Fuji Electric

Innovating Energy Technology

User's Manual

USER'S MANUAL

FRENIC-VG Series

Stack Type Edition

24A7-E-0018d

High Performance Vector Control Inverter

FRENIC-VG

User's Manual

(Stack Type Edition)

Revision History	Revision Symbol	Year and Month of Change	Description
First Edition	–	2013-03	–
Second Edition	a	2016-03	1. Inverters • 400V series → 630kW to 800kW units added (external views, etc.) • 690V series added → 90kW to 450kW 2. Converters (diode rectifiers) • 690V series added. 3. Converters (PMW converters) • 400V series → 630kW to 800kW units added (external views, etc.) 4. Filter stacks • 400V series added. 5. Other • Content renewed (addition of sections added at later date, etc.)
Third Edition	b	2017-03	1. Converters (PMW converters) • 690V series added. 2. Converters (filter stacks) • 690V series added. 3. Other • Content renewed (addition of sections added at later date, etc.)
4th Edition	c	2019-02	Content renewed.
5th Edition	d	2019-07	Content renewed.

The information contained herein is subject to change for improvement without prior notice.

The information in this manual is correct at the time of publication. However, if concerns arise or if mistakes are found, please contact the retailing store of purchase or a sales office of Fuji Electric Co., Ltd. listed at the end of this document.

Preface

This manual describes information on the installation of FRENIC-VG series stack type inverters and converters and the selection of peripheral devices, with specialization in hardware. Please refer to the separate volume user's manual for operation methods such as function setup.
Please read this manual thoroughly for correct operation. Improper handling may result in prevention of normal operation, decrease of service life, or cause of failure.

The table below lists other materials related to the use of the FRENIC-VG series. Read them in conjunction with this manual as necessary.

Name		Material Number	Description
Catalog		24A1-☐-0002* (Formerly MH659)	Product overview, features, specifications, external dimensions, options, etc.
User's Manual	Unit Type Function Code Edition	24A7-☐-0019* (Formerly MHT286)	1) Description of function codes, keypad operating instructions, etc. for the FRENIC-VG series (unit type/stack type) 2) Overview of the FRENIC-VG unit type, features, specifications, replacement documentation, etc.
	Option Edition	24A7-☐-0045* (Formerly MHT286)	Functional description of various option cards for the FRENIC-VG series, the RS-485, etc. * For information on the functional safety option (OPC-VG1-SAFE), refer to the manual of the option card. The functions and other aspects of other options are described in this manual.
	Stack Type Edition (this manual)	24A7−☐−0018*	Features, specifications, cabinet design materials, etc. for the FRENIC-VG stack type inverters and converters
	UPAC Option Edition	24A7−☐−0044*	UPAC option card specifications, description of the interface between the inverter and UPAC, description of application package software (orientation, dancer type winder), etc.
Instruction Manual	FRENIC-VG stack type (400V)	INR-SI47-1721*-☐	Inspection upon delivery, installation and wiring of the product, keypad operating instructions, troubleshooting, maintenance and inspection, specifications, etc.
	FRENIC-VG stack type (690V)	INR-SI47-1841*-☐	
	RHD-D stack type (400V)	INR-SI47-1786*-☐	
	RHD-D stack type (690V)	INR-SI47-1852*-☐	
	RHC-D stack type (400V)	INR-SI47-1722*-☐	
	RHC-D stack type (690V)	INR-SI47-1944*-☐	
	RHF-D stack type (400V)	INR-SI47-1770*-☐	
	RHF-D stack type (690V)	INR-SI47-1945*-☐	
FRENIC-VG Loader Instruction Manual	WPS-VG1-STR	INR-SI47-1588*-☐	Instructions for use of the inverter support loader software, FRENIC-VG Loader (free-of-charge version)
	WPS-VG1-PCL	INR-SI47-1616*-☐	Instructions for use of FRENIC-VG Loader (paid version) Includes tracing functions in addition to all the functions of the free-of-charge version (WPS-VG1-STR).

Note 1) Placeholders "☐" appearing in material numbers in the table above will be replaced with symbols such as J (Japanese), E (English), C (Chinese).
Asterisks (*) appearing in material numbers will be replaced with a revision number (a, b, c...).

Note 2) The materials are subject to change without notice. Be sure to obtain the latest editions before use.

Correspondence Method to "Guideline on Measures to Suppress Harmonics for Users Serviced by High Voltage or Special High Voltage" (General Purpose Inverters)

For more information, refer to Appendix 7 of this manual.

Structure of this manual

This manual is structured as follows.

Chapter 1 Overview

This chapter describes the overview, features and the control system of the FRENIC-VG stack type inverter and the recommended configuration for the inverter and peripheral devices.

Chapter 2 Specifications

Rated output, control method, product overview, specifications for the specialized motor, protective function details, basic connection diagrams, and terminal functions of the FRENIC-VG are described. Additionally, descriptions for the operating environment, storage environment, product quality assurance, precautions for use, external dimensions, examples of basic connections, and protective function details are provided.

Chapter 3 Transportation and Storage

Descriptions of the transportation method for the FRENIC-VG, converter stack and the cabinet, the FRENIC-VG name plate, storage environment, and storage method are provided.

Chapter 4 Installation and Wiring

Cabinet construction design documents and wiring specifications, conditions and precautions for the selection of electrical lines and crimped terminals are described for installation the FRENIC-VG and converter on the cabinet.

Chapter 5 Peripherals

The purpose of peripheral devices and options, connection configuration, and precautions for the FRENIC-VG are described.

Chapter 6 Converter System

The specifications, protective function details, and basic connection diagrams are described for the PWM converter (RHC-D series), which is the converter providing input to FRENIC-VG, and for the diode rectifier (RHD-D series). Additionally, the selection method for the peripheral devices and electrical wiring sizes for the converters are described.
Lastly, the resistance regenerative braking unit and the braking resistance are described.

Chapter 7 EMC Compatible Peripherals

Introduction and operation of devices with noise countermeasures as well as noise countermeasures are described.

Chapter 8 Operation

Provides references to the operating method for the FRENIC-VG described in the separate volume, "FRENIC-VG unit Type Function Code Edition" (24A7-☐-0019).

Chapter 9 Selecting Model

The selection method for the motor and inverter capacities is described. The inverter output torque characteristics required when selecting the capacity, the procedure for capacity selection, and the equation for capacity selection are described. In addition, the braking resistor selection needed in choosing the capacity, MD/LD specification selection, and the control method selection methods are shown.
Lastly, function setup, connection configuration, and reduced unit operation are explained for the case of direct parallel connection control method.

Chapter 10 Maintenance and Inspection

The daily inspection, periodic inspection, and periodic part replacement for using the inverter in the long term are described. In addition, the maintenance for the air filter used in the cabinet is explained.

Chapter 11 Troubleshooting

The troubleshooting procedures for inverter malfunctions, alarms, and minor failures are described.
The content guides the user to the individual troubleshooting steps after determining the event as an alarm or a failure based on the displayed content.

Chapter 12 Cabinet Construction

Introduction of the protection level and the cooling method selection matching the installation environment of the cabinet housing the inverter are provided.

Appendix

The guidelines concerning safety in Japan, overview of JEM standards, harmonics guideline, and case studies of inverter noise countermeasures are shown.

CONTENTS

Appendix

■ Safety precautions

Please read the instructions manual carefully before installation, wiring (connection), operating, or performing maintenance checkup, and operate the product correctly. Additionally, ensure that you have sound knowledge of the device and familiarize yourself with all safety information and precautions.

Safety precautions are classified into the following categories in this manual.

⚠WARNING	Failure to heed the information indicated by this symbol may lead to dangerous conditions, possibly resulting in death or serious bodily injuries.
⚠CAUTION	Failure to heed the information indicated by this symbol may lead to dangerous conditions, possibly resulting in medium level or minor bodily injuries and/or substantial property damage.

Following the cautionary advices contained under the CAUTION title may still cause serious consequences.

These safety precautions are of utmost importance and must be observed at all times.

Application

(1) FRENIC-VG stack type inverter

⚠WARNING

- The FRENIC-VG is an equipment to drive 3 phase motors. The inverter may not be used for single-phase motors and other purposes.
- The FRENIC-VG cannot drive 3 phase motors independently by connecting to a commercial power supply.
  Use the PWM converters or diode rectifiers specified by Fuji Electric Co., Ltd in combination with the FRENIC-VG.

  Otherwise, fire or accidents may occur.
- FRENIC-VG may not be used for applications directly related to human safety such as life supporting systems.
- Although the product is manufactured under strict quality control, install safety devices for applications where serious accidents or property damages are foreseen in relation to the failure of the inverter.

  Otherwise, accidents may occur.

(2) RHC-D (PWM converter)

⚠WARNING

- RHC-D (PWM converter) is an equipment to be used in combination with Fuji Electric's inverter to drive 3 phase motors. It may not be used for other purposes.

  Otherwise, fire or accidents may occur.
- The RHC-D may not be used for applications directly related to human safety such as life supporting systems.
- Although the product is manufactured under strict quality control, install safety devices for applications where serious accidents or property damages are foreseen in relation to the failure of the inverter.

  Otherwise, accidents may occur.

(3) RHD-D (diode rectifier)

⚠WARNING

- RHD-D (diode rectifier) is an equipment to be used in combination with Fuji Electric's inverter to drive 3 phase motors. It may not be used for other purposes.

  Otherwise, fire or accidents may occur.
- The RHD-D may not be used for applications directly related to human safety such as life supporting systems.
- Although the product is manufactured under strict quality control, install safety devices for applications where serious accidents or property damages are foreseen in relation to the failure of the inverter.

  Otherwise, accidents may occur.

(4) RHF-D (filter stack dedicated to RHC-D)

⚠WARNING

- The RHF-D (filter stack dedicated to RHC-D) is an equipment to be used in combination with Fuji Electric's PWM converter (RHC-D) and inverter to drive 3 phase motors. It may not be used for other purposes.

  Otherwise, fire or accidents may occur.
- The RHF-D may not be used for applications directly related to human safety such as life supporting systems.
- Although the product is manufactured under strict quality control, install safety devices for applications where serious accidents or property damages are foreseen in relation to the failure of the inverter.

  Otherwise, accidents may occur.

Installation

⚠WARNING ⚠

- Install the inverter on a base made of metal or other non-flammable material.
- Do not install close to flammable objects.

  Otherwise, fire may occur.
- The protection structure of the product body is IP00, and contact with the main circuit terminal block (live part) is possible. For this reason, implement measures such as installation in locations where individuals cannot easily contact.

  Otherwise, it could cause electric shock and injury.

⚠CAUTION

- Do not support the product by its front cover during transportation.

  Otherwise, it could cause the product to drop, resulting in injury.
- Prevent foreign materials such as lint, paper fibers, sawdust, dust, and metallic chips from entering the product and from accumulating on the cooling fins.
- Install by using screws and bolts at the defined tightening torque, following the specified installation method.

  Otherwise, fire or accidents may occur.
- Do not install or operate products which are damaged internally or externally.

  Otherwise, it could cause fire, accidents and injuries.

Wiring

⚠WARNING ⚠

- Shutdown of the entire power supply system caused by functioning of the ground-fault relay in the upstream power supply line is operationally undesirable. When appropriate earth leakage (zero phase current) detecting devices are not installed in the power supply system, install an earth leakage circuit breaker (ELCB) on the input side of each converter (diode rectifier, PWM converter, filter stack).
- Connect to the power supply through molded-case circuit-breakers and earth leakage circuit breakers (with overcurrent protection) on each converter (diode rectifier, PWM converter, filter stack). Use recommended devices with the recommended capacities for the molded-case circuit-breaker and earth leakage breaker.
- Use wires in the specified size.
- Tighten terminals with the specified torque.
- When multiple combinations of inverters and motors exist, do not use multicore cables for the purpose of handling the wiring together.
- Do not connect surge killers to the inverter output (secondary) circuit.

  Otherwise, fire may occur.

- Perform C type grounding construction following the supply voltage systems for the converter (diode rectifier, PWM converter, filter stack).
- Always connect the grounding terminal [⏚G] to an earthing conductor or earthing copper bar for the converter (diode rectifier, PWM converter, filter stack) and the FRENIC-VG.

  Otherwise, electric shock or fire may occur.

- Qualified electricians should carry out wiring.
- Be sure to perform wiring after turning the power OFF.

  Otherwise, electric shock may occur.

- Always wire after the product is installed.

  Otherwise, it could cause electric shock and injury.

- Confirm that the phase number and the rated voltage of the power supply input to the converter (diode rectifier, PWM converter, filter stack) matches the phase number and voltage of the power supply to connect.
- Do not connect the power supply lines to the output terminals (P, N) of the converter (diode rectifier, PWM converter).
- Do not connect the power supply lines to the inverter output terminals (U, V, and W).

  Otherwise, fire or accidents may occur.

- In general, sheaths of the control signal wires are not specifically designed to withstand high voltage (i.e., reinforced insulation is not applied). Therefore, if a control signal wire comes into direct contact with a live conductor of the main circuit, the insulation of the sheath may be damaged. In this case, the main circuit high voltage may be applied on the control signal wire, so make sure that the control signal wires do not come into contact with live conductors of the main circuit.

  Otherwise, it could cause an accident or an electric shock.

⚠WARNING ⚠

- When moving the switches, check that the voltage between the major terminals P (+) and N (-) has fallen to a safe voltage (below DC +25 V) using a tester after confirming that the LED monitor and the charge lamp have turned off and after 10 minutes has elapsed.
  The diode rectifier or filter stack does not contain the LED monitoring function.

  Otherwise, electric shock may occur.

⚠CAUTION

- Electric noise is generated from FRENIC-VG, PWM converter, filter stack, motor, and wiring. This may cause malfunction in the peripheral sensors and devices. To prevent malfunctions, implement noise countermeasures.

  Otherwise, accidents may occur.

Operation

⚠WARNING⚠

- Be sure to mount the front cover of the product before turning the power ON. Do not remove the cover when the power is ON.
- Do not operate the switches with wet hands.

  Otherwise, electric shock may occur.

<FRENIC-VG stack type inverter>

- If the auto-reset function has been selected, the inverter may automatically restart and drive the motor depending on the cause of tripping. Design the machine so that safety for human and the surroundings is ensured after restarting.
- If the stall prevention function (torque limiter) has been selected, the inverter may operate with acceleration/deceleration times and speed different from the setup. Design the machine so that safety is ensured even in these cases.

  Otherwise, accidents may occur.

- The keypad STOP keys are enabled only when the keypad operation is selected by F02 function code. Emergency shut down switch should be prepared separately. When the operation command method is switched from keypad operation command using link operation selection "LE", the STOP keys are disabled.
- After the cause of protective function actuation is removed, confirm that the run command is OFF and release the alarm. If the run command is ON when the alarm is released, the inverter will start supplying power to the motor. The motor may rotate, which could be dangerous.

  Otherwise, accidents may occur.

- If the "Restart mode after momentary power failure" (Function code F14 = 3 to 5) is selected, then the inverter automatically restarts running the motor when the power is recovered. Design the machine so that human safety is ensured after restarting.
- Set up the function codes after completely understanding this user's manual. When the equipment is operated while the function code date is changed indiscriminately, motor may rotate at torques and speed which the machine cannot tolerate.

  Otherwise, accidents or injuries may occur.

