Technical Information

Integrated Production Control System
CENTUM VP
System Overview (FCS Overview)

CENTUM VP

TI 33K01A12-50E

[Release 5]

YOKOGAWA ◆

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Introduction

CENTUM VP is an integrated production control system to manage and control wide-ranged plant operation such as petroleum refineries, chemical, steel, food, and power.

This manual (System Overview (FCS Overview)) provides a simple overview of CENTUM VP FCS (Field Control Station). Before reading this manual, read system Overview (General Overview) to understand the overview of CENTUM VP. After reading this manual, read manuals describing the details such as General Specifications.

■ Relevant Manual

TI 33K01A10-50E CENTUM VP System Overview (General Overview)

TI 32R01B10-01E Safety Instrumented System ProSafe-RS System Overview

■ Intended Readers for This Manual

This manual is mainly intended for:

Instrumentation, electric and computer engineers considering or executing the install of CENTUM VP.

■ Description of Figures

Figures in this manual may be highlighted or simplified, or partially omitted for better explanation.

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CENTUM VP
System Overview (FCS Overview)

TI 33K01A12-50E   1st Edition

CONTENTS

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1.   Overview of CENTUM VP FCS

Yokogawa developed all the CENTUM Series Field Control Stations (FCSs), including hardware and software, by our own selves. We know every corner of the software and the hardware and that knowledge enables us to sustain the service record of 99.99999% availability.

1.1   Compact Design

The size of each component is designed compact that reduces the overall "footprint" of the control system. It allows make efficient use of the limited spaces of the control and equipment rooms. Both the FCS and its I/O node units can be placed in remote classified locations (IEC Zone2/Class I Div. 2), that provides savings in installation costs.

1.2   Dual-redundancy and Reliability

There is no single point of failure in Yokogawa's FCS! The processor modules, power supplies, and I/O modules, including the communication bus, support a redundant configuration. The robustness of the FCS comes from this configuration known as "Pair and Spare" and the reliability of calculation results is guaranteed through real-time validation. Two processor modules have two MPUs each. MPU 1 and MPU 2 in the primary processor module are always comparing the calculation result, and if the results do not match, the first processor module goes into maintenance mode while the secondary processor module takes over process control. In order to make this switch over seamless, MPU 3 and MPU 4 are also calculating and comparing the results while the primary processor module is active. Pair and Spare is Yokogawa's unique technology, supporting impressive levels of availability for CENTUM and ProSafe-RS. This architecture has been approved by TÜV Rheinland for safety instrumented systems. The ProSafe-RS certification was granted to Yokogawa in exceptionally short period of time, and it was due in-part to our Pair and Spare technology.

1.3   Online Maintenance

Through an online maintenance function, FCS applications can be modified without shutting down the FCSs. It means, you can change logics and parameters without interrupting the process control. This is useful for expansion or modification of the plant in operation.

1.4   Open Structure and High Reliability

Yokogawa is committed to reduce costs for our customers by enabling the use of commercial off-the-shelf technology where appropriate. Third-party cables, switches and other network communication devices can be used with Yokogawa's Ethernet based Vnet/IP. Plant reliability is in no way compromised as the communication response is guaranteed (deterministic as opposed to probabilistic) thanks to Yokogawa's renowned reliability, dedicated protocol, and redundant configuration.

1.5   Function Blocks

The CENTUM VP provides functional blocks for monitoring, control, manipulations, calculations, logic functions, and sequences. Not only continuous control but also advanced control, complicated sequence control, and batch control are all executed in a redundant, secure, and reliable controller environment. Plant systems can be flexibly designed, ranging from small- to large-scale, through the combination of these control blocks.

1.6   Subsystem Integration and Digital Fieldnetworks Support

To meet the growing need for communication with manufacturing equipment including variable speed drives, PLCs, and "smart" motor protection relays for operation and monitoring, as well as with analyzers, weighing machines, smart instruments, and other instruments used for product inspection, CENTUM VP supports a wide variety of communication interfaces and digital fieldnetworks such as FOUNDATION fieldbus, PROFIBUS-DP, Modbus RTU, Modbus TCP/IP, and DeviceNet.

1.7   Unit Instruments

The multiple devices of a process facility which would previously have been handled individually can now be defined, operated, and monitored as a single unit, simplifying operation. Unit instruments can be applied to batch processes and continuous control processes that require complex management, expediting overall plant operation.
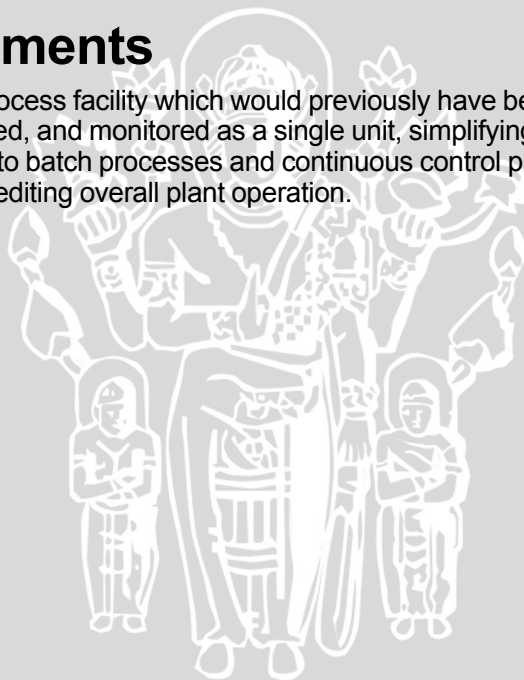
2.   Hardware

■ FCS Type

CENTUM VP supports the following FCS.

Table   FCS Types

Abbreviation	Product Name	FCU Model	Software Package
FFCS-V	FCS for Vnet/IP and FIO	AFV30□ (Rack-mount) AFV40□ (Cabinet Type)	LFS1700 Control Function for Field Control Station LFS1750 Node Expansion Package
FFCS-L	FCS for Vnet/IP and FIO	AFV10□ (Rack-mount)	LFS1500 Control Function for Field Control Station LFS1550 Node Expansion Package
FFCS	Compact FCS for FIO	AFF50□ (Rack-mount)	LFS1350 Control Function for Compact Field Control Station
KFCS	Standard FCS for FIO	AFS30□ (Rack-mount) AFS40□ (Cabinet Type)	LFS1300 Control Function for Standard Field Control Station
KFCS2	Enhanced FCS for FIO	AFG30□(Rack-mount) AFG40□ (Cabinet Type)	LFS1330 Control Function for Enhanced Field Control Station
LFCS	Standard FCS for RIO	AFS10□ (Rack-mount) AFS20□ (Cabinet Type)	LFS1100 Control Function for Standard Field Control Station
LFCS2	Enhanced FCS for RIO	AFG10□ (Rack-mount) AFG20□ (Cabinet Type)	LFS1130 Control Function for Enhanced Field Control Station
PFCS	Standard FCS for RIO	PFC□-S	LFS1000 Control Function for Standard Field Control Station
PFCS	Enhanced FCS for RIO	PFC□-E	LFS1020 Control Function for Enhanced Field Control Station
SFCS	Compact FCS for RIO	PFC□-H	LFS1120 Control Function for Compact Field Control Station

Note: "□" represents "S" (single) or "D" (duplexed).

2.1 FCS Components

FCS hardware consists of the following components.

Filed Control Unit (FCU):
  FCU is equipped with a processor for control computation, power supply, and control bus interface.

Node Unit (NU):
  Input/Output and communication modules are mounted on the NU. And NU transmits those module data to FCS.

ESB bus, ER bus, and Optical ESB bus:
  These are the communication buses to connect FCU and node unit, or in between the node units. The communication can be made redundant.

House Keeping Unit (HKU):
  HKU is the core of the house keeping functions such as to monitor the inside cabinet environment, as well as the status of FCS itself.
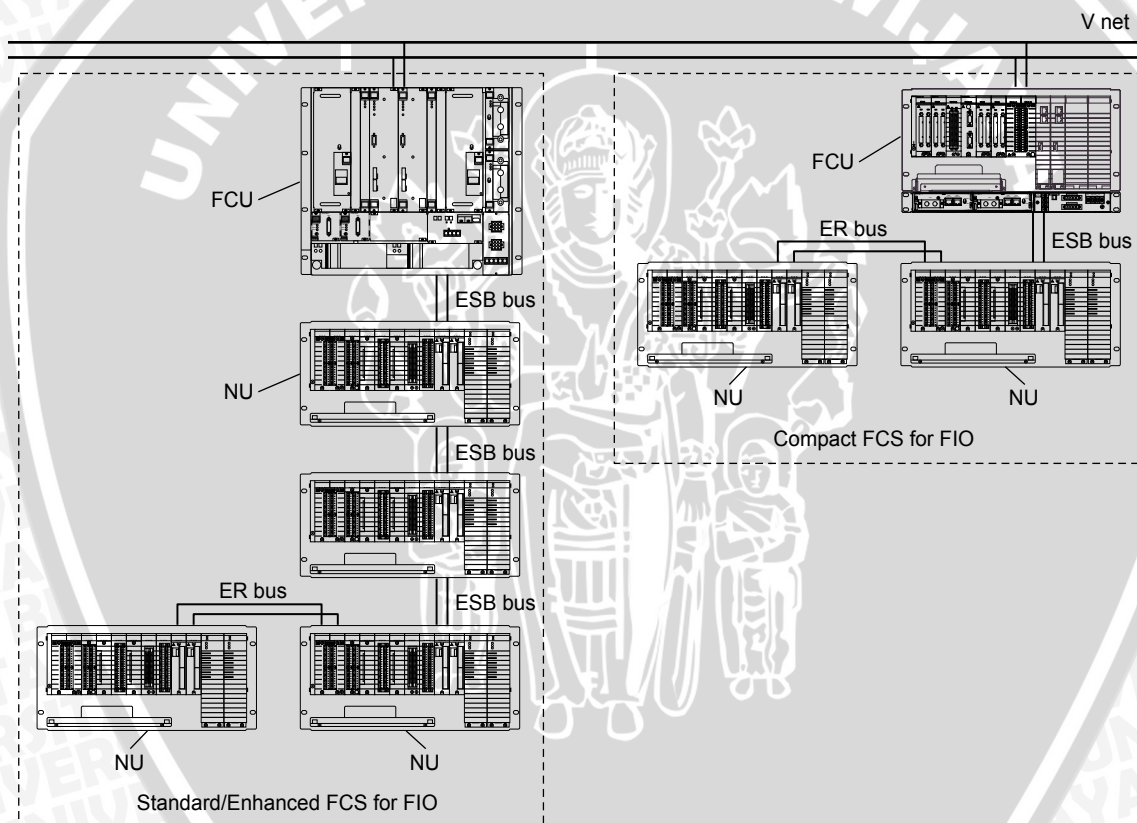
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Figure   Example configuration of FCSs for FIO

■ Field Control Unit (FCU)

FCU consists of cards and modules executing control computation for FCS.

