

Development of IO-Link Master Module

Author: Satoshi Namematsu*

1. Introduction

In line with the trend toward Industry 4.0 and IoT, it was recently suggested in Europe to use IO-Link to enhance seamless information-sharing through networks from end-use devices, such as sensors and actuators, to higher-level production management systems. Accordingly, sensor manufacturers in and outside Japan have been developing various devices such as sensors and actuators that are compatible with IO-Link. Mitsubishi Electric Corporation has developed remote IO-Link units that conform to IEC61131-9, which is an international standard for IO-Link.

This paper describes the characteristics of IO-Link and technologies for reducing the cost of remote IO-Link units and simplifying parameter setting.

2. Characteristics of IO-Link

IO-Link is an industrial digital communication standard for sensors and actuators used at manufacturing sites (bi-directional and point-to-point communications) and it was standardized in 2013 by IEC 61131-9. Networking with IO-Link has made it possible to obtain measured values, operation values, and diagnostic data from IO-Link devices in addition to conventional digital signals. IO-Link also makes it easier to set parameters when IO-Link devices are replaced.

This chapter describes the characteristics of IO-Link.

2.1 Improved information collection and accurate management (higher operation efficiency)

Conventionally, sensors transmit only control signals

(two levels of OK and NG, analog values). Since IO-Link provides data communications, it is possible to obtain measurement data, identification data, and setting information from IO-Link devices. Moreover, digitization of analog values prevents degradation of measurement data. In addition, since identification data and setting information can be obtained from IO-Link devices, the devices in use at manufacturing sites can be precisely managed and management costs can be reduced (Fig. 1).

2.2 Simple design work (standardized parts and operation)

Previously, it was necessary to prepare control units and cables (e.g., multiple signal wires, shield wires, and power supply wires) that matched the interfaces of sensors. In contrast, for IO-Link, standard IO-Link units are used as control units and standard IO-Link cables (unshielded three-wire cables [signal, power supply, and GND]) are used as cables. Therefore, there is less wiring at actual manufacturing sites and it is relatively simple and standardized, enabling simple equipment to be designed. This reduces the costs for equipment and management (Fig. 2).

2.3 Quick detection of deterioration and failure (preventive maintenance)

Conventional sensors can handle only control signals and so must be periodically maintained, making it time-consuming to identify a faulty section (whether a broken cable or faulty sensor) after a malfunction. With IO-Link, IO-Link devices send deterioration information

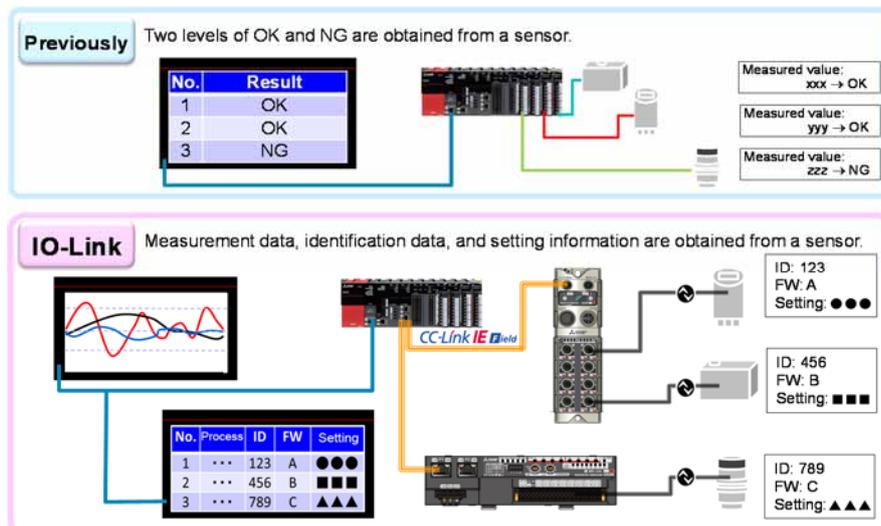


Fig. 1 Example of improvement in operation efficiency

(diagnostic information) and the sensor status can be monitored remotely from graphic operation terminals (GOTs) and PCs, thus reducing the number of times of maintenance. In addition, IO-Link makes it easier to locate faulty sections and reduces downtime (Fig. 3).

