User's Manual

Analog Output Module

IM 34M06H11-03E

Applicable Modules:

Model Code	Model Name
F3DA04-6R	Analog Output Module
F3DA08-5R	Analog Output Module

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IM 34M06H11-03E
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Applicable Product:

● Range-free Multi-controller FA-M3

- Model: F3DA04-6R, F3DA08-5R
- Name: Analog Output Module

The document number and document model code for this manual are given below.

Refer to the document number in all communications; also refer to the document number or the document model code when purchasing additional copies of this manual.

Document No.	:	IM 34M06H11-03E
Document Model Code	:	DOCIM

Media No. IM 34M06H11-03E (CD) 1st Edition : Apr. 2011 (AR)

Important

■ About This Manual

- This Manual should be passed on to the end user.
- Before using the controller, read this manual thoroughly to have a clear understanding of the controller.
- This manual explains the functions of this product, but there is no guarantee that they will suit the particular purpose of the user.
- Under absolutely no circumstances may the contents of this manual be transcribed or copied, in part or in whole, without permission.
- The contents of this manual are subject to change without prior notice.
- Every effort has been made to ensure accuracy in the preparation of this manual. However, should any errors or omissions come to the attention of the user, please contact the nearest Yokogawa Electric representative or sales office.

■ Safety Precautions when Using/Maintaining the Product

- The following safety symbols are used on the product as well as in this manual.

Danger. This symbol on the product indicates that the operator must follow the instructions laid out in this instruction manual to avoid the risk of personnel injuries, fatalities, or damage to the instrument. The manual describes what special care the operator must exercise to prevent electrical shock or other dangers that may result in injury or the loss of life.

Protective Ground Terminal. Before using the instrument, be sure to ground this terminal.

Function Ground Terminal. Before using the instrument, be sure to ground this terminal.

Alternating current. Indicates alternating current.

Direct current. Indicates direct current.

The following symbols are used only in the instruction manual.

WARNING

- Indicates a “Warning”.
- Draws attention to information essential to prevent hardware damage, software damage or system failure.

CAUTION

- Indicates a “Caution”
- Draws attention to information essential to the understanding of operation and functions.

TIP

- Indicates a “TIP”
- Gives information that complements the present topic.

SEE ALSO

- Indicates a “SEE ALSO” reference.
- Identifies a source to which to refer.

- For the protection and safe use of the product and the system controlled by it, be sure to follow the instructions and precautions on safety stated in this manual whenever handling the product. Take special note that if you handle the product in a manner other than prescribed in these instructions, the protection feature of the product may be damaged or impaired. In such cases, Yokogawa cannot guarantee the quality, performance, function and safety of the product.
- When installing protection and/or safety circuits such as lightning protection devices and equipment for the product and control system as well as designing or installing separate protection and/or safety circuits for fool-proof design and fail-safe design of processes and lines using the product and the system controlled by it, the user should implement it using devices and equipment, additional to this product.
- If component parts or consumable are to be replaced, be sure to use parts specified by the company.
- This product is not designed or manufactured to be used in critical applications which directly affect or threaten human lives and safety — such as nuclear power equipment, devices using radioactivity, railway facilities, aviation equipment, air navigation facilities, aviation facilities or medical equipment. If so used, it is the user’s responsibility to include in the system additional equipment and devices that ensure personnel safety.
- Do not attempt to modify the product.

■ Exemption from Responsibility

- Yokogawa Electric Corporation (hereinafter simply referred to as Yokogawa Electric) makes no warranties regarding the product except those stated in the WARRANTY that is provided separately.
- Yokogawa Electric assumes no liability to any party for any loss or damage, direct or indirect, caused by the use or any unpredictable defect of the product.

■ Software Supplied by the Company

- Yokogawa Electric makes no other warranties expressed or implied except as provided in its warranty clause for software supplied by the company.
- Use the software with one computer only. You must purchase another copy of the software for use with each additional computer.
- Copying the software for any purposes other than backup is strictly prohibited.
- Store the original media, such as floppy disks, that contain the software in a safe place.
- Reverse engineering, such as decompiling of the software, is strictly prohibited.
- No portion of the software supplied by Yokogawa Electric may be transferred, exchanged, or sublet or leased for use by any third party without prior permission by Yokogawa Electric.

■ General Requirements for Using the FA-M3 Controller

● Avoid installing the FA-M3 controller in the following locations:

- Where the instrument will be exposed to direct sunlight, or where the operating temperature exceeds the range 0°C to 55°C (32°F to 131°F).
- Where the relative humidity is outside the range 10 to 90%, or where sudden temperature changes may occur and cause condensation.
- Where corrosive or flammable gases are present.
- Where the instrument will be exposed to direct mechanical vibration or shock.
- Where the instrument may be exposed to extreme levels of radioactivity.

● Select an appropriate field wiring material:

- USE COPPER CONDUCTORS ONLY.

  Use copper conductors having temperature rating of minimum 75°C for the field wiring.

● Securely tighten screws:

- Securely tighten module mounting screws and terminal screws to avoid problems such as faulty operation.
- Tighten terminal block screws with the correct tightening torque as given in this manual.

● Securely lock connecting cables:

- Securely lock the connectors of cables, and check them thoroughly before turning on the power.

● Interlock with emergency-stop circuitry using external relays:

- Equipment incorporating the FA-M3 controller must be furnished with emergency-stop circuitry that uses external relays. This circuitry should be set up to interlock correctly with controller status (stop/run).

● Ground for low impedance:

- For safety reasons, connect the [FG] grounding terminal to a Japanese Industrial Standards (JIS) Class D (earlier called Class 3) Ground[*1]. For compliance to CE Marking, use braided or other wires that can ensure low impedance even at high frequencies for grounding.

  *1 Japanese Industrial Standard (JIS) Class D Ground means grounding resistance of 100 Ω max.

● Configure and route cables with noise control considerations:

- Perform installation and wiring that segregates system parts that may likely become noise sources and system parts that are susceptible to noise. Segregation can be achieved by measures such as segregating by distance, installing a filter or segregating the grounding system.

● Configure for CE Marking Conformance:

- For compliance to CE Marking, perform installation and cable routing according to the description on compliance to CE Marking in the “Hardware Manual” (IM34M06C11-01E).

- **Keep spare parts on hand:**
  - Stock up on maintenance parts including spare modules, in advance.
  - Preventive maintenance (replacement of the module or its battery) is required for using the module beyond 10 years. For enquiries on battery replacement service, contact your nearest Yokogawa Electric representative or sales office. (The module has a built-in lithium battery. Lithium batteries may exhibit decreased voltage, and in rare cases, leakage problems after ten years.)

- **Discharge static electricity before operating the system:**
  - Because static charge can accumulate in dry conditions, first touch grounded metal to discharge any static electricity before touching the system.

- **Never use solvents such as paint thinner for cleaning:**
  - Gently clean the surfaces of the FA-M3 controller with a cloth that has been soaked in water or a neutral detergent and wringed.
  - Do not use volatile solvents such as benzine or paint thinner or chemicals for cleaning, as they may cause deformity, discoloration, or malfunctioning.

- **Avoid storing the FA-M3 controller in places with high temperature or humidity:**
  - Since the CPU module has a built-in battery, avoid storage in places with high temperature or humidity.
  - Since the service life of the battery is drastically reduced by exposure to high temperatures, take special care (storage temperature should be from -20°C to 75°C).
  - There is a built-in lithium battery in a CPU module and temperature control module which serves as backup power supply for programs, device information and configuration information. The service life of this battery is more than 10 years in standby mode at room temperature. Take note that the service life of the battery may be shortened when installed or stored at locations of extreme low or high temperatures. Therefore, we recommend that modules with built-in batteries be stored at room temperature.

- **Always turn off the power before installing or removing modules:**
  - Failing to turn off the power supply when installing or removing modules, may result in damage.

- **Do not touch components in the module:**
  - In some modules you can remove the right-side cover and install ROM packs or change switch settings. While doing this, do not touch any components on the printed-circuit board, otherwise components may be damaged and modules may fail to work.

- **Do not wire unused terminals:**
  - Do not connect wires to unused terminals on a terminal block or in a connector. Doing so may adversely affect the functions of the module.

■ Waste Electrical and Electronic Equipment

Waste Electrical and Electronic Equipment (WEEE), Directive 2002/96/EC

(This directive is only valid in the EU.)

This product complies with the WEEE Directive (2002/96/EC) marking requirement.

The following marking indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category

With reference to the equipment types in the WEEE directive Annex 1, this product is classified as a “Monitoring and Control instrumentation” product.

Do not dispose in domestic household waste.

When disposing products in the EU, contact your local Yokogawa Europe B. V. office.

■ How to Dispose of the Battery Used in This Product

The following description about the new Battery Directive 2006/66/EC is only valid in the EU.

This product uses an embedded battery, which cannot be removed by a customer and should be disposed of together with the product.

Do not dispose in domestic household waste.

When disposing products in the EU, contact your local Yokogawa Europe B. V. office.

Battery category: Lithium battery

Note: With reference to Annex II of the new Battery Directive 2006/66/EC, the above symbol indicates obligatory separate collection.

Introduction

■ Overview of the Manual

This user manual, “Analog Output Module” (IM 34M06H11-03E), describes the specifications and the use of the Analog Output Module (F3DA04-6R, F3DA08-5R).

■ Related User Manuals

The manuals to be read depend on the CPU module to be used.
You should read the latest versions of the following user manuals, as required.

- **For information on the functions of the F3SP66 or F3SP67 sequence CPU modules, refer to:**
  - Sequence CPU – Functions User's Manual (for F3SP66-4S, F3SP67-6S) (IM34M06P14-01E)
  - Sequence CPU – Network Functions User's Manual (for F3SP66-4S, F3SP67-6S) (IM34M06P14-02E)
- **For information on the functions of the F3SP28, F3SP38, F3SP53, F3SP58, or F3SP59 sequence CPU modules, refer to:**
  - Sequence CPU – Functions User' Manual (for F3SP28-3N/3S, F3SP38-6N/6S, F3SP53-4H/4S, F3SP58-6H/6S, F3SP59-7S) (IM34M06P13-01E)
- **For information on the functions of the F3SP21, F3SP25, F3SP35, F3SP05, or F3SP08 sequence CPU modules, refer to:**
  - Sequence CPU – Functions User's Manual (for F3SP21, F3SP25, and F3SP35) (IM34M06P12-02E)
- **For information on the instructions used with sequence CPUs, refer to:**
  - Sequence CPU – Instructions User’s Manual (IM34M06P12-03E)
- **When creating programs using ladder language, refer to:**
  - FA-M3 Programming Tool WideField2 User’s Manual (IM34M06Q15-01E)
- **For information common to all sequence CPU modules on the specifications*, configuration*, installation, wiring, trial operation, maintenance and inspection of the FA-M3, or system-wide limitation of module installation, refer to:**

  Hardware Manual (IM34M06C11-01E)

  * : For information on the specifications of products other than power supply modules, base modules, I/O modules, cables and terminal block units, refer to their respective user’s manuals.

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FA-M3
Analog Output Module

IM 34M06H11-03E 1st Edition

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Appendices

1. Overview

The analog output modules F3DA04-6R and F3DA08-5R (hereafter referred to as this module or the module, in short) are digital-to-analog conversion output modules for use with the range-free controller FA-M3 and having 4 and 8 analog output channels respectively. The modules are to be mounted on a base unit of the FA-M3.

- **F3DA04-6R has four analog output channels and supports both voltage and current output.**
- **F3DA08-5R has eight analog output channels but only supports voltage output type.**

■ Features

The module has the following features:

- Fast digital-analog conversion speed of 2 µs per channel is achieved.
- The time required for analog output to change after data is written to the module is as short as 4 µs when one channel is used and 2 µs + 2 µs x (the number of channels to be updated) when multiple channels are used. *1
- 16-bit DAC ensures higher resolution and accuracy.
- The module updates the analog output only for channels whose output reference values (digital input values) have been updated. A shorter update time is achieved without requiring any special configuration as analog outputs are updated only for used channels.
- The F3DA04-6R has 4 output channels, which can be configured individually for voltage output or current output. The output type and output range for each channel can be configured by software to match the external device to be connected.
- The F3DA08-5R has 8 output channels for voltage output. The output range for each channel can be configured by software to match the external device to be connected.
- The output signal range of each channel is selectable from -10 to 10 V, 0 to 5 V, 0 to 10 V and 1 to 5 V for voltage output and selectable from 4 to 20 mA, 0 to 20 mA and -20 to 20 mA for current output. (The F3DA08-5R does not support current output.)
- Using the synchronous output function*2, all used output channels of the module can be updated at the same time whenever data is written to a user-defined channel. (The update time depends on the number of used channels, the usage conditions and the application program.)
- Each channel can be configured to hold its output or to output a specified value in the event of a CPU failure.
- The output terminals are electrically isolated from the internal circuitry. Each output terminal, however, is not isolated from the other output terminals and the external power supply terminals. The negative terminal of each channel is the common terminal and connected with each other.

*1:This is the required module processing time if the analog output module is installed together with a sequence CPU module in a main unit and output values are written collectively to output data registers using one special module write (WRITE) instruction. If the analog output module is installed in a sub-unit or if output values are written to output data registers individually, the interval between channel updates is given by the interval between data writing from the CPU module to the analog output module, which is 10 µs or longer.

*2:The synchronous update function, if enabled, updates the outputs of all used output channels at the same time whenever data is written to the output value register of a user-defined channel.

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2. Specifications

2.1 Model and Suffix Codes

Table 2.1 Model and Suffix Codes

Model	Suffix Code	Style Code	Option Code	Description
F3DA04	-6R	……	……	-10 to 10 V, 0 to 10 V, 0 to 5 V, 1 to 5 V, 4 to 20 mA, 0 to 20 mA and -20 to 20 mA; 4 outputs, 16-bit D/A conversion, 2 µs per channel
F3DA08	-5R	……	……	-10 to 10 V, 0 to 10 V, 0 to 5V, 1 to 5 V; 8 outputs, 16-bit D/A conversion, 2 µs per channel

2.2 Operating Environment

There is no restriction on the type of CPU modules that can be used with this module.

2.3 General Specifications

Table 2.2 General Specifications

Operating ambient temperature	0 to 55°C *1
Operating ambient humidity	10 to 90% RH (non-condensing)
Operating ambient atmosphere	Must be free of corrosive gases, flammable gases and heavy dust
Storage ambient temperature	-20 to 75°C
Storage ambient humidity	10 to 90% RH (non-condensing)

*1: Limited by usage conditions

2.4 Performance and Functional Specifications

■ Performance and Functional Specifications

Table 2.3 Performance and Functional Specifications

Item	Specifications *1	
	F3DA04-6R	F3DA08-5R
Number of outputs	4	8
Absolute maximum ratings	Output terminals: No external voltage or current must be applied. Between the terminals of external power supply: 30 V max.	
Isolation	Between output terminals and internal circuitry: Isolated (isolation coupler of digital signals, capacitance coupling), capable of withstanding 500 V DC for 1 minute. Between output terminals or between output terminals and external power supply: Not isolated, common negative.	
Output signal range	Voltage output: -10 to 10 V (-11 to 11 V) (default) 0 to 10 V (-0.5 to10.5 V) 0 to 5 V (-0.25 to 5.25 V) 1 to 5 V (0.1 to 5.25 V)	
	Current output: 4 to 20 mA (1.25 to 21 mA) 0 to 20 mA (-1 to 21 mA) -20 to 20 mA (-21 to 21 mA)	Current output: not applicable
Output impedance	Voltage output: 0.5 Ω max. Current output: 3 MΩ max Impedance at disabled output: 1 MΩ min. (or 100 kΩ if the external power supply is off) Leakage current at disabled output: ± 0.5 µA max.	
Allowable load resistance	Voltage output: 1 kΩ min. (for -10 to 10 V or 0 to 10 V range) *2 500 Ω min. (for 0 to 5 V or 1 to 5 V range) *2	
	Current output: 600 Ω min.	Current output: not applicable
Allowable capacitive load	Voltage output: 20 nF max.	
Allowable inductive load	Current output: 1 mH max., electropneumatic converter PK-5502 or equivalent	Current output: not applicable
Output update time*3	2 µs + 2 µs x (number of channels to be updated) For instance, 4 µs, 10 µs and 18 µs if 1, 4 and 8 channels are updated respectively.	
Synchronous output	DAC of all used channels of the same module can be updated synchronously. *4	
Output response time	Voltage output: ≈20 µs (for -10 to 10 V range with 2 kΩ load) Current output: ≈10 µs (for 4 to 20 mA range with 250 Ω load)	
Output resolution (16-bit DAC)	Voltage output: ≈0.5 mV (for -10 to 10 V or 0 to 10 V range); ≈0.2 mV (for 0 to 5 V or 1 to 5 V range). Current output: ≈0.5 µA (for 4 to 20 mA range) ≈1 µA (for 0 to 20 mA or -20 to 20 mA range)	
Overall accuracy	Voltage output (with10 MΩ load resistance): ± 0.1% of FS (23±2°C); ± 0.3% of FS (0 to 55°C)	
	Current output (with 100 Ω load resistance): ± 0.2% of FS (23±2°C); ± 0.3% of FS (0 to 55°C)	Current output: not applicable
Scaling	Output signal range can be set to any digital range within -30,000 and 30,000.	
CPU fail-time output	The output behavior at CPU failure is configurable for each channel independently.	
Current consumption	60 mA (excluding that of external power supply)	
External power supply	Rated voltage: 24 V DC Allowable voltage range: 19.2 to 30 V DC Current consumption: 200 mA (inrush current: 1 A)	
External connection	18-point terminal block, M3.5 screws	
External dimensions	28.9 (W) × 100 (H) × 106.2 (D) mm *5	
Weight	180 g	

*1: The module must be supplied with an external power supply. Unless otherwise indicated, all specifications assume that the external power supply is switched on

*2: The output terminals of this module are held at high impedance when not used (with no output value written). High impedance means a small leakage current at an output terminal. The impact of this leakage current should be considered if the input resistance of a connected device exceeds about 1 MΩ. The voltage caused by the leakage current at the input terminal of a connected device from the time this module is provided with an external power supply until it starts outputting a normal voltage is calculated as the leakage current multiplied by the input resistance of the connected device, and may be as high as ±17 V DC for a device with an input resistance of 34 MΩ or higher.

*3: The given output update time applies if the module is installed in the main unit and data to be updated is written collectively to the module using a WRITE instruction. Otherwise, 4 µs per channel is required.
*4: The update period for synchronous output depends on the number of channels used and the application program.
*5: Excluding protrusions (see External Dimensions for details).

WARNING

Never apply any voltage (or current) exceeding the absolute maximum rating, even for a short period of time, or it may cause permanent damage to an output range, a channel or the whole module. Such damage may be exhibited as performance degradation such as a larger offset or gain error, or functional failure such as total output failure.

■ Output Conversion Characteristics

Output conversion characteristics map output reference values (digital input values) to analog output values. Conversion characteristics vary with the selected output type and output signal range. Table 2.4 lists the output conversion characteristics with no scaling for each output signal range.

Table 2.4 Output Conversion Characteristics for Various Output Types and Output Signal Ranges *1

Output Type	Output Signal Range		Output Range		Remarks
	Analog Output Values	Digital Input Values	Analog Output Values	Digital Input Values	
Voltage output	-10 to 10V	-20000 to 20000	-11 to 11V	-22000 to 22000	Default state
	0 to 10V	0 to 20000	-0.5 to 10.5V	-1000 to 21000	
	0 to 5V	0 to 10000	-0.25 to 5.25V	-500 to 10500	
	1 to 5V	2000 to 10000	0.1 to 5.25V	200 to 10500	
Current output	4 to 20mA	2000 to 10000	1.25 to 21mA	625 to 10500	Selectable for F3DA04-6R only
	0 to 20mA	0 to 10000	-1 to 21mA	-500 to 10500	Selectable for F3DA04-6R only
	-20 to 20mA	-10000 to 10000	-21 to 21mA	-10500 to 10500	Selectable for F3DA04-6R only

*1: These are conversion characteristics with scaling disabled.