● FCU Configuration of KFCS and KFCS2

For duplexed FCU, mount two processor cards, power units, battery units, and ESB bus master interface cards.

Figure   Duplexed FCU Configuration (KFCS, KFCS2)

● FCU Configuration of FFCS

For duplexed FCU, mount two processor modules and power modules. You can also mount I/O modules. For adding node units, mount a bus interface module in an I/O module slot.
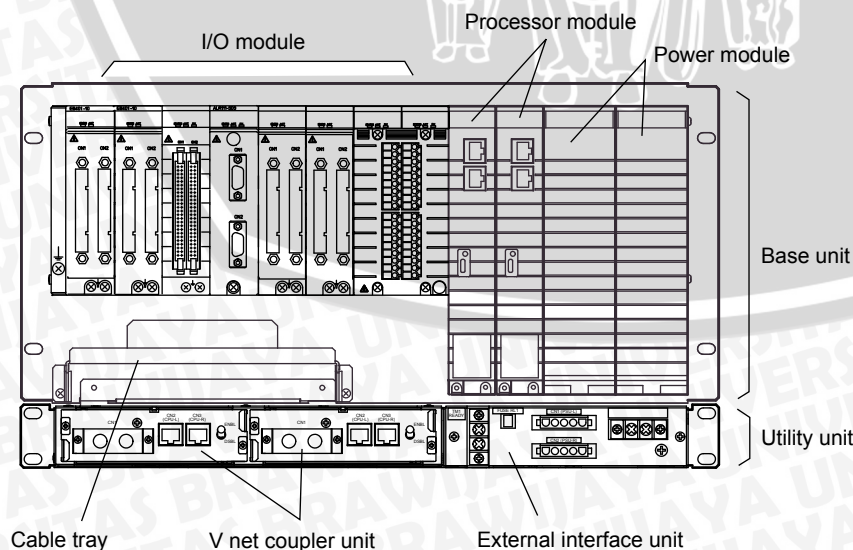
Figure   Duplexed FCU Configuration (FFCS)

■ Node Unit (NU)

Node unit (NU) is a signal processing unit converting and transmitting analog or digital process I/O signals received from field devices to the FCU.

Node unit (NU) includes ESB bus node unit (local node) mounted in FCS station and ER bus node unit (remote node) mounted in cabinets or panels close to plant-site. Node unit is composed of ESB bus slave interface module or ER bus slave interface module, I/O module, and power supply module.

- ESB Bus Slave Interface Module
  ESB bus slave interface module is a communication module available for dual-redundancy enabling the communication between local nodes and FCU.
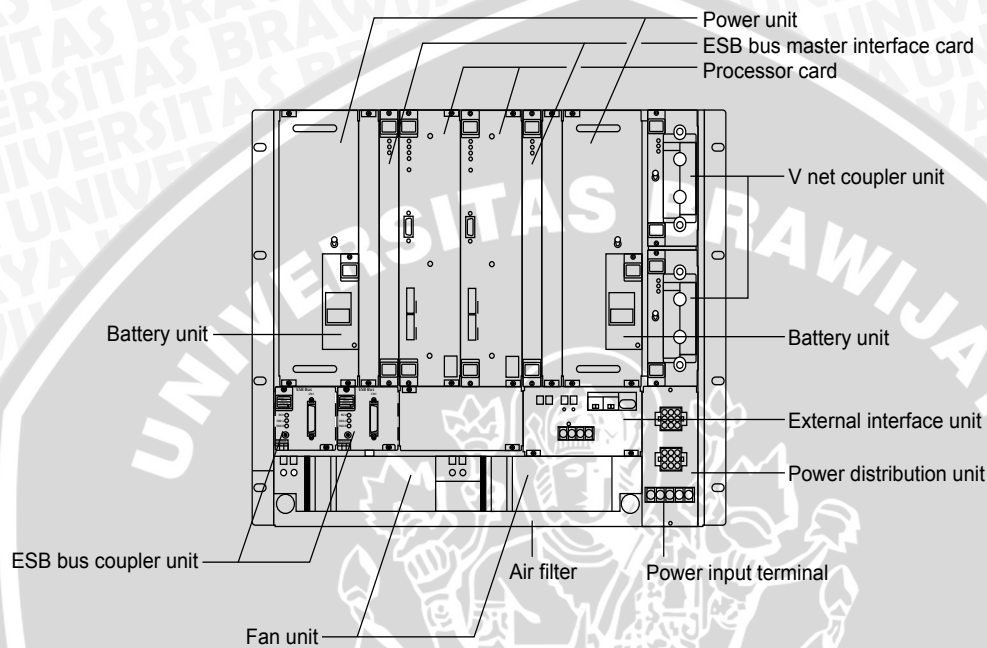
- ER Bus Interface Module
  ER Bus Interface module is a communication module available for dual-redundancy enabling the communication between local nodes and remote nodes. ER Bus Interface module includes Interface slave mounted in local nodes or FCU, and Interface Slave module mounted in remote nodes. Both modules can be dual-redundant.

- I/O Module
  I/O Module serves for input, convert, and output of analog or digital field signals.

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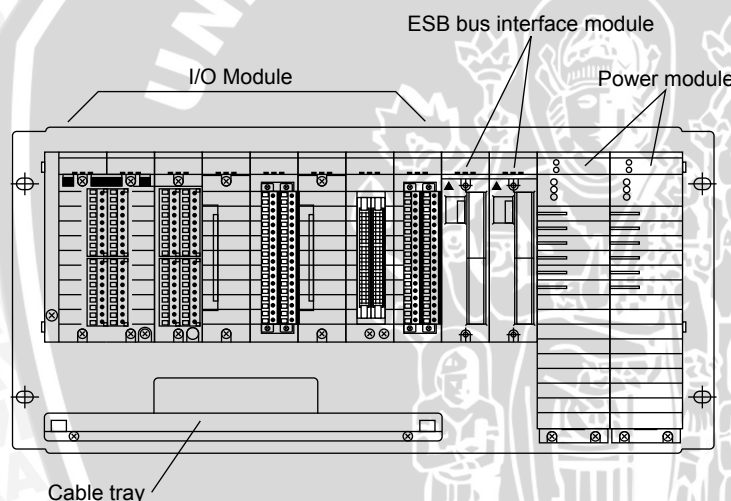
Figure   Local Node Configuration

■ ESB Bus and ER Bus

ESB bus (Extended Serial Backboard bus) is a communication bus available for dual-redundancy connecting ESB bus node units and FCU. ER bus (Enhanced Remote bus) is a high-speed communication bus available for dual-redundancy connecting ESB bus node units and ER bus node units (*1). Using ER bus, node units can be located away from FCU cabinet as well as in the cabinet. This availability for ER bus node units serves for the cases such as locating node units close to field devices, limiting power supply capacity for safety, or locating node units separately due to space issues. For ER bus, use Ethernet-compatible coaxial cable. Using optical cables or general-purpose optical repeaters, transmission distance can be extended. Furthermore, node units can be located separately in wide area via wireless network or public network.

*1: The compact FCS for FIO is able to connect a FCU and a ER bus node unit.
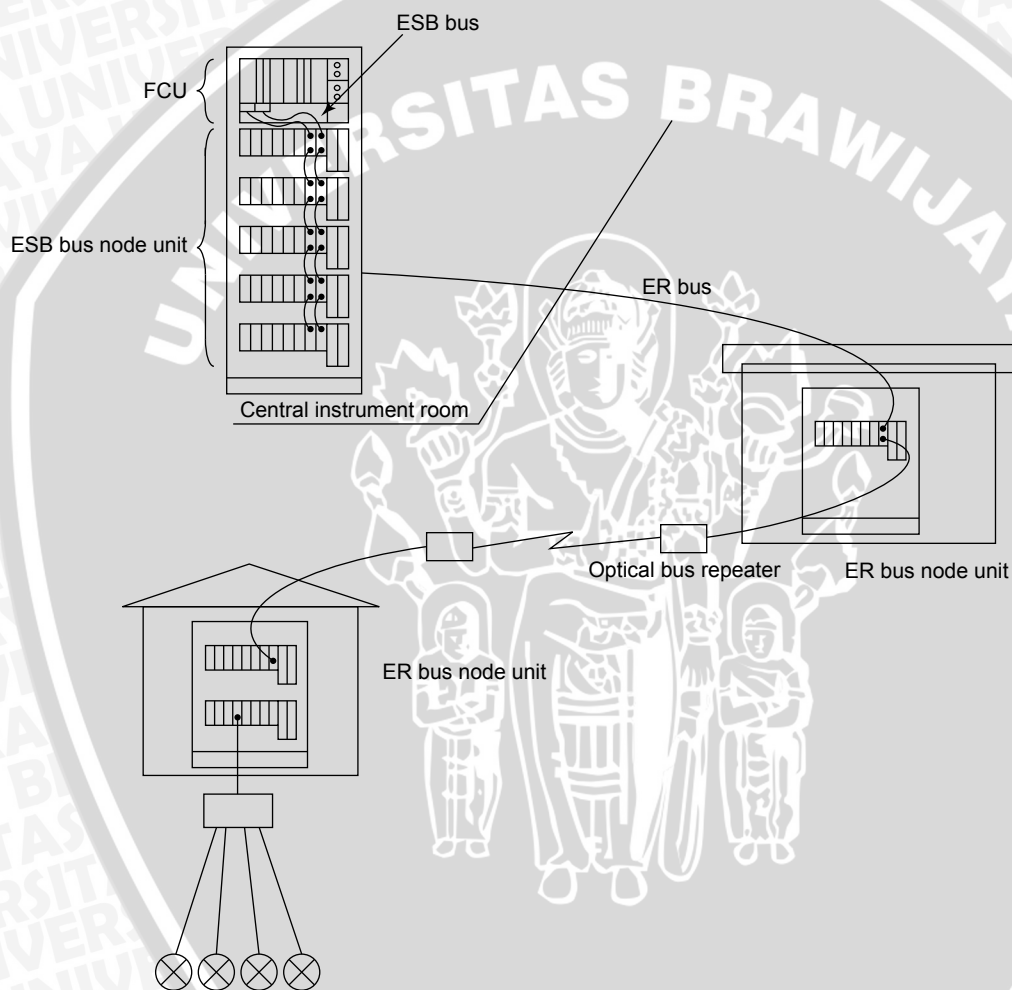
Figure   Example of Distributed Node Units

■ Optical ESB Bus

An optical ESB bus enables to transmit the conventional ESB bus signal for a long distance by using an optical fiber cable and an optical ESB bus repeater module. Connection types are selectable from chain and star topologies to extend the ESB bus transmittal distance up to 50 Km. An optical ESB bus is only applicable to use with FFCS-V.

