



Industrial
Summit 2021
Shenzhen, China
POWERING YOUR INNOVATION



IO-Link演示与设计考虑

Allen KE 柯新宇
自动化技术创新中心
意法半导体 亚太区

Automation
Competence
Center



- 1 IO-Link技术介绍
- 2 IO-Link主机与从属设备的收发器
- 3 IO-Link评估生态系统
- 4 自动化能力中心系统参考设计

IO-Link技术介绍



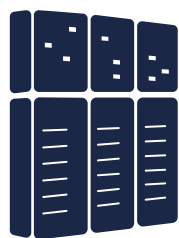
IO-Link连接的智能传感器与执行器

面向下一代工业的首选通信标准

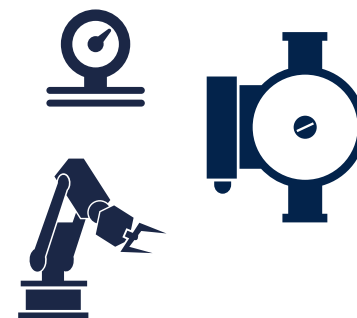


可编程控制器

智能传感器与执行器



IEC 61131-9



连接智能数字传感器与执行器

传感设备

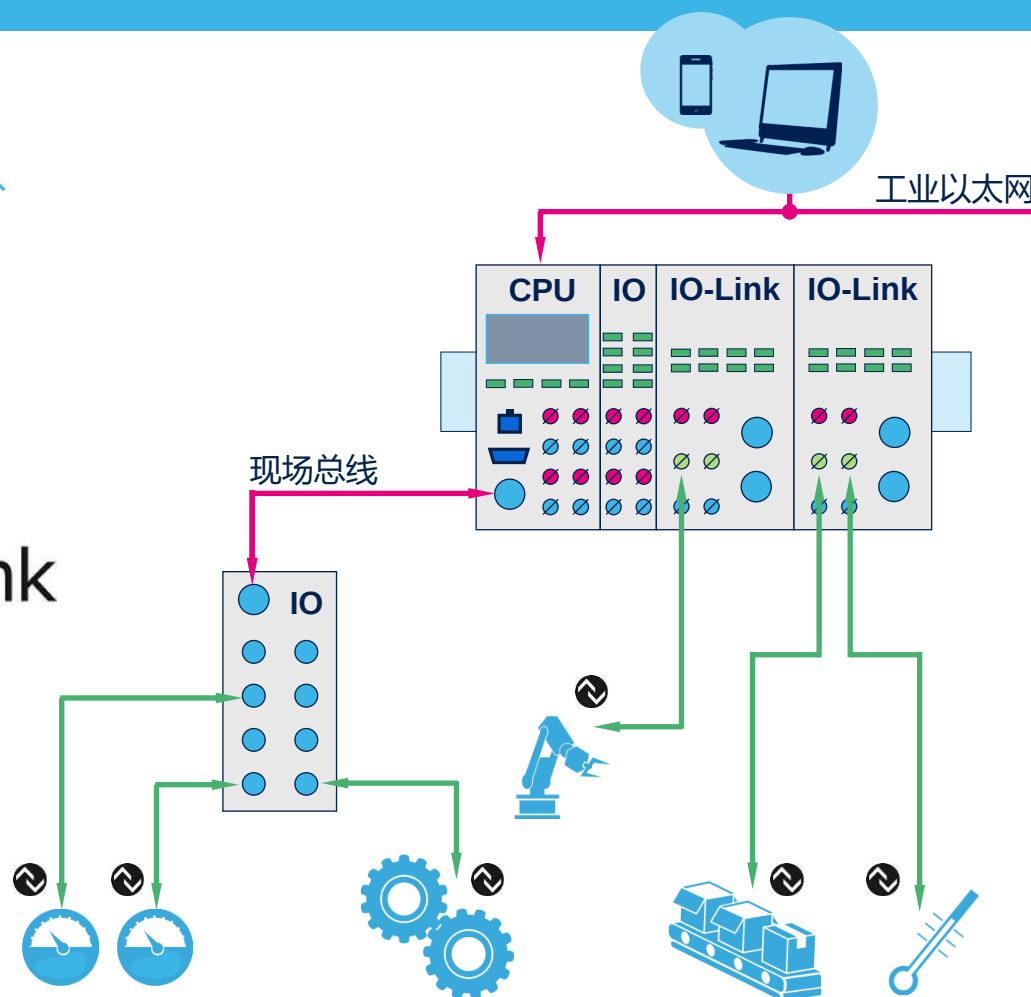


- 温度、压力、流量、接近度...

驱动



- 阀门、泵、灯、继电器、接触器...



