
Introduction

Fieldbus is an innovative technology to implement field information networking. Great expectations are placed on Fieldbus by the users and manufacturers of process control systems. Fieldbus-support products are expected to be commercialized by numerous process control system manufacturers starting early 1998.

This manual serves as a guide for users to introduce Fieldbus into their process control systems.

This manual has been written as Fieldbus products are being developed. Therefore, some topics are described based on preliminary specifications. Some sections of this manual are subject to periodic revision. Yokogawa welcomes users' suggestions on how this manual can be improved.

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Fieldbus

Technical Information

PART-A Outline of Fieldbus and Its Support Products

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CONTENTS

| | | |
|------------|---|-------------|
| A1. | Features of Fieldbus | A1-1 |
| A1.1 | Comparison with Conventional Communication Protocol..... | A1-2 |
| A1.2 | Reduced Wiring Cost | A1-4 |
| A1.3 | Improved Transmission Accuracy | A1-6 |
| A1.4 | Enhanced Data Transmission | A1-8 |
| A1.5 | Distributed Functions | A1-9 |
| A1.6 | Interoperability | A1-10 |
| A2. | International Standardization of Fieldbus | A2-1 |
| A2.1 | Progress of Fieldbus Standardization | A2-1 |
| A2.2 | Fieldbus Standard Specifications | A2-3 |
| A2.3 | Yokogawa's Efforts for Fieldbus Standardization | A2-4 |
| A3. | Fieldbus-ready Field Devices | A3-1 |
| A3.1 | Changes in Transmitters | A3-3 |
| A3.1.1 | Accuracy Improvement due to Digitalization..... | A3-4 |
| A3.1.2 | Multi-sensing Function Equipment | A3-6 |
| A3.1.3 | Multifunction Equipment | A3-7 |
| A3.2 | Actuator | A3-8 |
| A3.3 | Using Self-diagnostics Function..... | A3-10 |
| A3.4 | Upgrading from BRAIN System | A3-11 |
| A4. | Fieldbus-ready System Devices | A4-1 |
| A4.1 | Fieldbus Support in CENTUM CS 1000, CS 3000 and CENTUM CS | A4-2 |
| A4.2 | Fieldbus-ready Field Devices from Other Vendors | A4-5 |

**Fieldbus
 Technical Information
 PART-B Fieldbus Engineering**

TI 38K3A01-01E

CONTENTS

- B1. Managing Fieldbus Engineering B1-1**
 - B1.1 Engineering Process B1-1
 - B1.2 Difference between Fieldbus and Analog Signal Process Control Systems B1-4
 - B1.3 Fieldbus Tools B1-5
- B2. System Design Considerations B2-1**
 - B2.1 Considerations in Fundamental and Overall Design B2-2
 - B2.2 Individual Design Considerations B2-3
- B3. System Construction Considerations B3-1**
 - B3.1 New Construction of Fieldbus B3-1
 - B3.1.1 Mounting Terminators B3-3
 - B3.1.2 Mounting Couplers B3-3
 - B3.1.3 Cabling B3-4
 - B3.1.4 Installing Intrinsic Safety Barrier B3-4
 - B3.1.5 Handling the Shield Mesh B3-5
 - B3.2 Reusing Existing Cables B3-6
- B4. System Startup Considerations B4-1**
 - B4.1 Tool Necessary for Startup B4-1
 - B4.2 Technologies and Expertise Necessary for Startup B4-2
 - B4.3 Labor Savings in Startup Work B4-3
- B5. System Maintenance Considerations B5-1**
 - B5.1 Daily Maintenance B5-1
 - B5.2 Inspection and Maintenance B5-2
 - B5.3 Maintenance Management (Maintenance Plan/Device Management/Record Management) B5-3
 - B5.4 Future Maintenance B5-4

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A1. Features of Fieldbus

Fieldbus is a bidirectional digital communication protocol for field devices. Fieldbus technology drastically changes process control systems and is expected to replace the standard 4 to 20 mA analog communication protocol that most current field devices employ.

Fieldbus has the following features:

- Multiple devices can be connected with a single cable, reducing the number of cables.
- Wiring costs are reduced by minimizing the number of cables.
- A digital transmission protocol, ensures high-accuracy information processing.
- High-accuracy information processing allows strict quality control.
- Multiplex communications allow other information as well as process variables (PVs) and manipulated variables (MVs) to be transmitted from field devices.
- Communication between field devices allows truly distributed control.
- Interoperability enables devices from different manufacturers to be combined.
- A broad choice of devices from any manufacturer permits flexible system construction.
- Instrumentation systems, electrical devices, FAs, BAs, OAs, and analyzers can be integrated.
- Some adjustments and inspections of field devices can be performed in the instrument room.

The following sections explain the advantages of Fieldbus and the effect of Fieldbus on process control systems.

A1.1 Comparison with Conventional Communication Protocol

Fieldbus communication protocol has the advantage over analog communication protocol and hybrid communication protocol in information accuracy, transmission speed, and transmission amount. In addition, it is superior to those protocols in functionality, including the ability to communicate between connected devices and to communicate bidirectionally.

Analog Communication Protocol

Analog communication protocol is an information transmission technique using analog signals with a direct current of 4 to 20 mA. The topology, which is a one-to-one system, allows only one field device to be connected to a single cable. The transmission direction is one-way. Therefore, two different cables must be prepared: one to acquire information from the field device, and the other to transmit control signals to the field device.

Hybrid Communication Protocol

Hybrid communication protocol is a communication technique in which field device information is superimposed as digital signals on the conventional 4 to 20 mA analog signal. In addition to analog communication protocol capabilities, it is possible to remotely set up the field device range and zero-point adjustment. Also, maintenance information such as self-diagnostics of the field device can be obtained using a dedicated terminal.

Hybrid communication protocols were developed independently by each manufacturer. Therefore, devices from different manufacturers cannot communicate with each other. With the Yokogawa BRAIN system or the hybrid communication systems of other manufacturers, the self-diagnostics information cannot be exchanged between field devices from different manufacturers. The hybrid communication protocol mainly supports 4 to 20 mA analog communication, though it allows digital data communication. The digital data communication speed through the hybrid communication protocol is slower than that through the Fieldbus communication protocol.

Fieldbus Communication Protocol

Fieldbus communication protocol, which is different from analog or hybrid communication protocols, supports a perfect digital signal communication system. In addition, the Fieldbus communication protocol supports bidirectional communication. This allows more types and a larger amount of data to be transmitted in comparison to analog and hybrid communication protocols.

This protocol removes the restriction which allows only one field device to be connected to a single cable in an analog communication system. Multiple field devices can be connected to a single Fieldbus cable. Also, since international standardization of this protocol is being promoted, interoperability of field devices will be guaranteed.

Fieldbus solves, the problems of hybrid communication protocols, such as slow digital transmission speeds and lack of interoperability .

Table A1.1 compares conventional 4 to 20 mA analog communication, hybrid communication, and Fieldbus communication protocols.

Table A1.1 Comparison of Communication Protocols

| | Fieldbus | Hybrid | Analog |
|------------------------|----------------------------|---|-----------------------------|
| Topology | Multi-drop | One-to-one | One-to-one |
| Transmission method | Digital signal | 4 to 20 mA DC analog signal + digital signal | 4 to 20 mA DC analog signal |
| Transmission direction | Bidirectional | One-way (analog signal), bidirectional (digital signal) | One-way |
| Type of signal | Multiplex signal | Partially multiplex signal | Single signal |
| Standard | Under standardization (*1) | Differs depending on manufacturers | Standardized |

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* 1: Foundation Fieldbus Specifications are completed.

A1.2 Reduced Wiring Cost

The introduction of Fieldbus reduces wiring cost by means of multi-drop connections and multivariable transmission.

Multi-drop Connections

Connecting multiple field devices to a single cable is known as multi-drop connections. Reducing the number of cables has many advantages. Figure A1.1 shows an example of multi-drop connections.

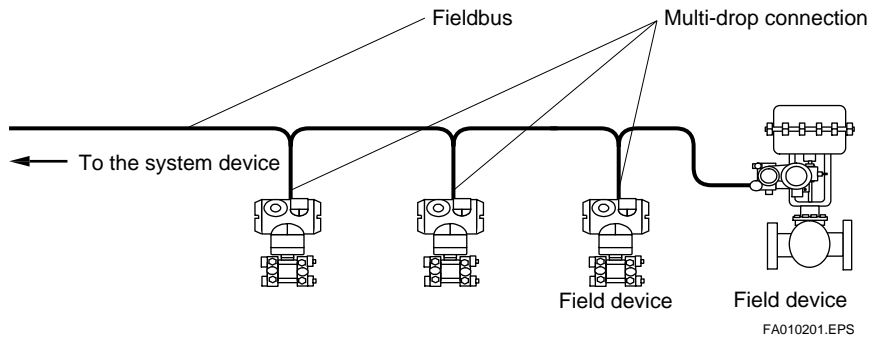


Figure A1.1 Multi-drop Connections

In a conventional analog communication system, only one field device can be connected to a single cable that leads to a system device. Multi-drop connections connect multiple field devices to a single cable. Multi-drop connections allow additional field devices to be connected to a cable which has already been laid.

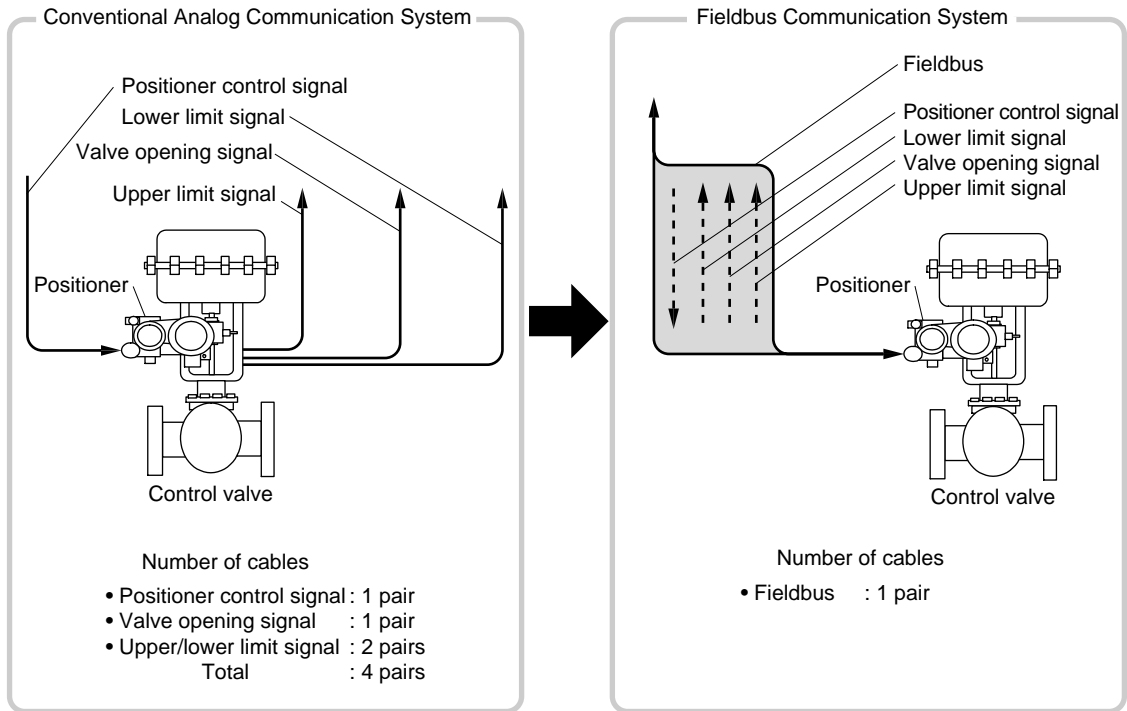
In the past, it was costly to connect multiple field devices. Using a Fieldbus communication system, it is possible to connect a large number of field devices to the Fieldbus because of low wiring cost by multi-drop connections. This will expand the scale of process control systems and promote a higher level of plant automation.

Multivariable Detection and Transmission

Multivariable is multiple measured variables. Multivariable detection means that one field device detects multiple measured variables. This is also called multi-sensing.

A conventional analog communication system requires one cable for each measured variable. Fieldbus supports multivariable transmission. Therefore, a field device can transmit all measured variables detected by the field device via a single cable.

Figure A1.2 shows the difference in wiring a control valve in two systems.



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Figure A1.2 Difference in Detection and Transmission between Analog and Fieldbus Communication Systems

In the conventional analog communication system, the control output signal to the positioner is usually transmitted. In a Fieldbus communication system, multiple pieces of information such as control signals, limit signals, and valve opening signals can all be detected and transmitted.

Multivariable detection and transmission can be used for:

- Monitoring the condition of the steam heat tracing of differential pressure transmitters by ambient temperature information.
- Detecting clogging in impulse lines by static pressure information.

Many other pieces of information will also be used to expand measurement and control capabilities.

A1.3 Improved Transmission Accuracy

Fieldbus improves transmission accuracy by eliminating errors that occur during data transmission in the conventional analog communication system.