● Example of Chain Type Connection
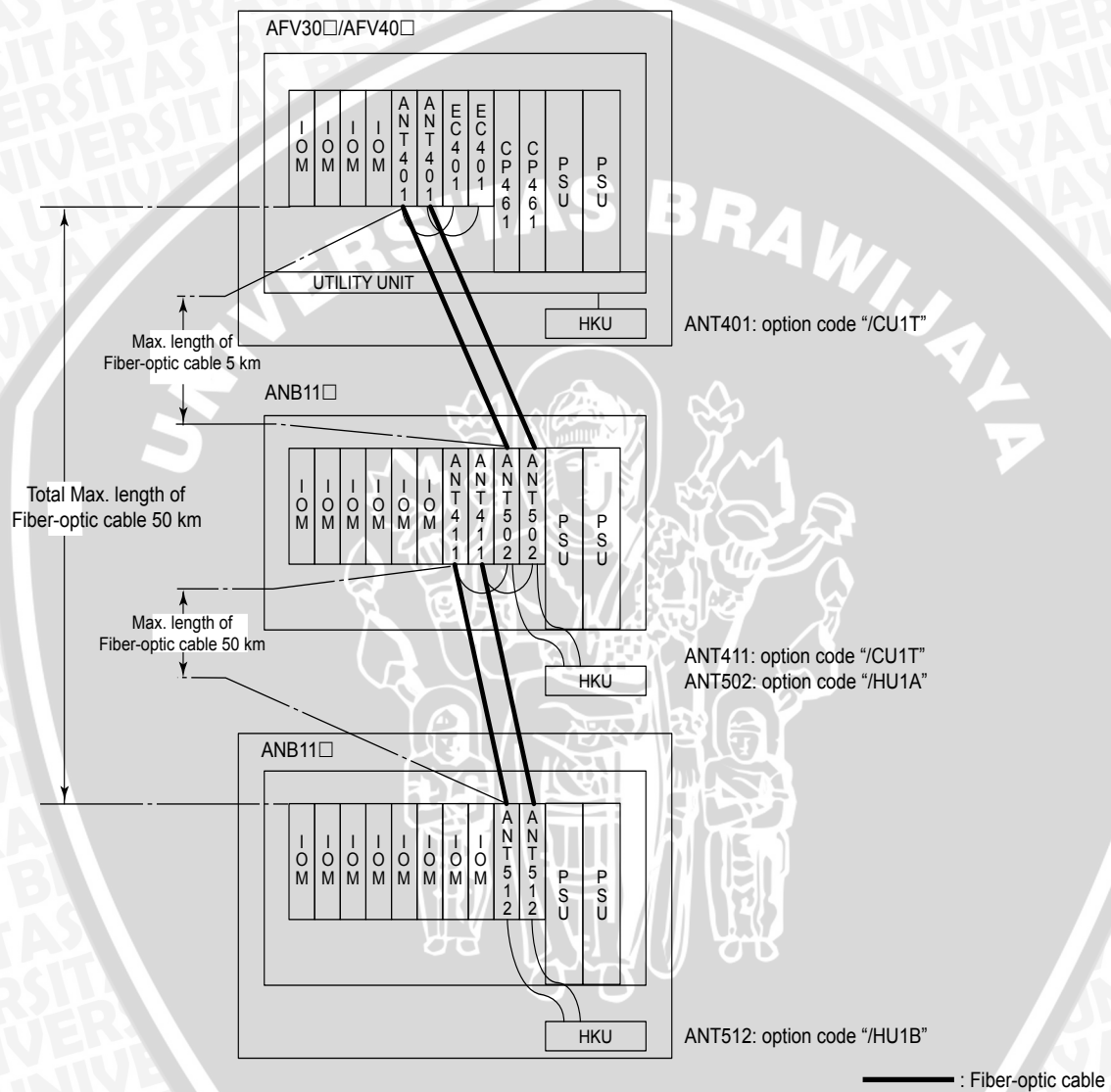
Figure　Example of Chain Connection Using HK Function

● **Example of Star Type Connection**

ANT401(B1, 2) : option code "/CU1T"
ANT411(IO7, 8) : option code "/CU1N"
ANT401(IO5, 6) : option code "/CU1N"

ANT512: option code "/HU1B"

ANT502: option code "/HU1A"
SB401: option code "/CU2T"

━━━ : Fiber-optic cable
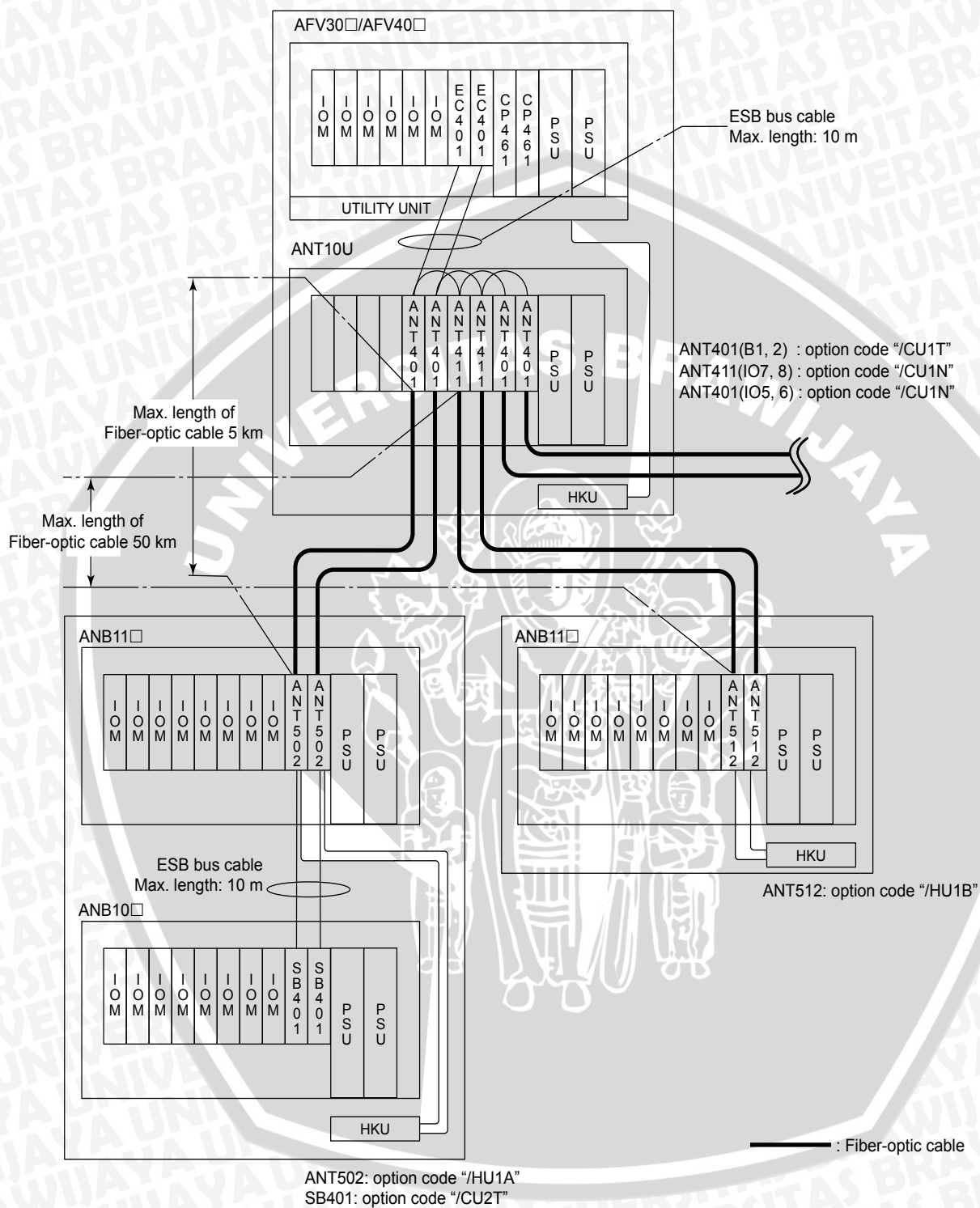
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Figure   Example of Star Connection Using HK Function

■ House Keeping Unit (HKU)

CENTUM VP FCS is equipped with a house keeping function that is to monitor the environment in the cabinet where FCS is mounted or the status of FCS itself. The FCS's reliability is improved by this house keeping function. Taking an example of FFCS-V, details of the house keeping unit (HKU) are described here.

HKU hardware is composed of HKU, DPU, fan power supply unit, node fan unit, vertical type power distribution unit, and utility unit. All of these are set inside the FCS cabinet. The table below shows an overview of each function unit.

Table   Overview of the HKU Function Units

Unit Name	Description
HKU (House Keeping Unit)	Alarm information such as cabinet temperature and performance status of cooling fans are controlled and monitored.
PDU (Power Distribution Unit)	Composed of a circuit breaker and a noise filter, PUD supplies power to the cabinet and protect it from malfunctions such as inrush current.
Fan Power Supply Unit	Supplies power to door fan, node fun, HKU, and contact output relays.
Node Fan Unit	FCU and nodes are cooled.
Power Supply Bus Unit, Vertical Type	Powers to the cabinet is distributed.
Utility Unit	Power supplies to FCU are supplied, and provide interfaces between FCU and HKU.

The HKU and its related units for AFV40D (with cabinet) is shown here.
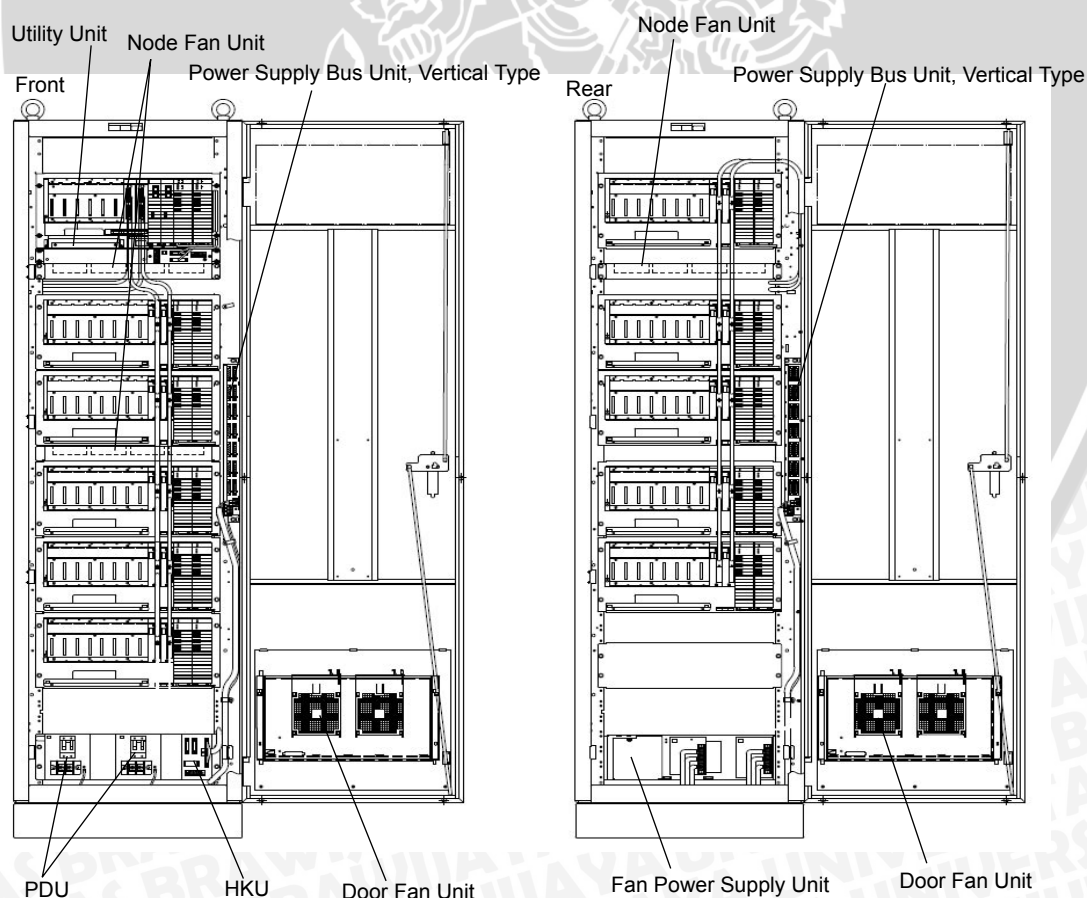
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Figure   HKU and its related units

HKU main unit displays the information given from each functional unit by the LED on the front. The table below shows the elements of the HKU for FFCS-V.