- Even if the inverter has interrupted power to the motor, voltage may be output to inverter output terminals U, V, and W if voltage is applied to the main input power supply of the PWM converter and the diode rectifier.
- Even if the motor is stopped by direct current braking or pre-excitation, voltage is output to inverter output terminals U, V, and W.

  Otherwise, electric shock may occur.

- The inverter can be readily set up for high speed operation. When changing the speed setting, carefully check the specifications of motors and the machine beforehand.

  Otherwise, it could cause injury.

<Diode rectifier, PWM converter, filter stack>

- When the protective function of the PWM converter is activated, confirm that the run command is OFF. Remove the cause of the protective function activation, and release the alarm. If the alarm is released while the run command is ON, the inverter may restart abruptly, which can be dangerous.

  Otherwise, accidents may occur.

- Voltage is applied to the individual main terminals P (+) - N (-) even while the FRENIC-VG is stopped when the input supply voltage is applied to the converter (diode rectifier, PWM converter, filter stack).

  Otherwise, electric shock may occur.

- While the filter stack is operating, an electromagnetic sound is generated from the reactors and resistors in it. If the product is installed in an area with noise restrictions, implement sound insulation.

⚠CAUTION

- Do not touch the cooling fins as they become hot.

  Risk of burn exists.

<FRENIC-VG stack type inverter>

- The brake function of the inverter does not provide mechanical holding.
- The digital input terminal contains functions for run, stop, and speed commands such as operation command "FWD" and coast-to-stop command "BX". The speed may change drastically or operation may start abruptly with changes in the function code setting through the digital input terminals. Perform changes to the function code settings after adequately securing safety.
- The manipulation method of the operation commands and the function to switch the speed commanding methods ("SS1, 2, 4, 8", "N2/N1", "KP/PID", "IVS", "LE", others) can be assigned to the digital input terminal. When switching these signals, the operation may start abruptly or the speed may change drastically depending on the conditions.

  Otherwise, accidents or injuries may occur.

<Diode rectifier, PWM converter, filter stack>

- Do not touch the reactor (filter reactor, pressurizing reactor, DC reactor, etc.) and the braking resistor as they become hot.

  Otherwise, it could cause injury.

Maintenance checkup and parts replacement

⚠WARNING ⚠

- When moving the switches at checkup, check that the voltage between the major terminals P (+) and N (-) has fallen to a safe voltage (below DC +25 V) using a tester after confirming that the LED monitor and the charge lamp have turned off and after 10 minutes has elapsed. The diode rectifier or filter stack does not contain the LED monitoring function.

  Otherwise, electric shock may occur.

- Be sure to perform the daily inspection and periodic inspection described in the instruction manual. Lengthy use of the product without inspection could result in inverter failure and damage, or accident and fire.
- A periodic inspection cycle of 1 to 2 years is recommended, however, the cycle may be reduced depending on usage conditions.
- It is recommended that parts for periodic replacement be replaced after the standard number of years indicated in the instruction manual. Lengthy use of the product without without replacing parts could result in inverter failure and damage, or accident and fire.

  Risk of burn exists.

<FRENIC-VG stack type inverter>

- Contact outputs [30A/B/C] and [Y5A/C] use relays, and may remain ON or OFF, or in an indefinite state when the life is reached. In the interests of safety, equip the product with an external protection function.
- Continued use of the product with battery consumed may result in loss of data.

  Risk of accident

<Diode rectifier>

- Contact outputs [73A/C], [1,2], and [ONA/C] use relays, and may remain ON or OFF, or in an indefinite state when the life is reached. In the interests of safety, equip the product with an external protection function.

  Risk of accident

<PWM converter>

- Contact outputs [30A/B/C], [Y5A/C], and [73A/C] use relays, and may remain ON or OFF, or in an indefinite state when the life is reached. In the interests of safety, equip the product with an external protection function.

  Risk of accident

⚠WARNING ⚠

<Filter stack>

- Contact outputs [1，2] and [ONA/B/C] use relays, and may remain ON or OFF, or in an indefinite state when the life is reached. In the interests of safety, equip the product with an external protection function.

  Risk of accident

- Maintenance checkup and parts replacement should be conducted only by qualified personnel.
- Take off watches, rings, and other metallic objects before starting work.
- Use insulated tools.
- Never modify the product.

  Otherwise, it could cause electric shock and injury.

Disposal

⚠CAUTION

- Treat the FRENIC-VG and converter (diode rectifier, PWM converter, filter stack) as industrial waste when disposing of them.

  Otherwise, it could cause injury.

- The batteries used in the FRENIC-VG fall under "primary batteries". Discard following the procedures for disposal defined by each municipality.

Speed control mode

⚠CAUTION

<FRENIC-VG stack type inverter>

- If the control parameters of the automatic speed regulator (ASR) are not appropriately configured under speed control, turning the run command OFF may not decelerate the motor due to hunting caused by high gain setting. Stop conditions may not be reached and the motor may continue running.
- Hunting state may be realized by high response in low speed regions during deceleration. The detected speed deviates from the zero speed area before the zero speed control duration (F39) elapses, and the stop conditions are not reached. The inverter enters the deceleration mode again and continues running.

  Otherwise, it could cause accidents or injuries.

⇒ Adjust the ASR control parameter to an appropriate value. Also implement countermeasures such as causing the alarm to trip when deviation results between the commanded speed and actual speed by using the speed mismatch alarm function. Additional measures may include switching by ASR control constant speed or determination of stopping speed detection by the commanded value.

Torque control mode

⚠CAUTION

<FRENIC-VG stack type inverter>

- When the motor is rotated by load-side torque exceeding the torque command under torque control, turning the run command OFF may not bring the stop conditions so that the inverter may continue running.

  Otherwise, it could cause accidents or injuries.

⇒ To cut off the inverter output, switch to speed control and decelerate to stop, or issue the coast-to-stop command and cut off the output.

General Precautions

⚠CAUTION
Part of the illustrations listed in this user's manual and the instruction manual bundled with the product may be shown without covers or shields in order to describe the details. When operating the product, be sure to reinstall the covers and shields exactly as specified, and operate it in accordance with the instruction manual.

Icons

The following icons are used throughout this manual.

Note: This icon indicates information which, if not heeded, can result in the inverter not operating to full efficiency, as well as information concerning incorrect operations and settings which can result in accidents.

Tip: This icon indicates information that can prove handy when performing certain settings or operations.

📖 This icon indicates a reference to more detailed information.

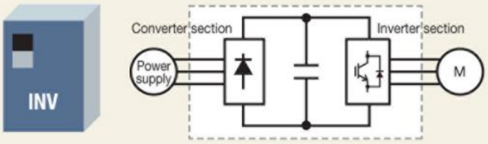
FRENIC-VG

1

Chapter 1 Overview

1.1 Product introduction

Inverter (Unit Type)



This type consists of the converter and inverter circuits.The inverter can be operated using a commercial power supply.
* DC power can also be supplied without using the converter circuit.

Structure

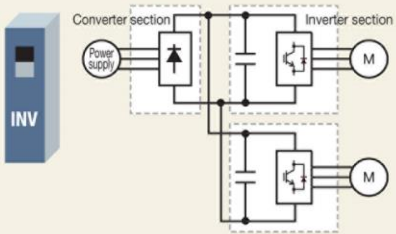
- Built-in converter (rectifier)
- Built-in control circuit
- External DC reactor as standard*
- DC input is available.

* Available for 75kW or higher capacity models

Features

Easier arrangement for small-scale system

Inverter (Stack Type)



The converter and inverter sections are separately set in this type.The converter (diode stack) or PWM converter is required depending on the intended use. Moreover, a combination of inverters can be used with one converter.

Structure

- The converter (rectifier) is separately set.
- External control circuit
- Built-in DC reactor

Features

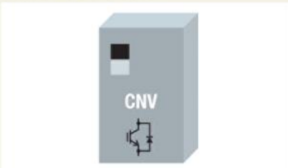
- DC supply enables the multi-drive arrangement
- Energy can be shared within DC bus lines.
- Downsized panel
- Large-capacity system is easily built.
- Easier maintenance

Converter

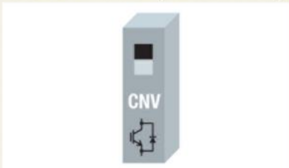
Diode rectifier (Stack Type)
RHD-D series

This converter is used where no electric power regeneration is required.

PMW converter (Unit Type)
RHC-C series*



PMW converter (Stack Type)
RHC-D series*(400V/690V)



Filter stack (Stack Type)
RHF-D series (400V/690V)

This converter is used where electric power regeneration or harmonic control is required.
Peripheral devices are separately required.
* D series and C series differ in form but show identical function and performance.
Please use them according to the installation space and purposes.

- Line-up features unit type and stack type, facilitating easy construction of large-capacity systems.
- The stack type offers support for up to the following capacities through direct parallel connection.
  Three-phase 400V series: Max. 2400kW (MD spec.), 3000kW (LD spec.)
  Three-phase 690V series: Max. 1200kW (MD spec.), 1200kW (LD spec.)

Inverter: Products Line-UP / Expand capacity range (parallel operation)
Converter: Products Line-UP / Expand capacity range (parallel operation)

Three-phase 200V series

Type	Series name	Form	Specifications *1 (applicable load)	Nominal applied motor [kW] (50 / 100 / 500 / 1000 / 5000)
Unit 	Inverter (FRENIC-VG)	Standard unit	HD (LD)	0.75kW / 90kW(110kW) / Direct parallel 250kW(300kW) / Multiwinding motor 500kW(630kW)
	PWM Converter (RHC-C)	Standard unit	MD(CT) (LD(VT))	7.5kW(11kW) / 90kW(110kW) / Isolation-less 250kW(300kW) / Isolation 500kW(630kW)

Three-phase 400V series

Type	Series name	Form	Specifications *1 (applicable load)	Nominal applied motor [kW] (50 / 100 / 500 / 1000 / 5000)
Unit 	Inverter (FRENIC-VG)	Standard unit	HD (LD)	3.7kW(37kW) / 630kW(710kW) / Direct parallel 1800kW(2000kW) / Multiwinding motor 3700kW(4200kW)
			MD	110kW / 450kW / Direct parallel 1200kW / Multiwinding motor 2600kW
	PWM Converter (RHC-C)	Standard unit	MD(CT) (LD(VT))	7.5kW(11kW) / 630kW(710kW) / Isolation-less 1800kW(2000kW) / Isolation 3700kW(4200kW)
Stack 	Inverter (FRENIC-VG)	Standard stack	MD (LD)	30kW(37kW) / 315kW(355kW) / Direct parallel 800kW(1000kW) / Multiwinding motor 1800kW(2000kW)
		Stack by phase	MD (LD)	630kW (710kW) / 800kW(1000kW) / Direct parallel 2400kW(3000kW) / Multiwinding motor 4800kW(6000kW)
	PWM Converter (RHC-D)	Standard stack	MD (LD)	132kW(160kW) / 315kW(355kW) / Isolation-less 800kW(1000kW) / Isolation 1800kW(2000kW)
		Stack by phase	MD (LD)	630kW (710kW) / 800kW(1000kW) / Isolation-less 2400kW(3000kW) / Isolation 4800kW(6000kW)
	Filter stack (RHF-D)	Standard stack	-	160kW / 355kW
	Diode rectifier (RHD-D)	Standard stack	MD (LD)	200kW (220kW) / 315kW(355kW) / Parallel connection 1450kW(1640kW)

Three-phase 690V series

Type	Series name	Form	Specifications *1 (applicable load)	Nominal applied motor [kW] (50 / 100 / 500 / 1000 / 5000)
Stack 	Inverter (FRENIC-VG)	Standard stack	MD (LD)	90kW (110kW) / 450kW(450kW) / Direct parallel 1200kW(1200kW) / Multiwinding motor 2700kW(2700kW)
	PWM Converter (RHC-D)	Standard stack	MD (LD)	132kW (160kW) / 450kW(450kW) / Isolation-less 1200kW(1200kW) / Isolation 2700kW(2000kW)
	Filter stack (RHF-D)	Standard stack	-	160kW / 450kW
	Diode rectifier (RHD-D)	Standard stack	MD (LD)	220kW (250kW) / 450kW / Parallel connection 2000kW

*1 Refer to "Ratings for intended use" on page 6 for specifications (applicable load).
* Unit type inverters have built-in brake circuits as standard (160kW or less).
* Configuration: Standard unit → Can be used with one set. Stack by phase → Categorized by phase, and one inverter set consists of three stacks.
* Multiple inverters can be connected with a single PWM converter and diode rectifier.
* Inverters can also be supplied with DC power (with generator, etc.) without the use of a converter circuit.
* Capacity expansion (parallel operation)
  Inverters
  · Direct parallel connection: One single-winding motor is driven by multiple inverters. (Drive is possible with up to three inverters)
  · Multi-winding motor drive: Specialized motor drive system with multiple windings around a single motor. (Drive is possible with up to six inverters)
  PWM converters
  · Transformer isolation (parallel system): System used to isolate the receiving power supply system and converter with a transformer. It is necessary to equip each converter input with a transformer. (No. of parallel connection units: max. 6)
  · Transformerless (parallel system): System in which a PWM converter is connected directly to the receiving power supply system. There is no need to isolate with a transformer. (No. of parallel connection units: max. 3)
* Filter circuits if used with transformerless parallel system (multiple units operating in parallel)
  Standard stack: Use a filter stack. (Filter circuits cannot be configured with peripheral equipment.)
  Stack by phase: Use peripheral equipment.

1.2 Features

1.2.1 A wide range of applications

1.2.1.1 Control method

Not only induction motors but also synchronous motors can be driven, and for induction motors, you can select the most suitable control method according to your individual needs.

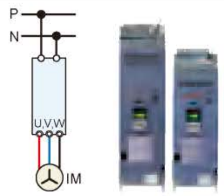
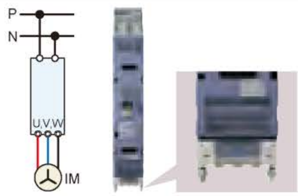
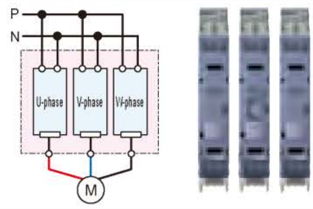
Target motors	Control method
Induction motor	• Vector control with a speed sensor • Vector control without a speed sensor • V/f Control
Synchronous motor	Vector control with a speed sensor (including magnetic pole position detection)

1.2.1.2 Product arrangement and easier change

The stack type inverters have an arrangement with consideration for the installation of the product into the cabinet and easier change.

(1) The inverters (132 to 800 kW) can easily be installed to the cabinet or changed because they have casters.

(2) With the inverters (630 to 800 kW), stacks are divided for each output phase (U, V and W), which has realized the lighter weight.

Nominal applied motor capacity [kW] (MD spec)	30 to 110	132 to 450	630 to 800
Type	400V: FRN30SVG1S-4□ to FRN110SVG1S-4□ 690V: FRN90SVG1S-69□ to FRN110SVG1S-69□	400V: FRN132SVG1S-4□ to FRN315SVG1S-4□ 690V: FRN132SVG1S-69□ to FRN450SVG1S-69□	FRN630BVG1S-4□ to FRN800BVG1S-4□
Categoly	Single unit	Single unit	Stack by phase
Wheels	Not provided	Provided	Provided
Arrangement			
Maintenance	The weight of one stack is reduced (50 kg or less) to give consideration to replacement work.	The models where each stack is heavy have wheels in order to change the stacks easily. A lifter for replacement is available. 	Trim weight by dividing the stack into 3 parts by each output phase (U, V and W). In the event of a breakdown, only the target phase needs to be replaced with a new one. The stack to be replaced should be an exclusive part. 
Approx.weight [kg]	30 to 45	95 to 135	135×3

1.2.1.3 Ratings for intended use

The operation mode for the motor is selected according to motor load condition. Motors one or two frame larger than inverter can be driven for light load (LD) use.

