Harmonas DEO

Harmonized Automation System — Dependable Open
DOPC™ IV Process Controller

Redundant DOPC IV Process Controller

1. Introduction

The DOPC IV process controller (hereafter called DOPC IV) controls the processes in the Harmonas-DEO™ system. The features of DOPC IV are introduced below.

Hardware Types

- There is a non-redundant type of DOPC IV, in addition to the triple modular redundant type that is used also for DOPC III.

High Reliability & Safety[*1]

- Triple modular redundant (TMR) CPUs are a standard feature. The system delivers continuous control, even with only one CPU.
- TMR architecture (see Fig. 2) ensures high reliability and safety.
- The use of three parallel CPUs means that operation cannot be interrupted by the failure of a unit. There is no lag while a backup takes over.

Advanced Functions

- Large capacity (up to 640 control loops, I/O connections for 120 units)
- Communications capacity of up to 10,000 parameters per second
- Control response calculation as fast as 100 ms
- Integration of function block controllers
- Sequence of event (SOE) recording
- Support for both conventional X-bus (1 Mbps) and FX-bus (5 Mbps) with increased I/O bus communication speed. (Using both bus types for the same controller is not permitted.)
- Three I/O types are supported: distributed I/O, base unit I/O, and signal unit I/O. All three may be used for a single controller.
- DOPC IV can communicate with other controller types (DOPC, DOPC II, DOPC III). It can also communicate with the Open PLC Linker II.[*2]

Powerful Integrated Engineering Environment (RTC)

- In the same engineering environment, it is possible to work on process-related tasks involving points, Control Language, and function block programs.
- By using the Software Simulator,[*3] simulation and debugging can be done without the need for a controller.

*1: The features listed below apply to the redundant type only.
*2: Open PLC Linker II (DOPL™ II) is a programmable logic controller (PLC) that is integrated into Harmonas-DEO.
*3: A software controller that can run on the Harmonas-DEO HMI (Human Machine Interface) or on the user's PC.

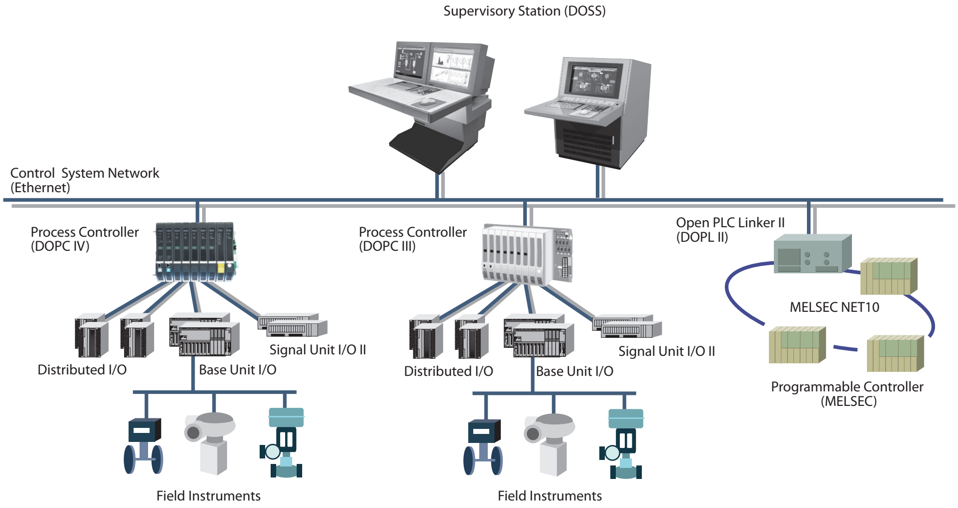

Figure 1. System Architecture

2. Functional Overview

DOPC IV consists of control modules that perform a calculation function, Ethernet modules that communicate with a higher-level network, and X-bus modules that communicate with a lowerlevel I/O network. Designed with powerful user programming functions, the control modules perform various control functions, such as regulatory control, logic control, and sequence control; and they execute I/O-related tasks, such as analog input/output and digital input and output.*1

2.1. Triple Modular Redundant Architecture*2

DOPC IV arranges control modules in a triple configuration*3 in which three control modules simultaneously perform the same calculation function. The Ethernet modules that input and output data to/from the higher-level network and the X-bus modules that input and output data to/from the lower-level network compare the outputs produced by these three control modules. If one of the three outputs differs, the output value from the other two modules is used, according to a two-out-of-three majority rule, so that the correct value is always output.*4

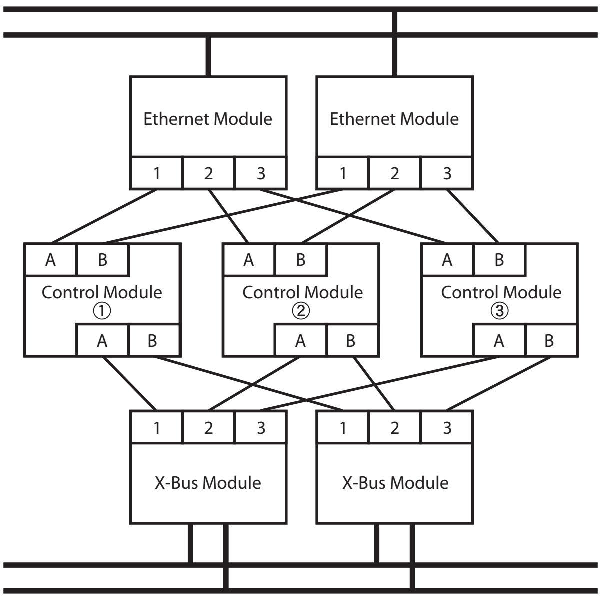

Figure 2. Conceptual Diagram of Triplex CPU Configuration

With a conventional standby redundancy system, there is a lag between the time when one unit of modules ceases to execute tasks and when a backup unit of modules takes over. With the triple module configuration, this time lag does not occur, and switching from the execution unit to the standby unit can be done in a completely uninterrupted manner.

2.2. I/O Subsystems

Table 1 shows the I/O subsystems that can connect to DOPC IV, classified by type and I/O bus communication speed.

Table 1. I/O Subsystems That Can Connect to DOPC IV

Type	Description	I/O bus (communication speeds)
Distributed I/O	With multiple I/O points	FX-bus (5 Mbps)
Base unit I/O (FX-bus)	With multiple I/O points	FX-bus (5 Mbps)
Base unit I/O (X-bus)*5	With multiple I/O points	FX-bus (1 Mbps)
Signal unit I/O II (FX-bus)	With Individually isolated I/O points (Analog type) With multiple I/O points (Digital type)	FX-bus (5 Mbps)
Signal unit I/O II (X-bus)*6	With Individually isolated I/O points (Analog type) With multiple I/O points (Digital type)	FX-bus (1 Mbps)

Distributed I/O

The distributed I/O consists of I/O module bases and I/O modules. Each I/O module base is designed specifically to be used with a particular type of I/O module. Field wiring is connected directly to the input/output terminal on the I/O module base.

One DOPC IV has a capacity of up to 120 modules.*7 Different types of I/O modules can be installed in one DOPC IV on the condition that the number of I/O modules does not exceed 120.*8 Wires can be connected to or disconnected from I/O modules even when they are energized. The analog input/output module and the pulse input module can be made redundant.

*1: Non-redundant DOPC IV has its higher-level network communications function integrated into the main base unit. (There are no separate Ethernet modules.)
*2: This is a feature of redundant DOPC IV only.
*3: Ethernet and X-bus modules use a duplex structure.
*4: If only two control modules are operating, for example during maintenance, and *∂output from one control module becomes unavailable due to a hardware failure or other reason, the majority rule is aborted and the remaining control module continues control.
*5: This is an optional feature.
*6: An optional feature requiring a cable converter.
*7: This assumes that all I/O modules are non-redundant. If all I/O modules are redundant, the maximum is 60 modules.
*8: With some types of I/O modules, there is a limit on the number of installable modules (see Table 3).

