The N-IO System Contributing to the Innovation of the DCS Engineering Environment

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Yokogawa's CENTUM VP R6.01 innovates the engineering environment of DCS. Specifically, it reduces the time and effort required for system construction and engineering. As a further enhancement, a new I/O system, Network I/O (N-IO), was added to the I/O lineup for CENTUM VP. This article describes the features of the N-IO system, outlines its components, and explains its expandability.

INTRODUCTION

In 2015, Yokogawa's CENTUM marked its 40th anniversary. Since its release in 1975, more than 25,000 systems have been installed worldwide. At every stage of evolution of CENTUM, from V, -XL, CS and CS3000 to the VP series, Yokogawa successively enhanced the functions of distributed control systems by incorporating the latest semiconductor, communication, and other technologies. However, customers' needs have changed greatly in recent years, such as more distributed installation in the upstream, shorter plant setup period and reduced total footprint including various peripherals. It is difficult to satisfy these needs with existing I/O systems (FIO) that are directly connected to controllers. Yokogawa has developed a new I/O system, Network I/O (N-IO), and added it to the I/O lineup for CENTUM VP. This paper describes the configuration of the N-IO system, its differentiators of flexible binding and flexible installation, and the features of each component.

CONFIGURATION OF N-IO SYSTEM

As shown in Figure 1, the N-IO system is an I/O system that is connected to the field control unit (FCU: A2FV50S/D) via the network-extended serial backboard (N-ESB) bus, optical ESB bus, or ESB bus. The N-IO system has one type of node and two types of node unit.

- N-IO node
- ESB bus node unit (ANB10S/D)
- Optical ESB bus node unit (ANB11S/D)

This paper focuses on the newly developed N-IO nodes.

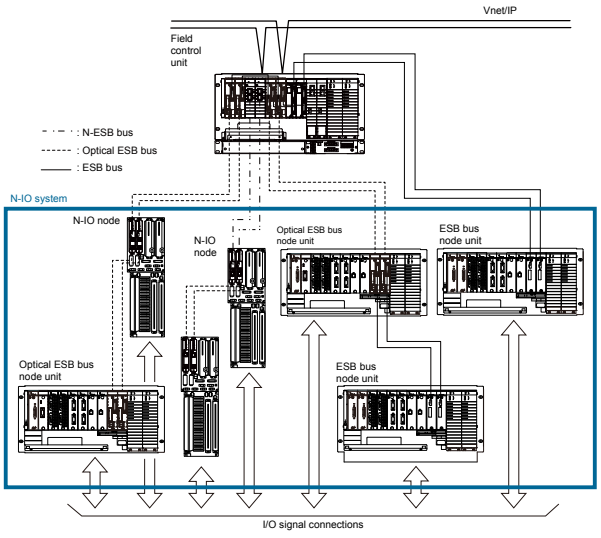

Figure 1 Configuration of the N-IO system

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COMPONENTS OF N-IO NODE

The N-IO node is a basic component of the I/O system connected to the FCU. As shown in Figure 2, this node consists of one node interface unit (NIU) and up to six input/output units (I/O unit: IOU).

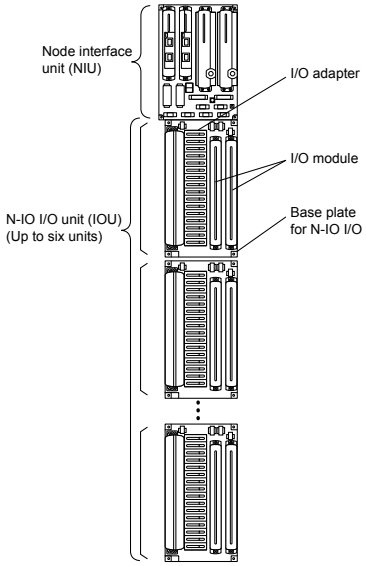

Figure 2 N-IO node configuration

Figure 3 shows the configuration of the NIU and its interfaces. The NIU has N-ESB bus interfaces to communicate with the FCU or other NIUs. The NIU also has flexible-serial backboard (F-SB) bus interfaces to communicate with IOUs and has a power supply function to feed them. The components for these functions comprise a redundant configuration. The N-ESB bus module (A2EN501) responsible for communication functions has a USB connector on its front panel, to which a PC with a setting application program called FieldMate Validator [1] is connected. With this configuration, I/O channels (terminals), their signal types and the connection of field devices beyond terminals can be defined even before the FCU controller starts operation. A project execution model [2] for shortening the project period, called the system free instrumentation (SFI) model, has been achieved by using this USB port.