Removing Error Factors

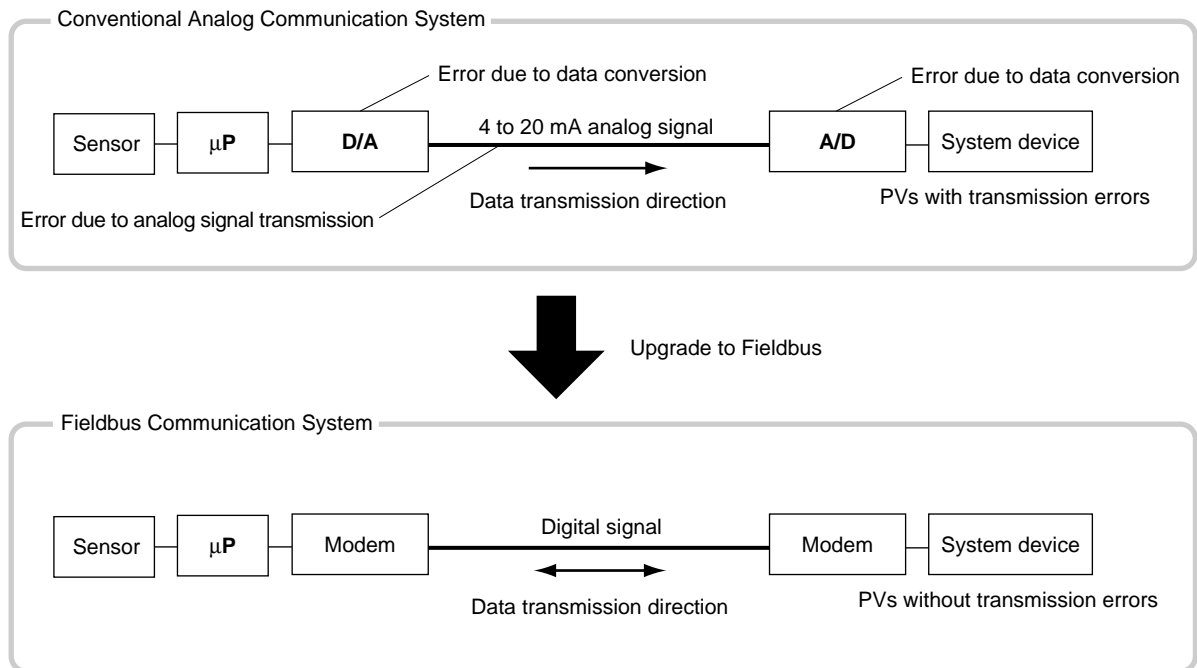
The following three factors cause errors in the conventional analog communication system.

- D/A conversion in the field device
- Analog signal transmission
- A/D conversion in the system device

For example, if data is transmitted from a field device with a microprocessor in the conventional analog communication system, an error may result during A/D and D/A data conversion.

Fieldbus eliminates conversion errors during data transmission.

Figure A1.3 shows the difference in transmission accuracy between the conventional analog communication system and the Fieldbus communication system.



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Figure A1.3 Difference in Transmission Accuracy between Analog and Fieldbus Communication Systems

Fieldbus transmits data using digital signals. A signal transmission error can not occur in digital signal transmission, unlike analog signal transmission. In addition, Fieldbus does not need A/D and D/A conversions because it always transmits data digitally. Fieldbus removes these three error factors, improving transmission accuracy.

System reliability improves with an increase in transmission accuracy. This allows stricter quality control, improving production efficiency.

Making the Most of Field Device Accuracy

Improved data transmission means accurate transmission of data which is detected by field devices. Especially digital field devices reduce transmission errors, and conversion errors of digital signals detected by sensors.

Therefore, a Fieldbus communication system can take advantage of high-accuracy field device performance.

A1.4 Enhanced Data Transmission

In a Fieldbus communication system, many pieces of field information as well as PVs and MVs can be exchanged between field devices. Fieldbus can transmit many kinds of data bidirectionally, so the system can achieve more advanced functionality than a conventional analog communication system.

Various Types of Data Transmission

Fieldbus can transmit various types of data.

The conventional analog communication system cannot transmit data other than PVs and MVs. Then, “hybrid communication,” an analog communication protocol with a digital data transmission function, allows various types of data transmission. However, the hybrid communication protocol has the following problems:

- The transmission speed is slow.
- Only one-to-one communication between a system device and a field device is possible.

Fieldbus solves the problems associated with hybrid communication.

- The transmission speed is fast.
- Multiple pairs of devices can simultaneously communicate among system devices and field devices, and between field devices.

Transmission of various types of data allows the following advanced functionalities.

- Since past maintenance information can be easily acquired, maintenance efficiency improves.
- Device management such as field device master file creation is automated.

Bidirectional Communication

Fieldbus transmits multiplexed digital information. This enables the system to perform bidirectional communication which the conventional analog communication system could not perform.

Data Exchange between Field Devices

Distribution of control to field devices is made possible by exchanging data between them.

A1.5 Distributed Functions

The use of Fieldbus implements integrated control over the entire plant and autonomous distributed control.

Installing Advanced Functions in Field Devices

Fieldbus allows exchange of field information used for control in addition to PVs and MVs.

Field devices with a calculation function and other functions can be adjusted from system devices. Although some functions such as correction computation have been installed in current field devices, various functions that use more information are expected to be included in future field devices. By doing this, a field device such as a positioner will be able to field-adjust valve control characteristics.

Distributing Functions to the Field

Field devices are equipped with advanced functions to provide some part of control that was performed by system devices. Distribution of control to field devices will change system device functions.

Functions of Field and System Devices

By higher-functionality in field devices and distribution of control functions, the functions will vary between field and system devices. For example, the user can install the PID function for each control object in a field device or a system device.

If the relation between loops is tight and they cover a wide range in a large-scale plant control, the PID function will be generally installed in the system device. Conversely, if the loops are relatively independent in a small-scale plant, the PID function may be installed in a field device. In an oil refinery, for example, the PID function is closely related to complex control, advanced control, optimized control, and integrated control over the entire plant. Therefore, excluding some independent control loops, the PID function will be installed in the system device.

A1.6 Interoperability

International standardization of the Fieldbus communication protocol being promoted ensures interoperability between devices. This increases flexibility in process control system configurations; it allows a combination of devices from different manufacturers.

Conventional hybrid communications can transmit digital signals, but information exchange between devices of different manufacturers is difficult because each device uses its manufacturer's protocol. Fieldbus-ready devices allow exchange of digital data between devices from different manufacturers.

Interoperability has the following benefits:

- Process control system configuration freedom increases since there is no need to choose one device manufacturer.
- Various systems, including instruments, motor drives, FAs, BAs, OAs, and analyzers can be integrated.

A2. International Standardization of Fieldbus

The international standards of Fieldbus are being unified by IEC/TC65/SC65C WG6 (International Electrotechnical Commission/Technical Committee 65/Sub-Committee 65C/Working Group 6), ISA (The International Society for Measurement & Control) SP50 Committee (which defined 4 to 20 mA analog signal as the standard electronic instrumentation signal), and the Fieldbus Foundation.

This chapter explains the progress of Fieldbus standardization and Fieldbus standards.

A2.1 Progress of Fieldbus Standardization

Fieldbus standardization has been promoted by IEC TC65 and the ISA SP50 Committee.

Recently, the Fieldbus Foundation, a private organization formed to promote Fieldbus, supports the international unification of Fieldbus standards.

Recognition as a Standardization Work Item

In 1984, the standardization concept for next-generation digital communication protocol for field devices was first proposed to the IEC, which is to replace the 4 to 20 mA analog communication protocol. In 1985, IEC/TC65/SC65C recognized the digital communication protocol as a new standardization work item and named it Fieldbus. IEC/TC65/SC65C WG6, and the ISA SP50 Committee which has already commenced Fieldbus standardization discussion consented to jointly standardize Fieldbus.

Establishment of The Fieldbus Foundation

The standardization of Fieldbus will have a great effect upon industry. Many views were presented at the ISA SP50 Committee, delaying Fieldbus standardization. To make up lost time and promote Fieldbus production, ISP (Interoperable Systems Project) was organized by Yokogawa, Fisher Control, Rosemount, and Siemens in August 1992. In February 1993, ISP became ISP Association. In March 1993, WorldFIP (Factory Instrumentation Protocol) was jointly created by Honeywell, A-B (Allen-Bradley), CEGELEC, Telemichanique, and several other companies.

After that, a consensus was obtained amongst customers that Fieldbus should conform to the internationally unified standard. In September 1994, in accordance with this decision, ISP Association and WorldFIP North America were combined into the Fieldbus Foundation.

A2.2 Fieldbus Standard Specifications

There are two kinds of Fieldbus specifications standardized by IEC1158-2 and ISA S50.02: low-speed and high-speed Fieldbus specifications.

IEC/ISA Standard Specifications

The low-speed and high-speed Fieldbus specifications are standardized as shown in Table A2.1 and Table A2.2.

Table A2.1 Fieldbus Specifications (Standard)

| Item | Low-speed Fieldbus | High-speed Fieldbus |
|---------------------------------------|---|---|
| Transmission speed | 31.25 kbps | 1.0 Mbps (in 1 Mbps mode or high-speed current mode) 2.5 Mbps (in 2.5 Mbps mode) |
| Number of connectable devices/segment | Max. 32 devices/segment | Max. 32 devices/segment (*1) |
| Cable | Twisted pair cable (shielded) | Twisted pair cable (shielded) |
| Power supply to connected devices | Enabled | Enabled |
| Intrinsic safety | Enabled | Enabled |
| Redundancy | Enabled | Enabled |
| Example of connected devices | Transmitter, control valve, field multiplexer, etc. | Multicomponent analyzer, PLC, remote I/O, etc. |

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*1: Using repeaters increase the number of connectable devices.

Table A2.2 Type of Low-speed Fieldbus Cables and Transmissible Length

| Type of cable | Cable specifications | Max. length of cable (reference value) |
|--|--------------------------------|--|
| Type A: Individually-shielded twisted pair cable | #18AWG (0.82 mm ²) | 1,900 m |
| Type B: Overall-shielded twisted pair cable | #22AWG (0.32 mm ²) | 1,200 m |
| Type C: Unshielded twisted pair cable | #26AWG (0.13 mm ²) | 400 m |
| Type D: Overall-shielded non-twisted cable | #16AWG (1.25 mm ²) | 200 m |

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Note: Yokogawa does not recommend the use of Type C.
For Types B and D, their use is restricted.
For details, see Part B Chapter 2.

A2.3 Yokogawa's Efforts for Fieldbus Standardization

Yokogawa, a member of the board of directors of the Fieldbus Foundation, plays a leading role in the international standardization of Fieldbus standards.

Tackling for Unified Fieldbus

Fieldbus is a key instrumentation technology as we move towards the 21st century, and will have a great influence on all fields of instrumentation. It is a technological theme in a new era of digital instrumentation.

Yokogawa is a member of the board of directors of the Fieldbus Foundation. Yokogawa is also a representative of the Fieldbus Foundation Japan Council, a sub-chairman of the Technical Committee, and dispatches personnel to the Major Development Committee at the Fieldbus Foundation.

Yokogawa consistently insists on the importance of achieving a unified International Fieldbus, contributing to international standardization, and establishing interoperability, and has played a leading role in attaining a standardized Fieldbus. Yokogawa will continue to strive towards its goals.

Services for Fieldbus Support Devices

Yokogawa exerts its greatest effort to promote Fieldbus, and provides the following services to add value for the customer:

Product Development

Fieldbus support products will be widely developed, ranging from various field devices to an integrated production control system, CENTUM CS.

Development of Field Device Control and Diagnostics Packages

Field device control and diagnostics packages which support enhanced field information will be developed.

A3. Fieldbus-ready Field Devices

When Fieldbus is introduced, the type and amount of transmissible information will drastically increase. Also, bidirectional communication of digital information can take place between a field device and a system device, and between field devices. To make the most of communication improvements and to satisfy more advanced needs, big changes will be taking place with field devices. This chapter explains the differences in field devices when Fieldbus is introduced in a communication system.