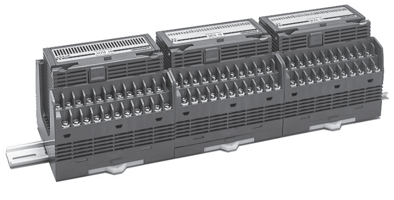

Figure 3. Distributed I/O Module

Table 2. Types of Distributed I/O Module

Module type	Number of I/O points per module	Redundant configuration
High level analog input module	16	Redundant
Low level input module	16	Non-redundant
RTD input module	16	Non-redundant
Digital input module	32	Non-redundant
Digital sink input module	32	Non-redundant
Digital input module with SOE	32	Non-redundant
Pulse input module	8	Redundant
Pulse sink input module	8	Redundant
Analog output module	16	Redundant
Digital output module	32	Non-redundant
Relay digital output module	16	Non-redundant

Table 3. Maximum Installable Distributed I/O Modules

Module type	Number of ports	Number of modules
Serial communication modules	2	8
Extended serial communication modules	1	4

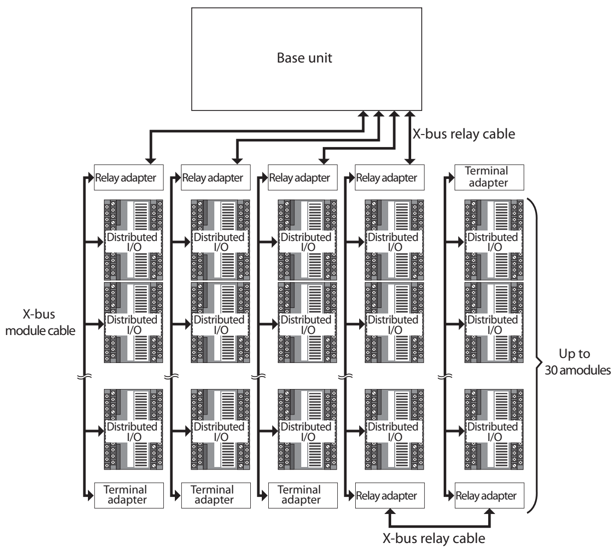

Figure 4. Distributed I/O connection diagram

Base Unit I/O (FX-bus/X-bus types)

Base unit I/O is either the FX-bus type or the X-bus type, differing in the communications speed of the I/O bus. Each bus type consists of I/O base units and I/O modules. Unlike the case of distributed I/O, one I/O base unit can accept a maximum of 12 connected I/O modules.

Base unit I/O can be connected to field wiring in two different ways: (1) direct connection to the input/output terminal of the I/O module (the FTB method) and (2) connection via a special cable to the input/output terminal of the I/O module (the RTP method).

A maximum of 96 modules can be connected to one DOPC IV.[*1] Different types of I/O modules can be combined freely if the number does not exceed 96.[*2]

Wires can be connected to and disconnected from I/O modules even when they are energized. The analog input/output module and the pulse input module can be made redundant.

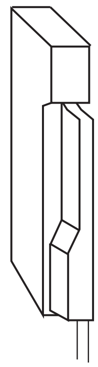

Figure 5. Distributed I/O connection diagram

Table 4. Types of Base Unit I/O Module

Module type	Number of I/O points per module	Redundant configuration	X-bus	FX-bus
High level analog input module	16	Redundant	●	●
High level multiplexer module	16	Non-redundant	●	
Low level multiplexer module	16	Non-redundant	●	
Low level input module	16	Non-redundant		●
RTD multiplexer module	16[*3]	Non-redundant	●	
RTD input module	16	Non-redundant		●
Analog output module	16	Redundant	●	●
Digital input module	32	Non-redundant	●	●
Digital output module	32	Non-redundant	●	●
Relay digital output module	16	Non-redundant	●	●
Pulse input module	8	Redundant	●	●

*1: If all I/O modules are non-redundant, 96 can be connected. If they are all redundant, a maximum of 48 modules can be connected.
*2: However, a module with a multiplexer (X-bus type only) must be used with a high level analog input module.
*3: The number of input points is 12 if the RTD multiplexer module is connected using the FTB method. It is 16 if it is connected using the RTP method.

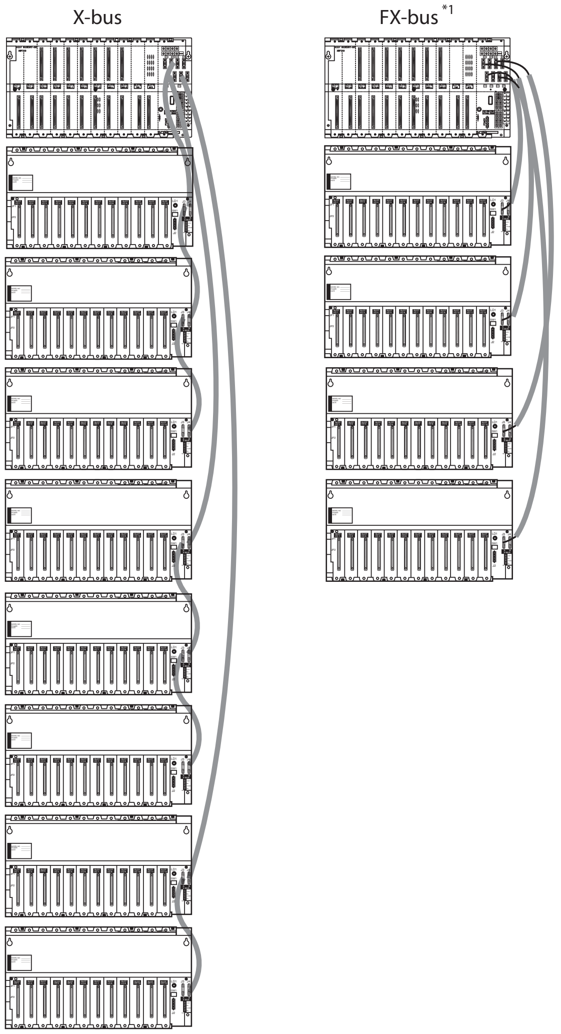

Figure 6. Base Unit I/O Connection Diagram

Signal unit I/O II (SIO II)

The signal unit I/O II (hereafter called SIO II) has analog I/O with individual isolation between input (or output) and the power supply and between units (500 Vac dielectric strength), or digital I/O *2 consisting of 32 photocoupler-isolated inputs and 32 semiconductor outputs.

[With analog I/O]

SIO II consists of signal units, a base unit, and FX-bus communication module(s). Up to 16 signal units can be mounted on a base unit and FX-bus communication modules can be configured for redundancy. Signal units and FX-bus communication modules can be hot-swapped. The analog input unit also has a transmitter power supply function (4–20 mA input).

Each channel can be set for its own input signal type. The input sensor type can be configured using the Signal Unit I/O-II Communicator.

[With digital I/O]

This SIO II consists of a base unit, digital input (DI) or digital output (DO) modules. With a base unit for relay terminal blocks and relay cables, the equipment can be connected to a relay terminal block. Also, if two modules are mounted on the base unit for redundant relay terminal blocks, 64 inputs/outputs are available.

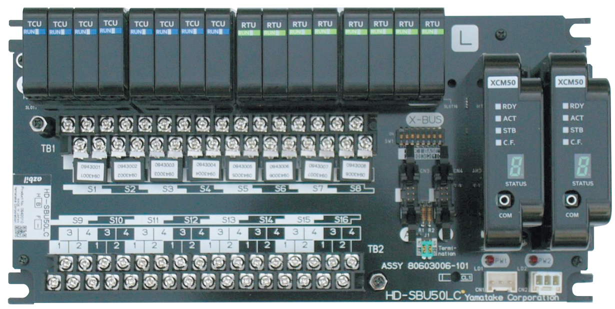

Figure 7. Signal Unit I/O II (analog I/O)

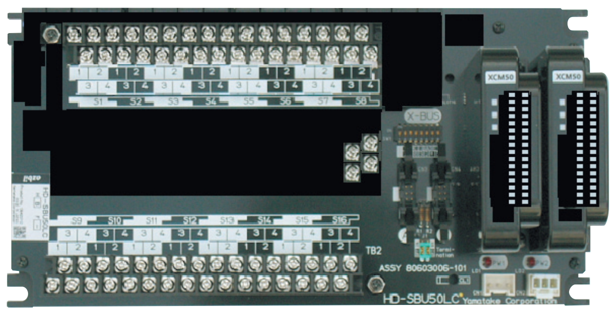

Figure 8. Signal Unit I/O II (digital I/O)

Table 5. Signal unit I/O II (analog)

Unit type	Main features	I/O points per unit
Analog input unit	1–5 V / 4–20 mAdc (converted to 1–5 V by a 250 Ω resistor)	1
Analog output unit	4-20 mAdc	1
Resistance temperature detector (RTD) input unit	JPt100, Pt100, JPt50, Ni508.4	1
Thermocouple (TC) input unit	T, J, E, K, R, S and mV	1
Accessory unit	Installed into an empty slot.	

Table 6. Signal unit I/O II (digital)

Module Type	Main features	I/O points per module
Digital output module	32 semiconductor outputs Compatible with DOPC IV and later	32
Digital input (source input) module	32 source inputs Compatible with DOPC IV and later	32
Digital input (sink input) module	32 sink inputs Compatible with DOPC IV and later	32

*1: If the FX-bus type is used, multiple I/O base units cannot be connected in a daisy chain configuration, which is not the case with the X-bus. To connect 4 or more I/O base units to one controller, electric repeaters must be used.