2.4 Automatic parameter setting (improved maintainability)

When replacing a sensor in the past, the parameters, which varied from sensor to sensor, had to be redefined using a special tool, ladder, or other tool, and operators needed to have such skills. Meanwhile, with IO-Link, immediately after an IO-Link device is replaced, the IO-Link unit sends the parameter settings that have been saved in the unit to the new IO-Link device automatically to redefine the parameters. Therefore, operators need to perform replacement only, and do not need to set parameters using special tools, etc., reducing downtime. In addition, the only task to be done is replacement, which prevents the situation where sensors can be replaced only by a certain person and others do not know

how to do it (Fig. 4).

3. Technologies Supporting Remote IO-Link Units

The developed remote IO-Link units bridge CC-Link IE field communication and IO-Link communication and function as IO-Link master units that control IO-Link devices.

Table 1 lists the main specifications of remote IO-Link units.

Chapter 2 described the characteristics of IO-Link. To expand the use of IO-Link, the cost of introducing (due to the addition of IO-Link communication functions) IO-Link systems needed to be reduced and technologies for simplifying parameter setting were required.

The next section describes technologies for reducing costs and simplifying parameter setting.

3.1 Cost reduction technologies

IO-Link communication functions have been added to sensors and actuators that used to handle only control

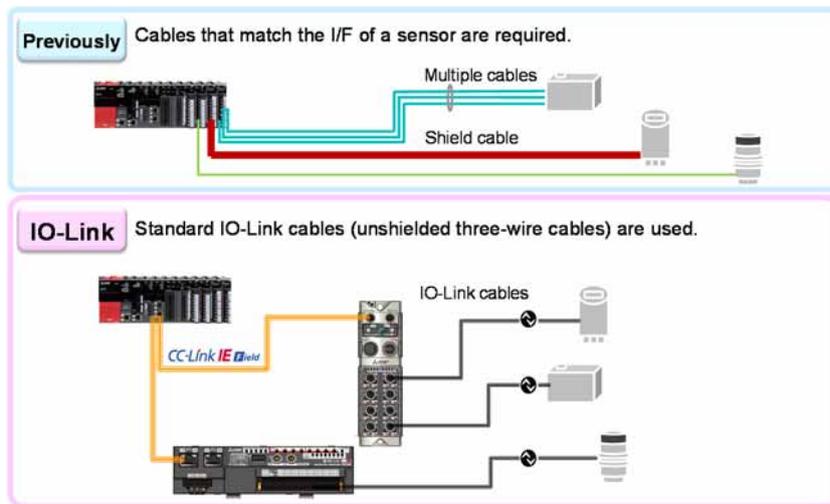


Fig. 2 Example of standardized parts and operations

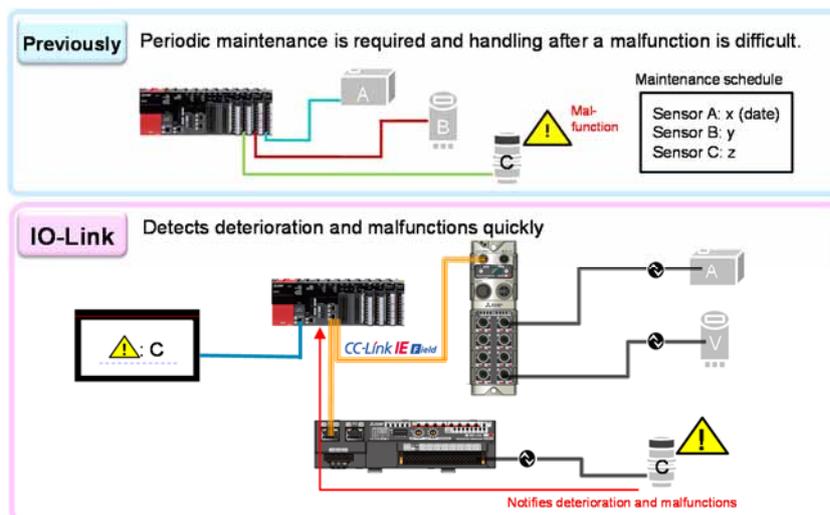


Fig. 3 Example of preventive maintenance

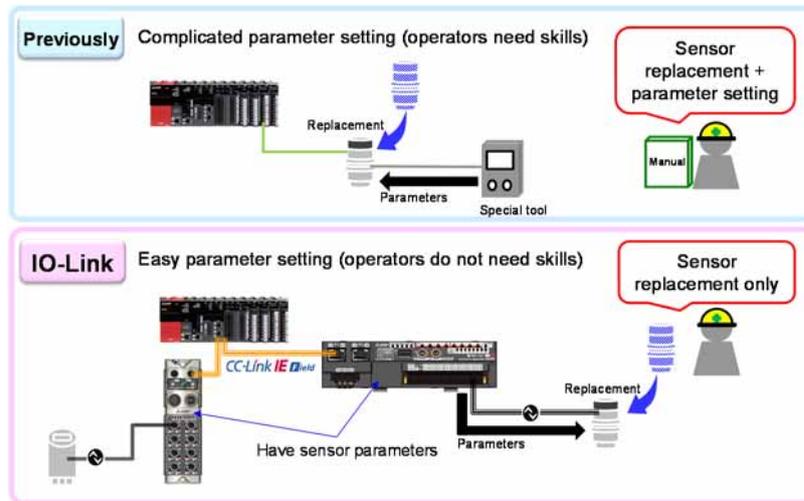


Fig. 4 Example of improved maintainability

Table 1 Main specifications of remote IO-Link units

Item	Description
Interface	<ul style="list-style-type: none"> • Bi-directional point-to-point communications • Signal (C/Q), power supply (L+), and GND (L-) • IO-Link mode (for IO-Link data communication) • SIO mode (conventional digital signals)