可靠的数字通信



诊断与可配置性



轻松调试与模块化

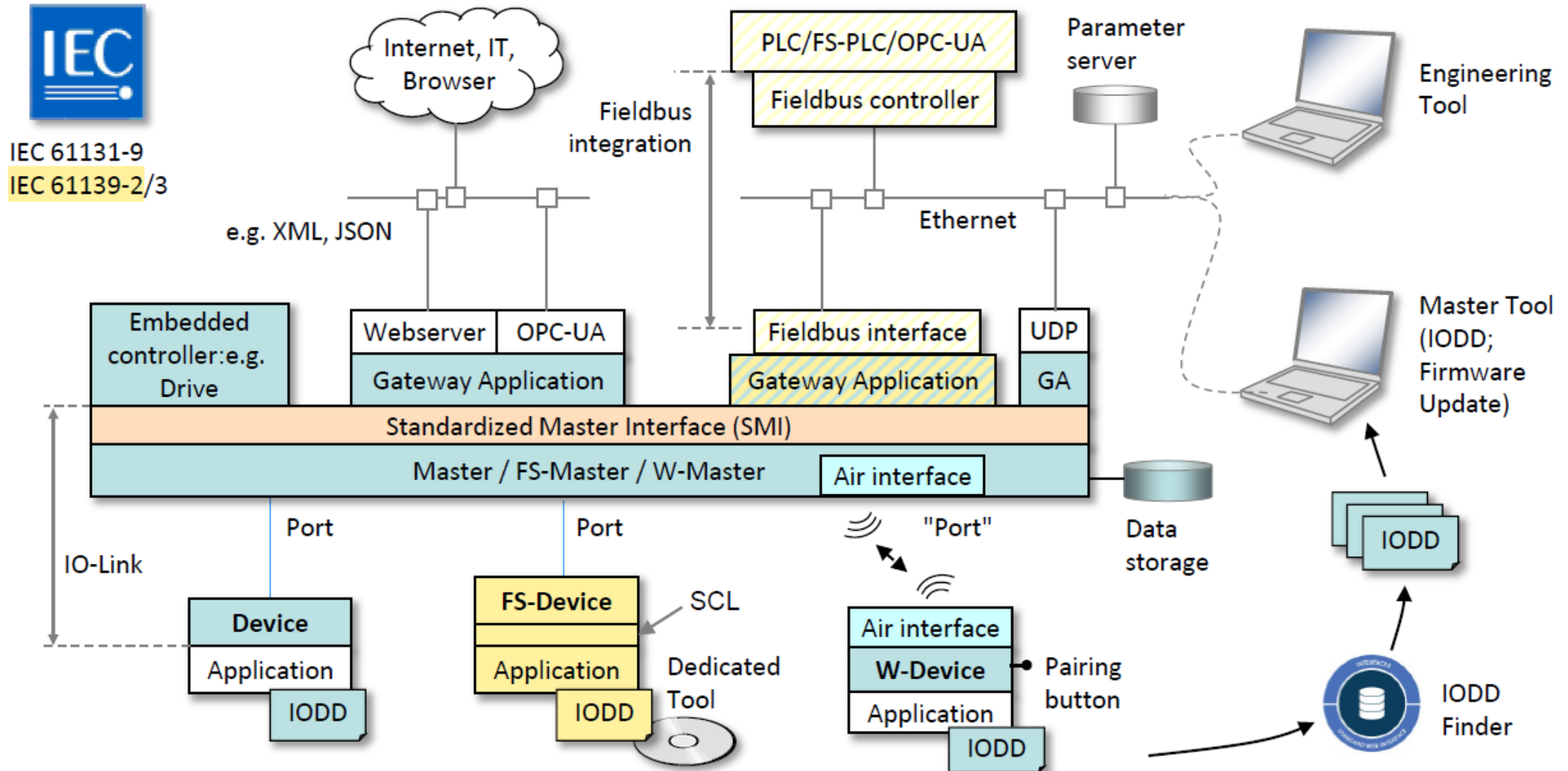


到2020年年底有2100万个IO-Link节点

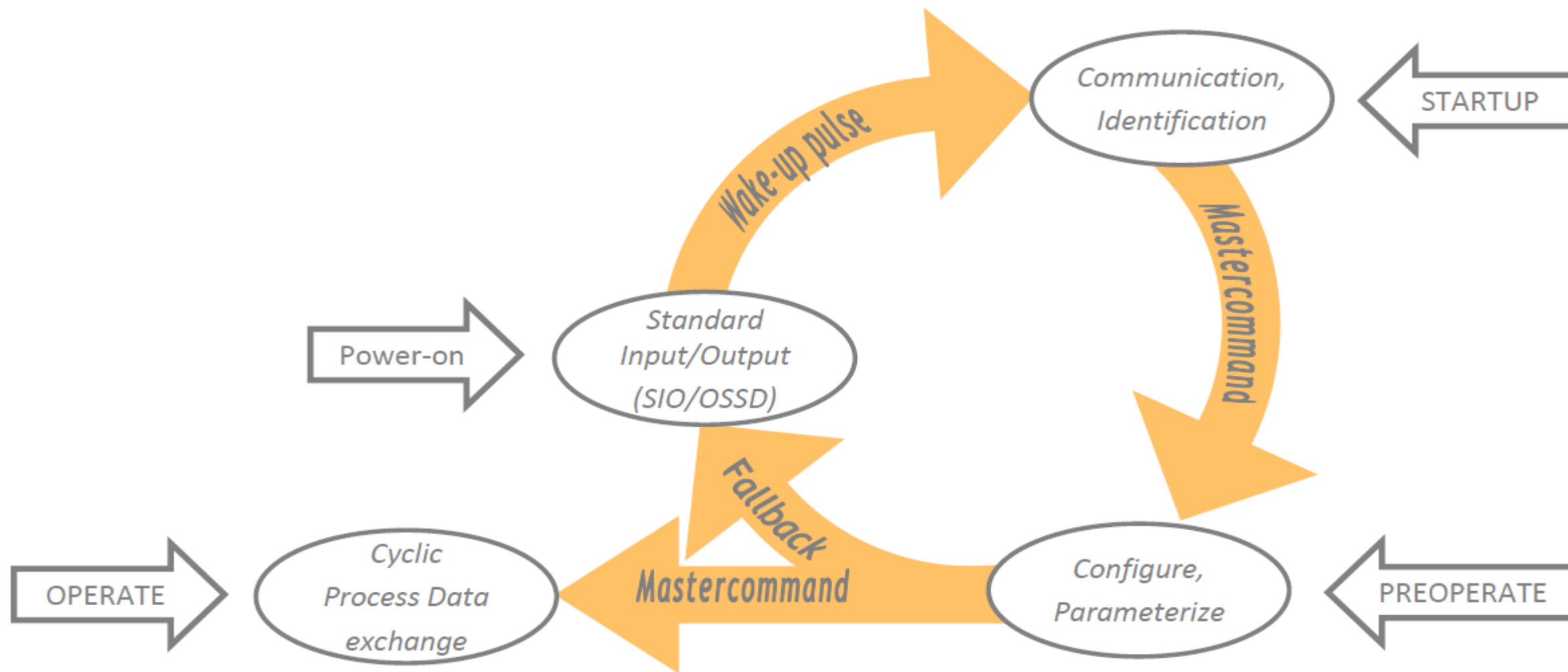
全球超过350家成员公司



IO-Link故事 (版本1.1.3或软件包2020)



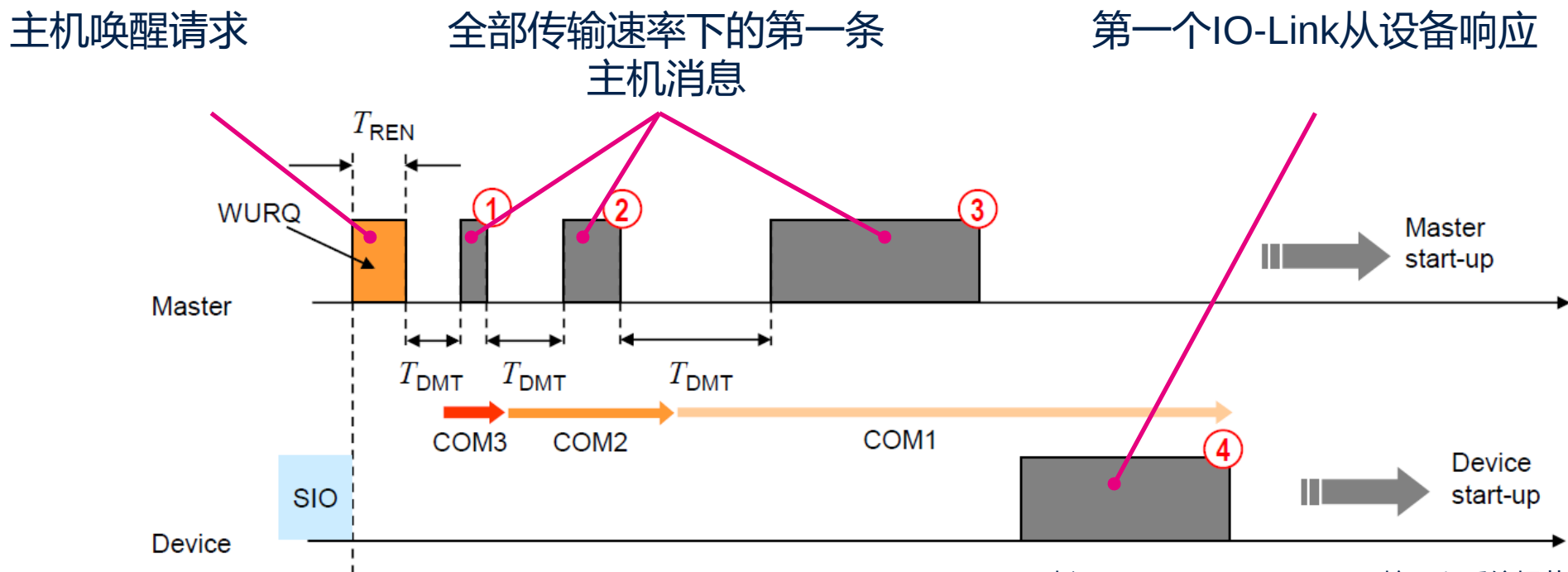
基本IO-Link的启动程序



IO-Link唤醒请求

物理层接口

- WURQ: IO-Link主机驱动C/Q线路，使其与从属设备具有相反的逻辑电平，并维持75至85 μ s
- IO-Link从属设备释放总线，并使主机能够发送第一条消息