Specification	Applied load	Feature	Applicable overload rating	Power supply voltage	Applicable motor capacity [kW]
MD	Middle Duty Spec		150%, 1min	400 V	30 to 800
				690 V	90 to 450
LD	Low Duty Spec	Can drive motors of frames one or two sizes larger.	110%, 1 min	400 V	37 to 1000
				690 V	110 to 450

1.2.1.4 Style designed specifically for installation in a panel

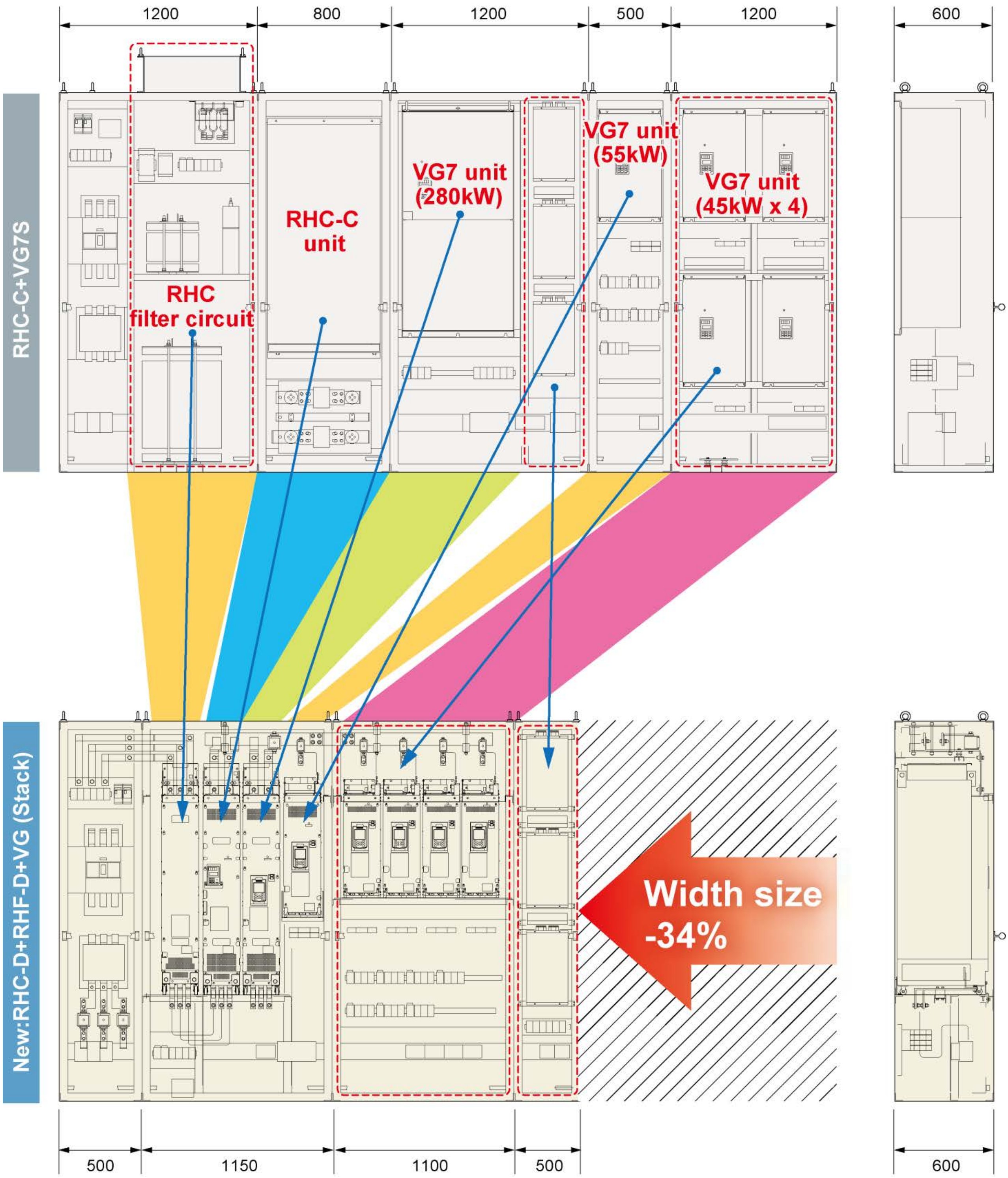
Fits in smaller panels

Designed specifically for installation in a panel, the stack type inverters fit in smaller panels than the conventional models.

For crane systems, the panel width can be reduced by 34%, compared with the conventional models.

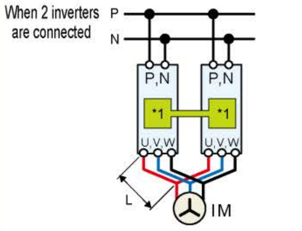
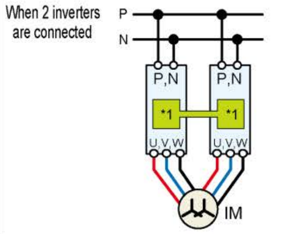
Also, the inverters can be easily installed in a panel and replaced, thanks to the dedicated design.

<Example of panel configuration for a crane system>

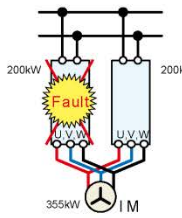


1.2.1.5 How to expand the capacity range of the inverters

Direct parallel connection system and multiwinding motor drive system are provided for driving a large capacity motor.

System		Direct parallel connection system	Multiwinding motor drive system
Features	Drive motor	Single-winding motor	Multiwinding motor (Exclusive use for multiwinding motors)
	Restriction of wiring length	The minimum wiring length (L) varies with the capacity.	There is no particular limit.
	Reduced capacity operation *2	Available	Available (However, the wiring should be switched over.)
Number of inverters to be connected		2 to 3 inverters	2 to 6 inverters
Arrangement diagram			

*1) OPC-VG1-TBSI is separately required.
*2) Reduced capacity operation. If a stack fails in case of direct parallel connection, the operation continues with lower output power using the stacks that have not failed.



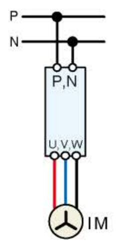
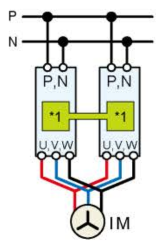
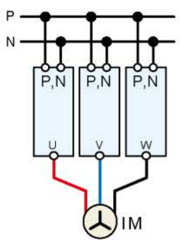
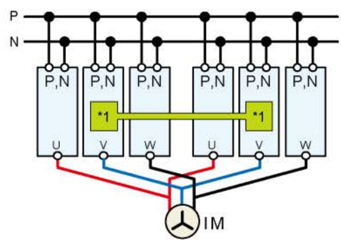
Example) If one inverter fails when 200kW x 2 inverters are driving a 355kW motor, the operation can continue with the 200kW inverter (capacity of one inverter).

Note) To start the reduced capacity operation, consideration is needed to the switch over operation of PG signals or motor constants and sequence circuit. For details, refer to chapter 9 of direct parallel.

■ Configuration table for direct parallel connection

2 or even 3 inverters of the same capacity can be connected in parallel to increase capacity or facilitate system redundancy. Typical combinations are shown in Table 1, however, other configurations are also possible.

Table 1 Direct parallel combination example (400V series, MD specification)

Connection system	Standard stack				Stack by phase			
								
Capacity [kW]	Applicable inverter	Applicable inverter	No. of units	Current [A]	Applicable inverter	Applicable inverter	No. of units	Current [A]
30	FRN30SVG1							
37	FRN37SVG1							
45	FRN45SVG1							
55	FRN55SVG1							
75	FRN75SVG1							
90	FRN90SVG1							
110	FRN110SVG1							
132	FRN132SVG1							
160	FRN160SVG1							
200	FRN200SVG1							
220	FRN220SVG1							
250	FRN250SVG1							
280	FRN280SVG1							
315	FRN315SVG1							
355		FRN200SVG1	2	716				
400		FRN220SVG1	2	789				
500		FRN280SVG1	2	988				
630		FRN220SVG1	3	1183	FRN630BVG1			
710		FRN280SVG1	3	1482	FRN710BVG1			
800		FRN280SVG1	3	1482	FRN800BVG1			
1000						FRN630BVG1	2	2223
1200						FRN630BVG1	2	2223
1500						FRN800BVG1	2	2812
1800						FRN630BVG1	3	3335
2000						FRN710BVG1	3	3905
2400						FRN800BVG1	3	4218

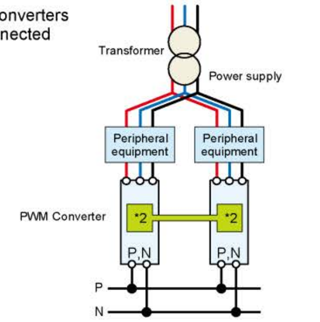
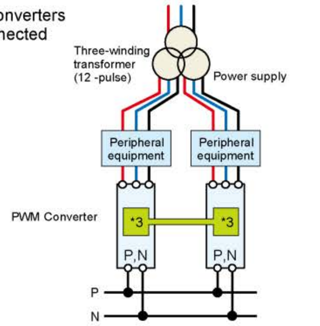
*1) OPC-VG1-TBSI is required for each stack.

For more information, refer to:

- "2.1.2. Multi-drive system" in Chapter 2
- "9.4.8.1. Direct parallel connection combinations and wiring lengths" in Chapter 9

1.2.1.6 How to expand the total capacity of the converter

You can expand the total capacity of the PWM converter (RHC-D) using either a "transformer isolation-less parallel system" or a "transformer insulation type parallel system".

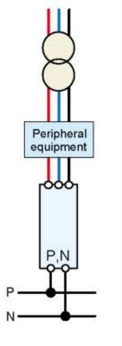
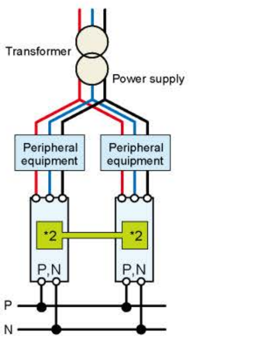
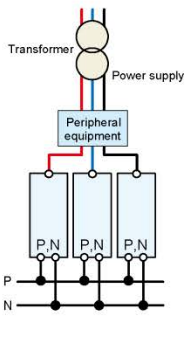
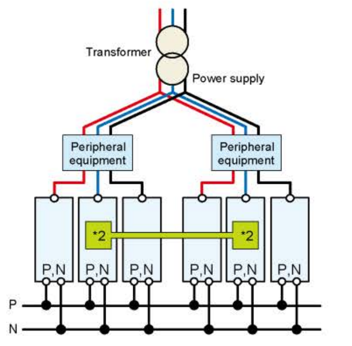
System	Transformer isolation-less parallel system This system involves connecting converter inputs to the power supply without isolating with a transformer, etc.	Transformer insulation type parallel system This system involves isolating respective converter inputs with a transformer.
Reduced capacity operation	Available	Available
Number of converter to be connected	2 to 3 converters	2 to 6 converters
Arrangement diagram	When 2 converters are connected 	When 2 converters are connected 

*2) OPC-VG7-SIR is required for each stack. *3) OPC-VG7-SI is required for each stack.

■ Transformerless parallel system configuration table

2 or 3 converters of the same capacity can be connected in parallel to increase capacity or facilltate system redundancy. Typical combinations are shown in Table 2, however, other configurations are also possible.

Table 2 Transformerless parallel system combination example (400V series, MD specification)

	Standard stack			Stack by phase		
Connection system						
Capacity [kW]	Applicable converter	Applicable converter	No. of units	Applicable converter	Applicable converter	No. of units
132	RHC132S-4D					
160	RHC160S-4D					
200	RHC200S-4D					
220	RHC220S-4D					
280	RHC280S-4D					
315	RHC315S-4D					
355		RHC200S-4D	2			
400		RHC200S-4D	2			
500		RHC280S-4D	2			
630		RHC315S-4D	2	RHC630B-4D		
710		RHC280S-4D	3	RHC710B-4D		
800		RHC280S-4D	3	RHC800B-4D		
1000					RHC630B-4D	2
1200					RHC630B-4D	2
1500					RHC800B-4D	2
1800					RHC630B-4D	3
2000					RHC710B-4D	3
2400					RHC800B-4D	3

*2) OPC-VG7-SIR is required for each stack.

For more information, refer to:

- PWM converter (RHC-D): "6.3.13. Parallel system (capacity expansion)" in Chapter 6
- Diode rectifier (RHD-D): "6.2.9. Multi-unit connection (capacity expansion)" in Chapter 6

1.2.1.7 A wide range of options

- A wide range of options are available that support high speed communication and other various interfaces.
- You can use option cards by just inserting them into the connectors provided inside the inverter. You can install up to four option cards.
  (There are some restrictions on the combinations of option cards. For more information, refer to "5.4.2. Restrictions on mounting control option cards and others" in Chapter 5.)

Categoly	Name		Type
Analog card	Synchronized interface		OPC-VG1-SN
	F/V converter*1		OPC-VG1-FV
	Analog input/output interface expansion card		OPC-VG1-AIO
Digital card (for 8-bit bus)	Di interface card		OPC-VG1-DI
	Dio extension card		OPC-VG1-DIO
	PG interface card	+5V line driver	OPC-VG1-PG
		Open collector	OPC-VG1-PGo
		ABS encoder with 17-bit high resolution	OPC-VG1-SPGT
	PG card for synchronous motor drive	Line driver	OPC-VG1-PMPG
		Open collector	OPC-VG1-PMPGo
	T-Link communication card		OPC-VG1-TL
	CC-Link communication card		OPC-VG1-CCL
	High-speed serial communication card (for UPAC)*1		OPC-VG1-SIU
Digital card (for 16-bit bus)	SX bus communication card		OPC-VG1-SX
	E-SX bus communication card		OPC-VG1-ESX
	User programming card		OPC-VG1-UPAC
	PROFINET-IRT communication card		OPC-VG1-PNET
Safety card	Functional safety card		OPC-VG1-SAFE
Field bus interface card	PROFIBUS-DP communication card		OPC-VG1-PDP
	DeviceNet communication card		OPC-VG1-DEV
Control circuit terminal	Terminal block for high-speed communications		OPC-VG1-TBSI

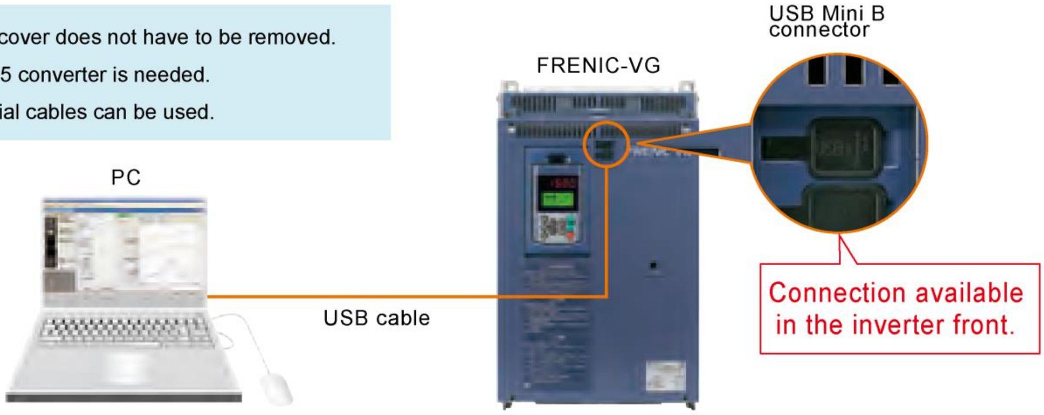
*1 comming soon

1.2.2 Easier maintenance and greater reliability

1.2.2.1 Upgraded PC loader functions

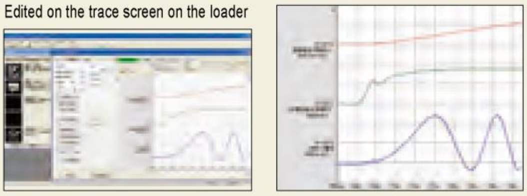
PC Loader can be used via the USB connector (mini B) provided on the front cover.