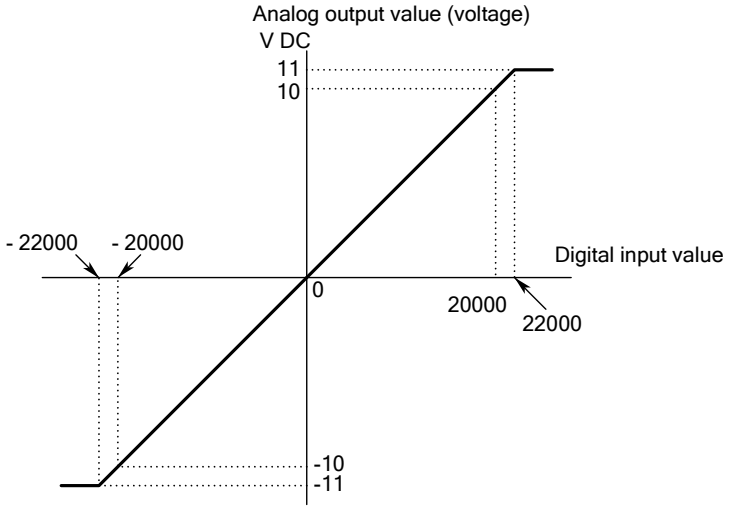

Figure 2.1 Conversion Characteristics Example for Voltage Output (-10 to 10 V signal range with no scaling)

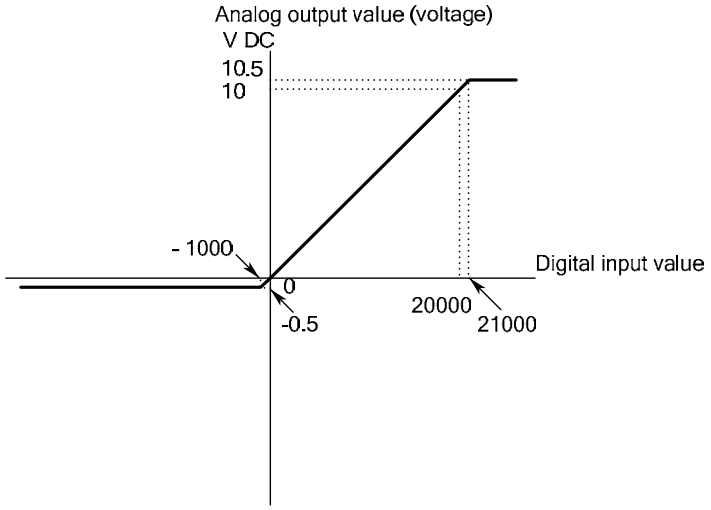

Figure 2.2 Conversion Characteristics Example for Voltage Output (0 to 10 V signal range with no scaling)

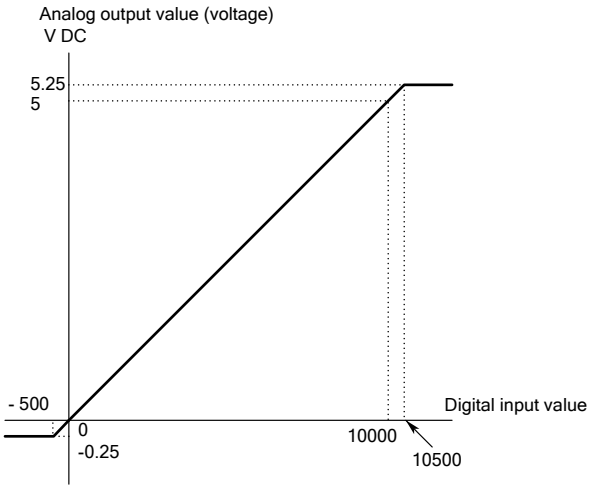

Figure 2.3 Conversion Characteristics Example for Voltage Output (0 to 5 V signal range with no scaling)

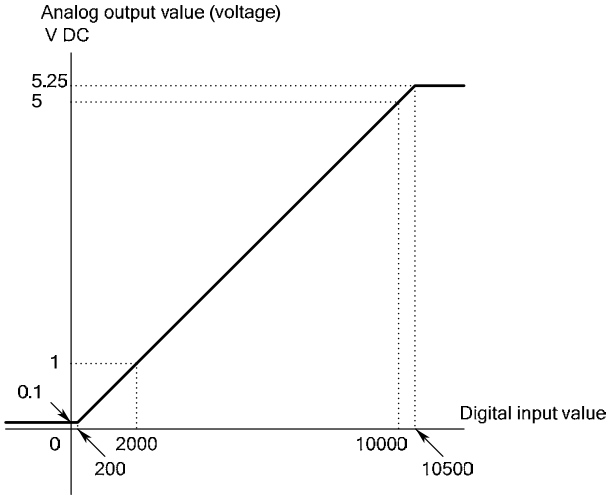

Figure 2.4 Conversion Characteristics Example for Voltage Output (1 to 5 V signal range with no scaling)

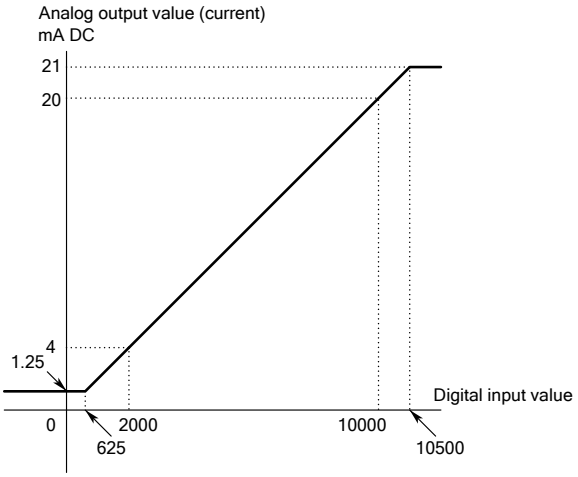

Figure 2.5 Conversion Characteristics Example for Current Output (4 to 20 mA signal range with no scaling)

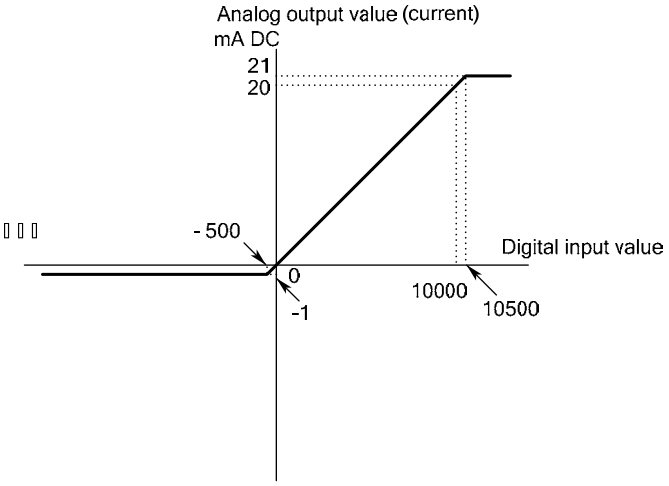

Figure 2.6 Conversion Characteristics Example for Current Output (0 to 20 mA signal range with no scaling)

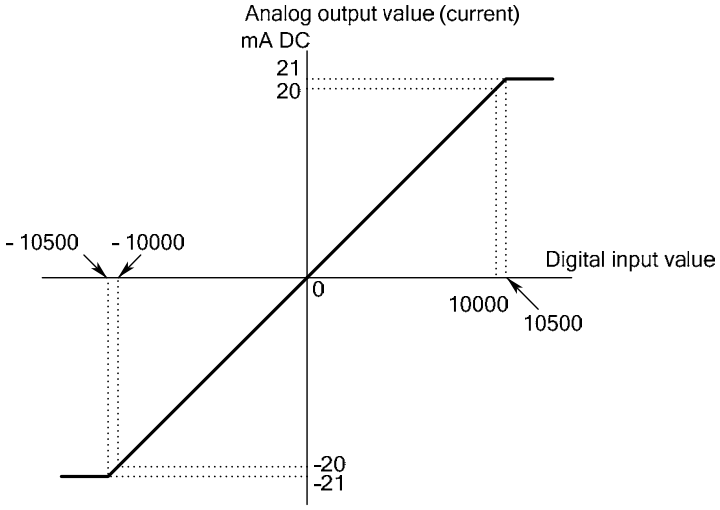

Figure 2.7 Conversion Characteristics Example for Current Output (-20 to 20 mA signal range with no scaling)

2.5 Components and Functions

■ F3DA04-6R

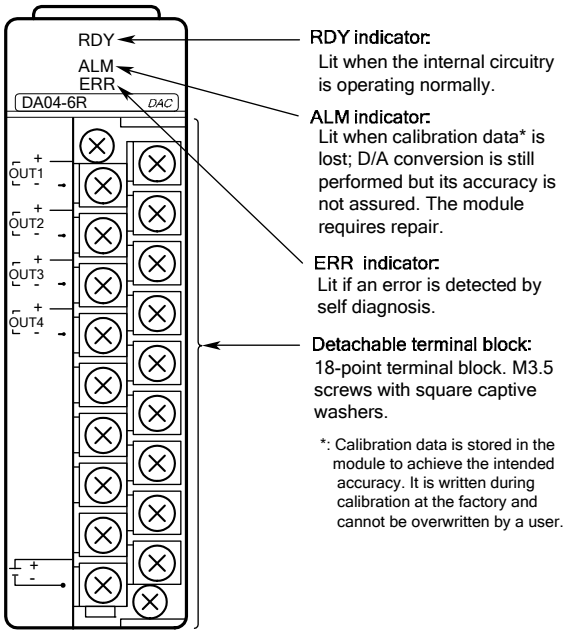

Figure 2.8 Components and Functions (F3DA04-6R)

■ F3DA08-5R

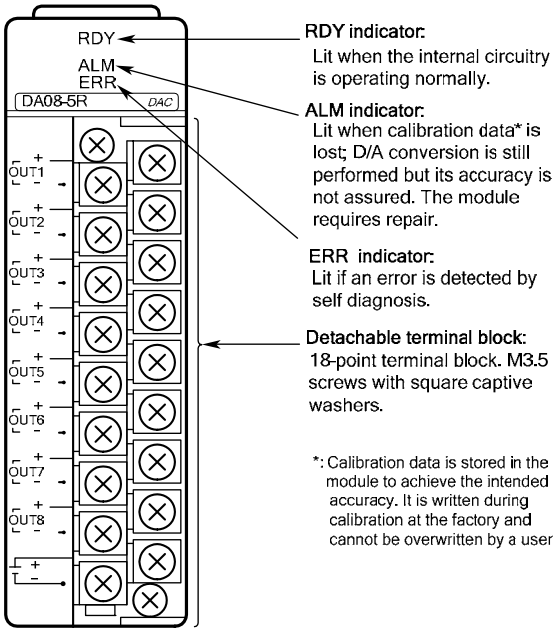

Figure 2.9 Components and Functions (F3DA08-5R)

2.6 Internal Circuit Diagrams

■ F3DA04-6R

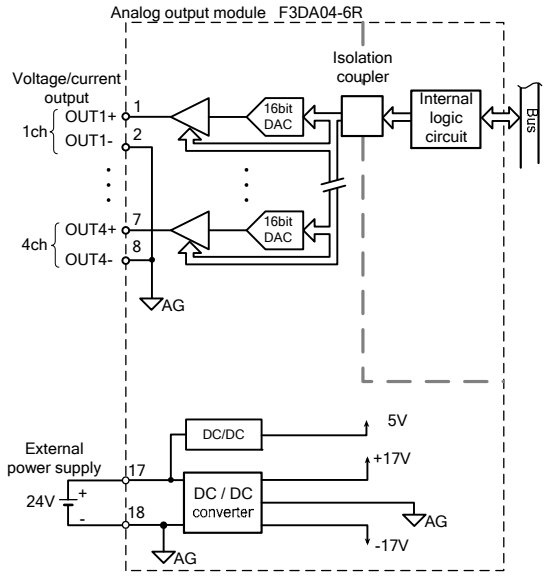

Figure 2.10 Internal Circuit Diagram (F3DA04-6R)

■ F3DA08-5R

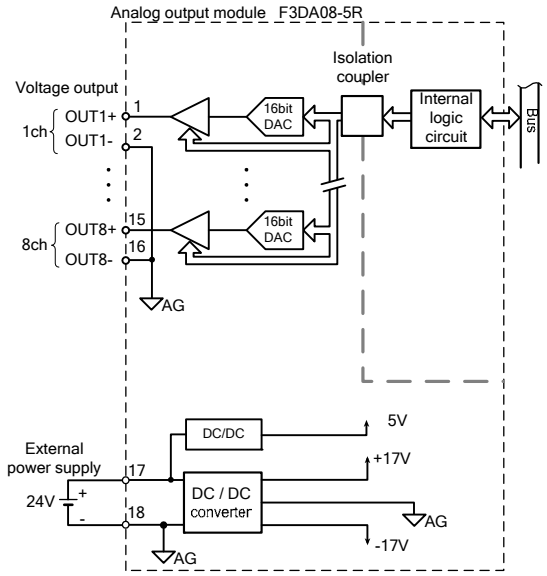

Figure 2.11 Internal Circuit Diagram (F3DA08-5R)

2.7 External Connection and Wiring Precautions

■ External Connection Diagram

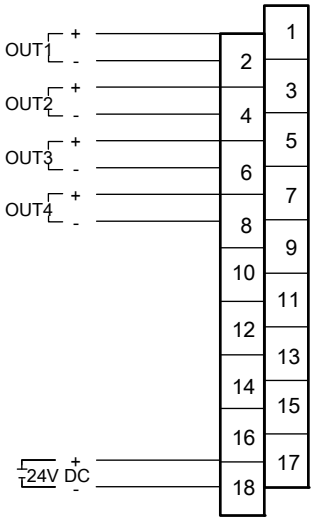

Figure 2.12 External Connection (F3DA04-6R)

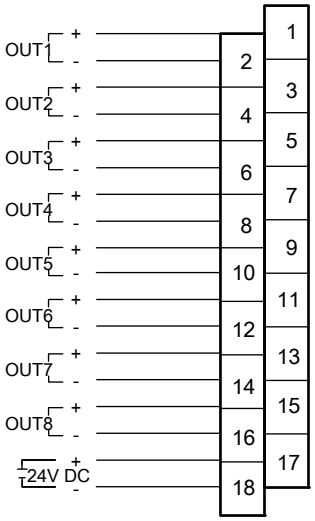

Figure 2.13 External Connection (F3DA08-5R)

CAUTION

This module requires an external power supply at a proper voltage for its proper functioning. Without an external power supply, it cannot produce any output. The external power supply must have sufficient capacity and adequate allowance for the trip current of the overcurrent protector. This module consumes a rated current of 200 mA per module and causes an inrush current of 1 A when the supply voltage reaches approximately 5 V and approximately17 V.

■ Wires and Crimp-on Terminals

Table 2.4 Wires and Crimp-on Terminals

Wire type	Shielded twisted pair
Wire temperature rating	75°C minimum
Wire connection	Use crimp-on terminals

	Manufacturer	Model	Compatible Conductor
Crimp-on terminals and compatible conductors	Japan Solderless Terminal Mfg Co., Ltd.	V1.25-M3	AWG22 to 18 (0.33 to 0.82 mm^2) (Copper wire)
	Nippon Tanshi Co., Ltd.	RAV1.25-3.5	
	Japan Solderless Terminal Mfg Co., Ltd.	V1.25-M4	
	Japan Solderless Terminal Mfg Co., Ltd.	V2-M4	WG16 to 14 (1.3 to 2.1 mm^2) (Copper wire)
Crimping torque	0.8 N· m		

CAUTION

Always use an appropriate crimping tool specified by the manufacturer.

■ Wiring Precautions

1. As analog signals are susceptible to noise, use shielded twisted-pair wires to connect signal destinations to the module to suppress noise.

2. Ground the shield of the twisted-pair cables to FG. The following are some possible ways to perform grounding:

- Connecting the shield to the FG terminal provided at the signal destination

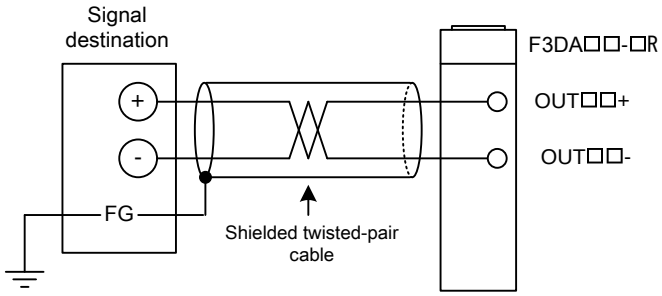

Figure 2.14 Wiring Example 1

- Removing the cable covering to expose the wire and clamp it to the FG terminal using a FG clamp to ground it.

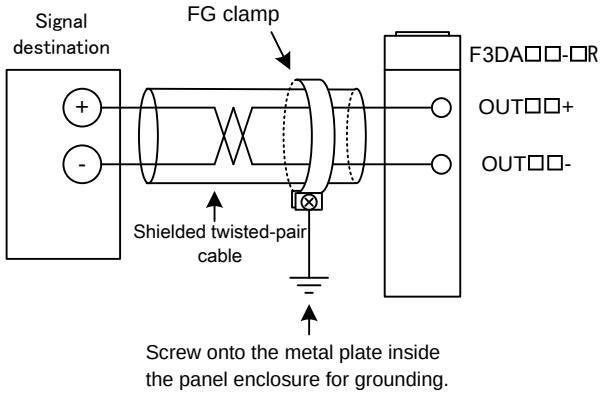

Figure 2.14 Wiring Example 2

Depending on the stability of the grounding points, it may be better to perform grounding either at the analog output module or at the signal destination. Select the more stable grounding point.

3. For compliance with EMC-related specifications, use FG clamps to perform grounding for systems installed with this module.

2.8 External Dimensions

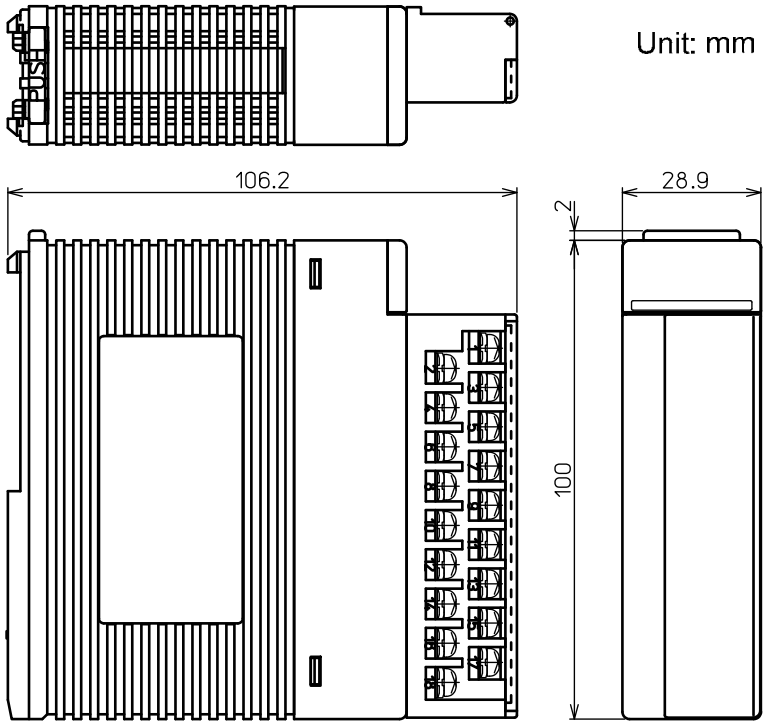

Figure 2.15 External Dimensions

3. Attaching and Detaching Modules

■ Attaching/Detaching Modules

Figure 3.1 shows how to attach this module to the base module. First hook the anchor slot at the bottom of the module to be attached onto the anchor pin on the bottom of the base module. Push the top of this module towards the base module until the anchor/release button clicks into place.