Communication rates	<ul style="list-style-type: none"> • Transmit mode COM1 (4.8 kbps) • Transmit mode COM2 (38.4 kbps) • Transmit mode COM3 (230.4 kbps)
Communication system	<ul style="list-style-type: none"> • Start-stop synchronization serial communication (UART communication)
Data type [Cyclic data]	<ul style="list-style-type: none"> • Process data (0- to 32-B data with higher priority [e.g., measurement data]) • Status (validity or invalidity of process data)
Data type [Acyclic data]	<ul style="list-style-type: none"> • Device data (parameters, ID data, diagnostic information) • Events (information on errors, warnings, maintenance, and other matters)

signals, which increases the costs. To reduce the initial cost when customers introduce IO-Link systems, it was necessary to reduce the cost of remote IO-Link units.

As shown in Fig. 5, a remote I/O unit that processes control signals can connect to the LSI terminal for communications via the I/O drivers. Meanwhile, a remote IO-Link unit requires IO-Link PHY (physical layer) (ICs for IO-Link communication) and microcomputers that control them. For the conventional IO-Link PHY, the IO-Link communication system was UART communication, which was used between the microcomputers for control and IO-Link PHY. However, there were few

microcomputers with eight UART communication channels, and so creating remote IO-Link units with eight channels, such as by using two microcomputers with four UART communication channels, would increase the cost.

Therefore, when selecting IO-Link PHY, the latest one was chosen. One chip of such IO-Link PHY has two IO-Link communication channels and serial peripheral interface (SPI) communication is used between a microcomputer for control and IO-Link PHY as shown in Fig. 6. Each IO-Link PHY has its own address and multiple IO-Link PHY chips can be controlled through one-channel SPI communication. In addition, with IO-Link communication (UART communication), IO-Link data from the microcomputer for control is stored in the first in first out (FIFO) in the IO-Link PHY via the SPI communication and IO-Link communication is realized by the UART generation circuit.