*2: An SIO II with digital I/O can be used only with DOPC IV.

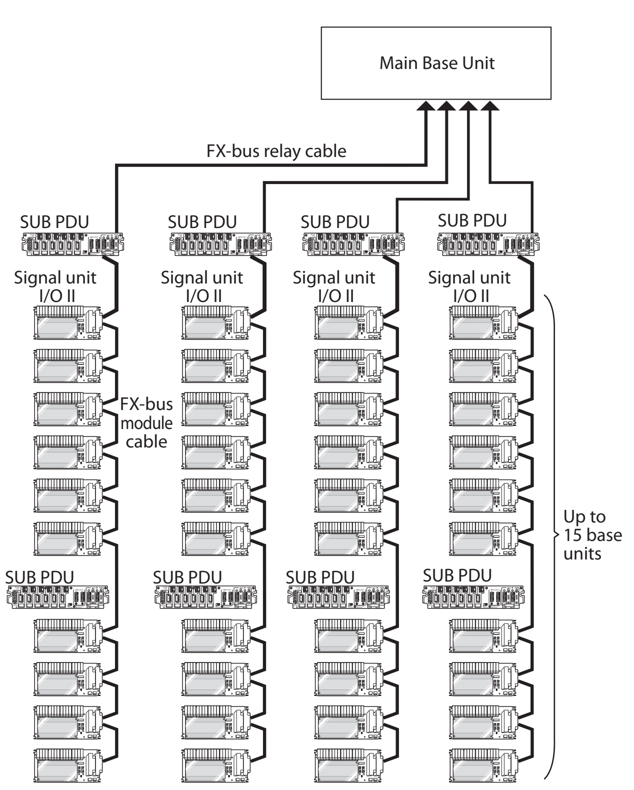

Figure 9. Signal Unit I/O II Connection Diagram

Remote I/O

The combined use of X-bus or FX-bus, extender modules, and electric repeaters allows DOPC IV to provide a remote I/O function.

By using X-bus or FX-bus, extender modules, and optical fiber cables, I/O modules can be placed at up to remote 4 sites, a maximum of 400 m from the cabinet (with a star connection).*1 These I/O modules at remote sites operate the same way as other electrically connected I/O modules (X-bus or FX-bus) of the same DOPC IV.

Because two I/O modules can be connected to one electric repeater,*2 a special wire cable, which is less expensive than optical fiber, can be used to install them at two different remote sites. By using two or more electric repeaters, the number of I/O modules at remote sites can be increased at a lower cost than with optical fiber cables. The use of this remote I/O function makes it possible to reduce cable and wiring costs substantially.

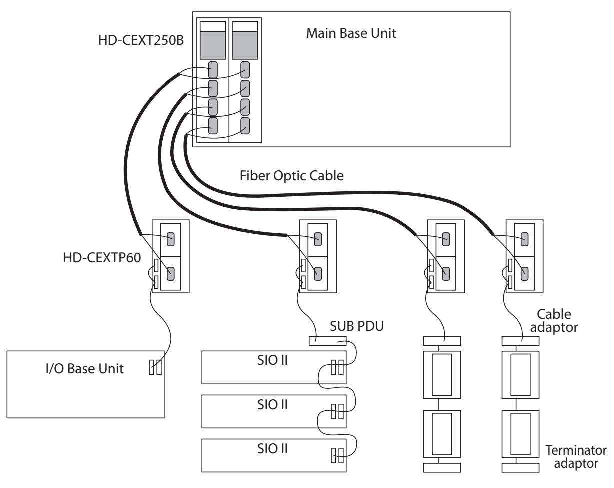

Figure 10. Example of a Remote I/O Connection Using FX-bus and Extender Modules

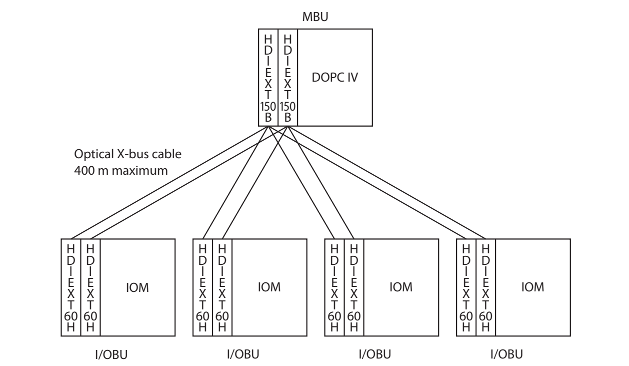

Figure 11. Example of a Remote I/O Connection Using X-us and Extender Modules

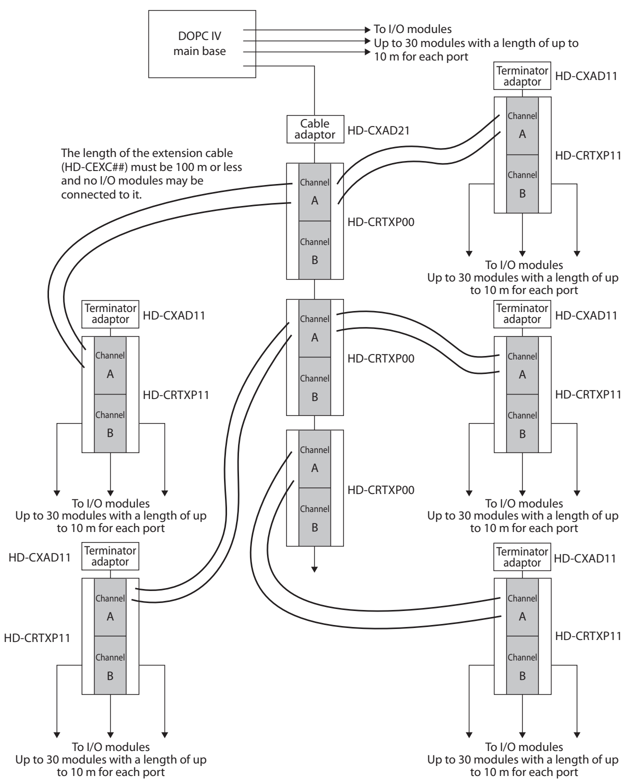

Figure 12. Example of a Remote I/O Connection Using Electric Repeater Modules

*1: For distances of 400 m or more, please consult with our nearest branch office.
*2: Electric repeaters can be used with the FX-bus (5 Mbps) only.

3. I/O Processing and Control Functions

DOPC IV provides a variety of control functions that meet a wide range of application needs for process automation. Control functions ranging from I/O processing to regulatory control, sequence control, logic control and more advanced control functions are easily implemented. These functions consist of functional units referred to as "data points." Broadly speaking, data points can be divided into two types, I/O points and control points. Online maintenance can be done on a point-by-point basis.

3.1. I/O Monitoring Functions (I/O Points)

The I/O monitoring function scans I/Os and executes I/O processing tasks. Input or output signals are acquired from the I/O subsystem and sorted into specific I/O point types according to the type of signal. They are then converted into engineering units and used to perform control tasks.

Since, with DOPC IV, I/O modules can be added or removed in online mode, the I/O monitoring range can be expanded during operation.[*1]

Sequence-of-event (SOE) recording is supported.[*2] This function is for monitoring a change in the conditions of digital input signals, recording it in increments of 1 ms, and transmitting it to higher-level devices.

Analog Input Points

High and low level analog input points carry out the functions noted below for signal conversion and signal processing. They also do conversion of industrial units. In addition, high level analog points linearize temperature inputs received from the MV/I converter.

- PV source selection (auto, manual and substitution)
- PV clamp
- Conversion of industrial units
- PV value status
- PV filter
- PV alarm:
    - Bad PV
    - PV high/low
    - PV high high and low low
    - PV change rate

Analog Output Points

Analog output points provide the following functions:

- Open circuit detection
- Linearization of output signals (five segments)
- Setup of output values in case of failure (hold or power off condition per module)
- Mode related function: DDC control

Digital Input Points

Digital input points provide the following functions:

- Input integration (maximum pulse rate = 15 Hz)
- Latch and status type input: detectable one-shot signal width (status input = scan cycle; latch input = 130 ms; slow counter input = 30 ms)
- Setting of alarm dead time
- Direct/Reverse processing of inputs
- PV source selection (auto, manual and substitution)
- Status alarm
- Sequence of event (status change scan performed every 1 ms)

Digital Output Points

Digital output points provide the following functions:

- Output type (each point configurable):
    - Status
    - Latch
    - Momentary
    - Pulse width modulation
- Predefinition of behavior (for example, hold output or turn power off) on a per-module basis if a problem develops.