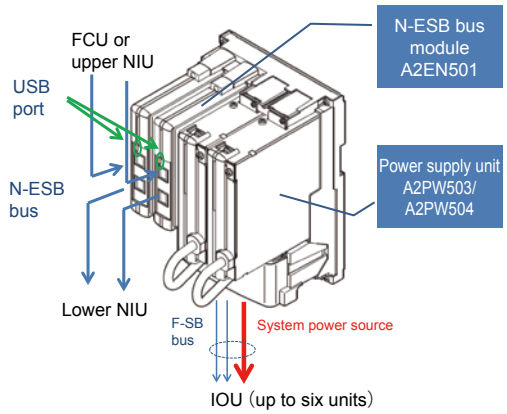

Figure 3 NIU configuration and its interfaces

Figure 4 shows the configuration of the IOU and its interfaces. The IOU has the F-SB communication function to communicate with the NIU. The I/O modules and I/O adapters installed on the IOU perform I/O operation with field devices according to the communication from the NIU. The IOU receives system power from the NIU to operate I/O modules and I/O adapters, and also receives field power from the field power supply to operate the field interface portion of the I/O adapters. IOUs, as a unit as shown in the figure, can be put in convenient places.

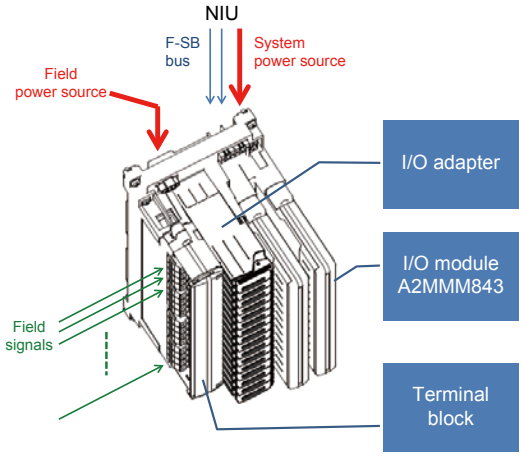

Figure 4 IOU configuration and its interfaces

HIGH FLEXIBILITY IN INSTALLATION OF N-IO NODES

To adapt to upstream applications where relatively few I/O points are widely distributed across the field, N-IO nodes are supposed to be installed in enclosures closer to field devices than the current node units of FIO. Different from the case of cabinets for FIO, various auxiliary equipment are put in a single enclosure together with the N-IO. Therefore, each component of an N-IO node must be able to be mounted more flexibly.

Both the N-ESB bus and F-SB bus adopt serial communication through flexible cables, ensuring high flexibility in installation.

N-ESB Bus Connecting FCU and N-IO Node

In the conventional system, the total length of the electrical ESB bus is limited to 10 m. The distance from the FCU to I/O nodes is limited by this, thus restricting the installation of I/O nodes. For the N-IO system, Yokogawa has developed the N-ESB bus that uses category 5 cable with a length of up to 100 m. Multiple NIUs can be connected to the N-ESB bus coupler module (A2EN402 or A2EN404) mounted on the FCU in the star topology. In addition, beyond these NIUs, up to 15 NIUs can be connected via the N-ESB bus in a daisy chain. This configuration has greatly increased the flexibility in connecting N-IO nodes in terms of both distance and topology. If a longer distance between an FCU and an N-IO node or between N-IO nodes is required, optical connection of up to 50 km can be used just like the existing ESB bus.

Installation of N-IO Node Components and Connection by F-SB Bus

An NIU and IOUs constituting an N-IO node can be mounted on DIN rails, in addition to the conventional mounting on a board by screw clamp. To secure the flexibility in mounting on DIN rails, the F-SB bus that connects the NIU and the IOU uses one-to-one connection with a maximum length of 2 m.