CAUTION

Always switch off the power before attaching or detaching the module.

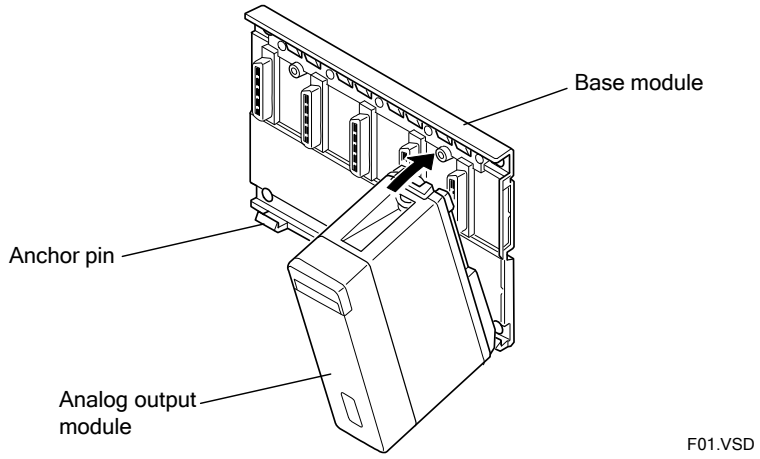

Figure 3.1 Attaching Modules

CAUTION

DO NOT bend the connector on the rear of the module by force during the above operation. If the module is pushed with improper force, the connector may bend, causing an error.

■ Detaching Modules

To remove this module from the base module, reverse the above operation.

Press the anchor/release button on the top of this module to unlock it and tilt the module away from the base module. Then lift the module off the anchor pin at the base.

■ Attaching Modules in Intense Vibration Environments

If the module is used in intense vibration environments, fasten the module with a screw. Use screws of type listed in the table below. Insert these screws into the screw holes on top of the module and tighten them with a Phillips screwdriver.

Screw Required
M4-size binder screw 12 to 15 mm long (or 14 to 15 mm if fitted with a washer)

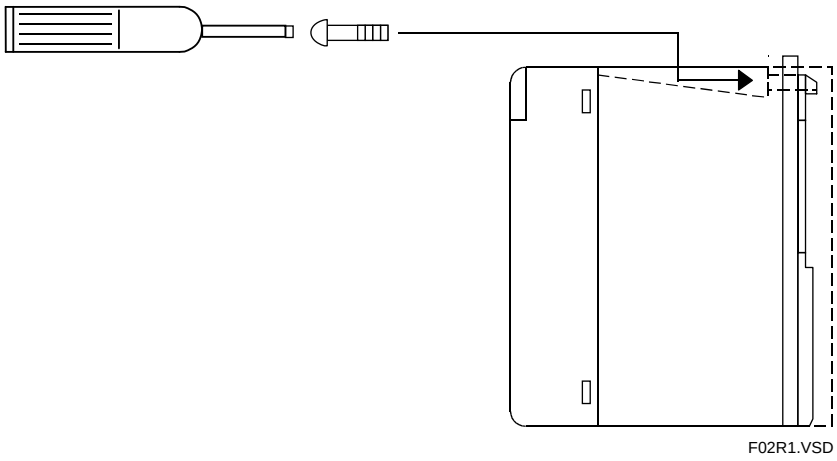

Figure 3.2 Securing Module Using Screws

4. System Status and Module Operation

This module is installed within an FA-M3 system and requires an external power supply. Thus its operation is affected by the operating conditions of the CPU module and other FA-M3 system components, as well as the external power supply. This chapter describes the operation of the module under various system conditions.

4.1 CPU Operation and Module Operation

This section describes the operations of this module under various system conditions: before and after FA-M3 system power on, under various operation modes (run and stop) of the sequence CPU module, at FA-M3 system power off, in a multi-CPU configuration and in the event of a CPU failure. The description in this section assumes that the external power supply to this module is normal.

CAUTION

Do not switch off and switch on the external power supply within a short interval (about five seconds). Otherwise, the module outputs may remain disabled. To enable the module outputs in this case, either switch off the external power supply for at least five seconds and then switch it on; or disable the outputs of all used channels and then set their output types and ranges again. For details on how to set output type and range, see Section 6.4, “Output Type and Range Settings.”

■ Module Operation before FA-M3 System Power On

Before the FA-M3 system is powered on, both the CPU module and this module are not operating. None of the RDY, ALM, and ERR indicators of this module are lit. All output terminals of this module are disabled (held at high impedance) regardless of whether the external power supply is on or off. High impedance may cause a leakage current of up to ±0.5 μA at an output terminal. The influence of this leakage current should be considered if the external device connected to an output terminal of this module has high input impedance.

Table4.1 Module Operation before FA-M3 System Power On

System Status	CPU Module Indicators	This Module’s Indicators	Outputs of this Module
Power off	RDY: ●(off) RUN: ●(off) ALM: ●(off) ERR: ●(off)	RDY: ●(off) ALM: ●(off) ERR: ●(off)	Disabled (held at high impedance)

■ Module Operation at FA-M3 System Power On

When the FA-M3 system is powered on, both the CPU module and this module start operating. The operation sequence of the CPU module and this module after power on is described below.

- When the system is powered on, both the CPU module and this module perform separate self-diagnosis. During the self-diagnosis (before the RDY indicator is lit), the outputs of this module remain in the same states as before power on.
- When the self-diagnosis of this module is completed, its RDY indicator lights up. The self-diagnosis of the CPU module takes a longer time. As the CPU module resets all I/O modules of the system as part of its startup process, the RDY indicator of this module goes off and then lights up again. The states of the outputs of this module remain unchanged.
- When the self-diagnosis of the CPU module is completed, its RDY indicator lights up. The RDY indicator of this module is already lit but even at this point, the states of its outputs remain unchanged.
- After completing its self-diagnosis, the CPU module, unless configured to start in stop mode, starts executing its resident program and its RUN indicator is lit. When the CPU module writes data to the output value registers of this module, the module begins output to the corresponding channels.

Table 4.2 Module Operation after FA-M3 System Power On

System Power Supply	CPU Module Indicators	This Module's Indicators	Outputs of this Module
On (during startup)	RDY: ●(off) RUN: ●(off) ALM: ●(off) ERR: ●(off)	RDY: ●(off) ALM: ●(off) ERR: ●(off)	Disabled (held at high impedance).
	RDY: ●(off) RUN: ●(off) ALM: ●(off) ERR: ●(off)	RDY: ○(lit) ALM: ●(off) ERR: ●(off)	Disabled (held at high impedance)
On (after startup)	RDY: ○(lit) RUN: ●(off) ALM: ●(off) ERR: ●(off)	RDY: ○(lit) ALM: ●(off) ERR: ●(off)	Disabled (held at high impedance).
	RDY: ○(lit) RUN: ○(lit) ALM: ●(off) ERR: ●(off)	RDY: ○(lit) ALM: ●(off) ERR: ●(off)	Voltage or current output according to the specified output type and range.

TIP

Regardless of the operation mode setting, output from the output terminal of an individual channel begins when data is first written to the channel's Output Value register. Even if synchronous update mode is selected, the first output update after system startup is executed asynchronously for individual channels.

■ Module Operation under Various Sequence CPU Operation Modes

The operation of this module under various operation modes (run, debug, and stop modes) of the sequence CPU module is described below.

- When the CPU module is in Run mode, this module produces a specified level of output of a specified output type and scaling within a specified range according to output instructions (written output value data) from the CPU module.
- When the CPU module is in Debug mode, this module produces a specified level of output of a specified output type and scaling within a specified range according to output instructions from the CPU module.
- When the CPU module is in Stop mode, this module maintains its output. Specifically, if the CPU module is started up in Stop mode, each output of this module remains disabled (held at high impedance) but if the CPU module is switched from Run or Debug mode to Stop mode, each output of this module maintains its output level preceding the switch.

Table 4.3 Relationship between the Operations of the CPU Module and this Module

Operation Mode	CPU Module Indicators	This Module's Indicators	Outputs of this Module
Run	RDY: ○(lit) RUN: ○(lit) ALM: ●(off) ERR: ●(off)	RDY: ○(lit) ALM: ●(off) ERR: ●(off)	A specified level of output of a specified output type is produced within a specified output range.
Debug	RDY: ○(lit) RUN: ○(lit) ALM: ●(off) ERR: ●(off)	RDY: ○(lit) ALM: ●(off) ERR: ●(off)	A specified level of output of a specified output type is produced within a specified output range.
Stop	RDY: ○(lit) RUN: ●(off) ALM: ●(off) ERR: ●(off)	RDY: ○(lit) ALM: ●(off) ERR: ●(off)	Output levels are maintained.

CAUTION

If you manually switch the CPU module to Stop mode using a programming tool or otherwise, each output of this module will maintain its prior output level without switching to its fail-time output. If the CPU module automatically switches to Stop mode following CPU failure detection, however, each output of this module will switch to its fail-time output and operate according to its fail-time operation mode setting.

■ Module Operation in Multi-CPU Configuration

Two or more CPU modules can write output data to this module separately.

CAUTION

Avoid using this module in a multi-CPU configuration if a short update time or a stable update period is required as it is difficult to control update time in a multi-CPU configuration.

CAUTION

Beware that this module's operation in the event of a CPU failure in a multi-CPU configuration is different from its operation in a single-CPU configuration. In a multi-CPU configuration, the module's CPU fail-time operation settings are disabled and its outputs are always updated in accordance to its output value registers.

TIP

It is difficult to control the update time in a multi-CPU system. This is because a CPU module which tries to access this module may have to wait for other CPU modules to finish accessing other I/O modules. Moreover, this waiting time is difficult to control because these other data accesses occur asynchronously with the CPU module's operation.

■ Module Operation under CPU Module Failure State

This module operates according to the fail-time operation mode setting of each channel when the CPU module is in failed state.

- If the fail-time operation mode is set to hold output, the module maintains the same output level as before the CPU failure.
- If the fail-time operation mode is set to output the fail-time output value, the module outputs a predefined fail-time output value.

Table 4.4 CPU Fail-time Operation of this Module

CPU Module Status	Fail-time Operation Mode	This Module's Indicators *	Outputs of this Module
Failure	Hold output	RDY: ○(lit) ALM: △(indefinite) ERR: △(indefinite)	The prior output level is maintained.
	Fail-time output	RDY: ○(lit) ALM: △(indefinite) ERR: △(indefinite)	The fail-time output value is output.

*: The ALM and ERR indicators maintain the same state (off, lit or flashing) as before the CPU failure.

CAUTION

In a multi-CPU configuration, this module's CPU fail-time operation function and settings are disabled, and its outputs are always updated according to its output value registers.

CAUTION

The fail-time operation mode for this module cannot be specified using the "Output When Stopped" setting on the [DIO Setup] tab of the Configuration dialog box of the programming tool. It must be specified using the module's Fail-time Operation Mode data registers.

CAUTION

When the CPU module is in failed state, if the external power supply is switched off and then switched on again, the outputs of this module will be held at high impedance (and will not be restored to their output levels prior to the power off).

CAUTION

If the CPU module detects an error but is configured to continue operation for this type of error, it will continue its operation and this module will similarly continue normal operation without switching to fail-time operation.

■ Module Operation after FA-M3 System Power Off

When the FA-M3 system is switched off, this module stops operation with all outputs disabled (held at high impedance) regardless of its fail-time operation mode settings. High impedance may cause a leakage current of up to ±0.5 μA at an output terminal. The influence of this leakage current should be considered especially if the external device connected to an output terminal of this module has high input impedance.

Table 4.5 Module Operation after FA-M3 System Power Off

System Power Supply	CPU Module Indicators	This Module's Indicators	Outputs of this Module
Off	RDY: ●(off) RUN: ●(off) ALM: ●(off) ERR: ●(off)	RDY: ●(off) ALM: ●(off) ERR: ●(off)	Disabled (held at high impedance)

4.2 External Power Supply Status and Module Operation

The operation of this module depends on the status of both the external power supply and the FA-M3 system power supply. The module keeps the output terminal of a channel disabled (held at high impedance) until both the power supplies are switched on and the CPU module writes data to the channel's output value register in the module. High impedance may cause a leakage current of up to ±0.5 µA at an output terminal. The influence of this leakage current should be considered especially if the external device connected to an output terminal of this module has high input impedance.

Table 4.6 Module Operation Relative to External Power Supply Status and FA-M3 System Power Supply Status

External Power Supply	FA-M3 System Power Supply	This Module's Indicators	Outputs of this Module
OFF	OFF	RDY: ●(off) ALM: ●(off) ERR: ●(off)	Disabled (held at high impedance)
	ON	RDY: ○(lit) ALM: ◎(flashing) ERR ◎(flashing)	Disabled (held at high impedance)
ON	OFF	RDY: ●(off) ALM: ●(off) ERR: ●(off)	Disabled (held at high impedance)
	ON	RDY: ○(lit) ALM: ●(off) ERR: ●(off)	Disabled (held at high impedance) initially but output becomes available after the application program starts running *.

*: For details, see the description under "■ Module Operation under Various Sequence CPU Operation Modes."

WARNING

Never apply any voltage or current to the output terminals of this module, even for a short period of time, or it may cause permanent damage to an output range, a channel or the whole module. Such damage may be exhibited as performance degradation such as a larger offset or gain error, or functional failure such as total output failure.

CAUTION

Do not switch off and switch on the external power supply within a short interval (about five seconds). Otherwise, the module outputs may remain disabled. To enable the module outputs in this case, either switch off the external power supply for at least five seconds and then switch it on; or disable the outputs of all used channels and then set their output types and ranges again. For details on how to set output type and range, see Section 6.4, "Output Type and Range Settings."

4.3 Analog Output Update

This section describes the operation of this module when the CPU module operates in Run mode and writes data to output value registers of this module after system power up.

This module provides two analog output update modes, namely, immediate update mode and synchronous update mode. In immediate update mode, analog outputs of this module are updated immediately after the CPU module writes output values into this module. In synchronous update mode, outputs of all channels are updated synchronously only when the CPU module writes an output value for a predefined trigger channel into this module. For details, see Subsection 4.3.1, “Analog Output Update in Immediate Update Mode,” and Subsection 4.3.2, “Analog Output Update in Synchronous Update Mode.” The registers related to analog output update are listed in Table 4.7.

Table 4.7 Analog Output Update Related Input/Output Data Registers

Data Position Number		Name	Symbol	Description	R/W *1
Sequence CPU	BASIC CPU				
1	1	Output value 1	OUT1	Instructed output values (digital input values) Default value: 0	R/W
2	2	Output value 2	OUT2		
3	3	Output value 3	OUT3		
4	4	Output value 4	OUT4		
5	5	Output value 5	OUT5		
6	6	Output value 6	OUT6		
7	7	Output value 7	OUT7		
8	8	Output value 8	OUT8		

*1: ”R/W” indicates a register for reading and writing. “R” indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

SEE ALSO

For details on the setting related to output update mode, see Section 6.1, “Output Update Mode Setting.”

4.3.1 Analog Output Update in Immediate Update Mode

In immediate update mode, the analog outputs of this module are updated immediately when the CPU module writes output values to this module. The Output Value I/O data registers are constantly monitored to see if their values have been updated. When output values are updated, the updated values are delivered to the DA converter (DAC) and analog outputs are updated accordingly. As shown in Figure 4.1, if two or more channels have their output values updated at the same time, they are processed sequentially in ascending order of their channel numbers.

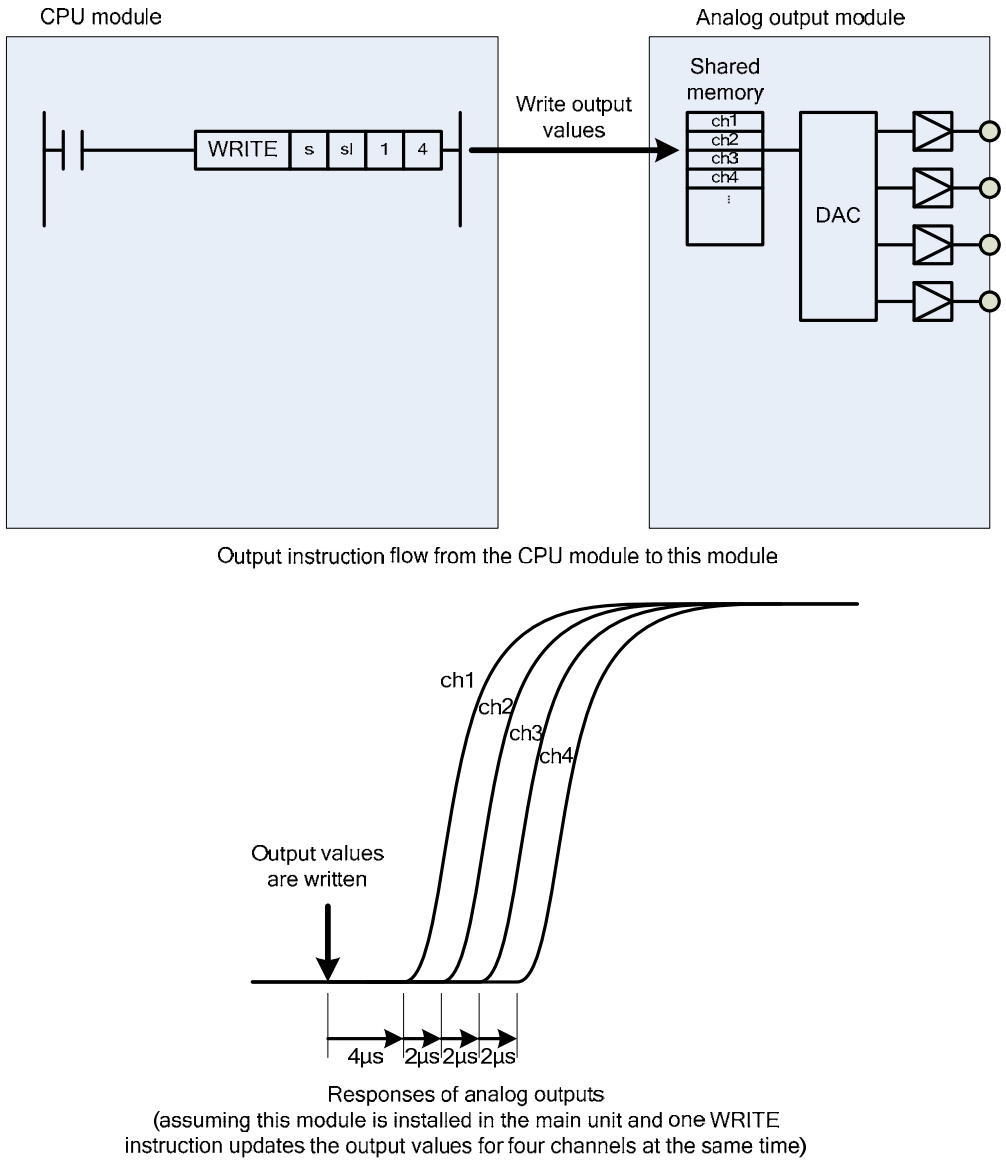

Figure 4.1 Example of Analog Output Update in Immediate Update Mode (Typical values are indicated)

TIP

This module delivers an updated output value to the DA converter only when the output value I/O data register has been updated with a different value by the CPU module. For fast response, an updated output value is not delivered to the DA converter if it is the same as the previous value.