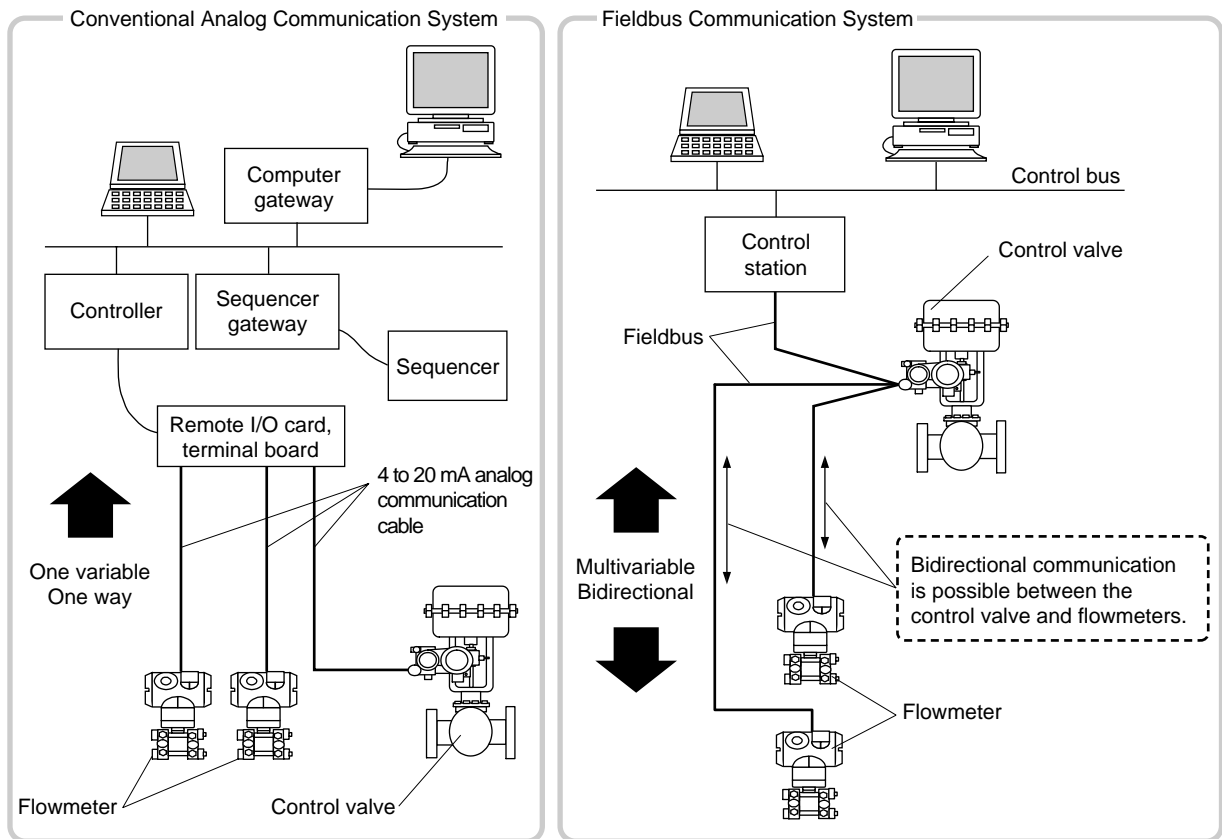
Difference between Analog and Fieldbus Communication Systems

The Fieldbus communication system transmits information differently from the conventional analog communication system. It has the following capabilities:

- A large amount of information can be transmitted
- There are many types of transmissible information, both control and non-control information
- Digital information can be transmitted
- Bidirectional communication is possible between a field device and a system device
- Bidirectional communication is possible between field devices

According to those differences, the information handled by field devices (field information) will change significantly.

Figure A3.1 shows the differences between analog and Fieldbus communication systems.



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Figure A3.1 Difference between Analog and Fieldbus Communication Systems

Advanced Functionality of Field Devices

By making the most of Fieldbus communication system features, it is possible to have more advanced control over the system. As a result, more advanced functionality will be required in field devices.

For example, by transmitting self-diagnostics information from a field device to the system device, with the appropriate timing, the system can control the field device according to its status and can predict a problem in the field device. Also, by exchanging PV and MV values between field devices, autonomously distributed control of multiple field devices will be possible.

Once the main power to the process control systems was changed from air to electricity, new electric-powered field devices appeared on the market. Similarly, when the communication protocol of process control systems changes from analog communication to Fieldbus communication, new field devices that support Fieldbus communication capabilities will appear on the market.

Field devices are primarily categorized into transmitters and actuators. Fieldbus will bring about changes in both components. The following sections describe what changes will occur in transmitters and actuators.

A3.1 Changes in Transmitters

The Fieldbus communication system can transmit digital information in a single line. Therefore, the function of a transmitter will change greatly.

In a conventional analog communication system, transmitters are primarily designed to transmit the PV value to be measured to the system device. This is because the analog communication system performs one-way communication, from a field device to a system device, or vice versa.

By using the Fieldbus communication system, the type and amount of information being transmitted through a single cable will increase drastically, and will be far greater than that of a conventional analog communication system. In addition, bidirectional communication can be performed between a field device and a system device, and between field devices. Since digital information can be transmitted to field devices without conversion, information will be much more reliable.

A3.1.1 Accuracy Improvement due to Digitalization

Since the Fieldbus communication system transmits information digitally, it can transmit the measured data from a transmitter to the system device with minimum error. Many transmitters with drastically higher accuracy will soon come to market.

Improvement of Transmission Accuracy

A transmitter compatible with the conventional analog communication protocol indicated a PV value as a percentage (0 to 100 % relative value) of the measuring range, and transmitted this value to the system device after converting to a 4 to 20 mA analog signal. The system device used the 4 to 20 mA analog signal that was transmitted, after converting it to the appropriate engineering unit.

Errors occur during the conversion of these values.

In contrast, a transmitter compatible with the Fieldbus communication protocol expresses a PV value in engineering units and transmits this value, without modification, to the system device as a digital signal. The system device uses the digital signal as it was transmitted. The Fieldbus communication system does not require signal conversion, thereby eliminating conversion errors that occur during transmission of measured data.

The Fieldbus communication system provides for higher data transmission accuracy compared to the analog communication system.

Using the example of the orifice flowmeter which uses a differential pressure transmitter, the difference in transmission accuracy between the analog and Fieldbus communication systems is described below.

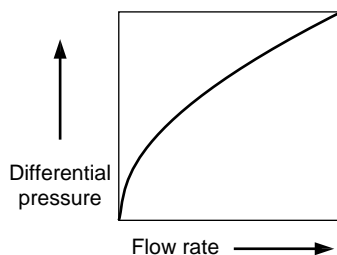
In a conventional analog communication system, the differential pressure generated at the orifice, proportional to the square of the flow rate, was measured by a differential pressure transmitter and transmitted to the system device after converting to a 4 to 20 mA signal. If the differential pressure, (Δ , at the orifice is 2 kPa when the flow rate is 20 Nm³/h, the output signal of the differential pressure transmitter will be as shown in Table A3.1. The analog communication system generates an error when this output signal is converted to an analog signal.

If the differential pressure is converted to a flow rate on the system device side, the transmission error will be changed by the flow rate because this conversion is not linear as shown in Figure A3.2.

Table A3.1 Analog Signal Data

| Output | Differential pressure | Flow rate |
|--------|-----------------------|-----------------------|
| 4 mA | 0 kPa | 0 Nm ³ /h |
| 20 mA | 2 kPa | 20 Nm ³ /h |

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Figure A3.2 Relationship between Differential Pressure and Flow Rate

In contrast, the Fieldbus communication system transmits the flow signal in engineering units as a digital signal. Therefore, there is no error during transmission. In this example, the flow rate measured at the orifice is transmitted to the system device in the same unit as that of the measured value of the differential pressure transmitter.

Improvement of Transmitter Measuring Accuracy

If the transmission accuracy is improved by the Fieldbus communication protocol, the improvement of transmitter measuring accuracy will be a factor in improving the accuracy of the entire process control system. To perform measurements at higher accuracy, field devices that employ a superior measurement principle will be widely used.

For example, conventional mechanical flow meters and level meters will be replaced by electric flow meters and level meters that employ digital technology.

Since the Fieldbus communication system transmits the measured data in engineering units, a transmitter with a wide measuring range will show the original measuring performance. The width of the measuring range is one of the most important factors in determining the quality of transmitters.

Yokogawa's Transmitters Employ Digital Technology Measurement Principles

Yokogawa has already developed and offered transmitters that employ digital technology measurement principles to a wide variety of process control systems that use the Fieldbus communication protocol.

Yokogawa has developed and offered the following main transmitters which both produce a digital signal:

- Differential pressure transmitter DPharp: Employs an oscillating type sensor.
- Vortex flowmeter YEWFO: Measures flow rate on the basis of Karman vortex frequency.

A3.1.2 Multi-sensing Function Equipment

The function used to measure multiple variables with a single transmitter is known as the multi-sensing function.

In a Fieldbus communication system, it is possible to transmit multiple pieces of information over a single cable. To make the most of this Fieldbus feature, users will demand transmitters equipped with a multi-sensing function.

In a conventional analog communication system, a transmission cable with a pair of wires is required to transmit one measured value. For example, a transmitter that can perform multiple measurements, such as the Coriolis flowmeter, requires multiple cables to transmit multiple measurement variables.

The Fieldbus communication system allows the Coriolis flowmeter to transmit multiple measurement variables via a single cable.

Transmitters that can perform only one measurement will be enhanced with the multi-sensing function to make use of the Fieldbus communication system.

For example, the differential pressure transmitter will be able to measure process pressure, ambient temperature, etc., in addition to flow rate, which was the transmitter's original function. If a temperature sensor for measuring the process temperature is combined with this differential pressure transmitter, all flow rate, pressure, and temperature variables necessary for process control will be accessible by the transmitter alone.

Possible multi-sensing objects that will be assigned to the main transmitters are shown below.

- Differential pressure flowmeter: Mass flow, volume flow, pressure, temperature
- Electromagnetic flowmeter: Volume flow, conductivity, temperature
- Vortex flowmeter: Mass flow, volume flow, temperature, pressure
- Coriolis flowmeter: Mass flow, volume flow, density, temperature
- Differential pressure level meter: Liquid level, density and specific gravity, tank internal pressure, temperature
- Positive displacement level meter: Liquid level, temperature
- Ultrasonic level meter: Liquid level, temperature
- Temperature transmitter: Humidity, ambient temperature, vibration
- pH meter: pH, temperature
- Conductivity meter: Conductivity, temperature
- DO meter: DO, temperature

A3.1.3 Multifunction Equipment

A Fieldbus communication system can transmit other information in addition to the PV value. To make the most of this feature, the transmitter will be expected to calculate the PV value and process it into the required control information.

A transmitter that incorporates multiple functions, such as the calculation function, is known as a multifunction transmitter. Multifunction transmitters will be used as part a Fieldbus communication system.

The main function of transmitters used in a conventional analog communication system is to measure a PV value at high-accuracy and transmit it. To do this, additional devices are used for converting the measured PV value into the information necessary for control.

A multifunction transmitter can calculate the PV value in engineering units required by the client and transmit it to the system device.

If a multifunction transmitter is used in combination with the above multi-sensing function, it is possible to drastically simplify the process control system.

For example, assume that there is a differential pressure transmitter which can multi-sense the flow rate, pressure, and temperature. If a calculation function is added to this differential pressure transmitter, it allows the transmitter to calculate the actual flow rate after temperature-pressure compensation using the measured flow rate, pressure, and temperature, and before executing transmission.

To attain the above functions, a conventional analog communication system would require three transmitters, one each for flow rate, pressure, and temperature, and an additional calculator for temperature-pressure compensation. A single multifunction transmitter with multi-sensing can process all of this.

This will not only drastically reduce the instrumentation cost, but will also improve the reliability.

A3.2 Actuator

Fieldbus is expected to offer many possibilities for actuators.

This section explains, using a typical control valve actuator, the changes that will take place in actuators.

Control Valve Changes

The progress brought about by Fieldbus communication protocol will drastically change the role of the control valve.

A control valve compatible with a conventional analog communication protocol controls a valve using a positioner and according to the MV value transmitted from the system device.

On the other hand, a control valve compatible with Fieldbus communication protocol will not only control the valve to a constant opening, but also return the valve opening value, with respect to the MV value, back to the system device. This will promise more stabilized control of the system.

Also, this valve and its positioner will be able to perform valve characteristic modifications, temperature compensations, etc., which were usually made by the system device. This will make it possible to compensate for valve operation as close to the process state as possible, while monitoring the valve characteristics.

If this positioner and valve are combined with a flowmeter, the feedback control of a control valve, which is currently handled by the system device, will be handled by only the control valve.

Features of control valves compatible with the Fieldbus communication protocol are summarized next.

Features of Control Valves Compatible with the Fieldbus Communication Protocol

- Improvement of valve controllability
- Remote monitoring of control valves
- Modification and improvement of valve characteristics
- Stabilized control together with operability and complete closure of valves
- Improved valve stability
- Ease-to-operate adjustment and stabilization characteristics of valves
- Reduction of valve accessory devices

Figure A3.3 shows the compensation curves of valve flow characteristics. By using the functions of the Fieldbus communication protocol, the following compensation will be made easily and stable flow characteristics control will be achieved.

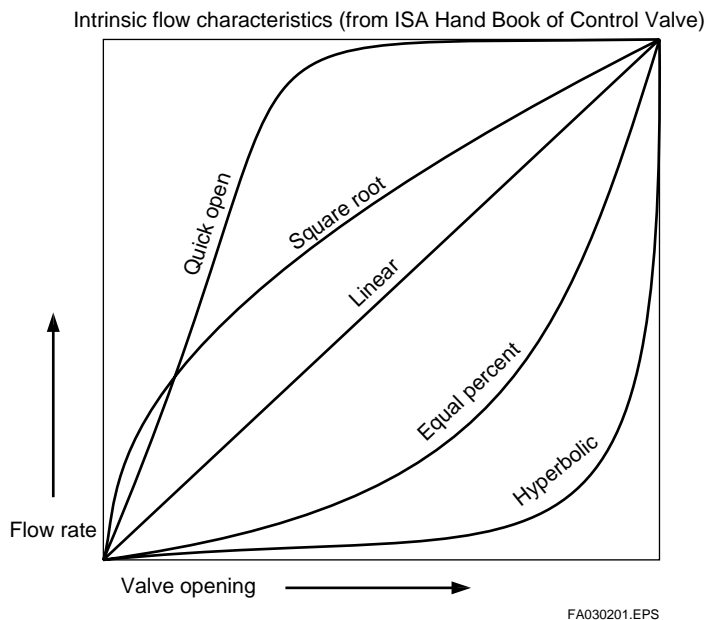


Figure A3.3 Modification of Valve Flow Characteristics

A3.3 Using Self-diagnostics Function

The Fieldbus communication system can predict a problem in a field device using the self-diagnostics function.

Integration of Instrumentation and Self-diagnostics Functions

The conventional analog communication system can handle only one signal on a single cable. The system handles the PV or MV value and the self-diagnostics information as completely different data, even if it is information from the same field device.

