IO-LINK

Handbook

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Introduction

Today's fanless programmable logic controller (PLC) and IO-Link® gateway systems must dissipate large amounts of power depending on the I/O configuration (IO-Link, digital input/output, analog input/outputs). As these PLCs evolve into new Industry 4.0 smart factories, special attention must be considered to achieve smarter, faster, and lower power solutions. At the heart of this revolution is an exciting new technology called IO-Link, which enables flexible manufacturing to improve factory throughput and operational efficiency. This exciting new technology enables traditional sensors to become intelligent sensors. At Maxim, we provide a portfolio of advanced factory automation solutions that create pathways toward achieving Industry 4.0, enhanced by our IO-Link technology portfolio.

Sensors are found everywhere—ubiquitous in our everyday lives. In the manufacturing environment, all manufactured products require an array of sensors that work in unison to help machines detect an object, determine the distance to an object, configure the colors and composition of an object, and monitor the temperature and pressure of an object or liquid.

Constantly sending a technician to the factory floor to change a sensor and then re-calibrate it to the correct manufacturing parameters for a single product costs time and money. This negatively impacts the manufacturing flow and represents lost productivity. If we multiply this same level of maintenance for many different types of products on a manufacturing line, then the unproductive time spent shutting down production and changing or reconfiguring a sensor is the single-most costly expense that all manufacturing lines incur.

IO-Link is a technology that enables a traditional binary or analog sensor to become an intelligent sensor that no longer just gathers data, but allows a user to remotely change its settings based on real-time feedback obtained on the health and status of other sensors on the line, as well as the manufacturing operation it needs to perform. IO-Link technology enables sensors to become interchangeable through a common physical interface that uses a protocol stack and an IO Device Description (IODD) file to enable a configurable sensor port. It is truly plug-and-play ready while providing the ability to reconfigure parameters on-the-fly.

IO-Link is a powerful technology that will play a pivotal role over time in factory, process, and building automation as well as other industries. It will not only save manufacturers billions every year but will expand new markets for more customization of products. If you are involved in factory, process, or building automation, watch IO-Link technology as it continues to unleash the true power of Industry 4.0 and changes the way we think of manufacturing.

Jeff DeAngelis,
Managing Director
Industrial & Healthcare Business Unit

Maxim Integrated

Section 1: Introduction to IO-Link

Old School Sensor

Historically, a sensor included a sensing element and a way to get the sensing data to a controller. Data was often transferred in analog format (Figure 1) and was unidirectional (sensor to master only). This added extra steps to the process (such as digital-to-analog and analog-to-digital conversion) which, in turn, added extra cost, larger footprints and susceptibility to noise. These "old school" sensors worked, but as technology advanced, sensor manufacturers integrated more functionality into sensors, eliminating some of these problems with the introduction of binary sensors.

However, data was still limited to unidirectional communication from the sensor to the master, limiting error control and requiring a technician on the factory floor for manual calibration.

Manufacturers needed a better solution to meet the demands of Industry 4.0, smart sensors, and reconfigurable factory floors. The solution that emerged is IO-Link.

Tiny Binary Sensor Drivers

Binary sensors have only two states: On or Off. Examples of binary sensors are pressure switches, temperature switches, through-beam photoelectric sensors, proximity sensors, and pushbuttons. Binary sensor output drivers, such as the **MAX14838**/**MAX14839** (Figure 2), are 24V/100mA drivers optimized for use in industrial sensors. These devices integrate the high-voltage (24V) circuitry commonly found in industrial sensors, such as a configurable or pin-selectable PNP/NPN/push-pull driver and an integrated linear regulator that meets common sensor power requirements. The output driver interfaces between the sensor or sensor microcontroller unit (MCU) and the digital input (DI) module of the PLC.

To provide flexibility in supporting a broad range of physical sensor types, logic inputs allow the output driver to be configured for high-side (PNP), low-side (NPN), or push-pull operation. An additional input allows the user to select between normally open and normally closed logic. The MAX14838/MAX14839 are highly integrated products, making them ideal for robust sensor solutions in a tiny footprint due to integrated reverse-polarity protection, an on-board LDO, and LED drivers.

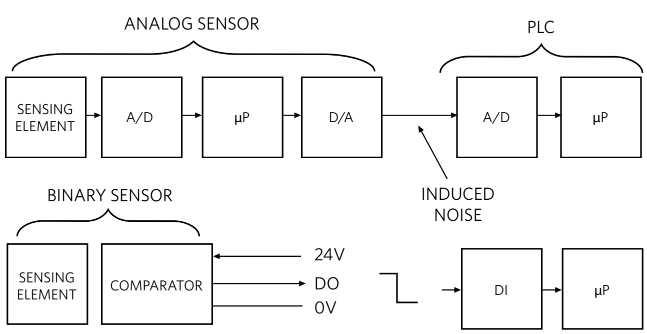


Figure 1. Evolution of Sensors from Analog to Binary

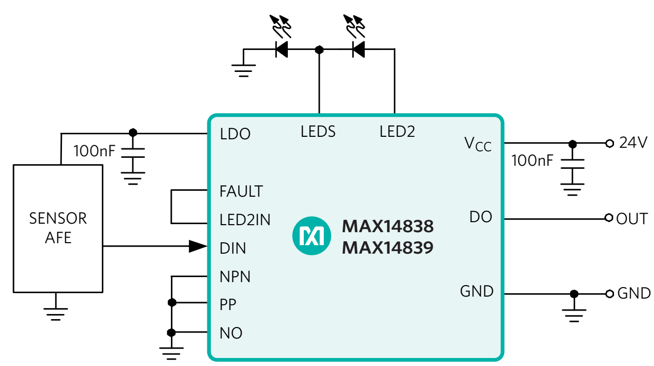


Figure 2. 24V Pin-Configurable Industrial Sensor Output Driver

IO-Link: An Open, Low-Cost Sensor Interface

IO-Link is a standardized technology (IEC 61131-9) regulating how sensors and actuators in industrial systems interact with a controller. The IO-Link Company Community (www.io-link.com) was formed in 2008 by a group of 41 sensor and actuator manufacturers who started the IO-Link consortium with the goal to standardize the hardware (PHY layer) interface and the communication (data) protocol for IO-Link products. Currently, there are over 100 companies in the consortium including semiconductor vendors and software vendors. Maxim has been a member of the IO-Link consortium since 2009.

IO-Link is a point-to-point communication link with standardized connectors, cables, and protocols. The IO-Link system is designed to work within the industry-standard 3-wire sensor and actuator infrastructure and is comprised of "IO-Link master" and "IO-Link device" products (Figure 3).

IO-Link Nodes

The number of installed IO-Link nodes continues to rapidly grow as sensor companies move from older analog sensors to "smart" IO-Link-based sensors, enabling the promise of reconfigurable manufacturing as outlined by Industry 4.0 (Figure 4).

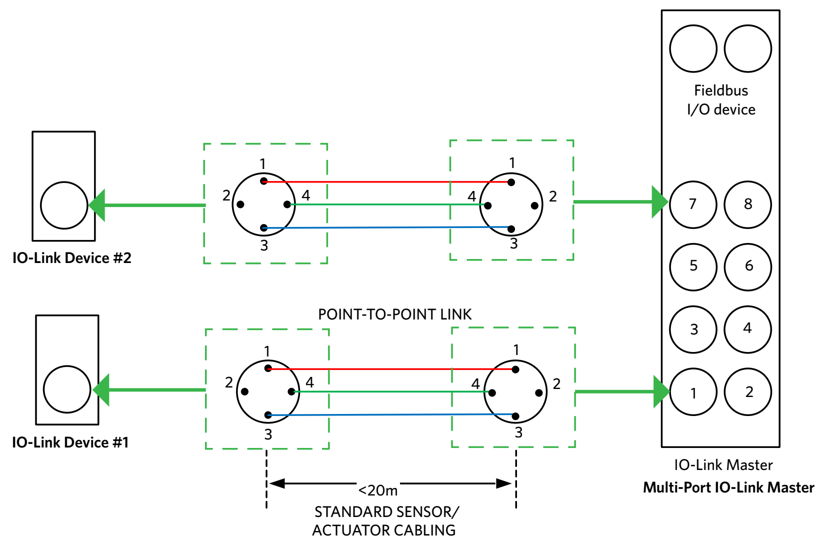


Figure 3. IO-Link Master/Device Interface

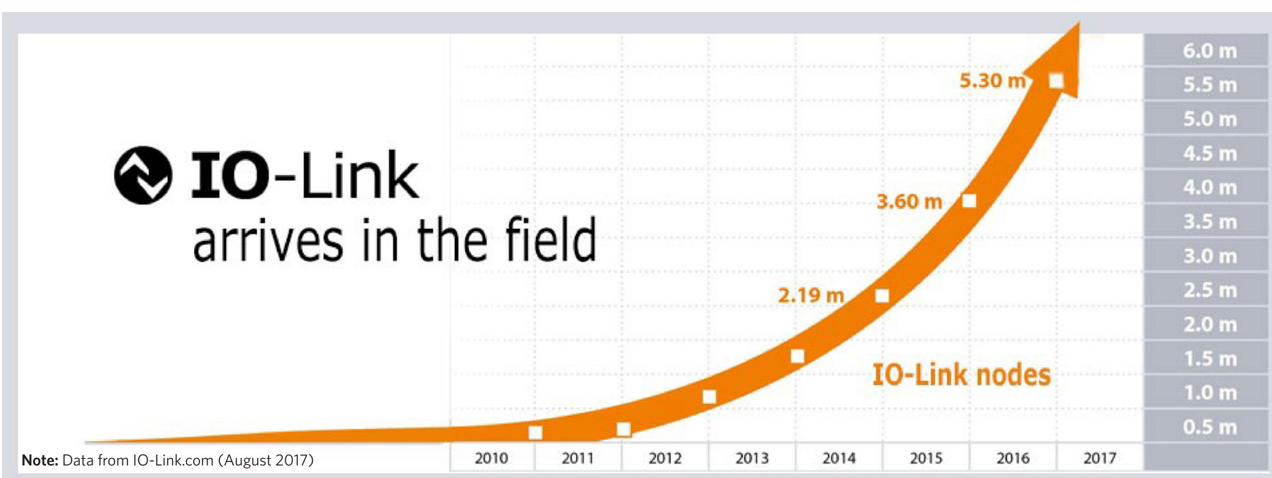


Figure 4. Projected Growth in Number of IO-Link Nodes

IO-Link System

The point-to-point connection between the IO-Link master (multi-port controller or gateway) and the IO-Link device (sensor or actuator) uses standard connectors (usually M12) and a 3- or 4-wire cable up to 20 meters in length. The master can have multiple ports (commonly four or eight). Each port of the master connects to a unique IO-Link device, which can operate in either SIO mode or bidirectional communication mode. IO-Link is designed to work with existing industrial architectures such as fieldbus or industrial Ethernet and connects to existing PLCs or human-machine interfaces (HMIs), enabling rapid adoption of this technology (Figure 5).

For full details of IO-Link, refer to the IO-Link Interface and System Specification Version 1.1.2 dated July 2013 at www.io-link.com.

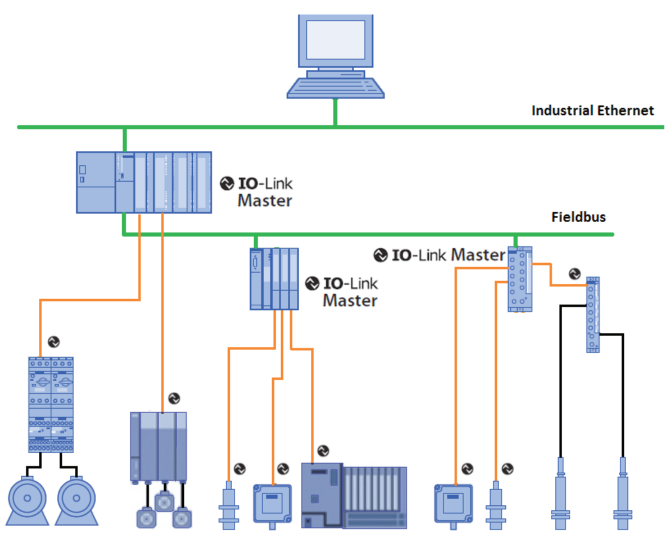


Figure 5. IO-Link Compatibility with Existing Industry Protocols

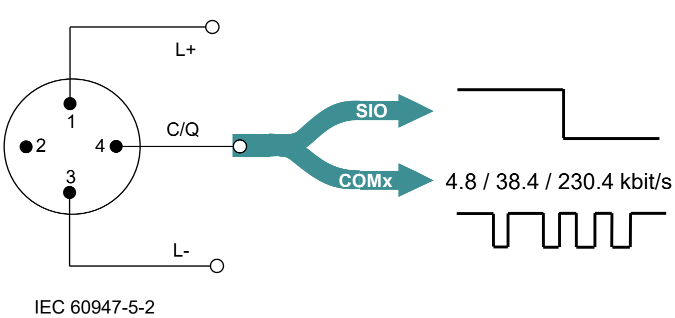


Figure 6. IO-Link Pin Definitions

IO-Link Interface Standardized as SDCI in IEC-61131-9

IO-Link is a standard for Single-Drop Communication Interface (SDCI), which was standardized as IEC-61131-9, while also providing backwards-compatibility with binary sensors IEC 60974-5-2 (Figure 6 and Table 1). IO-Link sensors have the best features of binary sensors while adding bidirectional data capability. IO-Link masters can interface with both binary and IO-Link sensors, allowing IO-Link to be easily added to an existing system. The IO-Link standard states that communications must be within 20 meters with unshielded cables using standard connectors common to industrial systems. M8 and M12 connectors are the most predominant. Communication is point-to-point and requires a 3-wire interface (L+, C/Q, and L-). Communication between master and slave devices is half-duplex with 3 transmission rates: COM1 4800 baud, COM2 38.4k baud, COM3 230.4k baud.

The supply range in an IO-Link system is 20V to 30V for the master, and 18V to 30V for the device (sensor or actuator). The IO-Link device must function within 300ms after L+ exceeds the 18V threshold.

The two communication modes are standard I/O (SIO) and SDCI. In SIO mode, backward compatibility is ensured with existing sensors in the field, using 0V or 24V to signal OFF or ON to the IO-Link master. In IO-Link mode, communication is bidirectional at one of three data rates. The IO-Link device only supports one data rate while the IO-Link master must support all three data rates. Communication is with 24V pulses using a nonreturn-to-zero (NRZ) on the C/Q line where a logic 0 is 24V between CQ and L- and a logic 1 is 0V between CQ and L-. In IO-Link mode, pin 2 can be in DI mode as a digital input, or DO mode as a digital output, or not connected (NC).

Table 1. IO-Link Pin Definitions

Pin	Signal	Designation	Standard
1	L+	24V	IEC 61131-2
2	I/Q	Not connected, DI, or DO	IEC 61131-2
3	L-	0V	IEC 61131-2
4	Q	"Switching signal" (SIO)	IEC 61131-2
	C	"Coded switching" (COM1, COM2, COM3)	IEC 61131-9

Physical Layer IO-Link Standardized Connectors

Standardized connectors and cables are used as defined by IEC 61131-9. Port Class A connectors have 4-wire connections (maximum) to support the 3-wire connection system (L+, L-, C/Q) with a fourth wire that can be used as an additional signal line (DI or DO). Port Class B connectors have 5-wire connections for devices that require extra power from an independent 24V supply (Figure 7 and Table 2).

Table 2. Alternative IO-Link Pin Definitions

Pin	Signal	Designation	Remark
1	L+	Power supply (+)	See Table 7*
2	I/Q P24	NC/DI/DO (port class A) P24 (port class B)	Option 1: NC (not connected) Option 2: DI Option 3: DI, then configured DO Option 4: Extra power supply for power devices (port class B)
3	L-	Power supply (-)	See Table 7*
4	C/Q	SIO/SDCI	Standard I/O mode or SDCI
5	NC N24	NC (port class A) N24 (port class B)	Option 1: Shall not be connected on the master side (port class A) Option 2: Reference to the extra power supply (port class B)
Note: M12 is always a 5 pin version on the Master side (female)			

*In the IO-Link Interface and System Specification Version 1.1.2, July 2013.

