CENTUM CS FIELDBUS COMMUNICATION FUNCTIONS

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We have developed fieldbus communication functions for our distributed control system CENTUM CS that comply with the specifications of the Fieldbus Foundation. These new functions enable cascade control of the CENTUM CS control function and the field device control function, and also support the operation and monitoring functions of the field device control function. The fieldbus communication module (ACF11) interfaces with the fieldbus. It can also be connected to a node on the remote IO bus (RIO bus), thereby making the system construction flexible.

This paper introduces the characteristics of the CENTUM CS fieldbus system, with the main focus on its communication functions.

INTRODUCTION

A fieldbus is a bidirectional, multidrop, digital communication system developed to replace the conventional 4-20 mA communication lines that connect intelligent field devices with a control system. Fieldbus is continually reviewed in an effort to standardize the fieldbus specifications to comply with the specifications of the IEC and ISA.(1)

The features of the fieldbus include a reduction in the amount of cable required, field-distributed control functions, and bidirectional transfer of control data. Among these, the field-distributed control functions are attracting particular attention as field devices become increasingly "digital" and more and more "advanced." This means that the control functions implemented in a distributed control system are being distributed throughout the field. Drastic innovations in control systems are not always favorable though, and we believe there needs to be a way of shifting gradually from the existing systems to more advanced systems.(2)

The CENTUM CS fieldbus communication functions were developed with the aim of reducing the burdens of plant operation. This was achieved by standardizing the operation and monitoring functions, including the functions for the control of field devices, in an environment where the fieldbus coexists with a conventional analog communication line. One major technical challenge in this achievement was communication between field devices and higher-order control equipment while prioritizing the characteristics of fieldbus communication functions among other things.

The CENTUM CS fieldbus communication functions are designed to comply with the fieldbus standards specified by the Fieldbus Foundation, while still upholding Yokogawa Electric's traditional ideas of instrumentation. Accordingly, these functions integrate fieldbus capabilities into the CENTUM CS control, operation and monitoring functions, to form one of the key technologies for the Enterprise Technology Solutions (ETS) offer.

FEATURES

The CENTUM CS fieldbus system features:

(1) System Expandability

- The fieldbus system can be installed in combination with a conventional 4-20 mA analog communication line. In addition, the system is designed to be flexible and accept step-by-step expansions, that is, additions and expansions according to growing application needs.

(2) Combination of DCS Control Functions and Field Device Control Functions

- In anticipation of the fieldbus age, the CENTUM CS system has used floating-point data in its data processing from the outset. The system can therefore continue to produce precision data for control computations.
- Like conventional discrete input/output data, the I/O data of a

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field device can be handled as process I/O data. Consequently, there is no need for the system to be aware of the fieldbus.

- Whatever fault may occur, the fieldbus system can detect failures in field devices or in the process in virtually no time at all. In addition, the FCS function blocks are designed to act correctly (bumpless output control, for example) depending on the operating condition of the fieldbus function blocks.

(3) Operation and Monitoring of Field Device Control Functions

- The fieldbus system provides a human-machine interface function that is designed to operate the control functions of field devices (parameter tuning, for example) and continuously monitor their operating condition. The interface allows the control functions to be operated and monitored in virtually the same way as done for earlier CENTUM CS control functions.

(4) Failure Monitoring

- The fieldbus system can constantly monitor alarms for faults, such as failures in field devices and device alarms (such as I/O failures) raised by the field devices voluntarily. This makes preventive maintenance easy.
- The extensive diagnosis functions of the fieldbus communication modules minimize functional degradation in the system due to imperfections.

(5) Field Device Management

Using a device management tool, users can monitor the device status and parameter data that is essential for field device maintenance, from an off-site location such as the instrument room. This makes system maintenance easy.