The Fieldbus communication system can handle multiple signals on a single cable. The system can handle the PV or MV value and the self-diagnostics information in the same environment. Instrumentation and self-diagnostics will be performed under the same environment by integrating work from the field into a single network.

This idea is far different from the conventional one which has separated instrumentation from self-diagnostics.

Problem Prediction Function

Since Fieldbus represents the measured values in engineering units, it allows the system to accurately measure slight changes in pressure and temperature, other than the PV value. This enables the system to detect the symptoms of problems that were difficult to predict.

For example, suppose the system cannot judge whether the self-diagnostics result of a field device is abnormal or normal. The current analog communication system can transmit a self-diagnostics result as either abnormal or normal. Therefore, if a result cannot be judged as being abnormal or normal, the system always handles it as abnormal for safety. If a minor abnormality is generated in field devices, a number of alarms will be displayed on the panel in the instrument room. However, if minor abnormalities in field devices are handled as normal to reduce alarms in the instrument room, the symptom of a major problem may not be detected.

If a self-diagnostics result cannot be judged as abnormal or normal, Fieldbus communication system can transmit the status information to the system device. The use of this status information allows the system device to chronologically analyze changes in field devices and predict their problems.

A3.4 Upgrading from BRAIN System

It is technically difficult to replace all current field devices that support analog communication with those that support Fieldbus communication. However, the BRAIN system that supports hybrid communication can be upgraded only by replacing the part of the amplifiers used as a communication interface.

Yokogawa intends to provide a smooth upgrade from the BRAIN system support devices to the Fieldbus support ones by satisfying the following three points:

- The users can upgrade to Fieldbus by themselves.
- The upgraded system maintains the same reliability as previous system.
- The upgraded system benefits the users.

A4. Fieldbus-ready System Devices

The control system that uses Fieldbus communication handles more advanced information than the conventional analog communication system. Information reception, display and record management are more important factors in control systems.

This chapter describes the Yokogawa system devices that support Fieldbus.

The “H1 Fieldbus Communication Protocol” indicated in this chapter and Part B are the “FOUNDATION Fieldbus (Low Speed Voltage Mode)” of the Fieldbus Foundation.

A4.1 Fieldbus Support in CENTUM CS 1000, CS 3000 and CENTUM CS

The CENTUM CS 1000 Production Control System, CENTUM CS 3000 Integrated Production Control System, and CENTUM CS support Fieldbus. These systems are connected to field devices via I/O modules which support 1-5 V DC/4-20 mA I/Os, thermocouple and resistance temperature detector inputs, and digital I/O. The Fieldbus Communication Module can also be combined with such conventional analog communication modules.

Figures A4.1, A4.2 and A4.3 show CENTUM CS 1000, CENTUM CS 3000 and CENTUM CS system configurations which support the H1 Fieldbus.

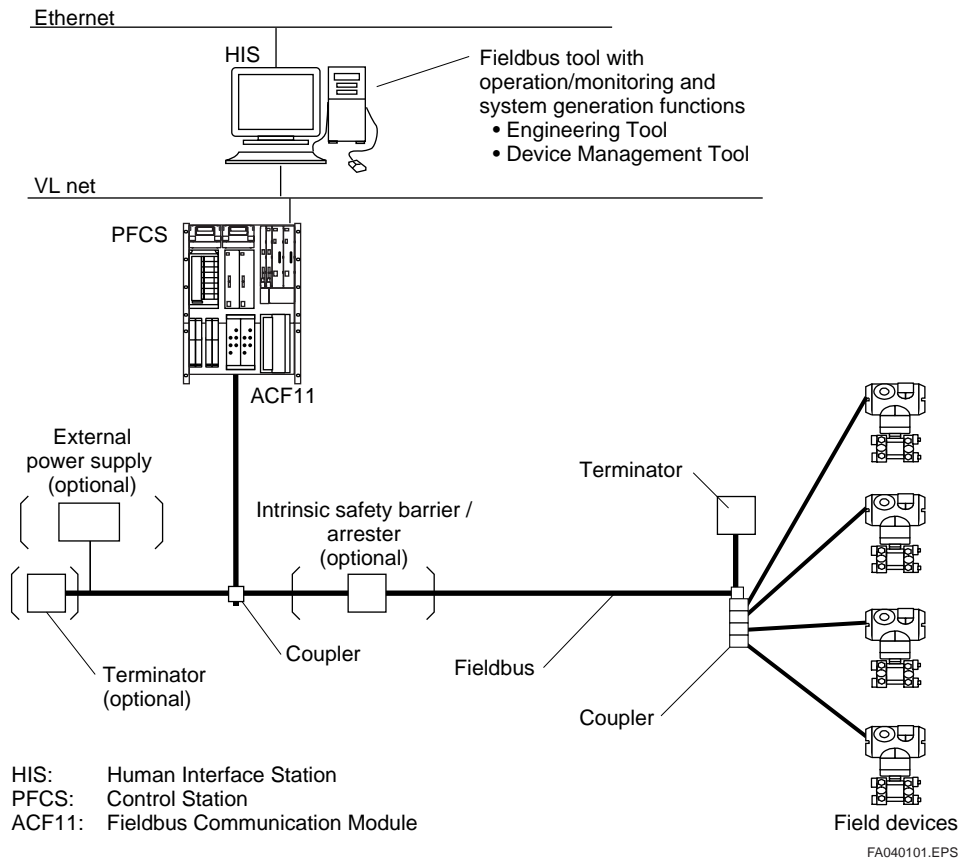


Figure A4.1 CENTUM CS 1000 Connected to H1 Fieldbus

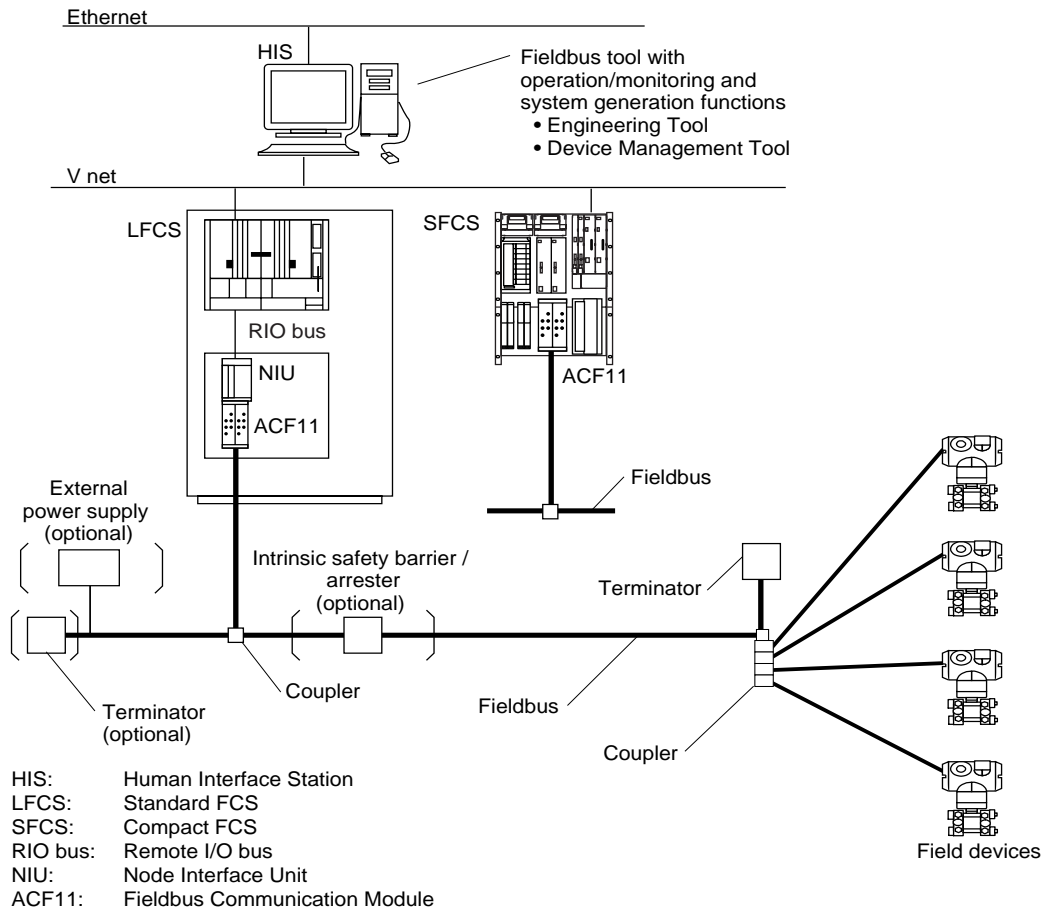


Figure A4.2 CENTUM CS 3000 Connected to H1 Fieldbus

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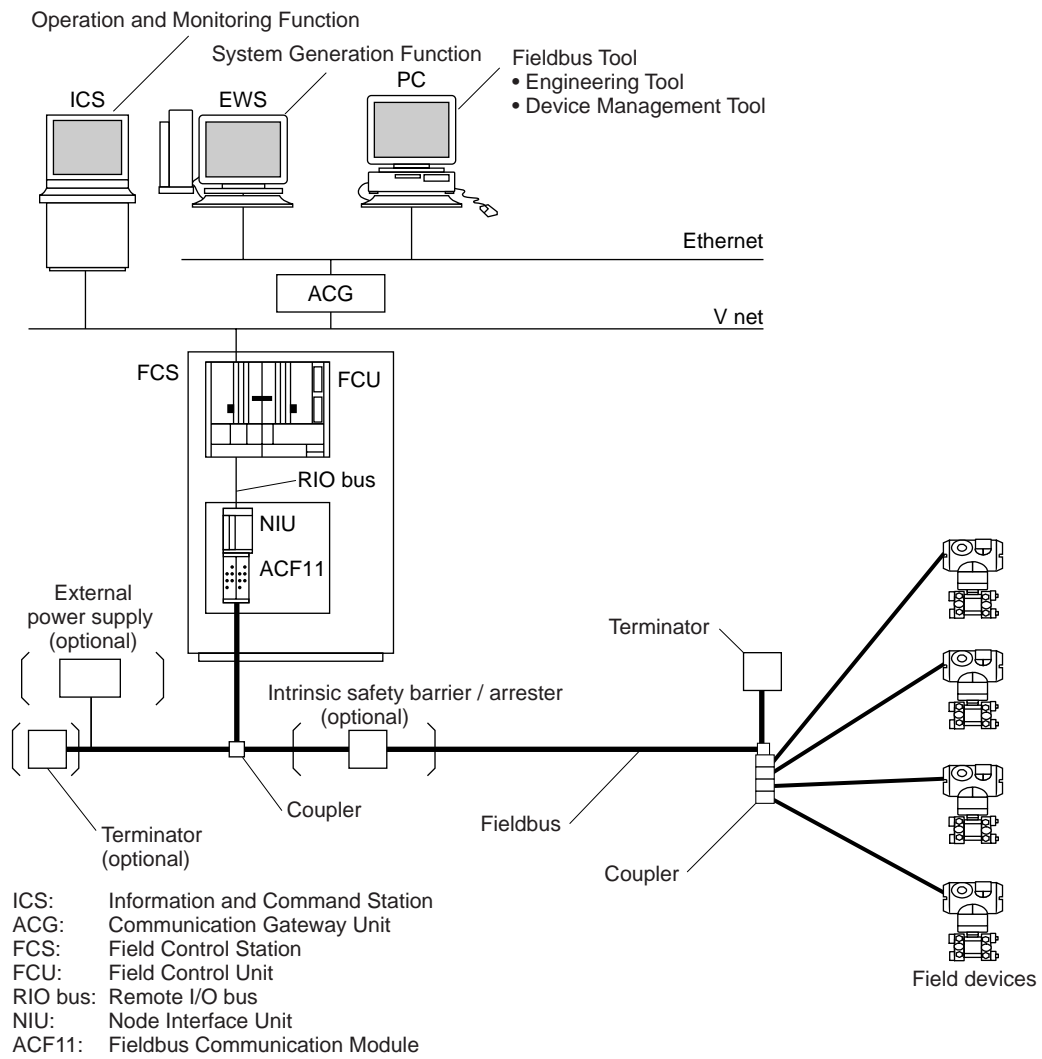


Figure A4.3 CENTUM CS Connected to H1 Fieldbus

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A4.2 Fieldbus-ready Field Devices from Other Vendors

Yokogawa provides support for Fieldbus-ready field devices from other vendors under the following conditions:

Use devices certified and registered by the Fieldbus Foundation

The Fieldbus Foundation will certify and register field devices that meet the Foundation specifications, and give a party the qualification to approve Fieldbus-ready devices. Yokogawa provides support for field devices certified and registered by the Fieldbus Foundation or a qualified party.

Non-certified Fieldbus accessories (e.g. cables, external bus power supplies, barriers and arresters) should be used according to the conditions provided by their makers. We plan to inform you of proven Fieldbus accessories as preferred devices.

Use devices as instructed

Use devices according to the conditions provided by their makers. The maker should assume responsibility for the quality, performance and warranty of their field devices.

Test devices

A user who uses field devices from other makers is responsible for testing them.

Yokogawa supports only standard Fieldbus specifications, not manufacturer-specific extensions

Yokogawa's system devices support information and functions that meet the standard specifications prescribed by the Fieldbus Foundation. They may not support another manufacturer's proprietary functions.

