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Introduction to IO-Link technology

With IO-Link technology, the classic sensor network in the factory automation plant becomes more efficient and smart. In fact, the inherent value of sensors and actuators increases; not only can they interface with the analog world (i.e. the classic industrial proximity sensor), but now offer enhanced capabilities in terms of communication and self-diagnostics. As described in Figure 1, with IO-Link, behind the higher level fieldbus infrastructure, there is point-to-point communication which is now self-contained, capable of providing everything industrial sensor manufacturers are looking for in the Industry 4.0 era.

Figure 1 – Typical factory automation network with IO-Link architecture
The IO-Link architecture is simple. The end-point (sensor or actuator) needs an IO-Link transceiver to connect to the network.

As shown in Figure 2, ST’s L6362A IO-Link transceiver IC (Device) is used to connect the end-point (sensor or actuator) to the network. On the left side of Figure 2, the L6360 transceiver (Master) is the access point to the remaining part of the network to be interfaced to a PLC or any industrial gateway. The protocol stacks for the L6360 and the L6362A are stored in their associated microcontroller. Both ICs also support standard IO mode (SIO mode) communication.

Formed in 2006, the IO-Link communication standard is defined in IEC 61131-9, sponsored by the main European manufacturers of industrial sensors and control systems. ST, as a global semiconductor company, joined the IO-Link consortium at the beginning, and remains an active contributor in defining the standard’s specifications.

The list of companies in the IO-Link consortium is increasing and does not only include sensor and actuator manufacturers. While the core was established in Europe, today worldwide industrial players recognize the high value of being part of the IO-Link story. For an up-to-date list of member companies, visit www.io-link.com.
IO-Link specifications

IO-Link is a serial, bi-directional, point-to-point communication protocol able to supply energy to the end device. At high level, the specifications can be summarized as follows:

- Standard industrial cabling, which makes IO-Link a universal solution that is extremely easy to integrate in existing infrastructures.
- Efficiency in communication, thanks to the protocol’s robustness.
- Smart configurability

STANDARD INDUSTRIAL CABLEING

In factory automation, connectors and cables play a huge role in terms of reliability and overall cost of the application. As a standard Plug & Play technology, IO-Link does not require dedicated cables or connectors. In fact, standard M5, M8 and M12 (in most of cases) connectors are used in a 3- or 4-pole configuration, with a maximum cable length of 20 m.

EFFICIENCY IN COMMUNICATION

With the Master capable of communicating either in analog or binary mode (8-, 12- or 16-bit), a standard data frame typically takes 2 bytes of process data per cycle with a maximum transmission time of 400 μs at 230 kBd (transmission rates are defined in the protocol specification v1.1).

To secure device portability throughout the industrial network life (i.e. a replacement of a sensor or an actuator), all the parameters are stored in the Master, so that, when a replacement occurs, the Device can get the information needed, resulting in a Plug & Play installation.

SMART CONFIGURABILITY

The IO-Link Device Description (IODD) file stores critical information, usually in XML format, about the sensor i.e. device ID, main functions, manufacturer and product part number. The IODD unambiguously identifies the device and makes it easier for developers to integrate any sensor or actuator into the existing IO-Link network.

A list of sensors compatible with the IO-Link standard and their IODD file can be found on the IO-Link website.

A service called IODDfinder is also available to help developers in understanding which vendors and associated devices can be used.