Table   HKU display elements

Name	Color	Description
RDY	Green	The initial HKU information is being collected when it is blinking. When blinking stops, HKU is in routine operation. (Both represent normal operation status.)
LNK	Green	HK-BUS CARRIER DETECT
D-FAN	Red	The DFAN UNIT (door fan/roof fan) failed.
N-FAN1	Red	Either node FAN Unit 1 or SC FAN Unit on the front failed.
N-FAN2	Red	Node FAN Unit 2 failed.
N-FAN3	Red	Either node FAN Unit 3 or SC FAN Unit on the rear failed.
N-FAN4	Red	Node FAN Unit 4 failed.
PSU HK /AUX HK	Red	Either the fan power unit or the contact I/O failed.
PSU TB	Red	PS4 power unit failed, when it is installed.
ID1	Red	Displays the failure 1. (See the table "Combination of the failed units.")
ID2	Red	Displays the failure 2. (See the table "Combination of the failed units.")
ID3	Red	Displays the failure 3. (See the table "Combination of the failed units.")
ID4	Red	Displays the failure 4. (See the table "Combination of the failed units.")

Table   Combination of the failed units

ID	D-FAN	N-FANx	PSU HK / AUX HK	PSU TB	Temperature anomaly
ID1	Door Fan 1	1st from the left	Fan Power Supply 1	Front, Left	AIR OUT
ID2	Door Fan 2	2nd from the left	Fan Power Supply 2	Front, Right	AIR IN
ID3	Door Fan 3	3rd from the left	–	Rear, Left	–
ID4	Door Fan 4	4th from the left	Contact Input	Rear, Right	–

When the cabinet is installed in a remote location, the HK information is transmitted to FCU via an optical ESB bus. All these HK information can be monitored on an HIS through FCS status display view.

2.2   FCS Configuration

FCS is composed of FCU, node units, ESB bus, etc.. You can select the configuration of these components according to the requirement for your operation.

Table   FCS Configuration

Component	Type	FFCS-V	FFCS-L	FFCS	KFCS, KFCS2	LFCS, LFCS2	PFC□ -H/-S/-E
CPU configuration	Single	Yes	Yes	Yes	Yes	Yes	Yes
	Duplexed	Yes	Yes	Yes	Yes	Yes	Yes
ESB bus	Single	Yes	Yes	Yes	Yes	Yes	Yes
	Duplexed	Yes	Yes	Yes	Yes	Yes	Yes
ER bus	Single	No	Yes	Yes	Yes	No	No
	Duplexed	No	Yes	Yes	Yes	No	No
Optical ESB bus	Single	Yes	No	No	No	No	No
	Duplexed	Yes	No	No	No	No	No
Mounting	Rack mountable	Yes	Yes	Yes	Yes	Yes	Yes
	Cabinet type	Yes	No	No	Yes	Yes	No
V net	Single	No	No	Yes	No	No	Caution (*1)
	Duplexed	No	No	Yes	Yes	Yes	
Vnet/IP	Duplexed(*2)	Yes	Yes	No	No	No	No

Yes: Available
No: Not available

*1:   For PFCS-S/-E single CPU, use single V net. For PFCD-S/-E duplexed CPU, use duplexed V net. However, for PFC□-H use duplexed V net always.
*2:   Vnet/IP supports only duplexed network.

2.3 I/O Module

I/O modules include input modules converting process signals to digital data format used in FCS and output modules converting digital data to analog or contact signals.

CENTUM VP I/O modules provide various choices for isolated types or connector types to respond flexibly to any requirements.

■ I/O Modules for FIO

Table   I/O Modules for FIO (1/2)

Models	Name
Analog I/O Modules	
AAI141	Analog Input Module (4 to 20 mA, 16-Channel, Non-Isolated)
AAV141	Analog Input Module (1 to 5 V, 16-Channel, Non-Isolated)
AAV142	Analog Input Module (-10 V to +10 V, 16-Channel, Non-Isolated)
AAI841	Analog I/O Module (4 to 20 mA Input, 4 to 20 mA Output, 8-Channel Input/8-Channel Output, Non-Isolated)
AAB841	Analog I/O Module (1 to 5 V Input, 4 to 20 mA Output, 8-Channel Input/8-Channel Output, Non-Isolated)
AAV542	Analog Output Module (-10 V to +10 V, 16-Channel, Non-Isolated)
AAI143	Analog Input Module (4 to 20 mA, 16-Channel, Isolated)
AAV144	Analog Input Module (-10 V to +10 V, 16-Channel, Isolated)
AAV544	Analog Output Module (-10 V to +10 V, 16-Channel, Isolated)
AAI543	Analog Output Module (4 to 20 mA, 16-Channel, Isolated)
AAT141	TC/mV Input Module (16-Channel, Isolated)
AAR181	RTD Input Module (12-Channel, Isolated)
AAI135	Analog Input Module (4 to 20 mA, 8-Channel, Isolated Channels)
AAI835	Analog I/O Module (4 to 20 mA, 4-Channel Input/4-Channel Output, Isolated Channels)
AAT145	TC/mV Input Module (16-Channel, Isolated Channels)
AAR145	RTD/POT Input Module (16-Channel, Isolated Channels)
AAP135	Pulse Input Module (8-Channel, Pulse Count, 0 to 10 kHz, Isolated Channels)
AAP149	Pulse Input Module for Compatible PM1 (16-Channel, Pulse Count, 0 to 6 kHz, Non-Isolated)
AAP849	Pulse Input Module/Analog Output Module (8-Channel Input/8-Channel Output, Non-Isolated)
Analog I/O Modules with HART Communication Function	
AAI141-H	Analog Input Module (4 to 20 mA, 16-Channel, Non-Isolated)
AAI841-H	Analog I/O Module (4 to 20 mA Input, 4 to 20 mA Output, 8-Channel Input/8-Channel Output, Non-Isolated)
AAI143-H	Analog Input Module (4 to 20 mA, 16-Channel, Isolated)
AAI543-H	Analog Output Module (4 to 20 mA, 16-Channel, Isolated)
AAI135-H	Analog Input Module (4 to 20 mA, 8-Channel, Isolated Channels)
AAI835-H	Analog I/O Module (4 to 20 mA, 4-Channel Input/4-Channel Output, Isolated Channels)

Table   I/O Modules for FIO (2/2)

Models	Name
Digital I/O Modules	
ADV151	Digital Input Module (32-Channel, 24 V DC, Isolated)
ADV141	Digital Input Module (16-Channel, 100 V to 120 V AC, Isolated)
ADV142	Digital Input Module (16-Channel, 200 V to 240 V AC, Isolated)
ADV551	Digital Output Module (32-Channel, 24 V DC, Isolated)
ADV157	Digital Input Module (32-Channel, 24 V DC, Pressure Clamp Terminal Support Only, Isolated)
ADV161	Digital Input Module (64-Channel, 24 V DC, Isolated)
ADV557	Digital Output Module (32-Channel, 24 V DC, Pressure Clamp Terminal Support Only, Isolated)
ADV561	Digital Output Module (64-Channel, 24 V DC, Isolated)
ADR541	Relay Output Module (16-Channel, 24 to 110 V DC/100 to 240 V AC, Isolated)
ADV859	Digital I/O Module for Compatible ST2 (16-Channel Input/16-Channel Output, Isolated Channels)
ADV159	Digital Input Module for Compatible ST3 (32-Channel Input, Isolated Channels)
ADV559	Digital Output Module for Compatible ST4 (32-Channel Output, Isolated Channels)
ADV869	Digital I/O Module for Compatible ST5 (32-Channel Input/32-Channel Output, Isolated, Common Minus Side Every 16-Channel)
ADV169	Digital Input Module for Compatible ST6 (64-Channel Input, Isolated, Common Minus Side Every 16-Channel)
ADV569	Digital Output Module for Compatible ST7 (64-Channel Output, Isolated, Common Minus Side Every 16-Channel)
ADV851	Digital I/O Module (16-Channel input, 16-Channel output, 24 V DC)
Communication Modules	
ALR111	RS-232C Communication Module (2-Port)
ALR121	RS-422/RS-485 Communication Module (2-Port)
ALE111	Ethernet Communication Module
ALF111	FOUNDATION fieldbus (FF-H1) Communication Module (4-Port)
ALP111	PROFIBUS-DPV1 Communication Module
Turbomachinery I/O Modules	
AGS813	Servo Module(Isolated)
AGP813	High Speed Protection Module(Isolated)

● **Combination between I/O Module and Terminal Block**

To connect between I/O module and field devices, mount a pressure clamp terminal or KS cable interface adapter on I/O module. User's MIL connector cable can also be used.