Reduced Footprint

The N-IO system aims to reduce the total footprint including the wire marshaling beyond I/O modules. In the conventional FIO configuration, terminal blocks are prepared in addition to I/O modules, and they are connected with dedicated cables. In the case of N-IO, various components, such as node units for mounting I/O modules, terminal boards and cables for connecting them, were reviewed and integrated as shown in Figure 5. With the features of universal functionality and I/O adapters described later, N-IO eliminates marshaling wiring of field wires as preparations for I/O connection.

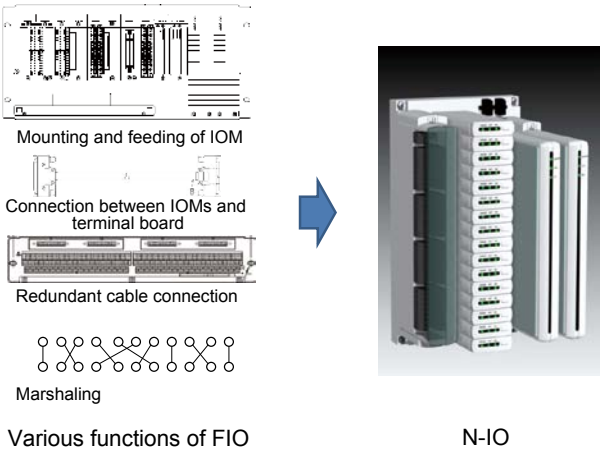

Figure 5 Integration of existing components into IOU

For connecting field wires to I/Os, detachable terminal blocks are used. Wires can be connected to the block while being detached from the IOU, thus greatly improving the efficiency of connecting work. Two types of terminals, push-lock and spring-lock, are available to meet users' requirements.

Conditions of Installation Environment for N-IO Node

Assuming usage in cold regions, the operating temperature range of the N-IO node is from -40 °C to +70 °C, the lower limit of which is 20 °C lower than that of the conventional node. The allowable altitude is also extended from 2000 m to 3000 m. In the case that users cannot prepare field power sources for such severe operating conditions, an adapter for mounting the power supply on a DIN rail is provided so that the power supply unit for the NIU (A2PW503 or A2PW504) can be used.

IOU CONFIGURATION AND ITS FUNCTIONS

The IOU consists of multipoint I/O modules (A2MMM843), I/O adapters and other components. The A2MMM843 is a key module, and its functions can be configured by channel. The I/O adapter extends the functions of the I/O module and is used in combination with it. When connecting field devices, multi-core instrumentation cables from field devices are connected to the terminal blocks. Then, depending on the types of signals, an appropriate I/O adapter is selected and the functions of each channel of the I/O module are defined by FieldMate Validator. This procedure achieves flexible binding without marshaling panels, and reduces the footprint.

Figure 6 shows signal paths in the IOU. Two I/O modules can be mounted for redundancy. Signals from them are connected or transmitted to field devices via the adapter and terminal block.

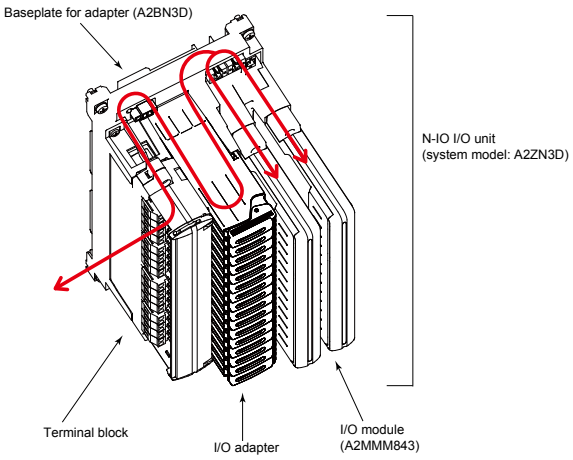

Figure 6 Signal paths in the IOU

Analog Digital 16-ch I/O Module (A2MMM843)

The analog digital 16-ch I/O module (IOM) has two features, universal functionality and online IOM replacement in a single configuration.

Universal Functionality

In the conventional system, signals from field devices are assigned to I/O modules depending on the types, ranges of signals etc. The connection is achieved by hardware wiring using marshaling panels, which makes it troublesome to adjust the connection to reflect changes in the type or number of signals. The I/O module with universal functionality solves this problem.

