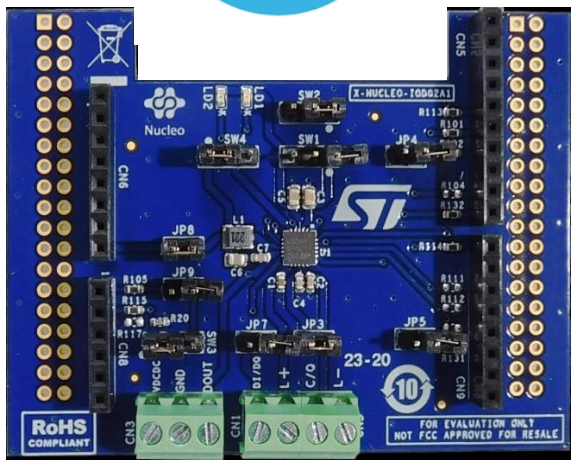
X-NUCLEO-IOD02A1
STEVAL-IOD002V1

Nucleo Board for IO-Link Platform based on L6364

- Process Stage Reverse Polarity
- SPI with Selectable Transmission mode
- ON/OFF Green LED
- Fault signalization by Red LED
- Thermal Fault Red LED
- Process Stage EMC Compliancy

X-CUBE-IOD02

- IODD XML file
- Stack Libraries (IAR, KEIL, GCC)



L6364Q (QFN20L)
X-NUCLEO-IOD02A1
- Available

L6364W (CSP19)
STEVAL-IOD002V1
- Available

STDES-IOD002V1
STDES-IOD004V1

Design examples with L6364Q and L6364W

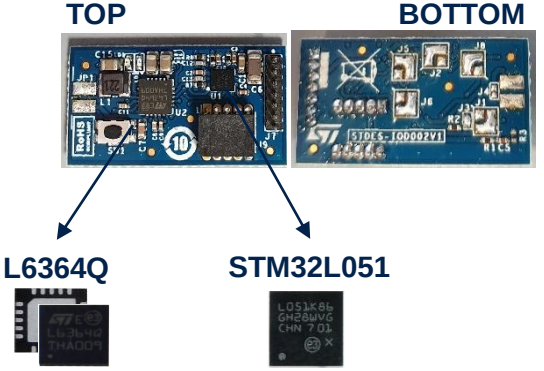
- Process Stage Reverse Polarity
- SPI with Selectable Transmission mode
- ON/OFF Green LED
- Fault signalization by Red LED
- Thermal Fault Red LED
- Process Stage EMC Compliancy

STSW-IOD02L051/IOD04G071

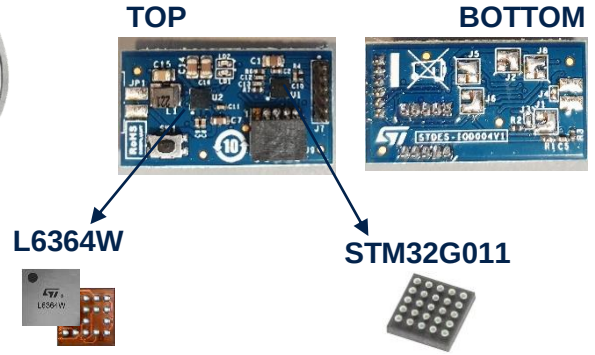
- IODD XML file
- Stack Libraries (IAR, KEIL, GCC)

In development

STDES-IOD002V1



STDES-IOD004V1



- ✓ Basic Reference Designs
  - ✓ L6364Q or L6364W
  - ✓ STM32L051 or STM32G071
  - ✓ 10 pins expansion connector
  - ✓ 7 or 6 SWD connector

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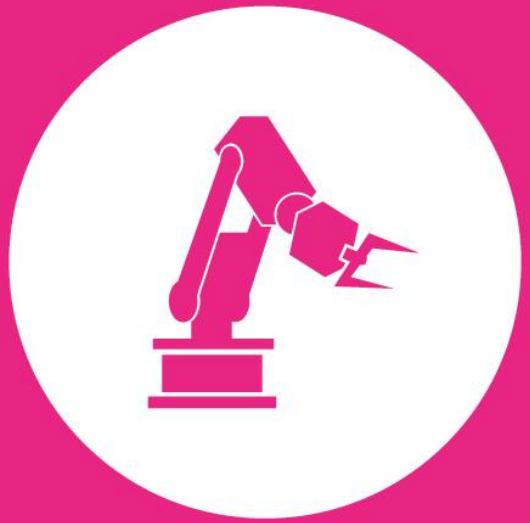
Automation Competence Center System Reference Design