The Fieldbus standardization facilitates operation and maintenance of field devices from different manufacturers. Yokogawa can meet a variety of user needs, including startup and maintenance work on process control systems including products (components) from other makers, based on accumulated knowhow about devices and their usage.

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B1. Managing Fieldbus Engineering

In a process control system that uses Fieldbus, the engineering process differs from that of a process control system that uses conventional analog signals. This chapter explains the engineering process in a process control system using Fieldbus.

In part B, all descriptions are related to only the H1 (31.25 kbps) Fieldbus.

B1.1 Engineering Process

The engineering of a process control system that employs Fieldbus is divided into five steps: design, production, construction, startup, and maintenance. Each step has multiple task processes and each task process includes detailed task items.

Figure B1.1 shows the engineering process for the process control system using Fieldbus technology.

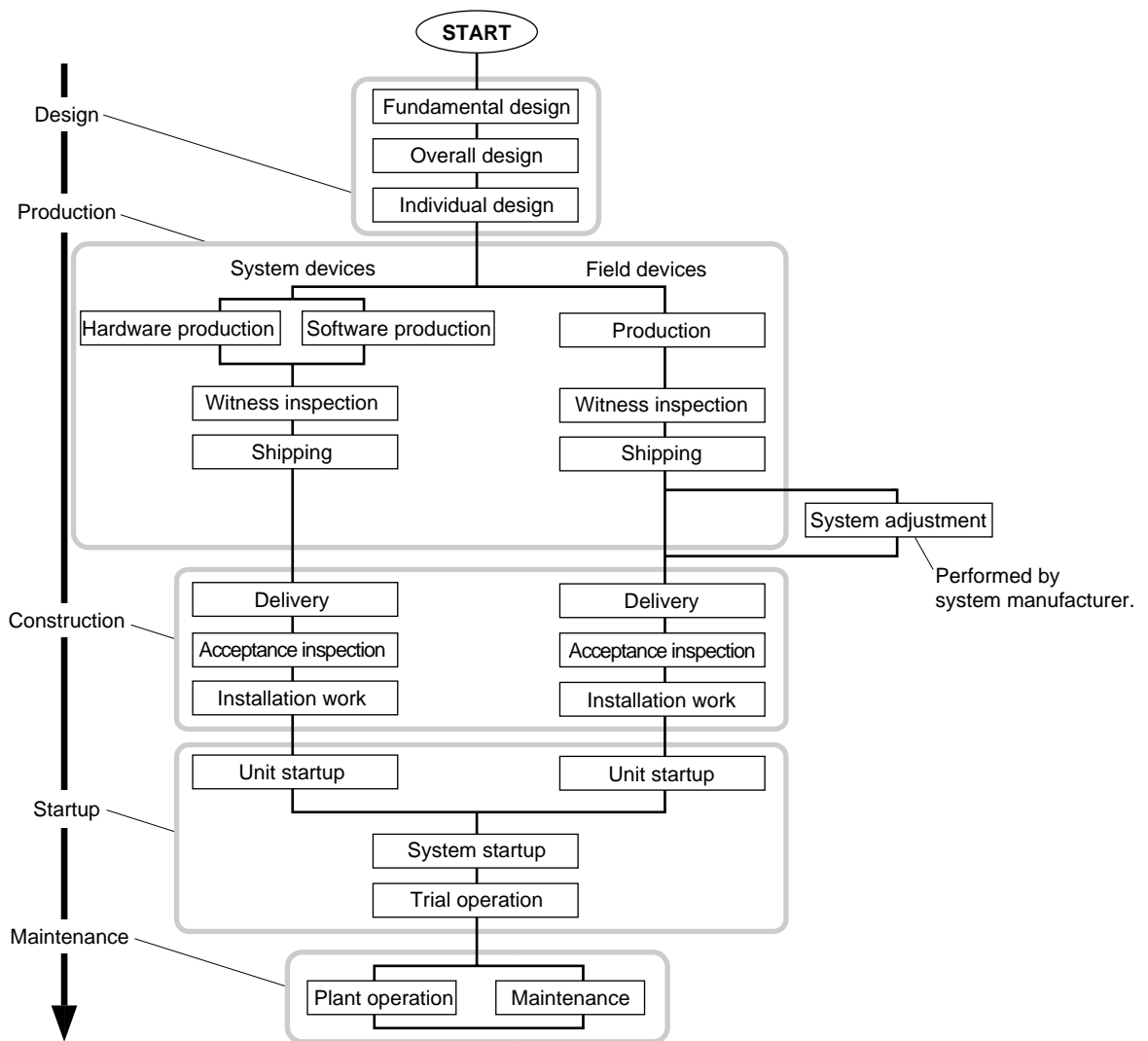


Figure B1.1 Engineering Process

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Design

The specifications of the process control system are verified by completing the fundamental design, overall design, and individual design for the system.

SEE ALSO

For detailed information about designing the process control system using Fieldbus, refer to “B2. System Design Considerations.”

Production

According to the specifications that are confirmed in the design process, system devices and field devices are produced. Production work is completely performed by Yokogawa. No other work needs to be performed by the user.

Construction

The manufactured system devices and field devices are delivered to the user’s facility. Then, according to the system layout that has been clarified in the design step, wiring such as Fieldbus cabling is installed.

Acceptance inspection is performed for the field devices before installation. The process control system using Fieldbus needs to be closely inspected. The following items require especially close inspection.

- Parameter settings specific to field devices
- Parameter settings (device tags) required for Fieldbus communication

After inspection, system devices are installed in the instrument room, and field devices in the field. The system devices and field devices are connected to the Fieldbus.

SEE ALSO

For detailed information about constructing a process control system using Fieldbus, refer to “B3. System Construction Considerations.”

Startup

In the startup step, unit startup, system startup and the trial operation is performed.

Startup (Unit and System)

The following checks are required.

- Unit identification for all field devices
- Confirmation of data input/output between system devices and field devices

(The input/output definition on the system device side must be completed by this time.)

Trial Operation

This includes adjustment of various control constants and parameters. These parameters are for the built-in function blocks in field devices and for the function blocks managed by control function in system devices.

SEE ALSO

For detailed information about starting up the process control system using Fieldbus, refer to “B4. System Startup Considerations.”

Maintenance

During plant operation, the field device status is managed using a device management tool which is supported by the upper-level system device.

Also, error generation is monitored using the self-diagnostics function of field devices. However, it depends on whether the field device has the self-diagnostics function.

With maintenance work, parameters can be confirmed by directly connecting field tools to field devices. The communication status can be checked by directly connecting the LAN analyzer to Fieldbus.

Some field devices may have a maintenance record management function of their own. The maintenance record data on the field device will be automatically uploaded to the maintenance record management package in the maintenance support system in near future.

SEE ALSO

For detailed information about maintaining the process control system using Fieldbus, refer to “B5. System Maintenance Considerations.”

B1.2 Difference between Fieldbus and Analog Signal Process Control Systems

Process control systems using Fieldbus differ greatly from those using a conventional analog signal, in that the parameters for Fieldbus configuration definitions also need to be set.

Setting Parameters Specific to Field Devices

Various parameters for field devices must be set up.

The following main parameters must be set:

- Input filter process parameter
- Compensation parameter
- Range parameter

Setting Parameters for Fieldbus Communication and Its Functions

New parameters for Fieldbus communication and its functions have been added.

The following main parameters must be set:

- Address
- Communication parameter
- Function block functional definition
- Link information (connecting device tag, output parameter, etc.)

B1.3 Fieldbus Tools

Yokogawa intends to offer various tool packages that support process control systems employing Fieldbus communication. These tool packages are referred to as Fieldbus tools. If engineering tools are used with the system in each step, engineering work will be easily processed.

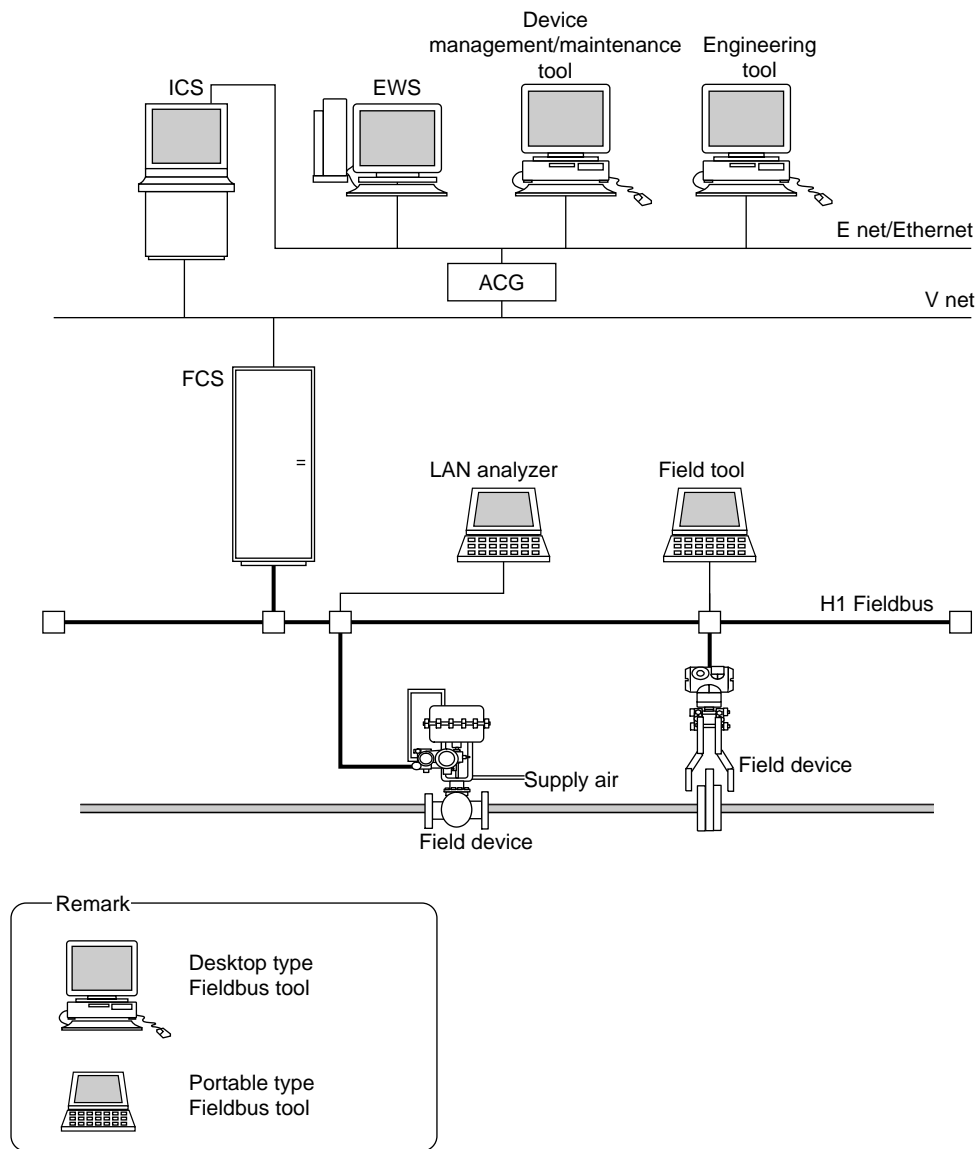
Type of Fieldbus Tools

Yokogawa will offer the following types of Fieldbus tools.

- Desktop type
- Portable type

Figure B1.2 shows an example of the types of Fieldbus tools to be offered.

The Fieldbus tools may be installed in one PC in the system.



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Figure B1.2 Types of Fieldbus Tools to be Offered

Desktop Type Fieldbus Tool

This type is offered in consideration of the following maintenance work.

- Engineering, device management, maintenance, etc., are performed by integrating the tool in the system devices. A Fieldbus tool is installed in a personal computer (PC). This PC is connected on the LAN (Ethernet) of system devices for which remote setting of field device parameters, remote diagnostics of field devices, etc., are to be performed.
- Setup and testing are performed for the field device before it is installed in the field.

This PC is connected directly to a field device to set parameters and check the operation of only the device.

Portable Type Fieldbus Tool

This type is used for direct Fieldbus maintenance in the field.

The Fieldbus tool is installed in a handy terminal (or portable PC). This terminal is connected to Fieldbus to monitor the Fieldbus communication status, etc. It is also used to set parameters and check the operation of a field device.

B2. System Design Considerations

Designing a process control system that uses Fieldbus communication protocol, it is necessary to thoroughly understand the design considerations, including Fieldbus. This chapter describes the designing considerations of a process control system that employs Fieldbus technology.

Importance of Process Control System Design

To design a process control system, the design procedure should follow the these steps.

- Fundamental design
- Overall design with respect to common specifications
- Individual design

First perform the fundamental design, then the overall design for the specified system. If the fundamental and overall design have not been completed, an inconsistency with specifications and a return to an earlier step may occur. The more sophisticated the process control system becomes, the more important the fundamental and overall design will be.

During the individual design, the individual components to be designed are identified on the basis of the fundamental and overall design.

Designing Process Control Systems With Fieldbus Technology

In designing Fieldbus process control systems, more items require consideration than those of systems using conventional analog signals. However, this does not indicate a difficulty in designing Fieldbus process control systems. What you have to do is to add Fieldbus-related items to design items of conventional process control systems. You don't need to change a conventional design method.

B2.1 Considerations in Fundamental and Overall Design

During the fundamental design of a process control system that uses Fieldbus, it is necessary to properly consider the purpose of the system and its construction costs. Also, in the overall design, the process control system configuration and the integrating or grouping range and extent must be carefully considered.