4.3.2 Analog Output Update in Synchronous Update Mode

In synchronous update mode, when the CPU module writes output values into this module, they are immediately processed and delivered to the DA converter, but it is only when the CPU module writes an output value for the output update synchronization channel into this module that all module outputs are updated at the same time with their new analog values. The output update synchronization channel is a channel specified as a trigger channel for synchronous output update by setting a channel number to the output update mode register. When the CPU module writes data to the output value register of the trigger channel, the outputs of the other channels are updated at the same time.

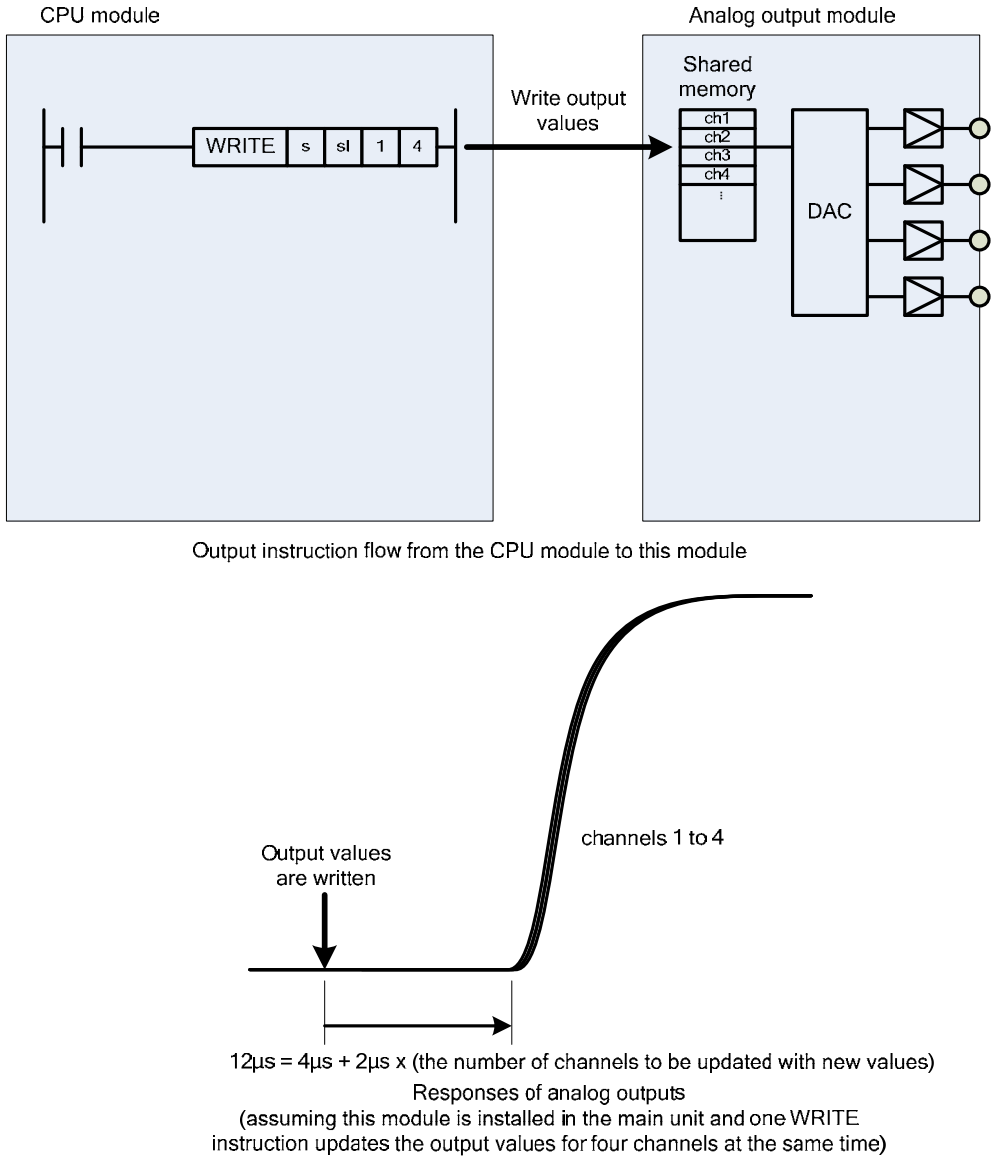

Figure 4.2 Example of Analog Output Update in Synchronous Update Mode (Typical values are indicated)

CAUTION

Although all channels are instructed to update their outputs at the same time, the voltage or current change appearing at output terminals may exhibit small deviations in response. For more information, see Subsection 4.3.3, “Analog Output Response.”

CAUTION

When specifying the output update synchronization channel (trigger channel) using the Output Update Mode Setting register, you must specify the largest channel number of all channels used in the module. Moreover, when writing output values to output value registers, either write output values for all channels collectively or write output values in ascending order of their channel numbers (for example, channel 1 followed by channel 2). Otherwise, the module will not be able to update all channels synchronously.

TIP

This module delivers an updated output value to the DA converter only when the output value I/O data register has been updated with a different value by the CPU module. An updated output value is not delivered to the DA converter if it is the same as the previous value except that an updated output value for the output update synchronization channel is always delivered to the DA converter even if it is the same as the previous value. In this way, response time is shortened without adversely affecting the synchronous output operation.

TIP

To reduce the update time, install the module in the main unit, and write output values to the respective registers of all channels of the module collectively. When using a sequence CPU module, write data for all used channels collectively using one special module write (WRITE) instruction specified with an appropriate transfer data size instead of using multiple WRITE Instructions specified with a transfer data size of 1 word.

4.3.3 Analog Output Response

This section describes the response of the analog output appearing at output terminals as a voltage or current level. For details on analog output update in each output update mode, see Subsection 4.3.1, “Analog Output Update in Immediate Update Mode,” and Subsection 4.3.2, “Analog Output Update in Synchronous Update Mode.” The response speed of this module is represented by the rate of output change for voltage output or by the time required for output level change from 10% to 90% for current output.

■ Voltage Output Response Speed

The voltage output response speed of this module is represented as the rate of output change (= through rate). It is about 2 V/µs for a load of 2 kΩ. For example, if this module is instructed to change a voltage output from -10 V to 10 V, the output changes at a rate of about 2 V/µs and takes about 20 µs to settle.

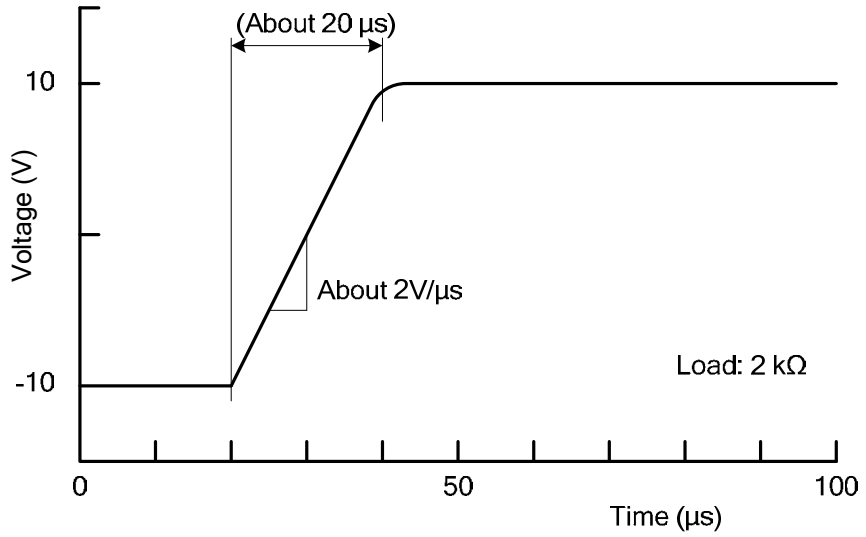

Figure 4.3 Voltage Output Response Speed

■ Current Output Response Speed

The current output response speed of this module is represented as the time required for output level change from 10% to 90%. It varies with the load and the magnitude of the output level change. For example, if this module drives a 250 Ω load and is instructed to change its output level from 4 mA to 20 mA, the response time is about 10 µs.

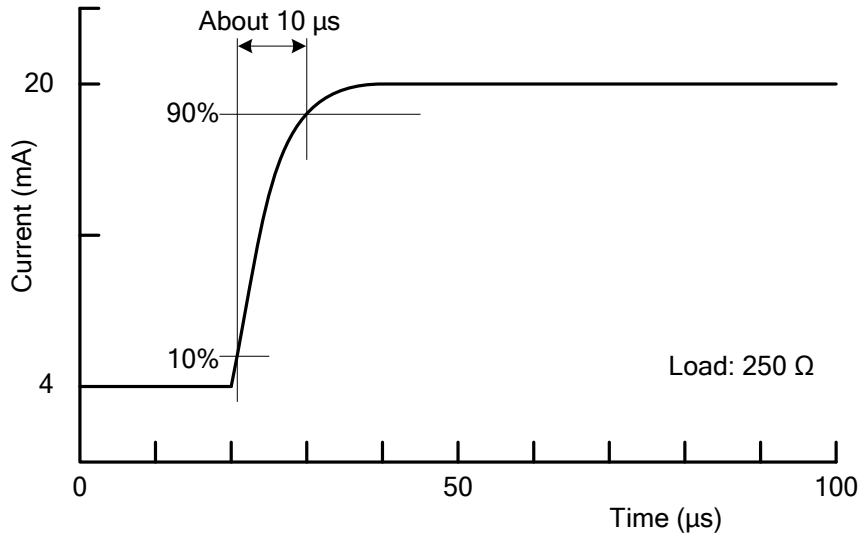

Figure 4.4 Current Output Response Speed

TIP

The response time tends to increase with load resistance and the magnitude of output level change.

5. Accessing the Module

This module provides 16-bit input/output data registers and 16-bit mode registers for interfacing with the CPU module. This chapter describes what data can be read or written to each register and how. Unlike some other modules, this module has neither bit-based I/O relays nor interrupt feature to the CPU module.

5.1 Module Access Using Commands

Tables 5.1 and 5.2 list the commands for accessing the I/O data registers and mode registers of the module respectively.

Table 5.1 Commands for Accessing Input/Output Data Registers

	Read	Write
Ladder	READ	WRITE
	HRD	HWR
BASIC	ENTER	OUTPUT

Table 5.2 Commands for Accessing Mode Registers

	Read	Write
Ladder	READ	WRITE
	HRD	HWR
BASIC	STATUS	CONTROL

CAUTION

For details on how to use each command, read the CPU instructions user manual for the respective CPU modules.

5.2 Input/Output Data Registers

Input/output data registers store 16-bit data and are used for specifying output values, reading error status and reading operation modes.

CAUTION

In Table 5.3, only registers listed explicitly with data position number, name, symbol and description are valid data registers of the module. Non-listed data position numbers are omitted intentionally. Do not write to non-listed I/O data registers. Writing to non-listed I/O data registers will not affect module operation but is prohibited for future expansion and compatibility reasons.

CAUTION

The “R/W” column in Table 5.3 indicates whether a data register is read-only (‘R’) or read-write-enabled (‘RW’). Any data written to a read-only data register is ignored. Although such data may be retrievable by reading the read-only data register immediately after writing to it, the written data has no effect on module operation and will subsequently revert to its previous value.

Table 5.3 List of Input/output Data Registers (part 1 of 2)

Data Position Number		Name	Symbol	Description	R/W*1	See Also
Sequence CPU	BASIC CPU					
1	1	Output value 1	OUT1	Instructed output values (digital input values) Default value: 0	R/W	4.3
2	2	Output value 2	OUT2			
3	3	Output value 3	OUT3			
4	4	Output value 4	OUT4			
5	5	Output value 5	OUT5			
6	6	Output value 6	OUT6			
7	7	Output value 7	OUT7			
8	8	Output value 8	OUT8			
. . .	. . .					
201	201	Error status	ERR_STS	Result of self-diagnosis	R	7.
. . .	. . .					
209	209	Output update mode	OUT.MD_RBK	0: immediate update mode 1 to 8: synchronous update mode	R	6.1
210	210					
211	211	Operation mode 1	MD1_RBK	Output type and output signal range. Bits 15 to 12: output type and output signal range. Bits 11 to 0: not used, always zero.	R	6.4
212	212	Operation mode 2	MD2_RBK			
213	213	Operation mode 3	MD3_RBK			
214	214	Operation mode 4	MD4_RBK			
215	215	Operation mode 5	MD5_RBK			
216	216	Operation mode 6	MD6_RBK			
217	217	Operation mode 7	MD7_RBK			
218	218	Operation mode 8	MD8_RBK			

*1: ”R/W” indicates a register for reading and writing. “R” indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

Table 5.3 List of Input/output Data Registers (part 2 of 2)

Data Position Number		Name	Symbol	Description	R/W*1	See Also
Sequence CPU	BASIC CPU					
220	220	Scale high limit 1	SH1_RDBK	Scale high and low limits for channel 1	R	6.3
221	221	Scale low limit 1	SL1_RDBK			
222	222	Fail-time output value 1	POUT1_RBK	User-specified output value for channel 1 in the event of CPU failure	R	6.2
. . .	. . .					
230	230	Scale high limit 2	SH2_RDBK	Scale high and low limits for channel 2	R	6.3
231	231	Scale low limit 2	SL2_RDBK			
232	232	Fail-time output value 2	POUT2_RBK	User-specified output value for channel 2 in the event of CPU failure	R	6.2
. . .	. . .					
240	240	Scale high limit 3	SH3_RDBK	Scale high and low limits for channel 3	R	6.3
241	241	Scale low limit 3	SL3_RDBK			
242	242	Fail-time output value 3	POUT3_RBK	User-specified output value for channel 3 in the event of CPU failure	R	6.2
. . .	. . .					
250	250	Scale high limit 4	SH4_RDBK	Scale high and low limits for channel 4	R	6.3
251	251	Scale low limit 4	SL4_RDBK			
252	252	Fail-time output value 4	POUT4_RBK	User-specified output value for channel 4 in the event of CPU failure	R	6.2
. . .	. . .					
260	260	Scale high limit 5	SH5_RDBK	Scale high and low limits for channel 5	R	6.3
261	261	Scale low limit 5	SL5_RDBK			
262	262	Fail-time output value 5	POUT5_RBK	User-specified output value for channel 5 in the event of CPU failure	R	6.2
. . .	. . .					
270	270	Scale high limit 6	SH6_RDBK	Scale high and low limits for channel 6	R	6.3
271	271	Scale low limit 6	SL6_RDBK			
272	272	Fail-time output value 6	POUT6_RBK	User-specified output value for channel 6 in the event of CPU failure	R	6.2
. . .	. . .					
280	280	Scale high limit 7	SH7_RDBK	Scale high and low limits for channel 7	R	6.3
281	281	Scale low limit 7	SL7_RDBK			
282	282	Fail-time output value 7	POUT7_RBK	User-specified output value for channel 7 in the event of CPU failure	R	6.2
. . .	. . .					
290	290	Scale high limit 8	SH8_RDBK	Scale high and low limits for channel 8	R	6.3
291	291	Scale low limit 8	SL8_RDBK			
292	292	Fail-time output value 8	POUT8_RBK	User-specified output value for channel 8 in the event of CPU failure	R	6.2
. . .	. . .					
301	301	Fail-time operation 1	F_MD1_RBK	Module operation in the event of CPU failure Bit15=0: hold output Bit15=1: output specified value Bits 14 to 0: always 0.	R	6.2
302	302	Fail-time operation 2	F_MD2_RBK			
303	303	Fail-time operation 3	F_MD3_RBK			
304	304	Fail-time operation 4	F_MD4_RBK			
305	305	Fail-time operation 5	F_MD5_RBK			
306	306	Fail-time operation 6	F_MD6_RBK			
307	307	Fail-time operation 7	F_MD7_RBK			
308	308	Fail-time operation 8	F_MD8_RBK			

*1:"R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

5.3 Mode Registers

Mode registers store 16-bit data and are used for defining output operation and output values in the event of a CPU failure, as well as high and low limits for scaling. Written data can also be read. Beware that data position numbers of mode registers differ for a sequence CPU module and a BASIC CPU module.

CAUTION

In Table 5.4, only registers listed explicitly with data position number, name, symbol and description are valid mode registers of the module. Non-listed data position numbers are omitted intentionally. Do not write to non-listed mode registers. Writing to non-listed mode registers will not affect module operation but is prohibited for future expansion and compatibility reasons.

CAUTION

Be sure to obey data validity restrictions given in the Description column of Table 5.4 when writing data to mode registers. Although invalid written data will be ignored and has no effect on module operation, writing an out-of-range value to a mode register is prohibited for future expansion and compatibility reasons. However, if current output is specified for the F3DA08-5R, which does not support current output, besides reporting a setting error, the module also disables the output (hold at high impedance).

Table 5.4 Mode Registers (part 1 of 2)

Data Position Number		Name	Symbol	Description	R/W *1	See Also
Sequence CPU	BASIC CPU					
501	1	Fail-time operation setting 1	F_MD1	Specify the module operation in the event of CPU failure. Bit15=0: hold output (default). Bit15=1: output specified value Bits 14 to 0: not used, must always be 0.	R/W	6.2
502	2	Fail-time operation setting 2	F_MD2			
503	3	Fail-time operation setting 3	F_MD3			
504	4	Fail-time operation setting 4	F_MD4			
505	5	Fail-time operation setting 5	F_MD5			
506	6	Fail-time operation setting 6	F_MD6			
507	7	Fail-time operation setting 7	F_MD7			
508	8	Fail-time operation setting 8	F_MD8			
509	9	Output update mode setting	OUT_MD	Specify immediate update mode or output update synchronization channel for synchronous update mode. *2 0: immediate update mode (default) 1 to 8: synchronization channel for F3DA08-5R 1 to 4: synchronization channel for F3DA04-6R	R/W	6.1
510	10					
511	11	Operation mode setting 1	MD1	Specify the output type and output signal range. *3 Bits 15 to 12: output type and output signal range Bits 11 to 0: not used, must always be 0. Default value: 0 For details, see Figure 6.8, “Operation Mode Setting.”	R/W	6.4
512	12	Operation mode setting 2	MD2			
513	13	Operation mode setting 3	MD3			
514	14	Operation mode setting 4	MD4			
515	15	Operation mode setting 5	MD5			
516	16	Operation mode setting 6	MD6			
517	17	Operation mode setting 7	MD7			
518	18	Operation mode setting 8	MD8			
519	19	Operation mode setup flag	MD_SET	1: begin operation mode setup; 0: operation mode setup completed *2	R/W	6.4

*1: ”R/W” indicates a register for reading and writing. “R” indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.
*2: Writing a value not listed in the Description column is prohibited. An out-of-range value, if written, is ignored and operation continues according to the previous setting.
*3: Operating Mode Settings 1-8 are applied when the value of 1 is written to the Operation Mode Setup Flag. For details, see the section indicated in the “See Also” column.