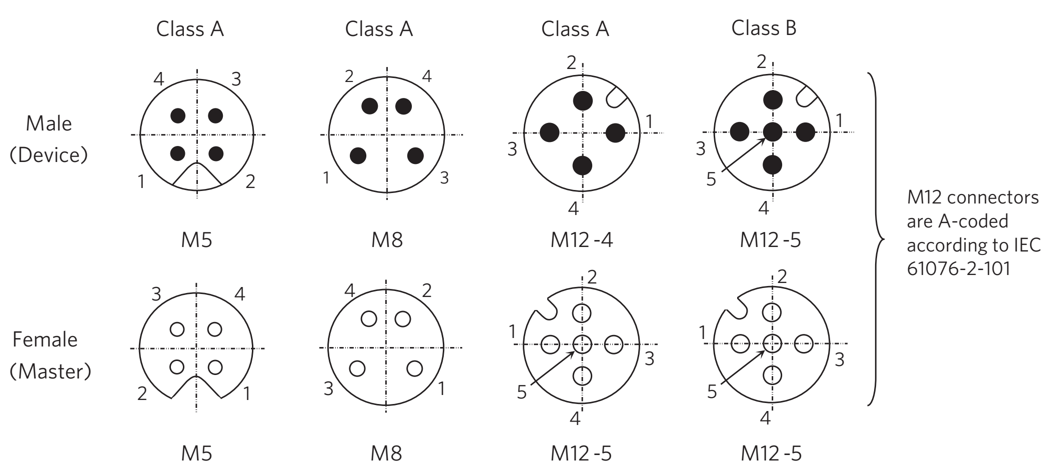


Figure 7. Alternative IO-Link Connectors

Physical Layer Electrical Specifications

The supply range in an IO-Link system is 20V to 30V for the master, or 18V to 30V for the device (sensor or actuator). Important related specifications (Table 3) include:

- A rising IO-Link signal must be above 13V to be registered as a "logic high."
- A falling IO-Link signal must be below 8V to be registered as a "logic low."

Note that the high and low detection time (t_H and t_L in the timing diagram) are 1/16 of a bit (minimum). t_{ND} is the noise suppression duration (t_{ND} must be less than 1/16 of a bit) (Figures 8a and 8b).

Communication uses a UART frame consisting of 11 bits = 1 start bit + 8 data bits + 1 parity bit + 1 STOP bit. Durations are defined by the transmission rate which depends upon the device.

Table 3. IO-Link Signal Electrical Specifications

Property	Designation	Min	Typ	Max	Unit	Remark
$VTHH_{D,M}$	Input threshold 'H'	10.5	N/A	13	V	See Note 1
$VTHL_{D,M}$	Input threshold 'L'	8	N/A	11.5	V	See Note 1
$VHYS_{D,M}$	Hysteresis between input thresholds 'H' and 'L'	0	N/A	N/A	V	Shall not be negative. See Note 2
$VIL_{D,M}$	Permissible voltage range 'L'	$VO_{D,M}$ - 1.0	N/A	N/A	V	With reference to relevant negative supply voltage.
$VIH_{D,M}$	Permissible voltage range 'H'	N/A	N/A	$V+_{D,M}$ + 1.0	V	With reference to relevant positive supply voltage.

Note 1: Thresholds are compatible with the definitions of type 1 digital inputs in IEC 61131-2.
Note 2: Hysteresis voltage VHYS = VTHH - VTHL.

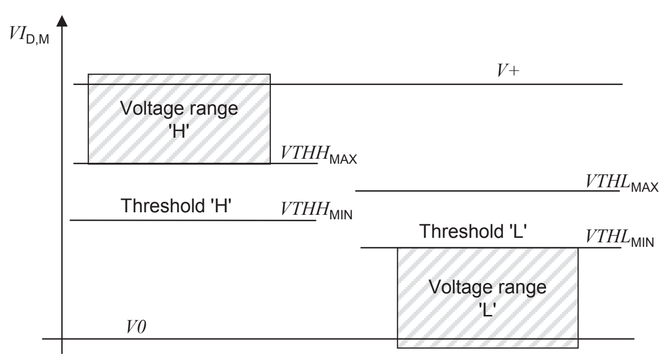
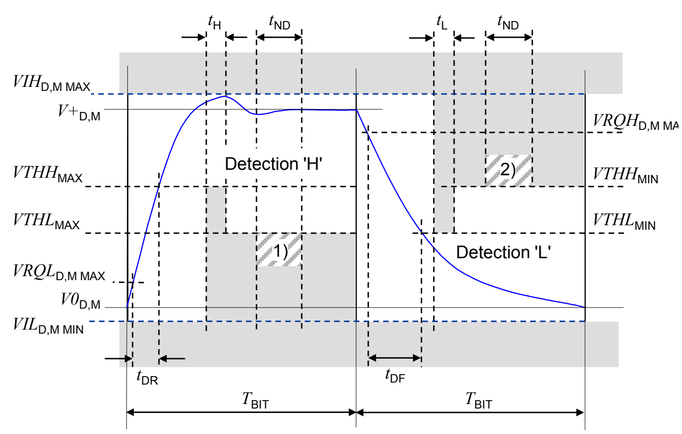


Figure 8a. IO-Link Signal Electrical Thresholds



NOTE In the figure, 1) = no detection 'L'; and 2) = no detection 'H'

Figure 8b. IO-Link Signal Electrical Characteristics

IO-Link in the Automation Hierarchy

An IO-Link device is connected as a point-to-point link to a port in an IO-Link master. If implemented as a PLC plug-in module, it does not have gateway functionality and as such, is not a fieldbus. The IO-Link master is essentially a gateway, with responsibility for establishing communication using fieldbuses or some other type of backplane, enabling the IO-Link devices to become fieldbus I/O nodes (Figure 9).

IO-Link functionality in a system reduces maintenance, increases uptime, and transforms a manual sensor installation into one which allows a user to "plug-and-play and walk away." The parameter settings can be downloaded from the controller to set up (or reconfigure) a device. This means a technician is no longer needed on the shop floor to do initial setup and machine downtime is reduced when it is required to reconfigure devices.

IO-Link allows for continuous diagnostics and improved data logging and error detection to further reduce operating costs. Commonly used connectors and cables enable standardized installation with direct binary sensor upgrades. Since IO-Link sensors have configurable settings (for example PNP, NPN, or push-pull outputs that can be changed while in progress), the number of product units the sensor vendor needs to support is also reduced.

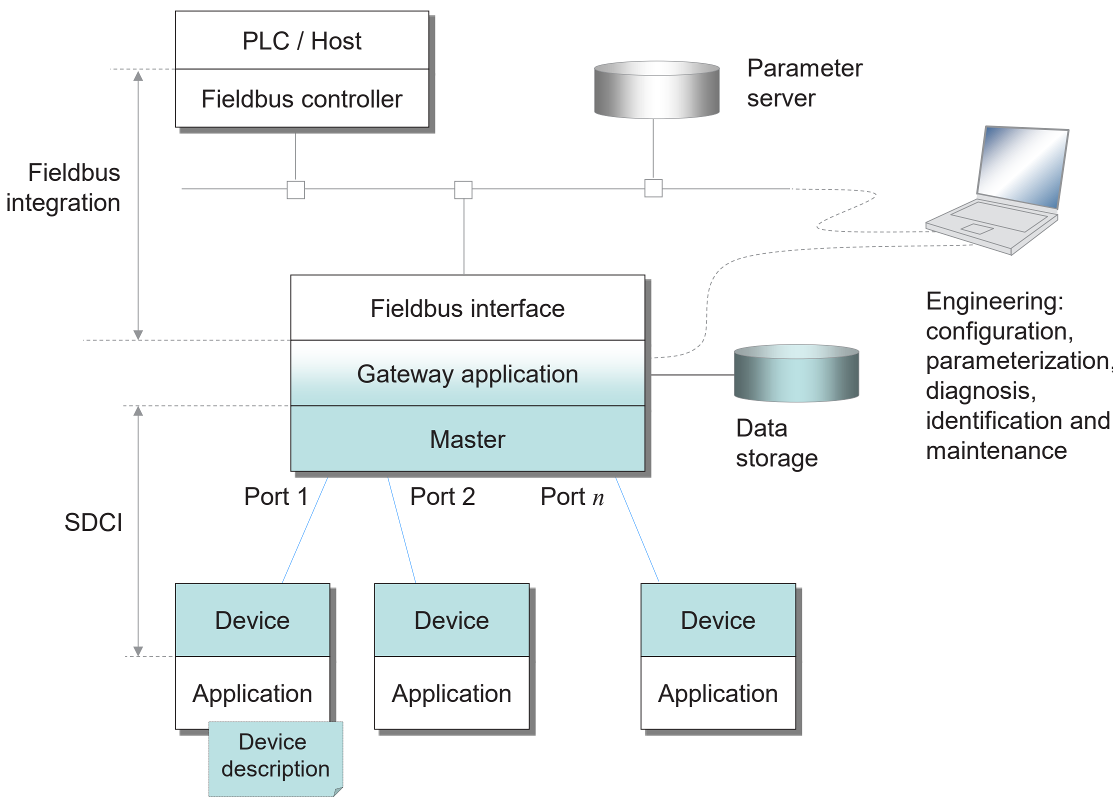


Figure 9. IO-Link Fieldbus Interconnection

IO-Link – Enabling Intelligent Sensors

To summarize, IO-Link is a point-to-point connection that may be layered over any given network. As an integral part of the I/O module, the IO-Link master is installed either in the control cabinet or directly in the field as a remote I/O with an IP 65/67 enclosure rating. The IO-Link device is coupled with the master using a standard sensor/actuator cable measuring up to 20 meters in length. The device—which may be any sensor, any actuator, or a combination of the two—produces and consumes signals (binary switching, analog, input, output) that are transmitted directly via IO-Link in a digitized format.

IO-Link is very powerful and flexible, allowing some of the intelligence to be moved from the PLC closer to the sensors on the factory floor. For example, by using pin 2 (I/Q) as a DI/DO, in addition to the C/Q line, the user can take in digital input signals from a binary sensor and then drive a lamp with the DO (to signify, for instance, if a threshold has been surpassed). This can be done from the sensor itself.

As mentioned, IO-Link is backwards-compatible with SIO binary signals. With IO-Link-capable sensors, users communicate with existing PLCs through a standard digital input communication. As PLC modules are upgraded with an IO-Link master, bidirectional communication is enabled through the C/Q line on an IO-Link.

Industrial Sensor Ecosystem

Figure 10 shows an example of our industrial sensor ecosystem which includes products for all key functions, including binary sensor output drivers, IO-Link devices, and IO-Link masters.

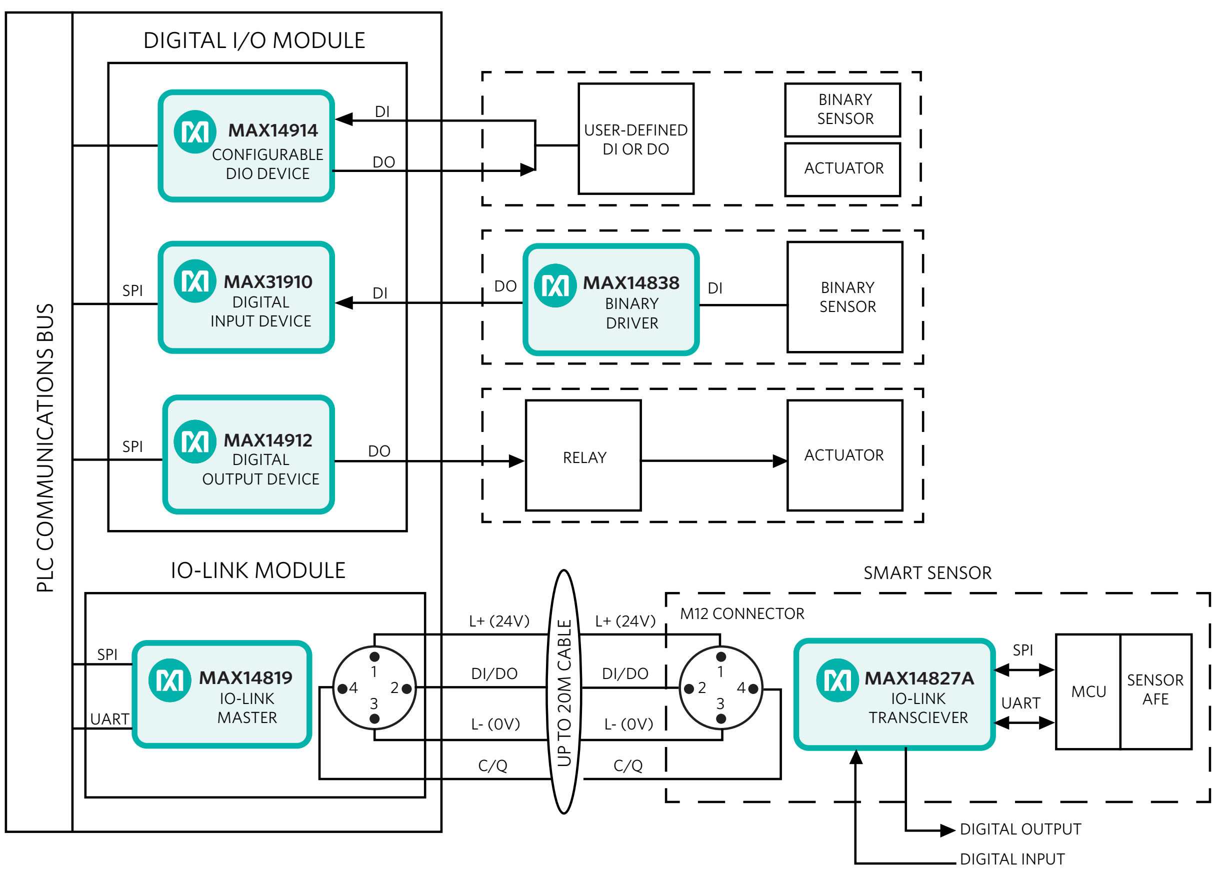


Figure 10. Industrial Sensor Ecosystem

Section 2: IO-Link Environment

Data Link Layer

All IO-Link data exchange is master-slave based, with the IO-Link master sending a request and the device required to answer. The data link layer manages the exchange of messages between the IO-Link master and device. Messages are called M-sequences which are frames that have a length between 1 and 66 UART words. The messages can contain process data, on-request data, and system management commands/requests. A special DL handler in the master manages operating modes (SIO, wake-up, COM rates) and handles errors and wake-up requests.

The process data handler ensures the cyclical process data exchange while the on-request handler manages the acyclic exchange of event, control, parameter and ISDU data.

Data Types

IO-Link data communication is either cyclic or acyclic (Figure 11). Cyclic communication occurs during normal operation. For example, the master requests sensing data from the sensor. Acyclic data is on-request and can contain:

1. Configuration or maintenance information. For example, the master may configure the device after power-up or request the device configuration right before power-down
2. Event triggered, which is reported with three levels of severity:
   - Notifications
   - Warnings
   - Errors
3. Service data for large data structures.
4. Page data for direct reading of device parameters.

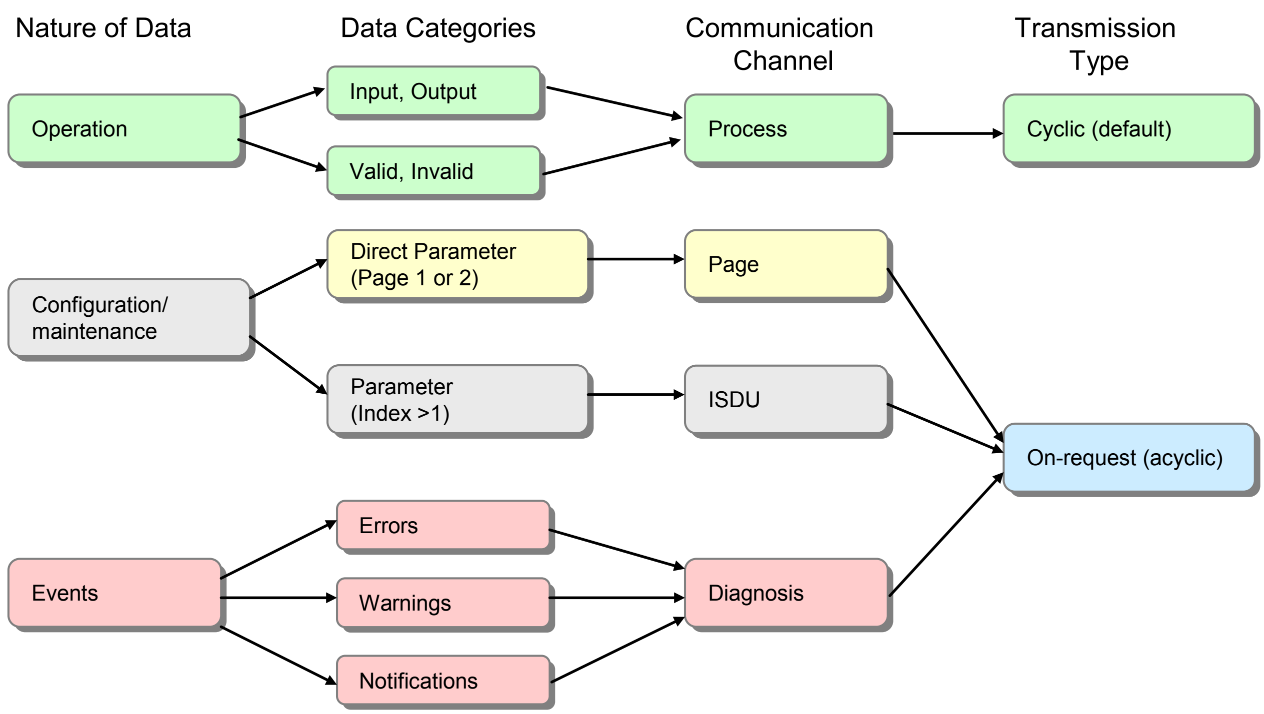


Figure 11. IO-Link Transmission Types

Master-Device Communication

All communication between the master and a device (sensor or actuator) begins with a request from the master and follows a fixed schedule (Figure 12). A device must answer all master requests. The sum of this back-and-forth communication is called an M-sequence (message sequence). An M-sequence can take many different forms and varies in total length. Although M-sequence communication may vary, all communication between a port and device takes place on this fixed schedule.

