Revolutionizing Sensing in Industrial Automation with IO-Link

IO-Link Ready Dual Channel Resistive Sensor Signal Conditioner ZSSC3286

Abstract

This white paper explores IO-Link, a digital communication interface technology, designed for industrial automation. By examining its key features, components, benefits, and applications, this document aims to provide a comprehensive understanding of how IO-Link is transforming the landscape of industrial operations. We highlight the ZSSC3286 sensor signal conditioner, which integrates the IO-Link stack, including the Smart Sensor Profile, further enhancing its capabilities.

The ZSSC3286 is a dual path sensor signal conditioning IC (SSC) for highly accurate amplification, digitization, and sensor-specific correction of sensor signals. The ZSSC3286 supports IO-Link connectivity with an integrated IO-Link stack running the IO-Link Smart Sensor Profile for digital measuring and switching sensors. The device is suitable for bridge and half-bridge sensors, as well as external voltage-source elements. The programmable, integrated sensor front-end allows optimally applying various sensors for a broad range of applications. Digital compensation of the sensor offset, sensitivity, temperature drift, and non-linearity is accomplished via a 32-bit ARM based math core running a correction algorithm with calibration coefficients stored in a non-volatile, reprogrammable memory. The ZSSC3286 supports system configuration, calibration, and firmware update via the IO-Link or I2C interface.
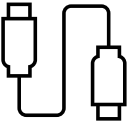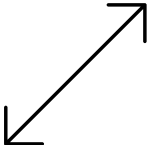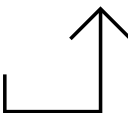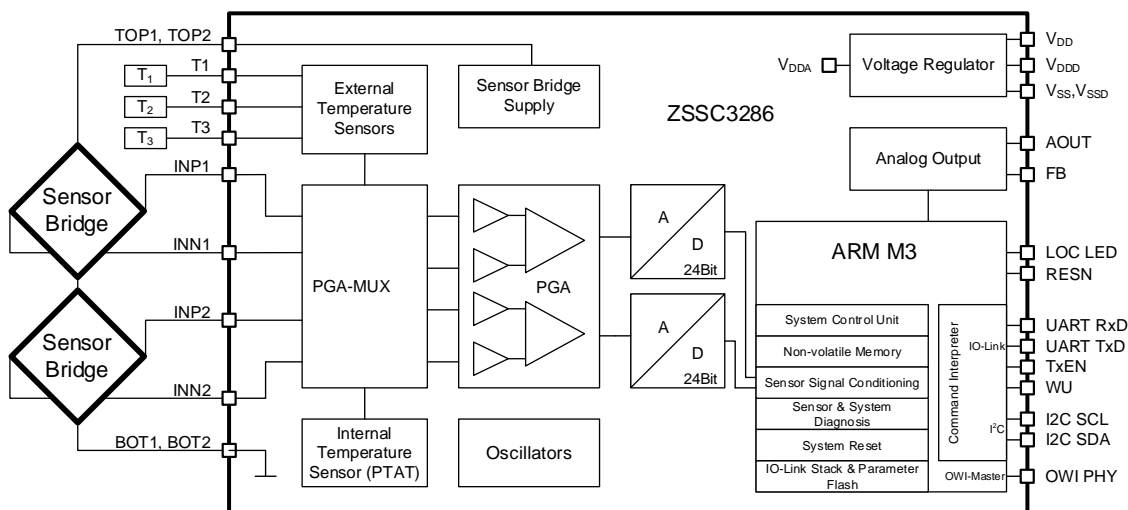

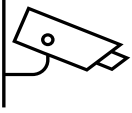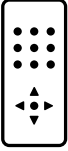**Figure 1. ZSSC3286 typical Application Diagram**

IO-Link: An Overview

Introduction of IO-Link

In the realm of industrial automation, the need for intelligent, efficient, and interoperable communication systems has never been greater. The IO-Link (SDCI) technology, standardized in IEC 61131-9, addresses this need by offering a versatile and robust solution for connecting sensors, actuators, and other devices to control systems. This white paper provides an overview of IO-Link, highlighting its potential to revolutionize industrial processes, and introduces the ZSSC3286 sensor signal conditioner as a prime example of IO-Link sensor integration.