Table 5.4 Mode Registers (part 2 of 2)

Data Position Number		Name	Symbol	Description	R/W*1	See Also
Sequence CPU	BASIC CPU					
520	20	Scale high limit setting 1	SH1	Specify the scale high limit and scale low limit for channel 1. *2 Default value: 0; Data range: -30000 to 30000	R/W	6.3
521	21	Scale low limit setting 1	SL1			
522	22	Fail-time output value setting 1	POUT1	Specify the output value in the event of CPU failure for channel 1. *3	R/W	6.2
...	...					
530	30	Scale high limit setting 2	SH2	Specify the scale high limit and scale low limit for channel 2. *2 Default value: 0; Data range: -30000 to 30000	R/W	6.3
531	31	Scale low limit setting 2	SL2			
532	32	Fail-time output value setting 2	POUT2	Specify the output value in the event of CPU failure for channel 2.*3	R/W	6.2
...	...					
540	40	Scale high limit setting 3	SH3	Specify the scale high limit and scale low limit for channel 3. *2 Default value: 0; Data range: -30000 to 30000	R/W	6.3
541	41	Scale low limit setting 3	SL3			
542	42	Fail-time output value setting 3	POUT3	Specify the output value in the event of CPU failure for channel 3. *3	R/W	6.2
...	...					
550	50	Scale high limit setting 4	SH4	Specify the scale high limit and scale low limit for channel 4. *2 Default value: 0; Data range: -30000 to 30000	R/W	6.3
551	51	Scale low limit setting 4	SL4			
552	52	Fail-time output value setting 4	POUT4	Specify the output value in the event of CPU failure for channel 4. *3	R/W	6.2
...	...					
560	60	Scale high limit setting 5	SH5	Specify the scale high limit and scale low limit for channel 5. *2 Default value: 0; Data range: -30000 to 30000	R/W	6.3
561	61	Scale low limit setting 5	SL5			
562	62	Fail-time output value setting 5	POUT5	Specify the output value in the event of CPU failure for channel 5. *3	R/W	6.2
...	...					
570	70	Scale high limit setting 6	SH6	Specify the scale high limit and scale low limit for channel 6. *2 Default value: 0; Data range: -30000 to 30000	R/W	6.3
571	71	Scale low limit setting 6	SL6			
572	72	Fail-time output value setting 6	POUT6	Specify the output value in the event of CPU failure for channel 6. *3	R/W	6.2
...	...					
580	80	Scale high limit setting 7	SH7	Specify the scale high limit and scale low limit for channel 7. *2 Default value: 0; Data range: -30000 to 30000	R/W	6.3
581	81	Scale low limit setting 7	SL7			
582	82	Fail-time output value setting 7	POUT7	Specify the output value in the event of CPU failure for channel 7. *3	R/W	6.2
...	...					
590	90	Scale high limit setting	SH8	Specify the scale high limit and scale low limit for channel 8. *2 Default value: 0; Data range: -30000 to 30000	R/W	6.3
591	91	Scale low limit setting	SL8			
592	92	Fail-time output value setting 8	POUT8	Specify the output value in the event of CPU failure for channel 8. *3	R/W	6.2

*1: "R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.
*2: For details on the module operation with default setting where both the scale high limit and the scale low limit are zero, see the section indicated in the "See Also" column.
*3: The Fail-time Output Value Setting is valid only if the corresponding Fail-time Operation Setting indicates to "output specified value". It is ignored if the Fail-time Operation Setting indicates to "hold output". The default value is 0.

CAUTION

All registers of the module are non-retentive, and will revert to their default values after system power off and power on. Therefore, you must specify the register values again after each power on.

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6. Functions and Settings

This chapter describes this module's functions and the settings related to each function. After power on and before a user program writes data to the output value registers, all outputs of the module are held at high impedance (disabled). To use the module, first configure each of its output channels by specifying the output type, output range, scale high limit, scale low limit and other function-related settings as required. Thereafter, the module will update its channel outputs according to these settings when data is written to output value registers by the user program.

Figure 6.1 shows the four main setting groups for configuring module operation, namely, the output update mode setting, the CPU fail-time operation settings, the scaling settings as well as the output type and range settings.

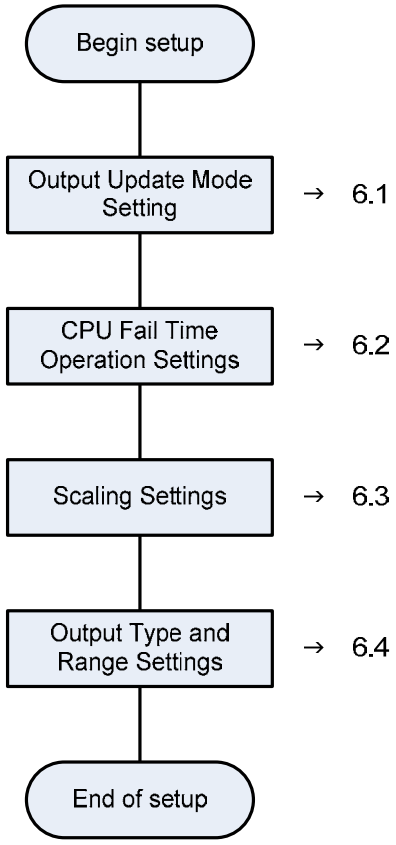


Figure 6.1 Flowchart for Configuring Analog Output Modules F3DA04-6R and F3DA08-5R

CAUTION

You should specify the various settings shown in Figure 6.1 before writing output values.

Changing a scaling setting, output type or range setting after operation has begun (after writing output values) may result in unintended transient voltage or current output immediately following the setting change. To avoid this problem, put the output into disabled (high impedance) state temporarily before changing the setting and output value. For details on how to do so, see the description entitled "■ Disabling Output (putting output in high-impedance state)" in Section 6.4, "Output Type and Range Settings."

6.1 Output Update Mode Setting

The output update mode setting can be used to specify how analog outputs of the module are to be updated. Select immediate update mode to update channels individually or select synchronous update mode to update all channels synchronously. Tables 6.1 and 6.2 list the registers for writing and reading this setting respectively.

Table 6.1 Output Update Mode-related Mode Registers

Data Position Number		Name	Symbol	Description	R/W *1
Sequence CPU	BASIC CPU				
509	9	Output update mode setting	OUT.MD	Specify immediate update mode or output update synchronization channel for synchronous update mode. *2 0: immediate update mode (default) 1 to 8: output update synchronization channel for F3DA08-5R 1 to 4: output update synchronization channel for F3DA04-6R	R/W

*1: "R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.
*2: Writing a value not listed in the Description column is prohibited. An out-of-range value, if written, is ignored and operation continues according to the previous setting.

Table 6.2 Output Update Mode-related Data Registers

Data Position Number		Name	Symbol	Description	R/W *1
Sequence CPU	BASIC CPU				
209	209	Output update mode	OUT.MD_RBK	0: immediate update mode 1 to 8: output update synchronization channel for synchronous update mode	R

*1: "R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.
*2: Writing a value not listed in the Description column is prohibited. An out-of-range value, if written, is ignored and operation continues according to the previous setting.

Set the output update mode by writing to the Output Update Mode Setting register. Specify 0 for immediate update mode.

For synchronous update mode, specify the largest channel number of all used channels of a module. Writing an output value to the Output Value register of this channel thereafter will cause all outputs of the module to be updated at the same time.

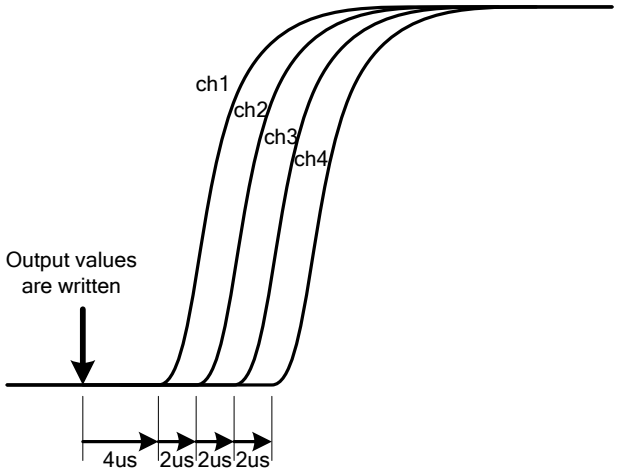
An out-of-range setting value, if specified, will be reported as a setting error and ignored, and module operation will continue with the previous setting. If this happens, you can confirm the current output update mode by reading the Output Update Mode register.

SEE ALSO

For details on detection of setting errors, see Chapter 7, "Self Diagnosis."

6.1.1 Immediate Update Mode

In immediate update mode, the module updates an output channel every time data is written to its Output Value register from the CPU module and thus, delivers the fastest response to the CPU module. As channels are updated individually, there is a difference in update timing between channels, which is about 2 µs under the most favorable operating conditions. On the other hand, the update timing interval between channels may be much longer, about 10 µs if the module is installed in a sub-unit and the output value for each channel is written using a special module write instruction (WRITE) specified with transfer data size of 1. This timing difference arises primarily from the difference in timing of data writing by the CPU module into the analog output module.



Responses of analog outputs
(Assuming that the module is mounted in the main unit and one WRITE instruction updates output values for four channels at the same time.)

Figure 6.2 Example of Analog Output Update in Immediate Update Mode (Typical values are indicated)

TIP

To reduce update time, install the module in the main unit, and write output values to the respective registers of all channels of the module collectively. When using a sequence CPU module, you can shorten the update time and update interval between channels by writing data for all used channels collectively using one special module write (WRITE) instruction specified with an appropriate transfer data size.

TIP

It is difficult to control the update time in a multi-CPU system. This is because a CPU module which tries to access this module may have to wait for other CPU modules to finish accessing other I/O modules. Moreover, this waiting time is difficult to control because these other data accesses occur asynchronously with the CPU module's operation.

6.1.2 Synchronous Update Mode

In synchronous update mode, the module updates the outputs of all used channels collectively when an “output value” is written to the output value register of a specified synchronization channel by the CPU module and thus, delivers a slower response to the CPU module than the immediate update mode. The shortest update time achievable under the most favorable operating condition is 12 µs when 4 channels are in use and 20 µs when 8 channels are in use. The outputs of all used channels are updated at the same time after this update time lapse. Under the least favorable operating condition, for instance, when the module is installed in a sub-unit, the shortest update time achievable is 44 µs when 4 channels are in use and 84 µs when 8 channels are in use.

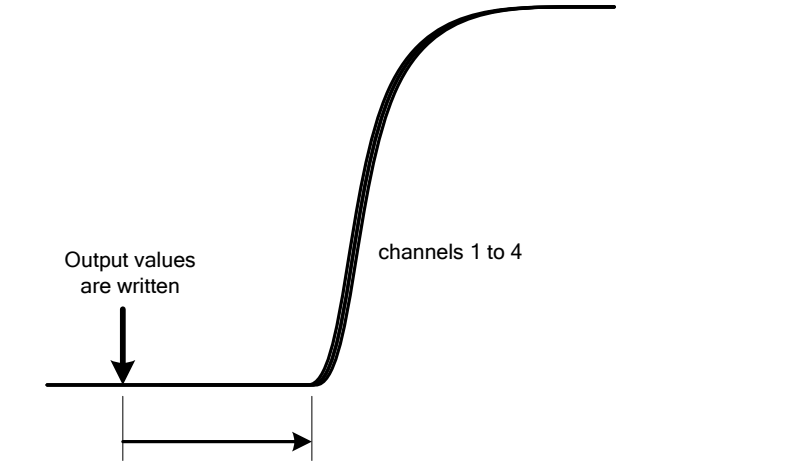


Figure 6.3 Example of Analog Output Update in Synchronous Update Mode (Typical values are indicated)

CAUTION

When specifying the output update synchronization channel (trigger channel) using the Output Update Mode Setting register, you must specify the largest channel number of all channels used in the module. Moreover, when writing output values to output value registers, either write output values for all channels collectively or write output values in ascending order of their channel numbers (for example, channel 1 followed by channel 2). Otherwise, the module will not be able to update all channels synchronously.

TIP

To reduce the update time, install the module in the main unit, and write output values to the respective registers of all channels of the module collectively. When using a sequence CPU module, you can shorten the update time and update interval between channels by writing data for all channels collectively using one special module write (WRITE) instruction specified with an appropriate transfer data size.

6.2 CPU Fail-time Operation Settings

The CPU fail-time operation settings can be used to define the module's output operation in the event of a CPU failure. Tables 6.3 and 6.4 list the registers for writing and reading these settings respectively.

Table 6.3 CPU Fail-time Operation Related Mode Registers

Data Position Number		Name	Symbol	Description	R/W*1
Sequence CPU	BASIC CPU				
501	1	Fail-time operation setting 1	F_MD1	Specify the module operation for a channel in the event of a CPU failure. Bit15=0: hold output (default). Bit15=1: output specified value Bits 14 to 0: not used, must always be 0.	R/W
502	2	Fail-time operation setting 2	F_MD2		
503	3	Fail-time operation setting 3	F_MD3		
504	4	Fail-time operation setting 4	F_MD4		
505	5	Fail-time operation setting 5	F_MD5		
506	6	Fail-time operation setting 6	F_MD6		
507	7	Fail-time operation setting 7	F_MD7		
508	8	Fail-time operation setting 8	F_MD8		
522	22	Fail-time output value setting 1	POUT1	Specify the output value for a channel in the event of a CPU failure *2 The default value is 0.	R/W
532	32	Fail-time output value setting 2	POUT2		
542	42	Fail-time output value setting 3	POUT3		
552	52	Fail-time output value setting 4	POUT4		
562	62	Fail-time output value setting 5	POUT5		
572	72	Fail-time output value setting 6	POUT6		
582	82	Fail-time output value setting 7	POUT7		
592	92	Fail-time output value setting 8	POUT8		

*1: "R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

*2: The Fail-time Output Value Setting is valid only if the corresponding Fail-time Operation Setting indicates to "output specified value". It is ignored if the Fail-time Operation Setting indicates to "hold output".

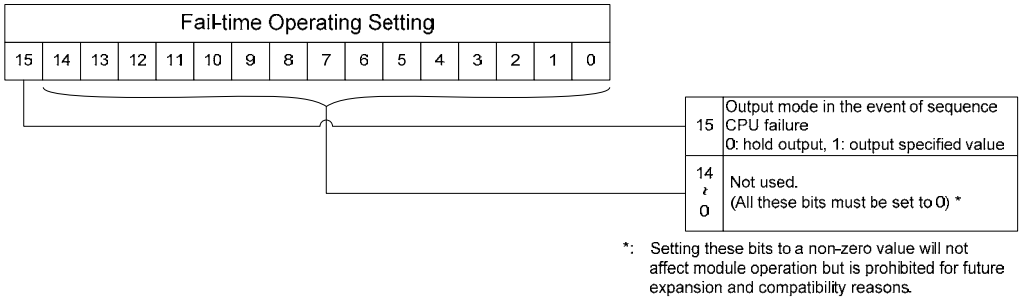


Figure 6.4 Detailed Description of the Fail-time Operation Setting Register

Use the Fail-time Operation Setting register of each channel to select whether to hold the output immediately preceding a CPU failure or to output the value preset in the Fail-time Output Value Setting register in the event of a CPU failure.

CAUTION

In a multi-CPU configuration, the CPU fail-time operation function and settings are disabled, and the module's outputs are always updated according to the Output Value registers.

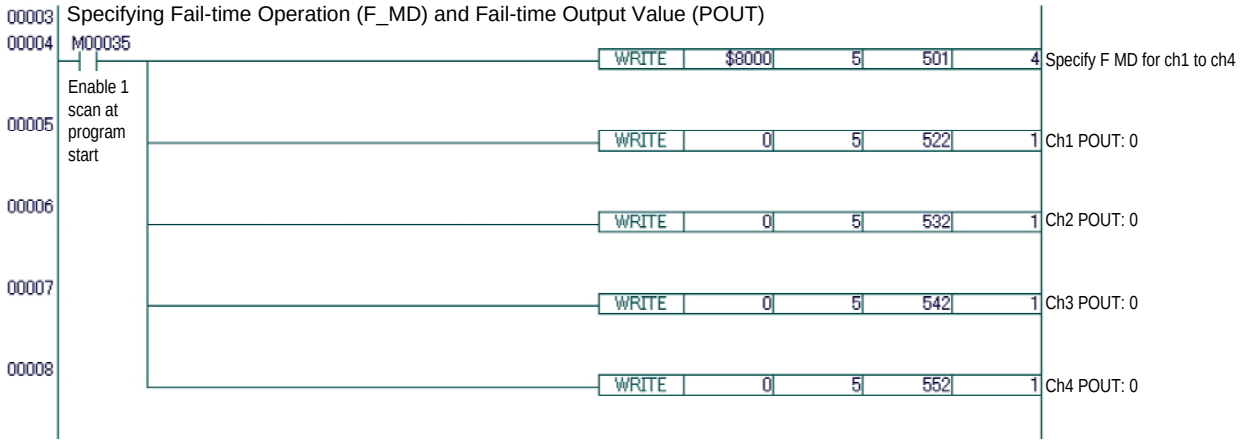


Figure 6.5 Sample Program for Specifying the CPU Fail-time Operation Settings

Table 6.4 CPU Fail-time Operation Related Data Registers

Data Position Number		Name	Symbol	Description	R/W*1
Sequence CPU	BASIC CPU				
222	222	Fail-time output value 1	POUT1_RBK	Output value for a channel in the event of a CPU failure *2	R
232	232	Fail-time output value 2	POUT2_RBK		
242	242	Fail-time output value 3	POUT3_RBK		
252	252	Fail-time output value 4	POUT4_RBK		
262	262	Fail-time output value 5	POUT5_RBK		
272	272	Fail-time output value 6	POUT6_RBK		
282	282	Fail-time output value 7	POUT7_RBK		
292	292	Fail-time output value 8	POUT8_RBK		
301	301	Fail-time operation 1	F_MD1_RBK	Module operation for a channel in the event of a CPU failure Bit15=0: hold output Bit15=1: output specified value Bits 14 to 0: always 0.	R
302	302	Fail-time operation 2	F_MD2_RBK		
303	303	Fail-time operation 3	F_MD3_RBK		
304	304	Fail-time operation 4	F_MD4_RBK		
305	305	Fail-time operation 5	F_MD5_RBK		
306	306	Fail-time operation 6	F_MD6_RBK		
307	307	Fail-time operation 7	F_MD7_RBK		
308	308	Fail-time operation 8	F_MD8_RBK		

*1:"R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

*2: The Fail-time Output Value is valid only if the corresponding Fail-time Operation indicates to "output specified value". It is ignored if the Fail-time Operation indicates to "hold output".

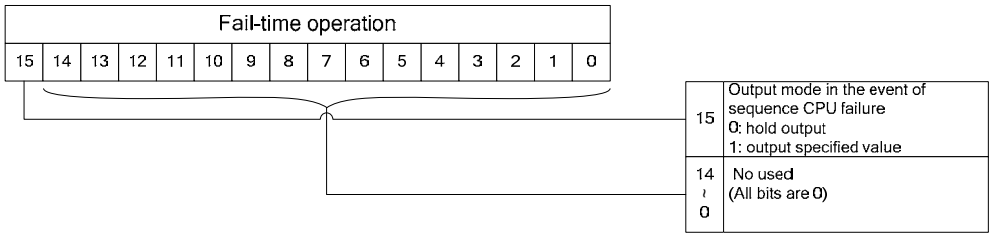


Figure 6.6 Detailed Description of the Fail-time Operation Register

Read the Fail-time Operation register of each channel to determine the module's operation in the event of a CPU failure, specifically, whether the module will hold the last output or output the value preset in the Fail-time Output Value register in the event of a CPU failure.