- The front cover does not have to be removed.
- No RS-485 converter is needed.
- Commercial cables can be used.



[Fault diagnosis using the trace back function]

Edited on the trace screen on the loader



- Internal data, time and date around the fault are recorded.
  The real-time clock (clock function) is built-in as standard.
- Data are backed up by battery.
  Trace data can be stored in the memory even while the power is off.
  *Battery: 30kW or more (built-in as standard), up to 22kW (available as option: OPK-BP)
- Trace waveform can be checked on the PC loader

[Easy edit and detail monitor]

Data editing and detailed data monitor analysis operations are much easier than with a conventional PC loader.

Function code setting	User-defined displays (customized displays), data explanation display for each code.
Trace function	Real-time trace: for long-term monitoring Historical trace: for detailed data diagnosis for short periods Trace back: for fault analysis (last three times)

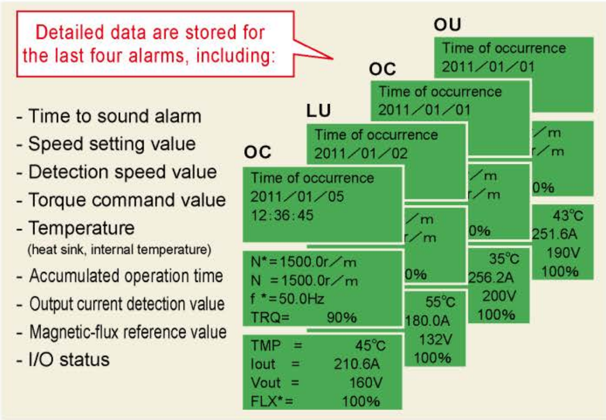
*The paid-for loader software (WPS-VG1-PCL) supports real-time tracing and historical tracing.
*The paid-for loader software (WPS-VG1-STR) is contained in the CD-ROM provided with the product. (Can be downloaded from the Fuji website.)

1.2.2.2 Multifunctional Keypad

- Wide 7-segment LED ensures easy view.
- The back-light is incorporated in the LCD panel, which enables easy inspection in a dark control panel.
- Enhanced copy feature
  Function codes can be easily copied to other inverters.
  (Three patterns of function codes can be stored.)
  Copying data in advance reduces restoration time when problems occur, by replacing the Keypad when changing the unit.
- Remote control operation is available.
  The Keypad can be remotely operated by extending the cable length at the RJ-45 connector.
- JOG (jogging) operation can be executed using the Keypad.
- The HELP key displays operation guidance.

1.2.2.3 More reliable functions

Save alarm data



- The number of alarm data to be stored has been increased from the conventional model.

  Thanks to the real-time clock function built-in as standard, the complete data of the latest and last 3 alarm occurences is stored: time, speed command, torque, current and others. This enables machine units to be checked for abnormalities.

⇒As for previous model, new alarm data overwrote and deleted existing alarm data. This is solved with the new VG model.

Alarm severity selection

Alarm severity (serious and minor) can be selected, eliminating the risk of critical facility stoppage due to a minor fault.

	30-relay output	Y-terminal output	Inverter output	Selection
Motor overload, communications error, DC fan lock, etc.	No output (minor fault)	Provided	Operation continued	Can be selected for each function.
	Output	Not provided	Shut off	
Blown fuse, excessive current, ground fault, etc.	Output	Not provided	Shut off	Fixed

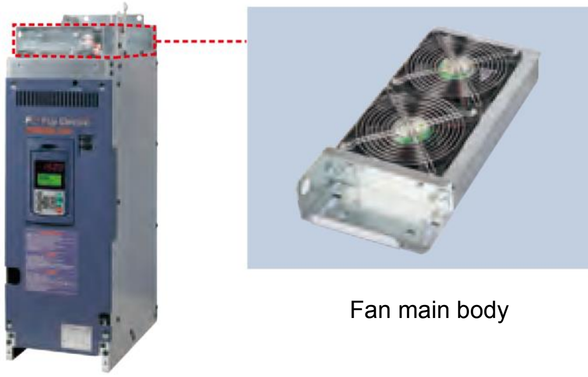
PG fault diagnosis

- The PG interface circuit incorporated as standard detects disconnection of the power supply line as well as the PG signal line.
- A mode was added that judges if it is a PG fault or a fault on the inverter side
  Simulated output mode is provided at the PG pulse output terminal (FA and FB). Operation can be checked by connecting this to the PG input terminal.

1.2.2.4 Easy change of the cooling fan

The cooling fan installed at the top can easily be changed without drawing the stacks out of the cabinet.

However, for the 220 to 800 kW inverter, remove the two connection bars from the DC side and change the cooling fan.



Fan main body

1.2.2.5 Components with a longer service life

For the various consumable parts inside the inverter, their designed lives have been extended to 10 years.

This also extends the equipment maintenance cycles.

<Life conditions>

- Ambient temperature: 30°C
- Load factor: 100% (MD Spec), 80% (LD Spec)

Life-limited component	Design lifetime[*1]
Cooling fan	10 years
Smoothing capacitor on main circuit	
Electrolytic capacitors on PCB	

1.2.2.6 Enhanced lifetime alarm

- Lifetime alarms can be checked easily on the Keypad and PC loader (optional).
- Facility maintenance can be performed much more easily.

Items			
Inverter accumulated time (h)	No. of inverter starts (times)	Facility maintenance warning Accumulated time (h) No. of starts (times)	Inverter lifetime alarm information is displayed.

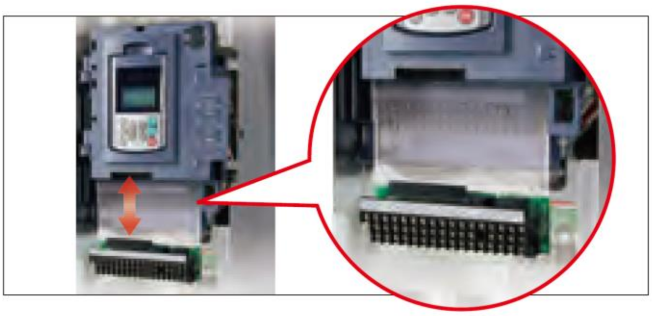
1.2.2.7 Useful functions for test run and adjustment

- You can customize the display of function codes (by showing or hiding individual items on the loader).
- A simulated fault alarm can be issued by a special function on the Keypad.
- Monitor data hold function
- Simulated operation mode
  Simulated connection allows the inverter to be operated with internal parts in the same way as if they were connected to the motor, without actually being connected.
- The externally input I/O monitor and PG pulse states can be checked on the Keypad.

1.2.2.8 Easy wiring (removable control terminal block)

By the use of removable control terminal block:

- The terminal block can be connected to the inverter after control wiring work is completed. Wiring work is simplified.
- Restoration time for updating equipment, problem occurrence, and inverter replacement has been drastically reduced. Just mount the wired terminal block board to the replaced inverter.



1.2.3 Adaptation to environment and safety

1.2.3.1 Conforms to safety standards

- The functional safety (FS) function STO that conforms to the FS standard IEC/EN61800-5-2 is incorporated as standard.
- The FS functions STO, SS1, SLS and SBC that conform to FS standard IEC/EN 61800-5-2 can be also made available by installing the option card OPC-VG1-SAFE. (Available only when the product is used in conjunction with the MVK dedicated motor.)

Safety function	STO: Safe Torque Off	This function shuts off the output of the inverter (motor output torque) immediately.
	SS1: Safe Stop 1	This function decreases the motor speed to shut down the motor output torque (by STO FS function) after the motor reaches the specified speed or after the specified time has elapsed.
	SLS: Safely Limited Speed	This function prevents the motor from rotating over the specified speed.
	SBC: Safe Brake Control	This function outputs a safe signal of the motor brake control.

1.2.3.2 Enhanced environmental resistance

Environmental resistance has been enhanced compared to conventional inverters.

(1) Environmental resistance of cooling fan has been enhanced.

(2) Ni and Sn plating is employed on copper bars.

* Environmental resistance has been enhanced on the FRENIC-VG compared to conventional models; however, the following environments should be examined based on how the equipment is being used.

a. Sulfidizing gas (present in some activities such as tire manufacturers, paper manufacturers, sewage treatment, and the textile industry)
b. Conductive dust and foreign particles (such as with metal processing, extruding machines, printing machines, and waste treatment)
c. Others: under unique environments not included under standard environments
   Contact Fuji before using the product in environments such as those indicated above.

1.2.3.3 RoHS directive compliance

FRENIC-VG complies with European regulations that limit the use of specific hazardous substances (RoHS) as a standard.

Six hazardous substances

Lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyl (PBB), polybrominated biphenyl ether (PBDE)

*Does not apply to the parts of some inverter models.

About RoHS

Directive 2002/95/EC, promulgated by the European Parliament and European Council, limits the use of specific hazardous substances included in electrical and electronic devices.

1.2.4 Functional compatibility with previous models

The FRENIC-VG has functional compatibility with our previous models of vector control inverters.

- Compatibility with the FRENIC5000VG7S

  The function codes of the FRENIC-VG are compatible with those of the VG7, and therefore the latter can be set for the FRENIC-VG without making any changes (except for the function codes for the M3).

  In addition, function codes can be uploaded from the VG7 via the FRENIC-VG loader and directly copied to the FRENIC-VG.

1.3 Control method

1.3.1 Features and applications of control methods

Inverter-based speed regulators for AC motors are most commonly used to control the rotational speed of loads.

This section describes the basic configuration of some speed control methods, their characteristics, and hints about their applications.

Speed control systems are generally classified into open-loop control and closed-loop control. (Refer to Figure 1.3.1-1.)

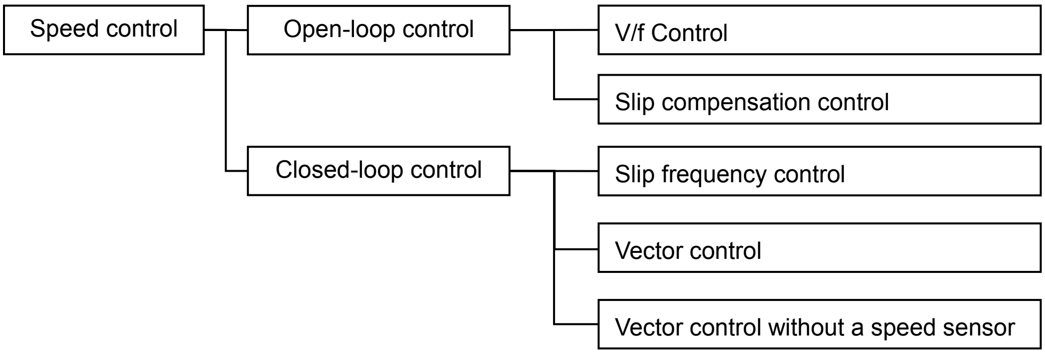


Figure 1.3.1-1: Classification of speed control methods

1.3.1.1 Open-loop speed control

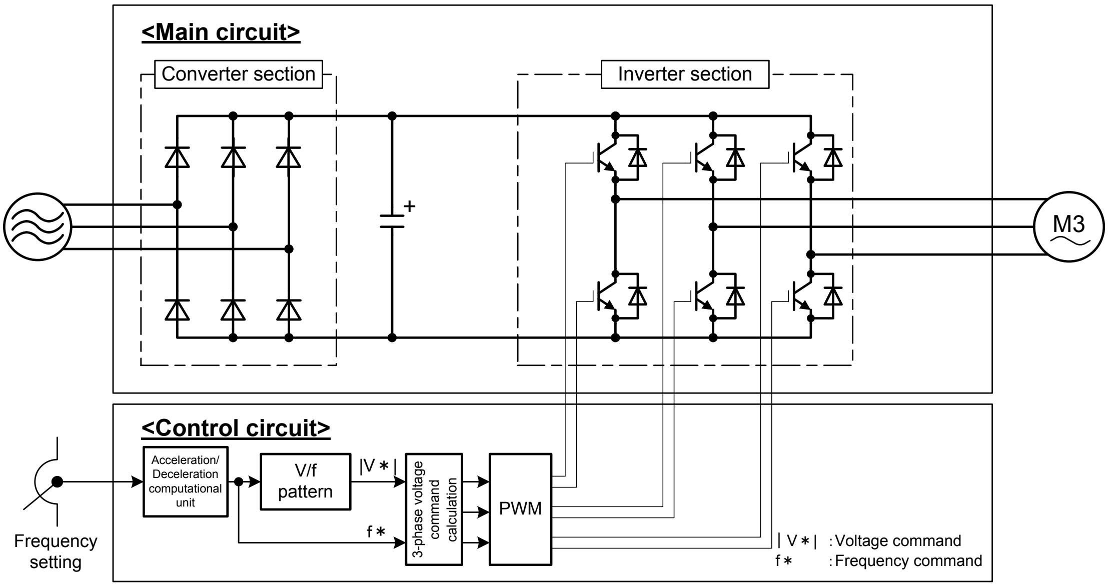


Figure 1.3.1-2: Basic configuration of open-loop speed control

As the basic configuration of open-loop control shown in Figure 1.3.1-2 demonstrates, this control method is designed to control the rotational speed of the load with the aid of the frequency output by the inverter, while information about the speed under control is not fed back. The "speed-torque characteristic" of an induction motor traces a slight gradient across frequencies f1 to f6, as shown in Figure 1.3.1-3. If the voltage frequency supplied to the motor is constant, the rotational speed shows little variation in response to variations in the load; for example, the slip at the rated torque is several percent. To put it another way, when controlling the speed of the motor by changing the output frequency of the inverter, "V/f control," which controls the ratio between the terminal voltage of the motor and the applied voltage, is generally applied.