The figure below shows the combination between I/O module and terminal block.
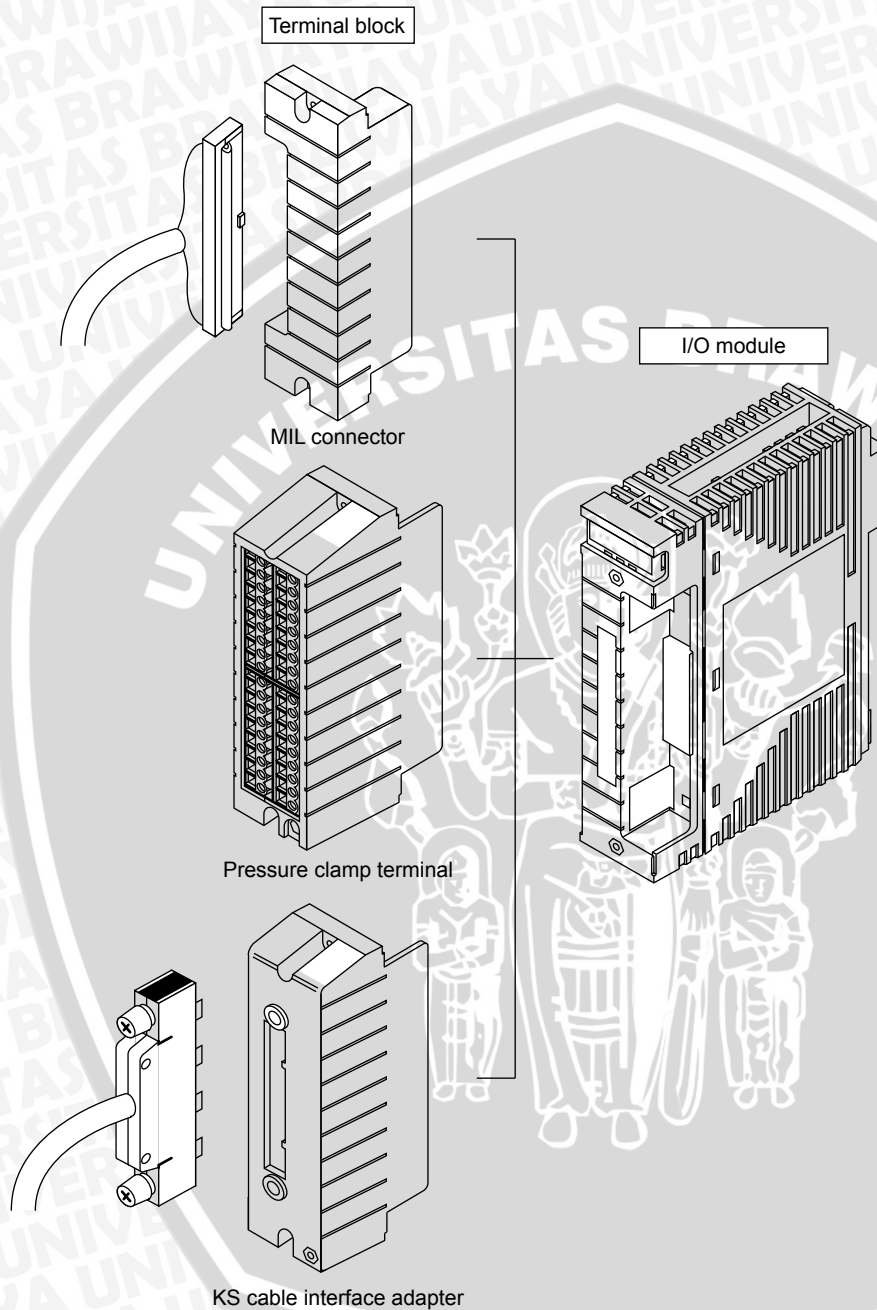
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Figure   Terminal Blocks and I/O Module

- **Field wiring using Pressure Clamp Terminal**

    A field signal cable whose end is uncovered can be directly connected to analog or digital I/O module equipped pressure clamp terminal block. Two to three signal cables can be connected for every I/O channel.

- **Field wiring using KS Cable Interface Adapter**

    I/O module equipped with KS cable interface adapter can be connected to a terminal board with KS cable. Field signal cables are connected to a terminal board with M4 screws.

■ I/O Modules for RIO

I/O modules for RIO are shown in the below table.

Table   I/O Modules for RIO (1/2)

Models	I/O Module Names
Analog I/O Modules	
AAM10	Current/Voltage Input Module (Simplified Type)
AAM11	Current/Voltage Input Module
AAM11B	Current/Voltage Input Module (supports BRAIN)
AAM21	mV, Thermocouple, and RTD Input Module
AAM21J	mV, Thermocouple, and RTD Input Module (supports IEC584-1995, IEC751-1995)
APM11	Pulse Input Module
AAM50	Current Output Module
AAM51	Current/Voltage Output Module
AMC80	Multipoint Control Analog I/O Module
Relay I/O Modules	
ADM15R	Relay Input Module
ADM55R	Relay Output Module
Multiplexer Modules (16 Points, Terminal Type)	
AMM12T	Voltage Input Multiplexer Module
AMM22M	mV Input Multiplexer Module
AMM22T	Thermocouple Input Multiplexer Module
AMM22TJ	Thermocouple Input Multiplexer Module
AMM32T	RTD Input Multiplexer Module
AMM32TJ	RTD Input Multiplexer Module (supports IEC751-1995)
AMM42T	2-Wire Transmitter Input Multiplexer Module
AMM52T	Output Multiplexer Module
Multiplexer Modules (Connector Type)	
AMM12C	Voltage Input Multiplexer Module
AMM22C	mV Input Multiplexer Module
AMM25C	mV Input Multiplexer Module with Thermocouple Interface (15 Points, RJC Input port added)
AMM32C	RTD Input Multiplexer Module (16 Points)
AMM32CJ	RTD Input Multiplexer Module (16 Points, conforms to IEC751-1995)

Table   I/O Modules for RIO (2/2)

Models	I/O Module Names
Digital I/O Modules	
ADM11T	Contact Input Module (16 Points, Terminal Type)
ADM12T	Contact Input Module (32 Points, Terminal Type)
ADM51T	Contact Output Module (16 Points, Terminal Type)
ADM52T	Contact Output Module (32 Points, Terminal Type)
ADM11C	Contact Input Module (16 Points, Connector Type)
ADM12C	Contact Input Module (32 Points, Connector Type)
ADM51C	Contact Output Module (16 Points, Connector Type)
ADM52C	Contact Output Module (32 Points, Connector Type)
Communication Modules	
ACM11	RS-232C Communication Module
ACM12	RS-422/RS-485 Communication Module
ACM21	RS-232C General-purpose Communication Card
ACM22	RS-422/RS-485 General-purpose Communication Card
ACM71	Ethernet Communication Module (for PFCS/PFCD)
ACF11	Fieldbus Communication Module
ACP71	PROFIBUS Communication Module

3. Control Function

Figure below shows Configuration of Control Functions.