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

<table>
<thead>
<tr>
<th>Transmission data rates allowed</th>
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<tbody>
<tr>
<td>COM1</td>
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<td>COM2</td>
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<td>COM3</td>
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<th>Pin assignment according to IEC 60974-5-2</th>
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<td>1</td>
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<td>3</td>
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Figure 3 – The 3-wire connection recommended in the standard
The L6360 is a monolithic IO-Link master port compliant with PHY2 (3-wire), supporting COM1 (4.8 kBd), COM2 (38.4 kBd) and COM3 (230.4 kBd) modes.
Great flexibility is given by the programmability of the C/Q₀ output pin as high-side, low-side or push-pull configurations are allowed.
Overload and short circuit issues are taken into account thanks to programmable cut-off current, cut-off current delay time, and restart delay time values, combined with thermal shutdown and automatic restart functions.
The L6360 communicates with the microcontroller through a standard 2-wire I²C interface by means of nine registers where IC status and fault conditions are stored and can be monitored (i.e. L+ line, over-temperature, C/Q overload, linear regulator under-voltage, and parity check). The L6360 transfers, through the PHY2 (C/Q₀ pin), data received from a host microcontroller through the USART (IN C/Q₀ pin), or to the USART (OUT C/Q₁ pin) data received from PHY2 (C/Q₁ pin).
The supply voltage is monitored for low-voltage conditions.
The feature appreciated in most industrial applications is the IC’s capability to drive two LEDs through programmable sequences. Any kind of load (capacitive, resistive or inductive up to 10 mJ) can be driven by the IC with the C/Q₀ and L+ lines.
For more details on the L6360’s features, consult the associated datasheet.
To help developers evaluate the L6360's functionalities, the STEVAL-IFP016V2 demonstration board is available. It can be connected with any external microcontroller through a dedicated connector. The board takes as inputs the signals coming from the microcontroller, providing outputs working at 24 V for industrial applications. With the STEVAL-IFP016V2, the L6360 can work both as the IO-Link master and in standard IO mode.

A large GND area on the printed circuit board is designed to minimize noise and ensure good thermal performance.

The interface is compatible with the STEVAL-PCC009V2 and STEVAL-PCC009V1 universal interface evaluation boards ensuring EMC-immunity against ESD, burst, surge, RF noise, etc., in compliance with IEC61000-4-2, IEC61000-4-4, IEC61000-4-5, and IEC61000-4-6 standards.
The L6362A is an IO-Link and SIO (standard IO) mode transceiver IC compliant to PHY2 (3-wire connection) supporting COM1 (4.8 kBd), COM2 (38.4 kBd) and COM3 (230.4 kBd) modes. Low-side, high-side and push-pull output configurations are allowed with the IC which can drive any kind of load (resistive, capacitive or inductive). It is an ideal interface for industrial sensors running in the 24 V environment, to be connected to PLCs, industrial IO modules or IO-Link master side. This IC includes a full set of protections especially for reverse polarity among $V_{cc}$, GND, OUTH, OUTL and I/Q pins, which is a key feature in managing industrial parts. Other protections are output short-circuit, overvoltage and fast transient conditions ($\pm 1$ kV, 500 $\Omega$ and 18 $\mu$F coupling). For more information, consult the datasheet.

**KEY FEATURES**

- Extremely efficient power stage
  - $R_{DSON} = 0.8 \Omega / 1 \Omega$ (low-/high-side)
  - Output current up to 300 mA
  - Modes: high-side, low-side, push-pull
  - Able to drive L/C/R up to 500 mJ/30 $\mu$F
- 5 V or 3.3 V, 10 mA selectable linear regulator
- COM1, COM2 and COM3 modes supported

- Wake-up detection supported
- Full set of protections including reverse polarity, over / under-voltage, overload, over-temperature…
- High EMC robustness (Burst, Surge, ESD…)
- -40 to +125 °C operating ambient temperature
- Tiny DFN package (3 x 3 mm)
The IC features a very efficient power stage with extremely low $R_{\text{DS(on)}}$, 0.8 Ω in case of low-side and 1 Ω for the high-side switch. Thanks to this, the chip achieves the lowest power dissipation on the market when driving loads. It has also a very positive influence on the EMC immunity, the chip sustains also strong surge pulses (1 kV/500 Ω) without any external protections.

The tiny DFN package (3 x 3 mm) makes the final applications very compact, in order to be easily integrated in industrial sensor cases.

The STEVAL-IFP017V3 evaluation board is designed to analyze the L6362A’s features. The board is recommended to test all the IC’s advanced features such as the fast demagnetization and the reverse polarity, as well as the protection set including overload, overtemperature and open wire on the supply lines.

Thanks to the IC’s robustness, with the STEVAL-IFP017V3, the IEC 61000-4-4 (burst), IEC 61000-4-2 (ESD) and EN60947-5-2 / IEC 61000-4-5 (surge) requirements can be met without additional external components.