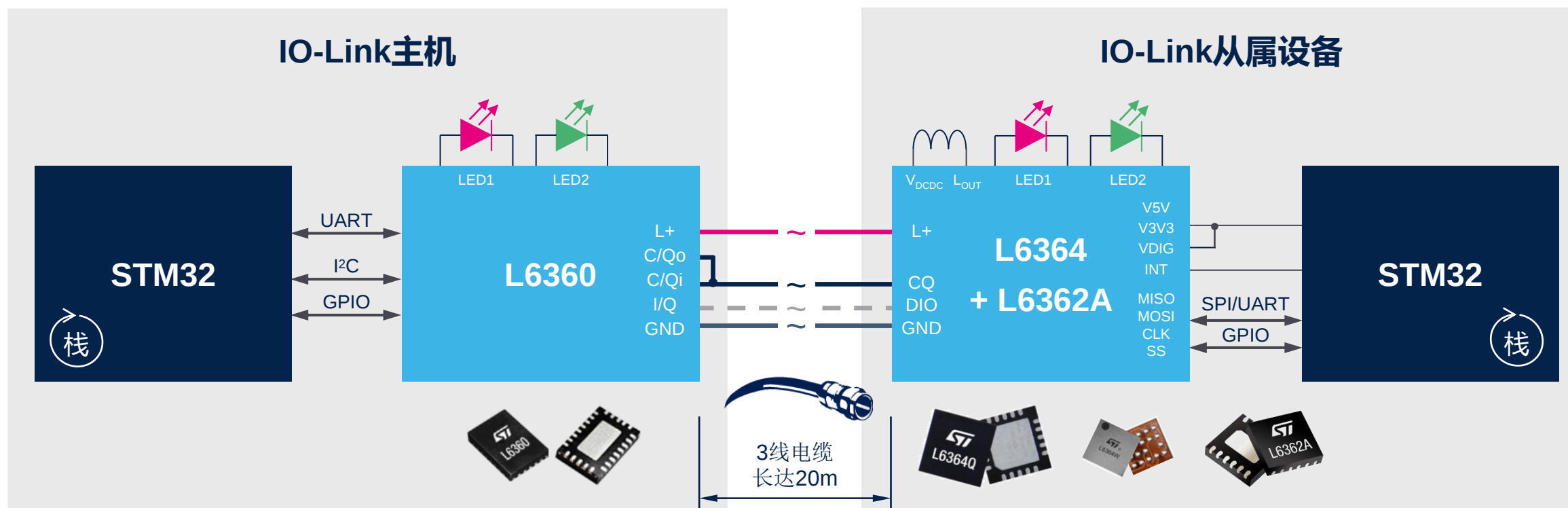
来源: IEC 61131-9、IO-Link接口和系统规范

IO-Link 主机与从属设备的收发器



由意法半导体驱动

基于意法半导体组件的点对点通信



新型双通道IO-Link从设备



L6364Q / L6364W

双通道IO-Link从设备

QFN

4 × 4 mm



CSP

2.5 × 2.5 mm



两个可配置的I/O
高达500 mA / 2.5Ω

支持CRC的集成式M
序列管理

DC/DC转换器
+ 两个50mA线性稳压器

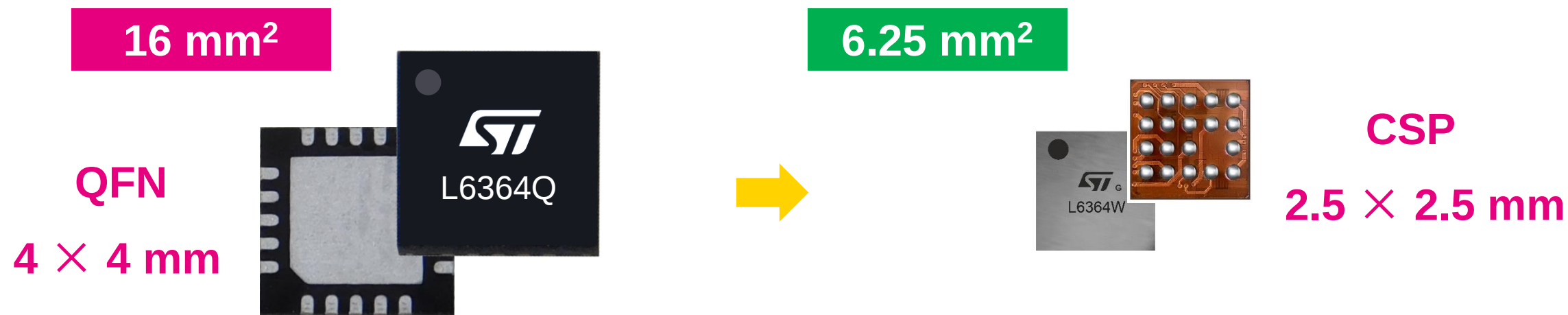
工作电压范围大
4.5 – 35 V

配置和诊断
SPI总线上

全套保护，
包括反向极性与浪涌

CSP vs. QFN封装比较

双通道IO-Link从设备L6364



节约60 %以上的板空间!

IO-Link从设备芯片定位

适用于每个设备的最佳应用



L6362A

- ✓ 最低的 $R_{DS(on)}$ → 最低的功耗
- ✓ 强电磁兼容性
- ✓ 能够驱动高容性负载
- ✓ 通用24V线路接口
- ✓ 易于使用
- ✓ 性价比高



L6364W / Q



- ✓ 高度集成 → 降低了MCU要求
- ✓ 自动时钟获取减少振荡器电路并提供灵活性
- ✓ 广泛的可配置性
- ✓ 两个并行通道，适用于高输出电流
- ✓ 每个通道所占用的空间极小

评估生态系统



life.augmented

X-NUCLEO-IOD02A1

基于L6364的IO-Link平台Nucleo板

过程段反接保护

带可选发送模式的SPI

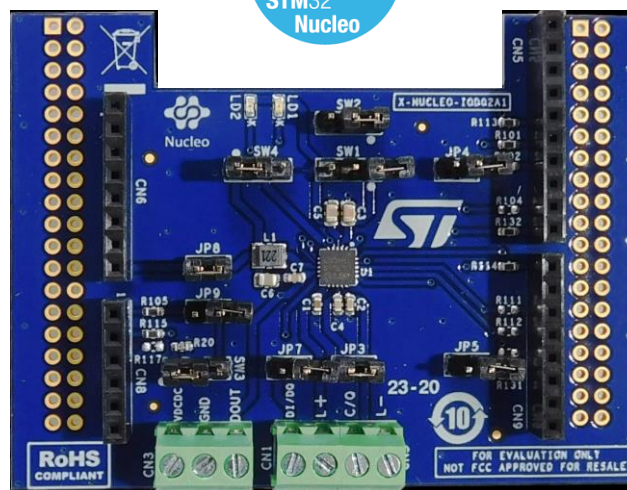
用于状态和诊断的两个用户LED

过程段EMC兼容

X-CUBE-IOD02

IODD XML文件

协议栈库 (IAR、KEIL、GCC)