The A2MMM843 offers functions for analog input (4-20 mA), analog output (4-20 mA), digital input, and digital output at each channel. These modes are determined individually by using software tools such as FieldMate Validator. In detail, the A2MMM843 allows two-wire and four-wire signal input for the analog input mode, dry contact input and NAMUR standard conforming signal input for the digital input mode, and voltage output and current output for the digital output mode. Figure 7 is a conceptual diagram showing this function.

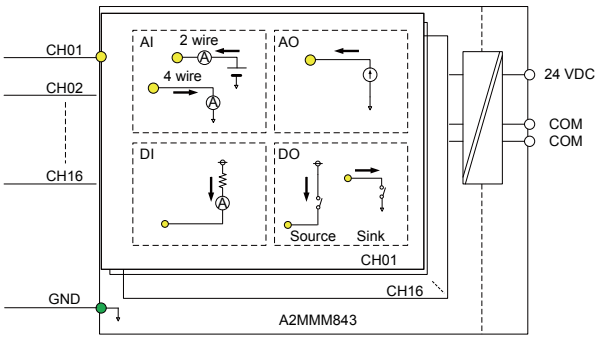

Figure 7 Universal functionality of the A2MMM843

Analog input (two-wire and four-wire) and analog output modes comply with the HART7 standard. Using the HART7 protocol, the A2MMM843 can collect data and receive event notifications from field devices through 16 channels simultaneously.

LEDs are arranged on the front side of the A2MMM843 to indicate the operation status of each channel. For example, they light up when their signals are in the ON state in the DI/DO mode and blink when any anomaly in wiring is detected.

Online IOM Replacement in a Single Configuration

Just like conventional I/O modules for DCS, the A2MMM843 supports a redundant configuration for achieving high availability. In addition, the A2MMM843 provides a procedure for online IOM replacement in a single configuration. With this procedure, I/O operation can be continued as much as possible in the event of IOM failure. According to Yokogawa's survey, an 80% failure in multi-channel I/O modules constitutes the malfunction of a single channel. But even in such a case, with the traditional single configuration system, normally operating channels also need to be stopped during the replacement. The new procedure for the N-IO system described in the right part of Figure 8 overcomes this weakness.

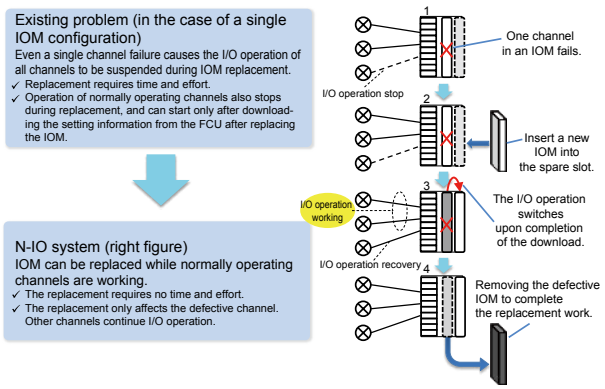

Figure 8 Procedure for online IOM replacement in a single configuration

I/O Adapter (A2SXXXXX)

By switching functions for each channel, the A2MMM843 can cover various signal types that are required for DCS in process automation.

Furthermore, the I/O adapters can be used to expand signal types to those that cannot be covered by the switching. When interfaces with wider signal types are required, this is possible by selecting an appropriate I/O adapter. Table 1 shows the lineup of I/O adapters, which are placed between the channel of the A2MMM843 and the terminal block.

Table 1 Lineup of I/O adapters

Model	Product	Extended function
A2SAP105	Pulse input signal adapter (0 to 10 kHz)	Contact ON/OFF, voltage pulse, current pulse, isolated channels
A2SDV105	Digital input adapter (24 VDC voltage input, dry contact input)	Voltage input, dry contact input, isolation
A2SDV505	Digital output adapter (24 VDC, 0.5 A current source)	24 VDC, 0.5 A output, current source, isolation
A2SDV506	Relay output adapter (24 VDC, 0.5 A dry contact output)	24 VDC, 0.5 A relay contact (dry contact NO/NC), isolated channels
A2SMX801	Pass-through I/O signal adapter (pass-through I/O signal)	For using the basic functions of A2MMM843, non-isolated

The through adapter transfers signals intact between the A2MMM843 and the terminal block. Figure 9 shows the external view of an adapter.