UART Data on the C/Q Line

All data is UART framed. The master initiates communication and the device must answer within t_A < 11-bit intervals (Figure 13).

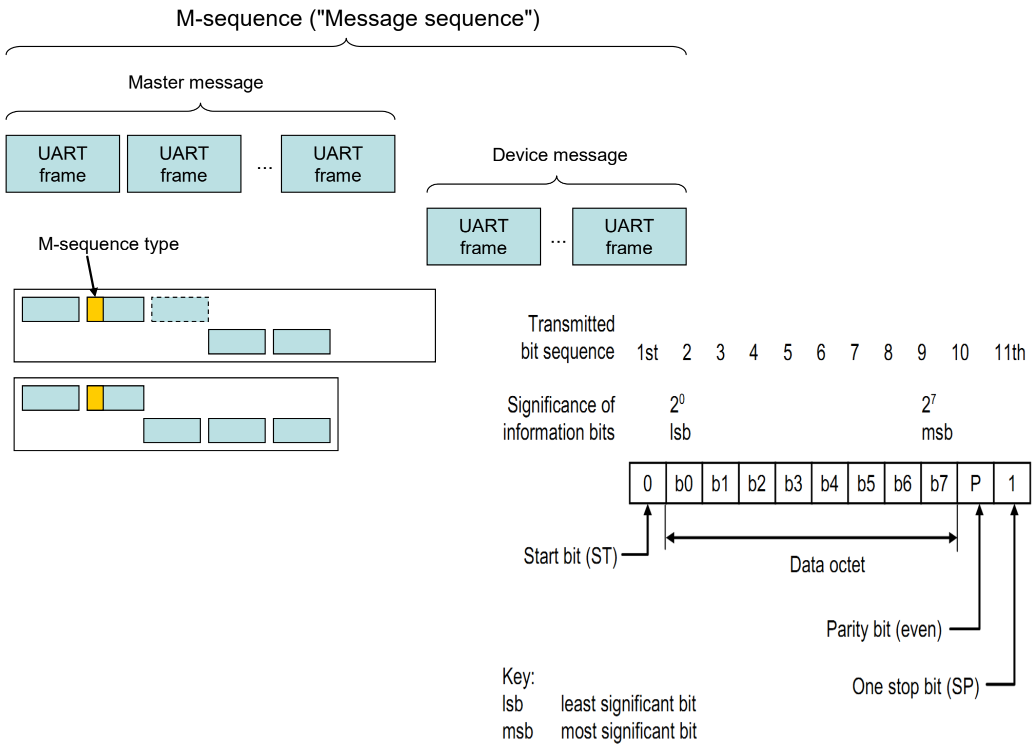


Figure 12. IO-Link Master-Device Communication Sequence

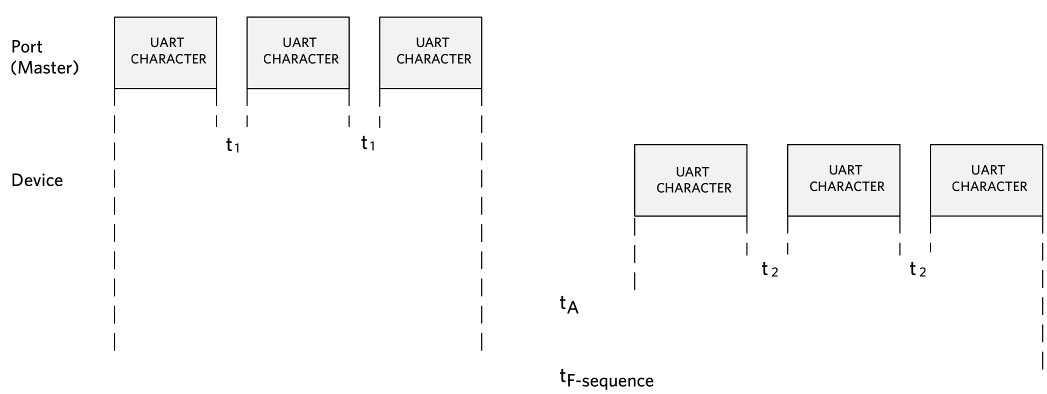


Figure 13. UART Framing

Wake-Up Request

When a master wants to configure a device (sensor or actuator) or communicate with it for the first time, it will send a wake-up request. A wake-up request starts by shorting the C/Q line for 80µs with a current pulse of at least 500mA (Figure 14). The device must be ready for communication within 500µs (T_{REN}).

- A wake-up period is typically 80µs (75µs, min or 85µs, max).
- The master sources (or sinks) the current to generate the wake-up pulse. If the line is low, the master will source current to pull it high. If the line is high, the master will sink current to pull it low.
- The wake-up pulse is detected by the IO-link device (which either monitors the current on the line or detects a voltage change of low-to-high or high-to-low).
- When the wake-up request is received, the IO-Link device must configure itself to receive mode. This must occur within 500µs of receiving the request, or an error will be generated by the master.

IO-Link Data Rate Selection

Once the master has sent a wake-up request to the device (to set it to receive mode), the master then learns more about it by establishing the data rate for communication (Figure 15):

- The master sends multiple messages at the COM3, COM2, and COM1 data rates (fastest to slowest), and waits for the device to respond after each send:
  - Any given device is required to support only one of the COM1, COM2, or COM3 data rates.
- The device will respond at its rated data rate:
  - When the device responds, the master is then able to communicate with the device.
  - The master can then read out the minimum cycle time capability of the IO-Link device.
- The master can retry the wake-up sequence a maximum of two times to establish IO-Link communication.
  - If the wake-up request fails, and then fails a second time (max retries = 2), the device must set the C/Q line to SIO (DI/DO binary sensor) mode.

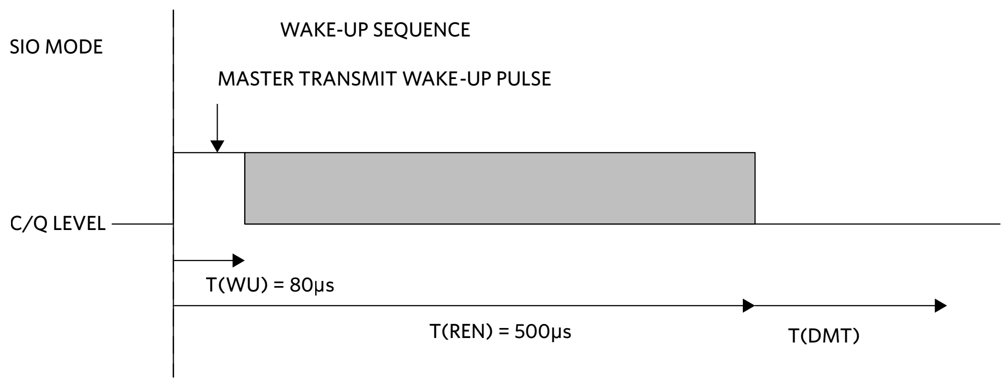


Figure 14. Wake-Up Sequence

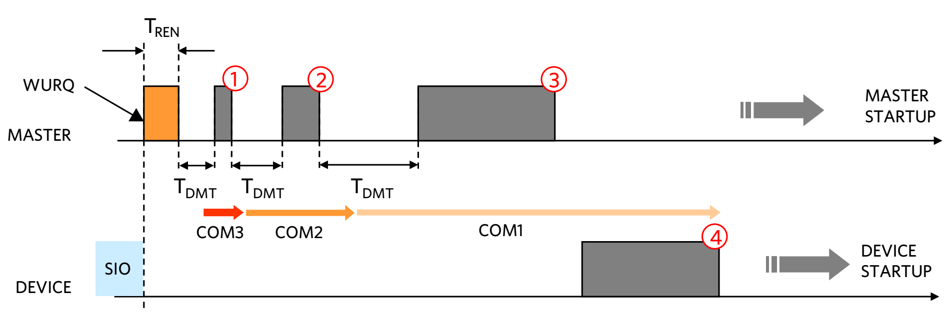


Figure 15. Data Rate Selection

The IO-Link IODD

All IO-Link devices (sensors or actuators) must have an associated IO-Link Device Description (IODD) file available (Figure 16). This is used by the IO-Link master for purposes of identification, data interpretation, and configuration.

- The IODD contains:
    - All necessary properties to establish communication
    - Device parameters
    - Identification information
    - Process and diagnostic information
    - An image of the device and the manufacturer's logo
- IODD files are XML files
- The structure of the IODD is outlined in a separate document from the IEC 61131-9 standard.

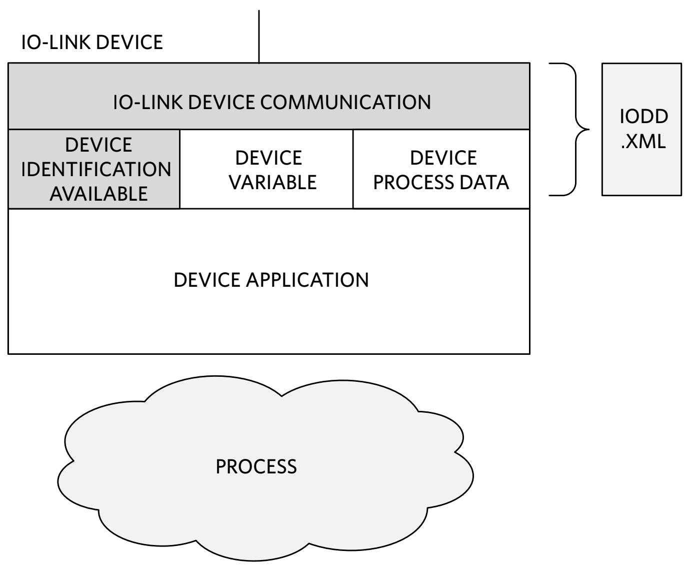


Figure 16. IODD File

Section 3: Designing an IO-Link Sensor

In this section, we will look at reference design examples that demonstrate how to design a smart sensor system as well as a system to support legacy binary sensors that interface to an IO-Link port.

Sensor Design Considerations

The basic structure of an IO-Link sensor (Figure 17) includes some fundamental building blocks which the system designer must consider:

- Sensor type (optical, temperature, etc.,)
- MCU that interfaces with the sensor and runs the IO-Link device stack
- IO-Link transceiver (or physical layer/PHY)
- Power supply and the various voltage and current ratings required
- Connector type
- External protection (TVS for surge, EFT/burst, ESD, etc.)

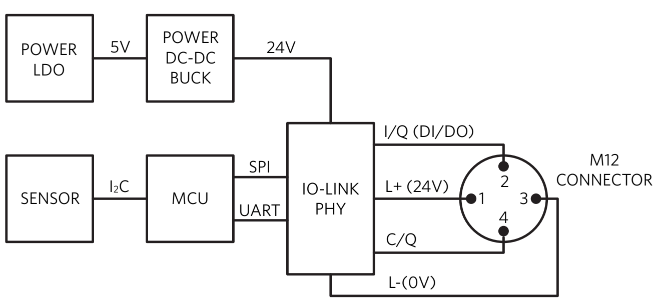


Figure 17. Building Blocks of an IO-Link Sensor

IO-Link Smart Sensor Design Features

Figure 18 shows the **MAXREFDES27** proximity sensor next to a paper clip to demonstrate its tiny form-factor. This design is compliant with IO-Link version 1.1 and 1.0 and includes transient voltage suppression as well as reverse-polarity and short-circuit protection.

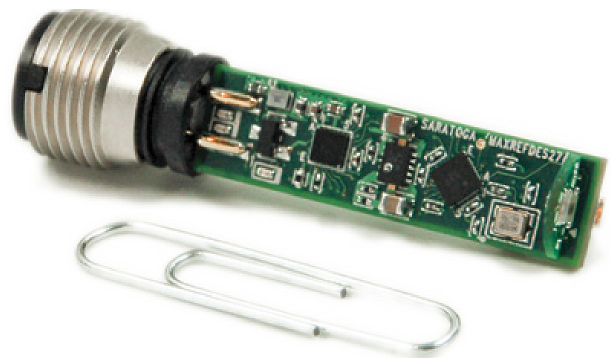


Figure 18. MAXREFDES27 Proximity Sensor

IO-Link Proximity Sensor: MAXREFDES27

The MAXREFDES27 is a tiny IO-Link proximity sensor with an IR receiver, a matching infrared (IR) LED driver, an IO-Link transceiver, and an energy-efficient step-down converter—all on an 8.2mm x 31.5mm printed circuit board (PCB). We collaborated with Technologie Management Gruppe Technologie und Engineering (TMG TE) in designing the MAXREFDES27 as an IO-Link version 1.1/1.0-compliant proximity sensor reference design. The MAXREFDES27 design consists of an industry-standard IO-Link device transceiver (**MAX14821**), a tiny low-dropout linear regulator (**MAX8532**), an efficient high-voltage step-down converter (**MAX17552**), a Renesas ultra-low-power 16-bit microcontroller (RL78) utilizing TMG TE's IO-Link device stack, and a proximity sensor (**MAX44000**) as shown in Figure 19.

The MAXREFDES27 consumes minimal power, space, and cost, making it an all-around solution for many industrial control and automation proximity-sensing applications. The MAX14821 IO-Link device transceiver is IO-Link version 1.1/1.0 physical layer-compliant with configurable outputs (push-pull, PNP, or NPN), reverse-polarity/short-circuit protection, and extensive fault monitoring, all in a tiny 2.5mm x 2.5mm wafer-level package (WLP). The MAX17552 high-voltage synchronous step-down converter efficiently converts 24V to 5V with an ultra-small footprint. The MAX8532 then regulates the 5V down to 2.85V.

The MAX44000's integrated LED driver shines IR, then reads the IR reflected from the target object using its internal IR receiver with an I^2C interface. The IR LED current is software-adjustable and the MAX44000 is available in a miniature optical 2mm x 2mm OTDFN package. For documentation purposes, the sub-board, which lies perpendicular to the main board and contains the MAX44000, is called MAXREFDES28. An ultra-low-power RL78/G1A microcontroller provides system control.

Transient voltage suppressor (TVS) diodes are not all equal. The SDC36 TVS diodes have a clamping voltage less than 55V and meet both IEC 61000-4-2 (ESD) and IEC 61000-4-4 (EFT). There are many smaller TVS diodes on the market that cannot meet these specifications.

The MAXREFDES27 uses an industry-standard M12 connector, which allows a 4-wire or the conventional 3-wire cable to be used, keeping costs low. The MAXREFDES27 consumes less than 7mA (typ).