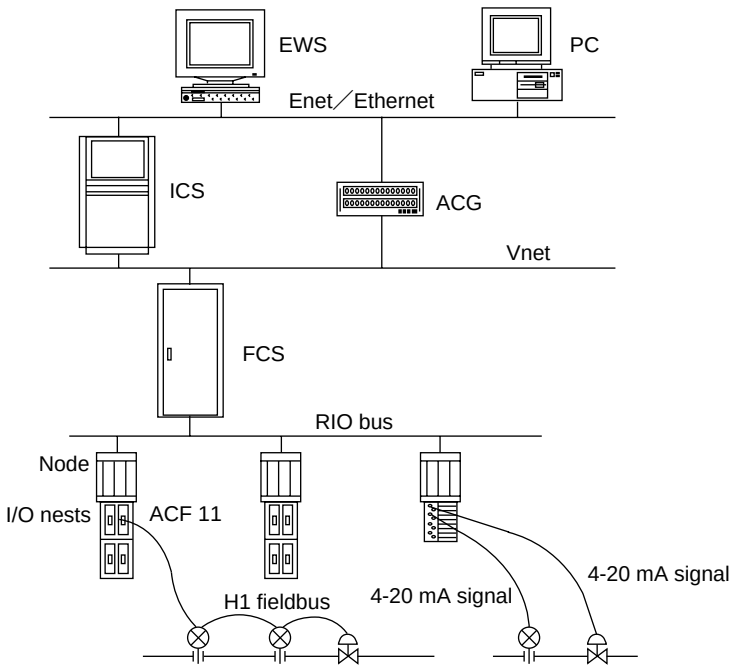

Figure 1 CENTUM CS System Configuration

SYSTEM CONFIGURATION

1. System Configuration

Figure 1 shows the system configuration.

As shown in the figure, the CENTUM CS fieldbus system consists of the following equipment.

(1) Information and Command Station (ICS)

The ICS performs the operation and monitoring function of a distributed control system. In addition to the conventional functions, the ICS can operate and monitor fieldbus function blocks and receive alert messages (alarms and events).

(2) Engineering Workstation (EWS)

The EWS performs the engineering function of a distributed control system. In addition to the conventional functions, the EWS can engineer the fieldbus communication module (ACF11).

(3) Field Control Station (FCS)

The FCS performs the control function of a distributed control system. In addition to the conventional functions, the FCS can run a process for cascade connection to the fieldbus and interface field devices with the ICS.

(4) Fieldbus Communication Module (ACF11)

The ACF11 module serves as a link master in the fieldbus system and can relay data between the FCS and field devices.

(5) Personal Computer (PC)

The PC runs software tools for engineering and maintaining field devices.

2. Fieldbus Communication Module (ACF11)

Figure 2 is an external view of the ACF11 fieldbus communication module. The ACF11 module is installed in the node of an RIO bus and can be used in combination with conventional 4-20 mA analog modules. The functions provided by the ACF11 module include:

(1) Relaying data between a higher-order control function and field devices

(2) Link Active Scheduler (LAS) and Time Master functions based on FOUNDATION™ fieldbus specifications

(3) Monitoring failures in field devices

(4) Monitoring failures in FCS control functions and RIO bus

(5) Recovering equipment, including field devices, from momentary power failure

For momentary power failures that last less than the specified period of time, this function can prevent FCS function blocks from entering the MAN mode.

Table 1 summarizes the hardware specifications of the ACF11 module. The module features:

- Built-in bus power supply

When there are only a small number of devices, no external power supply is required and

Figure 2 External View of ACF11 Module

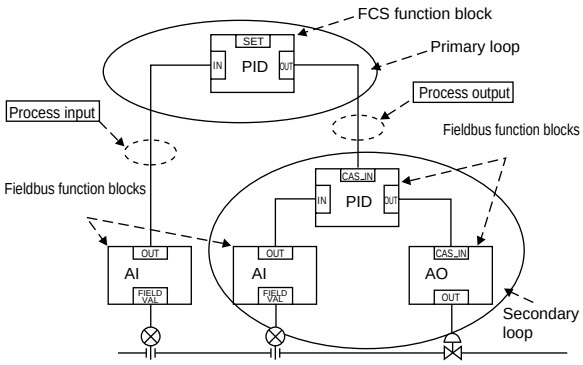

Figure 3 Block Connection

engineering therefore extremely easy.

- Error detection and correction (EDC) function
  Since the module's memory handles vast amounts of control I/O data, it is equipped with an EDC function in order to ensure reliability.
- Maintenance support function
  The maintenance support function makes it easy to revise programs and provides a communication port for monitoring the internal operation.

CONTROL FUNCTIONS

1. Process I/Os

Figure 3 shows how FCS function blocks are connected to fieldbus function blocks. If viewed from the FCS function blocks in the figure, it is possible to handle the I/Os of the fieldbus function blocks in the same way as conventional process I/Os. In addition, these I/Os provide the following necessary functions for cascading between the FCS function blocks.

(1) Detection of Device Failures
Since any device failure can be instantaneously determined from the data status of a fieldbus function block, it is possible for a control block in the primary loop to change to an appropriate mode.

(2) Detection of Clamped Output
From the data status of a fieldbus function block, an FCS function block can detect any clamped output.

(3) Output Tracking
Upon recovery from a failure in any field device or communication line, an FCS block can track the output of the field device in order to bumplessly continue the output action.

With these functions, the new fieldbus system enables flexible application design even in cases where control functions are distributed throughout the field. Though different from fieldbus function blocks, the FCS function blocks have the capability of initialization handshaking based on the data status. This allows the FCS function blocks to be connected to the fieldbus function blocks without problems.