CAUTION

In a multi-CPU configuration, the CPU fail-time operation function and settings are disabled, and the module's outputs are always updated according to the Output Value registers.

6.3 Scaling Settings

The scaling settings can be used to map the high limit and low limit of the output signal range of a channel to any arbitrary digital input values (scale high and low limits). Tables 6.5 and 6.6 list the registers for writing and reading these settings respectively.

Table 6.5 Scaling Settings Related Mode Registers

Data Position Number		Name	Symbol	Description	R/W *1
Sequence CPU	BASIC CPU				
520	20	Scale high limit setting 1	SH1	Specify the scale high and low limits for channel 1. Default value: 0; Data range: -30000 to 30000	R/W
521	21	Scale low limit setting 1	SL1		
530	30	Scale high limit setting 2	SH2	Specify the scale high and low limits for channel 2. Default value: 0; Data range: -30000 to 30000	R/W
531	31	Scale low limit setting 2	SL2		
540	40	Scale high limit setting 3	SH3	Specify the scale high and low limits for channel 3. Default value: 0; Data range: -30000 to 30000	R/W
541	41	Scale low limit setting 3	SL3		
550	50	Scale high limit setting 4	SH4	Specify the scale high and low limits for channel 4. Default value: 0; Data range: -30000 to 30000	R/W
551	51	Scale low limit setting 4	SL4		
560	60	Scale high limit setting 5	SH5	Specify the scale high and low limits for channel 5. Default value: 0; Data range: -30000 to 30000	R/W
561	61	Scale low limit setting 5	SL5		
570	70	Scale high limit setting 6	SH6	Specify the scale high and low limits for channel 6. Default value: 0; Data range: -30000 to 30000	R/W
571	71	Scale low limit setting 6	SL6		
580	80	Scale high limit setting 7	SH7	Specify the scale high and low limits for channel 7. Default value: 0; Data range: -30000 to 30000	R/W
581	81	Scale low limit setting 7	SL7		
590	90	Scale high limit setting 8	SH8	Specify the scale high and low limits for channel 8. Default value: 0; Data range: -30000 to 30000	R/W
591	91	Scale low limit setting 8	SL8		

*1: ”R/W” indicates a register for reading and writing. “R” indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

The scale high limit or scale low limit can be set to any value between -30000 to 30000 but the specified scale high limit must be larger than the scale low limit. Scaling enables output values to be specified in a more convenient or more intuitive manner. To enable scaling for a channel, write the digital input value corresponding to the high limit of its output signal range and the digital value corresponding to the low limit of its output signal range to the Scale High Limit Setting register and Scale Low Limit Setting register for the channel respectively.

An out-of-range setting value, if specified, will be reported as a setting error and ignored, and module operation will continue with the previous setting. If this happens, you can confirm the scale high limit and scale low limit by reading the Scale High Limit register and Scale Low Limit register listed in Table 6.6.

SEE ALSO

For details on detection of setting errors, see Chapter 7, “Self Diagnosis.”

CAUTION

Immediately after module startup (power on), both the Scale High Limit Setting and Scale Low Limit Setting have default values of zero, and the scaling function is disabled. The module, however, will operate according to the default scale high and low limits listed in Table 6.7. The scale high limit value and scale low limit value can be read from the Scale High Limit register and Scale Low Limit register respectively.

Table 6.6 Scaling Settings Related Data Registers

Data Position Number		Name	Symbol	Description	R/W*1
Sequence CPU	BASIC CPU				
220	220	Scale high limit 1	SH1_RBK	Scale high and low limits for channel 1	R
221	221	Scale low limit 1	SL1_RBK		
230	230	Scale high limit 2	SH2_RBK	Scale high and low limits for channel 2	R
231	231	Scale low limit 2	SL2_RBK		
240	240	Scale high limit 3	SH3_RBK	Scale high and low limits for channel 3	R
241	241	Scale low limit 3	SL3_RBK		
250	250	Scale high limit 4	SH4_RBK	Scale high and low limits for channel 4	R
251	251	Scale low limit 4	SL4_RBK		
260	260	Scale high limit 5	SH5_RBK	Scale high and low limits for channel 5	R
261	261	Scale low limit 5	SL5_RBK		
270	270	Scale high limit 6	SH6_RBK	Scale high and low limits for channel 6	R
271	271	Scale low limit 6	SL6_RBK		
280	280	Scale high limit 7	SH7_RBK	Scale high and low limits for channel 7	R
281	281	Scale low limit 7	SL7_RBK		
290	290	Scale high limit 8	SH8_RBK	Scale high and low limits for channel 8	R
291	291	Scale low limit 8	SL8_RBK		

*1: "R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

Table 6.7 Output Signal Range and Default Values of Scale High and Low Limits

Output Type	Output Setting *1	Output Signal Range	Scale		Output Range		Remarks
			High Limit	Low Limit	Analog Output Values	Digital Output Values	
Voltage output	$0	-10 to 10V	-20000	20000	-11 to 11V	-22000 to 22000	Default operation mode setting
	$8	0 to 10V	0	20000	-0.5 to 10.5V	-1000 to 21000	
	$4	0 to 5V	0	10000	-0.25 to 5.25V	-500 to 10500	
	$C	1 to 5V	2000	10000	0.1 to 5.25V	200 to 10500	
Current output	$E	4 to 20mA	2000	10000	1.25 to 21mA	625 to 10500	Selectable only for F3DA04-6R
	$6	0 to 20mA	0	10000	-1 to 21mA	-500 to 10500	
	$2	-20 to 20mA	-10000	10000	-21 to 21mA	-10500 to 10500	

*1: Output setting corresponds to the first 4 bits of the Operation Mode Setting register.
*2: These are default scale high and low limit values. The scaling range is configurable within -30000 to 30000.

CAUTION

An output value can be set to any value between -32768 and 32767. However, if you specify a scale high limit and a scale low limit, say, to the largest allowable value of 30000 for the Scale High Limit Setting and the smallest allowable value of -30000 for the Scale Low Limit Setting respectively, the output range will be limited by the valid output value range between -30000 and 30000.

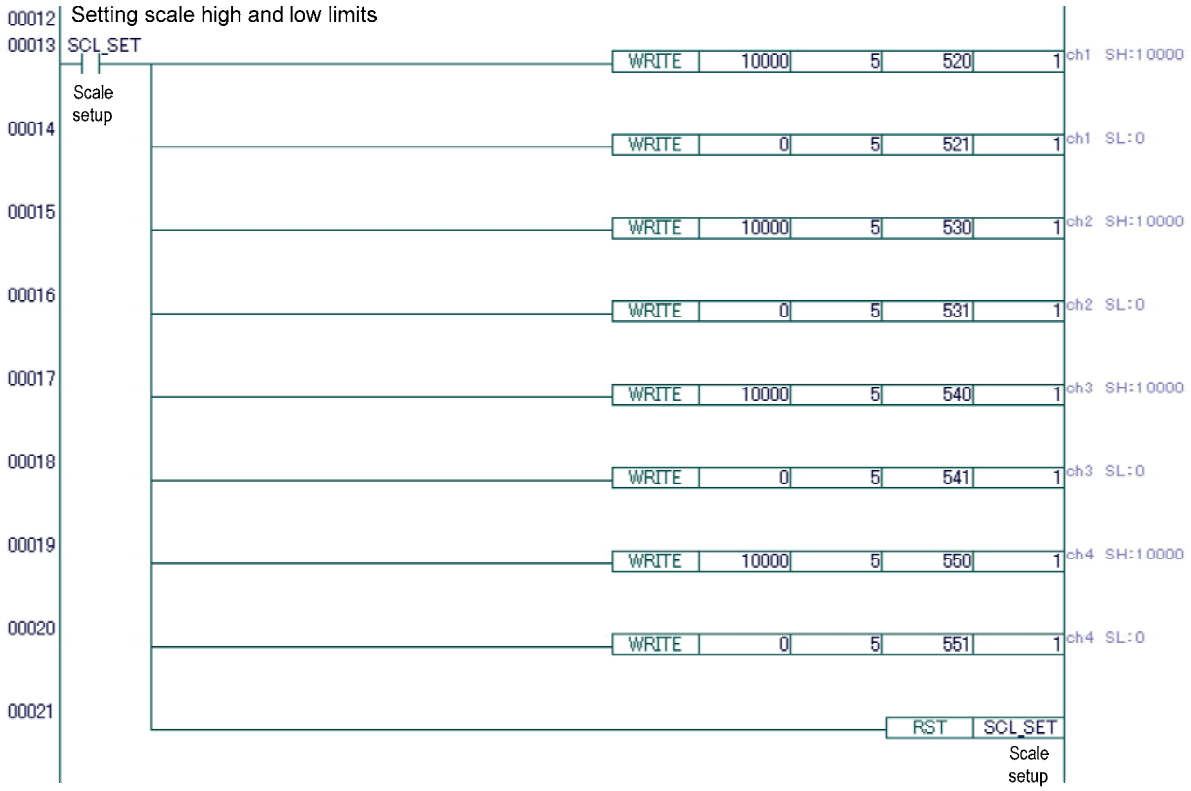


Figure 6.7 Sample Program for Setting Scale High and Low Limits

CAUTION

The analog output modules F3DA04-6R and F3DA08-5R handle all register data as 16-bit (word) integer data. Therefore, you need to understand that specifying a small scale high or low limit will have the effect of lowering the output resolution as the smallest unit of the digital input value (=1) will then correspond to a large percentage of the analog output span. For instance, with the scale settings given in the above sample program, the average resolution will be about 1.6 µA and about 0.4 mV if the output signal ranges are 4 to 20 mA and 1 to 5 V respectively, which are much lower than the hardware resolutions of about 0.5 µA and about 0.2 mV respectively.

CAUTION

This module gives priority to scaling setup, output type and range setup processing. If any of these settings are changed for a channel, analog output update of other channels may be interrupted for up to 1 millisecond. If this update interruption is not acceptable for a given output during production operation, assign it to a channel of an analog output module which does not require the above settings to be changed for other channels during production operation.

6.4 Output Type and Range Settings

The output type and range settings can be used to select the analog output type and range for each channel. Tables 6.8 and 6.9 list the registers for writing and reading these settings respectively.

Table 6.8 Output Type and Range Settings Related Mode Registers

Data Position Number		Name	Symbol	Description	R/W*1
Sequence CPU	BASIC CPU				
511	11	Operation mode setting 1	MD1	Specify the output type and output signal range. *2 Bits 15 to 12: output type and output signal range Bits 11 to 0: not used, must always be 0. Default value: 0 For details, see Figure 6.8, “Operation Mode Setting.”	R/W
512	12	Operation mode setting 2	MD2		
513	13	Operation mode setting 3	MD3		
514	14	Operation mode setting 4	MD4		
515	15	Operation mode setting 5	MD5		
516	16	Operation mode setting 6	MD6		
517	17	Operation mode setting 7	MD7		
518	18	Operation mode setting 8	MD8		
519	19	Operation mode setup flag	MD_SET	1: begin operation mode setup 0: operation mode setup completed	R/W

*1: ”R/W” indicates a register for reading and writing. “R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.
*2: Operating Mode Settings 1-8 are applied when the value of 1 is written to the Operation Mode Setup Flag. After the settings are applied, the Operation Mode Setup Flag reverts to 0 and Operation Modes 1 to 8 at data position numbers 211 to 218 are updated accordingly.

Table 6.9 Output Type and Range Settings Related Data Registers

Data Position Number		Name	Symbol	Description	R/W *1
Sequence CPU	BASIC CPU				
211	211	Operation mode 1	MD1_RBK	Output type and output signal range. Bits 15 to 12: output type and output signal range. Bits 11 to 0: not used, always zero. For details, see Figure 6.8, “Detailed Description of the Operation Mode Setting Register.”	R
212	212	Operation mode 2	MD2_RBK		
213	213	Operation mode 3	MD3_RBK		
214	214	Operation mode 4	MD4_RBK		
215	215	Operation mode 5	MD5_RBK		
216	216	Operation mode 6	MD6_RBK		
217	217	Operation mode 7	MD7_RBK		
218	218	Operation mode 8	MD8_RBK		

*1: ”R/W” indicates a register for reading and writing. “R” indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

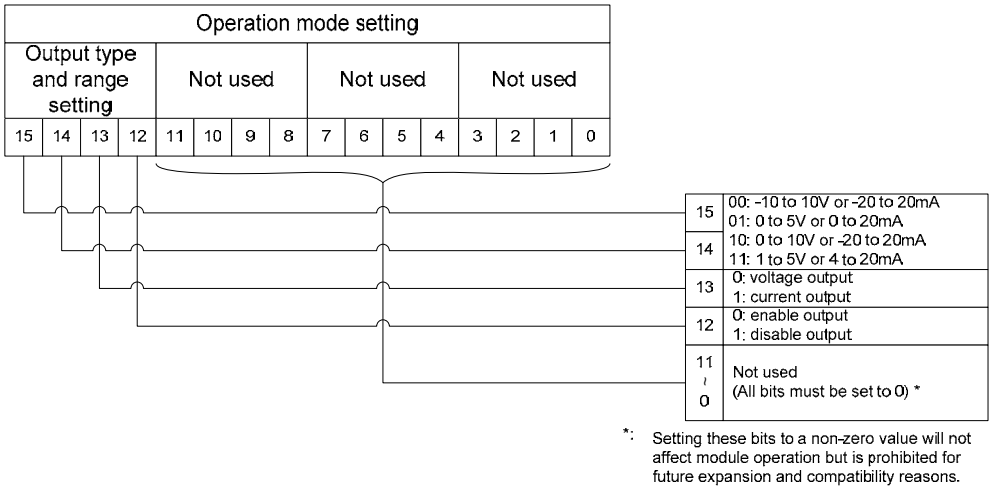


Figure 6.8 Detailed Description of the Operation Mode Setting Register

TIP

For details on the conversion characteristics of each output type and output signal range, see Table 2.4 and Figures 2.1 to 2.7 under “■ Output Conversion Characteristics” in Section 2.4, “Performance and Functional Specifications.”

■ Procedure for Configuring Output Type and Range

The output type and output signal range of each channel can be configured using the Operation Mode Setting register provided for each channel. To configure the output type and range for one or more channels, first write the required output type and range settings to their respective Operation Mode Setting registers. Then, write a value of 1 to the Operation Mode Setup Flag register to initiate application of these settings. Beware that updates to Operation Mode Setting registers will not be applied until this is done. When processing of all updated Operation Mode Setting registers are completed, the Operation Mode Setup Flag automatically reverts to 0 to indicate that the settings have been applied. This process takes about 1 millisecond. When data is written to output value registers thereafter by an application program, the module updates the output channels according to the applied settings and at the same time, reflects the applied settings to the respective Operation Mode registers. If an invalid setting is specified, the module reports a setting error.

SEE ALSO

For details on detection of setting errors, see Chapter 7, “Self Diagnosis.”

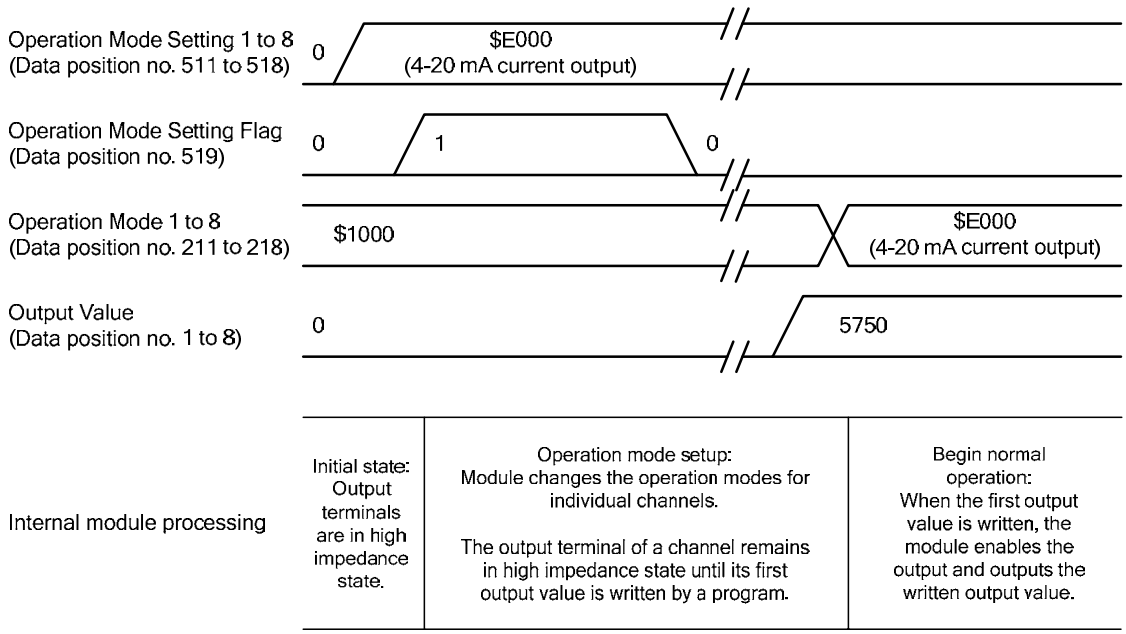


Figure 6.9 Example of Module Operation during Operation Mode Setup (This setup must be done before writing output values.)

CAUTION

Analog output module F3DA08-5R does not support current output. Do not specify current output in the Operation Mode Setting for F3DA08-5R. Doing so will result in a parameter error and flashing of the ALM LED indicator, as well as disabling of the output (the output terminal is held at high-impedance and $1000 is saved to the Operation Mode register) and flashing of the ERR LED indicator.

CAUTION

If output type and range setup is performed after voltage or current output has begun, the Operation Mode Setup Flag will be cleared and modified output type and range setting will be enabled. At the same time, the output value will be output as voltage or current according to the new Operation Mode Setting.

CAUTION

This module gives priority to scaling setup, output type and range setup processing. If any of these settings are changed for a channel, analog output update of other channels may be interrupted for up to 1 millisecond. If this update interruption is not acceptable for a given analog output during production operation, assign it to a channel of an analog output module which does not require the above settings to be changed for other channels during production operation.

TIP

Writing data to the Operation Mode Setting 1 to 8 registers and the Operation Mode Setup Flag register at the same time will not cause a problem.

TIP

Operation mode setup processing will not be done for a channel with unmodified Operation Mode Setting. For such a channel, even if a value of 1 is written to the Operation Mode Setup Flag, its output will not go high impedance or generate a glitch.