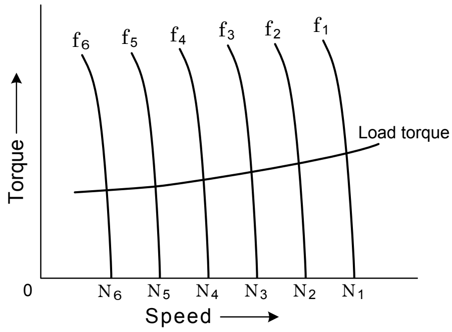


Figure 1.3.1-3: Speed - Torque characteristics

Open-loop control does not require any speed sensor and is adopted mainly for general-purpose inverters. It is used to make the speed of existing motors variable or when a squared-deceleration torque load, such as a fan or pump, does not require very fast response.

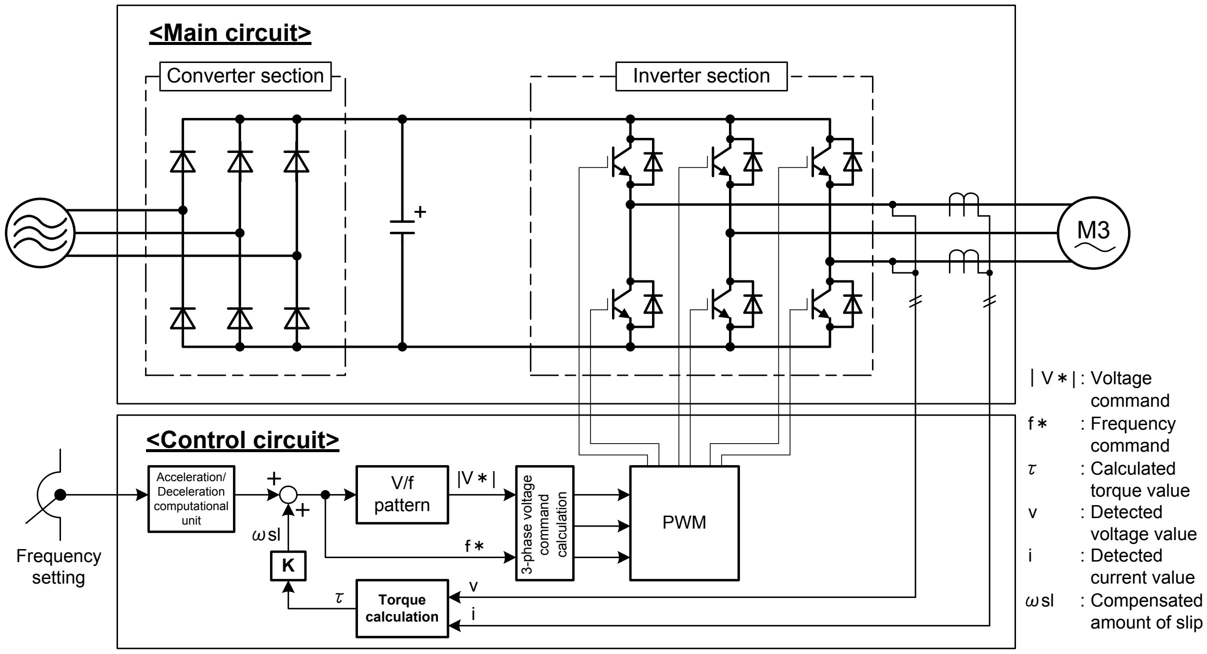


Figure 1.3.1-4: Speed control using slip compensation method

The factors that determine the accuracy of the rotational speed in open-loop speed control include load torque fluctuation, the accuracy of the output frequency, and power voltage fluctuation. To deal with load torque fluctuations, a "slip compensation control method" is used, which, as shown in Figure 1.3.1-4, keeps the rotational speed constant by calculating the output torque from the terminal voltage and primary current of the motor and compensating the output frequency of the inverter based on the calculated output torque.

1.3.1.2 Closed-loop speed control

"Closed-loop speed control" is the method of compensating speed fluctuations by feeding back speed information.

Closed-loop speed control ensures speed control with a high degree of accuracy by feeding back the rotational speed under control and can, therefore, be applied to paper machines, machine tools, etc.

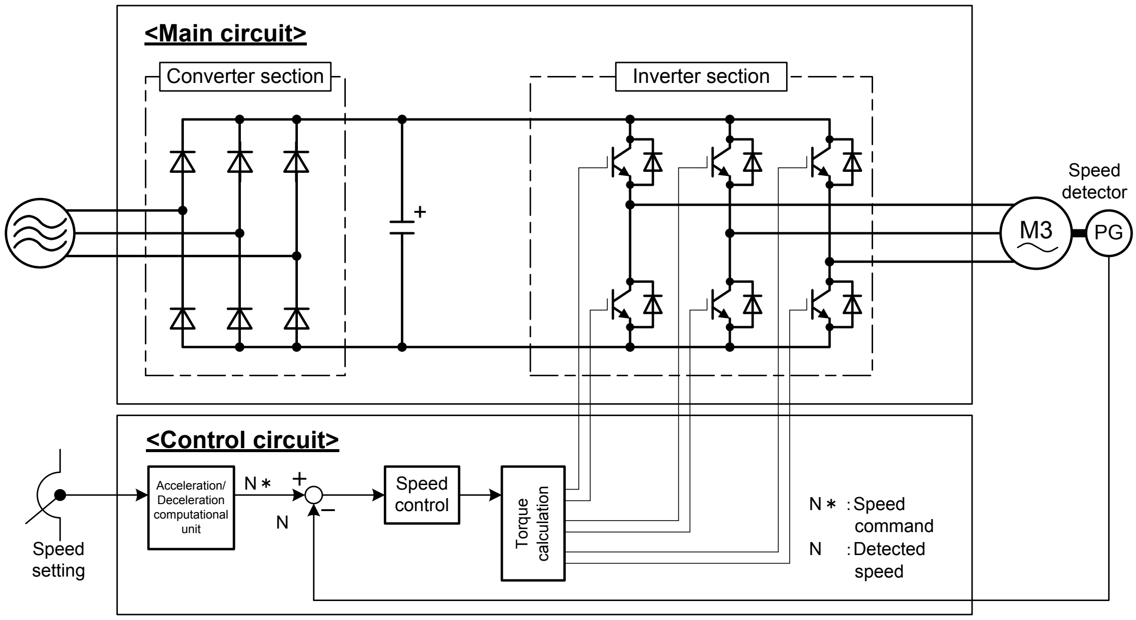


Figure 1.3.1-5: Basic configuration of closed-loop speed control

Figure 1.3.1-5 shows the basic configuration of closed-loop speed control. Speed information is fed back from a speed detection sensor, such as a pulse generator (PG), compared with the speed command, and the output frequency of the inverter is controlled so that the speed command and the detected speed value will match.

As speed control methods, slip frequency control, vector control with a speed sensor, and vector control without a speed sensor are applied. This section presents an overview of each control method.

This high-performance vector control inverter FRENIC-VG series uses vector control included in closed-loop control to control speed.

a) Slip frequency control

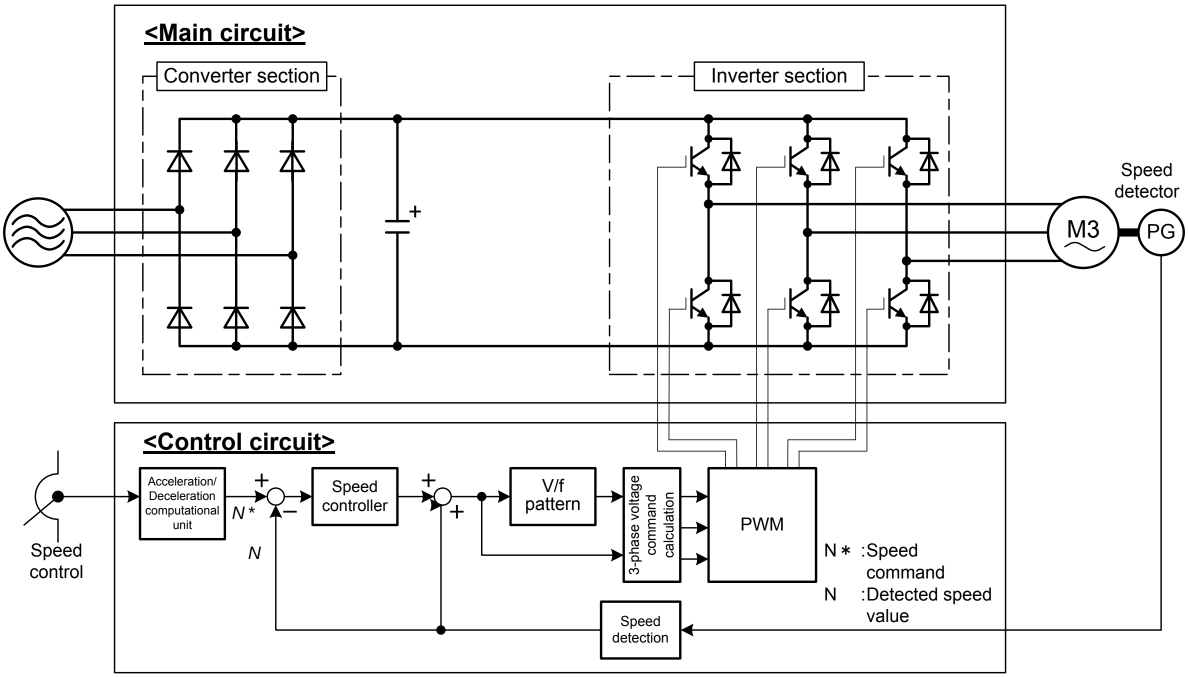


Figure 1.3.1-6: Configuration of slip frequency control

Figure 1.3.1-6 shows the configuration of slip frequency control.

The output of the speed controller becomes a slip frequency responsive to the load, and speed fluctuations are compensated by adding this slip frequency to actual speed. Since this control method is relatively simple, it is applied to the speed control of general-purpose inverters. Note that it is suitable for applications that do not require high-speed response because V/f control is used for basic control.

b) Vector control with a speed sensor

Vector control is the control method that enables AC motors to respond faster.

This control method is intended to achieve an equal level of control performance to DC motors by separating the primary current of an AC motor into a magnetic flux current and a torque current to be controlled.

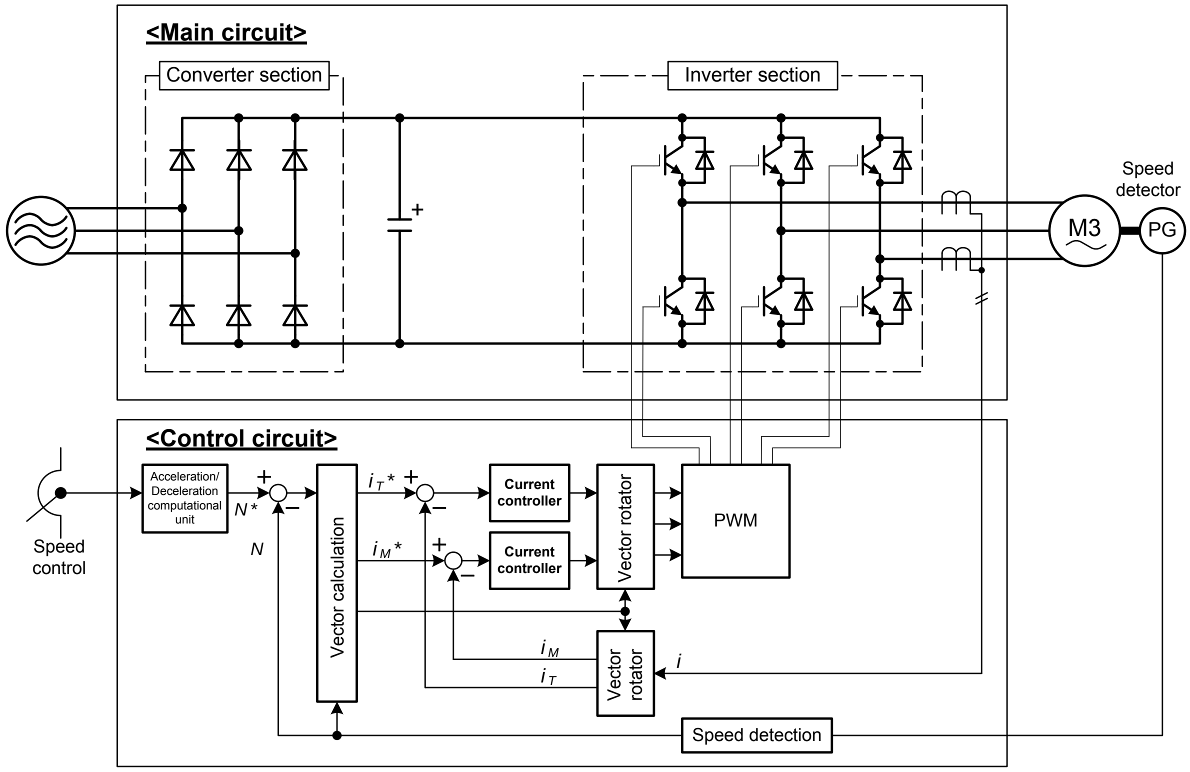
Compared with the V/f control method, vector control combines the following performance characteristics and is suitable for applications requiring fast response and a high degree of accuracy.

(1) Satisfactory acceleration/deceleration characteristic

(2) Broad speed control range

(3) Feasibility of torque control

(4) Fast control response



N∗ : Speed command
N : Detected speed value
iT∗ : Torque current command value
iM∗ : Excitation current command value
iT : Detected torque current value
iM : Detected excitation current value
I : Motor current (instantaneous value)

Figure 1.3.1-7: Example of configuration of vector control

Figure 1.3.1-7 shows an example of the configuration of vector control. Performance considerably depends on the accuracy of the grasping of the motor constant because the vector calculation unit uses the motor constant. In addition, variations in the motor constant due to the temperature condition also greatly affect performance. This control is complicated and thus applied mainly in combination with a dedicated inverter and a dedicated motor.

c) Vector control without a speed sensor

Vector control with a speed sensor offers distinguished performance backed by fast response and a high degree of accuracy. On the other hand, since it requires a speed sensor, it is sometimes confronted by such issues as the mounting of the speed sensor and wiring from the speed sensor. In contrast to vector control with a speed sensor, vector control without a speed sensor is the method of performing vector control by estimating the rotational speed from the terminal voltage or primary current of the motor without using a speed sensor, and using this estimated value as a speed feedback signal. Vector control without a speed sensor is slightly inferior to vector control with a speed sensor in performance.

Figure 1.3.1-8 shows a configuration of vector control without a speed sensor.