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┌─────────────────────────┐
│ Control Function        │
└─────────────────────────┘
   │
   ├──┌─────────────────────────┐
   │  │ Function Block          │
   │  └─────────────────────────┘
   │     │
   │     ├──┌──────────────────────────────┐
   │     │  │ Regulatory Control Block     │
   │     │  └──────────────────────────────┘
   │     │
   │     ├──┌──────────────────────────────┐
   │     │  │ Calculation Block            │
   │     │  └──────────────────────────────┘
   │     │
   │     ├──┌──────────────────────────────┐
   │     │  │ Sequence Control Block       │
   │     │  └──────────────────────────────┘
   │     │
   │     ├──┌──────────────────────────────┐
   │     │  │ Faceplate Block              │
   │     │  └──────────────────────────────┘
   │     │
   │     ├──┌──────────────────────────────┐
   │     │  │ Unit Instruments and Operation│
   │     │  └──────────────────────────────┘
   │     │
   │     ├──┌──────────────────────────────┐
   │     │  │ Valve Pattern Monitor        │
   │     │  └──────────────────────────────┘
   │     │
   │     ├──┌──────────────────────────────┐
   │     │  │ Off-site Block               │
   │     │  └──────────────────────────────┘
   │     │
   │     └──┌──────────────────────────────┐
   │        │ System Function Block (*1)   │
   │        └──────────────────────────────┘
   │
   ├──┌─────────────────────────┐
   │  │ Input/Output Function   │
   │  └─────────────────────────┘
   │     │
   │     ├──┌──────────────────────────────┐
   │     │  │ Process Control Input/Output │
   │     │  └──────────────────────────────┘
   │     │     │
   │     │     ├──┌──────────────────────────────┐
   │     │     │  │ Process Input/Output         │
   │     │     │  └──────────────────────────────┘
   │     │     │
   │     │     ├──┌──────────────────────────────┐
   │     │     │  │ Communication Input/Output   │
   │     │     │  └──────────────────────────────┘
   │     │     │
   │     │     └──┌──────────────────────────────┐
   │     │        │ Fieldbus Input/Output        │
   │     │        └──────────────────────────────┘
   │     │
   │     └──┌──────────────────────────────┐
   │        │ Software Input/Output        │
   │        └──────────────────────────────┘
   │           │
   │           ├──┌──────────────────────────────┐
   │           │  │ Internal Switch              │
   │           │  └──────────────────────────────┘
   │           │
   │           └──┌──────────────────────────────┐
   │              │ Sequence Message             │
   │              └──────────────────────────────┘
   │
   └──┌─────────────────────────┐
      │ Control Drawing         │
      └─────────────────────────┘
```

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*1:   System function block is supported by FFCS-V only.

Figure   Configuration of Control Functions

3.1   Function Block

Function block is a basic unit for control and calculations. Continuous control, sequence control (sequence tables and logic charts) and calculations are performed by function blocks. Regulatory control blocks, calculation blocks, and sequence control blocks are interconnected in a manner similar to the conventional instrument flow diagrams.

■ Regulatory Control Block

Regulatory control block performs calculation using analog process values for process control and monitoring.

Table   Regulatory Control Blocks (1/2)

Block type	Model	Name
Input Indicator Block	PVI	Input Indicator Block
	PVI-DV	Input Indicator Block with Deviation Alarm
Controller Block	PID	PID Controller Block
	PI-HLD	Sampling PI Controller Block
	PID-BSW	PID Controller Block with Batch Switch
	ONOFF	Two-Position ON/OFF Controller Block
	ONOFF-E	Enhanced Two-Position ON/OFF Controller Block
	ONOFF-G	Three-Position ON/OFF Controller Block
	ONOFF-GE	Enhanced Three-Position ON/OFF Controller Block
	PID-TP	Time-Proportioning ON/OFF Controller Block
	PD-MR	PD Controller Block with Manual Reset
	PI-BLEND	Blending PI Controller Block
	PID-STC	Self-Tuning PID Controller Block
Manual Loader Block	MLD	Manual Loader Block
	MLD-PVI	Manual Loader Block with Input Indicator
	MLD-SW	Manual Loader Block with Auto/Man SW
	MC-2	Two-Position Motor Control Block
	MC-2E	Enhanced Two-Position Motor Control Block
	MC-3	Three-Position Motor Control Block
	MC-3E	Enhanced Three-Position Motor Control Block
Signal Setter Block	RATIO	Ratio Set Block
	PG-L13	13-Zone Program Set Block
	BSETU-2	Flow-Totalizing Batch Set Block
	BSETU-3	Weight-Totalizing Batch Set Block
Signal Limiter Block	VELLIM	Velocity Limiter Block
Signal Selector Block	SS-H/M/L	Signal Selector Block
	AS-H/M/L	Auto-Selector Block
	SS-DUAL	Dual-Redundant Signal Selector Block
Signal Distributor Block	FOUT	Cascade Signal Distributor Block
	FFSUM	Feed-Forward Signal Summing Block
	XCPL	Non-Interference Control Output Block
	SPLIT	Control Signal Splitter Block
Alarm Block	ALM-R	Representative Alarm Block
Pulse Count Input Block	PTC	Pulse Count Input Block

Table   Regulatory Control Blocks (2/2)

Block type	Model	Name
YS Instrument Block	SLCD	YS Controller Block
	SLPC	YS Programmable Controller Block
	SLMC	YS Programmable Controller Block with Pulse-Width Output
	SMST-111	YS Manual Station Block with SV Output
	SMST-121	YS Manual Station Block with MV Output Lever
	SMRT	YS Ratio Set Station Block
	SBSD	YS Batch Set Station Block
	SLCC	YS Blending Controller Block
	SLBC	YS Batch Controller Block
	STLD	YS Totalizer Block
FOUNDATION fieldbus Faceplate Block	FF-AI	FOUNDATION fieldbus Analog Input Block
	FF-DI	FOUNDATION fieldbus Discrete Input Block
	FF-CS	FOUNDATION fieldbus Control Selector Block
	FF-PID	FOUNDATION fieldbus PID Control Block
	FF-RA	FOUNDATION fieldbus Ratio Block
	FF-AO	FOUNDATION fieldbus Analog Output Block
	FF-DO	FOUNDATION fieldbus Discrete Output Block
	FF-OS	FOUNDATION fieldbus Output Splitter Block
	FF-SC	FOUNDATION fieldbus Signal Characterizer (Totalizer) Block
	FF-IT	FOUNDATION fieldbus Integrator Block
	FF-IS	FOUNDATION fieldbus Input Selector Block
	FF-MDI	FOUNDATION fieldbus Multiple Discrete Input Block
	FF-MDO	FOUNDATION fieldbus Multiple Discrete Output Block
	FF-MAI	FOUNDATION fieldbus Multiple Analog Input Block
	FF-MAO	FOUNDATION fieldbus Multiple Analog Output Block
	FF-SUNV	Simple Universal Block

■ Sequence Block

Sequence block performs sequence control such as interlock sequence or process monitoring sequence processed according to a defined order.

Table   Sequence Block

Block type	Model	Name
Sequence Table Block	ST16	Sequence Table Block
	ST16E	Rule Extension Block
Logic Chart Block	LC64	Logic Chart Block
SFC Block	_SFCSW	3-Position Switch SFC Block
	_SFCPB	Pushbutton SFC Block
	_SFCAS	Analog SFC Block
Switch Instrument Block	SI-1	Switch Instrument Block with 1 Input
	SI-2	Switch Instrument Block with 2 Inputs
	SO-1	Switch Instrument Block with 1 Output
	SO-2	Switch Instrument Block with 2 Outputs
	SIO-11	Switch Instrument Block with 1 Input and 1 Output
	SIO-12	Switch Instrument Block with 1 Input and 2 Outputs
	SIO-21	Switch Instrument Block with 2 Inputs and 1 Output
	SIO-22	Switch Instrument Block with 2 Inputs and 2 Outputs
	SIO-12P	Switch Instrument Block with 1 Input, 2 One-Shot Outputs
	SIO-22P	Switch Instrument Block with 2 Inputs, 2 One-Shot Outputs
	SI-1E	Enhanced Switch Instrument Block with 1 Input
	SI-2E	Enhanced Switch Instrument Block with 2 Inputs
	SO-1E	Enhanced Switch Instrument Block with 1 Output
	SO-2E	Enhanced Switch Instrument Block with 2 Outputs
	SIO-11E	Enhanced Switch Instrument Block with 1 Input and 1 Output
	SIO-12E	Enhanced Switch Instrument Block with 1 Input and 2 Outputs
	SIO-21E	Enhanced Switch Instrument Block with 2 Inputs and 1 Output
	SIO-22E	Enhanced Switch Instrument Block with 2 Inputs and 2 Outputs
	SIO-12PE	Enhanced Switch Instrument Block with 1 Input, 2 One-Shot Outputs
	SIO-22PE	Enhanced Switch Instrument Block with 2 Inputs, 2 One-Shot Outputs
Sequence Auxiliary Block	TM	Timer Block
	CTS	Software Counter Block
	CTP	Pulse Train Input Counter Block
	CI	Code Input Block
	CO	Code Output Block
	RL	Relational Expression Block
	RS	Resource Scheduler Block
Valve Monitoring Block	VLVM	Valve Monitoring Block

■ Calculation Block

Calculation block supplements Regulatory control and Sequence control performing general-purpose calculation of analog and contact signals.

Table   Calculation Block (1/2)

Block type	Model	Name
Arithmetic Calculation Block	ADD	Addition Block
	MUL	Multiplication Block
	DIV	Division Block
	AVE	Averaging Block
Analog Calculation Block	SQRT	Square Root Block
	EXP	Exponential Block
	LAG	First-Order Lag Block
	INTEG	Integration Block
	LD	Derivative Block
	RAMP	Ramp Block
	LDLAG	Lead/Lag Block
	DLAY	Dead-Time Block
	DLAY-C	Dead-Time Compensation Block
	AVE-M	Moving-Average Block
	AVE-C	Cumulative-Average Block
	FUNC-VAR	Variable Line-Segment Function Block
	TPCFL	Temperature and Pressure Correction Block
	ASTM1	ASTM Correction Block: Old JIS
	ASTM2	ASTM Correction Block: New JIS
Logic Operation Block	AND	Logical AND Block
	OR	Logical OR Block
	NOT	Logical NOT Block
	SRS1-S	Set-Dominant Flip-Flop Block with 1 Output
	SRS1-R	Reset-Dominant Flip-Flop Block with 1 Output
	SRS2-S	Set-Dominant Flip-Flop Block with 2 Output