Key Features and Benefits

Standardization	
	IO-Link stands out as an open standard, ensuring seamless interoperability between devices from different manufacturers. This standardization is crucial for creating flexible and scalable automation systems by making IO-Link integrable into all common fieldbus systems.

Point-to-Point Communication	
	IO-Link employs a straightforward point-to-point communication model using standard unshielded 3-wire cables. Unlike traditional fieldbus systems that rely on complex network topologies, each IO-Link device is directly connected to an IO-Link master. This simplifies the communication architecture and reduces costs in large-scale industrial setups simultaneously.

Bidirectional Communication	
	The protocol supports bidirectional, serial data exchange via robust 24V logic level, allowing for both read and write operations. This feature is essential for dynamic control and real-time monitoring, providing a comprehensive view of system performance through permanent access to process data and diagnosis information.

Backward Compatibility	
	One of IO-Link's significant advantages is its backward compatibility with traditional sensor interfaces. This ensures that existing systems can be upgraded without extensive modifications, offering a smooth transition to more advanced automation solutions.

| **Enhanced Diagnostics and Monitoring**	
	IO-Link provides detailed diagnostic information and status data, enabling predictive maintenance and efficient troubleshooting. This capability significantly reduces downtime and enhances system reliability.
Remote Parameterization	
	Devices can be configured and adjusted remotely, streamlining the setup process and allowing for real-time modifications during operation. This feature enhances flexibility and responsiveness in dynamic industrial environments and markets, as well as allowing efficient project implementation.
Versatile Data Handling	
	IO-Link supports various data types, including process data, service data, and events. This versatility ensures comprehensive data utilization, aiding in more informed, thus optimized processes.

Components of an IO-Link System
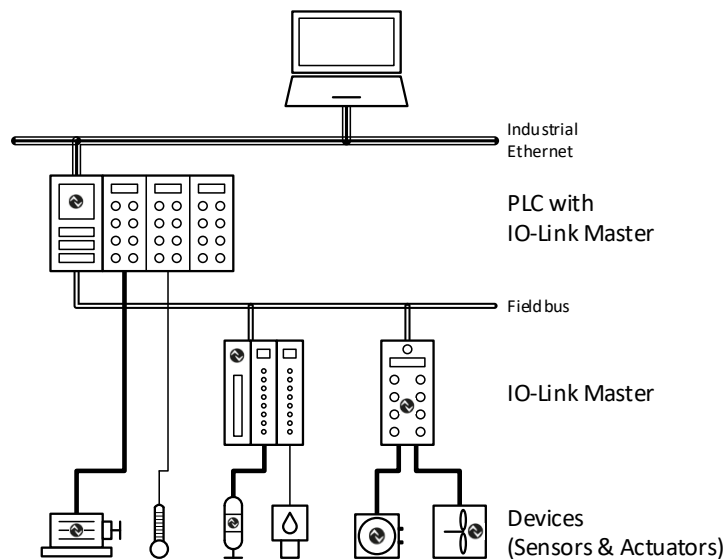
Figure 2. Typical Automation System Architecture with IO-Link

IO-Link Master

The IO-Link master acts as the interface between IO-Link devices and the higher-level control system, such as a Programmable Logic Controller (PLC). It can connect multiple IO-Link devices and non-IO-Link devices through its ports, facilitating efficient data exchange and control while ensuring backwards compatibility.