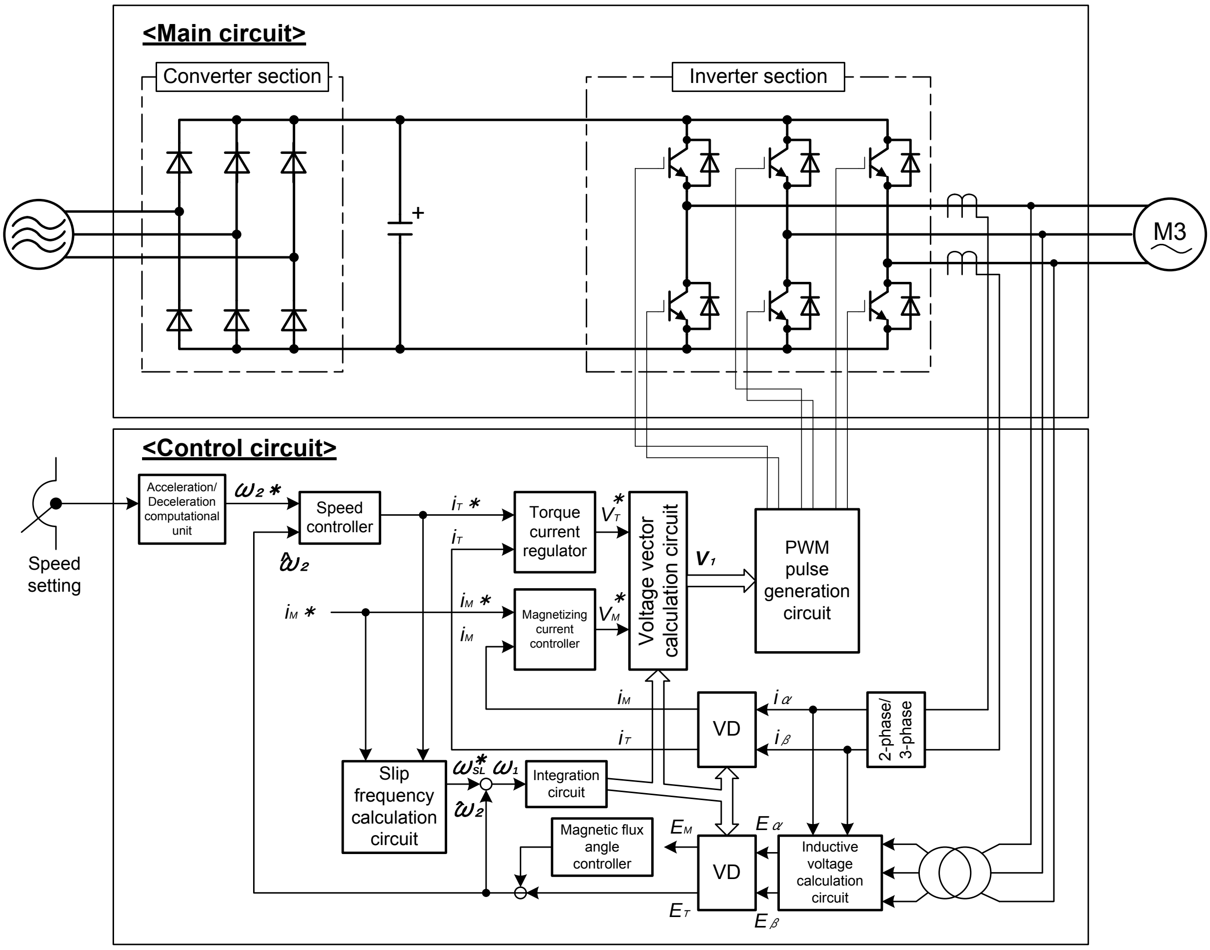


Figure 1.3.1-8: Example of configuration of vector control without a speed sensor

The FRENIC-VG series is capable of performing this control in combination with a general-purpose motor. However, the specifications of this combination, including control performance, are lower than those of the combination of the FRENIC-VG series and a dedicated motor.

FRENIC-VG

2

Chapter 2 Specifications

2.1 Standard specifications

This chapter describes the standard specifications for a multi-drive system where a single-drive system of the FRENIC-VG is used in conjunction with multiple units of the FRENIC-VG.

2.1.1 Single-drive system

2.1.1.1 MD spec (for medium overloads)

3-phase 400V series

■ **Standard stack**

Type: FRN_ _ _SVG1S-4☐		30	37	45	55	75	90	110	132	160	200	220	250	280	315
Nominal applied motor capacity [kW]		30	37	45	55	75	90	110	132	160	200	220	250	280	315
Rated capacity [kVA] *1		45	57	69	85	114	134	160	192	231	287	316	356	396	445
Rated current [A]		60	75	91	112	150	176	210	253	304	377	415	468	520	585
Overload capability		150% of the rated current for 1 minute *2													
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2) and "PWM converter specifications" (section 6.3.2).													
	Auxiliary control power input	Single-phase, 380 to 480 V, 50/60 Hz													
	Auxiliary fan power input	—					Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3								
	Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%													
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter), resistance regenerative braking (braking unit) Braking torque: 150%													
Carrier frequency [kHz] *4		2 kHz													
Approx. mass [kg]		30	30	30	37	37	45	45	95	95	95	125	135	135	135
Enclosure		IP00 open type													

■ **Phase-specific stack**

Type: FRN_ _ _BVG1S-4☐*5		630	710	800	
Nominal applied motor capacity [kW]		630	710	800	
Rated capacity [kVA] *1		891	1044	1127	
Rated current [A]		1170	1370	1480	
Overload capability		150% of the rated current for 1 minute *2			
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2) and "PWM converter specifications" (section 6.3.2).			
	Auxiliary control power input	Single-phase, 380 to 480 V, 50/60 Hz			
	Auxiliary fan power input	Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3			
	Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%			
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter), resistance regenerative braking (braking unit) Braking torque: 150%			
Carrier frequency [kHz] *4		2 kHz			
Approx. mass [kg]		135 x 3	135 x 3	135 x 3	
Enclosure		IP00 open type			

The MD spec above applies when Function code F80 = 0, 2, or 3. The keypad display shows "HD", however, when F80 = 0 or 2. (Initial value = 0)

*1 This specification applies when the rated output voltage is 440 V.

*2 When the inverter output frequency converted is less than 1 Hz, the inverter may trip due to an overload earlier than this specification depending on the ambient temperature or other conditions.

*3 For 380 to 398 V/50 Hz or 380 to 430 V/60 Hz, connector switching is required inside the inverter.

*4 Operating synchronous motors other than Fuji Electric's standard synchronous motor (GNF2 type series) at low carrier frequency may cause demagnetization due to heating of the permanent magnet by output current harmonics. Always confirm the motor's allowable carrier frequencies.

*5 A set of three phase-specific stacks (Type: FRN_ _ _BVG1S-4☐) for U, V and W phases constitutes a single inverter unit. (One unit each for output phases U, V, and W)

3-phase 690V series

■ **Standard stack**

Type: FRN_ _ _SVG1S-69□		90	110	132	160	200	250	280	315	355	400	450
Nominal applied motor capacity [kW] *5		90	110	132	160	200	250	280	315	355	400	450
Rated capacity [kVA] *1		120	155	167	192	258	317	353	394	436	490	550
Rated current [A]		100	130	140	161	216	265	295	330	365	410	460
Overload capability		150% of the rated current for 1 minute *2										
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2).										
	Auxiliary control power input	Single-phase, 575 to 690 V, 50/60 Hz										
	Auxiliary fan power input	Single-phase, 660 to 690 V, 50 Hz/60 Hz, 575 to 600 V, 50 Hz/60 Hz *3										
	Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%										
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter), resistance regenerative braking (braking unit) Braking torque: 150%										
Carrier frequency [kHz] *4		2 kHz										
Approx. mass [kg]		45	45	95	95	95	135	135	135	135	135	135
Enclosure		IP00 open type										

The MD spec above applies when Function code F80 = 0, 2, or 3. The keypad display shows "HD", however, when F80 = 0 or 2. (Initial value = 0)

*1 This specification applies when the rated output voltage is 690 V.

*2 When the inverter output frequency converted is less than 1 Hz, the inverter may trip due to an overload earlier than this specification depending on the ambient temperature or other conditions.

*3 For 575 to 600 V, 50 Hz/60 Hz, connector switching is required inside the inverter.

*4 Operation at frequencies lower than the allowable carrier frequency of the synchronous motor may cause demagnetization due to heating of the permanent magnet by output current harmonics. Always confirm your synchronous motor's allowable carrier frequencies.

*5 This nominal applied motor capacity assumes the use of a 690 V motor. When you use a motor with different voltage specifications or want to choose a motor more accurately, make sure that the inverter's rated current is higher than or equal to the motor's rated current.

2.1.1.2 LD spec (for light overloads)

3-phase 400V series

■ **Standard stack**

Type: FRN_ _ _SVG1S-4□		30	37	45	55	75	90	110	132	160	200	220	250	280	315
Nominal applied motor capacity [kW]		37	45	55	75	90	110	132	160	200	220	250	280	315	355
Rated capacity [kVA] *1		57	69	85	114	134	160	192	231	287	316	356	396	445	495
Rated current [A]		75	91	112	150	176	210	253	304	377	415	468	520	585	650
Overload capability		110% of the rated current for 1 minute *2													
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2) and "PWM converter specifications" (section 6.3.2).													
	Auxiliary control power input	Single-phase, 380 to 480 V, 50/60 Hz													
	Auxiliary fan power input	—					Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3								
	Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%													
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter), resistance regenerative braking (braking unit) Braking torque: 110%													
Carrier frequency [kHz] *4		2 kHz													
Approx. mass [kg]		30	30	30	37	37	45	45	95	95	95	125	135	135	135
Enclosure		IP00 open type													

■ Phase-specific stack

Type: FRN_ _ _BVG1S-4□ *5	630	710	800
Nominal applied motor capacity [kW]	710	800	1000
Rated capacity [kVA] *1	1044	1127	1409
Rated current [A]	1370	1480	1850
Overload capability	110% of the rated current for 1 minute *2		
Input power: Main power input	Refer to "Diode rectifier specifications" (section 6.2.2) and "PWM converter specifications" (section 6.3.2).		
Input power: Auxiliary control power input	Single-phase, 380 to 480 V, 50/60 Hz		
Input power: Auxiliary fan power input	Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3		
Input power: Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%		
Braking system, braking torque	Braking system: Depending on power regenerative braking (PWM converter), resistance regenerative braking (braking unit) Braking torque: 110%		
Carrier frequency [kHz] *4	2 kHz		
Approx. mass [kg]	135 x 3	135 x 3	135 x 3
Enclosure	IP00 open type		

The above specifications apply when Function code F80 = 1 (LD spec).

*1 This specification applies when the rated output voltage is 440 V.

*2 When the inverter output frequency converted is less than 1 Hz, the inverter may trip due to an overload earlier than this specification depending on the ambient temperature or other conditions.

*3 For 380 to 398 V/50 Hz or 380 to 430 V/60 Hz, connector switching is required inside the inverter.

*4 Operating synchronous motors other than Fuji Electric's standard synchronous motor (GNF2 type series) at low carrier frequency may cause demagnetization due to heating of the permanent magnet by output current harmonics. Always confirm the motor's allowable carrier frequencies.

*5 A set of three phase-specific stacks (Type: FRN_ _ _BVG1S-4□) for U, V and W phases constitutes a single inverter unit. (One unit each for output phases U, V, and W.)

3-phase 690V series

■ Standard stack

Type: FRN_ _ _SVG1S-69□	90	110	132	160	200	250	280	315	355	400
Nominal applied motor capacity [kW] *5	110	132	160	200	250	280	315	355	400	450
Rated capacity [kVA] *1	155	167	192	258	281	353	394	436	490	550
Rated current [A]	130	140	161	216	235	295	330	365	410	460
Overload capability	110% of the rated current for 1 minute *2									
Input power: Main power input	Refer to "Diode rectifier specifications" (section 6.2.2).									
Input power: Auxiliary control power input	Single-phase, 575 to 690 V, 50/60 Hz									
Input power: Auxiliary fan power input	Single-phase, 660 to 690 V, 50 Hz/60 Hz, 575 to 600 V, 50 Hz/60 Hz *3									
Input power: Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%									
Braking system, braking torque	Braking system: Depending on power regenerative braking (PWM converter), resistance regenerative braking (braking unit). Braking torque: 150%									
Carrier frequency [kHz] *4	2 kHz									
Approx. mass [kg]	45	45	95	95	95	135	135	135	135	135
Enclosure	IP00 open type									

The above specifications apply when Function code F80 = 1 (LD spec).

*1 This specification applies when the rated output voltage is 690 V.

*2 When the inverter output frequency converted is less than 1 Hz, the inverter may trip due to an overload earlier than this specification depending on the ambient temperature or other conditions.

*3 For 575 to 600 V, 50 Hz/60 Hz, connector switching is required inside the inverter.

*4 Operation at frequencies lower than the allowable carrier frequency of the synchronous motor may cause demagnetization due to heating of the permanent magnet by output current harmonics. Always confirm your synchronous motor's allowable carrier frequencies.

*5 This nominal applied motor capacity assumes the use of a 690 V motor. When you use a motor with different voltage specifications or want to choose a motor more accurately, make sure that the inverter's rated current is higher than or equal to the motor's rated current.

2.1.2 Multi-drive system

To drive a motor of 315 kW or above, you can combine multiple units of the FRENIC-VG in conjunction.
Observe the specifications given in this section.

2.1.2.1 MD spec (for medium overloads)

3-phase 400V series

■ **Direct parallel connection (2 or 3 parallel systems)**

Type: FRN_ _ _SVG1S-4☐		200	220	280	220	280	280
Number of parallel systems		2			3		
Nominal applied motor capacity [kW]		355	400	500	630	710	800
Rated current [A]		716	789	988	1183	1482	1482
Rated capacity [kVA] *1		545	601	752	901	1129	1129
Overload capability		150% of the rated current for 1 minute *2					
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2) and "PWM converter specifications" (section 6.3.2).					
	Auxiliary control power input	Single-phase, 380 to 480 V, 50/60 Hz					
	Auxiliary fan power input	Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3					
	Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%					
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter, power regenerative), resistance regenerative braking (braking unit). Braking torque: 150%					
Carrier frequency [kHz]		2 kHz					
Approx. mass [kg]		95 x 2	125 x 2	135 x 2	125 x 3	135 x 3	135 x 3
Enclosure		IP00 open type					

■ **Phase-specific stack + direct parallel connection (2 or 3 parallel systems)**

Type: FRN_ _ _BVG1S-4☐ *4		630	630	800	630	710	800
Number of parallel systems		2			3		
Nominal applied motor capacity [kW]		1000	1200	1500	1800	2000	2400
Rated current [A]		2223	2223	2812	3335	3905	4218
Rated capacity [kVA] *1		1694	1694	2143	2541	2976	3214
Overload capability		150% of the rated current for 1 minute *2					
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2) and "PWM converter specifications" (section 6.3.2).					
	Auxiliary control power input	Single-phase, 380 to 480 V, 50/60 Hz					
	Auxiliary fan power input	Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3					
	Allowable fluctuation	Voltage: +10 to -15% (phase-to-phase unbalance rate within 2% *4), Frequency: +5 to -5%					
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter, power regenerative), resistance regenerative braking (braking unit). Braking torque: 150%					
Carrier frequency [kHz]		2 kHz					
Approx. mass [kg]		135 x 6	135 x 6	135 x 6	135 x 9	135 x 9	135 x 9
Enclosure		IP00 open type					

The MD spec above applies when Function code F80 = 0, 2, or 3. The keypad display shows "HD", however, when F80 = 0 or 2. (Initial value = 0)

*1 This specification applies when the rated output voltage is 440 V.

*2 When the inverter output frequency converted is less than 1 Hz, the inverter may trip due to an overload earlier than this specification depending on the ambient temperature or other conditions.

*3 For 380 to 398 V/50 Hz or 380 to 430 V/60 Hz, connector switching is required inside the inverter.

*4 A set of three phase-specific stacks (Type: FRN_ _ _BVG1S-4☐) for U, V and W phases constitutes a single inverter unit.
(Each of the U, V, W phases uses one stack, so six stacks for 2 parallel systems and nine stacks for 3 parallel systems are required.)

Note: Direct parallel connection requires the optional high-speed serial communication support terminal block (OPC-VG1-TBSI).