Adoption of the IO-Link PHY reduced the number of necessary parts and realized a remote IO-Link unit with one reasonably-priced general-purpose microcomputer and eight-channel IO-Link communication.

3.2 Technologies for simplifying parameter setting

It used to be impossible to access IO-Link devices from PCs through various network communication protocols (Ethernet → CC-Link IE field → IO-Link). Therefore, as shown in Fig. 7 (1), when an IO-Link device was installed, the customer needed to write a ladder program according to the manual of the IO-Link device manufacturer and to define parameters via a sequencer. However, setting parameters by writing a ladder program requires skills, and customers often made errors. Therefore, as shown in Fig. 7 (2), Mitsubishi Electric Corporation has simplified parameter setting by using a graphical user interface (GUI) on a PC.

The next section describes the technologies for simplifying parameter setting.

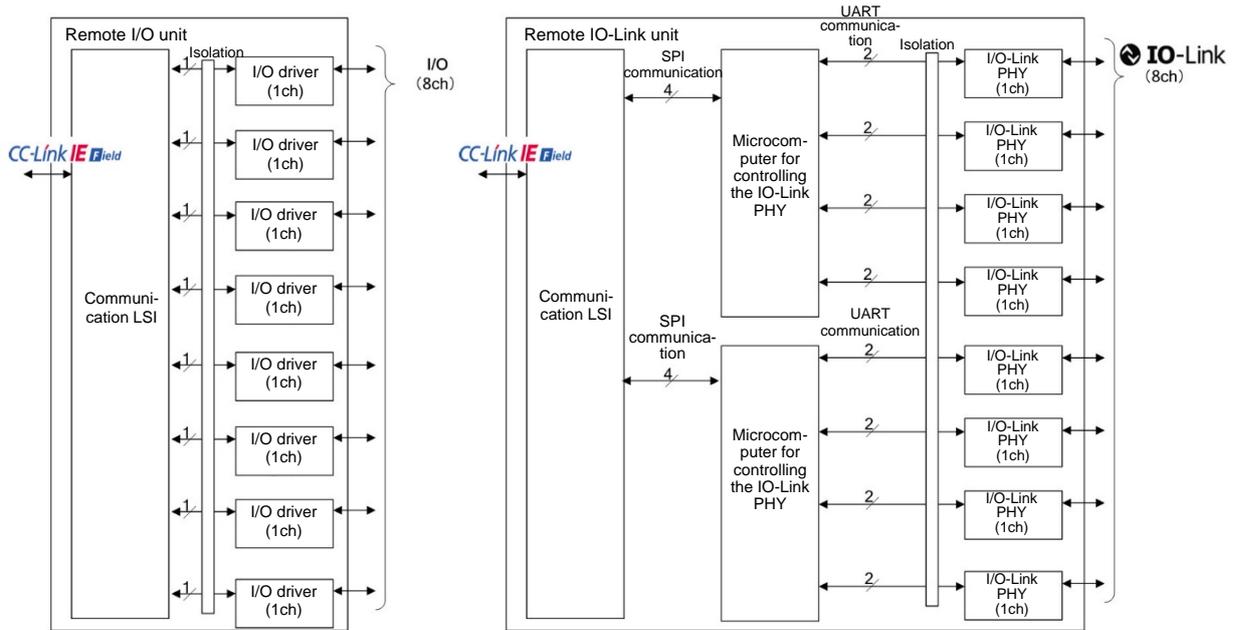


Fig. 5 Comparison of the configuration of remote I/O and remote IO-Link units

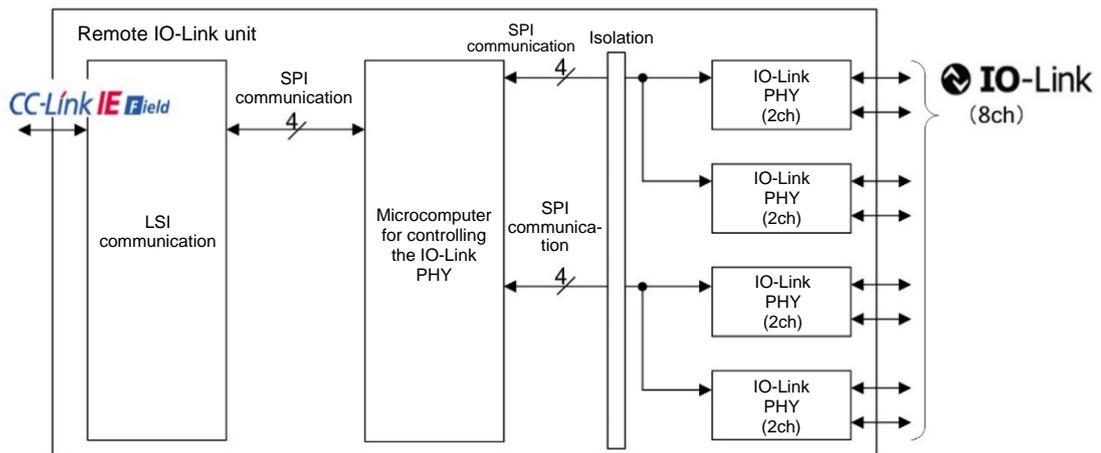


Fig. 6 Configuration of a remote IO-Link unit with the new type of chip

3.2.1 Development of an FDC tool

Mitsubishi Electric Corporation has developed IO-Link device management and configuration software, called MELSOFT Field Device Configurator (FDC), as a tool for setting GUIs on a PC. The FDC is compatible with the open specification of Field Device Tool (FDT) that can start from engineering software GxWorks3.

Customers import an IO Device Description (IODD) file that contains IO-Link device setting information written in Device Description Language into the FDC. In the FDC tool, a Device Type Manager (DTM) (software driver) called an IODD interpreter interprets the imported IODD file successively and acts as DeviceDTM. This DeviceDTM provides a GUI that allows customers to define IO-Link device parameters.

The IO-Link standard requires that IO-Link device manufacturers provide an IODD file for each IO-Link device without exception. Customers only need to import such provided IODD file into the FDC, which makes it possible to set the parameters of IO-Link devices without errors.

3.2.2 SLMP protocol compatible with IO-Link

To set IO-Link device parameters using the FDC tool on a PC (to allow data to reach the devices), Seamless Message Protocol (SLMP)¹ had to be compatible with the IO-Link communication protocol. For this purpose, for SLMP communication frames, the structure of request (read and write) frames that corresponded to the data types (process data, device data, and event data)