Pulse Input Points

Pulse input points provide the following functions:

- Pulse input integration (totalizing)
- Contact or open collector input (2- or 3-wire system voltage pulse can be entered by using a system pack pulse conversion module.)
- Pulse rate of up to 5 kHz
- Instantaneous value calculation and industrial unit conversion
- PV source selection (auto, manual and substitution)
- PV value status
- PV filter
- PV alarm
- Integration function (use of regulatory PV totalizer algorithm)

3.2. Control Functions (Control Points)

Control functions are classified into the following types of control point:

Regulatory PV Point (RegPV)

Standard I/O processing functions, like industrial unit conversion and alarms, are directly carried out by the above-mentioned I/O monitoring functions. The regulatory PV point performs process variable (PV) calculations and compensation functions. PV processing is accomplished using algorithms such as flow rate compensation, integration and variable dead time compensation. Detailed configuration possibilities include alarm suppression, signal filtering, and algorithm and calculation formula options. For available algorithms and other supported functions, see Table 7.

Table 7. Regulatory PV Point Features

Algorithms	Functions
Data acquisition Flow rate compensation Middle of three High/low/average selector Summing Integration (totalizer) Variable dead time lead/lag compensation General linearization Calculator algorithm	PV source (automation, manual, substitution) PV clamp Engineering unit conversion and extended PV range check PV status PV filtering PV alarm - Bad PV - High/low PV limits - High high and low low PV limits

Regulatory Control Point (Reg Ctl)

Regulatory control points are used to carry out the control functions of DOPC IV. Configuration of the algorithms listed in Table 8 determines the regulatory control point functions. Each algorithm has configurable options, allowing complicated control to be achieved by simple menu selection. Standard functions include initialization and windup protection. Set point lamping (by operator entry of target values and lamp time) is also available.

*1: This function can be used only with DOPC IV. To remove or move an I/O module, related points or sequences must be made inactive, deleted, stopped, etc. Also, to change the number of control points of a controller, etc., the controller must be in IDLE mode (as usual when making such a change).

*2: To use the SOE function, it is necessary to use a digital input module with SOE.

Table 8. Regulatory Control Point Features

Algorithms	Functions
PID	Mode/mode attribute
With PID field forward	Red tag
With PID external feedback	Initialization
Position proportion on/off control	Windup protection
Ratio control	External mode switchover
Lamp/soak	Safety cutoff
Automatic/manual station	Limit (output)
Speed type addition	PV source
Switch	PV alarm
Override selector	- Bad PV
	- High/low PV limits
	- High high and low low PV limits

Digital Composite Point (Dig Comp)

Digital Composite points are multi-input and multi-output points that provide an interface to discrete equipment, like motors, pumps and solenoid valves. Digital Composite points provide interlock processing functions as a standard feature. Dig Comp points can also display interlock states on the screen of an open supervisory station. The displayed states have information effective for tracking the cause of the interlock. The local "hand/ off/ auto" switches generally used for motor driving equipment can also be handled. Figure 13 shows the major parameters related to this type of control point.

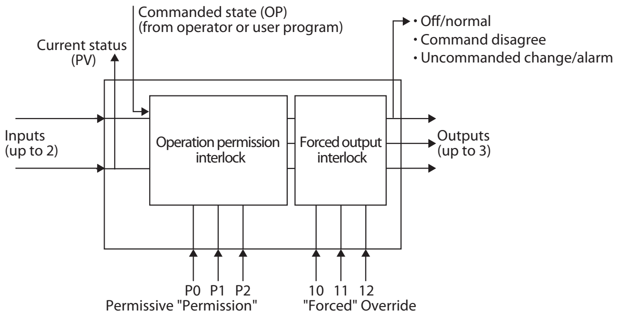

Figure 13. Structure of Digital Composite Points

Logic Point (Logic)

Logic points are used with digital composite points to provide interlock logic functions. A logic point has the processing equivalent of up to two pages of relay ladder logic. A logic point consists of a logic block, flag, numeric value variable, input connection and output connection. There are three possible configurations of logic point inputs, outputs, and logic blocks (see Table 9). In addition to offering logic block functions, logic points can also be used for data transfer. In this role they read data from input connections and transfer it via output connections to the parameters of other defined databases.

Table 9. Configuration Options for Logic Points

Configuration / Type	Max. Inputs	Max. Outputs	Max. Logic blocks
Option 1	12	4	16
Option 1	12	8	8
Option 1	12	12	0

Note: Each logic point provides six status flags, six user flags and four numeric value variables.

Table 10. Logic-Block Algorithms

Logic	AND OR NOT NAND NOR XOR QUALIFIED-OR2 (2-input agreement) QUALIFIED-OR3 (3-input agreement)
Comparison	EQ (= dead band) NE (dead band) GT (> dead band) GE (= dead band) LT (< dead band) LE (= dead band)
Delay	DELAY ON DELAY OFF DELAY
Pulse	FIXPLS (fixed length pulse) MAXPLS (maximum time limit pulse) MINPLS (minimum time limit pulse)
Watch dog timer	W A TCHDOG
Flip flop	FLIPFLOP
Input error check	CHECKBAD
Switch	SWITCH
Change detection	CHDETECT

Function Block Point (FB)

A function block point offers 92 different types of function blocks (see Table 10) and up to 8191 functions can be used in a single point. Function blocks conform to the SAMA (Scientific Apparatus Makers Association) block notation system. The user arranges function blocks in a logic diagram to construct control functions.

Table 11. Function Block Algorithms

Arithmetic operation (8 types)	ADD (addition) MOD (modulo)	SUB (subtraction) EXPT (exponent xy)	MUL (multiplication) SUM (4-point addition)	DIV (division) DADD (digital addition)
Single number value variable (13 types)	ABS (absolute value) LOG (customary logarithm) TAN (tangent) PSQRT (percent square root)	SQR (square) EXP (exponent ex) ATAN (arctangent)	SQRT (square root) SIN (sine) TRUNC (truncation)	LN (logarithm natural) COS (cosine) ROUND (rounding)
Selection (9 types)	MAX (maximum value) HSE (high selector) SW (switch)	MIN (minimum value) LSE (low selector) SFT (softening switch)	AVG (average value) MID3 (middle of three) ALSW (alternate switch)	
Detection (12 types)	HLM (high limiter) LLM (low limiter) DRL (rate-of-change limiter) HMS (high monitor)	LMS (low monitor) DRM (rate-of-change monitor) DMS (deviation monitor) NUMCHK (normality check)	BADCHK (badness check) INFCHK (infinity check) QLTCHK (change check 1) CHGCHK (change check 2)	
Conversion (4 types)	PTE (EU value conversion)	ETP (% conversion)	FUNC (function conversion)	CONV (data type conversion)
Logical operation (11 types)	AND (logical product) NOR (inverted logical sum) RS (reset)	OR (logical sum) XOR (exclusive logical sum) ORIN4 (4-input logical sum)	NOT (inversion) QOR2 (2-input majority decision) ANDIN4 (4-input logical product)	NAND (inverted logical product) SR (set)
Comparison (6 types)	EQ (= dead band) band)	NE (LT (< dead band)	dead band) LE (= dead band)	GT (> dead band) GE (= dead
Pulse (3 types)	FIXPLS (fixed length pulse) pulse)	MAXPLS (maximum time limit pulse)		MINPLS (minimum time limit
Timer (5 types)	CYCPLS (timer) OFFDLY (off delay)	WDT (watch dog timer)	DELAY (delay)	ONDLY (on delay)
Counter (4 types)	UCNT (up counter)	DCNT (down counter)	AAV (analog integration)	PAV (pulse integration)
Control operation (8 types)	PID (PID operation) LDLG (leading/delay)	PRO (proportion) DED (waste time)	INT (integration) TF (filtering time)	DIF (differentiation) DLTPV (speed type PV)
Others (9 types)	RMP (lamp) SG (single) ANFP (analog faceplate)	MAV (movement average) FL (flag)	ANMA (analog memory) TIMFL (one shot FL)	GW (gateway) REDTAG (read tag)

Process Module Data Point (Proc Mod)

Process control often requires flexible control programs that can be used for continuous, batch, or hybrid applications. A process module data point is a user-created program (CL program) written in a special-purpose control language. This language provides powerful sequence control and calculation functions. CL programs can access analog input and output, digital input and output, logic block status, alarm status, failure status, numeric value variables, and flags. Process module data points provide phase, step and statement structures suitable for implementing batch process control functions. They can also activate a sequence for hold, shutdown, or emergency shutdown, making use of the powerful functionality of multilevel error processing.

Flag Point

Flag points indicate two states, such as on and off, and accept input of Boolean algebra values. Flag points can be changed by operators or user programs. DOPC IV allows up to 8192 flags, 2048 of which support off-normal alarms (a change from steady state generates the alarm).