3-phase 690V series

■ Direct parallel connection (2 or 3 parallel systems)

Type: FRN_ _ _SVG1S-69☐		250	280	355	400	450	400	450	
Number of parallel systems		2					3		
Nominal applied motor capacity [kW]		450	500	630	710	800	1000	1200	
Rated current [A]		504	561	694	779	874	1169	1311	
Rated capacity [kVA] *1		602	670	829	930	1044	1397	1566	
Overload capability		150% of the rated current for 1 minute *2							
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2).							
	Auxiliary control power input	Single-phase, 575 to 690 V, 50/60 Hz							
	Auxiliary fan power input	Single-phase, 660 to 690 V, 50/60 Hz, 575 to 600 V, 50/60 Hz *3							
	Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%							
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter, power regenerative), resistance regenerative braking (braking unit). Braking torque: 150%							
Carrier frequency [kHz]		2 kHz							
Approx. mass [kg]		135 x 2	135 x 2	135 x 2	135 x 2	135 x 2	135 x 3	135 x 3	
Enclosure		IP00 open type							

The MD spec above applies when Function code F80 = 0, 2, or 3. The keypad display shows "HD", however, when F80 = 0 or 2. (Initial value = 0)

*1 This specification applies when the rated output voltage is 690 V.

*2 When the inverter output frequency converted is less than 1 Hz, the inverter may trip due to an overload earlier than this specification depending on the ambient temperature or other conditions.

*3 For 575 to 600 V, 50/60 Hz, connector switching is required inside the inverter.

Note: Direct parallel connection requires the optional high-speed serial communication support terminal block (OPC-VG1-TBSI).

2.1.2.2 LD spec (for light overloads)

3-phase 400V series

■ **Direct parallel connection (2 or 3 parallel systems)**

Type: FRN_ _ _SVG1S-4☐		200	250	315	250	250	315
Number of parallel systems		2			3		
Nominal applied motor capacity [kW]		400	500	630	710	800	1000
Rated current [A]		789	988	1235	1482	1482	1853
Rated capacity [kVA] *1		601	752	941	1129	1129	1412
Overload capability		110% of the rated current for 1 minute *2					
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2) and "PWM converter specifications" (section 6.3.2).					
	Auxiliary control power input	Single-phase, 380 to 480 V, 50/60 Hz					
	Auxiliary fan power input	Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3					
	Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%					
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter, power regenerative), resistance regenerative braking (braking unit). Braking torque: 110%					
Carrier frequency [kHz]		2 kHz					
Approx. mass [kg]		95 x 2	135 x 2	135 x 2	135 x 3	135 x 3	135 x 3
Enclosure		IP00 open type					

■ **Phase-specific stack + direct parallel connection (2 or 3 parallel systems)**

Type: FRN_ _ _BVG1S-4☐ *4		630	710	800	630	710	800
Number of parallel systems		2			3		
Nominal applied motor capacity [kW]		1200	1500	1800	2000	2400	3000
Rated current [A]		2603	2812	3515	3905	4218	5273
Rated capacity [kVA] *1		1983	2143	2678	2976	3214	4018
Overload capability		110% of the rated current for 1 minute *2					
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2) and "PWM converter specifications" (section 6.3.2).					
	Auxiliary control power input	Single-phase, 380 to 480 V, 50/60 Hz					
	Auxiliary fan power input	Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3					
	Allowable fluctuation	Voltage: +10 to -15% (phase-to-phase unbalance rate within 2% *4), Frequency: +5 to -5%					
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter, power regenerative), resistance regenerative braking (braking unit). Braking torque: 110%					
Carrier frequency [kHz]		2 kHz					
Approx. mass [kg]		135 x 6	135 x 6	135 x 6	135 x 9	135 x 9	135 x 9
Enclosure		IP00 open type					

The above specifications apply when Function code F80 = 1 (LD spec).

*1 This specification applies when the rated output voltage is 440 V.

*2 When the inverter output frequency converted is less than 1 Hz, the inverter may trip due to an overload earlier than this specification depending on the ambient temperature or other conditions.

*3 For 380 to 398 V/50 Hz or 380 to 430 V/60 Hz, connector switching is required inside the inverter.

*4 A set of three phase-specific stacks (Type: FRN_ _ _BVG1S-4☐) for U, V and W phases constitutes a single inverter unit. (Each of the U, V, W phases uses one stack, so six stacks for 2 parallel systems and nine stacks for 3 parallel systems are required.)

Note: Direct parallel connection requires the optional high-speed serial communication support terminal block (OPC-VG1-TBSI).

3-phase 690V series

■ Direct parallel connection (2 or 3 parallel systems)

Type: FRN_ _ _SVG1S-69☐		250	315	355	400	355	400
Number of parallel systems		2				3	
Nominal applied motor capacity [kW]		500	630	710	800	1000	1200
Rated current [A]		561	694	779	874	1169	1311
Rated capacity [kVA] *1		670	829	930	1044	1397	1566
Overload capability		110% of the rated current for 1 minute *2					
Input power	Main power input	Refer to "Diode rectifier specifications" (section 6.2.2).					
	Auxiliary control power input	Single-phase, 575 to 690 V, 50/60 Hz					
	Auxiliary fan power input	Single-phase, 660 to 690 V, 50/60 Hz, 575 to 600 V, 50/60 Hz *3					
	Allowable fluctuation	Voltage: +10 to -15%, Frequency: +5 to -5%					
Braking system, braking torque		Braking system: Depending on power regenerative braking (PWM converter, power regenerative), resistance regenerative braking (braking unit). Braking torque: 150%					
Carrier frequency [kHz]		2 kHz					
Approx. mass [kg]		135 x 2	135 x 2	135 x 2	135 x 2	135 x 3	135 x 3
Enclosure		IP00 open type					

The above specifications apply when Function code F80 = 1 (LD spec).

*1 This specification applies when the rated output voltage is 690 V.

*2 When the inverter output frequency converted is less than 1 Hz, the inverter may trip due to an overload earlier than this specification depending on the ambient temperature or other conditions.

*3 For 575 to 600 V, 50/60 Hz, connector switching is required inside the inverter.

Note: Direct parallel connection requires the optional high-speed serial communication support terminal block (OPC-VG1-TBSI).

2.2 Common specifications

This section provides common specifications of the FRENIC-VG.

2.2.1 Installation environment and conformity with standards

Item			Explanation
Safety standards	Provided as standard	Stop function	Safe Torque Off (STO)* The external digital input signal (terminal EN1 or EN2) forcibly turns off the inverter's output circuit on the hardware side so that the motor coasts to a stop.
Product standards	Conformity with standards		(1) US and Canadian Safety Standards UL, cUL (UL508C, C22.2 No. 14) (400V series only) (2) European Safety Standards IEC/EN 61800-5-2: SIL2 IEC/EN 62061: SIL2 (3) Machinery Directive EN ISO13849-1: PL-d IEC/EN 60204-1: Stop category 0 (4) Low Voltage Directive IEC/EN 61800-5-1 (Over voltage category: 3) (5) EMC Directives IEC/EN 61800-3, IEC/EN 61326-3-1 (Emission) EMC-filter (optional): Category C3 (Immunity) 2nd Env.
Installation environment	Installation location (Note 1)		• Shall be installed indoor (free from corrosive gases, flammable gases, dusts, oil mist). Pollution degree 2: IEC60664-1 • Shall not be exposed to direct sunlight.
	Ambient temperatures		-10 to +40°C
	Ambient humidity		5 to 95% RH (without condensation)
	Altitude (Note 2)		• Lower than 1,000 m (For use in an altitude between 1,001 to 3,000 m, the output current should be derated.) • In an altitude between 2,001 to 3,000 m, the insulation of the control circuit is degraded from reinforced insulation to basic one.
	Vibration		Compliance standards: IEC61800-2 Amplitude 0.3 mm : 2 to 9 Hz 1 m/s^2 : 9 to 200 Hz Compliance standards: IEC61800-5-1 Amplitude 0.075 mm : 10 to less than 57 Hz 1G : 57 to 150 Hz
	Storage temperature		-25 to +70°C (-10 to max. +30°C for long-term storage)
	Storage humidity		5 to 95% RH (without condensation)

(Note 1) Do not install the inverter in an environment where it may be exposed to lint, cotton waste or moist dust or dirt which will clog the heat sink of the inverter.
If the inverter is to be used in such an environment, install it in a dustproof panel of your system.

(Note 2) Insulation and cooling (heat radiation) are dependent on the density of air.
Due to the atmospheric pressure, insulation breakdown easily occurs and the dielectric strength decreases. In an altitude of 2,001 to 3,000 m, therefore, the insulation of the control circuit is degraded from reinforced insulation to basic one.
In addition, as the air is thin, the cooling effect (radiation effect) decreases so that the temperature of the heat generating devices such as inverter increases.
If you install the inverter in an altitude above 1,000 m, apply an output current derating factor as listed in Table 2.2.1-1.

Table 2.2.1-1: Output current derating factor in relation to altitude

Altitude	Output current derating factor
1,000 m or lower	1.00
1,001 to 1,500 m	0.97
1,501 to 2,000 m	0.95
2,001 to 2,500 m	0.91
2,501 to 3,000 m	0.88

2.2.2 Control methods

This section outlines the motor drive controls and methods.

Item			Explanation
Control method	For induction motor		• Vector control with a speed sensor • Vector control without a speed sensor • V/f Control
	For synchronous motor		Vector control with a speed sensor (incl. magnetic pole position detection)
	Test mode		Simulation mode
Driving method	Single drive		• Standard stack: A single standard stack drives a single motor. • Phase-specific stack: A set of three phase-specific stacks drives a single motor. (The control printed circuit board is mounted on the V-phase stack. As a master, the V-phase stack controls two slave stacks (U- and W-phase ones). (Available under vector control with/without a speed sensor and V/f control)
	Multi-drive	Multiwinding motor drive	Drives a multiwinding motor (Number of windings: 2 to 6). Note that the same number of inverters as the number of windings is required. (Available only under vector control with a speed sensor) The option OPC-VG1-TBSI should be used.
		Direct parallel connection	Drives a single motor (single winding) with two or three inverters. (Available under vector control with a speed sensor and V/f control of induction motors) The option OPC-VG1-TBSI should be used.
		Phase-specific stack (Multi-drive function)	Drives a multiwinding motor of a large capacity with two or more inverters of phase-specific stack type. Direct parallel connection is possible. The option OPC-VG1-TBSI should be used.

Figure 2.2.2-1 shows the skeleton configuration for drive systems.

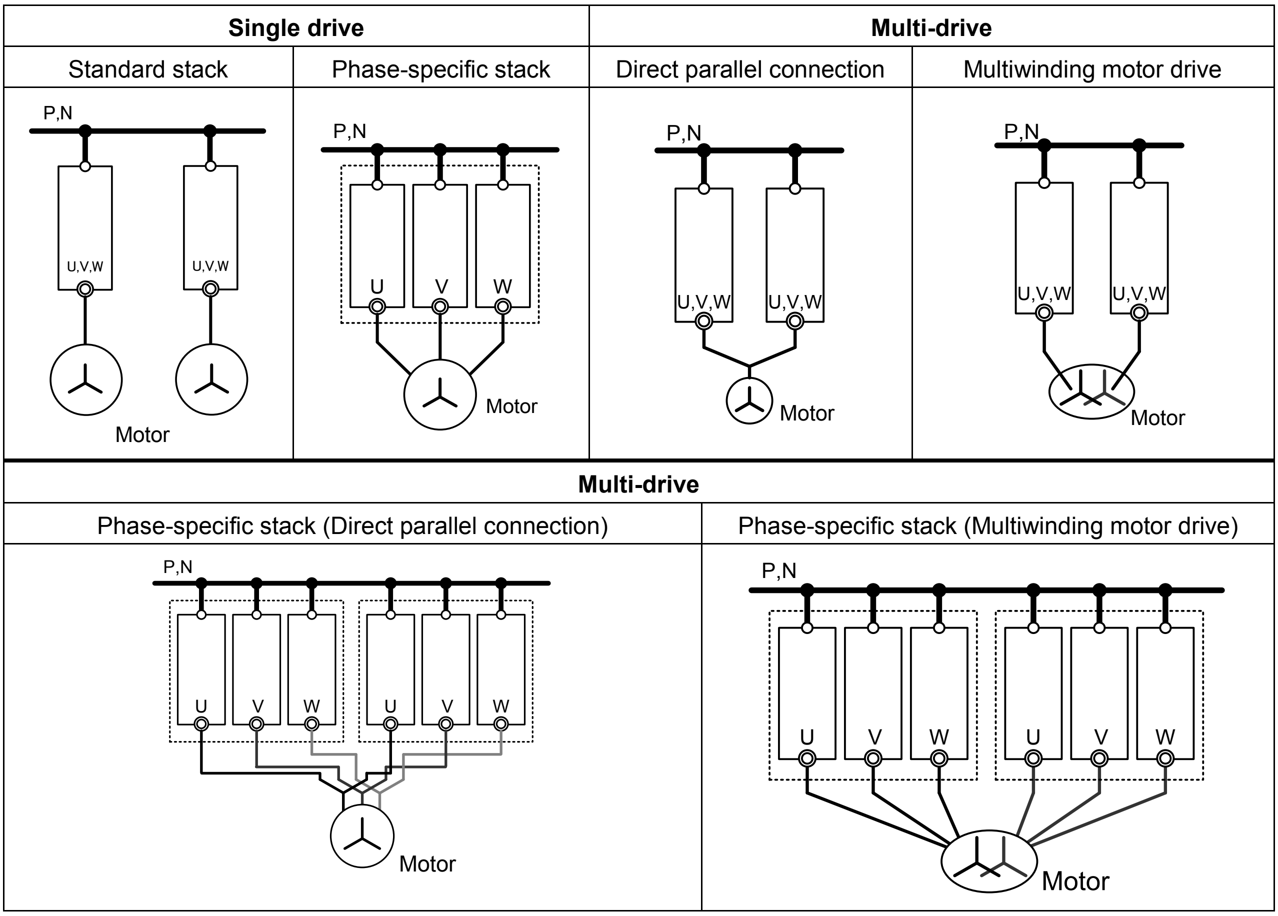


Figure 2.2.2-1: Stack configuration summary by driving method

2.2.3 Control performance

The table below lists the control performance specifications of motors.

