IO-Link Wireless Exposé

The base technology of IO-Link is subject matter of the international standard IEC 61131-9. It specifies a single-drop digital communication interface technology between Master/Gateways and Devices (sensors, actuators) and has been expanded now to wireless communication. This document gives a short introduction of the technology.

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Industrial Wireless Communication

The Industrial Demand

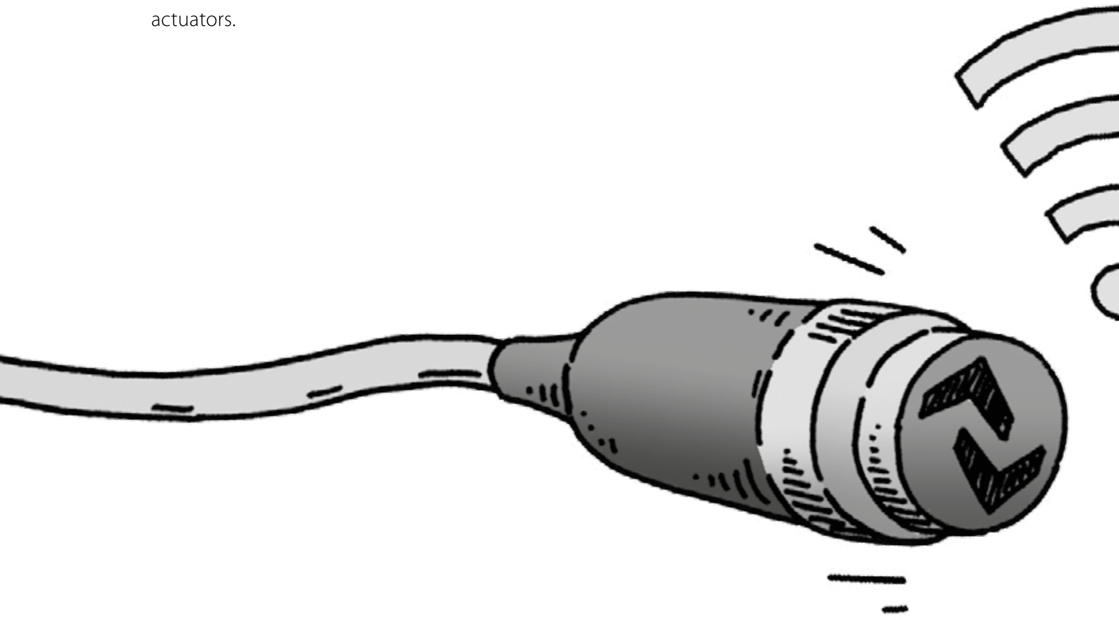
With the onset of the Industrial 4.0 (Industrial IoT) evolution, communication needs are changing rapidly. Machine-to-machine (M2M) communication such as connected robots, warehouse automation, and factory processing machinery are becoming more and more prevalent and demanding higher availability, better robustness, lower latency, and deterministic patterns.

In this evolution, cable-based communication simply cannot fulfil the requirements demanded by the tremendous increase in connected devices in terms of flexibility, mobility and monitoring. IO-Link Wireless, an extension of the IO-Link standard, is the first wireless protocol that addresses these needs and presents reliable and deterministic wireless communication to sensors and actuators.

Standard Availability

The IO-Link Wireless standard was recently published (IO-Link Wireless System Extensions – www.io-link.com/ilwse) and is under public review. IO-Link Wireless, for the first time, presents a reliable, real-time and deterministic protocol for industrial factory automation control systems. It's expected that this standard extends the serial wired cables in industrial control applications, add mobility and flexibility that are missing in the wired protocol and takes the industrial machinery communication to the next level.

This paper provides a high-level description of the IO-Link Wireless protocol. For more information please review the standard (IO-Link Wireless System Extensions – www.io-link.com/ilwse).