The newly introduced Renesas CCE4511 4-Channel IO-Link Master PHY is a perfect fit for the IO-Link system, providing an IO-Link hardware frame handler to reduce implementation effort and improve performance of the microcontroller. Different configuration options optimize the PHY for a variety of applications. See Figure 3 for a typical IO-Link master application.
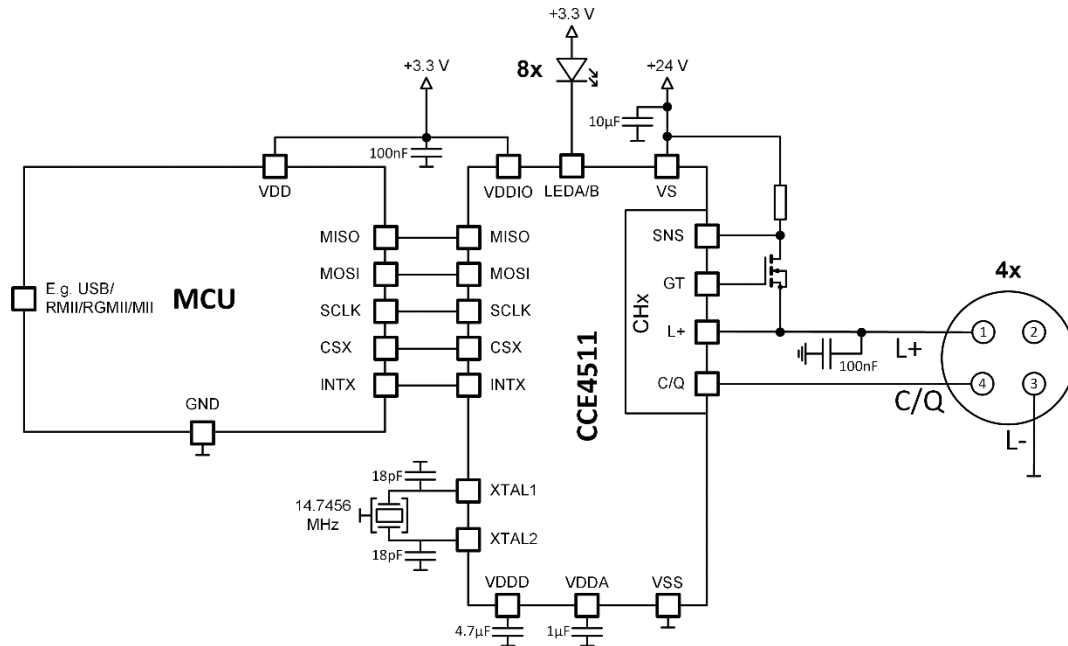

Figure 3. Typical IO-Link Master Solution using CCE4511

IO-Link Devices

These include sensors, actuators, and other field devices equipped with IO-Link communication capabilities. A notable example is the ZSSC3286 sensor signal conditioner with integrated IO-Link stack, including the Smart Sensor Profile for enhanced functionality and ease of integration. A complete IO-Link sensor solution is formed by combining the ZSSC3286 with the RH4Z2501 IO-Link PHY as shown in Figure 4.
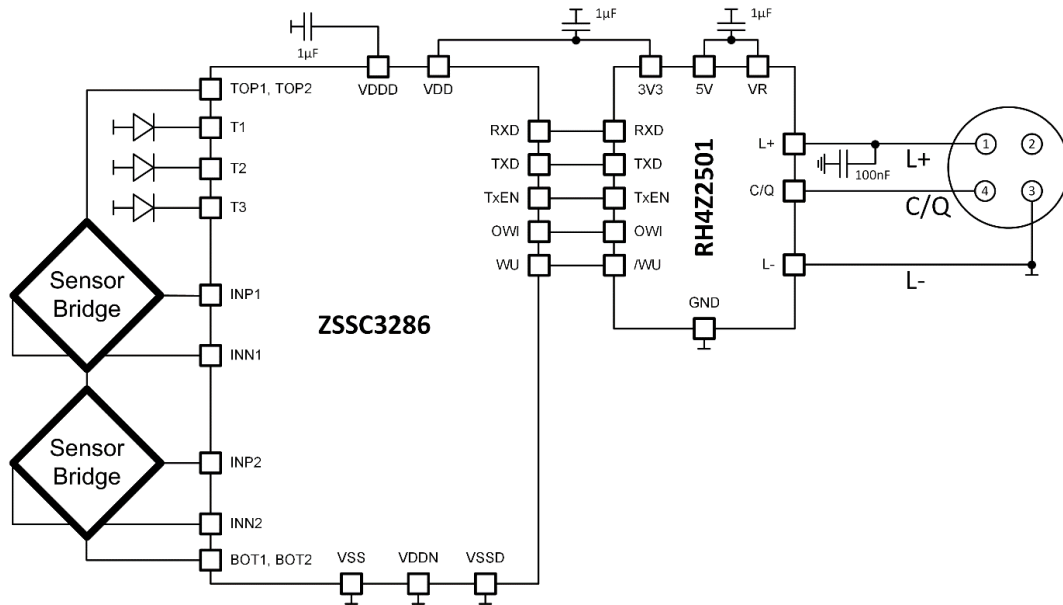
Figure 4. Typical IO-Link Sensor Solution using ZSSC3286 and RH4Z2501

Engineering Tools

Software tools are available for the configuration, parameterization, and diagnostics of IO-Link devices. These tools simplify system management and make it user-friendly.