X-NUCLEO-IOD02A1

兼容
NUCLEO-L073、NUCLEO-G071

包含IO-Link微型栈
和IODD文件

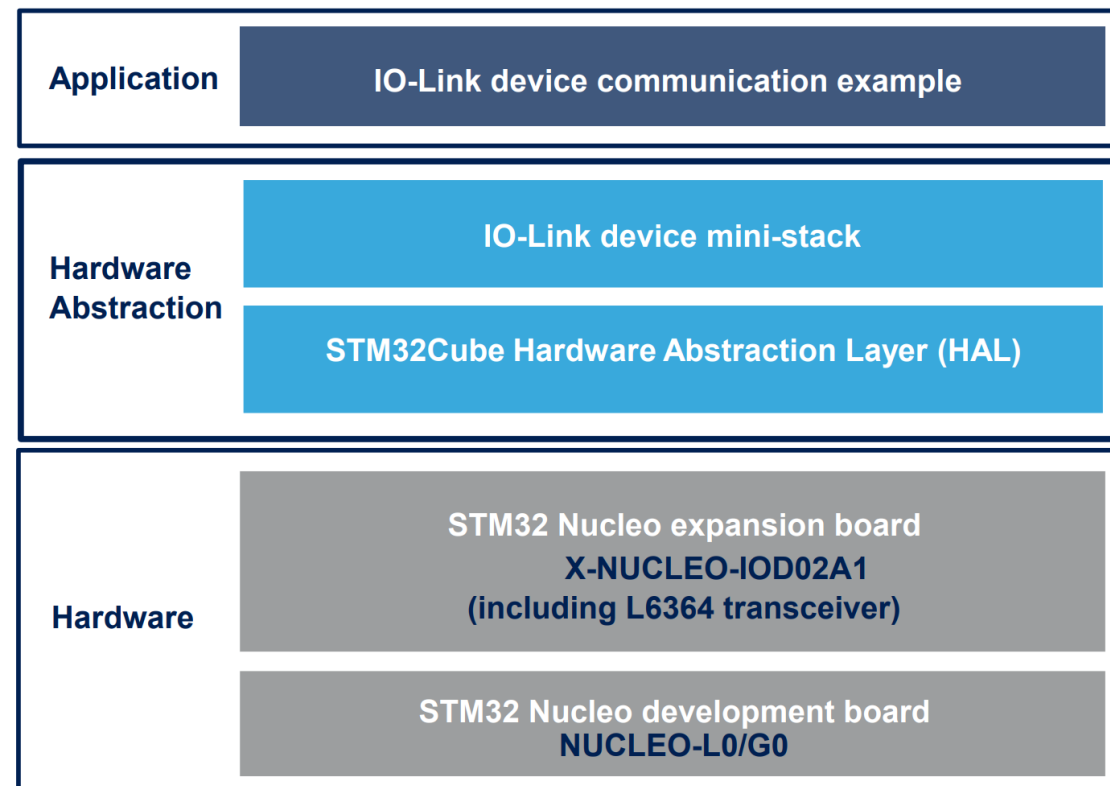
全部包含在X-CUBE-IOD02中

X-CUBE-IOD02: 适用于L6364的软件

STM32Cube的工业IO-Link从设备软件扩展

- 用于在L6364上构件应用的完整软件
 - 包括IO-Link从设备微型栈库支持
 - 单八位组, 多八位组IO-Link模式和UART透传模式
- COM2 (32.4kbit/s), COM3 (230.4kbit/s)
- GPIO、SPI、UART和IRQ配置
- 可轻松移植到不同的STM32微控制器
- (STM32CubeHAL) 上
- 包括X-NUCLEO-IOD02A1的示例应用程序
- 免费用户友好的许可

软件架构:



采用L6364的多传感器功能套件

采用工业传感器P-NUCLEO-IOD02A1的评估套件

过程段反接保护

带可选发送模式的SPI

用于状态和诊断的两个用户LED

过程段的电磁兼容

FP-IND-IODSNS1

X-CUBE-MEMS1

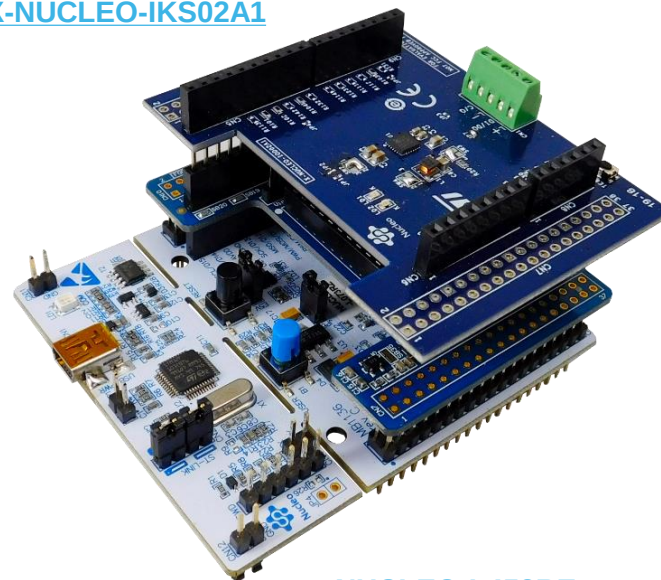
X-CUBE-IOD02

IODD XML文件

堆栈库 (IAR、KEIL、GCC)

X-NUCLEO-IOD02A1

X-NUCLEO-IKS02A1

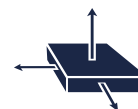


NUCLEO-L452RE

套件中的预编程Nucleo + L6364
+ 传感器板

包含IO-Link微型栈
和IODD文件

FP-IND-IODSNS1功能包包含所有
需要的固件



IQInterface - IO-Link测试仿真工具

用于IO-Link系统测试的实验室工具

IO-Link开发与调试工具

主机和从属设备仿真

允许通信与EMC测试的GUI和DLL

从属设备



IQInterface - IO-Link调试

IO-Link生产与开发工具



- 适用于以下设备的开发工具
 - IO-Link主机
 - IO-Link从属设备
- 允许在开发和系统调试期间评估和测试IO-Link通信
- RS232、USB、以太网连接接口
- 提供用于以下用途的GUI应用程序
 - IO-Link系统调试
- EMC测试
- 包括通信DLL和Python测试自动化库

IO-Link EMC要求

IO-Link规定了电磁兼容性要求

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		

定义了测试期间的M序列数量和最大错误率

未指定浪涌抗扰性，但通常由客户要求

IO-Link EMC要求

IO-Link规定了电磁兼容性要求

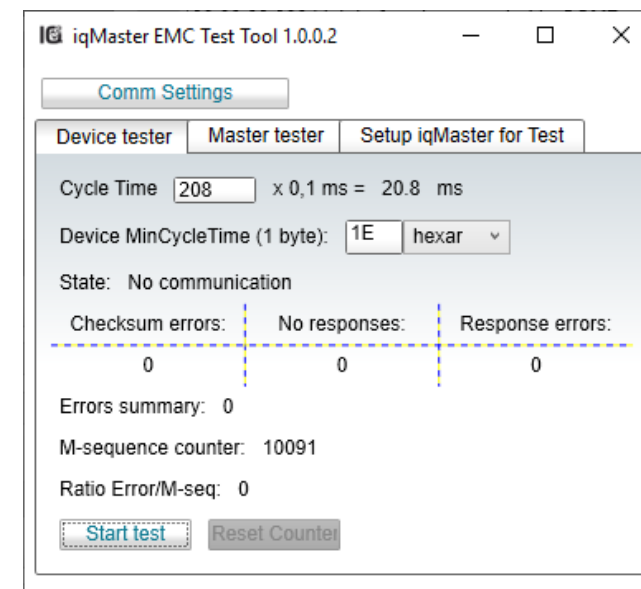
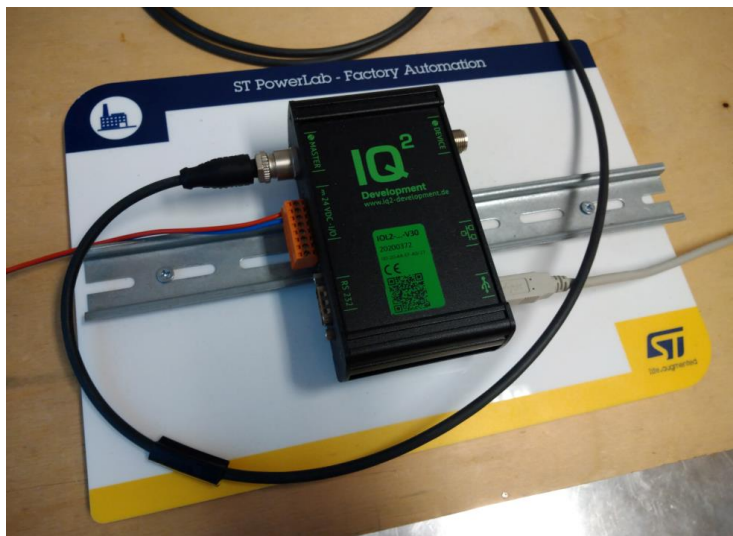
Transmission rate	Master		Device		Maximum of M-sequence errors
	t_{CYC}	Number of M-sequences of TYPE_2_5 (read) (6 octets)	t_{CYC}	Number of M-sequences of TYPE_0 (read) (4 octets)	
4,8 kbit/s	18,0 ms	300 (6 000)	100 T_{BIT} (20,84 ms)	350 (7 000)	6
38,4 kbit/s	2,3 ms	450 (9 000)	100 T_{BIT} (2,61 ms)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