Numeric Value Variable Point

Numeric value variable points are variables that save numeric values, which is especially useful for batch (recipe) operations. In DOPC IV, 9999 numeric value variable points are available.

Timer Point

Timer points are used by both operators and user programs to supervise process events. Timer points are processed once every second. DOPC IV has 768 available timer points.

Character string variable points

Character string variable points maintain text data with up to 64 characters (or 32 double-width Asian characters). They are useful for online sending of messages with character strings that vary. Character string variable points can be changed by operator or user program. There are 128 available character string variable points per DOPC IV. Even if character string variable points are defined, they are not included in the point processing schedule.

Date variable points

Date variable points store values that indicate a date and time or a period. If dates and times are used, 00 hours 00 minutes 00 seconds on January 1, 1997 is the start (zero) point. Date variable points are changed by operators or user programs. There are 128 available date variable points per DOPC IV. Even if date variable points are defined, they are not included in the point processing schedule.

Numerical array variable points

Each numerical array variable point stores an array of 100 numerical variables. They are useful in batch (recipe) operations. There are 240 available numerical array variable points per DOPC IV. Numerical array variable points are not included in the point processing schedule.

4. Alarm System Functions

DOPC IV supports a variety of alarm functions. When an alarm occurs, notifications appear at the open supervisory station on various types of screens. Alarms are generally classified as PV alarms or digital alarms.

PV Alarms

For process variables, configurable PV alarms are as follows. Alarms can be set in both I/O points and control points. In general, if a control point uses an I/O point, the alarm is set in the control point. Otherwise, it is set in the I/O point.

- High
- High high
- Low
- Low low
- Change rate high
- Change rate low
- Significant change
- Bad PV

A dead band can be set for the above high, high high, low, and low low alarms.

Digital Alarms

There are three types of digital alarm:

- Off-normal alarm
- Uncommanded change alarm
- Command disagree alarm

Off-normal alarms are generated when the PV is abnormal. Both uncommanded change alarms and command disagree alarms are set within digital composite points and detect a disagreement between input and output. A command disagree alarm detects a disagreement between input and output just after an output change, while an uncommanded change alarm detects a disagreement between input and output when no output change has been made. A dead band time can be set for the off-normal digital input alarms.

Alarm Priority

Alarm priority can be configured for individual alarm types for each point. A choice of seven alarm priorities can be assigned:

- Emergent (emergency)
- Important (high)
- Ordinary (low)
- Record only (journal)
- Print only (printer)
- Record and print only (journal printer)
- None (no action)

Contact Cutout

The contact cutout function allows a program to temporarily stop an alarm for each point having alarm functions. The "CONTCUT" parameter, which is available for points having alarm functions, can be turned on to put points in the alarm stop status.

5. Processing Performance

By combining adjustment control loops, logic functions, and sequence and I/O processes, DOPC IV tailors control functions to fit the needs of specific applications. Configuration needs to take into account restrictions on the maximum number of points per DOPC IV, the processing unit (PU) value, which is a unit of processing capability, and the memory unit (MU) value, which is the permitted memory size for a CL program.

Maximum Number of Points

Limits on the number of points settable per DOPC IV are as follows.

Table 12. Maximum Number of Points Per DOPC IV

Point type	Maximum number of points
Regulatory control	640
Regulatory PV	320
Process module	512
Logic	320
Digital composite	1024
Function block	511
Numeric value variable (NN)	9999
Flag variable (FL)	8192 (2048 with an alarm)
Timer variable (TM)	768
Character string variable (STR)	128
Date variable (DT)	128
Numerical array variable (NAR)	240
I/O	(No. of points per module × 120)

Maximum Number of Blocks

The following restrictions apply to function blocks, which are components of function block points.

Table 13. Maximum Number of Function Blocks

Per function block point	8191 blocks
Per DOPC IV	16383 blocks

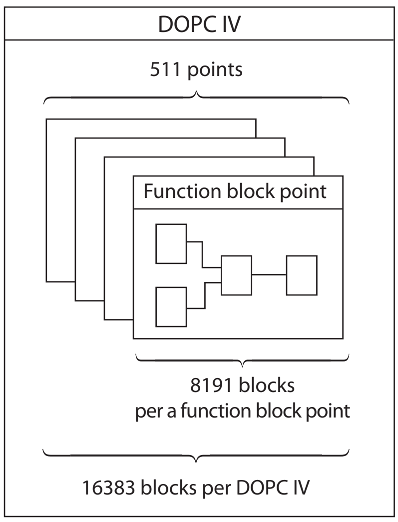

Figure 14.

Processing Unit (PU Value)

This unit represents the processing capability of the DOPC IV, based on factors such as the point types and control cycles. The following table lists the maximum PU values per DOPC IV and PU values for types of points.

Table 14. Maximum PU Value (Per DOPC IV)

Point type	PU value
Total of control points and function blocks	1520
Total of I/O points	1520

Table 15. List of PU Values (control cycle = 1 s).*1

Control Point

Control Point Name	1 s PU Value
RegPV	0.70
RegCtl	1.00
Logic	1.48
DigComp	0.22
ProcMod(short)	1.00
ProcMod (long)	2.00

X-bus (1 Mbps) I/O Module

I/O Module Name*2	1 s PU Value	500 ms PU Value	200 ms PU Value	100 ms PU Value
High-level analog input (redundant)	37.00	62.90	140.80	270.60
High-level analog input (non-redundant)	30.10	53.20	122.50	237.90
High-level multiplexer analog input	19.30	-	-	-
RTD multiplexer analog input	24.30	-	-	-
Low-level multiplexer analog input	25.70	-	-	-
Analog output (redundant)	41.00	69.70	155.90	299.60
Analog output (non-redundant)	22.60	39.90	92.00	178.70
Digital input (STATUS)	15.40	28.10	66.00	129.30
Digital input (LATCH)	29.60	43.90	86.80	158.30
Digital input (ACCUM)	86.10	107.40	171.20	277.50
Digital input (STATUS) redundant *3	16.80	29.50	67.40	130.70
Digital input (LATCH) redundant *3	37.20	51.50	94.40	165.90
Digital input (ACCUM) redundant *3	118.60	139.80	203.60	309.90
Digital output (STATUS)	14.10	23.70	52.20	99.80
Digital output (PULSE)	26.30	37.40	70.70	126.10
Digital output (PWM)	26.30	37.40	70.70	126.10
Digital output (PULSE (25 ms))	75.60	92.30	142.70	226.60
Digital output (PWM (25 ms))	75.60	92.30	142.70	226.60
Digital output (STATUS) redundant *3	26.00	45.00	102.10	197.30
Digital output (PULSE) redundant *3	45.00	67.17	133.70	244.60
Digital output (PWM) redundant *3	45.00	67.17	133.70	244.60
Digital output (PULSE (25 ms)) redundant *3	121.70	155.30	256.00	423.80
Digital output (PWM (25 ms)) redundant *3	121.70	155.30	256.00	423.80
Pulse input (redundant)	36.70	61.10	134.40	256.60
Pulse input (non-redundant)	25.10	44.40	102.30	198.90
Serial communication	60.10	-	-	-

FX-bus (5 Mbps) I/O Module

I/O Module Name*2	1 s PU Value	500 ms PU Value	200 ms PU Value	100 ms PU Value
High-level analog input (redundant)	25.00	39.00	81.00	151.00
High-level analog input (non-redundant)	21.00	35.00	77.00	147.00
RTD input	21.30	-	-	-
Low level analog input	21.30	-	-	-
Analog output (redundant)	28.70	45.10	94.40	176.60
Analog output (non-redundant)	13.40	21.70	46.30	87.40
Digital input (STATUS)	7.70	12.50	27.10	51.50
Digital input (LATCH)	20.10	25.00	39.60	64.00
Digital input (ACCUM)	69.70	74.60	89.20	113.60
Digital input (STATUS) redundant *3	9.00	13.90	28.50	52.90
Digital input (LATCH) redundant *3	27.70	32.60	47.20	71.60
Digital input (ACCUM) redundant *3	102.20	107.00	121.70	146.00
Digital output (STATUS)	5.90	7.20	11.10	17.70
Digital output (PULSE)	16.60	17.90	21.80	28.30
Digital output (PWM)	16.60	17.90	21.80	28.30
Digital output (PULSE (25 ms))	59.40	60.00	61.80	69.90
Digital output (PWM (25 ms))	59.40	60.00	61.80	64.90
Digital output (STATUS) redundant *3	9.50	12.10	20.00	33.00
Digital output (PULSE) redundant *3	24.10	25.30	29.00	35.00
Digital output (PWM) redundant *3	24.10	25.30	29.00	35.00
Digital output (PULSE (25 ms)) redundant *3	89.40	90.60	94.30	100.30
Digital output (PWM (25 ms)) redundant *3	89.40	90.60	94.30	100.30
Pulse input (redundant)	25.60	39.00	79.20	146.10
Pulse input (non-redundant)	16.50	27.10	59.10	112.30
Serial communication	48.70	-	-	-
Extended serial communication	313.50	-	-	-
Digital input with SOE	29.00	33.80	48.40	72.80