ZSSC3286 and IO-Link Integration

The ZSSC3286 sensor signal conditioner stands out by incorporating the IO-Link device stack, including the Smart Sensor Profile. This integration brings several advantages:

Enhanced Communication

By including the IO-Link stack, the ZSSC3286 ensures fast, reliable and efficient bidirectional communication with the IO-Link master, using the fast COM3 communication mode with a transmission rate of 230.4 kbit/s. Using an internal UART (IO-Link) clock recovery, the ZSSC3286 facilitates advanced data exchange and control without the need of on external crystal oscillator.

Smart Sensor Profile

IO-Link defines Smart Sensor Profiles (SSP) to standardize sensor data and terminology, enabling easier integration and replacement of devices regardless of manufacturer or sensor type. The inclusion of the Smart Sensor Profile 4.1.1 (Figure 5) improves interoperability by offering a freely configurable process data value together with two binary switching channels.

Measurement value	Scale	Vendor specific	Sensor Switching Channel 2	Sensor Switching Channel 1
31 - 16	15 – 8	7 – 2	1	0
IntegerT(16)	IntegerT(8)	6 bit	BOOL	BOOL

Figure 5. 32-bit Process Data (PD) structure for SSP 4.1.1

Output Signal Flexibility

Besides IO-Link, using SIO mode, the ZSSC3286 features digital binary switching signal and 16-bit DAC analog output options, ensuring backward / fallback compatibility. The additional output options are:

- Analog voltage output applications (0V…1V; 0V…5V; 0V…10V)
- 3-wire current loop (4mA…20mA)
- Alarm: binary switching signal output (mapping sensor switching channels from SSP)

Sensor Calibration

The ZSSC3286 features two AFE inputs for dual or differential sensing applications. Sensor calibration is seamlessly integrated with the IO-Link interface, leveraging its capabilities for automated processes. The IO-Link master acts as the interface between the ZSSC3286 and the higher-level control system, enabling an efficient calibration process.

Advanced Diagnostics

With the integrated IO-Link stack, the ZSSC3286 provides detailed diagnostic information, helping to predict and prevent potential issues, thereby reducing downtime. On-board diagnostics:

- Sensor connection status
- AFE self-test
- Memory integrity
- IO-Link ISDU command validity

Remote Parameterization and Firmware Updates

The ZSSC3286 can be configured, adjusted and updated remotely via the IO-Link master, allowing for real-time modifications and enhancing system flexibility. This capability ensures that devices can be kept up to date with the latest settings and firmware enhancements, improving performance and adding new features without the need for physical intervention.