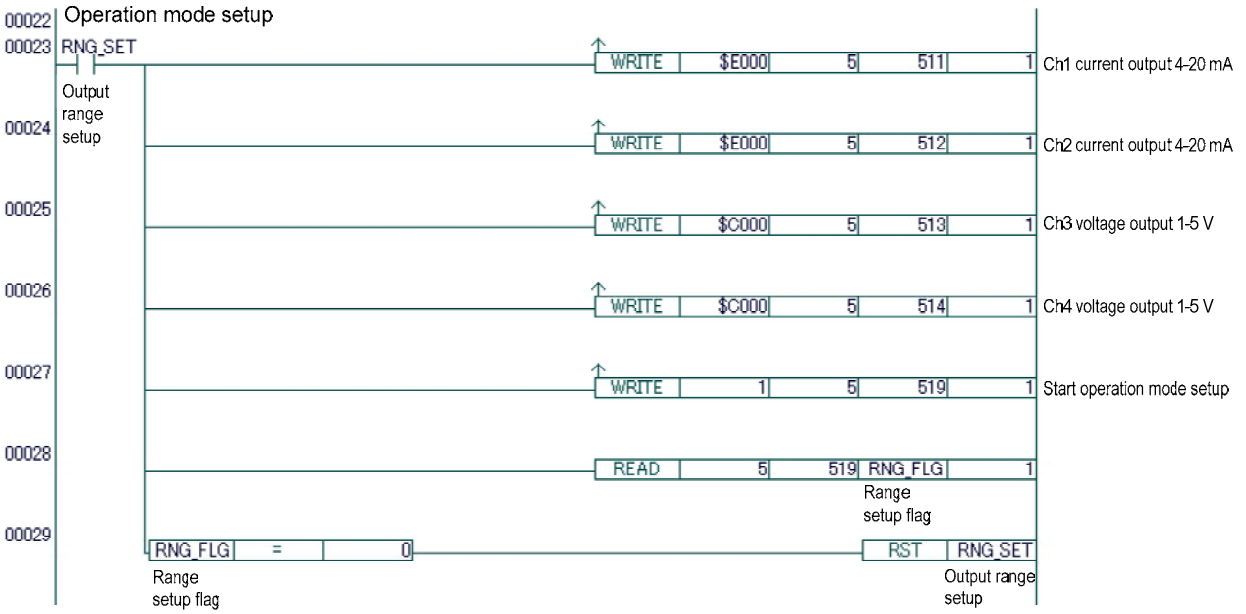


Figure 6.10 Sample Program for Setting Output Type and Range

■ Disabling Output (putting output into high-impedance state)

The output terminals of this module can be put into high impedance state. This feature is useful for preventing unintended transient voltage or current output immediately following a change in scaling setting, output type or range setting after operation has begun (that is, after output values have been written and voltage or current output from output terminals has begun). For this purpose, first disable the output (put it into high-impedance state); next, specify the scaling settings and output value as required, and then specify the output type and range setting. Finally, enable the output type and range setting and the specified output value will be output as current or voltage according to the new scale, output type and range settings.

SEE ALSO

For details on which register to use for disabling an output and how to do so, see Section 6.4, “Output Type and Range Settings.”

7. Self-diagnosis

This chapter describes the self-diagnosis function of the module. The self-diagnostics checks can be broadly categorized into startup checks, which are performed at startup, and monitoring checks, which are performed constantly during module operation. When an error or an invalid operation setting is detected during self-diagnosis, the ALM LED or the ERR LED located on the module front lights up or flashes and the appropriate error code listed in Table 7.2 is saved into the Error Status register listed in Table 7.1. If more than one abnormality is detected, the LED indicators and error status indicate the most serious abnormality. If no error is detected, the ALM LED and the ERR LED are unlit and the error status is $0000.

Table 7.1 Self-diagnosis-related Registers

Data Position Number		Name	Symbol	Description	R/W*1
Sequence CPU	BASIC CPU				
201	201	Error status	ERR_STS	Result of self-diagnosis	R

*1: "R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

Table 7.2 Error Codes

Error Code *1	Error Description	LED Status *2			Error Details and Module Operation	Remedy	See Also
		RDY	ALM	ERR			
$0000	Normal	○	●	●	No error has been detected.		-
	Major hardware failure	●	△	△	There is a hardware failure. The MPU, ROM, RAM or some other internal logic circuit is operating abnormally. Outputs are held at high impedance.	Check the system and external power supply voltages. If the error persists after power off and on, replace or repair the module.	7.1 7.2
$C0□□	Internal circuit power voltage error	○	●	○	There is a hardware failure. The power supply voltage of an internal circuit is abnormal. Outputs are held at high impedance.		7.1
$B000	ECC error	○	●	◎	There is a data error which cannot be corrected automatically by the Error Check and Correction (ECC) function. Until the system is restarted, outputs follow the Fail-time Operation Settings.	Restart the system.	7.2
$A000	Calibration data loss	○	○	●	There is a hardware failure. Data required for maintaining accuracy is lost. The module may not meet accuracy specifications but is usable.	Replace or repair the module.	7.1
$1000	External power failure	○	◎	◎	There is an external power failure. External power supply is off or its voltage is below requirements. Outputs are held at high impedance. The Disabled Output bit of Operation Mode is set.	Check the output voltage of the external power supply.	7.1 7.2
$0F0■	Output driver overheat	○	◎	●	Overheating of output driver due to overload	Ensure appropriate load.	7.2
$0E0■	Current output open	○	◎	●	Open-circuit load on current output channel	Check output wiring.	7.2
$0D0■	Voltage output short-circuit	○	◎	●	Shorted load on voltage output channel	Check output wiring.	7.2
$00F■	Operation mode setting error	○	◎	◎	Operation Mode Setting is invalid. Current output has been wrongly specified for F3DA08-5R. Outputs are held at high impedance.	Specify a supported output type.	7.2
$00E0	Output update mode setting error	○	◎	●	Output Update Mode Setting is out of the valid range of: 0 to 8 for F3DA08-5R or 0 to 4 for F3DA04-6R. The setting is ignored and operation continues with preceding conditions.	Specify a supported output update mode.	7.2
$00D■	Scaling setting error	○	◎	●	Scaling settings are out of the valid range of: -30000≤SL<SH≤30000. The settings are ignored and operation continues with preceding conditions.	Specify valid scale high limit and scale low limit values.	7.2

*1: ■=channel number. If error is detected in more than one channel, the smallest channel number is reported.
□=indefinite
*2: ○=lit; ◎=flashing; ●=off; △=off or lit

7.1 Self-diagnostic Startup Checks

This section describes the self-diagnostic startup checks, which are performed at module startup.

Table 7.3 lists the self-diagnostic checks that are performed by the module after startup and before the RDY LED indicator is lit. If an error is detected, it will be indicated by the LED indicators located on the module front and by an error code in the error status register. If an external power supply voltage error is detected, however, power voltage checks for component output circuits are withheld and performed only after the external power supply voltage becomes normal.

Table 7.3 Self-diagnostic Startup Checks

Checked Item	Description of Diagnostic Checks	Error Code *1	LED Status *2		
			RDY	ALM	ERR
Internal logic circuits	FPGA configuration check, ROM sum check and RAM read/write check		●	△	△
Component power supply voltages	Power voltage checks for the MPU, FPGA, memory and other system circuits Power voltage checks for DAC, output driver and other output circuits If the external power supply is off, however, power voltage checks for output circuits are withheld and performed only after the external power supply is available.	$C0□□	○	●	○
Calibration data	Non-volatile FRAM memory sum check	$A000	○	○	●

*1: □=indefinite
*2: ○=lit; ●=off; △=off, lit or flashing

7.2 Self-diagnostic Monitoring Checks

This section describes the self-diagnostic monitoring checks, which are performed constantly during module operation.

Table 7.4 lists the self-diagnostic monitoring checks that are constantly performed by the module after the RDY LED indicator is lit. If an error is detected, it will be indicated by the LED indicators located on the module front and by an error code in the error status register. If an external power supply voltage error is detected, however, power voltage checks for output circuits described under “component power supply voltages” of Table 7.3 will be performed together with these self-diagnostic monitoring checks after the external power supply is restored.

Table 7.4 Self-diagnostic Monitoring Checks

Checked Item	Description of Diagnostic Checks	Error Code *1	LED Status *2		
			RDY	ALM	ERR
MPU runaway computation	Monitors MPU for runaway computation error using watchdog timer.		●	△	△
Memory data error	Monitors RAM data and attempts automatic correction. An error is reported if a detected memory error cannot be corrected automatically by the ECC function,	$B000	○	●	◎
External power supply	Checks for interruption of external power supply.	$1000	○	◎	◎
Output driver overheat	Checks for overheating of output driver. An error is reported if the junction temperature exceeds about 150°C.	$0F0■	○	◎	●
Current output open	Checks for open circuit (wire discontinuity) on current output channels.	$0E0■	○	◎	●
Voltage output short-circuit	Checks for short-circuit on voltage output channels.	$0D0■	○	◎	●
Operation mode settings	Checks for data integrity between module model and range settings.	$00F■	○	◎	◎
Output update mode setting	Performs range check (0 to 8 for F3DA08-5R or 0 to 4 for F3DA04-6R) for output update mode setting.	$00E0	○	◎	●
Scaling settings	Performs range check (-30000≤SL<SH≤30000) for scaling settings.	$00D■	○	◎	●

*1: ■=channel number. If error is detected in more than one channel, the smallest channel number is reported.
*2: ○=lit; ◎=flashing; ●=off; △=off, lit or flashing

WARNING

If an output driver overheat error is detected by self-diagnosis, you must immediately set the output of the channel concerned to 0 V or 0 mA and, at the same time, disable the output. If this measure is not effective, cut off the external power supply.

WARNING

If a voltage output is shorted, a short-circuit current of about 16 mA will flow through the channel concerned. The current is limited by the overcurrent protector to prevent damage to the output driver. However, if the short-circuit condition is left unattended, it may cause internal circuits to be overheated or even damaged. Therefore, if a voltage output short-circuit error is detected by self-diagnosis, it should be dealt with promptly.

CAUTION

If an output driver overheat, current output open or voltage output short-circuit condition is present in any channel, the output update time of the module may be prolonged by up to 200 µs. To ensure stable output updates, do not leave any of these conditions unattended.

CAUTION

An open circuit condition on a current output terminal is detected by checking for abnormal voltage rise which is caused when current fails to flow. As such, when the current output is near 0 mA, an open circuit condition may fail to be detected because the output terminal voltage does not rise sufficiently. An open circuit condition may also fail to be detected if its duration is too short as about 100 ms is required for detection.

CAUTION

A short-circuit condition on a voltage output is detected by checking for tripping of the overcurrent protector. As such, when the voltage output is near 0 V, a short-circuit condition on a voltage output may fail to be detected because the overcurrent protector is not tripped. A short-circuit condition may also fail to be detected if its duration is too short as about 100 ms is required for detection of overcurrent.

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8. Sample Program

This sample program performs initialization by specifying the output update mode setting, followed by the CPU fail-time operation settings, the operation mode settings (output type and range settings) and the scaling settings for channels 1 to 4. After initialization, it initiates analog output by writing to the module digital output values, which are assumed to be pre-stored in data registers D00001 to D00004.

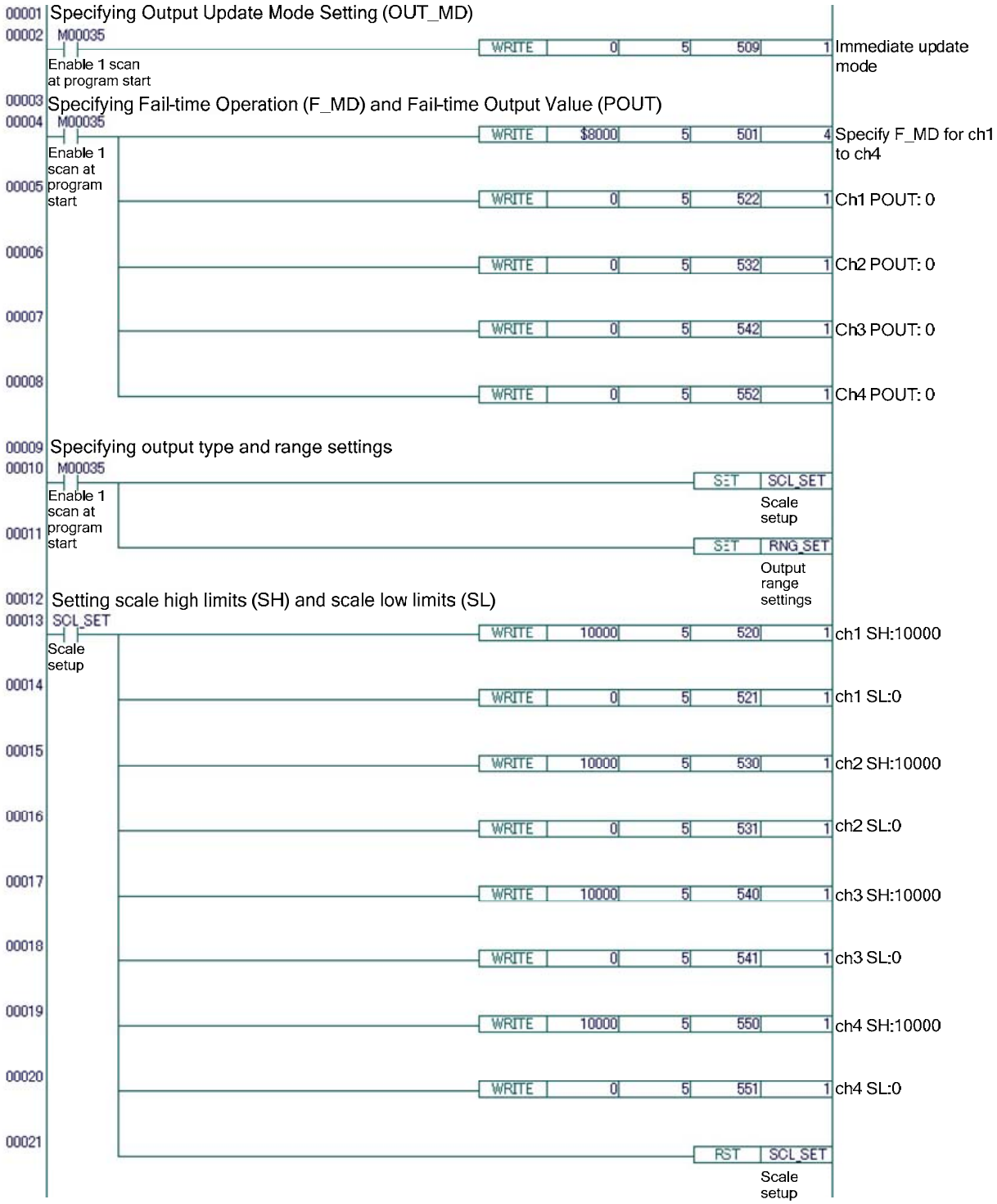

Figure 8.1 Sample Program (initialization part 1)

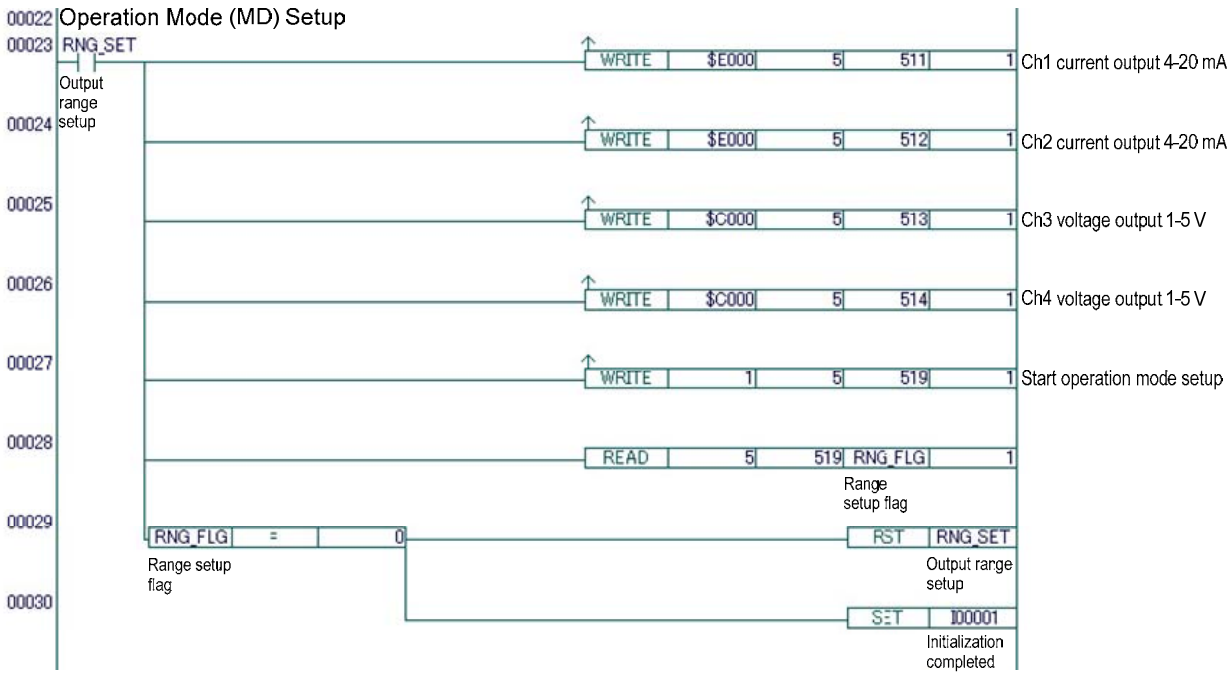

Figure 8.1 Sample Program (initialization part 2)

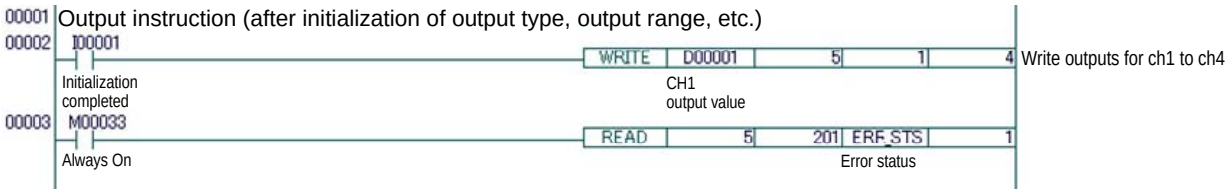

Figure 8.2 Sample Program (main program part)

9. Troubleshooting

This chapter describes the procedure for troubleshooting operation problems related to the module.

If abnormal operation of the FA-M3 system including the analog output module is observed, such as no voltage or current output, unstable output update or a lit or flashing LED indicator other than the RDY LED, try to identify and solve the problem by following the troubleshooting flowchart given below.