Function Block

Function Block	1 s PU Value	Function Block	1 s PU Value	Function Block	1 s PU Value
ADD	0.027	LLM	0.018	LE	0.027
SUB	0.027	DRL	0.044	FIXPLS	0.027
MUL	0.027	HMS	0.018	MAXPLS	0.027
DIV	0.027	LMS	0.018	MINPLS	0.027
MOD	0.022	DRM	0.044	CYCPLS	0.031
EXPT	0.027	DMS	0.027	WDT	0.027
SUM	0.031	NUMCHK	0.018	DELAY	0.018
DADD	0.031	BADCHK	0.018	ONDLY	0.031
ABS	0.018	INFCHK	0.018	OFFDLY	0.031
SQR	0.018	QLTCHK	0.018	UCNT	0.022
SQRT	0.018	CHGCHK	0.027	DCNT	0.022
LN	0.027	PTE	0.022	AAV	0.031
LOG	0.027	ETP	0.022	PAV	0.031
EXP	0.027	FUNC	0.031	PID	0.083
SIN	0.027	CONV	0.035	PRO	0.027
COS	0.027	AND	0.022	INT	0.053
TAN	0.027	OR	0.022	DIF	0.070
ATAN	0.027	NOT	0.022	LDLG	0.044
TRUNC	0.027	NAND	0.022	DED	0.040
ROUND	0.027	NOR	0.022	TF	0.053
PSQRT	0.018	XOR	0.022	DLTPV	0.027
MAX	0.031	QOR2	0.027	RMP	0.035
MIN	0.031	SR	0.022	MAV	0.048
AVG	0.031	RS	0.022	ANMA	0.031
HSE	0.027	ORIN4	0.031	GW	0.022
LSE	0.027	ADDIN4	0.031	SG	0.018
MID3	0.031	EQ	0.027	FL	0.018
SW	0.027	NE	0.027	TIMFL	0.031
SFT	0.044	GT	0.027	REDTAG	0.009
ALSW	0.022	GE	0.027	ANFP	0.031
HLM	0.018	LT	0.027		

*1: The PU values in the table assume a 1 second control cycle. If the control cycle is shorter, the PU value is greater.
*2: The PU values for I/O are per module.
*3: Redundant digital inputs and outputs can be used only for DOPC IV.

Memory Unit (MU) Value

The MU value is determined by the total size of the CL programs. It indicates to the user how much DOPC IV memory is available. The MU value tells only the amount of memory used to store the CL programs themselves.

For MU value calculation, a CL program is divided into units of about three statements each. The MU value is then found by the number of units. Each unit is called a CL block, with 1 CL block = 1 MU. The maximum MU value per DOPC IV is 48640.

In contrast to PU values, MU values are not affected by control cycles or the number of I/O points.

Control Cycles

Control cycles are selectable per DOPC IV from among 1 s, 500 ms, 200 ms and 100 ms (for combinations, see Table 15). Not only the control cycles, but also some of the data points can be processed at high speed (100 ms) by means of the fast scan function.

Table 16. Combination of Control Cycles

SCANRATE Parameter	Point Type			
	RegcTl, RegPV	Logic, DigComp	PromMod	FB
Reg1 Log1	1 s	1 s	1 s	Selection of the following control cycles per point - 1 s - 500 ms - 200 ms - 100 ms
Reg1 Log2	1 s	500 ms	1 s	
Reg1 Log5	1 s	200 ms	1 s	
Reg1 Log10	1 s	100 ms	1 s	
Reg2 Log2	500 ms	500 ms	1 s	
Reg2 Log5	500 ms	200 ms	1 s	
Reg2 Log10	500 ms	100 ms	1 s	
Reg5 Log5	200 ms	200 ms	1 s	
Reg5 Log10	200 ms	100 ms	1 s	
Reg10 Log10	100 ms	100 ms	1 s	
Fast scan	100 ms	100 ms	100 ms	

Scheduling

In control point scheduling, calculation cycles are automatically assigned to points based on the control cycle and point-mix so that DOPC IV can smoothly execute 100 ms processing cycles. So that each second can be divided into ten equal parts, processing in each 100 ms segment is limited to 152 PU.

Either AUTO or I/O MANUAL can be selected for scheduling of I/O modules.

If AUTO is selected, DOPC IV will assign calculation cycles to modules automatically. I/O module calculations are scheduled based on the control cycle and I/O module definition so that DOPC IV can smoothly execute each 100 ms processing cycle.

If I/O MANUAL is selected, specify a calculation cycle separately for each module. In this case, processing in each 100 ms can include up to 180 PU. (However, the limit on the total, a maximum of 1520 PU, is unchanged.) Also, if I/O MANUAL is selected, I/O modules can be added or removed while DOPC IV is in standby mode.

Communications capabilities

DOPC IV allows accesses of up to 10000 parameters per second, or 200 packets*1 per second, per unit, including input/ output connections, accesses using the read/write statements of CL/DOPC, and accesses to and from the DOSS node and other devices in the network.

*1: Packets are blocks of parameters. DOPC IV transmits and receives parameters in packets.

6. Smart Debug

The smart debug function can check operations of various control functions and I/O processing functions provided by DOPC IV without using I/O modules.

This function can be carried out for individual DOPC IVs. After the transition to the debug mode, the function neither receives input from I/O modules nor transmits output to I/O modules, except for performing controlling operations within DOPC IV and I/O processing operations.

Engineers can set any desired values on DOPC IV as virtual process data, making the debugging of CL programs, etc., easy. Engineers can operate and supervise the status of the debug mode on the open supervisory station.

7. Software Simulation

The software simulation function (optional) allows stand-alone PCs to carry out DOPC IV functions virtually. The function allows the user to create and debug applications in an environment without actual connected devices. One PC can carry out virtual operations for more than one DOPC IV.

8. Auto Restart

DOPC IV offers various options for restart processing, as determined by the restart type specified before operation begins and by the results of self-diagnosis performed at the time of restart. No operator intervenes in this operation.

8.1. Cold Restart

A cold restart takes place as the first startup after system installation or database initialization. A database load is required for the startup to be performed. A cold restart requires that the DIP switch on the base unit be set to the ON position.

8.2. Warm Restart

The usual restarting method. This method is used for startup after power failures, which put DOPC IV in a sleep state. Warm restart is designed to minimize startup operation. Control loops that send output to field devices are put into manual mode. For the restart sequence, either automatic start, stop at the first step, or stop at the final execution position can be selected. This restart process requires that the DIP switch on the base unit be set to OFF. Additionally, the inputs of external terminals need to be set to OFF (open) status.

8.3. Hot Restart

Hot restart is for automatic recovery from a brief interruption. Process control restarts with the contents of the databases unchanged from their status just before the interruption. The databases are not reinitialized. Hot restart requires setting the DIP switch on the base unit to OFF, and requires the inputs of external terminals be turned ON (closed).

9. Designed-in Safety and Reliability

DOPC IV incorporates various elements of safe and reliable design to maximize the process operation rate and minimize downtime. The overall design of DOPC IV aims for high reliability and safety over the circuits and entire system architecture. For instance, a decrease in the overall number of parts used for executing functions improves the reliability of DOPC IV. In addition to the use of heat resistant parts, adoption of CMOS technologies achieves high reliability as well as a high density design. Redundancy in X-bus communications is provided as a standard function. Optional redundancy of I/O modules can provide high-level analog inputs and analog outputs and pulse inputs with one-to-one backup and automatic switchover. Redundancy in network communications can be achieved by duplicating the communications modules.

DOPC IV employs a wide range of self-diagnostic functions for problem detection. Problems can be classified as major failures (HF) and minor failures (SF). DOPC IV status is indicated with LED lamps on the modules or is displayed on the system status screen of an open supervisory station.

Module replacement makes DOPC IV maintenance easy. Hot swapping with power turned on is also allowed for all modules.

10. Hardware Configuration

DOPC IV consists of a base unit and various modules installed in the unit. The structure of the base unit allows the base unit itself to be housed in a standard cabinet or to be mounted on a control board. All modules, including I/O modules, can be driven by 24V DC power supply and can be hot-plugged.

10.1. Control Communications Block

DOPC IV control communications blocks come in two types, as shown in Table 17. The difference between them is the X-bus communication speed and the resultant main base unit required to support the specific speed.