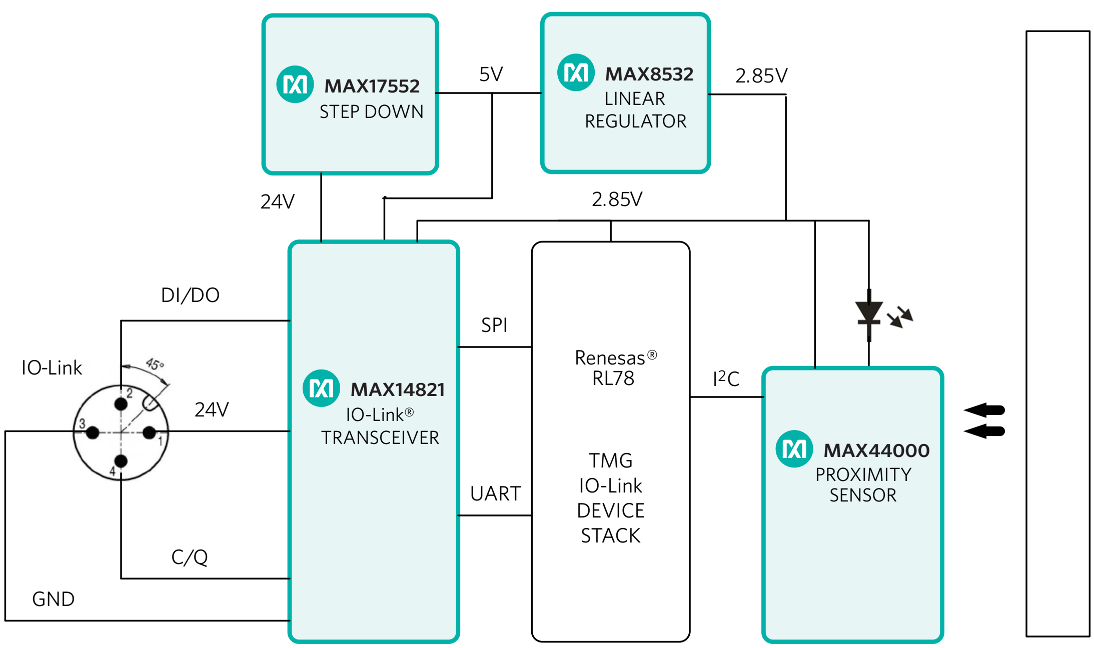


Figure 19. MAXREFDES27 IO-Link Proximity Sensor Block Diagram

Description of Software

The MAXREFDES27 was verified using TMG TE's IO-Link Device Tool V3, which comes with the purchase of the TMG-USB IO-Link master TS hardware. Contact TMG TE for more information. It was also verified using Balluff's IO-Link Device Tool version 2.11.1, which comes with the purchase of the Balluff USB IO-Link master, part number BNI USB-901-000-A501. Contact Balluff or one of their local distributors for ordering information. Download the IODD file (*.xml) located under the Design Resources section of the MAXREFDES27 product page and go to the Quick Start section for step-by-step instructions on how to use the software (Figure 20).

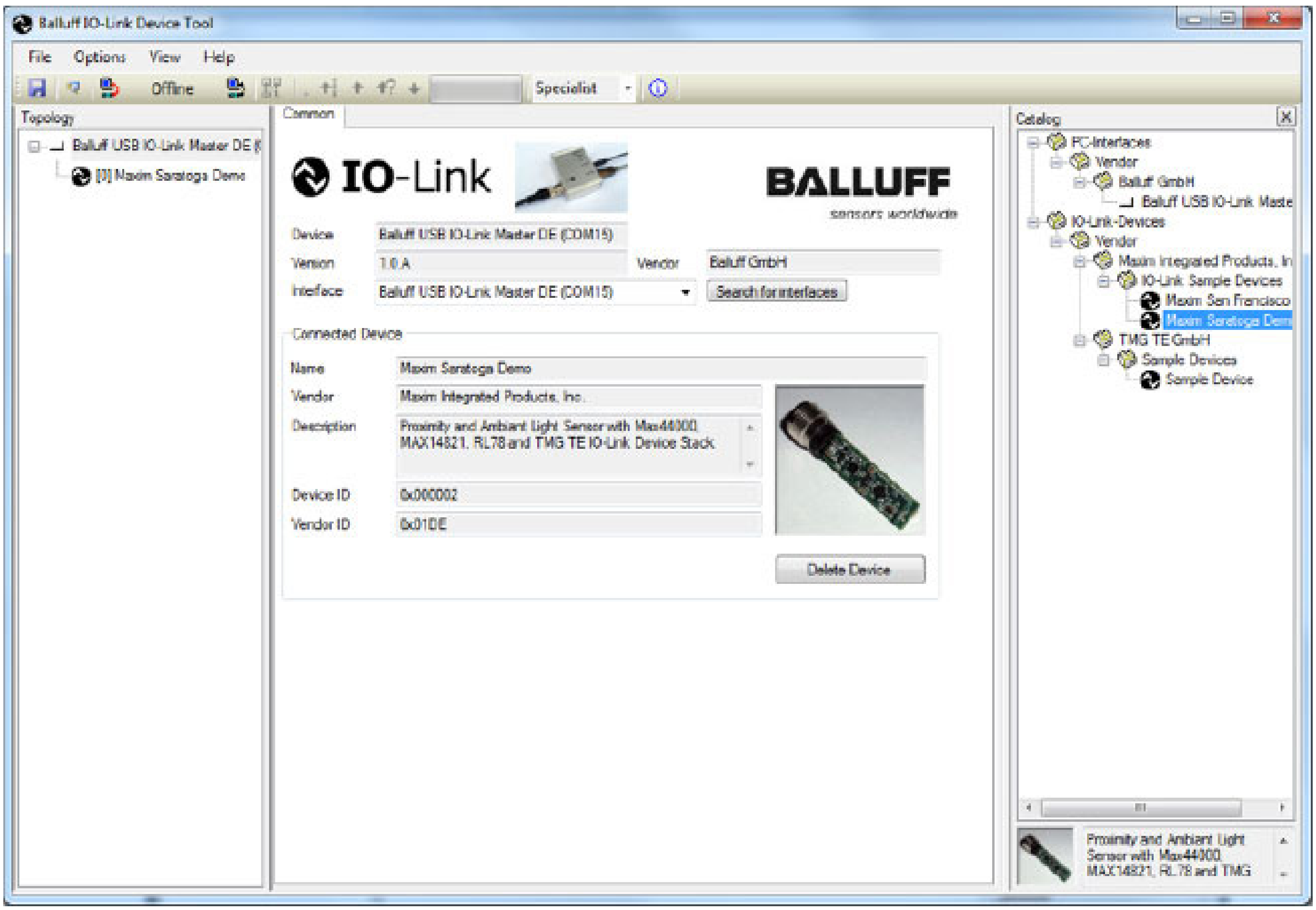


Figure 20. MAXREFDES27 Software Interface

IO-Link Digital Input Hub: MAXREFDES36

PLCs and distributed control systems (DCSs) use more digital inputs than all other input signal types combined. Running wires in parallel back to the PLC for industrial digital inputs is not only expensive but also creates a wiring rat's nest that is difficult to maintain. Fieldbuses improved the situation considerably by moving the I/O interface from the PLC to a remote I/O hub mounted close to the field sensors. IO-Link can function directly from the PLC or can be integrated into all standard fieldbuses, quickly making it the de facto standard for universally communicating with smart devices like the **MAXREFDES36**.

The MAXREFDES36 is an IO-Link 16-channel digital input hub that fits on a small 53.75mm x 72mm PCB. We collaborated with TMG TE in designing the MAXREFDES36 as an IO-Link version 1.1/1.0-compliant digital input hub reference design. The MAXREFDES36 design consists of an industry-standard IO-Link device transceiver (MAX14821), an efficient high-voltage step-down converter (MAX17552), a Renesas ultra-low-power 16-bit microcontroller (RL78) utilizing TMG TE's IO-Link device stack, and two digital input serializers (**MAX31913***) as shown in Figure 21.

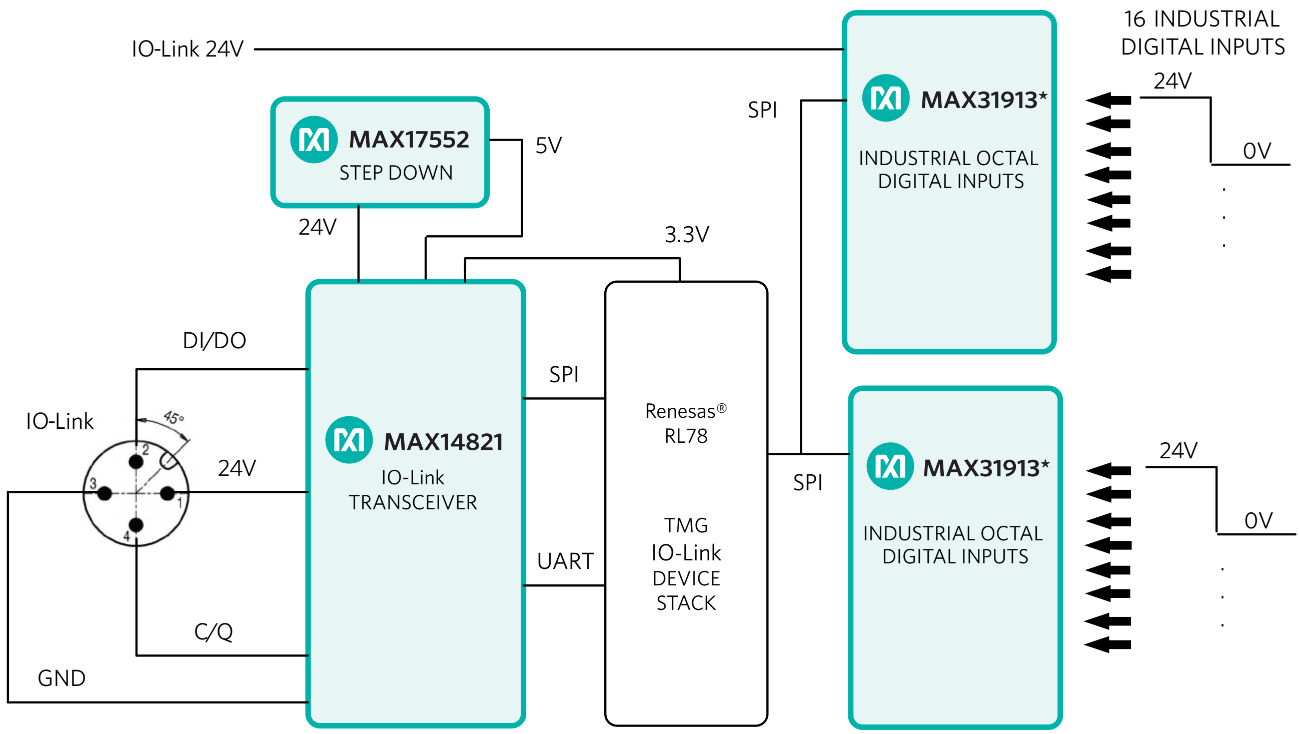


Figure 21. MAXREFDES36 Digital Input Hub Block Diagram

*The recommended replacement for MAX31913 is MAX31910 or MAX31911.

Description of Software

The MAXREFDES36 was verified using TMG TE's TMG IO-Link Device Tool V3, which comes with the purchase of the TMG-USB IO-Link master TS hardware. Contact TMG TE for more information. It was also verified using Balluff's IO-Link Device Tool version 2.11.1, which comes with the purchase of the Balluff USB IO-Link master, part number BNI USB-901-000-A501. Contact Balluff or one of their local distributors for ordering information. Download the IODD file (*.xml) located in the Download All Design Files section of the MAXREFDES36 product page's Design Resources tab. Go to the Quick Start section for step-by-step instructions on how to use the software. Figure 22 shows a screenshot of the Balluff IO-Link Device Tool.

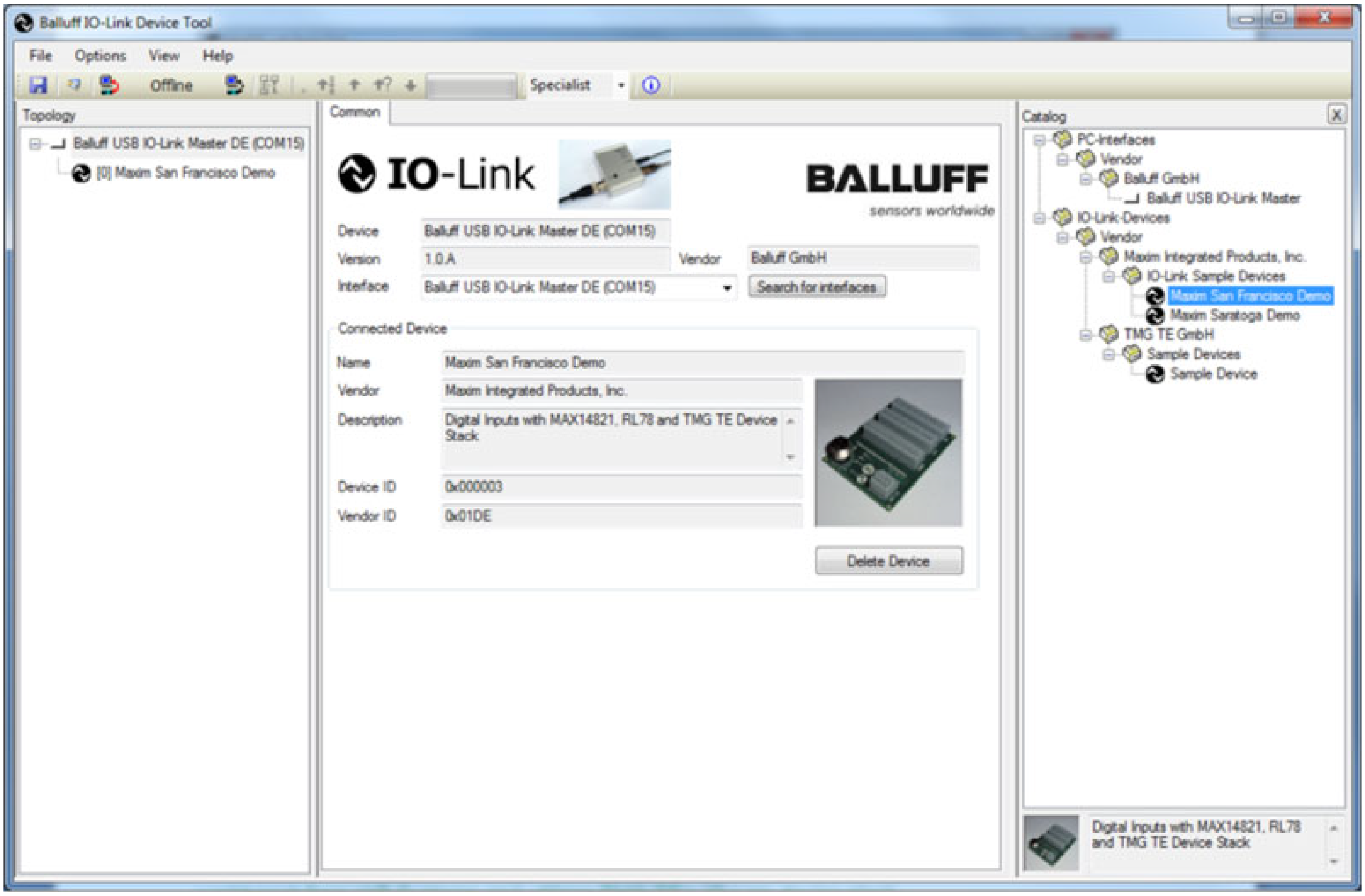


Figure 22. Balluff IO-Link Device Software

Section 4: Designing an IO-Link Master

In this section, we will look at reference design examples that demonstrate how to design a multi-port master for a smart sensor system using IO-Link.

IO-Link Master Design Objectives

When designing an IO-Link master solution, there are common system design questions that must be considered:

Hardware Design:

- How many IO-Link ports should the system have?
- Should the ports be Class A or Class B?
- Should the connectors in a Class A port support pin 2?
- What miswiring cases should be accommodated for over-voltages or reverse polarity?
- Should the PCB design be modular and able to accommodate different port counts?
- How much current should the L+ supply provide?
- What is the form-factor?

EMC Compliance:

- Who will perform the compliance testing?

As an example, the Maxim design team for the MAXREFDES145 eight-port IO-Link master reference design chose to create an 8-port master due to the popularity of the configuration and to provide an alternative to their existing 4-port master. They used the MAX14819 dual-channel IO-Link master transceiver and the STM 32F4 Arm® Cortex® M4 microcontroller, implementing isolation between the USB interface and the IO-Link channels. The reference design fits on a single 5in. x 3in. PCB. For software, the design team partnered with TEConcept, who supplied the IO-Link-compliant software stack and performed the compliance testing. The design includes a TVS diode at each of the IO-Link ports, and is tested to IEC 610004-2 and IEC 610004-5 for transient immunity to ESD and surge immunity.