Fundamental Design Considerations

During the fundamental design of a process control system that uses Fieldbus, the following must be taken into consideration.

- Purpose of the process control system
- Cost of system implementation (Total estimation including the construction cost)
- Delivery period of the system implementation
- Safety conception
- Operation procedure
- Maintenance procedure

Overall Design Considerations

During the overall design of the process control system that uses Fieldbus, including common specifications, take the following into consideration.

- Configuration of the process control system (hardware and software configuration)
- Integrating or grouping range and scope
- Safety design and reliability design
- Remedies for abnormalities
- Interface design
- Expansion support

B2.2 Individual Design Considerations

In individual design, the contents of fundamental design and overall design are realized. This section describes major considerations in designing individual process control systems that employ Fieldbus. There are also many other items to be considered other than those described here.

Integrating or Grouping Range and Extent

- Integration of buses between the process control system and other systems
- Consistency of operation types between the process control system and other systems
- System integration through upper-level communication and lower-level communication
- Connectable number of field devices and their grouping
- Clarification of hardware and software configuration with system configuration drawings

Safety Design and Reliability Improving Design

- Selecting explosion-protective devices and construction (power supply for safe construction)
- Function assignment in Fieldbus system and conventional system
For example, the emergency shutdown system should be assigned to the conventional analog control system.
- Selection and redundancy of cables, field devices, and Fieldbus interface units
- Fail-safe design, safety measurements using troubleshooting, and equipment diagnostics design
- Selection of noise resistant devices and wiring route to minimize noise (affected by high-voltage or motors)
- Selection of devices to be combined
When selecting devices to be combined, check device specifications, actual field records and certification by the Fieldbus Foundation.
- Design of a master device and a data backup system

Wiring Method

A few different types of cables are given below, but the data is given for reference only. We recommend that you use Type A cable.

Selection of Wiring Cables

Consider noise, cost, flexibility, and resistance to explosion.

Twisted Pair Wire Insulation

A low-capacitance cable with insulator (DPEV) such as polyethylene is appropriate.

Field Device Connecting Method

Consider the number of field devices and the connection method (such as bus, tree, and single).

Cable Selection and Total Length

If using a twisted-pair cable for the main line, exercise care with regard to the kind and total length of cabling.

The total length of cabling for Fieldbus is as follows:

- Type A (Individually-shielded twisted pair cable) 1900 m
- Type B (Overall-shielded twisted pair cable) 1200 m
- Type D (Overall-shielded non-twisted cable) 200 m

Some Type B cables attenuate signals largely. To secure signal amplitude, 20 field devices or fewer must be connected and total cable length must be 600 m or shorter; 10 field devices or fewer must be connected and total cable length must be 1,200 m or shorter.

When using Type D cables, up to 2 pairs of cables must be used for Fieldbus and each pair must be separated from each other to prevent interruption.

When using multi-core cables, do not send signals other than fieldbus signals or analog signals (incl. hybrid communication) through the same cable.

Number of Branch Cables and Total Length

In tree-structured wiring, exercise care with regard to the total length of cabling in accordance with the number of branch cables (number of field devices to be connected).

The maximum lengths of segments of Type A cable are given below.

- 1-12 field devices connected: 120 m
- 15-18 field devices connected: 90 m
- 19-24 field devices connected: 30 m
- 25-32 field devices connected: 0 m

The number of connected field devices may be restricted by power supplies, communication performance and other conditions.

Individual Fieldbus Interface Design

- Design of fieldbus interface considering transmission speed and cycle, connections between field devices and loops
- Arrangement of information type and quantity (essential, expected, and convenient information)
- Design considering extension (Consider installation of spare wiring and devices)
- Address setting for each tag of field devices

Extension and Modification of Existing System

- Clarification of the purpose and extent of expansion, investigation of influence on the existing system, and merit of system construction
- Tentative feasibility study for introduction of Fieldbus
- Design of interface with existing devices (analog/digital conversion)
- Investigation of the usability of existing wiring

TIP

Fieldbus is still being introduced. Therefore, in designing a process control system that uses Fieldbus, consider the following in addition to usual design considerations.

- Field records of each system device and field device
- Effect of information missing caused by trouble in a single Fieldbus segment.
- Specifications of wiring cables

These problems will be solved. In the near future Fieldbus will be easier to use.

B3. System Construction Considerations

When designing a process control system that uses Fieldbus, it is necessary to thoroughly understand construction considerations for Fieldbus. This chapter describes considerations in constructing a process control system that employs Fieldbus.

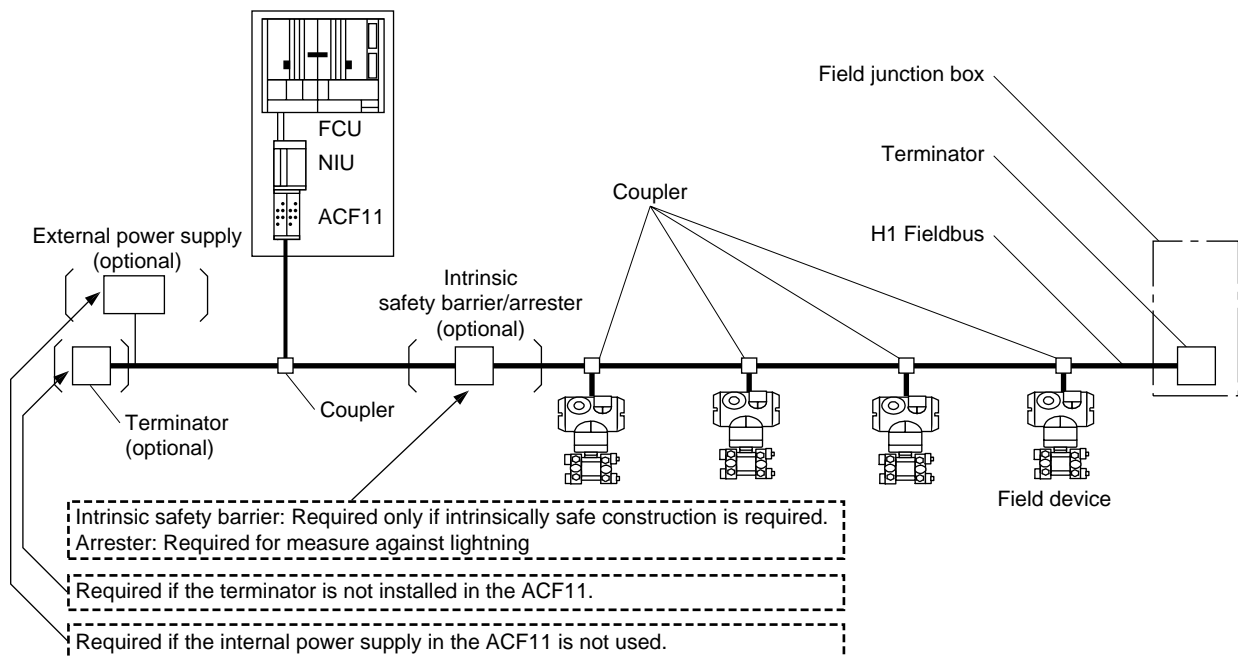
B3.1 New Construction of Fieldbus

For wiring a process control system that uses Fieldbus, new construction examples of typical system wiring configurations “bus type” and “tree type” are explained below.

Example of Bus-type Wiring

In bus-type wiring construction, the power supply and system devices are installed in the instrument room. A Fieldbus segment is installed from the Fieldbus Communication Module (ACF11), which is connected to the system devices, and goes out to a number of field devices. Various types of field devices may be connected to this Fieldbus. A terminator is also connected to both ends of the Fieldbus. Each terminator may be located in the field junction box.

Figure B3.1 shows an example of bus-type wiring.



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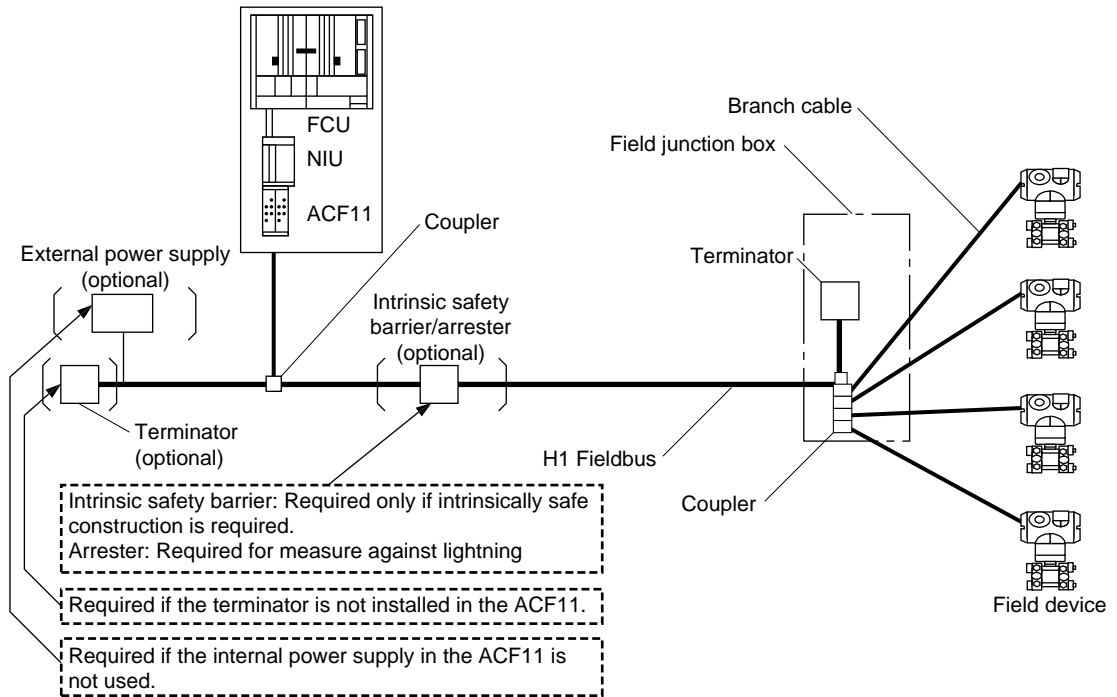
Figure B3.1 Example of Bus-type Wiring

Example of Tree-type Wiring

In tree-type wiring construction, various types of field devices are connected to Fieldbus segments via the field junction box. If the field devices are concentrated in a certain area, connect the terminator at the center of the area to cut the total length of branch cable to each field device.

SEE ALSO

The maximum length of cables in tree-type wiring is the same as that in bus-type. For details, refer to "Wiring Method" in "B2.2 Individual Design Considerations."



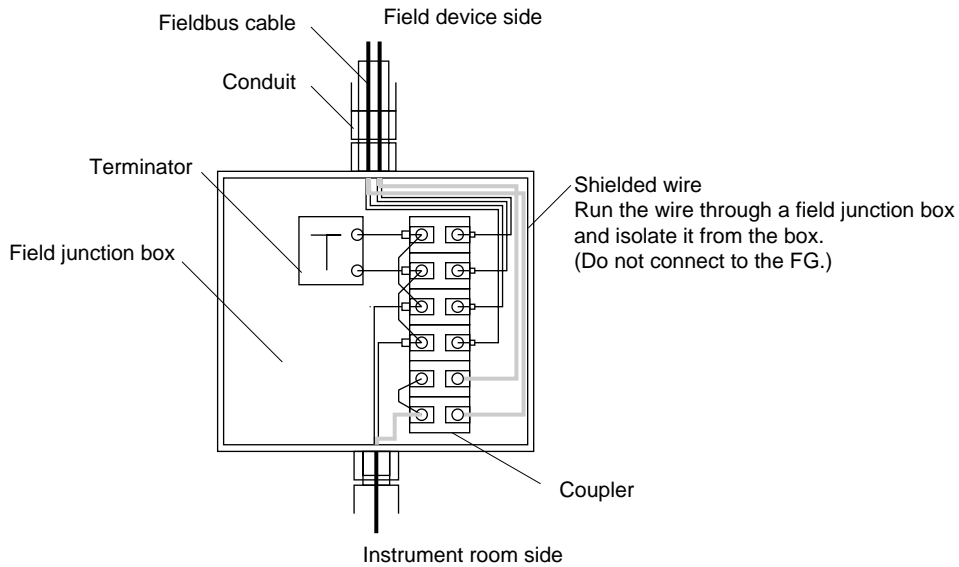
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Figure B3.2 Example of Tree-type Wiring

B3.1.1 Mounting Terminators

Terminators must be always mounted on both ends of a Fieldbus segment. Various types of terminators such as a field device built-in type and a stand alone type will be commercialized from different manufacturers.

Install terminators in a pull box or a field junction box to improve resistance and prevent mechanical shock, or use the field device built-in type. Mount two terminators for one Fieldbus segment.