Table 17. Control Communications Block Types

Communication speed	Redundancy	Main unit
FX-bus (5 Mbps)	Redundant	HD-DCDDB00
X-bus (1 Mbps)	Redundant	HD-DCDDB01
FX-bus (5 Mbps)	Non-Redundant	HD-DCSDB001
X-bus (1 Mbps)	Non-Redundant	HD-DCSDB011

Control Module (HD-MSC400)

This control module is a DOPC IV controller and consists of CPU and RAM memory. Use of nonvolatile memory prevents data loss even if a power failure continues for a long time. The results of self-diagnosis within the control module are indicated by LEDs on the front face of the modules.

Ethernet Module (HD-ETM400)*1

This module can communicate with other equipment in the control system LAN. By performing 2-out-of-3 voting for values output from the MSCs to the control system LAN, this module ensures accurate output. The results of self-diagnosis within the communications module are displayed by LEDs on the front face of the module.

X-bus Module (HD-XBM400)

This module can communicate with I/O modules. By means of 2-out-of-3 voting for values output from MSCs to X-bus for I/O modules, this module ensures accurate output to the I/O modules.

Status Output Module (HD-TRM400)*1

This module serves as an interface between the external I/O terminal block located on the right side of the base unit and the other modules.

Battery Backup Module (HD-BPS400)

If there is a power failure, this module supplies power until the control module saves the databases to nonvolatile memory (after saving, the database contents are stored regardless of the duration of the power failure).

10.2. Auxiliary Terminal

In addition to the terminals available for field instrument inputs and outputs, DOPC IV provides equipment to display system states externally and to distinguish instantaneous (momentary) power interruptions from power failures. A terminal on the main unit makes contact outputs for indicating system states and contact inputs for specifying a restart from an instantaneous power interruption. The power down monitor (HAS-PDM00) monitors the AC power supply, compares the AC power failure time with a specified instantaneous interruption definition time, and determines the restart method for DOPC IV (for restart processing, see section 8). The power down monitor and base unit are connected via a base unit terminal.

10.3. Power Supply

Both DC and AC power supplies are available for DOPC IV. A large-capacity (STX) DC power supply is also available.

Table 18. Power Supply Specifications

AC	Type: J-STX## Voltage: 115 V AC, 230 V AC Frequency: 50 or 60 Hz ±1 Hz Grounding: Class D
DC	Type: HAS-PDP00 Voltage: 22 to 30 V Ripple: 0.8 V P-P Instantaneous interruption: 1 ms or less Grounding: Class D

*1: Available for the redundant type only.

11. Dimensions and Mounting

DOPC IV is housed in a dedicated space-saving cabinet or in an ERG cabinet. 24V DC power is distributed to the base unit or system pack via special connector cables by means of a distribution panel inside the cabinet. A remote terminal panel can be mounted in a cabinet using a sub-panel kit. A cabinet installation example and dimensions of the components are shown below.

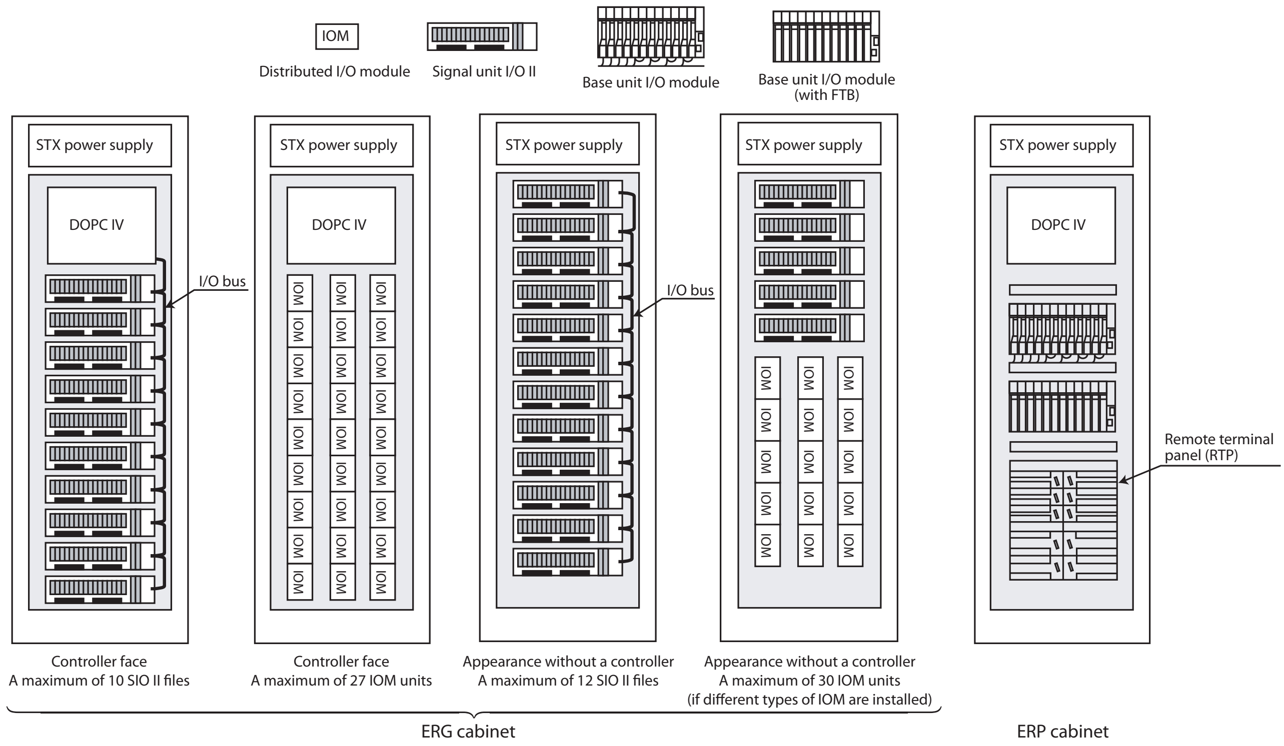

Figure 15. Examples of Cabinet Setups

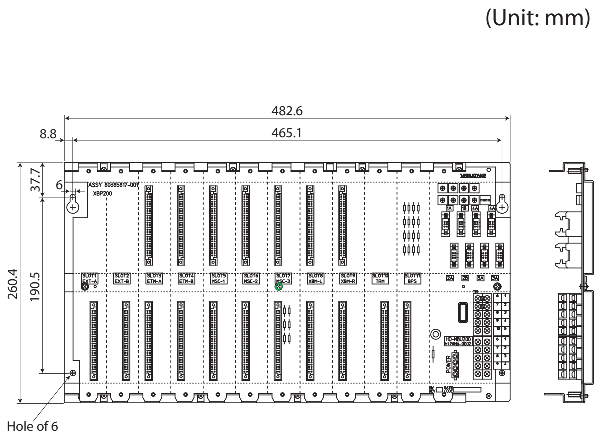

Figure 16. Main Base Unit (Redundant)

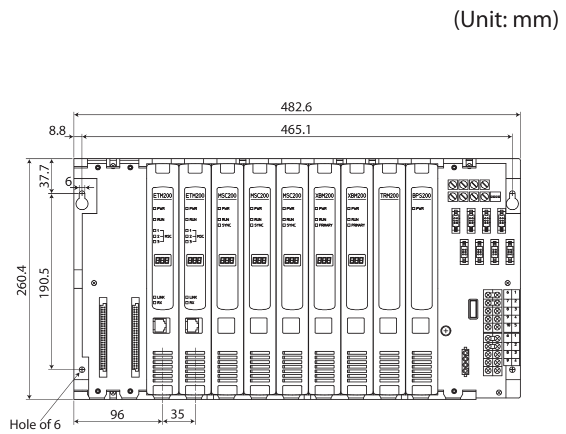

Figure 17. Control Communications Block (Redundant)

(Unit: mm)

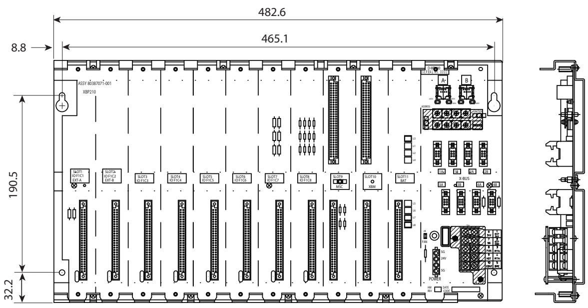

Figure 18. Main Base Unit (Non-Redundant, Long)

(Unit: mm)