8-Port IO-Link Master: MAXREFDES145

The **MAXREFDES145** is a fully IO-Link-compliant, eight-port IO-Link master reference design (Figure 23). This design uses TEConcept's IO-Link master stack and is both an IO-Link master reference design as well as an IO-Link sensor/ actuator development and test system. Eight IO-Link ports allow for simultaneous testing of up to eight different sensors (or actuators). The reference design has eight robust female M12 connectors, the most common connector used for IO-Link, and ships with two black IO-Link cables to quickly connect to IO-Link-compatible sensors and actuators. An AC-to-DC (24VDC/1A) power supply provides at least 125mA simultaneously to each port (more when fewer ports are used). A micro-USB connector allows for quick connectivity to a Windows® PC.

The easy-to-use TEConcept Control Tool (CT) GUI software, with IODD file import capability, makes the MAXREFDES145 a must-have for any company or engineer serious about developing IO-Link products.

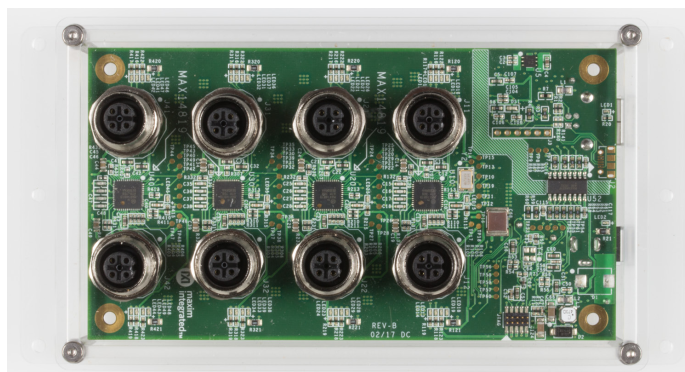


Figure 23. MAXREFDES145 8-Port IO-Link Master Reference Design

Description of Hardware

The MAXREFDES145 IO-Link master consists of four main blocks: four dual-channel **MAX14819** IO-Link master transceivers, two digital isolators for the SPI interface, a microcontroller, and a USB connection as shown in Figure 24. The MAX14819 IO-Link master transceivers are IO-Link version 1.1.2 physical layer-compliant. These transceivers feature integrated 5V linear regulators, configurable C/Q outputs (push-pull, high side or low side) with configurable output drive capability, auxiliary digital inputs, and reverse-polarity/overvoltage or short-circuit protection.

An STM32F4 Arm Cortex M4 microcontroller provides system control. A USB port is implemented using the FTDI FT2232 USB-to-SPI transceiver and driver. An on-board **MAX15062** high voltage, synchronous step-down converter provides power to the STM32F4 microcontroller from the 24V supply.

Two digital isolators, the four-channel **MAX14931** and the two-channel **MAX12931**, protect the USB interface from high voltage and large ground differentials that may occur when the MAX14819 master transceivers are connected to IO-Link peripherals. All communication between the USB port/PC and the SMT32F4 microcontroller passes through these isolators. A stand-alone SPI header (J3) is available on the MAXREFDES145 to allow the user to bypass the USB interface or directly communicates with the STM32F4 using an external SPI master.

High-level protection TVS diodes at each of the eight IO-Link interface ports and at the power-supply inputs provide 1kV/42Ω surge and reverse-polarity protection for each master transceiver on the MAXREFDES145. Additionally, power and status LEDs (for each channel) provide quick visual confirmation that the board is working and communicating.

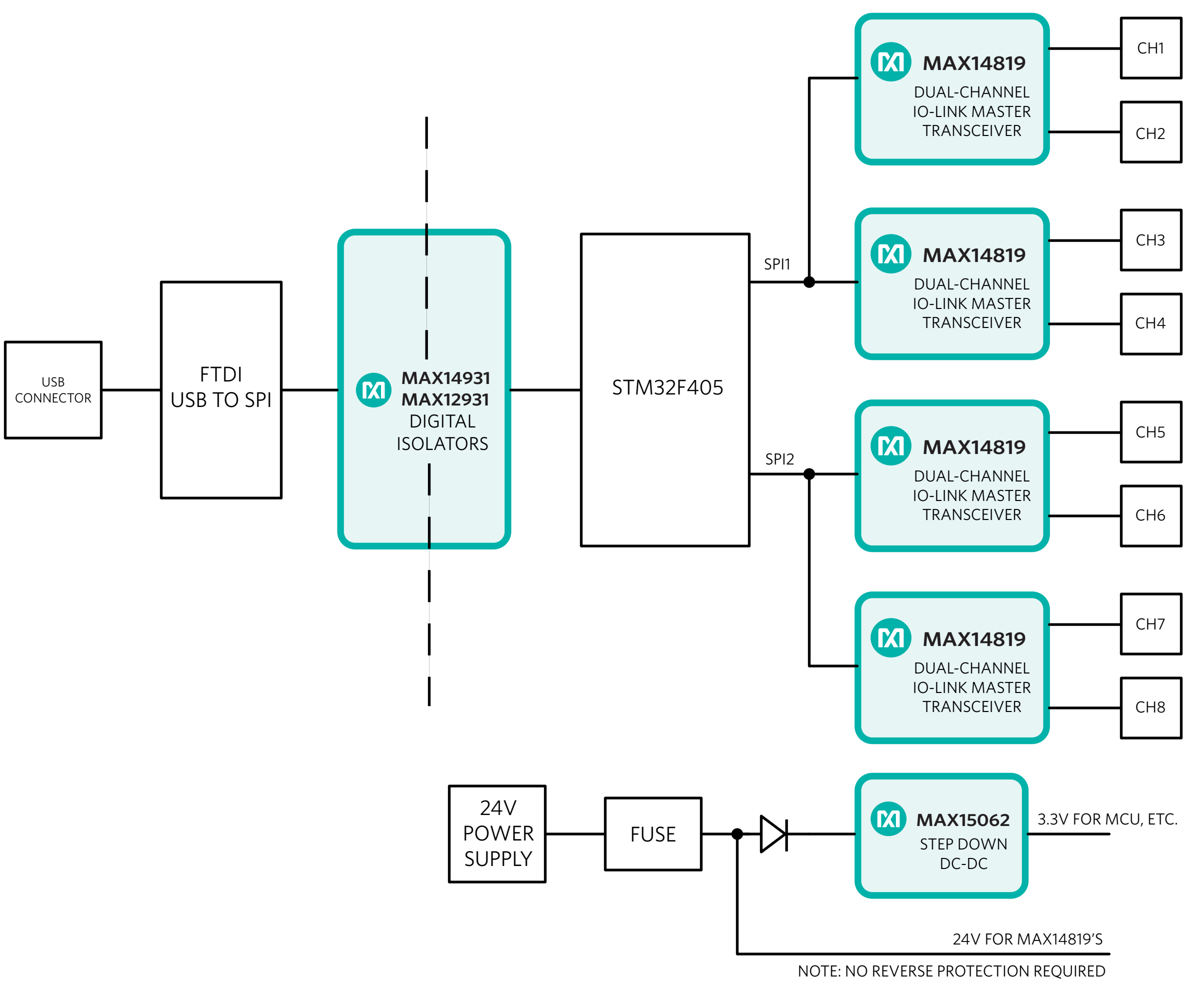


Figure 24. MAXREFDES145 8-Port IO-Link Master Block Diagram

Description of Software

The TEConcept CT Windows-compatible GUI software features IODD file import capability, connects to a PC via USB, and is available for download from the Design Resources tab of the MAXREFDES145 product page. The TEConcept CT software is shown in the Details tab of the MAXREFDES145's product page and a complete step-by-step Quick Start guide is also downloadable from the MAXREDES145's Design Resources tab.

The TEConcept IO-Link master stack ships preprogrammed inside the MAXREFDES145 hardware with a perpetual time license displayed by the TEConcept CT software. This allows MAXREFDES145 to be used for development and testing purposes. If the users wish to design their own products using the MAX14819, an unlimited time license can be purchased from TEConcept GmbH by providing them with a valid hardware ID and key number. Press the Export Hardware ID button located in the license key management window as shown in Figure 25. Provide the hardwareID.txt file when requesting the infinite time license from TEConcept GmbH. Contact information for TEConcept GmbH is found in the list of Software Stack Vendors in the IO-Link Handbook's Appendix of Technical Resources.

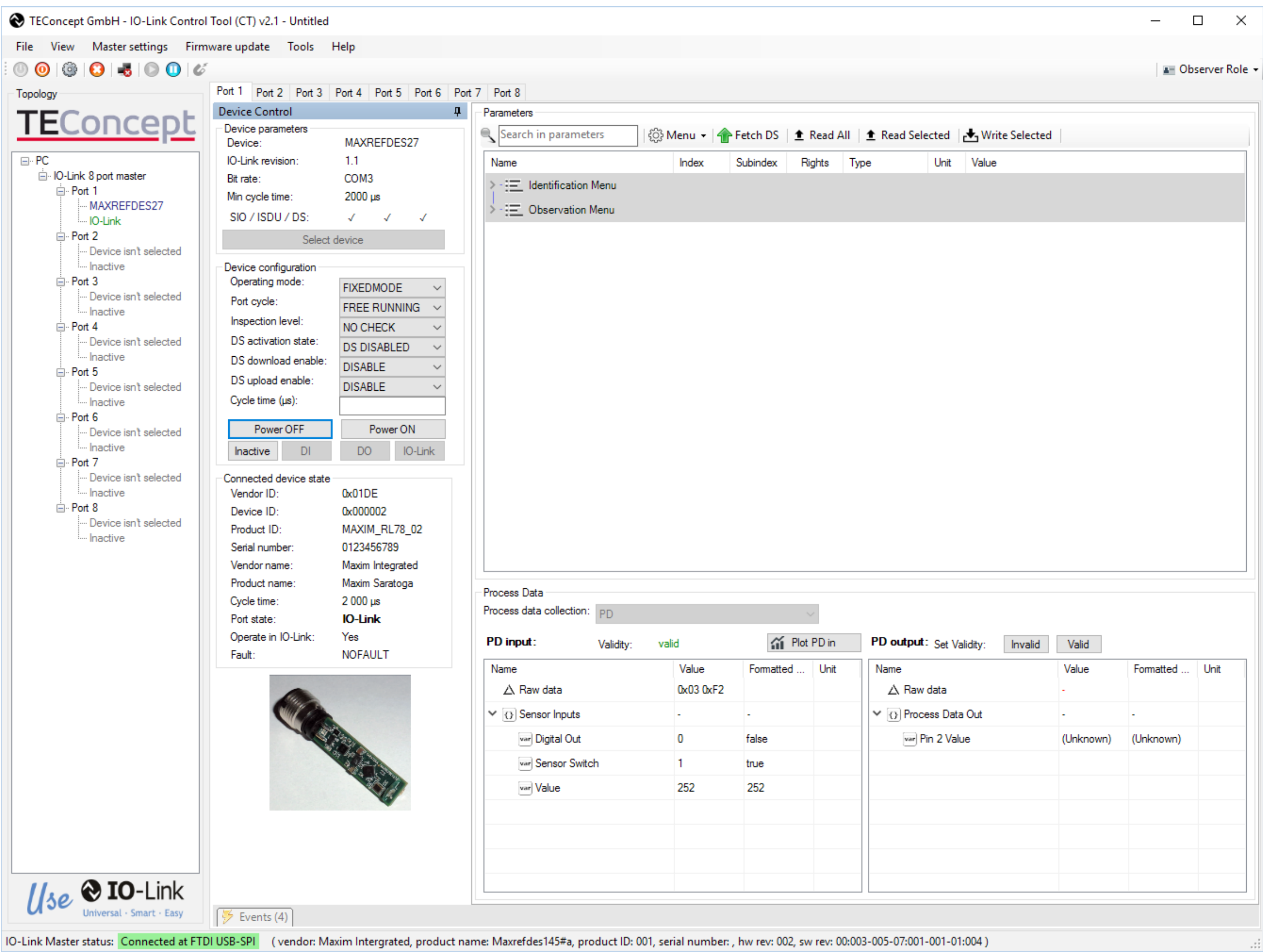


Figure 25. TE Concept IO-Link Software

IO-Link Master Test Reports

The MAXREFDES145 is a fully compliant IO-Link version 1.1 master. See the detailed test report (all 716 pages) on our website at **MAXREFDES145 8-Port IO-Link Master Test Report**.

Name	
Description	DUT Check Info
State	Successful
State info	
Expected result	Successful
Optional step	No
Comment	
Start of execution	2017-05-04 15:25:40.391
End of execution	2017-05-04 15:25:43.542
Vendor name	Maxim Integrated
Product name	Maxrefdes145#b
Product ID	001
Serial No.	
Hardware Rev.	002
Firmware Rev.	00:005-006-07:001-001-01:005
Description	8 port IO-Link Master.

Figure 26. Details of MAXREFDES145 IO-Link Master Test Report

Section 5: Improving System Performance

In IO-Link applications, the transceiver acts as the physical layer interface to a microcontroller running the data link layer protocol while supporting up to 24V digital inputs and outputs. Our transceivers have long supported all IO-Link specifications and feature the lowest power dissipation.

Figure 27 highlights the evolution of power dissipation by our device transceivers under full load conditions compared to our competitor. The thermal camera clearly shows that the MAX14827A dissipates significantly less power.

Our first IO-Link device transceiver, the **MAX14820**, dissipated just under 900mW with the drivers under full load conditions. The second-generation **MAX14826** reduced the already low power dissipation of its predecessor by more than half, dissipating only 400mW under full load conditions. The most recent IO-Link transceiver, the MAX14827A, dissipates a remarkably low 70mW when driving a 100mA load—achieving more than 80% lower power dissipation than the closest competitive device. For even lower dissipation while driving, the C/Q and DO drivers on our transceivers can also be paralleled.

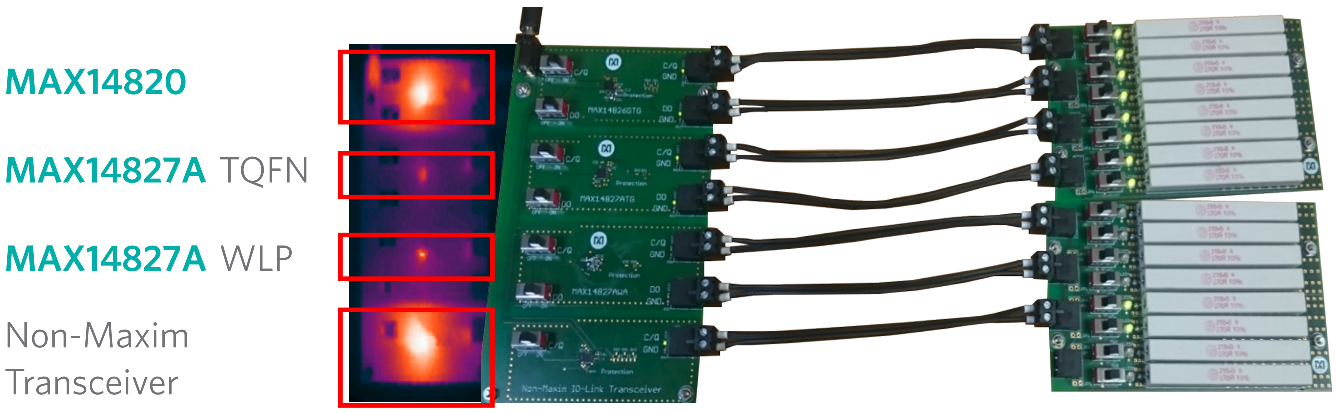


Figure 27. Comparison of Transceiver Power Dissipation at Full Load, Relative to Competitive Device

Electromagnetic Compatibility (EMC) Requirements

Industrial environments are harsh and system designers must meet minimum EMC requirements to ensure IO-Link devices can survive some common transients. We start by designing robust IO-Link ICs which typically meet these levels:

- ESD: ±8kV for air discharge
- ESD: ±4kV for contact discharge (based on the IEC 61000-4-2 standard).

Note: The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment, but does not specifically refer to integrated circuits.

EMC Test Levels

Table 4 shows the various system-level EMC test levels from Table G.2 of the IO-Link Interface and System Specification.