Automation

Competence

Center



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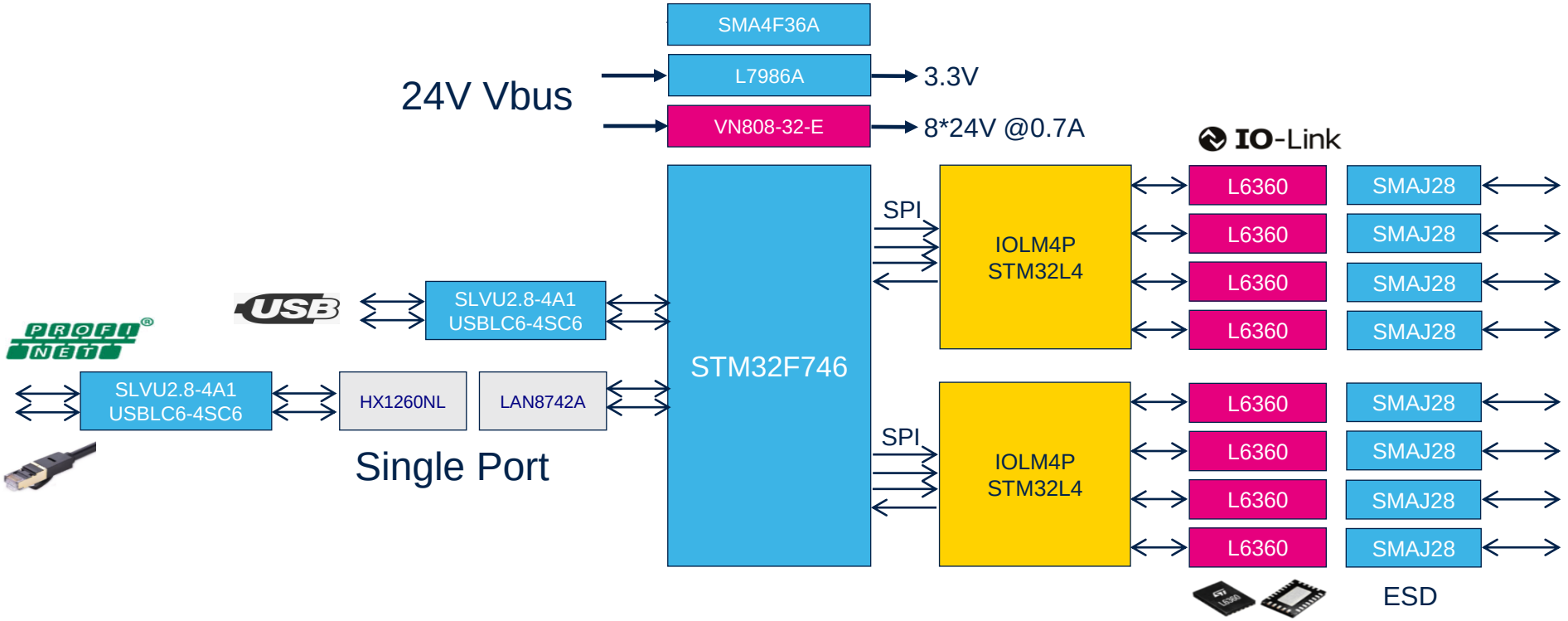
8-Port IO-Link Master based on IOLM4P



Features:

- Ready to use with 8-Port IO-Link Master PC Control Tool
- Extensive functions with customized STM32F7 High level Master Access Program