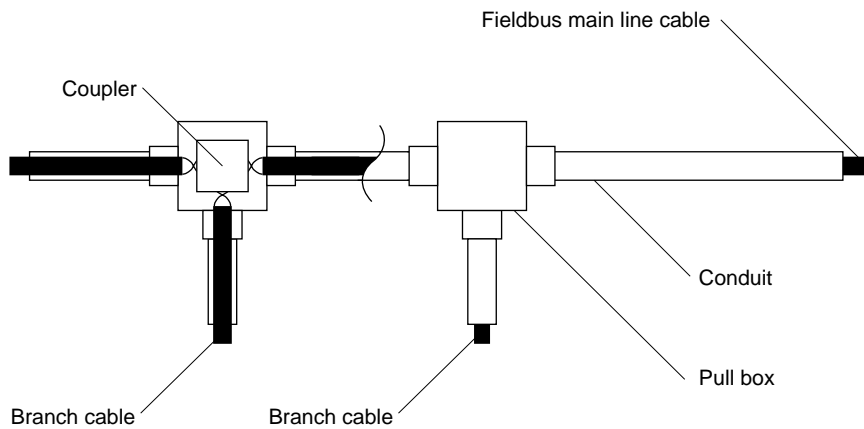


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Figure B3.3 Mounting Terminators

B3.1.2 Mounting Couplers

Each field device is connected to Fieldbus via a coupler and branch cables. To prevent mechanical shock, a coupler is mounted inside a pull box or a field junction box.



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Figure B3.4 Mounting Couplers

B3.1.3 Cabling

To protect the Fieldbus cable, use standard conduits. If the Fieldbus cable is stored in the cable rack or wiring duct, separate the cable as far from the other cable as possible in the same way low-level signal cables are installed.

SEE ALSO

For more information, refer to “Chapter 6 Cabling Requirements” in “CENTUM CS Installation Guide (TI 33G1J10-01E).”

B3.1.4 Installing Intrinsic Safety Barrier

If intrinsically safe construction is required, install the intrinsic safety barrier at the closest place to the field in the instrument room. The cables in the non-hazardous area and hazardous area must be wired separately.

Note that the intrinsic safety barrier attenuates signals.

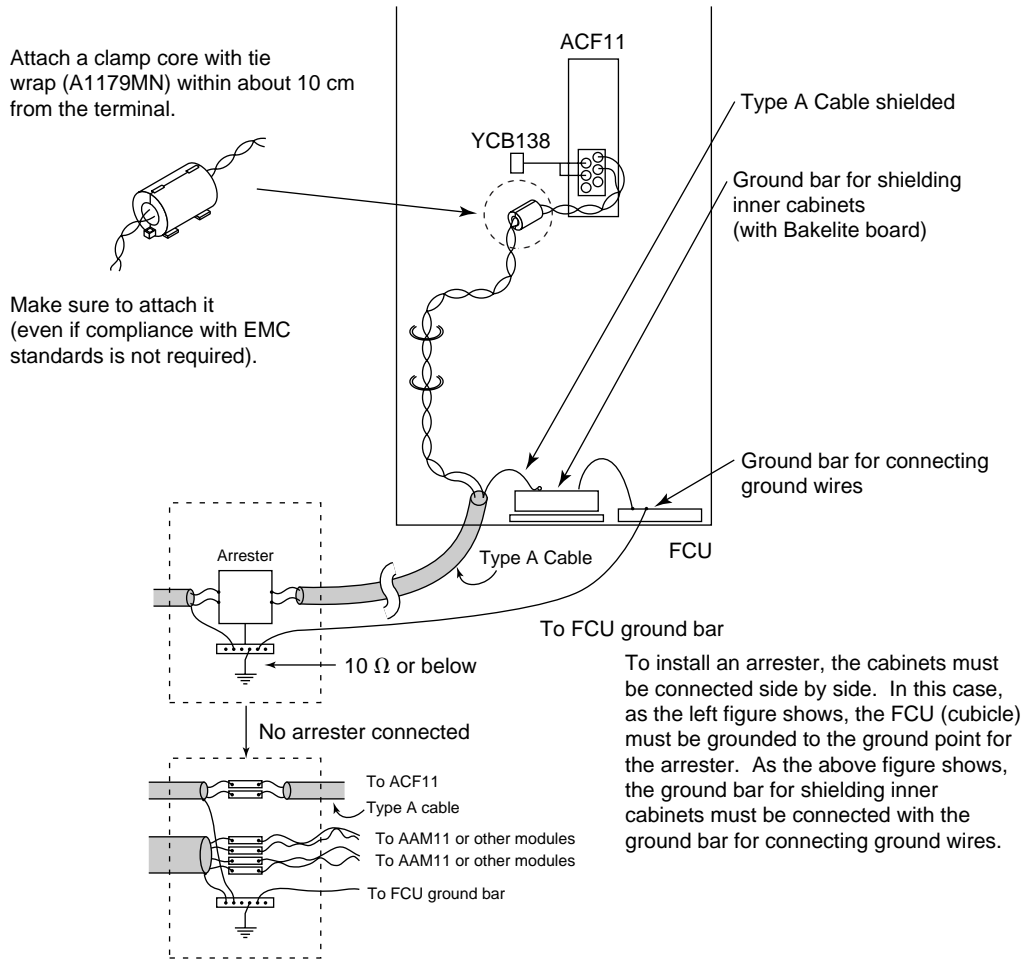
B3.1.5 Handling the Shield Mesh

If using a shielded cable, consider the following when handling the shield mesh.

- Grounding of shield mesh at the coupler
- Grounding location and number of grounds

As a rule, the shielded fieldbus must be grounded at one point in the building in the instrument room.

Figure B3.5 shows that the shielded fieldbus is grounded at one point in the building where the FCS is installed when using the ACF11 Fieldbus Communication Module.



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Figure B3.5 Handling Shield for the ACF11

B3.2 Reusing Existing Cables

If the cables of the existing process control systems are reused, examine the segment to be reused. Also, check the existing cables for insulation deterioration and fatigue.

Here, the reuse of existing cables is explained using a typical example of a process control system in an oil refinery plant or petrochemical plant.

In an oil refinery or a petrochemical plant, the cables equivalent to the overall-shielded un-twisted 2-core cable CVVS-1.25 mm² have been installed since explosion-proof construction was required. Also, from the field junction box to the Fieldbus Communication Module (ACF11), the cables equivalent to the overall-shielded non-twisted multi-core cable CVVS-1.25 mm² have been installed. Figure B3.6 shows an example of existing cables in an oil refinery or a petrochemical plant.

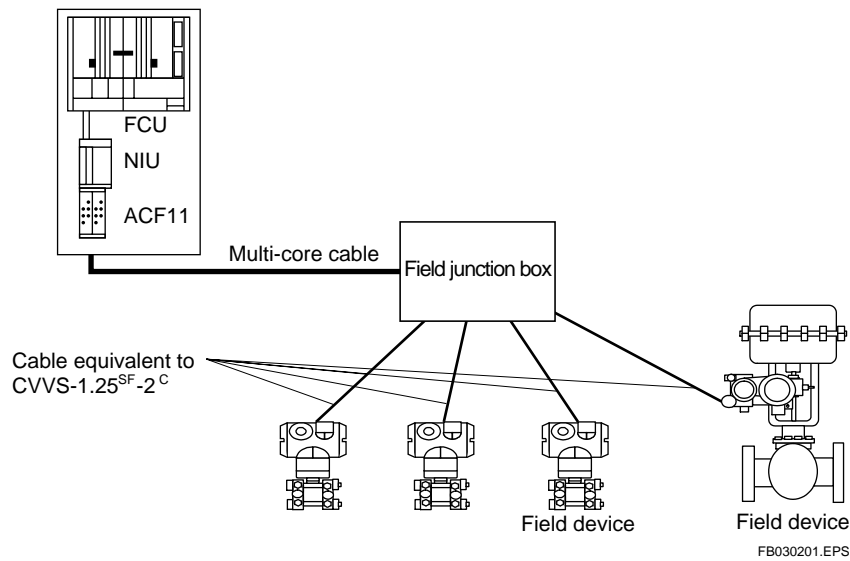


Figure B3.6 Example Configuration of Process Control System for Fieldbus Segment

Reusing the Cables from Field Devices to Field Junction Box

Most of the existing cables (branch cables), from field devices to the field junction box, use the overall-shielded non-twisted 2-core cable CVVS-1.25 mm². In this case the maximum cable length depends on the type of cable and the number of field devices connected.

Table B3.1 lists the types of cables and specifications.

Table B3.2 lists the maximum length of branch cables according to the number of devices on the Fieldbus.

Table B3.1 Types of Cables (Reference value)

| Types of cables | Symbol of cable | Cable size | Max. length of cable |
|---|-----------------|----------------------|----------------------|
| Type A (Individually shielded twisted pair cable) | KPEVS | 1.25 mm ² | 1,900 m |
| Type B (Overall-shielded twisted pair cable) | KPEVS | 1.25 mm ² | 1,200 m |
| Type D (Overall-shielded non-twisted cable) | CVVS | 1.25 mm ² | 200 m |

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Table B3.2 Maximum Length of Type A Branch Cables (Reference value)

| Number of devices on Fieldbus | Max. length (total) of branch cables |
|-------------------------------|--------------------------------------|
| 1 to 12 | 120 m |
| 15 to 18 | 90 m |
| 19 to 24 | 30 m |
| 25 to 32 | 0 m |

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SEE ALSO

For cable types and branch cables, refer to “Wiring Method” in “B2.2 Individual Design Considerations.”

Reusing the Cables from Field Junction Box to Instrument Room

Most of the existing cables (main line cables), from the field junction box to the instrument room (relay terminal board), use the overall-shielded non-twisted multi-core cable CVVS-1.25 mm². Up to the maximum length of cable listed in Table B3.1 can be reused.

This cable can be used for Fieldbus because noise interference due to cross talk is usually within the permissible range.

If multiple types of cables are connected, the maximum length of each cable is shorter than that in Table B3.1.

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B4. System Startup Considerations

Before starting up a Fieldbus control system, it is necessary to thoroughly understand all aspects concerning system startup. This chapter describes the tools and technologies required for starting up the Fieldbus system, and the differences in the startup processes between Fieldbus system and conventional analog system.

B4.1 Tool Necessary for Startup

For startup of a Fieldbus control system, use tools that are different from those of a conventional analog system. This section describes a variety of tools required to start up the system.

The following tools are expected to be released by each maker.

Digital Signal Instrument

By introducing Fieldbus, the digital multimeter, current generator and other tools that are used to start up a conventional analog system will be replaced with instruments for Fieldbus.

Those conventional instruments were used to measure analog signals. However, all devices that support Fieldbus transmit data via digital communication. To start up a Fieldbus system, instruments for digital communication are required.

These digital signal instruments are connected to field devices or system devices, and which read/write digital signals. Since a digital signal instrument can read digital signals directly from a field device, its measuring accuracy will drastically improve compared with that of the digital multimeter.

Also, digital signal instruments can be used effectively for bench tests of the system.

LAN Analyzer

For starting up a process control system that uses the Fieldbus communication protocol, a LAN analyzer may be necessary for measuring signals on the Fieldbus. The LAN analyzer is equipped with a function that supports troubleshooting which can track down the source of a communication problem between devices connected to Fieldbus.

Field Device Maintenance Tool

For startup of a Fieldbus system, a field device maintenance tool for parameter setting (especially remote setup) of field devices is required.

This maintenance tool is built in a desktop type PC or a hand-held terminal.

B4.2 Technologies and Expertise Necessary for Startup

To start up a Fieldbus control system, technologies and expertise that are different from those for a conventional analog system is required. This section describes the technologies and expertise required to start up a Fieldbus system.

Wiring Technology

Wiring has been greatly changed by the use of the Fieldbus. One of the main advantages of Fieldbus is that it minimizes wiring. However, greater care is required in the termination of communication cables. Since many signals are handled over a single communication cable, wiring problems will greatly affect the system. It is necessary to carefully check whether wiring complies with communication-cable and field-device specifications including communication transmission quality.

Technology for Field Devices

Although measuring methods (measuring principles) for pressure and flow rate are not different from that of a conventional transmitter, output signals from sensors are digitized, allowing easier handling of field devices.

Remote maintenance by the field device maintenance tool saves labor in field device signal processing, such as operation checks, device adjustment, setting modifications, and data maintenance management.

Knowledge of System Software

Fieldbus is a communication system. Therefore, startup engineers must have knowledge about communication software setup, communication protocol, etc.

Knowledge of Application Software

In a Fieldbus control system, there are the following three control methods:

- All control is performed at the field device side, and only monitoring is performed at the system side.
- All control signals are transmitted to system devices, and control is performed on the system side.
- A combination of the above two methods allows the best control for specific application.

These control methods promote distributed control more than conventional control systems where all control is performed at the system side. For example, by assigning simple control to field devices, the system device can perform higher-level control (such as multivariable control and advanced control). Startup engineers must have knowledge about advanced control. Because of distributed control, a system device will be closer to a control computer, therefore the startup engineers are also required to have knowledge about information processing in addition to conventional control and instrumentation.

B4.3 Labor Savings in Startup Work

In the startup of a process control system that uses Fieldbus, labor savings can be achieved in some processes, which is different from a conventional analog system. This section describes the processes in which labor savings can be achieved.

Loop Check

Loop Check of Process Control System That Uses a Conventional Analog Signal

Usually two types of loop check were conducted: indoor loop check and total loop check.

In the indoor loop check, the loop from the relay terminal board to the system device is tested to check for incorrect indoor wiring and poor signal quality. In the total loop check, a loop check is performed to check for incorrect wiring and poor signal quality between a field device and the system device. Troubleshooting in the total loop check is made easier by performing the indoor loop check.

This procedure, however, requires many man-hours since these checks must be performed on all loops.