定义了测试期间的M序列数量和最大错误率

IO-Link EMC要求

EMC抗扰度测试



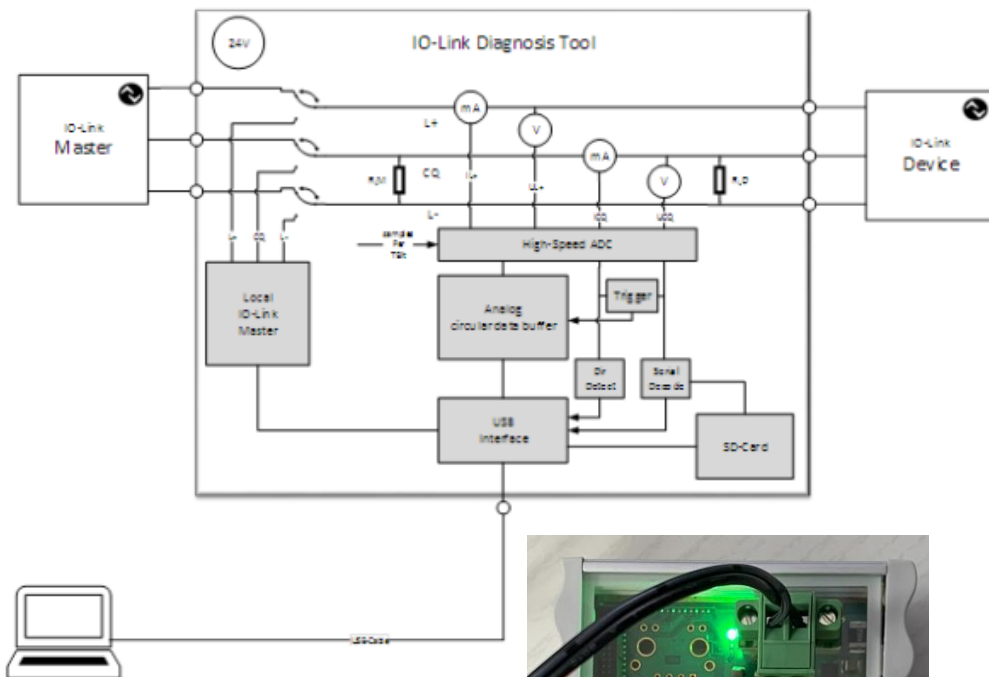
快速脉冲测试(EFT)
IEC 61000-4-4标准



±1kV (5kHz)
通过电容钳制来应用



诊断工具

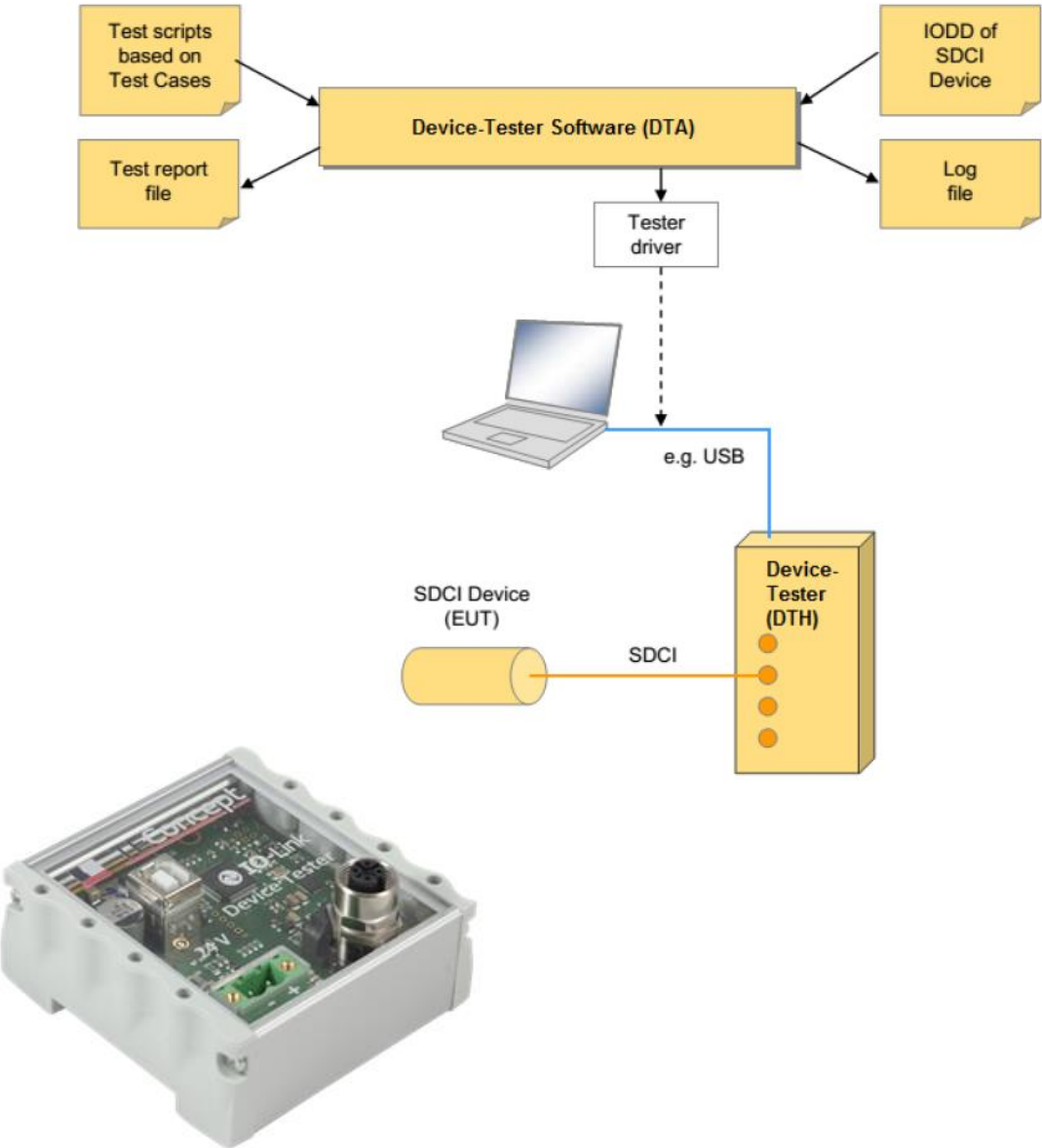


Raw View Msequence View X							
Filter Settings							
Timestamp	Cycle Time	Access	Address	Master Request	Response Delay	Device Response	PD validity
00:05.970465	0 μs	R	2	0xA2 0x00	33.8 μs	0x04 0x3F	valid
00:05.971672	1206 μs	R	3	0xA3 0x11	33.8 μs	0x01 0x3C	valid
00:05.972910	1238 μs	R	4	0xA4 0x33	32.9 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

Protocol View X 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, 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	
00:34.793091	OPERATE	Event status	Read event status code	Event with details: activated events: 1	

- 周期时间
- 入门
- 地址
- 请求
- 响应
- 响应延迟
- PD延迟
- 状态
- 动作
- 消息
- 详细信息

从设备测试仪



测试日志和跟踪

Test case:

Test ID: SDCI_TC_0037

Name: TCD_DLPC_OPER_OPERSTUP1

Group: Startup

Version: 1.1

Purpose: Test correct state transition from OPERATE to STARTUP

EUT: Device and Legacy-Device, except Devices with zero length process data

Spec.: [9], see 7.2.3.5, 9.3.3.2

Initial s.: Operate

Category: Device protocol test; test to pass (positive testing)

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

Step information:

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 IO-Link communication on error: No
- Next state on error: Startup

Store:

-

Log:

Test: SDCI_TC_0037

Set Device initial 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:

- Cycle time: 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. [Device state: E_DEVICESTATE_SIO]

Trace:

Test case: SDCI_TC_0037

Set initial state:

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

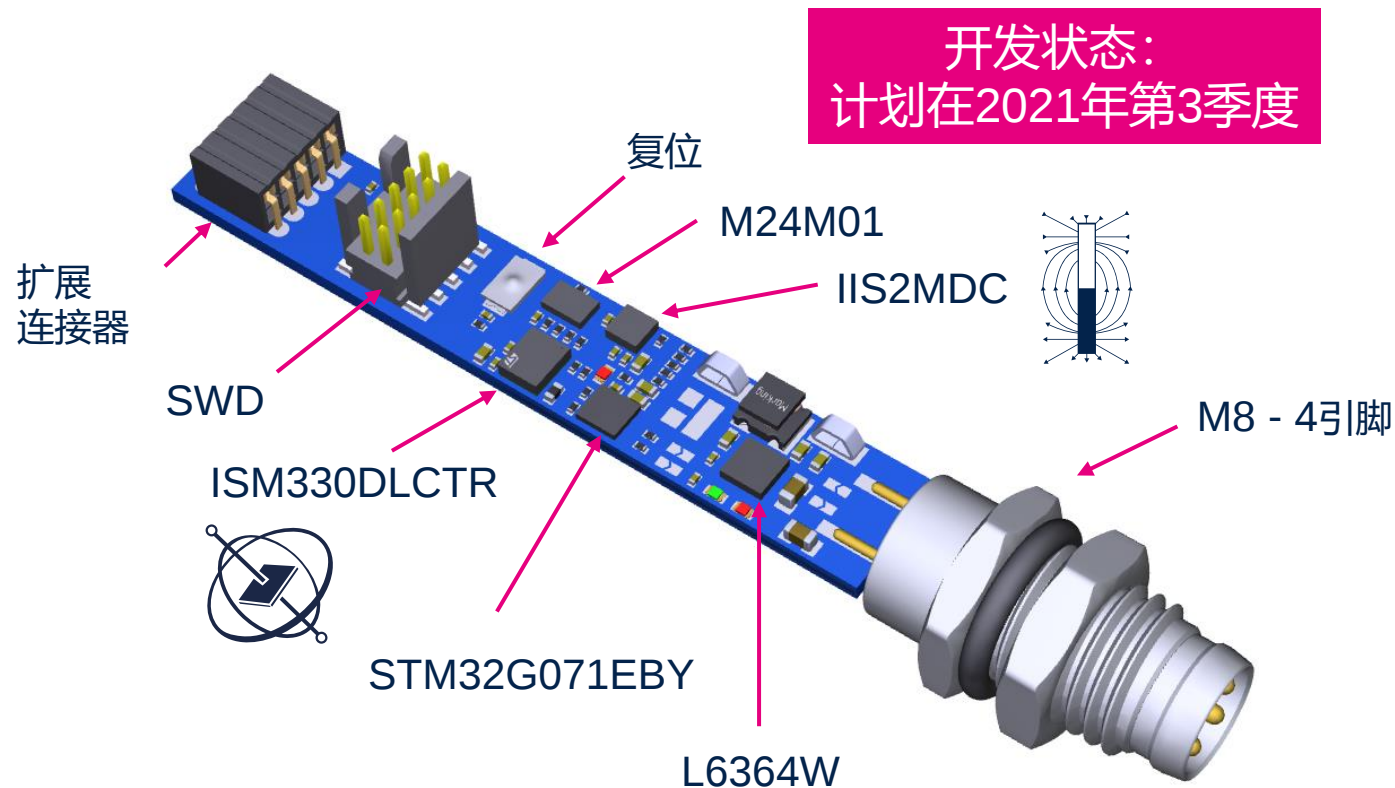
(Set DTH parameters)

基于L6364W的IO-Link工业传感器参考设计套件

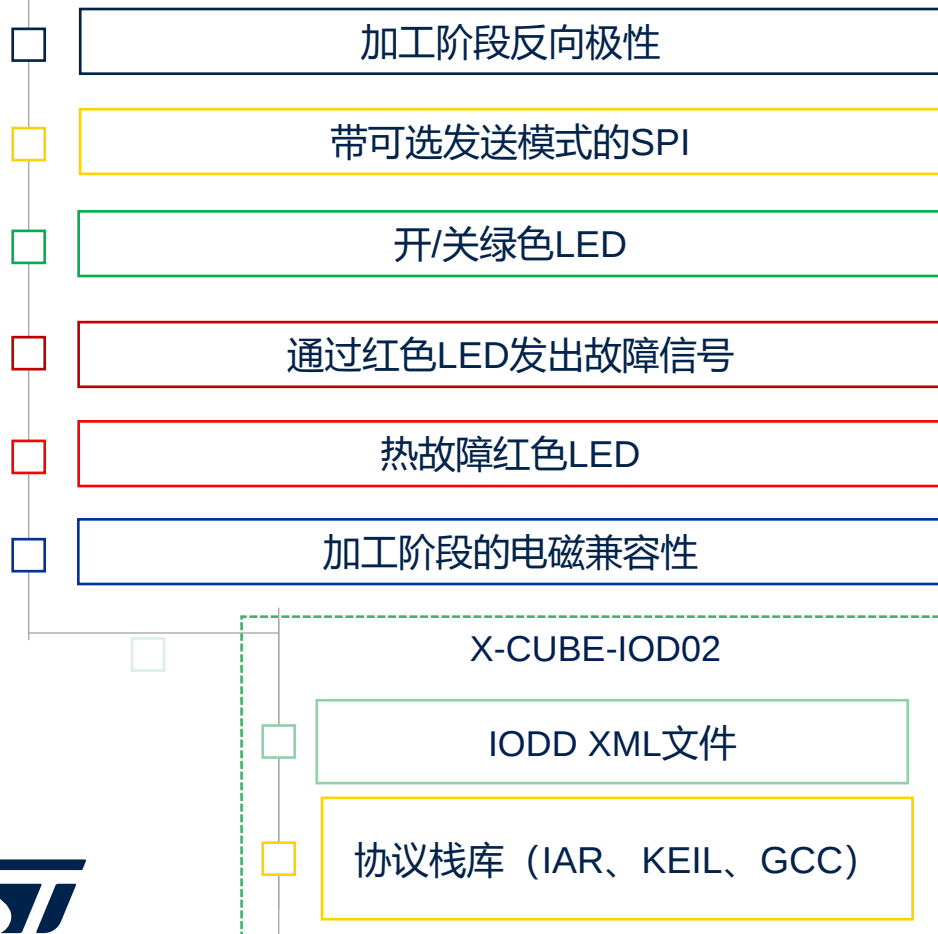
- 基于L6364W的多传感器板
- 兼容IO-Link v.1.1/COM3
- 最小的尺寸PCB 45×7.5mm
- SWD编程接口和工业现场侧连接器M8

将在套件中提供，具有全部所需附件，包括：

- STLINKV3-MINI编程器
- M8-M12适配器线缆
- IO-Link固件包



基于L6364的IO-Link平台Nucleo板



L6364Q (QFN20L)
X-NUCLEO-IOD02A1

- 可提供



L6364W (CSP19)
STEVAL-IOD002V1

- 可提供

采用L6364Q和L6364W的设计示例

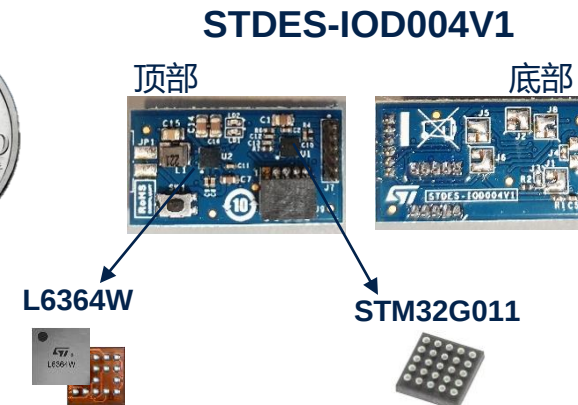
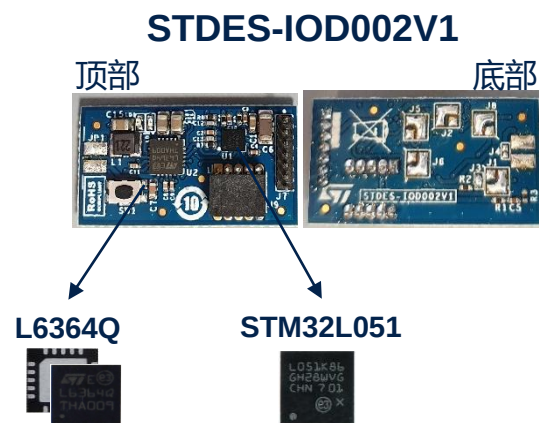
- ☐ 加工阶段反向极性
- ☐ 带可选发送模式的SPI
- ☐ 开/关绿色LED
- ☐ 通过红色LED发出故障信号
- ☐ 热故障红色LED
- ☐ 加工阶段的电磁兼容性