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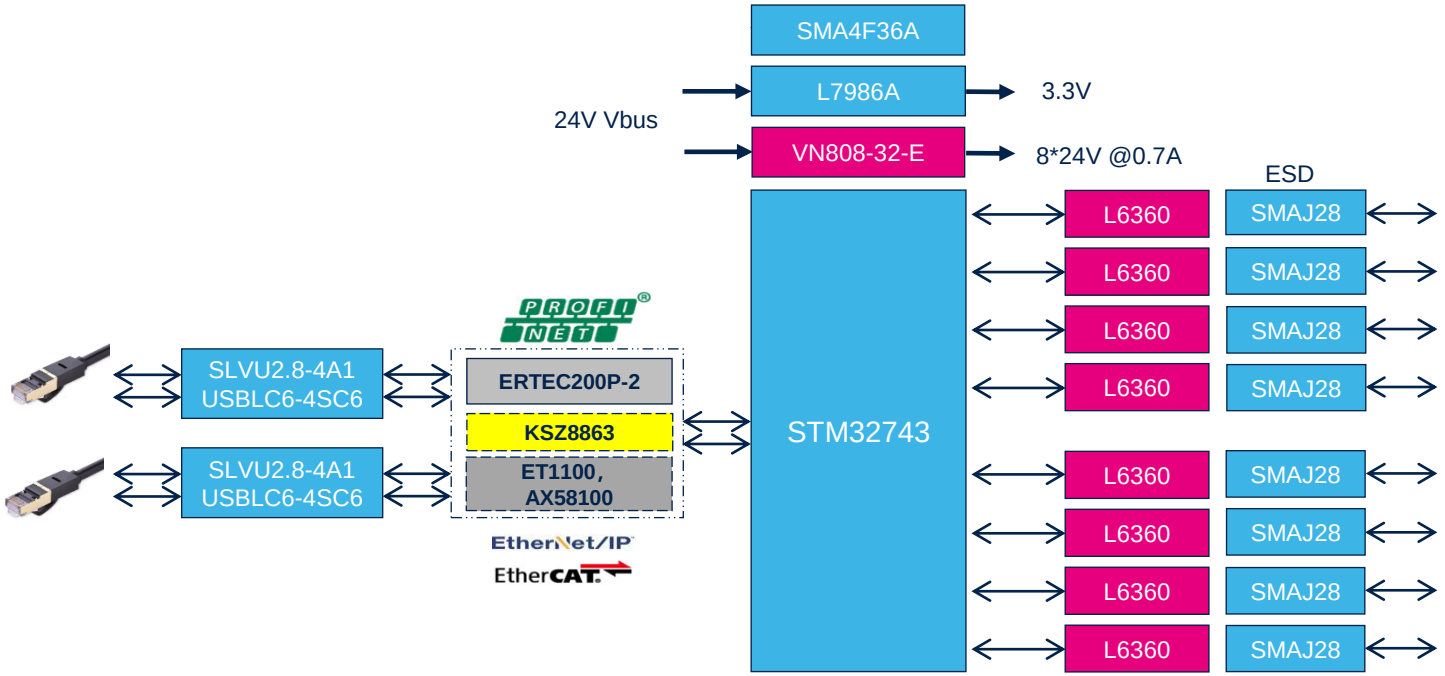
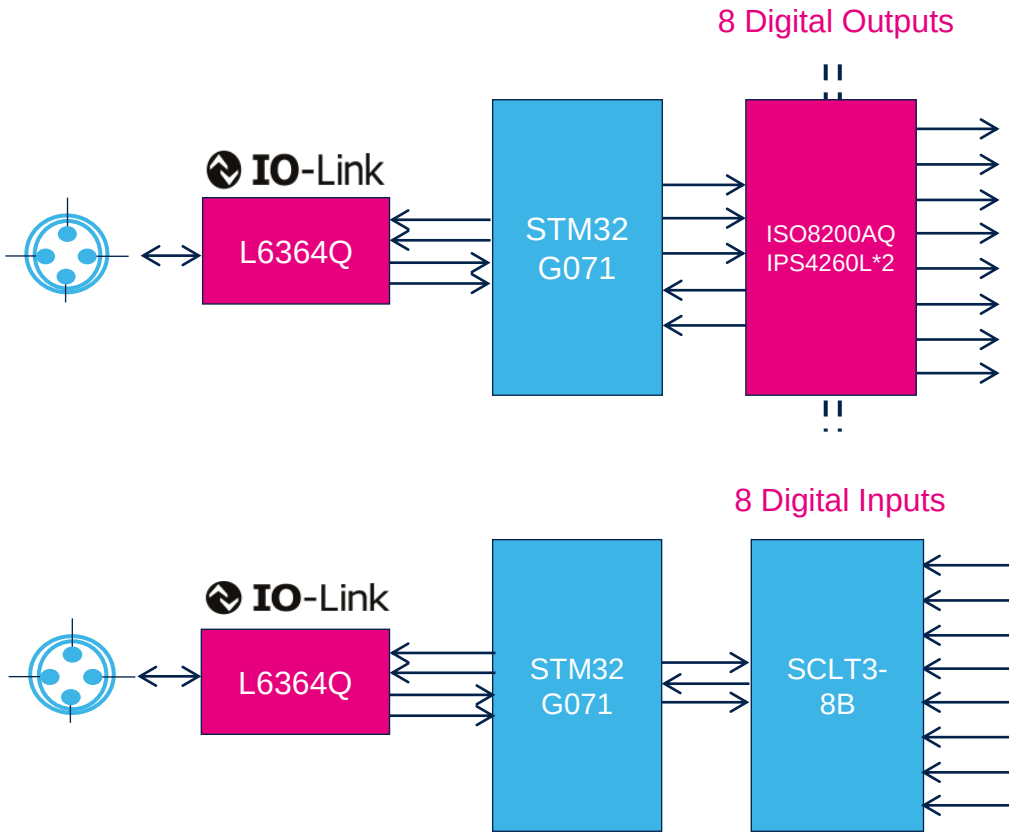
8-Port Master with TMG Stack



Features:

- single MCU as controller
- TMG stack with EthernetIP

IO-Link to 8-ch DI/DO



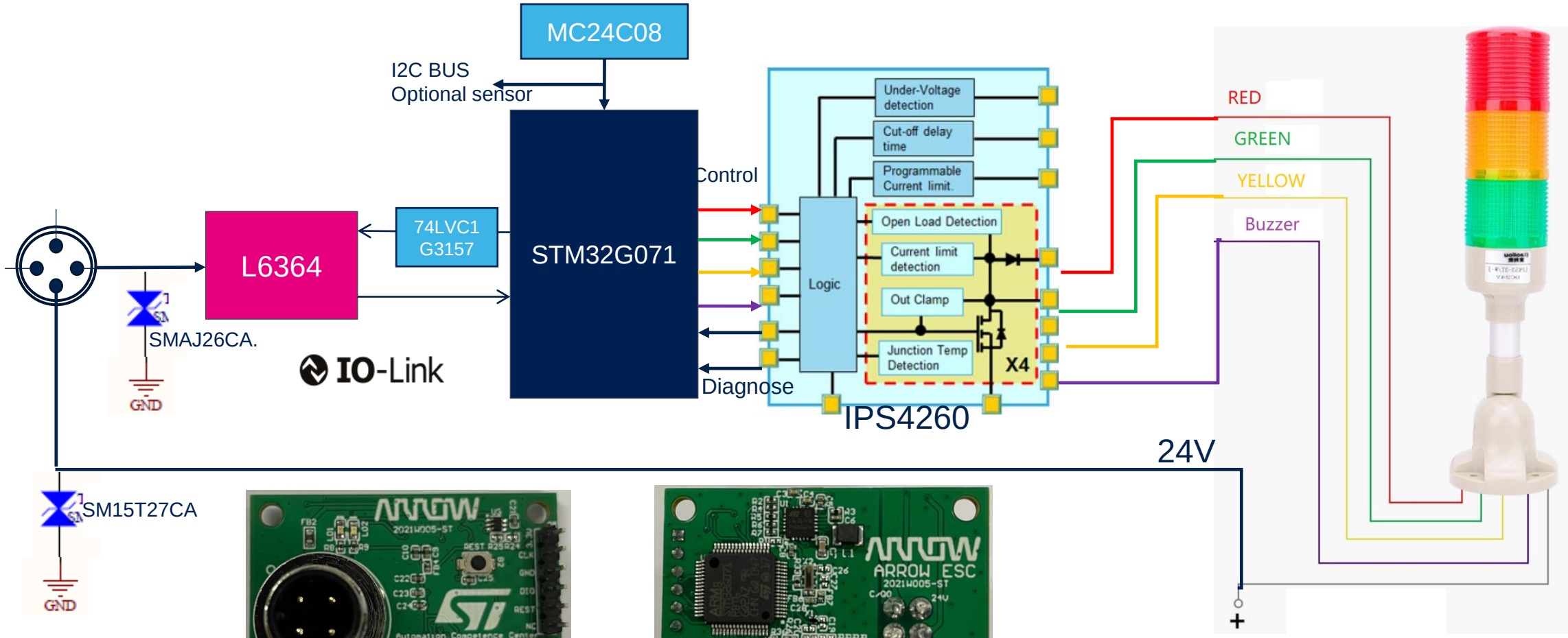
Key P/Ns:

STM32G071
M24C08
L6364Q
ISO8200AQ / SCLT3-8B
SMB15F23AY
SMA4F28A

Features:

- TEConcept mini stack for IO-Link devices
- TMG device stack

IO-Link Actuator LED Tower Light



Features:

- TEConcept mini stack for IO-Link devices

Summary

IO-Link Technology

- Defined by market leaders
- Fully standardized
- Universal
- Easy to use
- Rapidly growing

Use IO-Link
Universal · Smart · Easy

Master & Device ICs

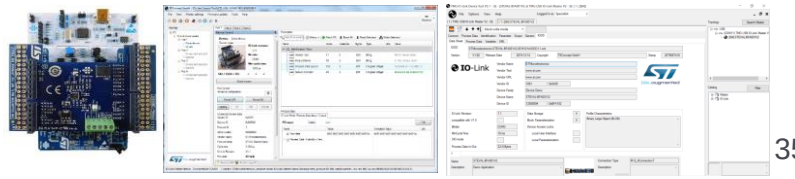
- Scalable ICs portfolio
- Very low ON resistances
- Extensive protections
- Rich feature set
- Wide programmability & diagnostics

STM32 Open Development Environment

TEConcept
Technologie Management Gruppe
Technologie und Engineering

IO-Link Stack + Evaluation ecosystem

- Product evaluation tools
- System-oriented designs
- Hardware + Firmware
- Graphical User Interfaces
- IO-Link stacks available



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