Loop Check of Process Control System That Uses Fieldbus

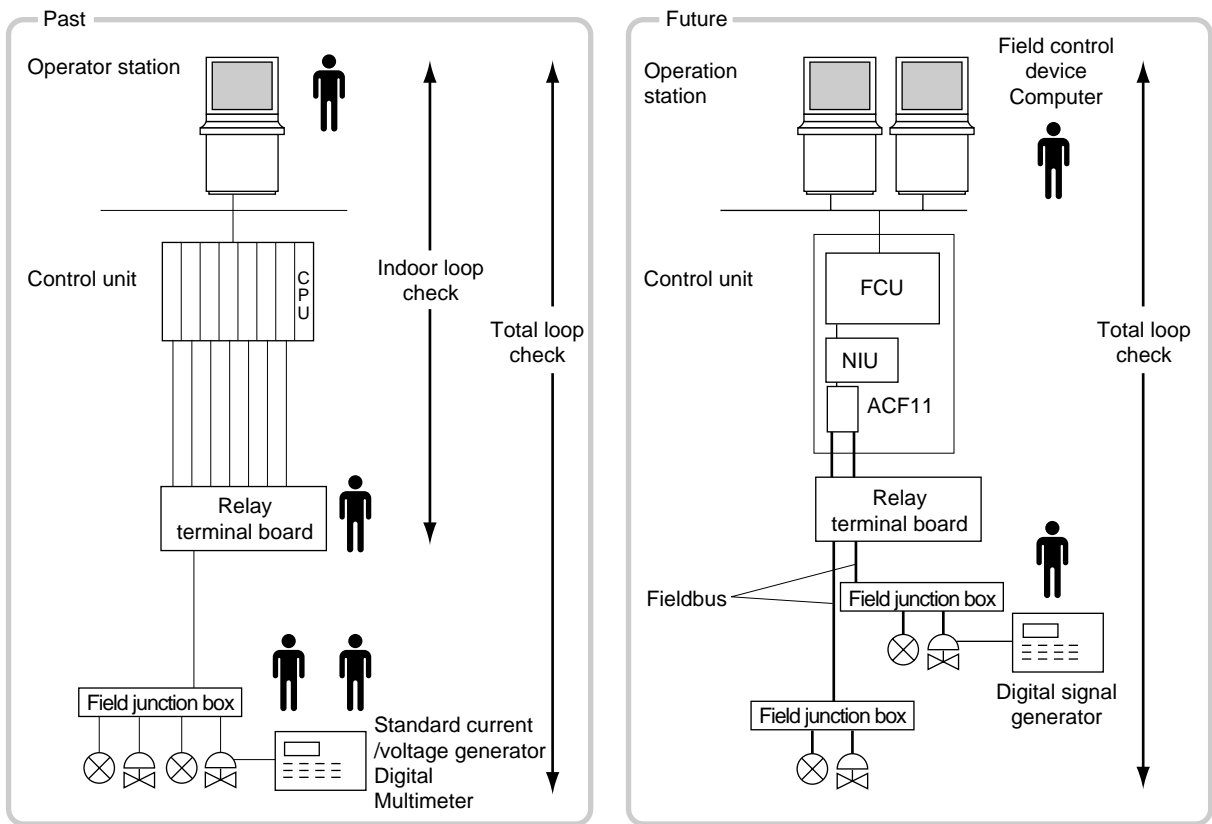
In a loop check of a process control system that uses Fieldbus, man-hours can be saved in the following ways, as compared with a conventional system.

There is no need to check twice, indoor loop check and total loop check, as described above.

If Fieldbus is connected from field devices directly to the system device, only the total loop check is required. In this total loop check, a digital signal oscillator can be connected to a field device to pass signals from the field device to Fieldbus. Since the check can be performed without disconnecting any wiring, a more reliable check will be ensured.

In addition, incorrect wiring is minimized because multiple field devices can be connected to a single Fieldbus line. The high-accuracy and high-stability of transmitters are guaranteed thanks to digitization, and this requires no consideration of accuracy deterioration in transmission. If the operation of devices has been confirmed through the single unit test after the assembling or bench test, there is no need for actual environment tests by applying pressure or connecting a resistor with an equivalent temperature.

In these ways, the time spent on loop checks can be drastically reduced.



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Figure B4.1 Loop Check of Process Control System That Uses Fieldbus Communication

Interlock Check

During the interlock check, various plant functions are checked. The functions to be checked include that for production itself in the plant, and that for maintaining plant safety, etc.

To perform this check, not only is system device software modification frequently required, but so are relay board and other modifications. In a conventional analog communication system, actual wiring modifications and software modifications took place about half of the time.

In a process control system using Fieldbus, interlock processing can be independently implemented on the field device side. By combining the interlock function of the system device, this check can be performed by modifying software.

Therefore, the cost and period that have been expended for modification of the conventional hardware will be eliminated.

Trial Operation

With the multivariable information of field devices, high-level control (such as multivariable control and advanced control) in addition to standard control will be possible during trial operation.

Also, the time and labor required for plant startup will be reduced because automatic fine-tuning is possible using the operation support system.

Range Free Devices

Using Fieldbus technology, there is no need to specify the range or span of a device. This system uses the actual digital measurement without regard to the “percent of span” or “percent of full scale.”

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B5. System Maintenance Considerations

Since a process control system that uses Fieldbus is provided with numerous system maintenance functions that are superior to those of systems with an analog signal. Labor savings and higher-efficiency of maintenance work will be possible on field devices.

This chapter explains the difference between the maintenance work of process control systems that use Fieldbus and that of conventional maintenance work.

B5.1 Daily Maintenance

In a process control system that uses Fieldbus, daily maintenance can be performed more efficiently than in an analog control system.

Daily Field Inspection

In a process control system that uses a conventional analog signal, inspections of the field are made by operators at given times to check the operation status of field devices and to record changes in the installation environments. Daily inspection is performed to detect abnormal states and maintain stable operation of the system.

In a process control system that uses Fieldbus, the type and amount of information to be acquired will increase drastically due to bidirectional digital communication and the multi-sensing function. This allows operators to perform remote monitoring and remote operation-status management from the instrument room, greatly reducing the operators' daily inspection workload.

Maintenance during System Operation

In a process control system that uses conventional analog signals, daily maintenance work during system operation (such as check for zero-point of field devices, check for device status, and parameter adjustment) must be performed in the field.

In a process control system that uses Fieldbus, maintenance work can be performed remotely from the instrument room. The daily maintenance information can be acquired in realtime using the self-diagnostics function and bidirectional digital communication function of field devices. Therefore, daily maintenance information will be effectively used to determine which items require maintenance during the inspection activity.

B5.2 Inspection and Maintenance

In a process control system that uses Fieldbus, periodic inspection and maintenance will be performed more effectively than in a system that uses analog signals.

Function and Accuracy Check

Due to technological progress and the introduction of Fieldbus, which claims high-accuracy, high-stability, reliability improvement, and maintainability improvement of field devices, the following advances are expected.

Maintainability Improvement by Remote Operation

In a process control system that uses Fieldbus, range setup and zero adjustment of field devices can be made remotely, thus improving maintainability. Also, device management work such as field device master file creation is automated.

Effect of High-Accuracy and Multi-sensing of Field Devices on Maintenance

Due to the high accuracy and multi-sensing of field devices, high-accuracy measuring instrument and simultaneous multifunction check equipment are required for inspection of functions and the accuracy of field devices. High-accuracy measuring instrument and simultaneous multifunction check equipment may be difficult to install in the field, depending on the installation environment. Therefore, field devices may need to be removed and brought to a workshop for inspection and maintenance.

Disassembly and Consumables Replacement

In a process control system that uses Fieldbus, the method used to maintain and replace instrumentation equipment will change to such that includes CBM in addition to TBM, due to the improvement of the device status monitoring function and diagnostics function.

Time-Based Maintenance (TBM)

This is a method for maintaining/replacing based upon all devices every periodic cycle, which is determined based on the shutdown cycle of a plant or a system, according to regulations and the service life of devices.

Condition-Based Maintenance (CBM)

This is a method for maintaining/replacing based upon individual devices according to the status of each device while monitoring device status. It is also referred to as status monitoring maintenance.

In conventional time-based maintenance, maintenance/replacement is performed in shorter cycles than the device life to avoid damage, in most cases. Therefore, a device with no problem may be disassembled for maintenance or replaced.

In a process control system that uses Fieldbus, sufficient maintenance/replacement is performed according to the status of each device. This reduces extra costs caused by too much maintenance being performed.

B5.3 Maintenance Management (Maintenance Plan/ Device Management/Record Management)

In a process control system that uses Fieldbus, device status information such as the device tag, serial number, internal parameters, maintenance record, and self-diagnostics results can be acquired in realtime from each field device. If that information is stored in the maintenance database of device management tools, it is possible to perform device management of all field devices and to continually monitor the status of field devices.

This allows the client to perform preventive maintenance with respect to each field device status and to determine the periodic maintenance plan based on maintenance data.

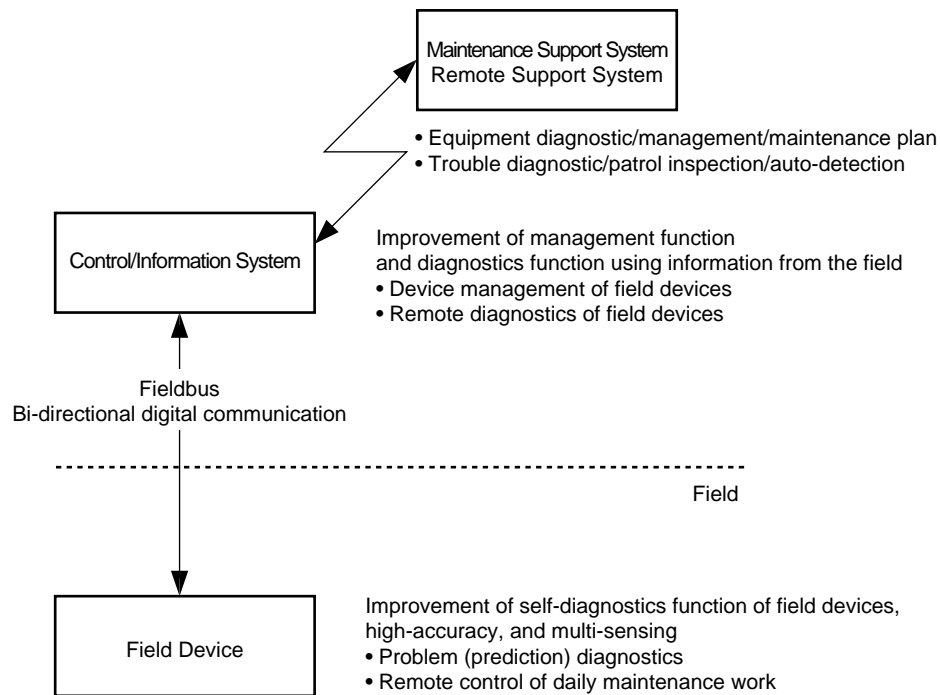
B5.4 Future Maintenance

With the introduction and acceptance of Fieldbus, a variety of maintenance support systems will be developed using Fieldbus features such as bidirectional digital communication, multi-sensing, multifunction, bidirectional communication between field devices, and interoperability. These systems will further contribute to the productivity increases, safety improvements, and maintainability improvements the clients are expecting.

For example, the following systems will be developed.

- Maintenance Support System (creation and management of device master file, maintenance record, and consumables list)
- Field Device RMS Package (remote maintenance)
- Field Device Diagnostics Package (environment diagnostics, deterioration diagnostics, and service life diagnostics)

Figure B5.1 shows the future of maintenance in a process control system that uses Fieldbus.



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Figure B5.1 Maintenance Image in Process Control System Using Fieldbus

Fieldbus Technical Information

TI 38K3A01-01E

INDEX

A

Actuator A3-8

C

Changes in Transmitters A3-3
Comparison with Conventional Communication
Protocol A1-2
Considerations in Fundamental and Overall
Design B2-2

D

Daily Maintenance B5-1
Difference between Fieldbus and Analog Signal
Process Control Systems B1-4
Distributed Functions A1-9

E

Engineering Process B1-1
Enhanced Data Transmission A1-8

F

Features of Fieldbus A1-1
Fieldbus Standard Specifications A2-3
Fieldbus Support in CENTUM CS 1000, CS 3000
and CENTUM CS A4-2
Fieldbus Tools B1-5
Fieldbus-ready Field Devices A3-1
Fieldbus-ready Field Devices from Other Vendors
..... A4-5
Fieldbus-ready System Devices A4-1
Future Maintenance B5-4

I

Improved Transmission Accuracy A1-6
Individual Design Considerations B2-3
Inspection and Maintenance B5-2
International Standardization of Fieldbus A2-1
Interoperability A1-10

L

Labor Savings in Startup Work B4-3

M

Maintenance Management (Maintenance Plan/
Device Management/Record Management)
..... B5-3
Managing Fieldbus Engineering B1-1

N

New Construction of Fieldbus B3-1

P

Progress of Fieldbus Standardization A2-1

R

Reduced Wiring Cost A1-4
Reusing Existing Cables B3-6

S

System Construction Considerations B3-1
System Design Considerations B2-1
System Maintenance Considerations B5-1
System Startup Considerations B4-1

T

Technologies and Expertise Necessary for Startup
..... B4-2
Tool Necessary for Startup B4-1

U

Upgrading from BRAIN System A3-11
Using Self-diagnostics Function A3-10

Y

Yokogawa's Efforts for Fieldbus Standardization
..... A2-4

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