Table 1 Hardware Specifications of ACF11 Module

Item	Specifications
Number of modules that can be installed	80 modules/FCS (i.e., [10 modules/RIO node] X 8 nodes)
Number of fieldbuses	1 segment/ACF11 module
Communication speed	31.25 Kbps in the voltage wire mode
Connection	By means of 4-mm screw terminals
Built-in bus power supply	Output voltage: 18 to 20 V DC (fixed to 19 V DC) Continuous output current: 80-mA maximum (with an overcurrent limiter) Transient output current: 100-mA maximum (for a maximum duration of 2 ms)
External dimensions	188 (D) X 215 (H) X 43.6 (W) (mm)
LED indicator	RDY, CTL, RCV and SND
Withstanding voltage	1500 V AC, tested between the fieldbus and the system
Maintenance	Online maintenance is possible. (Equipment to be maintained: Module itself and cable connectors)
EMC standard	Complies with CE marking (as part of a CENTUM CS system)

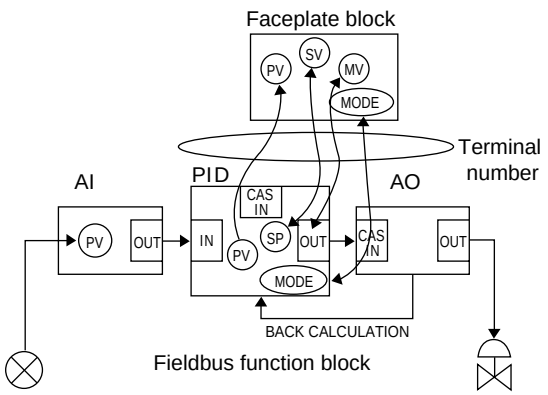

Figure 4 Operation and Monitoring Using a Faceplate Block

Figure 5 Faceplate Block Tuning Panel

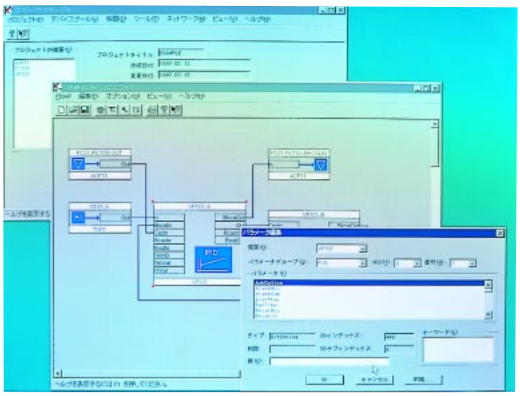

Figure 6 Engineering Tool Builder Screens

2. Operation and Monitoring of Field Device Control Functions

As a means of monitoring the operating condition of field device control functions (namely, the internal parameters of fieldbus function blocks), the CENTUM CS fieldbus system can display and set the parameters of fieldbus function blocks using on-demand communication functions.

Like the conventional process I/Os, each parameter of the fieldbus function blocks can be dealt with using a terminal number. By linking this terminal number with a faceplate block, the parameter can be viewed and set on a parameter tuning panel like those of FCS function blocks. This implements ICS-based operation and monitoring functions for fieldbus function blocks.

Figure 4 shows how each parameter of the PID control block relates to the process variable (PV), setpoint (SP), manipulated variable (MV) and mode of the faceplate block in a control loop consisting of an analog input (AI) block, PID control block and analog output (AO) block. Figure 5 shows a display of the faceplate block tuning panel.

3. Alarms and Events

Alert messages (alarms and events) issued by field devices are received by the ACF11 module and transferred through an FCS up to an ICS. These alerts are then stored in the ICS as historical messages. These messages can be referenced using the "historical report function" or viewed using the device management tool.

FIELDBUS ENGINEERING

The fieldbus engineering function is implemented by means of a tool that runs under Windows NT (fieldbus engineering tool) and coexists with other general-purpose tools. This tool enables the following:

- Engineering even in cases when no field devices are connected (off-line condition)
- Data exchange between tools using field device object files compliant to the Common File Format[3]
- Automatic scheduling of fieldbus control and communication

Figure 6 shows an example of the various engineering tool builder screens.

CONCLUDING REMARKS

Fieldbus technology is expected to spread dramatically by the year 2000 as a replacement for 4-20 mA analog transfer technology. Yokogawa Electric strongly supports fieldbus standardization, participating in the Fieldbus Foundation's development of fieldbus specifications and demonstrating the usefulness of fieldbus technology in experiments and other activities.

The CENTUM CS fieldbus communication functions discussed in this paper have been developed as a forerunner of fieldbus technology on the basis of Yokogawa Electric's previous experience and expertise. We believe these new functions will contribute significantly to the spread and development of fieldbus technology.

We will continue to research further functional improvements and cost reductions in new fieldbus systems, taking into consideration a balance of fieldbus systems and distributed control systems, in order to offer users the full advantages of fieldbus technology.

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