STSW-IOD02L051/IOD04G071

IODD XML文件

协议栈库 (IAR、KEIL、GCC)

研发中

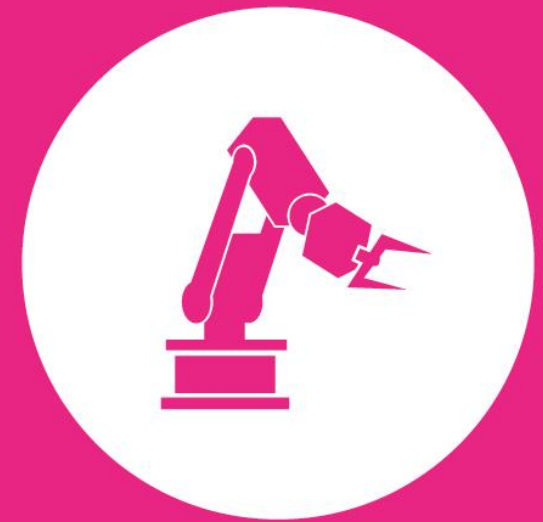


基本参考设计

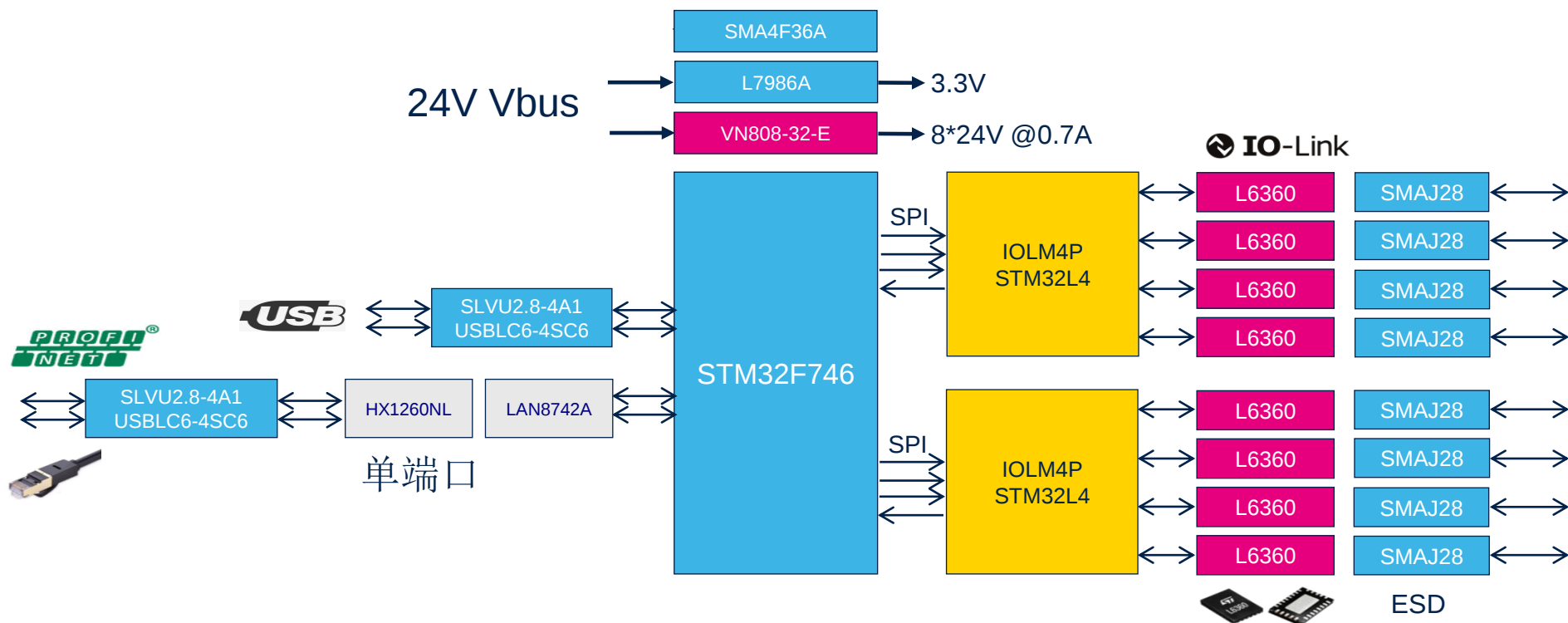
- L6364Q 或 L6364W
- STM32L051 或 STM32G071
- 10引脚扩展连接器
- 7或6 SWD连接器

自动化能力中心系统参考设计

Automation Competence Center



基于IOLM4P的8端口IO-Link主机

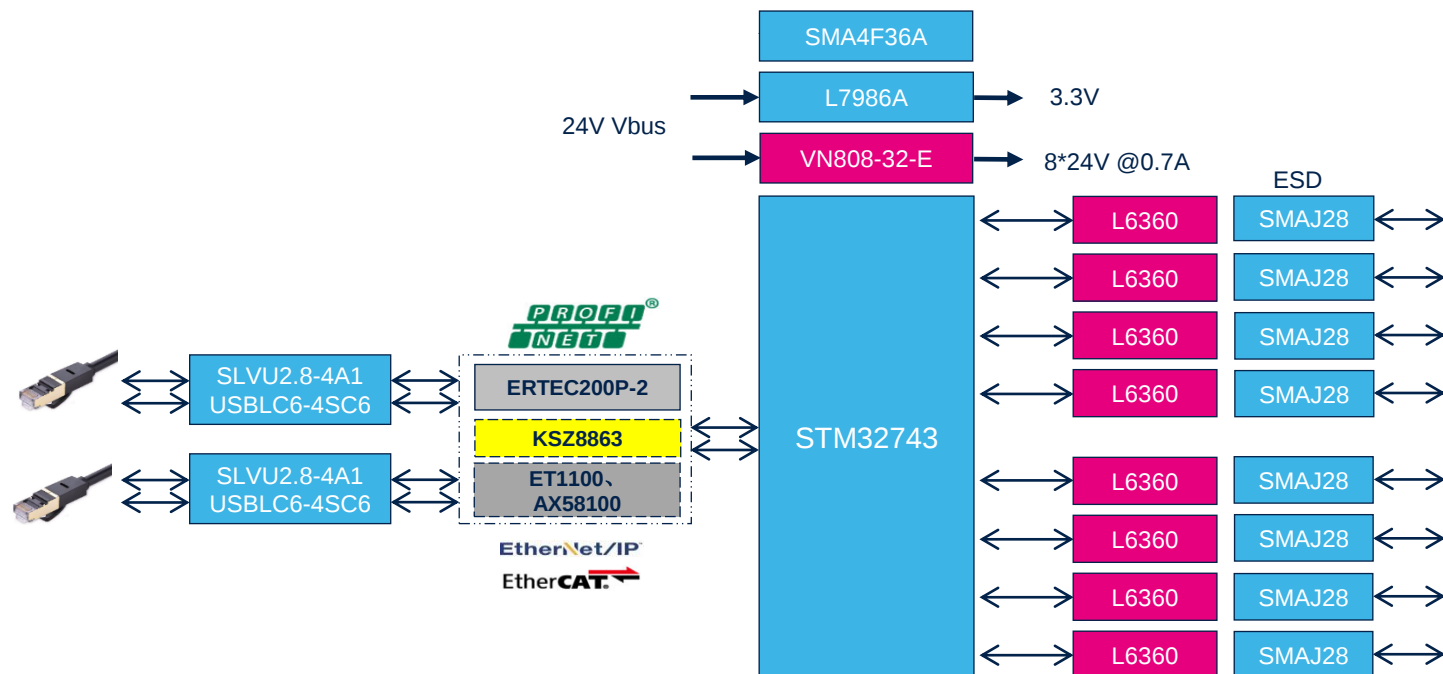


特性:

- 即用型8端口IO-Link主机PC控制工具
- 通过定制的STM32F7高级主机访问程序可实现广泛的功能



带TMG栈的8端口主机

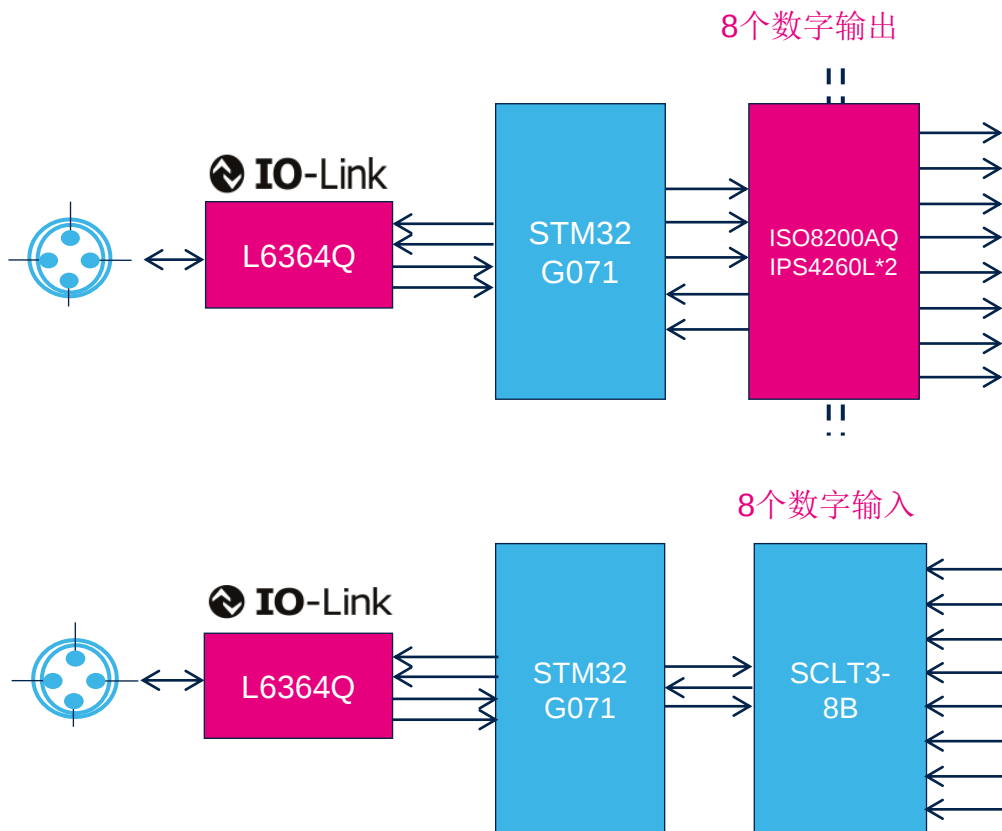


特性:

- 单个MCU作为控制器
- 支持EthernetIP的TMG栈



IO-Link至8通道 DI/DO



主要P/N:

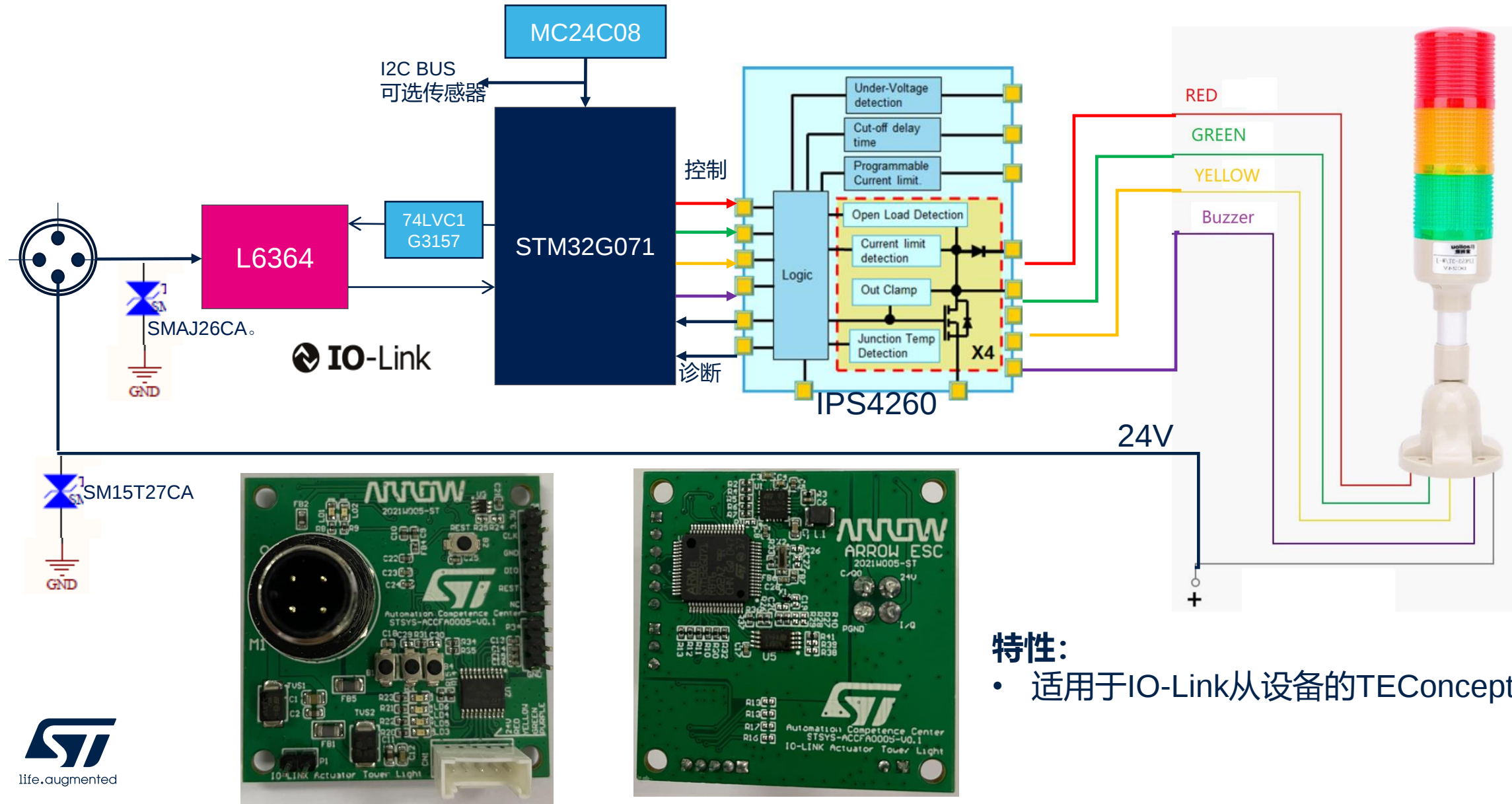
- STM32G071
- M24C08
- L6364Q
- ISO8200AQ / SCLT3-8B
- SMB15F23AY
- SMA4F28A



特性:

- 适用于8通道的TEConcept微型栈
- TMG设备栈

IO-Link执行器LED塔灯



特性:

- 适用于IO-Link从设备的TEConcept微型栈

IO-Link技术

- 由市场领导者定义
- 完全标准化
- 通用型
- 使用方便
- 迅速增长

Use  **IO-Link**
Universal · Smart · Easy

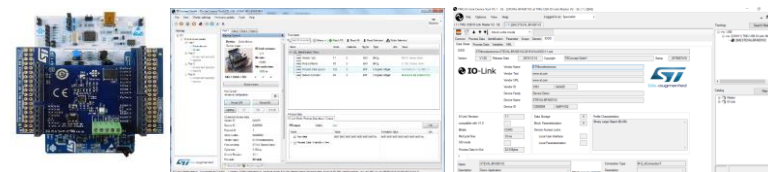
主机和从属设备IC

- 可扩展的IC产品组合
- 极低的导通电阻
- 全面的保护
- 丰富特性集
- 广泛的可编程性与诊断



IO-Link协议栈 + 评估生态系统

- 产品评估工具
- 面向系统的设计
- 硬件 + 固件
- 图形用户界面
- 可提供IO-Link协议栈





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