	SRS2-R	Reset-Dominant Flip-Flop Block with 2 Output
	WOUT	Wipeout Block
	OND	ON-Delay Timer Block
	OFFD	OFF-Delay Timer Block
	TON	One-Shot Block (rising-edge trigger)
	TOFF	One-Shot Block (falling-edge trigger)
	GE	Comparator Block (greater than or equal)
	GT	Comparator Block (greater than)
	EQ	Equal Operator Block
	BAND	Bitwise AND Block
	BOR	Bitwise OR Block
	BNOT	Bitwise NOT Block
General-Purpose Calculation Block	CALCU	General-Purpose Calculation Block
	CALCU-C	General-Purpose Calculation Block with String I/O

Table   Calculation Block (2/2)

Block type	Model	Name
Calculation Auxiliary Block	SW-33	3-Pole 3-Position Selector Switch Block
	SW-91	1-Pole 9-Position Selector Switch Block
	DSW-16	Selector Switch Block for 16 Data
	DSW-16C	Selector Switch Block for 16 String Data
	DSET	Data Set Block
	DSET-PVI	Data Set Block with Input Indicator
	BDSET-1L	1-Batch Data Set Block
	BDSET-1C	1-Batch String Data Set Block
	BDSET-2L	2-Batch Data Set Block
	BDSET-2C	2-Batch String Data Set Block
	BDA-L	Batch Data Acquisition Block
	BDA-C	Batch String Data Acquisition Block
	ADL	Station Interconnection Block

■ Faceplate Block

Faceplate block is a function block displaying unified multiple function blocks as a single tag.

Table   Faceplate Block

Analog Faceplate Block	INDST2	Dual-Pointer Indicating Station Block
	INDST2S	Dual-Pointer Manual Station Block
	INDST3	Triple-Pointer Manual Station Block
Sequence Faceplate Block	BSI	Batch Status Indicator Block
	PBS5C	Extended 5-Pushbutton Switch Block
	PBS10C	Extended 10-Pushbutton Switch Block
Hybrid Faceplate Block	HAS3C	Extended Hybrid Manual Station Block

■ Unit Instrument and Operation

Unit instruments handle the operation and control of a whole process unit. Operations handle the operation and control of each phase of a process unit.

Table   Unit Instrument and Operation

Block type	Model	Name
Unit Instrument	_UTSW	3-Position Switch-Type Unit Instrument
	_UTPB	5-Pushbutton-Type Unit Instrument
	_UTAS	Analog-Type Unit Instrument
Non-Resident Unit Instrument	_UTSW-N	Non-Resident Unit Instrument with Three-Position Switch
	_UTPB-N	Non-Resident Unit Instrument with Five-Pushbutton Switch
	_UTAS-N	Analog Non-Resident Unit Instrument
Operation	OPSBL	SEBOL-Type Operation
	OPSFC	SFC-Type Operation
	OPSFCP1	SFC-Type Operation with Floating-Data Parameters
	OPSFCP2	SFC-Type Operation with Character-Data Parameters
	OPSFCP3	SFC-Type Operation with Floating/Character-Data Parameters
	OPSFCP4	SFC-Type Operation with Integer/Character-Data Parameters
	OPSFCP5	SFC-Type Operation with Floating/Integer-Data Parameters

■ Valve Pattern Monitor

Valve pattern monitor is a function block for unified monitoring of open-close status of multiple valves.

Table   Valve Pattern Monitor

Block type	Model	Name
Valve Pattern Monitor	VPM64	64-Data Valve Pattern Monitor
	VPM128	128-Data Valve Pattern Monitor
	VPM256	256-Data Valve Pattern Monitor
	VPM512	512-Data Valve Pattern Monitor
	VPM64A	64-Data Valve Pattern Monitor with Alarm
	VPM128A	128-Data Valve Pattern Monitor with Alarm
	VPM256A	256-Data Valve Pattern Monitor with Alarm
	VPM512A	512-Data Valve Pattern Monitor with Alarm

■ Off-site Block

Off-site block is a function block for batch blending and shipment control performed off-site of oil refineries or other plant facilities.

Table   Off-site

Block type	Model	Name
Off-Site Block	FSBSET	Batch Set Control Block
	BLEND	Blending Master Control Bloc

■ System Function Block

System function block acts as an interface for notifying FCS's internal operation status to the outside of FCS. These blocks are provided by FFCS-V only.

Table   System Function Block

Block type	Model	Name
System Function Block	FCS_CPU	CPU Load Information
	FCS_COM	Communication Load Information
	FCS_IOC	I/O Load Information
	FCS_SBL	SEBOL Operation Information

3.2   Input and Output Functions

There are two types of input and output (I/O) functions: Process I/O exchanges data with field devices outside FCS; and software I/O is for virtual data exchange within the FCS.

■ Process Control Inputs/Outputs

Using process inputs/outputs, an FCS can receive signals from process detectors and output signals to process control elements.

Table   Process Control Inputs/Outputs

Type	Symbol	Name
Process I/O	%Z	Process I/O
Communication I/O	%WW (*1)	Communication I/O - Word data
	%WB (*1)	Communication I/O - Bit data
Fieldbus I/O	%Z	Fieldbus I/O

*1:   When the extended communication I/O is applied for FFCS-V, use %XW for word data and %XB for bit data.

■ Software Inputs/Outputs

Software inputs/outputs are virtual inputs/outputs that are provided by the FCS's internal software.

Two types of software inputs/outputs are available: an "internal switch," which is used to exchange logical values between function blocks or other application functions; and a "message output," which is used to inform the occurrence of an event.

Table   Software Inputs/Outputs

Type	Symbol	Name
Internal Switch	%SW	Common Switch
	%GS	Global Switch
Message Output	%AN	Annunciator Message
	%PR	Print Message
	%OG	Operator Guide Message
	%VM	Multimedia Start Message
	%RQ	Sequence Message Request
	%CP	Supervisory Computer Event Message
	%M3	Supervisory Computer Event Message for PICOT
	%EV	Signal Event Message
	%RE	SFC/SEBOL Return Event Message

3.3   Control Drawing

Small control groups composed by function blocks and inputs/outputs are to be described in the control drawings. Engineering and maintenance works are simplified by unifying the process device control as a control drawing. Monitoring the whole plant or each process can also be specified as control drawings instead of specifying individual process unit or functions in between the different devices. The features of control drawings are described below.

- Connecting I/O and control blocks
  By connecting a line between the I/O and function block, or between the function blocks, the data flow definition can be visualized.

- Defining the order of control block implementation
  The implementation priority or order of performance can be determined among several function blocks described in the control drawing.

- Mix of Regulatory Control and Sequence Control
  Regulatory control and Sequence control can be mixed in Control drawing. Control functions can be flexibly configured according to the requirement for process.

- Free Signal Flow between Control Drawing
  Function block belonging to different Control drawing can be connected to another Control drawing.

■ Control Drawing example

An example of a simple reactor process mounted in Control drawing is shown below.
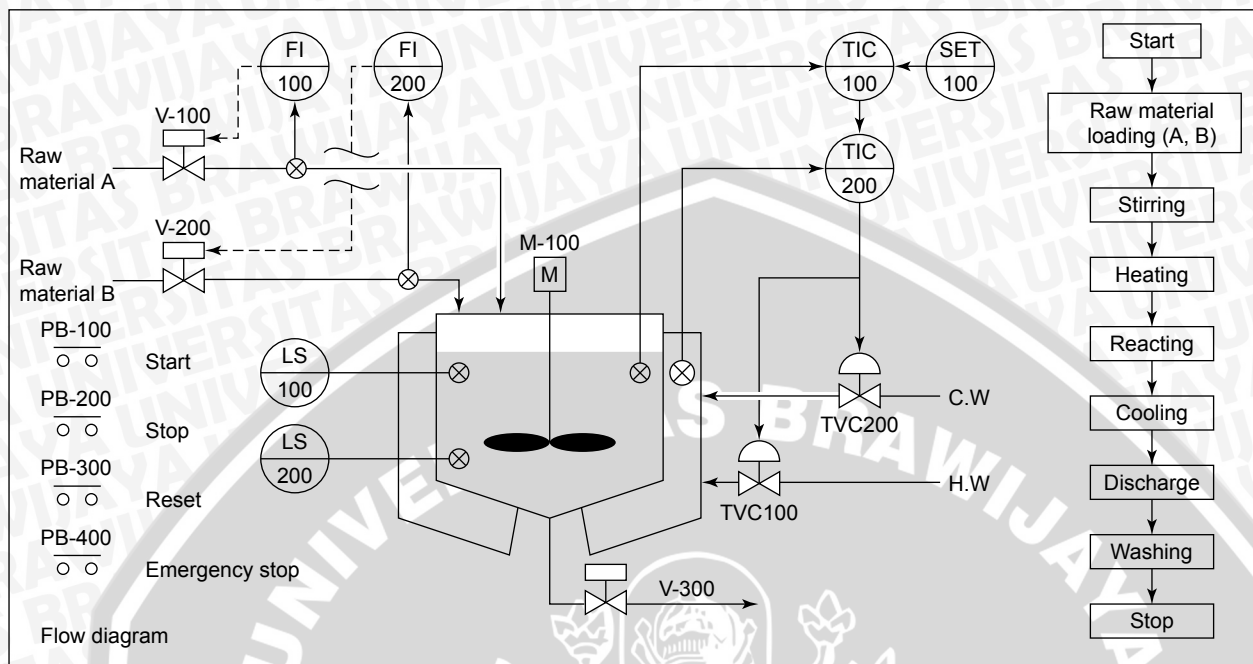
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Figure   Reactor Process Flow Diagram
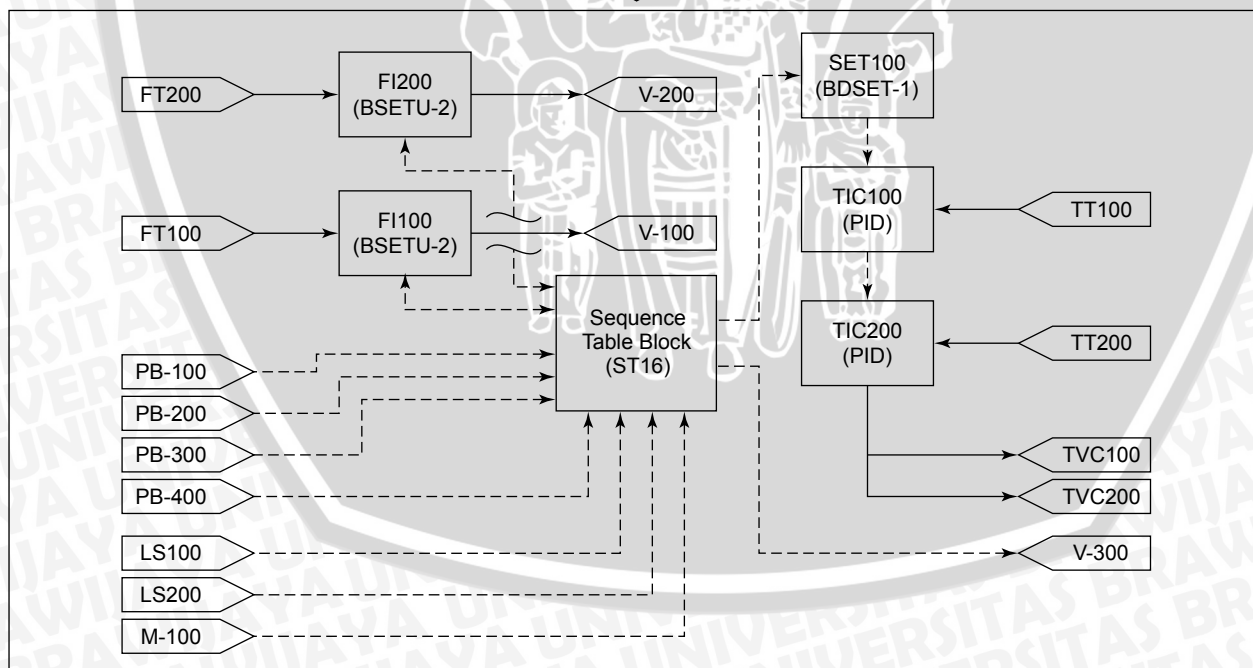
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Figure   Example of Control Drawing

■ Scan Period

The scan period is the period at which the function block is executed periodically. The periodic execution function block executes a process based on the scan period.

There are three types of scan periods: the basic scan, the medium-speed scan (*1) and the high-speed scan. One of these scan periods can be selected for each individual function block. However, the medium-speed scan and high-speed scan cannot be selected for some function blocks.

- • Basic Scan: Fixed to 1 second.

- • Medium-Speed Scan: Select [200 ms] or [500 ms].(*2), default is 500ms.

- • High-Speed Scan: Select [200 ms] or [500 ms].(*2), default is 200ms.

*1:   The medium-speed scan setting is not available for the PFCS and SFCS.
*2:   [50 ms], [100 ms] or [250 ms] can also be specified by direct entry from keyboard.

■ Order of Process Execution

The order of process execution refers to a sequence in which the control drawing and individual function block are executed in the periodic execution. The process timing of a periodic execution regulatory function block is determined by the orders of execution of the control drawings and the function blocks.

The following section describes the orders in which the control drawings and individual function blocks are executed in the periodic execution.

● Order of Process Execution for Control Drawings/Function Blocks

The diagram below shows an example of executing control drawings each consisting of function blocks being executed in the high-speed scan, medium-speed scan and basic scan. In this example, three control drawings are processed. The groups of high-speed scan function blocks in the respective drawings are indicated as A, B and C. Similarly, the groups of medium-speed scan function blocks in the respective control drawings are indicated as A', B' and C'; and the groups of basic scan function blocks, a, b and c. In the diagram below and the explanation that follows, the processing of the function blocks belonging to A, B and C is referred to as "high-speed processing"; processing of the function blocks belonging to A', B' and C', "medium-speed processing" ; and processing of the function blocks belonging to a, b and c, "basic processing." "Other processing" indicates processing of SFC blocks.
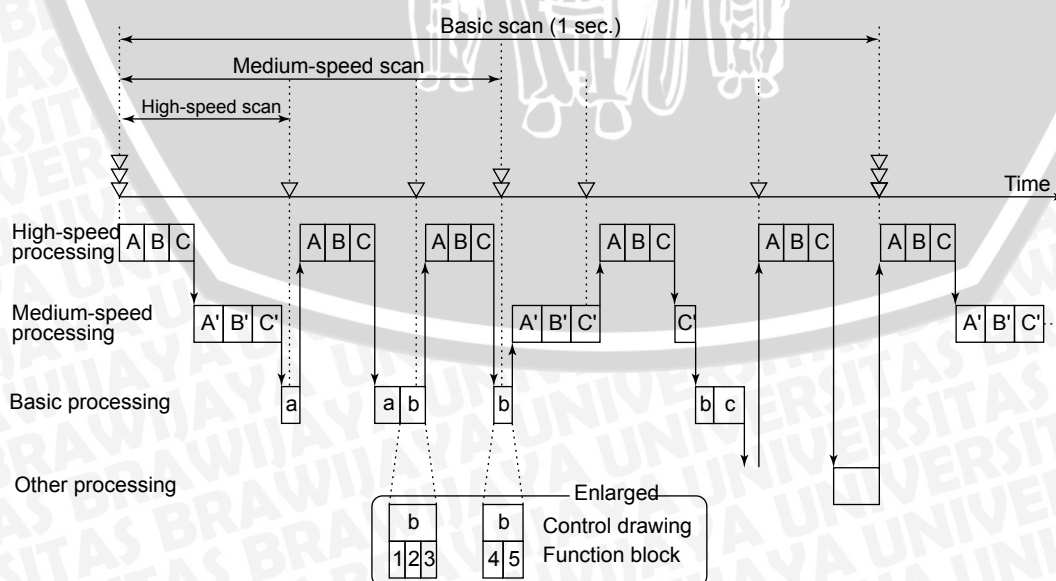
Figure   Example of Control Drawings/Function Blocks Process Execution