An electrically floating copper area is connected to the exposed pad of the L6362A working as a heatsink. Screw connectors to facilitate input and output management and LEDs for IC status are mounted on the board.
At the application level, ST provides the IO-Link demonstration kit composed of:

- **STEVAL-IDP004V1**: a 4-port master evaluation board mounting 4 L6360 transceivers
- **STEVAL-IDP003V1**: the device sub-kit with
  - **STEVAL-IDP003V1D**: the board mounting the L6362A transceiver
  - **STEVAL-IDP003V1A**: sensor daughter board for STEVAL-IDP003V1D mounting an accelerometer sensor (IIS328DQ)
  - **STEVAL-IDP003V1P**: sensor daughter board for STEVAL-IDP003V1D mounting a proximity sensor (VL6180X)
  - **STEVAL-IDP003V1T**: sensor daughter board for STEVAL-IDP003V1D mounting a temperature sensor (STTS751)
  - **STEVAL-IDP003V1V**: sensor daughter board for STEVAL-IDP003V1D mounting a vibration sensor (IIS2DH)

The STEVAL-IDP004V1 multi-port evaluation board is designed to provide a complete master unit with several communication interfaces such as IO-Link, SIO mode (Standard IO), RS-485, CAN and USB. Each of these are supplied using low voltage reference obtained by DC/DC converter in buck configuration, and handled by STM32F205RBT7 Cortex® M3 microcontroller. The block diagram below shows the STEVAL-IDP004V1’s main characteristics.

- **Standard 4-pole M12 female industrial connectors have been soldered onto the STEVAL-IDP004V1, making the solution very close to the final application**
- **Layout routing and protections are implemented to improve robustness in terms of EMC compliance**
With the STEVAL-IDP004V1 multi-port evaluation board, the ST IO-Link kit lets developers use a generic RS-232 PC interface (i.e. HyperTerminal or Tera Term) to run programming procedures and acquire remote sensor data using an RS-485 interface.

Up to 4 STEVAL-IDP003V1D boards can be connected to the master STEVAL-IDP004V1 board, with four different sensors to run the first application case, with firmware examples provided as part of the ST IO-Link demonstration kit.

The STEVAL-IDP003V1D board includes the L6362A IO-Link device transceiver to interface with sensors on the bus, a power-stage circuit to generate a lower voltage reference for the microcontroller and sensors using a DC/DC converter in buck configuration and a low-drop voltage regulator for the 3.3 V voltage reference.

The STM32L071CZY ultra-low-power ARM Cortex® M0+ microcontroller handles the communication on IO-Link bus and the communication with sensors using respectively the USART and the I2C peripheral.

Further details about the ST IO-Link demonstration kit are available on www.st.com.

**THE STEVAL-IDP003V1D BOARD TAKES CARE OF:**

- Layout routing, to improve robustness against EMC and ESD (IEC61000-4-2/4, EN60947-5-2) stress, and reduce board size as much as possible
- Only 8 x 70 mm, with 0.8 mm thickness to fit industrial application cases
- Can be connected with any sensor daughterboard above listed
- Standard 4-pole M12 male industrial connector on board

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![Figure 12 – STEVAL-IDP003V1 block diagram with the STEVAL-IDP003V1D as the main part represented on the left](image)
IO-Link stack, tools and development services

ST provides semiconductor solutions covering all IO-Link application hardware both on the Master and Device sides. Our tools are provided to let you easily evaluate our products and rapidly develop final applications.

ST microcontrollers are supported by a rich "ecosystem" for all integrated peripherals, providing various advanced functionalities. Firmware libraries allowing several levels of hardware abstraction are also available for free download on www.st.com.

ST actively cooperates with its long-established market-leading partners in providing IO-Link software stacks ported on STM8 and STM32 microcontroller platforms (for the full list, it is recommended to visit www.st.com).

One of the key partners in this field is TEConcept, which (on top of other activities) offers the following services/tools for our products:

- IO-Link master and device stacks optimized for ST MCUs (STM32, STM8) and ST IO-Link transceivers
- Master and device evaluation tools with full IO-Link functionality
- Master and device tester tools enabling also full EMC compliance evaluation
- Other IO-Link products/tools

For more detailed information, please refer to TEConcept’s website at https://www.teconcept.de