Table 4. IO-Link EMC Test Levels

Phenomena	Test Level	Performance Criterion	Constraints
Electrostatic discharges (ESD) IEC 61000-4-2	Air discharge: ±8kV Contact discharge: ±4kV	B	See G.1.4. a)
Radio-frequency electromagnetic field. Amplitude modulated. IEC 61000-4-3	80MHz to 1000MHz 10V/m 1400MHz to 2000MHz 3V/m 2000MHz to 2700MHz 1V/m	A	See G.1.4. a) and G.1.4, b)
Fast transients (Burst) IEC 61000-4-4	±1kV	A	5kHz only. The number of M-sequencers in Table G.1 shall be increased by a factor of 20 due to the burst/cycle ratio 15ms/300ms. See G.1.4,c)
	±2kV	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	0.15MHz to 80MHz 10V EMF	A	See G.1.4. b) and G.1.4, d)
Voltage dips and interruptions IEC 61000-4-11	Not required for an SDCI link		—

Physical Layer: EMC Requirements Standardized

Note that the IEC 61000-4-2 standard covers ESD testing and performance of finished equipment, but does not specifically refer to integrated circuits. Typically, our transceivers can withstand around 1.5kV ESD transients on their own (based on the military standard used in the reliability reports) but will generally need external TVS diodes for added protection. However, we have reduced the size and requirements of these external diodes and reduced the BOM to save space and external component cost. Industrial environments are typically harsh requiring additional protection for circuits!

The IO-Link specification requires for equipment to be appropriately protected for robust operation:

- ESD: ±8kV for air discharge
- ESD: ±4kV for contact discharge (based on the IEC 61000-4-2 standard)
- Surge: Not required when the cable length is limited to 20m. Otherwise, protection levels range from ±500V to ±2kV
- Burst: ±1kV or ±2kV

While transceivers are increasingly robust, external protection is necessary for:

- ESD protection for the end product
- Surge and burst protection (TVS diodes)
- Optimized layout

Immunity Testing

Figures 28 and 29 demonstrate EFT and ESD testing of the MAX14819 in the MAXREFDES145 8-port master. The setup in Figure 28 is only for surge testing. The burst clamp is not shown. Board-level transient immunity standards include:

- IEC 61000-4-2 Electrostatic Discharge (ESD)
- IEC 61000-4-4 Electrical Fast Transient/Burst (EFT)
- IEC 61000-4-5 Surge Immunity

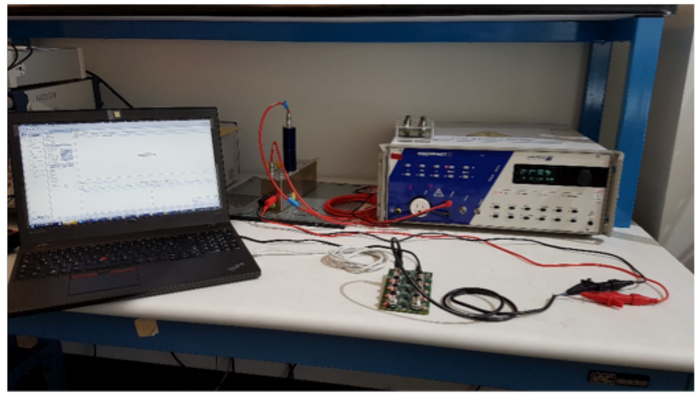


Figure 28. EFT Burst and Surge Testing of MAX14819

Figure 29. ESD Testing of MAX14819

Section 6: IO-Link Solutions

Why Choose Maxim IO-Link Transceivers?

Maxim joined the IO-Link consortium in 2009. We have a proven track record of long-term dedication and commitment to the industrial market and to our customers by having the industry's most complete IO-Link and binary sensor portfolios. These include the MAX14820, MAX14821, MAX14826, and MAX14827A device transceivers and the **MAX14824** and MAX14819 master transceivers. Note that IO-Link transceivers can also be used in binary sensor applications.

We have developed a complete ecosystem to make design-in fast and easy. The evaluation kits for all our transceivers include software (for configuration and reading/writing to the transceiver). Our IO-Link reference designs include both sensors and masters. Our dedicated team of designers, product definers, and applications engineers are readily available to provide customer support.

Our solutions are small and only getting smaller! Our IO-Link transceivers (Figure 30) are currently available in compact TQFN and WLP packages. The latest transceiver, the MAX14827A, is offered in a WLP package and reduces the solution footprint by up to 60%. As our transceivers increase in robustness, less external protection is required. With higher absolute maximum ratings, external protection components such as external protective diodes, can be smaller. Our transceivers include integrated 3.3V and 5V LDOs that can power external circuitry, reducing the need for external LDOs and keeping the overall solution small.

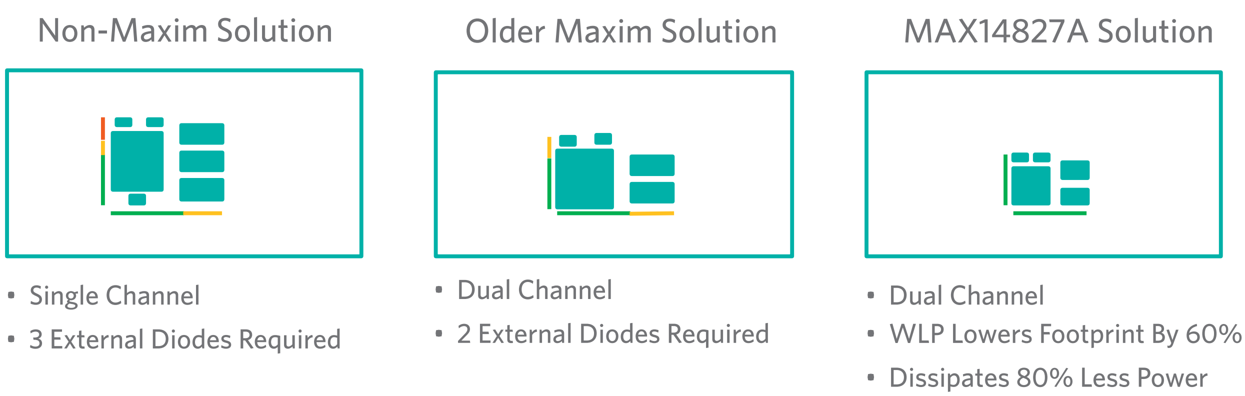


Figure 30. IO-Link Transceiver Solution Comparison

Product Selector Guide

Our long and committed history with IO-Link technology has resulted in the development of multi-generation transceivers on both the master and device side that focus on low power dissipation, small solution size, and robust communications (Table 5). With a full ecosystem of IO-Link device and master reference designs and evaluation kits, we are focused on providing quick evaluation of IO-Link technology.

Table 5. IO-Link Transceivers

Part Number	Interface	Description
IO-Link Master Transceivers		
MAX14819	IO-Link	Low-power dual-channel IO-Link master transceiver + supply controllers + UART/Framer + DI
MAX14824	IO-Link	Single-channel IO-Link transceiver
IO-Link Device Transceivers		
MAX14827A	IO-Link	Tiny low-power dual IO-Link device transceiver
IO-Link Sensor Drivers		
MAX14838/ MAX14839	Binary	24V/100mA pin-configurable industrial sensor output driver + protection
MAX14832	Binary	24V/100mA one-time-programmable (OTP) industrial sensor output driver + protection
MAX14836	Binary	24V dual-output sensor transceiver

100mA Tiny Binary Sensor Drivers: MAX14838/MAX14839

The MAX14838/MAX14839 24V/100mA drivers are optimized for use in industrial sensors. These devices integrate the high-voltage (24V) circuitry commonly found in industrial sensors, including a configurable PNP/NPN/push-pull driver and an integrated linear regulator that meets common sensor power requirements.

- Pin-Selectable High-Side (PNP), Low-Side (NPN), or Push-Pull Driver
- On-Board 5V Linear Regulator (MAX14838)/3.3V Linear Regulator (MAX14839) (Figure 31)
- Dual Integrated 2mA LED Drivers
- Integrated Protection Provides Robust Sensor Solutions
  - Reverse-Polarity Protection on DO, V_{CC}, and GND
  - 4.75V to 34V Supply Range (MAX14839)
  - V_{CC} Hot-Plug Protection
  - Thermal Shutdown Protection
  - ±8kV IEC 61000-4-2 Air Gap ESD Protection
  - -40°C to +105°C Temperature Range
  - ±1kV/2A Surge Protection

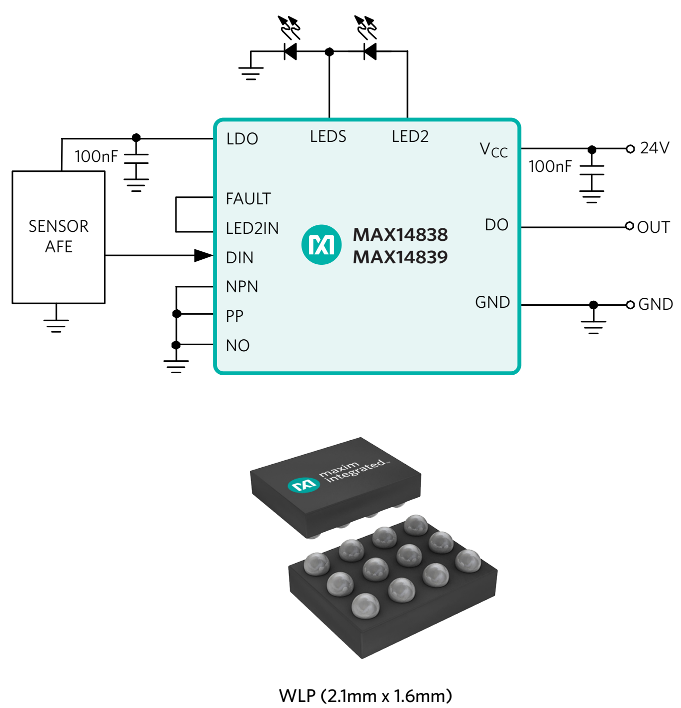


Figure 31. MAX14838/MAX14839 Binary Sensor Driver

Dual 250mA IO-Link Transceiver: MAX14827A

The **MAX14827A** integrates the high-voltage functions commonly found in industrial sensors, including drivers and regulators. The MAX14827A features two ultra-low-power drivers with active reverse-polarity protection (Figure 32). Operation is specified for normal 24V supply voltages up to 60V. Transient protection is simplified due to high-voltage tolerance allowing the use of micro TVS.

The device features a flexible control interface. Pin control logic inputs allow for operation with switching sensors that do not use a microcontroller. For sensors that use a microcontroller, an SPI interface is available with extensive diagnostics. For IO-Link operation, a three-wire UART interface is provided, allowing interfacing to the microcontroller UART. Finally, a multiplexed UART/SPI option allows using one serial microcontroller interface for shared SPI and UART interfaces.

The device includes on-board 3.3V and 5V linear regulators for low-noise analog/logic supply rails. The MAX14827A is available in a 24-pin TQFN package and a 25-pin WLP and is specified over the extended -40°C to +125°C temperature range.

- Lowest Power and Smallest IO-Link Transceiver
  - WLP Package (2.5mm x 2.5mm)
  - TQFN Package (4mm x 4mm)
- Low 2.3Ω (typ) R_{ON} Reduces Power Consumption
- Robust Protection: 65V Absolute Maximum for Smaller External Protection and Reverse-Polarity/Short-Circuit Protection

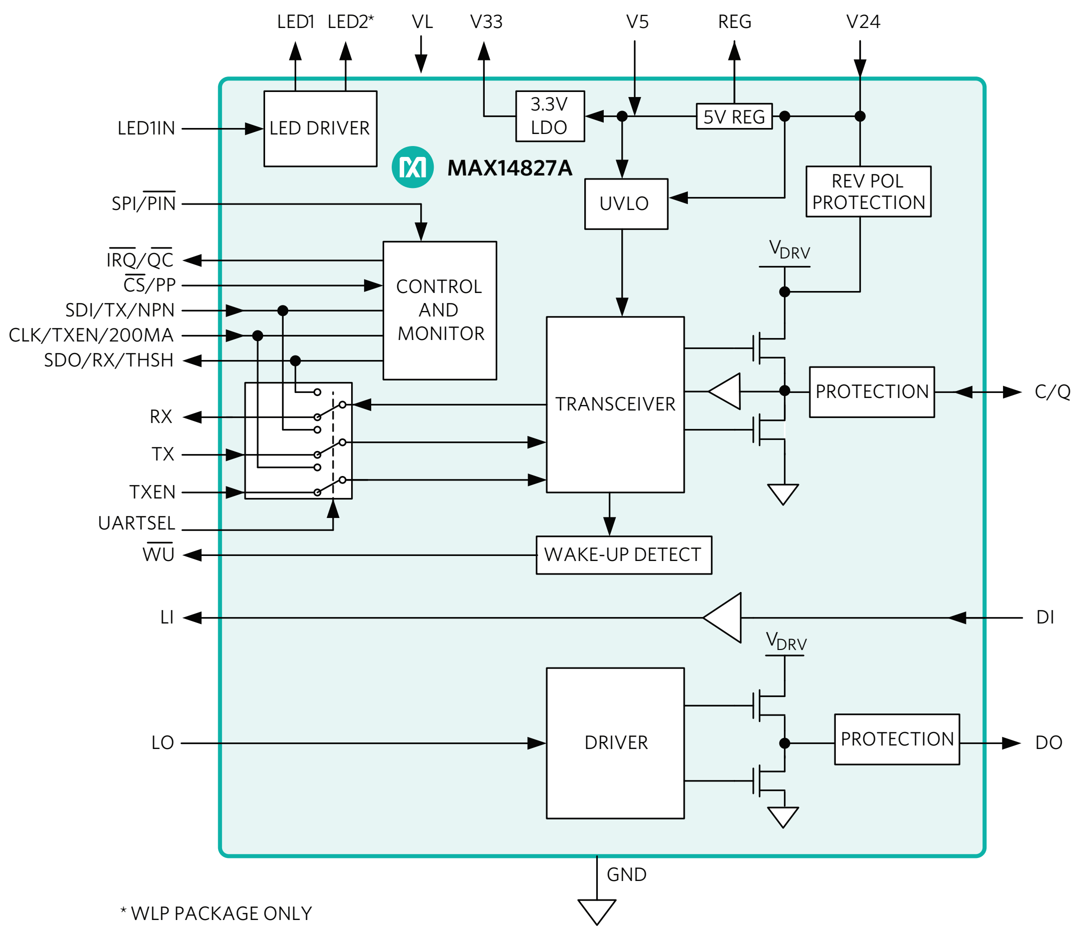


Figure 32. MAX14827A Dual-Channel IO-Link Transceiver

Dual-Channel IO-Link Master Transceiver: MAX14819

The **MAX14819** low-power, dual-channel, IO-Link master transceiver with sensor/actuator power-supply controllers (Figure 33) is fully compliant with the latest IO-Link and binary input standards and test specifications, IEC 61131-2, IEC 61131-9 SDCI, and IO-Link 1.1.2. This master transceiver also includes two auxiliary Type 1/Type 3 digital input (DI) channels. The MAX14819 is configurable to operate either with external UARTs or using the integrated framers on the IC. To ease selection of a microcontroller, the master transceiver features frame handlers with UARTs and FIFOs. These are designed to simplify time-critical control of all IO-Link M-sequence frame types. The MAX14819 also features autonomous cycle timers, reducing the need for accurate controller timing. Integrated communication sequencers also simplify wake-up management.

The MAX14819 integrates two low-power sensor supply controllers with advanced current limiting, reverse-current blocking on L+, and reverse-polarity protection capability to enable low-power robust solutions.

The MAX14819 is available in a 48-pin (7mm x 7mm) TQFN package and is specified over the extended -40°C to +125°C temperature range.