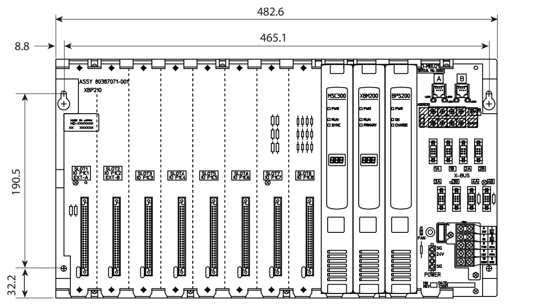

Figure 19. Control Communications Block (Non-Redundant, Long)

(Unit: mm)

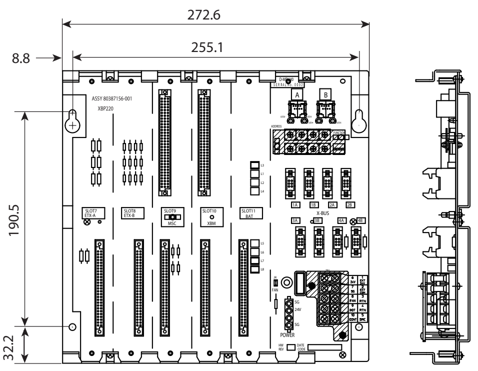

Figure 20. Main Base Unit (Non-Redundant, Short)

(Unit: mm)

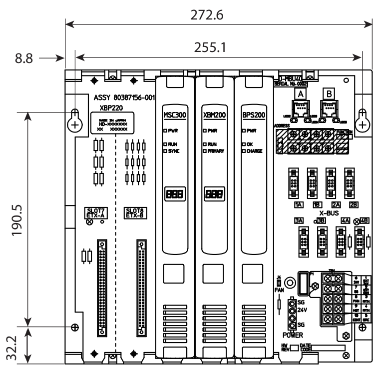

Figure 21. Control Communications Block (Non-Redundant, Short)

(Unit: mm)

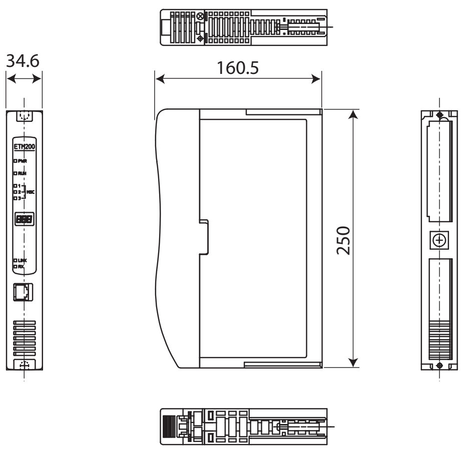

Figure 22. All Control Communications Block Modules

(Unit: mm)

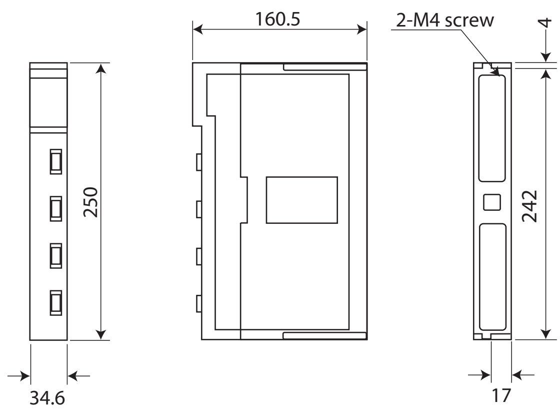

Figure 23. X-bus Extender Module (HD-CEXT250B)

(Unit: mm)

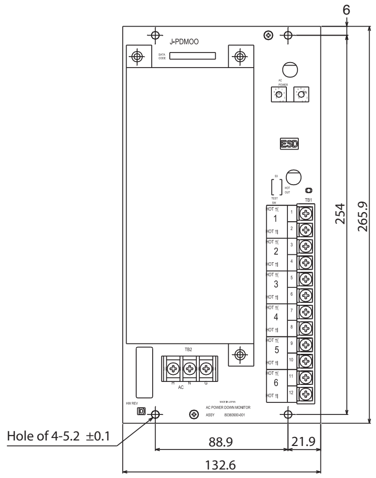

Figure 24. AC Power Down Monitor (HAS-PDM00)

12. Specifications

Table 19. Environment Conditions[*1]

Item		Standard conditions	Operating conditions	Operating limits	Transportation and storage conditions
Ambient temperature	Range (˚C) Rate of change (˚C/h)	23 ±2 ± 5	0 to 40 ± 20	0 to 50 ± 20	-40 to 70 —
Relative humidity	(% RH)	50 ± 10	5 to 95 (0.020 kg/kg)[*2]	5 to 95 (0.020 kg/kg)[*2]	5 to 95 (0.020 kg/kg)[*2]
Vibration	Acceleration(m/s^2) Amplitude (mm)	0 0	<1 (9 to 150 Hz) < 0.35 (2 to 9 Hz)	<1 (9 to 150 Hz) < 0.35 (2 to 9 Hz)	<5 (9 to 150 Hz) < 1.5 (2 to 9 Hz)
Impact	Acceleration (m/s^2) Duration (msec)	0 0	— —	< 40 < 20	< 40 —

Table 20. Power Consumption

Model No.	Description	Maximum current consumption (mA) at 24 V DC	Maximum inrush/ re-inrush current (A) at 24 V DC
HD-MSC400	Control module (for redundancy)	2500	20
HD-ETM400	Ethernet module (for redundancy)		
HD-XBM400	X-bus module (for redundancy)		
HD-TRM400	Status output module		
HD-BPS400	Battery backup module		
HD-CEXT60	X-bus extender module (1:1) (distributed type)	60	3
HD-CEXT250B	X-bus extender module (4 branches)	160	3

Table 21. Input-Output Specifications (Distributed I/O Modules)

Item		Specifications
FX-bus extender	Module model number Isolation Optical fiber cable used Length of optical fiber cable Data rate	HD-CEXT250B Isolation by optical data linking 2-core multi-component glass fiber (200/250 µm) Inter-station length of up to 400 m[*3] 5 Mbps

*1: These specifications apply when the standard cabinet is used to house the process controller.
*2: Maximum absolute temperature (mass ratio kg/kg' of vapor in wet air and dry air).
*3: For 400 m or more, please consult with our nearest branch office.

Table 22. Auxiliary Terminal Specifications

Item		Specifications
Terminal on the base unit	Number of I/O points per terminal	Digital outputs: 1 - Control module CPU reset outputs (WDT): 1 (primary/secondary) Digital inputs: 1 - Hot restart command inputs (HOT-RESTART): 1
	Digital output	
	- Output circuit configuration	Open collector output
	- Isolation	Optical isolation
	- Common	WDT signal - Emitter sides (-sides) are common.
	- External power supply	Voltage range: +15 to 30 V DC (Recommended voltage: 24 V)
	- Load current	Up to 0.5 A
	- Peak current	Up to 1.0 A
	- Leakage current	Up to 0.1 mA (40 V DC)
	- Transistor ON voltage	Up to 1.0 V (at 0.5 A)
	- Withstand voltage	1500 V DC
	Digital input	
	- Input circuit	Optocoupler input
	- Range of input signals	HOT-RESTART signal ON resistance: 1 k max. OFF resistance: 1 M min. Input impedance: 45k
Power-down monitor	Model number	HAS-PDM00
	Number of supported modules	Up to 6 units
	Number of input points	1
	Input signal	100 V AC, 50/60 Hz
	Number of output points	6
	Output signal	Transistor output (30 V, 600 mA). The transistor output turns on when instantaneous power interruption is detected.
	- ON voltage	2 V max.
	- Off leak current	0.1 mA max.
	- Isolation	Optocoupler isolation
	- Output hold	3.5±1 s (from detection of power recovery)
	Instantaneous power interruption time setting	0.6 to 9.9 s (can be set in 0.1 s increments)
	Accuracy of instantaneous power interruption time	±0.1 s

Table 23. Weight of Modules

Model number	Name	Mass (kg)	Model number	Name	Mass (kg)
HD-DCDDB00/01	Main unit (for redundancy)	8.2	HD-XBM400	X-bus module (for redundancy)	0.6
HD-DCSDB001	Main unit (for non-redundancy)	4.7	HD-BPS400	Battery backup module	0.8
HD-MBU400	Redundant main base unit	2.7	HD-TRM400	Status output module (for redundancy)	0.5
HD-MBU400L	Non-redundant main base unit (long)	2.7	HD-CEXT60	X-bus extender module	0.3
HD-MSC400	Control module (for redundancy)	0.6	HD-CEXT250B	X-bus extender module	0.5
HD-ETM400	Ethernet module (for redundancy)	0.6	HD-CEXTB12	X-bus extender module base	0.7

Azbil Corporation
Advanced Automation Company

1-12-2 Kawana, Fujisawa
Kanagawa 251-8522 Japan
URL: http://www.azbil.com/

1st Edition: Issued in Apr. 2014