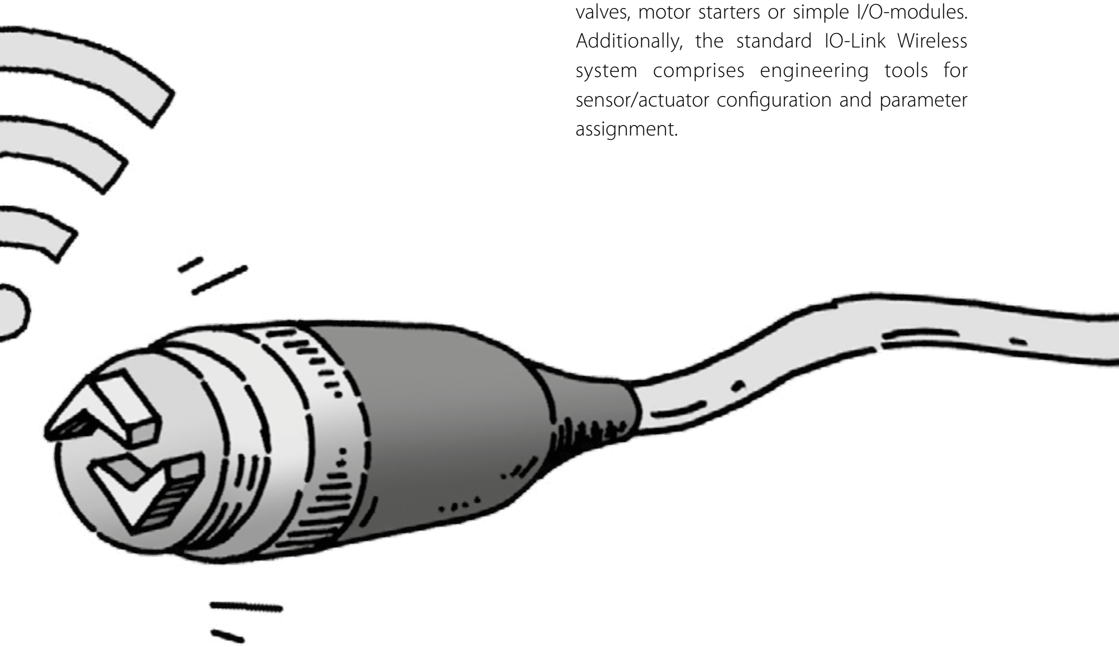
What is it IO-Link Wireless?

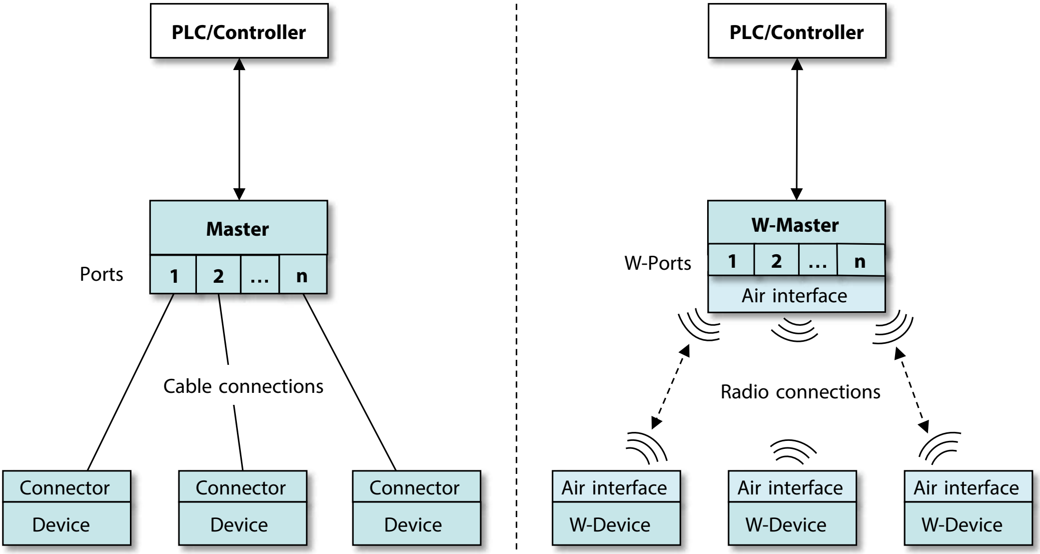
IO-Link Wireless defines wireless network communication between sensors, actuators and controllers (PLC) in the factory automation environment. It was designed to provide a similar level of performance and backward compatible interface as with cables so the migration from wired to wireless systems is made easy. IO-Link Wireless provides deterministic latency of 5 msec communication with 40 nodes (sensors or actuators). It presents reliability that is better than $10e^{-9}$ Packet Error Rate (PER). As an example, other wireless standards like WLAN, Bluetooth and Zigbee show PER that is 6 orders of magnitude less reliable (~1e-3) in industrial environments.

IO-Link Wireless supports roaming capabilities and the possibility to include battery-powered or energy-harvesting sensors with low energy consumption in the real-time network. One of the key features of IO-Link Wireless is the compatibility with the factory and process automation protocols. The system planning, setup, operation and maintenance standard engineering tools of IO-Link can be employed so that the backward compatibility with wired IO-Link solutions is guaranteed.

IO-Link Wireless System Description

An IO-Link Wireless system typically consists of an IO-Link Wireless fieldbus gateway (master), and IO-Link Wireless devices. Devices can be sensors, actuators, RFID-readers, valves, motor starters or simple I/O-modules. Additionally, the standard IO-Link Wireless system comprises engineering tools for sensor/actuator configuration and parameter assignment.