¹ Common protocol that links Ethernet and a CC-Link IE field network seamlessly

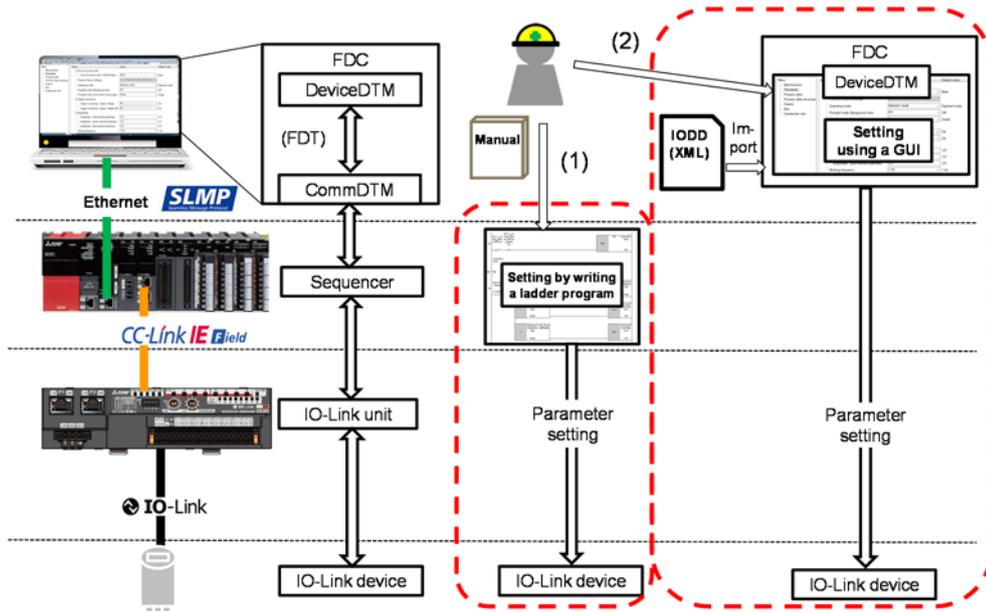


Fig. 7 Comparison of parameter setting of IO-Link devices

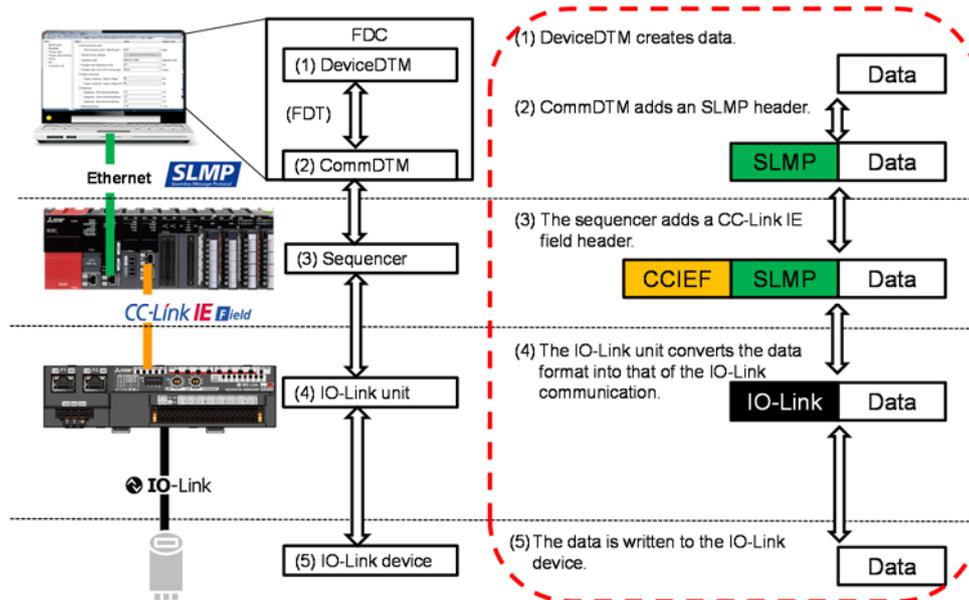


Fig. 8 Communication from a PC to an IO-Link device

of the IO-Link communication listed in Table 1 and corresponding response frame structure were defined.

3.2.3 Development of communication driver CommDTM

The developed SLMP compatible with IO-Link completes a system that can network from Ethernet to IO-Link devices.

We have developed the CommDTM communication driver that receives access requests from DeviceDTM to IO-Link devices based on the FDT specification and converts them into the created SLMP protocol.

The developed FDC tool, IO-Link-compatible SLMP

protocol, and developed CommDTM allow customers to define IO-Link device parameters using the FDC tool; the parameters are written to the IO-Link devices via a network of Ethernet, CC-Link IE field, and IO-Link as shown in Fig. 8 (1) to 8 (5).

4. Conclusion

This paper described the characteristics of IO-Link and technologies that support remote IO-Link units developed this time. We will continue to pioneer the sensor and sequencer market.