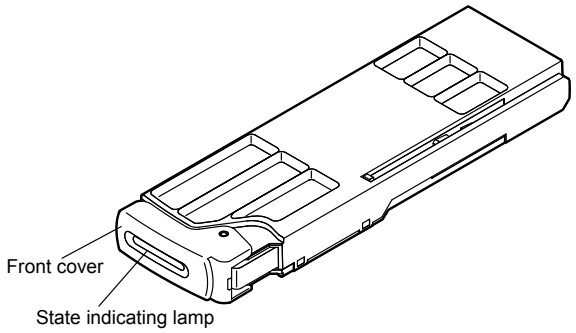

Figure 9 External view of I/O adapter

During startup and maintenance, the I/O system and field devices sometimes need to be temporarily disconnected. If I/O adapters are drawn out completely from their slots to do this, there is the risk of putting them back in the wrong slots. To eliminate this risk, a half-insertion mechanism to hold the I/O adapter position stable while cutting its electric connection is supported. Figure 10 shows a half-inserted I/O adapter.

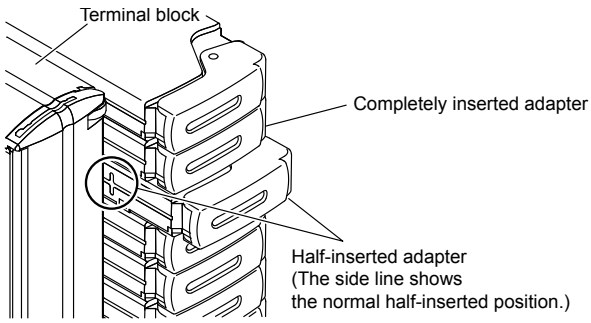

Figure 10 Half-inserted I/O adapter

Solutions for Intrinsic Safety Using A2BN4D and A2BN5D

Yokogawa, in cooperation with vendors, offers solutions for intrinsic safety using the N-IO system. For such solutions, Yokogawa has developed two types of base plate, on which intrinsic safety isolated barriers and the A2MMM843s are mounted adjacent to each other. These base plates achieve space-saving and enable the transmission of anomalies, such as disconnection of wires from the field detected by the barriers, to upper applications. Figure 11 shows IOUs with barriers mounted, barriers from MTL Instruments and Pepperl+Fuchs, respectively.

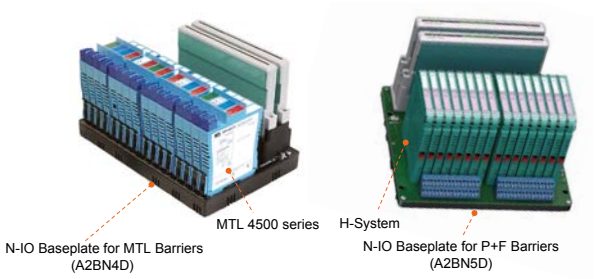

Figure 11 IOUs with intrinsic safety isolated barriers mounted

CONCLUSION

When developing the N-IO system, Yokogawa placed priority on providing a long period and continuously evolving I/O for DCS. Although not described in this paper, the N-ESB bus features a high speed of 100 Mbps and the F-SB bus of 24 Mbps, sufficient at the moment, and they can respond to the expansion of functions and the increase in data volume for the time being. If much higher speed is required to handle further increases in data volume in the future, the N-IO system can be modified to allow the coexistence of new and old communication rates by utilizing the one-to-one connection topology for the N-ESB bus and the F-SB bus. In addition, highly intelligent I/O adapters can be used by using serial communication between the A2MMM843 and I/O adapters. Yokogawa will enhance the N-IO system to promote wired and wireless field communication and to reduce footprint and cost by incorporating the functions of peripheral devices.

REFERENCES

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(2) Souichiro Konada, Kenji Torigoe, “A New Approach Based on SFI Concept for Shortening the Plant Construction Period,” Yokogawa Technical Report English Edition, Vol. 58, No. 2, 2015, pp.9-14