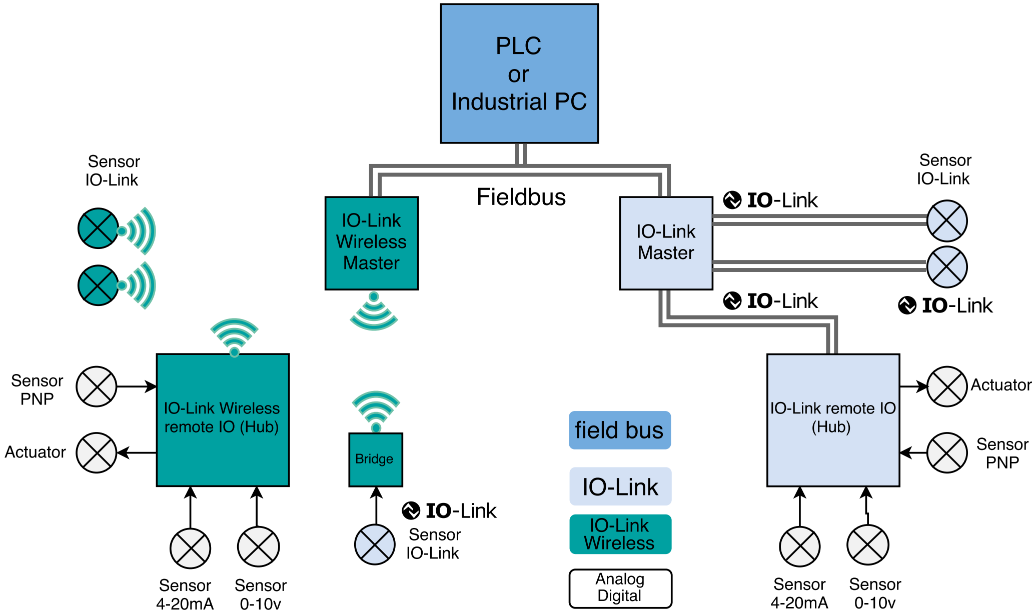


Compatible Architecture of Wired IO-Link and Wireless IO-Link

The following basic data types are defined:

- **Process data:** with a length of up to 32 Bytes, which are exchanged with every communication cycle.
- **Value status data:** indicating if the process data is valid or not, which is information also exchanged cyclically.
- **Parameter and diagnostic data:** such as identification information, settings, warnings and errors, which are exchanged on-request.

The next figure shows an example of a system architecture based on IO-Link wireless and wired. The architecture of the wireless IO-Link looks similar to the wired (star topology) but without the communication cables. IO-Link Wireless also supports bridge functionality between IO-Link to IO-Link Wireless. This feature that is part of the standard allows fast IO-Link devices to become wireless connected to the master.