- Low-Power Architecture
  - 1Ω (typ) Driver On-Resistance
  - 1.9mA (typ) Total Supply Current for 2 Channels
- Integrated Protection Enables Robust Systems

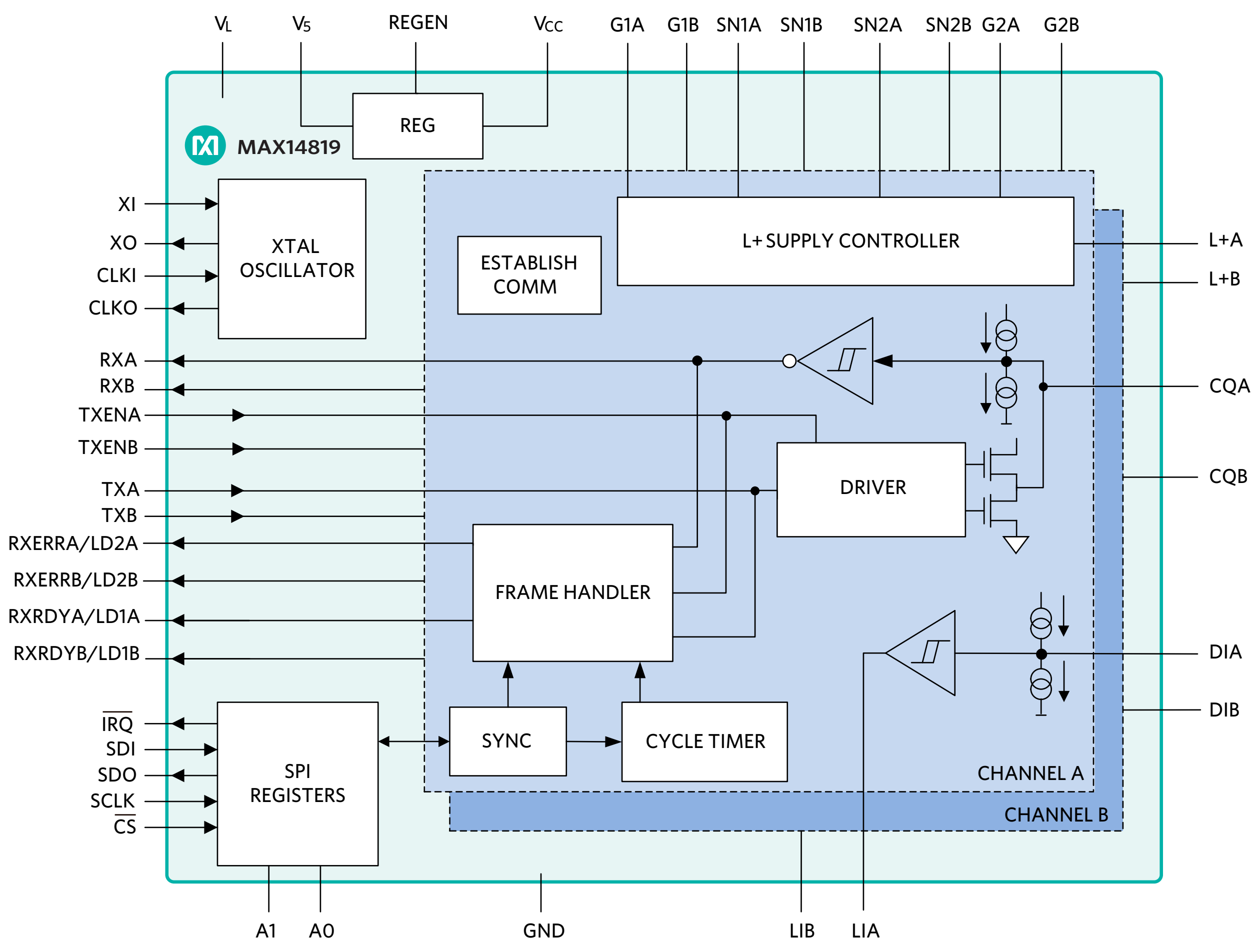


Figure 33. MAX14819 Dual IO-Link Master Transceiver

Evaluating an IO-Link Device

The MAX14827 evaluation kit (EV kit) consists of a MAX14827 evaluation board that is a fully assembled and tested circuit board that evaluates the MAX14827A IO-Link device transceiver. The MAX14827 EV kit (Figure 34) is designed to operate as a stand-alone board or with an Mbed™ board for easy software evaluation. The EV kit provides the user with an IO-Link-compliant device transceiver with a proven PCB layout. The EV kit is fully assembled and tested with a free GUI to make it easy to use for product evaluation and testing.

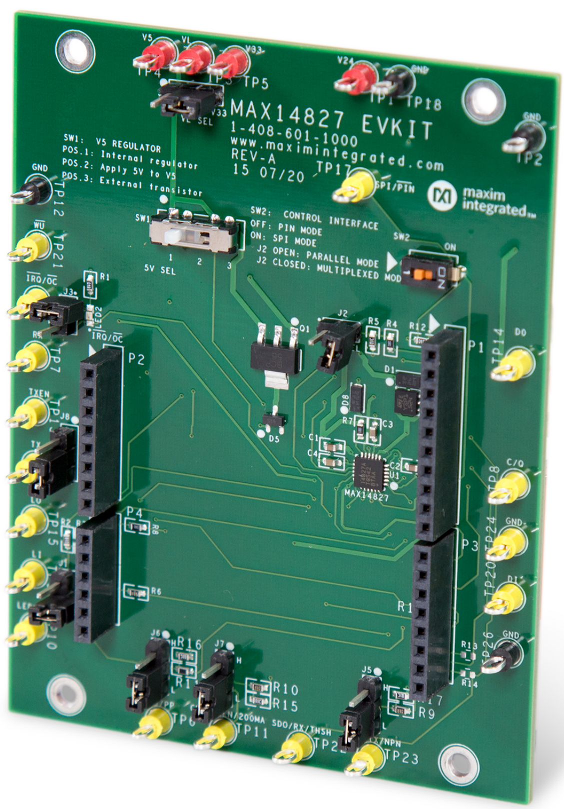


Figure 34. MAX14827 Evaluation Kit

Evaluating an IO-Link Master

The MAX14819 evaluation kit (EV kit) consists of the evaluation board and software. The EV kit (Figure 35) is a fully assembled and tested circuit board that evaluates the MAX14819 IO-Link dual-channel master transceiver. The MAX14819 EV kit includes Windows-compatible software that provides a GUI for exercising the features of the device. The EV kit is connected to a PC through a USB A-to-micro B cable.

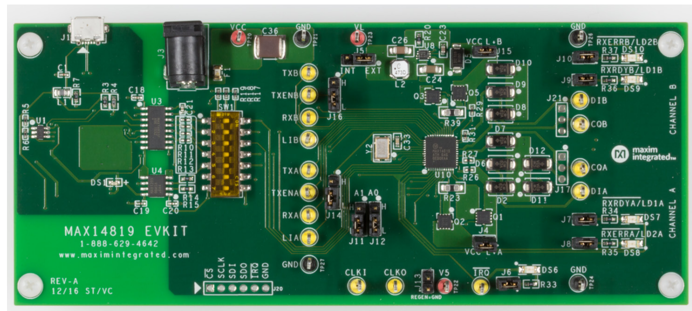


Figure 35. MAX14819 Evaluation Kit

Industrial IO-Link Reference Designs

Accelerate your designs with Maxim's IO-Link reference designs (Table 6). Each reference design includes high-performance products in tested circuits with design implementations from single parts and subsystems to full-system designs.

Table 6. IO-Link Reference Designs

Reference Design	Description
IO-Link Sensor	
MAXREFDES27	IO-Link Optical Proximity Sensor
MAXREFDES36	16-Channel Digital Input IO-Link Hub
MAXREFDES37	IO-Link Quad Servo Driver
MAXREFDES42	IO-Link RTD Temp Sensor
IO-Link Master	
MAXREFDES79	4-Port IO-Link Master
MAXREFDES145	8-Port IO-Link Master
MAXREFDES150	PLC with 4-Port IO-Link Master

Additional IO-Link Resources

IO-Link Webpages

IO-Link Transceivers and Binary Drivers

IO-Link Master Transceivers

IO-Link Device Transceivers

Binary Drivers

IO-Link Reference Designs

IO-Link Brochures

IO-Link Device Transceivers

Powering the Pocket IO PLC Development Platform

Put the Power of Industry 4.0 in Your Pocket: Meet the Pocket IO

IO-Link Application Notes and Articles

Application Note 6427: Calculating the Power Dissipation of the MAX14819 Dual-Channel IO-Link Master Transceiver

Application Note 5151: Special Considerations for Mode Changes During Active Operation of MAX14820/MAX14821 Sensor/Actuator Transceivers

Maxim Blog: To IO-Link And Beyond!

Maxim Blog: Vision Realized In Advancing Industry 4.0 Solutions

Videos

What is IO-Link?

Heat Map Comparison of IO-Link Device Transceivers

In the Lab: IO-Link Smart Sensor System Demo

Trademarks

Appendix of Technical Resources

Software Stack Vendors

Typically, IO-Link master and sensor manufacturers require a third party to generate the software stack. We have collaborated with key software vendors to support our IO-Link transceivers for sensor and master designs. Please contact our software partners directly for specific details of their products.

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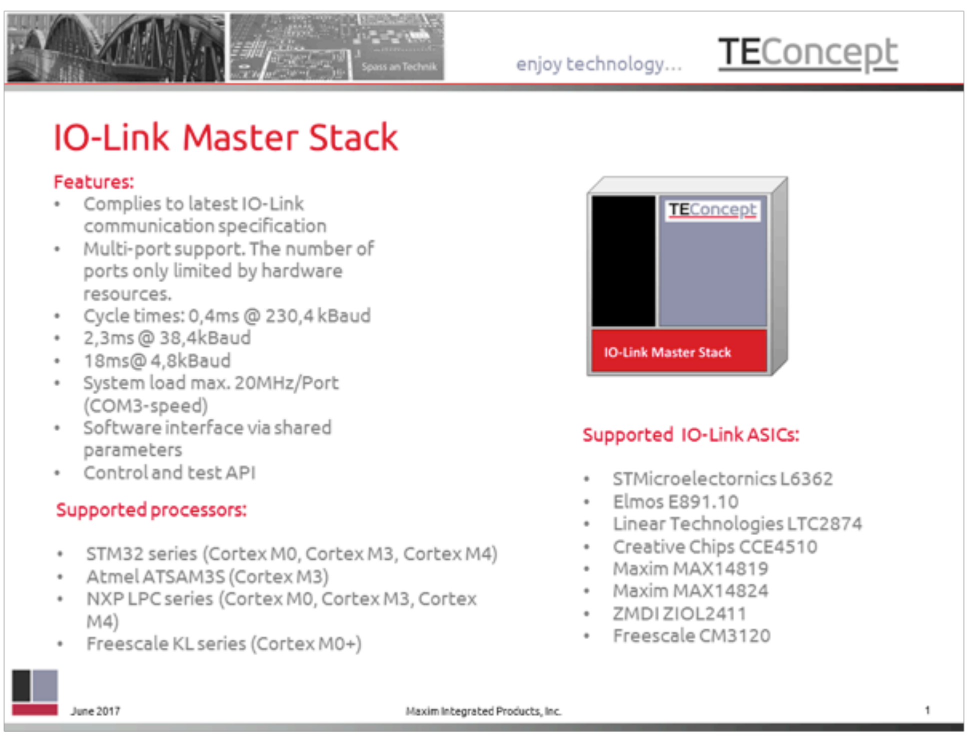
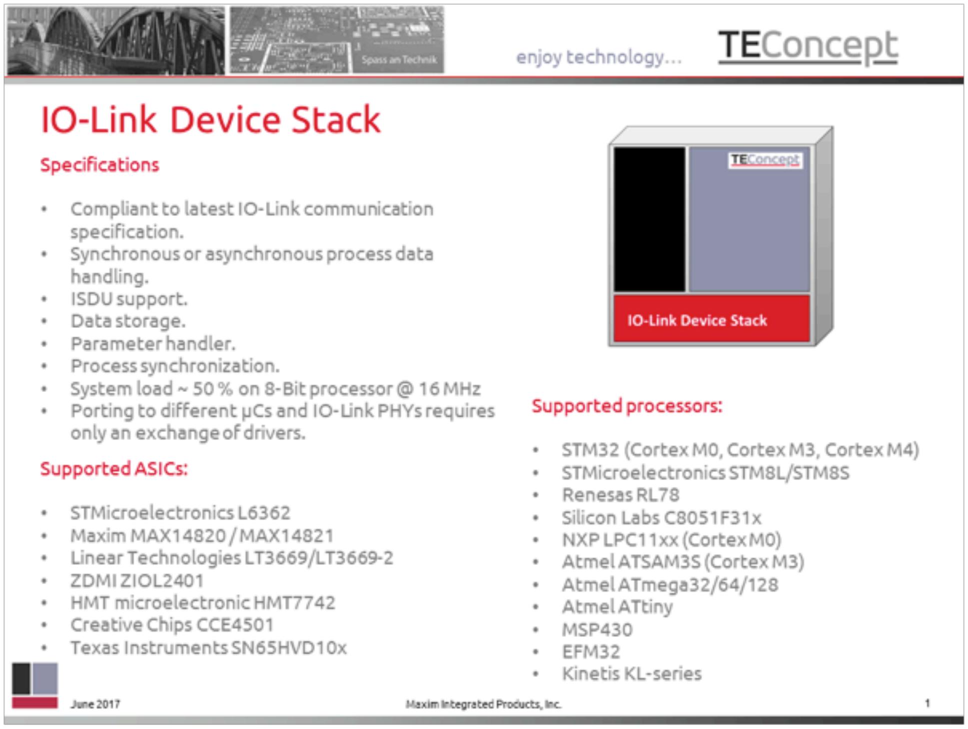
Technologie Management Gruppe Technologie und Engineering GmbH Zur Gießerei 10 76227 Karlsruhe Germany Phone: +49721828060 Email: willems@tmgte.de Web: **www.tmgte.com**	Technologie Management Gruppe Technologie und Engineering
IQ² Development GmbH Karlstraße 1 DE-72654 Neckartenzlingen Germany Phone: +49 (0) 7127 / 5706100 Fax: +49 (0) 7127 / 5706102 E-Mail: info@iq2-development.de Web: **www.iq2-development.de**	IQ² Development IO-Link Intelligent Components

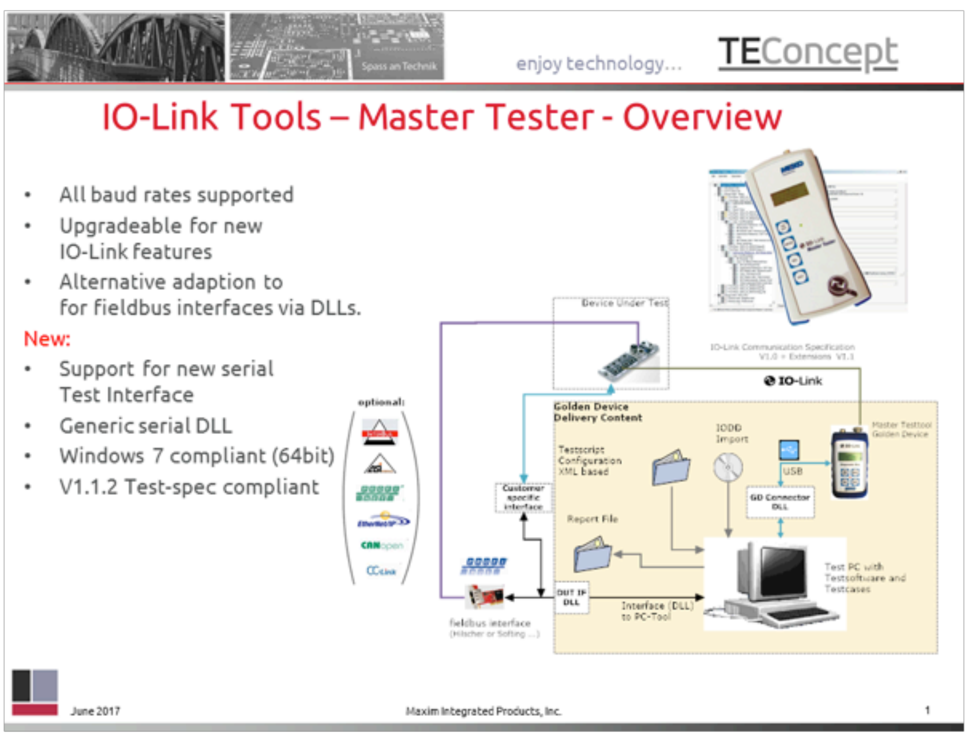
TEConcept Tools

Note: The following information is provided by TEConcept as an example of the types of products and services each software vendor provides. Please contact the software partner for further details.