- The high-speed processing has priority over the medium-speed processing or basic processing. The medium-speed processing has priority over the basic processing.

- Once processing of all high-speed function blocks have been completed, the medium-speed processing is executed.
  When execution of all high-speed and medium-speed processes of function blocks have been completed, the basic processing is executed.

- In case that the high-speed processing gets its timing for execution during the basic processing or medium-speed processing is being executed, the high-speed processing interrupts the basic processing or medium-speed processing by making the basic processing or medium-speed processing pause at the gap among function blocks' basic processing or medium-speed processing. Once all function blocks of high-speed processing are completed to execute, the basic processing or medium-speed processing is resumed from where it was interrupted.

- In case that the medium-speed processing its timing for execution during the basic processing is being executed, the medium-speed processing interrupts the basic processing by making the basic processing pause at the gap among function blocks' basic processing. Once all function blocks of medium-speed processing are completed to execute, the basic processing is resumed from where it was interrupted.

- The high-speed processing of function blocks are executed for each of the control drawings containing the function blocks and in the order of control drawing numbers. Function blocks having the same scan period within the same control drawing are executed in the set execution order (order of the function block numbers defined).
  The medium-speed processing and basic processing of function blocks are executed in the same order as applied to the high-speed processing.

- Processing of each function block is executed only once per single scan period.

- Other processes are executed in the idle time after the high-speed processing, medium-speed processing and basic processing are completed.

● Periodic SEBOL

SEBOL is a programming language used for process control to describe unit step processing of the SFC blocks. SEBOL usually runs during the CPU's idle time. However, FFCS-V is able to run and process the SEBOL according to the scan period. It is called the periodic SEBOL, to segregate it from the conventional type of SEBOL. By using the periodic SEBOL, sequence controls can be described by the programming language applications instead of performing them by the sequence tables or logic charts.

3.4 Online Maintenance Function

Online maintenance function enables the modification of the control functions during online control, without any effect on other than the modified function, namely the effect on plant operation is minimized. Most settings can be modified using online maintenance functions. The settings which can not be modified using online maintenance function are described below.

- FCS power switching from single to dual-redundant
- Fast scan period
- MC (Motor Control) instrument block pulse width setting
- MC instrument block start interval
- MLD-SW block auto mode (AUT/CAS) setting
- SEBOL statement "Drive" statement operation type
- SS-DUAL PV update during deviation alarm
- Alarm notify action when all AOF released
- User-defined status character string
- Alarm processing table
- Alarm priority level
- Status change command character string
- State transition matrix

3.5 Subsystem Communication

FCS can communicate with each subsystem such as PLC or analytical equipments. Subsystem communication function supports dual-redundant communication. CENTUM VP supports the following subsystem communications.

- FA-M3 communication (for Yokogawa's FA-M3 and FA500)

- DARWIN/DAQSTATION communication (for Yokogawa's DARWIN and DAQSTATION)

- MELSEC communication (for Mitsubishi general-purpose MELSEC sequencers)

- MELSEC-A communication (for Mitsubishi general-purpose MELSEC-A sequencers)

- PLC-5/SLC 500 communication (for Rockwell Automation's PLC-5/SLC 500 family of programmable controllers)

- Modbus communication (for Yokogawa's STARDOM, Schneider's Modicon and Yasukawa Electric Corporation's Memocon-SC)

- YS communication (for Yokogawa's YS100 SERIES and YEWSERIES 80)

- YS communication with direct connection (for Yokogawa's YS100 SERIES)

CENTUM VP may be able to communicate with other subsystems that are not listed here. For more details, please contact Yokogawa.
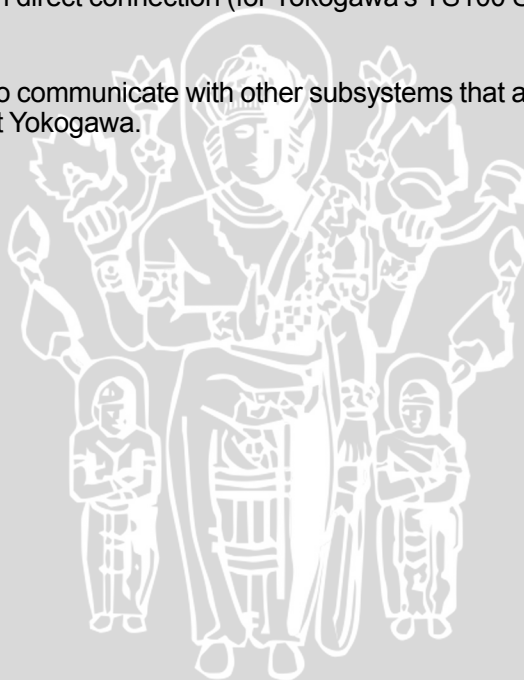
4. Redundancy

FCS is directly connected to processes. Therefore, FCS is required to have high reliability, high availability, data accuracy and data reliability. CENTUM VP FCS responds to these requirements realizing the availability over the best of 99.99999% (seven nines).

This chapter describes the redundancy of FCS supporting this high availability.

4.1 Redundancy Features

In addition to field-proven dual-redundancy technology, synchronous process execution on paired MPUs (microprocessor units) of active and standby processor cards in CENTUM VP FCS realizes seamless execution of each process control functions or user applications regardless of the switching of processor card.

This duplexed FCS has reliable features as follows:

(1) ECC memory (*1), WDT function (*2), and other technologies contribute establishing hardware reliability.

(2) Pair and Spare methodology detects transient control computation errors as well as hardware failures (*3) to avoid wrong data output. In case an error is detected, the active processor card is switched to the other processor card.

(3) Seamless switchover between the active and the standby processor cards is realized. Thus it is not necessary to consider dual-redundancy by software, productivity and quality of the software development have greatly been improved.

(4) One of the redundant processor cards can be replaced online when it is failed while the operation continues without stopping the process.

The features described above are field-proven and reliable technologies developed originally for CENTUM CS and it is inherited by CENTUM VP with enhancements.

*1:   Error check and correct (ECC) memory detects memory error as well as to identify where, in which bit, the error is occurred, and correct it by itself.
*2:   Watch dog timer (WDT) function watches software malfunction and hang up by setting a periodical watch dog operation (timer reset).
*3:   Unrecoverable hardware breakdown.

4.2 Redundancy Details

CENTUM VP FCS is available for dual-redundancy. This FCS consists of dual-redundant processor modules, Vnet/IP coupler, and power modules. For adding FIO node unit is added, install ESB-bus coupler module or ER bus interface module. Both modules can also be dual-redundant. (For dual-redundant FCS, ESB bus interface modules need to be dual-redundant.) Even if one module becomes defective, the control can be switched without interruption.
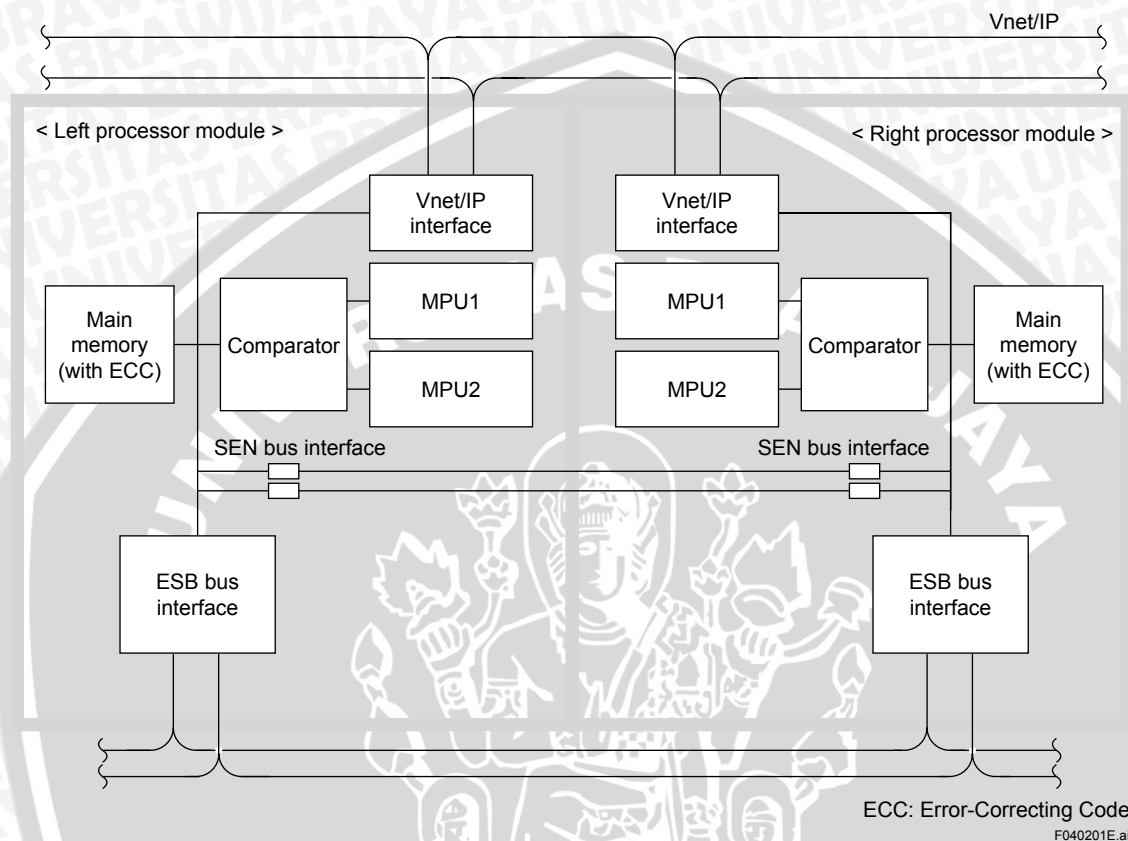

ECC: Error-Correcting Code

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Figure   Example of Duplexed (Dual-redundant) Processor Module Configuration

Dual-redundancy methodology is described below.

■ CPU

- Each processor module has two MPU. MPU1 and MPU2 mounted on each module perform same control computations and the results are compared by a comparator for each calculation. When the results of both MPU are same, the module is assumed to be normal and the results are transmitted to main memory devices and bus interface modules. The main memory devices with ECC (error-correcting code) correct transient reversed-bit errors.

- If the results from MPU1 and MPU2 are not same the comparator assumes it "calculation abnormal", the active processor module is switched to another one.

- Watch Dog Timer detects abnormal functions of active processor module. In case abnormal functions are detected, active processor module would be switched to another processor module.

- The standby processor module performing the same computations as the active module, switching to active status without interruption is possible.

- The processor module with calculation error performs self-diagnosis; if the hardware is not assumed abnormal, the error is assumed transient and the module status recovers from "abnormal" to "standby"

- Vnet/IP interface is an interface available for dual-redundancy mounted on CPU and connected to a dual-redundant control bus.

■ ESB Bus

Each processor module incorporates ESB-bus interface functions being available for dual-redundancy. Normally, ESB-bus interface function on active CPU is active and another is standby. If an abnormal factor is found in ESB function on active CPU, the standby CPU is switched into active. The active ESB-bus interface communicates with node units as master ESB bus. The dual-redundant ESB buses are used alternately; if an abnormal factor is found in one bus, the other bus will be used for communication. The recovery of bus is periodically tested to ensure the recovery.

■ Nodes Unit

In nodes, Node interface module and Node power module can be dual redundant. I/O module bus from Node interface module to each I/O module can also be dual-redundant.

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