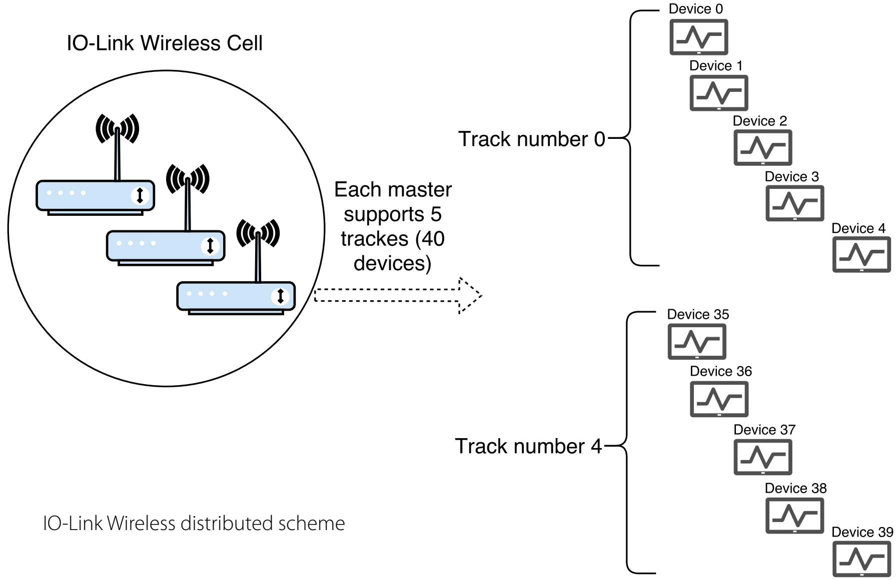


Compatible Architecture of Wired IO-Link and Wireless IO-Link

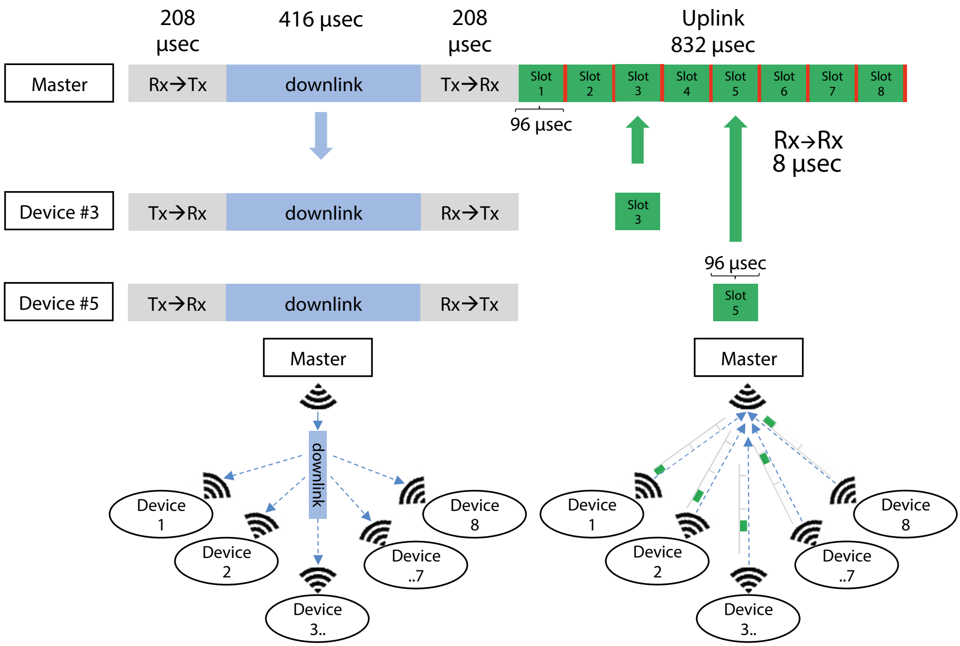
IO-Link Wireless Physical Layer – The Source of Robustness

In order to meet the high reliability requirements (PER of $10e^{-9}$) in industrial environments, a narrow band GFSK (Gaussian Frequency Shift Keying) modulation has been chosen. This modulation enjoys high power efficacy and good rejection to interferers, but also immunity to channel fading due to the narrow band, 1MHz. The same modulation serves other protocols like the low energy Bluetooth and 802.15.4 standards, but achieves different performance due to different medium access protocol schemes. To comply with regulatory standards, the maximum RF transmission power is 10 mW and 2.45 GHz ISM-band (unlicensed) have been chosen, even though this band suffers from wireless congested environments.

To guarantee highly reliable linkage in a congested environment, a combination of a frequency and time division media access scheme (F/TDMA) has been used. Downlink (DL) messages from the IO-Link master to the devices and uplink (UL) messages from the devices to the master are exchanged in a half-duplex mode in a defined timeframe. A cell can support up to 3 masters, while each master communicates with up to 40 sensors over 5 tracks. The next figure illustrates this scheme.



IO-Link Wireless distributed scheme



IO-Link Wireless TDMA

An improved coexistence behavior is achieved by using two mechanisms, frequency hopping and dynamic blacklisting, which allows operation of the wireless sensor/actuator network with low packet-error rates even in industrial plants where three WLAN bands are allocated in the 2.45 GHz band.

In terms of real-time, a cycle-time of 5 msec was specified to meet the reliability and in each cell up to 120 nodes (sensors or actuators) are sampled in each cycle-time. In a duration of 5 msec, two retransmits of cyclic data are supported in different channels to get better immunity to narrow band interferers or channel fading. Frequency-hopping algorithms minimize the channel fading but also improves coexistence behavior and allow devices to roam between masters.

Several concepts have been defined to reduce energy consumption to also allow devices with very limited energy resources to be integrated into the wireless communication system, such as long-term operable battery-powered devices.

One of the key features of IO-Link Wireless is support in roaming of devices between PLCs. It allows wireless device mobility between base station cells in a way that cyclic process data communication between PLC and device isn't interrupted during the handover process.

Summary

Reliable wireless was long sought for industrial automation applications. It has now been established

The benefits of using wireless for industrial automation applications are certainly alluring enough in terms of flexibility, cost reduction, higher mobility and better scalability. Modern factories understand the added value of a flexible production line. There is a rising demand for robotic arms, smart sensors and advanced actuators for automation, and unmanned automatic guided vehicle (AGV) to increase efficiency. Since much of the equipment is portable and the production line needs to be flexible, wireless is a better fit for connectivity. However, the downside of using wireless in industrial applications is that it's much harder to meet the reliability requirements demanded by industrial automation.

The IO-Link Wireless protocol was made to answer these challenges – high reliability, low latency, deterministic communication and compatibility to wired factory automation protocols.

More Information about IO-Link:
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