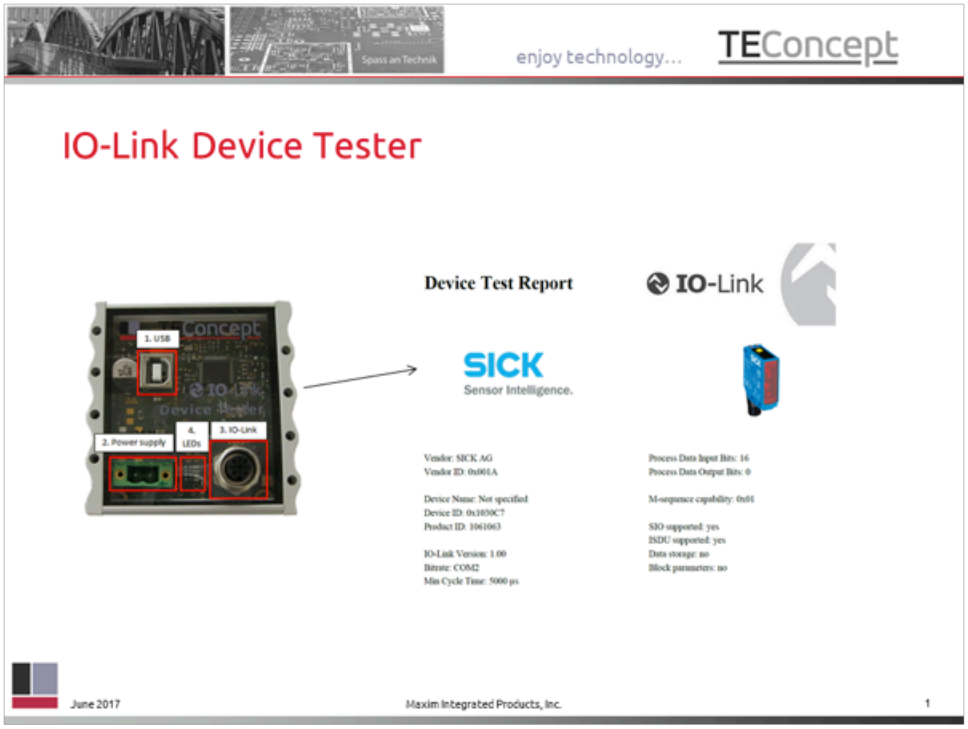


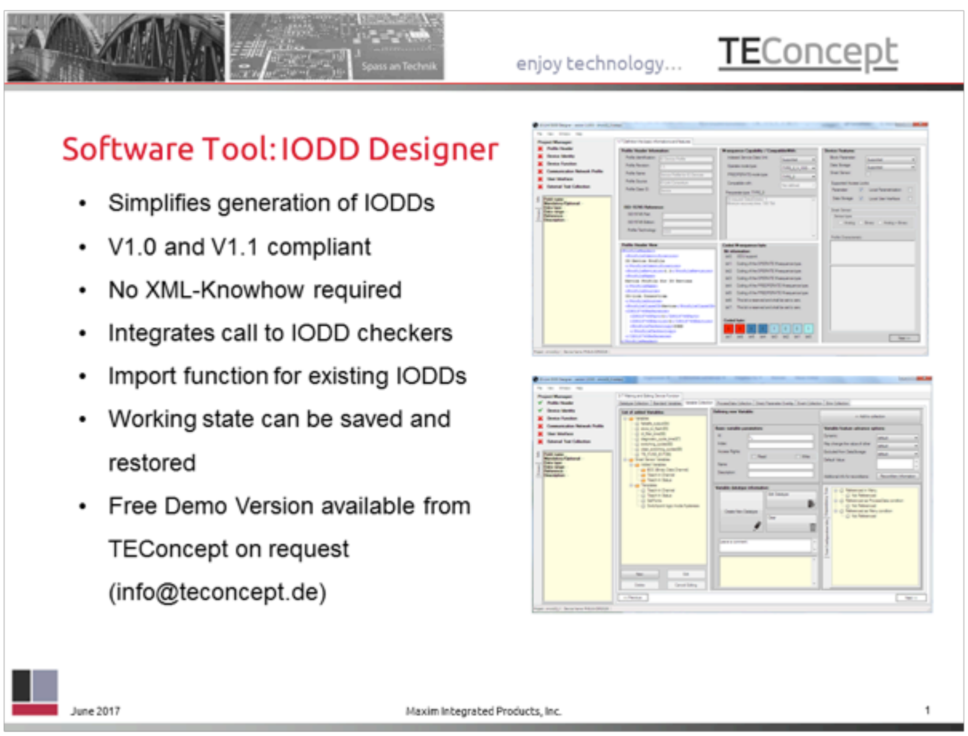
TEConcept Tools





TEConcept Tools





IO-Link Glossary

(Reprinted with permission from www.io-link.com.)

Acyclic data	Data transmitted from the controller only after a request (e.g., parameter data, diagnostic data).
COM1-3	IO-Link data transmission rates.
Cyclic data	Data that is transmitted by the controller automatically and at regular intervals (process data, value status).
DI	Digital input.
DQ	Digital output.
GSD file	The properties of a PROFINET device are described in a GSD file (generic Station Description), which contains all information required for configuring.
HMI	Human machine interface of an automatic system.
IEC 61131-9	International standard that deals with the basics of programmable controllers. Part 9 describes IO-Link under the designation *Single-drop digital communication interface for small sensors and actuators (SDCI).*
IODD	Electronic device description of devices (IO Device Description).
IO-Link device	Field device that is monitored and controlled by an IO-Link master.
IO-Link master	Represents the connection between a higher-level fieldbus and the IO-Link devices. The IO-Link master monitors and controls the IO-Link devices.
Parameter Assignment server	An IO-Link master according to IO-Link Specification 1.1 can act as a parameter assignment server for the IO-Link device.
Port	A port is an IO-Link communication channel.

IO-Link FAQs

Q: What components are recommended for protection during burst events?

A: We generally recommend that customers place pads for two capacitors (~220pF) on the C/Q line (one to GND and one to V_{CC}) for burst testing (IEC 61000-4-4). These capacitors should be placed as close to the IC as possible. Depending on the board, these capacitors may not be needed to pass burst testing, so we recommend testing without the capacitors first and then adding them, if needed.

TVS diodes with a clamp voltage lower than the absolute maximum ratings for the transceiver are required for protection during a surge event. Place TVS diodes as close to the IC as possible.

Q: Some IO-Link designs appear to have isolated ground planes. What is the isolation for?

A: While there is no requirement for isolation in the IO-Link specification, all IO-Link systems have isolation at some point in the signal chain. Isolation ensures that the controller/backplane is protected from any transient events that occur on the local 24V field supply. The isolation is usually placed in a location where the cost is minimized, for example, between the backplane and the controller or between the controller and the IO-Link transceiver.

Q: What is SIO and how does it relate to IO-Link?

A: Per the IO-Link specification, every IO-Link master port can be configured to operate in SIO (single input/output) mode or IO-Link (SDCI) communication mode. In SIO mode, the port can be configured to operate as a digital input or a digital output. See IEC 61121-2 for more information.

Q: Some IO-Link master transceivers have a DI input and some do not. What is DI?

A: DI is a digital input. Digital inputs are the most common inputs in industrial systems. DI is used to connect to binary sensors.

Q: Why does IO-Link support three different data rates?

A: Many industrial systems have existed for many years. While data rates in communication systems have increased significantly, many of those original sensors (often still operating in their original systems) were designed with slower software/communication capabilities. The IO-Link specification incorporates communication at three data rates that include most sensor capabilities to allow upgrades and improvements to industrial systems already in place, without requiring complete (and very expensive) overhauls.

Q: Do IO-Link masters and devices have to be surge protected?

A: Since IO-Link cables are specified for a maximum length of 20m, and the IEC 61000-4-5 surge standard mandates surge for cables longer than 30m, the IO-Link standard does not require surge protection.

Q: What is the maximum input capacitance pin that an IO-Link master may have on the C/Q pin?

A: An IO-Link master's input capacitance must be ≤ 1nF in receive mode in the frequency range up to 4MHz.

Q: What is the maximum capacitance that an IO-Link device may have?

A: The IO-Link device input capacitance should be ≤ 1nF. An exception is made in cases of COM1 or COM2 data rates in combination with push-pull driver operation, in which case, the maximum input capacitance may be up to 10nF.

Q: What is an IO-Link cable?

A: An IO-Link cable has at least 3 wires (C/Q, L+, and L-). The cable is not shielded.

Q: What is the maximum length of IO-Link cable?

A: The maximum cable length is 20m.

Q: What is the cable's worst-case resistance and capacitance allowed to be?

A: The loop wire resistance is 6.0Ω (max) while the maximum cable capacitance (C/Q to L+/L-) is 3.0nF (to 1MHz).

Q: Is the IO-Link cable terminated?

A: There is no specification for the termination of IO-Link cables. Hence, the voltage waveform on an IO-Link cable can exhibit overshoots.

Q: What is meant by IO-Link Cycle Time?

A: The IO-Link Cycle Time is the repetition rate at which the IO-Link master sends out its master message to the IO-Link device in Operate mode. This is the rate at which the device is provided with or requested for process data i.e., the rate at which a sensor is asked for in its measurement data or an actuator is given new data.

Q: What is the minimum IO-Link cycle time possible by the IO-Link standard?

A: The minimum cycle time is 400µs. Such small cycle times are only feasible with COM3 data rates.

Q: Can every IO-Link master support 400µs cycle times?

A: The IO-Link standard does not require that an IO-Link master support the 400µs minimum cycle time. Every IO-Link master specifies its own minimum cycle time capability.

Q: What is IO-Link communication based on?

A: IO-Link is based on a master-slave dialogue in which the IO-Link master polls the IO-Link device, which must answer the master message.

Q: How fast must an IO-Link device respond to an IO-Link master message?

A: An IO-Link device must send out its first bit within 10 bit times after the last bit of the master message. Hence, the response time depends on the data rate (COM rate).

Q: What topology does IO-Link employ?

A: IO-Link is a point-to-point connection in which an IO-Link master is connected to only one IO-Link device.

Q: What is the current drive capability of an IO-Link master C/Q port?

A: The C/Q pin of an IO-Link master can drive at least 100mA (min) continuously and 500mA (min) for a short time (for the IO-Link wake-up).

Q: What is the supply voltage range that an IO-Link master must provide for powering IO-Link devices?

A: An IO-Link master must provide a 24V power supply with a tolerance range of 20V (min) to 30V (max) to power IO-Link devices.

Q: At what load current must an IO-Link master be able to provide to an IO-Link device?

A: The IO-Link master must supply 200mA continuously.

Q: What is the supply range of an IO-Link device?

A: An IO-Link device must operate with a 24V nominal supply with a voltage range of 18V (min) and 30V (max).

Q: How much load current can an IO-Link device drive?

A: An IO-Link device is specified to drive at least 50mA. It is common for IO-Link devices to drive at least 100mA.

Q: Why are some IO-Link device transceivers able to drive 200mA or more load current?

A: While such high currents are not needed for IO-Link operation, they may be needed if an IO-Link device (such as a switching sensor) is specified to drive large loads, as in valves or relays, in standard binary output mode.

Q: Can an IO-Link device driver operate in PNP or NPN mode during IO-Link communication?

A: In general, IO-Link communication supports both push-pull and PNP modes. Push-pull is preferred, since the two logic states, defined when the device drives the C/Q line, are then defined by a low-impedance driver. PNP mode is possible for the lower COM rates, in which case, the C/Q low is defined by the 5mA pulldown in the IO-Link master.

Q: Can an IO-Link device operate in NPN mode?

A: An IO-Link device can only operate in NPN driver mode during SIO operation, if the IO-Link master supports NPN sensors. The IO-Link standard does not support NPN driver operation.

Q: I want to make my new IO-Link sensor compatible with older binary switching sensors that have PNP drivers. Can I operate the sensor in PNP mode?

A: When the sensor is operating in SIO mode, it can be operated in PNP mode so that it is compatible to the older sensors. When the sensor gets an IO-Link wake-up from the IO-Link master, it is suggested to switch its driver to push-pull mode.

Immunity Testing Results for MAXREFDES145

We test all of our reference designs for typical industrial requirements including ESD IEC 61000-4-2 and IEC 61000-4-5 as outlined by IEC 61000-4. The results for the MAXREFDES145 8-Port IO-Link Master are shown here.

Surge Test Results

All tests 5 pulses with 10 seconds between the pulses.

Channel 1 (40Ω/0.5μF CDN)				Channel 2 (40Ω/0.5μF CDN)			
C/Q	+500V	pass	(C/Q Mode is set to IO-Link)	C/Q	+500V	pass	(C/Q Mode is set to IO-Link)
C/Q	-500V	pass		C/Q	-500V	pass	
C/Q	+800V	pass		C/Q	+800V	pass	
C/Q	-800V	pass		C/Q	-800V	pass	
C/Q	+1000V	pass		C/Q	+1000V	pass	
C/Q	-1000V	pass		C/Q	-1000V	pass	
C/Q	+1200V	pass		C/Q	+1200V	pass	
C/Q	-1200V	pass		C/Q	-1200V	pass	
C/Q	+500V	pass	(C/Q Mode is set to DO, level is set high)	C/Q	+500V	pass	(C/Q Mode is set to DO, level is set high)
C/Q	-500V	pass		C/Q	-500V	pass	
C/Q	+800V	pass		C/Q	+800V	pass	
C/Q	-800V	pass		C/Q	-800V	pass	
C/Q	+1000V	pass		C/Q	+1000V	pass	
C/Q	-1000V	pass		C/Q	-1000V	pass	
C/Q	+1200V	pass		C/Q	+1200V	pass	
C/Q	-1200V	pass		C/Q	-1200V	pass	
C/Q	+500V	pass	(C/Q Mode is set to DO, level is set low)	C/Q	+500V	pass	(C/Q Mode is set to DO, level is set low)
C/Q	-500V	pass		C/Q	-500V	pass	
C/Q	+800V	pass		C/Q	+800V	pass	
C/Q	-800V	pass		C/Q	-800V	pass	
C/Q	+1000V	pass		C/Q	+1000V	pass	
C/Q	-1000V	pass		C/Q	-1000V	pass	
C/Q	+1200V	pass		C/Q	+1200V	pass	
C/Q	-1200V	pass		C/Q	-1200V	pass	
DI	+800V	pass		DI	+800V	pass	
DI	-800V	pass		DI	-800V	pass	
DI	+1000V	pass		DI	+1000V	pass	
DI	-1000V	pass		DI	-1000V	pass	
DI	+1200V	pass		DI	+1200V	pass	
DI	-1200V	pass		DI	-1200V	pass	

Immunity Testing Results for MAXREFDES145 (continued)

Surge Test Results

Channel 1 (40Ω/0.5µF CDN)				Channel 2 (40Ω/0.5µF CDN)			
L+	+500V	pass	L+ on	L+	+500V	pass	L+ on
L+	-500V	pass	L+ on	L+	-500V	pass	L+ on
L+	+550V	pass	L+ on	L+	+550V	pass	L+ on
L+	-550V	pass	L+ on	L+	-550V	pass	L+ on
L+	+600V	pass	L+ on	L+	+600V	pass	L+ on
L+	-600V	pass	L+ on	L+	-600V	pass	L+ on
L+	+700V	pass	L+ on	L+	+700V	pass	L+ on
L+	-700V	pass	L+ on	L+	-700V	pass	L+ on
L+	+800V	pass	L+ on	L+	+800V	pass	L+ on
L+	-800V	pass	L+ on	L+	-800V	pass	L+ on
L+	+900V	pass	L+ on	L+	+900V	pass	L+ on
L+	-900V	pass	L+ on	L+	-900V	pass	L+ on
L+	+1000V	pass	L+ on	L+	+1000V	pass	L+ on
L+	-1000V	pass	L+ on	L+	-1000V	pass	L+ on

V_{CC} tested without CDN, Impedance is 2Ω.		
V_{CC}	+500V	pass
V_{CC}	-500V	pass
V_{CC}	+550V	pass
V_{CC}	-550V	pass

Immunity Testing Results for MAXREFDES145 (continued)

ESD Test Results

Channel 1				Channel 2			
L+	+4kV	pass	Board not powered	L+	+4kV	pass	Board not powered
L+	-4kV	pass	Board not powered	L+	-4kV	pass	Board not powered
L+	+4kV	pass	L+ on	L+	+4kV	pass	L+ on
L+	-4kV	pass	L+ on	L+	-4kV	pass	L+ on
L+	+4kV	pass	L+ off	L+	+4kV	pass	L+ off
L+	-4kV	pass	L+ off	L+	-4kV	pass	L+ off
L+	+5kV	pass	Board not powered	L+	+5kV	pass	Board not powered
L+	-5kV	pass	Board not powered	L+	-5kV	pass	Board not powered
L+	+5kV	pass	L+ on	L+	+5kV	pass	L+ on
L+	-5kV	pass	L+ on	L+	-5kV	pass	L+ on
L+	+5kV	pass	L+ off	L+	+5kV	pass	L+ off
L+	-5kV	pass	L+ off	L+	-5kV	pass	L+ off

Learn more

For more information, visit:
www.maximintegrated.com/io-link

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