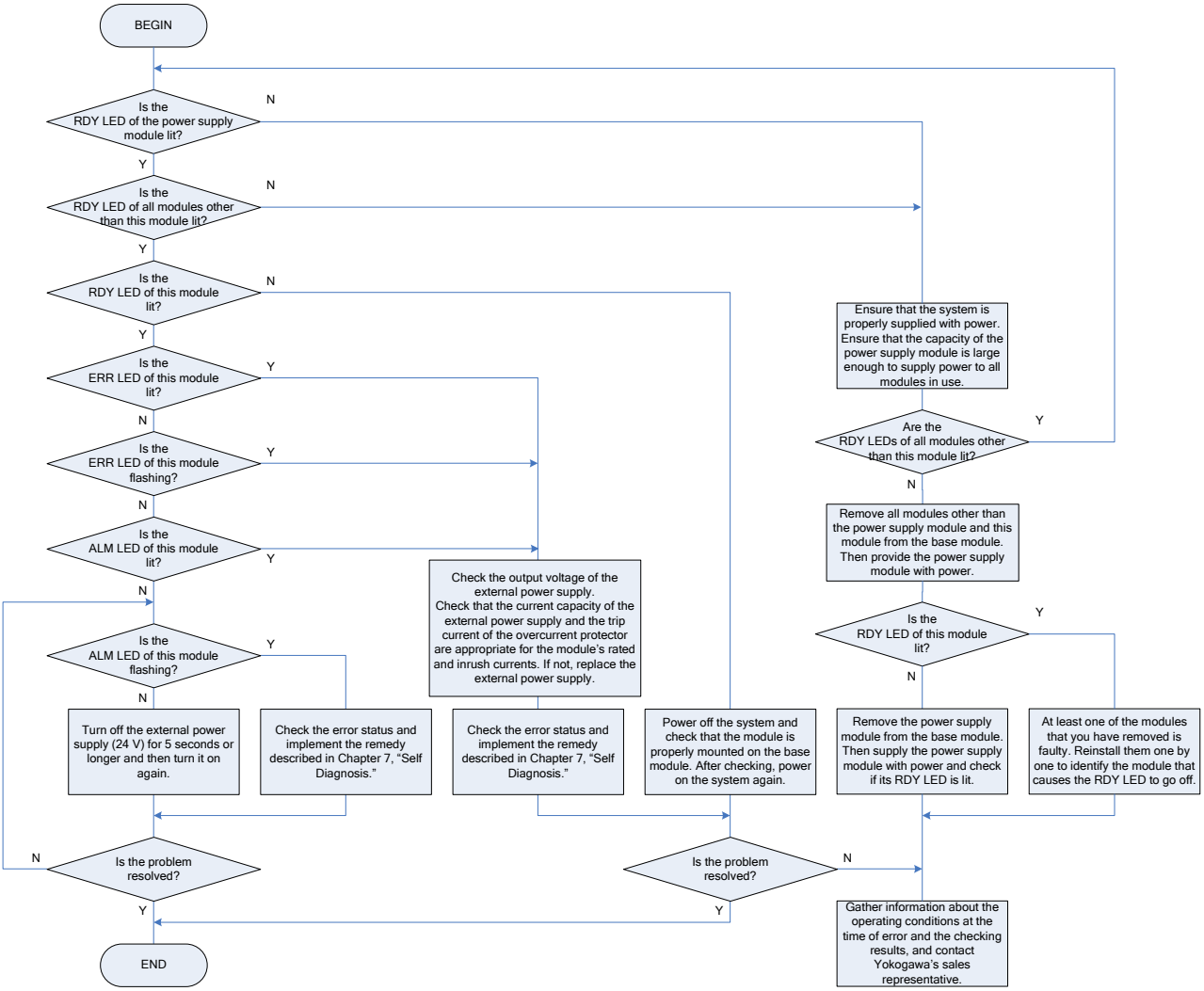

Figure 9.1 Troubleshooting Flowchart

TIP

If you still cannot solve a problem after following the troubleshooting flowchart shown in Figure 9.1, you may contact Yokogawa's technical support or sales office with the results of the above checks.

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Appendices

Appendix 1 Glossary

This appendix describes the terms related to the module specification.

Absolute maximum ratings
Absolute maximum ratings define maximum operating conditions that, if exceeded even for a short period of time, may cause permanent damage to an output range, a channel or the whole module. Such damage may be exhibited as performance degradation such as a larger offset or gain error, or functional failure such as total output failure.

Output signal range
The output signal range is the nominal output range. The digital values for the high limit and low limit of the output signal range can be specified using the scaling function. The actual allowable output range corresponding to this nominal output range is simply called the “output range”.

Output range
The output range is the actual allowable output range and is obtained by adding ±5% allowable over range to the output signal range. It is indicated within parentheses in the module specification. If a value exceeding the output range is specified in the Output Value register, the voltage or current output from the output terminal will be limited by the output range.

Allowable load resistance
The allowable load resistance specifies either the maximum or minimum load resistance allowed for each output, depending on the output type. If the module is operated with a load exceeding this limit, local overheating may result in component failure or the full output range may not be available.

Allowable capacitive load
The allowance capacitive load specifies a limit on voltage output as a necessary condition for prevention of output oscillation. This value is tested by evaluation but is not a guaranteed value.

Allowable inductive load
The allowance inductive load specifies a limit on current output as a necessary condition for prevention of output oscillation. This value is tested by evaluation but is not a guaranteed value.

Output update time
The output update time is the time required for D/A conversion by the module. It is the time required for D/A conversion plus the time for the required change in voltage or current output to appear at the output terminal of the module after an output value is written to the module by the CPU module.

Synchronous output (synchronous update mode)
The synchronous output function updates DACs of all active channels of the same module synchronously and is used to suppress difference in update timing between output channels. By presetting a (trigger) channel as the output update synchronization channel, outputs of the other channels are updated synchronously whenever the output value of the trigger channel is updated.

Output update synchronization channel
The output update synchronization channel acts as a trigger channel for output updates. By presetting a channel number in the Output Update Mode register, the outputs of other channels are updated synchronously whenever data is written to the Output Value register of this channel. You must specify the largest channel number among all active channels of the module as the output update synchronization channel. This is a system constraint for updating all channels synchronously.

Immediate update mode
In immediate update mode, the output of a channel is updated whenever data is written to its Output Value register from the CPU module. In other words, outputs of channels are updated individually.

Output response time
This is the time required for signal change from 10% to 90% level after an output change is instructed to the module.

Output resolution
The output resolution is the voltage or current value corresponding to the least significant bit of the DA converter. The smallest change in actual output voltage or current value is affected by the digital values specified for the scaling function.

Overall accuracy
The overall accuracy specifies output repeatability by expressing output error as a percentage of the output signal range. Two values are specified, one excluding the effect of ambient temperature (23°C±2°C) and the other including the effect of ambient temperature (0 to 55°C). As overall accuracy, like resolution, is affected by scaling, it is specified assuming default values for scaling.

Scaling function
The scaling function enables the high limit and low limit of the output range to be set to any arbitrary value between -30000 and 30000 independently for each channel. The default values vary with the specified output range.

CPU fail-time output
Each channel can be configured independently to either hold its output value or to output a specific value at CPU failure. In the latter case, the value is specified separately.

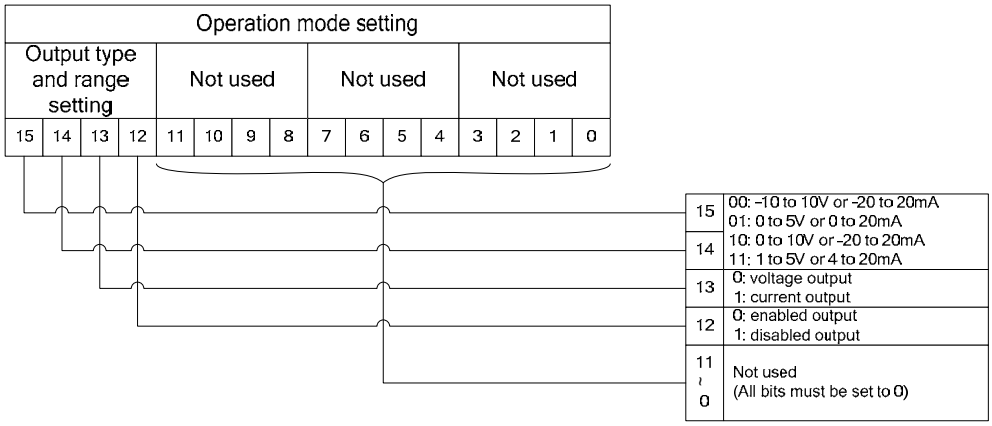
Appendix 2 List of Registers

■ Input/output Data Registers

Appendix Table 1 List of Input/Output Data Registers (part 1 of 2)

Data Position Number		Name	Symbol	Description	R/W*1	See Also
Sequence CPU	BASIC CPU					
1	1	Output value 1	OUT1	Instructed output values (digital input values) Default value: 0	R/W	4.3
2	2	Output value 2	OUT2			
3	3	Output value 3	OUT3			
4	4	Output value 4	OUT4			
5	5	Output value 5	OUT5			
6	6	Output value 6	OUT6			
7	7	Output value 7	OUT7			
8	8	Output value 8	OUT8			
. . .	. . .					
201	201	Error status	ERR_STS	Result of self-diagnosis	R	7.
. . .	. . .					
209	209	Output update mode	OUT.MD_RBK	0: immediate update mode 1 to 8: synchronous update mode	R	6.1
210	210					
211	211	Operation mode 1	MD1_RBK	Output type and output signal range. Bits 15 to 12: output type and output signal range. Bits 11 to 0: not used, always zero.	R	6.4
212	212	Operation mode 2	MD2_RBK			
213	213	Operation mode 3	MD3_RBK			
214	214	Operation mode 4	MD4_RBK			
215	215	Operation mode 5	MD5_RBK			
216	216	Operation mode 6	MD6_RBK			
217	217	Operation mode 7	MD7_RBK			
218	218	Operation mode 8	MD8_RBK			

*1: ”R/W” indicates a register for reading and writing. “R” indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.



Appendix Figure 1 Details of Operation Mode

Appendix Table 1 List of Input/Output Data Registers (part 2 of 2)

Data Position Number		Name	Symbol	Description	R/W*1	See Also
Sequence CPU	BASIC CPU					
220	220	Scale high limit 1	SH1_RDBK	Scale high and low limits for channel 1	R	6.3
221	221	Scale low limit 1	SL1_RDBK			
222	222	Fail-time output value 1	POUT1_RBK	Output value for channel 1 in the event of a CPU failure	R	6.2
. . .	. . .					
230	230	Scale high limit 2	SH2_RDBK	Scale high and low limits for channel 2	R	6.3
231	231	Scale low limit 2	SL2_RDBK			
232	232	Fail-time output value 2	POUT2_RBK	Output value for channel 2 in the event of a CPU failure	R	6.2
. . .	. . .					
240	240	Scale high limit 3	SH3_RDBK	Scale high and low limits for channel 3	R	6.3
241	241	Scale low limit 3	SL3_RDBK			
242	242	Fail-time output value 3	POUT3_RBK	Output value for channel 3 in the event of a CPU failure	R	6.2
. . .	. . .					
250	250	Scale high limit 4	SH4_RDBK	Scale high and low limits for channel 4	R	6.3
251	251	Scale low limit 4	SL4_RDBK			
252	252	Fail-time output value 4	POUT4_RBK	Output value for channel 4 in the event of a CPU failure	R	6.2
. . .	. . .					
260	260	Scale high limit 5	SH5_RDBK	Scale high and low limits for channel 5	R	6.3
261	261	Scale low limit 5	SL5_RDBK			
262	262	Fail-time output value 5	POUT5_RBK	Output value for channel 5 in the event of a CPU failure	R	6.2
. . .	. . .					
270	270	Scale high limit 6	SH6_RDBK	Scale high and low limits for channel 6	R	6.3
271	271	Scale low limit 6	SL6_RDBK			
272	272	Fail-time output value 6	POUT6_RBK	Output value for channel 6 in the event of a CPU failure	R	6.2
. . .	. . .					
280	280	Scale high limit 7	SH7_RDBK	Scale high and low limits for channel 7	R	6.3
281	281	Scale low limit 7	SL7_RDBK			
282	282	Fail-time output value 7	POUT7_RBK	Output value for channel 7 in the event of a CPU failure	R	6.2
. . .	. . .					
290	290	Scale high limit 8	SH8_RDBK	Scale high and low limits for channel 8	R	6.3
291	291	Scale low limit 8	SL8_RDBK			
292	292	Fail-time output value 8	POUT8_RBK	Output value for channel 8 in the event of a CPU failure	R	6.2
. . .	. . .					
301	301	Fail-time operation 1	F_MD1_RBK	Module operation for a channel in the event of a CPU failure Bit15=0: hold output Bit15=1: output specified value Bits 14 to 0: always 0.	R	6.2
302	302	Fail-time operation 2	F_MD2_RBK			
303	303	Fail-time operation 3	F_MD3_RBK			
304	304	Fail-time operation 4	F_MD4_RBK			
305	305	Fail-time operation 5	F_MD5_RBK			
306	306	Fail-time operation 6	F_MD6_RBK			
307	307	Fail-time operation 7	F_MD7_RBK			
308	308	Fail-time operation 8	F_MD8_RBK			

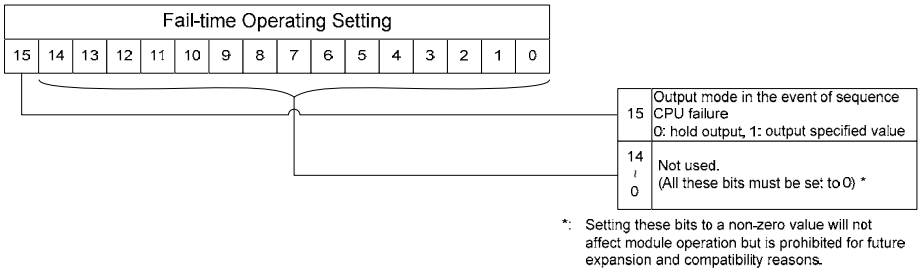
*1:"R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

■ Mode Registers

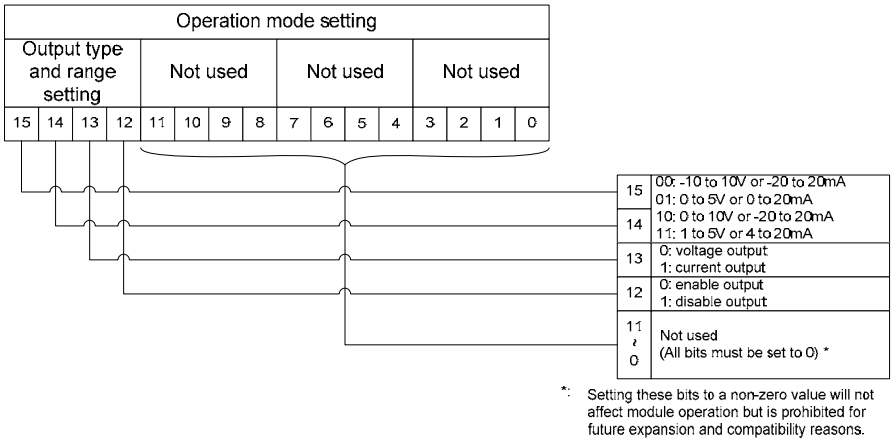
Appendix Table 2 Mode Registers (part 1 of 2)

Data Position Number		Name	Symbol	Description	R/W *1	See Also
Sequence CPU	BASIC CPU					
501	1	Fail-time operation setting 1	F_MD1	Specify the module operation for a channel in the event of a CPU failure. Bit15=0: hold output (default). Bit15=1: output specified value Bits 14 to 0: not used, must always be 0.	R/W	6.2
502	2	Fail-time operation setting 2	F_MD2			
503	3	Fail-time operation setting 3	F_MD3			
504	4	Fail-time operation setting 4	F_MD4			
505	5	Fail-time operation setting 5	F_MD5			
506	6	Fail-time operation setting 6	F_MD6			
507	7	Fail-time operation setting 7	F_MD7			
508	8	Fail-time operation setting 8	F_MD8			
509	9	Output update mode setting	OUT_MD	Specify immediate update mode or output update synchronization channel for synchronous update mode. *2 0: immediate update mode (default) 1 to 8: synchronization channel for F3DA08-5R 1 to 4: synchronization channel for F3DA04-6R	R/W	6.1
510	10					
511	11	Operation mode setting 1	MD1	Specify the output type and output signal range. *3 Bits 15 to 12: output type and output signal range Bits 11 to 0: not used, must always be 0. Default value: 0 For details, see Figure 6.8, “Operation Mode Setting.”	R/W	6.4
512	12	Operation mode setting 2	MD2			
513	13	Operation mode setting 3	MD3			
514	14	Operation mode setting 4	MD4			
515	15	Operation mode setting 5	MD5			
516	16	Operation mode setting 6	MD6			
517	17	Operation mode setting 7	MD7			
518	18	Operation mode setting 8	MD8			
519	19	Operation mode setup flag	MD_SET	1: begin operation mode setup 0: operation mode setup completed *2	R/W	6.4

*1: ”R/W” indicates a register for reading and writing. “R” indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.
*2: Writing a value not listed in the Description column is prohibited. An out-of-range value, if written, is ignored and operation continues according to the previous setting.
*3: Operating Mode Settings 1-8 are applied when the value of 1 is written to the Operation Mode Setup Flag. For details, see the section indicated in the “See Also” column.



Appendix Figure 2 Details of Fail-time Operation Setting



Appendix Figure 3 Details of Operation Mode Setting

Appendix Table 2 Mode Registers (part 2 of 2)

Data Position Number		Name	Symbol	Description	R/W*1	See Also
Sequence CPU	BASIC CPU					
520	20	Scale high limit setting 1	SH1	Specify the scale high limit and scale low limit for channel 1. *2	R/W	6.3
521	21	Scale low limit setting 1	SL1	Default value: 0; Data range: -30000 to 30000		
522	22	Fail-time output value setting 1	POUT1	Specify the output value for channel 1 in the event of a CPU failure. *3	R/W	6.2
・・・	・・・					
530	30	Scale high limit setting 2	SH2	Specify the scale high limit and scale low limit for channel 2. *2	R/W	6.3
531	31	Scale low limit setting 2	SL2	Default value: 0; Data range: -30000 to 30000		
532	32	Fail-time output value setting 2	POUT2	Specify the output value for channel 2 in the event of a CPU failure. *3	R/W	6.2
・・・	・・・					
540	40	Scale high limit setting 3	SH3	Specify the scale high limit and scale low limit for channel 3. *2	R/W	6.3
541	41	Scale low limit setting 3	SL3	Default value: 0; Data range: -30000 to 30000		
542	42	Fail-time output value setting 3	POUT3	Specify the output value for channel 3 in the event of a CPU failure. *3	R/W	6.2
・・・	・・・					
550	50	Scale high limit setting 4	SH4	Specify the scale high limit and scale low limit for channel 4. *2	R/W	6.3
551	51	Scale low limit setting 4	SL4	Default value: 0; Data range: -30000 to 30000		
552	52	Fail-time output value setting 4	POUT4	Specify the output value for channel 4 in the event of a CPU failure. *3	R/W	6.2
・・・	・・・					
560	60	Scale high limit setting 5	SH5	Specify the scale high limit and scale low limit for channel 5. *2	R/W	6.3
561	61	Scale low limit setting 5	SL5	Default value: 0; Data range: -30000 to 30000		
562	62	Fail-time output value setting 5	POUT5	Specify the output value for channel 5 in the event of a CPU failure. *3	R/W	6.2
・・・	・・・					
570	70	Scale high limit setting 6	SH6	Specify the scale high limit and scale low limit for channel 6. *2	R/W	6.3
571	71	Scale low limit setting 6	SL6	Default value: 0; Data range: -30000 to 30000		
572	72	Fail-time output value setting 6	POUT6	Specify the output value for channel 6 in the event of a CPU failure. *3	R/W	6.2
・・・	・・・					
580	80	Scale high limit setting 7	SH7	Specify the scale high limit and scale low limit for channel 7. *2	R/W	6.3
581	81	Scale low limit setting 7	SL7	Default value: 0; Data range: -30000 to 30000		
582	82	Fail-time output value setting 7	POUT7	Specify the output value for channel 7 in the event of a CPU failure. *3	R/W	6.2
・・・	・・・					
590	90	Scale high limit setting	SH8	Specify the scale high limit and scale low limit for channel 8. *2	R/W	6.3
591	91	Scale low limit setting	SL8	Default value: 0; Data range: -30000 to 30000		
592	92	Fail-time output value setting 8	POUT8	Specify the output value for channel 8 in the event of a CPU failure. *3	R/W	6.2

*1: "R/W" indicates a register for reading and writing. "R" indicates a read-only register. Any data written to a read-only register is ignored and has no effect on module operation.

*2: For details on the module operation with default setting where both the scale high limit and the scale low limit are zero, see the section indicated in the "See Also" column.

*3: The Fail-time Output Value Setting is valid only if the corresponding Fail-time Operation Setting indicates to "output specified value". It is ignored if the Fail-time Operation Setting indicates to "hold output". The default value is 0.

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