ZSSC3286 Tools

The ZSSC3286KIT is a powerful toolset enabling the user to build a complete IO-Link system for configuring and calibrating the ZSSC3286 sensor signal conditioner. It provides the intuitive ZSSC3286 GUI for setting up sensor parameters, monitoring performance, and executing calibration routines (Figure 6).
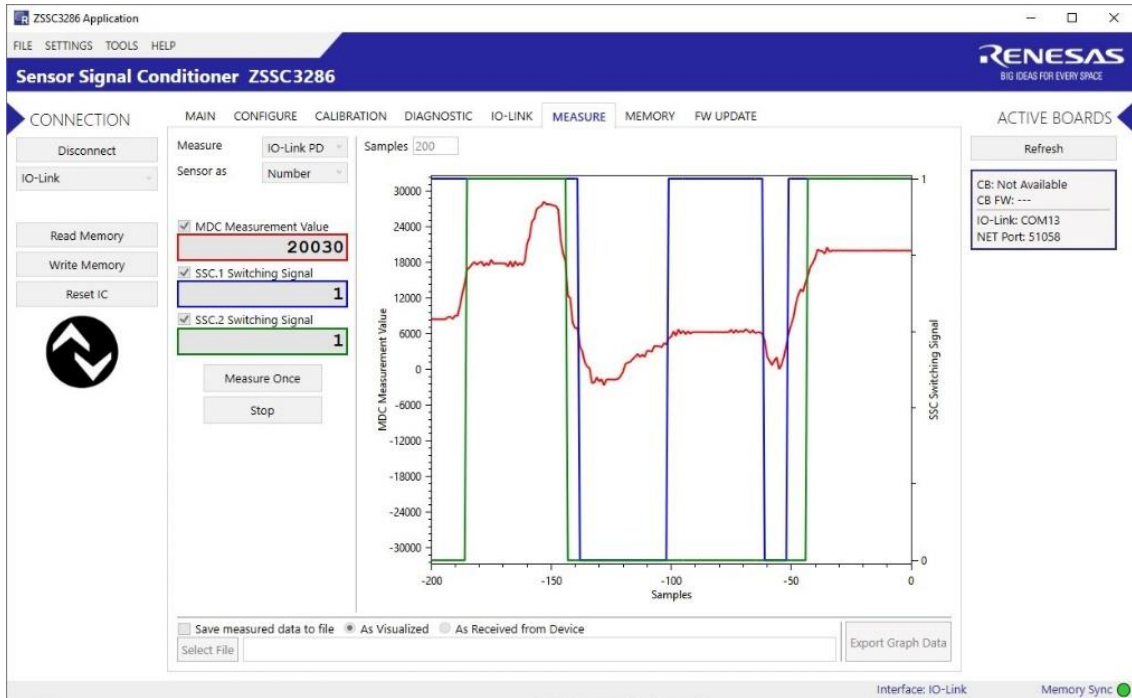
Figure 6. Renesas GUI: Measurement Tab

IO-Link Applications with ZSSC3286

The ZSSC3286 enables smart and energy-efficient IO-Link sensors best suitable but not limited to the following metrics:

- Pressure
- Flow
- Load
- Temperature

This opens a variety of industrial applications for an IO-Link device based on the ZSSC3286:

Manufacturing	
	IO-Link is extensively used in automated manufacturing lines for tasks such as quality control, material handling, and machine monitoring. Its capabilities enhance efficiency and precision even in harsh (EMC) environment for manufacturing processes.
Process Automation	
	Industries such as chemical, oil & gas, and pharmaceuticals leverage IO-Link for monitoring and controlling various process parameters. The protocol's reliability and data accuracy are crucial in these high-stakes environments.

Logistics	
	In warehouse automation and logistics, IO-Link aids in tracking, sorting, and inventory management. Its features improve operational efficiency and accuracy in logistics operations.
Robotics	
	Robotic systems benefit from IO-Link's precision and low latency in controlling and monitoring robotic arms and other components. This precision is essential for the reliable and energy-efficient operation of robotic systems.
Building Automation	
	IO-Link is used in smart buildings for controlling and monitoring HVAC systems, lighting, energy management and security systems. This allows for increased energy efficiency and more comfortable living through automated, data-driven decisions.

Conclusion

IO-Link represents a significant advancement in industrial automation, offering a more intelligent, flexible, and efficient approach to connecting and managing field devices. With the market-unique approach of the ZSSC3286 integrating the IO-Link stack, the customer can highly profit building enhanced system capabilities while enabling a seamless integration with reduced part count. By adopting IO-Link, industries can enhance their operational efficiency, reduce downtime, and achieve greater flexibility and cost-effectiveness.

Renesas provides a variety of products for the entire IO-Link system, enabling them to be combined into comprehensive solutions. Reference designs and dedicated support facilitate integration and optimal performance. As the IO-Link technology continues to evolve, it promises to unlock new potentials and drive further innovation in the automation industry.

This white paper provides a comprehensive overview of IO-Link, with a specific focus on the ZSSC3286 sensor signal conditioner and its integrated IO-Link stack, designed to inform and engage stakeholders in the industrial automation sector.

Glossary

Term	Description
ARM	Advanced RISC Machine (CPU type)
DAC	Digital-to-Analog-Converter
PD	Process Data
PLC	Programmable Logic Controller
SDCI	Single-Drop Digital Communication Interface
SIO	Standard Input Output (digital switching mode)
SSC	Sensor Signal Conditioner
SSP	Smart Sensor Profile