Item				Explanation
Induction motor control specifications	Vector control with a speed sensor	Setting resolution	Speed command	Analog setting: 0.005% of maximum speed Digital setting: 0.005% of maximum speed
			Torque command, Torque current command	0.01% of the rated torque
		Control accuracy	Speed	Analog setting: ±0.1% of maximum speed (at 25 ±10°C) Digital setting: ±0.005% of maximum speed (at -10 to +40°C)
			Torque	±3% of the rated torque (when a dedicated motor is in use)
		Control response speed		100 Hz
		Maximum speed		150 Hz (when converted to the inverter output frequency)
		Speed control range		1: 1500 (When the base speed is 1500 r/min: 1 to 1500 r/min to maximum speed *1) 1: 6 (Constant torque range: Constant output range)
	Vector control without a speed sensor	Setting resolution	Speed command	Analog setting: 0.005% of maximum speed Digital setting: 0.005% of maximum speed
			Torque command, Torque current command	0.01% of the rated torque
		Control accuracy	Speed	Analog setting: ±0.1% of maximum speed (at 25 ±10°C) Digital setting: ±0.1% of maximum speed (at -10 to +40°C)
			Torque	±5% of the rated torque
		Control response speed		20 Hz
		Maximum speed		150 Hz (when converted to the inverter output frequency)
		Speed control range		1: 250 (When the base speed is 1500 r/min: 6 to 1500 r/min to maximum speed *1) 1: 4 (Constant torque range: Constant output range)
	V/f Control	Setting resolution		Analog setting: 0.005% of maximum frequency Digital setting: 0.005% of maximum frequency
		Output frequency control accuracy		Analog setting: ±0.2% of maximum output frequency (at 25 ±10°C) Digital setting: ±0.01% of maximum output frequency (at -10 to +40°C)
		Maximum frequency		150 Hz
		Control range		0.2 to 150 Hz 1: 4 (Constant torque range: Constant output range)
Synchronous motor control specifications	Vector control with a speed sensor	Setting resolution	Speed command	Analog setting: 0.005% of maximum speed Digital setting: 0.005% of maximum speed
			Torque command, Torque current command	0.01% of the rated torque
		Control accuracy	Speed	Analog setting: ±0.1% of maximum speed (at 25 ±10°C) Digital setting: ±0.005% of maximum speed (at -10 to +40°C)
			Torque	±3% of the rated torque (when a dedicated motor is in use)
		Control response speed		100 Hz
		Maximum speed		150 Hz (when converted to the inverter output frequency)
		Speed control range		1: 1500 (When the base speed is 1500 r/min: 1 to 1500 r/min to maximum speed *1)

*1 In the case of the PG pulse resolution 1024 P/R.

2.2.4 Control functions

The table below lists the outline of the control function specifications.

Item	Explanation
Start/stop operation	• Keypad: FWD and REV keys (for forward/reverse rotation), STOP key (for stop) • Digital input signals: "Switch forward/reverse operation," "Coast to a stop," "Reset alarm," "Select multistep speed," etc.
Speed command	• Keypad: ∧ and ∨ keys • External potentiometer: Three-terminal variable resistor (1 to 5 kΩ) • Analog input signals: 0 to ±10 V, 4-20 mA • UP/DOWN control: When the digital input signal UP or DOWN is ON, the speed increases or decreases, respectively. • Multistep speed: The combination of the four digital input signals SS1, SS2, SS4 and SS8 enables 15 different speeds to be selected. • Digital signal: Using an option card enables speed setting with "16-bit parallel signals. • Serial link operation: RS-485 (provided as standard). Various communication options are available. • Jogging operation: FWD and REV keys or digital input on [FWD] and [REV] terminals in jogging mode.
Speed detection	(1) Induction motor • +15 V, +12 V complementary output PG (insulation type): Maximum frequency receivable: 100 kHz • +5 V line driver output PG (insulation type)*1: Maximum frequency receivable: 500 kHz (2) Synchronous motor: +5 V line driver output PG (insulation type) • ABS type *2: Maximum frequency receivable: 100 kHz • ABZ type *1: Maximum frequency receivable: 500 kHz • High-resolution serial transmission system (TS5667N253: TAMAGAWA SEIKI, Co., Ltd.) *3: 17 bits (one rotation) + 16 bits (multi-rotation) *1 When the option card OPC-VG1-PG (insulation type) is mounted. *2 When the option card OPC-VG1-PMPG is mounted. *3 When the option card OPC-VG1-SPGT is mounted.
Speed control	PI calculation with feed-forward terms. Switching of control parameters: Control parameters are switchable by external signals.
Running status signal	Transistor output signals: "Inverter running," "Speed arrival," "Speed detected," "Inverter overload early warning," "Torque limiting," etc. Analog output signals: "Motor speed," "Output voltage," "Torque," "Load factor," etc.
Acceleration/deceleration time	Specifies the acceleration/deceleration time for a run command to the motor (soft start/stop). • Four independent settings can be made for each of acceleration and deceleration. • S-curve acceleration/deceleration can be selected in addition to linear acceleration/ deceleration
Speed setting gain	Proportional relationship between analog speed setting and motor speed can be specified in the range of 0 to 200%.
Jump speed	Jump speed (3 points) and jump hysteresis width (1 point) can be specified.
Auto search for idling motor speed	Automatically searches for the idling motor speed to be harmonized and starts to drive it without stopping it.
Auto-restart after momentary power failure	Possible to restart the inverter after a momentary power failure without stopping the motor depending on the restart mode setting.
Slip compensation control	Compensates for decrease in speed according to the load for stabilized operation. (Available for IM under V/f control.)
Droop control	The motor speed droops in proportion to output torque. (Not available under V/f control.)

<table>
<tr><th colspan="2">Item</th><th colspan="2">Explanation</th></tr>
<tr><td colspan="2">Torque limit</td><td colspan="2">Limits the torque to the predetermined values.
(Selectable from "common to 4 quadrants", "independent driving and braking", etc.)</td></tr>
<tr><td colspan="2">Torque control</td><td colspan="2">Controls the motor in accordance with the torque command setting.</td></tr>
<tr><td colspan="2">PID control</td><td colspan="2">PID control with analog input.
Possible to select whether to use the PID output as speed setting or auxiliary setting to be added or subtracted to/from the main setting.</td></tr>
<tr><td colspan="2">Cooling fan ON/OFF control</td><td colspan="2">Stops cooling fans when the motor is stopped and the temperature is low for lifetime extension and noise reduction of the cooling fans.</td></tr>
<tr><td colspan="2">Toggle monitor control</td><td colspan="2">Monitors communication between the host equipment (PLC) and the inverter to see whether the communication is normal.</td></tr>
<tr><td colspan="2">Torque bias function</td><td colspan="2">The combination of the fixed value (one step, with the polarity switching function by the motor rotation direction) and external digital input signals provides three steps of torque bias internal setting. Analog setting (with Hold function) is available.</td></tr>
<tr><td colspan="2">Motor selection</td><td colspan="2">Selectable from the three types of motors, by Function code F79. Switchable between the three types of motors by the combination of digital input signals.</td></tr>
<tr><td colspan="2">Temperature detection</td><td colspan="2">Detects the motor temperature. The connectable thermistor types are as follows.
• NTC thermistor: Fuji Electric vector motor (MVK series) specification equivalent
• PTC thermistor: The trip level is specified by parameters. (Exclusively used for protection from motor overheat.)</td></tr>
<tr><td colspan="2">Self-diagnostic function for PG detection circuit</td><td colspan="2">Self-diagnoses the detection circuit of pulse encoder input signals (PA and PB).</td></tr>
<tr><td colspan="2">Load adaptive control</td><td colspan="2">Calculates the maximum allowable elevating speed (e.g., vertical carrier machine) according to the load to improve the operation efficiency of the equipment.</td></tr>
<tr><td colspan="2">UP/DOWN control</td><td colspan="2">Speed setting by the combination of digital input signals UP, DOWN, and CLR ("Clear ACC/DEC to zero")</td></tr>
<tr><td colspan="2">Stop function</td><td colspan="2">Three types of the stop functions by digital input signals STOP1, STOP2, and STOP3.</td></tr>
<tr><td colspan="2">PG pulse output</td><td colspan="2">Outputs motor PG signals or other input pulses with frequency divided by a fixed or variable frequency divider.
Switchable between open collector and complementary (equivalent to the voltage on the [PGP] terminal) transistor outputs, by means of a switch in the inverter unit.</td></tr>
<tr><td colspan="2">Observer</td><td colspan="2">Suppresses load disturbances and vibrations.</td></tr>
<tr><td colspan="2">Offline tuning</td><td colspan="2">Tunes the motor while the motor is stopped or running, for setting up motor parameters.</td></tr>
<tr><td colspan="2">Online tuning</td><td colspan="2">Tunes the motor parameters online to compensate for the temperature change.</td></tr>
<tr><td colspan="2" rowspan="2">Position control</td><td>Provided as standard</td><td>Position control by servo-lock and integrated oscillation circuit</td></tr>
<tr><td>Option</td><td>OPC-VG1-PG (PR): For pulse command input of line driver type
OPC-VG1-PGo (PR): For pulse command input of open collector type</td></tr>
<tr><td colspan="2">Pulse train, synchronous operation (option)</td><td colspan="2">OPC-VG1-PG (PR): For pulse command input of line driver type
OPC-VG1-PGo (PR): For pulse command input of open collector type</td></tr>
<tr><td rowspan="2">Multiplexed system</td><td>Multiwinding motor drive function</td><td colspan="2">Refer to Section 2.2.2 "Control systems." (Available only under vector control with a speed sensor)
Requires the option OPC-VG1-TBSI. (Maximum number of multiplexed units: 6)</td></tr>
<tr><td>Direct parallel connection*1</td><td colspan="2">Refer to Section 2.2.2 "Control systems."
(Available under vector control with/without a speed sensor)
Requires the option OPC-VG1-TBSI. (Maximum number of multiplexed units: 3)</td></tr>
<tr><td colspan="2">Phase-specific stack (Multi-drive function)</td><td colspan="2">Refer to Section 2.2.2 "Control systems."
Drives a multiwinding motor of a large capacity or enables direct parallel connection, by connecting two or more inverters composed of phase-specific stacks.
Requires the option OPC-VG1-TBSI.</td></tr>
</table>

*1 Available when the ROM version is H1/2 0021 or later.

2.2.5 Configuration/display functions

This section outlines the configuration and display functions.

Item		Explanation
Keypad	Display	7-segment LED monitor and backlit LCD
	Multilingual display	Japanese, English, Chinese, Korean
	When the inverter is running or stopped	• Detected speed value • Speed command value • Output frequency • Torque current command value • Torque command value • Torque calculation value • Output current • Output voltage • Power consumption (motor output) • Magnetic flux command value • Magnetic flux calculation value • DC intermediate voltage • PID command value • PID feedback value • Load shaft speed • Ai adjusted value (1, 2) • Ai adjusted value (Ai1) • PID output value • Optional monitor 1 to 6 • Ai adjusted value (Ai2) • Presence of digital input/output signal • Motor temperature • Heat sink temperature • Load factor • Input power • Integral power consumption • Operation time • Cumulative run time of the motor/Number of startups (for each motor), etc.
	When function codes are configured	Function code names and data are displayed.
	When an alarm occurs	Alarm factors that appear: • ArE (E-SX error) • ArF (Toggle abnormality error) • dCF (DC fuse blown) • dO (Excessive positioning deviation) • EC (Encoder communications error) • ECF (Safety stop circuit error) *1 • Et1 (Encoder error) • EF (Ground fault) • Er1 (Memory error) • Er2 (Keypad communications error) • Er3 (CPU error) • Er4 (Communications error) • Er5 (RS-485 communications error) • Er6 (Operation error) • Er7 (Output wire fault) • Er8 (A/D converter error) • Er9 (Speed mismatch) • ErA (UPAC error) *1 • Erb (Inter-inverter communications link error) • ErH (Hardware error) • Err (Mock alarm) • LOC (Start delay) • LU (Undervoltage) • nrb (NTC thermistor wire break error) • OS (Overspeed) • OC (Overcurrent) • OH1 (Heat sink overheat) • OH2 (External alarm) • OH3 (Inverter internal overheat) • OH4 (Motor protection) • OL1 (Overload of motor 1) • OL2 (Overload of motor 2) • OL3 (Overload of motor 3) • OLU (Inverter overload) • OPL (Output phase loss) • OU (Overvoltage) • PG (PG wire break) • SiF (Function safety card error) *1 • SrF (Function safety card error) *1 • SnF (Function safety card error) *1

*1 Available when the ROM version is H1/2 0021 or later.

Item			Explanation
Keypad	When a light alarm occurs		The light-alarm display "L -AL" appears. The inverter retains the cause of the light alarm to display it.
	When an alarm occurs		The following contents display by items. • The inverter retains the latest and the last 10 alarm codes and the latest and the last three pieces of alarm detailed information to display them. • It also retains the detailed contents of the latest and the last 3 alarms (including light alarms) to display them. • The calendar clock function retains the date and time when an alarm occurred to display them. Precision: ±27 seconds/month (Ta = 25°C) Data retention period: At least 5 years (at surrounding temperature of 25°C)
Loader	Historical trace *2		Reads out the sampling data held in the inverter and shows it graphically. Sampling interval: 62.5 μs to 1 s
	Real-time trace *2		Reads out the current data of the running inverter and shows it graphically in real-time. Sampling interval: 1 ms to 1 s
	Traceback		Reads out the sampling data held in the inverter and shows it graphically when an alarm has occurred. Sampling interval: 62.5 μs to 1 s (400 μs for sampling data except current) The sampling data is retained in the memory by the backup battery. Data retention period: At least 5 years (at the surrounding temperature 25°C)
	Operation monitor *2		I/O monitor, system monitor, alarm history monitor, etc.
	Configuration of function codes		Shows the configuration of the function codes, as well as enabling editing, transmitting, comparing, and initialization.
Charge lamp			Lights when DC power is applied to the inverter unit. Lights when only control power is ON.
Maintenance	Common functions		• Retains and displays the cumulative life of the main circuit capacitor and the cumulative run time of cooling fans. • Retains and displays the inverter operation time. • Retains and displays the maximum output current and the maximum internal temperature for the past one hour.
Communication	RS-485		I/O terminals for RS-485 communication. Up to 31 inverter units can be connected in multi-drop connection. Half-duplex system
	USB		Accessible from the front, connector type: mini B USB 2.0 Full Speed
Compatibility	VG7	Function code data	Selecting the VG7 compatible mode makes it possible to use the VG7 function codes as is on the FRENIC-VG (except function codes for the VG7 3rd motor). Possible to read out VG7 function code data using the FRENIC-VG Loader and write it as is into the FRENIC-VG. (Except special inverter versions.)
		Various communications tools	T-Link, SX-bus, and CC-Link are fully compatible with the VG7 so that software in the upper PLC is available as is. (Except special inverter versions.)

*2 Available in the paid-for version of FRENIC-VG Loader (WPS-VG1-PCL).

2.2.6 Protective functions

The table below lists the name of the protective functions, their description, and what appears on the LED monitor. If an alarm code appears on the LED monitor, remove the cause of activation of the protective function referring to Chapter 11 "Troubleshooting."

Item	Explanation	Display	Related function code
DC fuse blown	If a fuse in the main DC circuit blows due to a short circuit in the IGBT circuit or other reason, this protective function displays the error to prevent the secondary damage. The inverter could be broken, so immediately contact your Fuji Electric representative.	dCF	
DC fan lock	This function is activated when the DC fan stops.	dFA	H108
Excessive positioning deviation	This function is activated when the positioning deviation between the command and the detected values exceeds "Setting of function code **o18** (Excessive deviation value) x 10" in synchronous operation. Mounting an option makes **o18** effective and displays it on the keypad.	dO	o18
Encoder error 1	This function is activated by an encoder data error or encoder failure detection when the 17-bit high-resolution ABS interface (OPC-VG1-SPGT) is used.	Et 1	
Encoder communications error	This function is activated if an Encoder communication error occurs when the 17-bit high resolution ABS interface (OPC-VG1-SPGT) is used.	EC	
Safety stop circuit error*1	This function is activated when the input to either one of EN1 and EN2 is OFF for the duration exceeding 50 ms (which is regarded as a mismatch). The alarm state can be reset only by restarting the inverter.	ECF	
Ground fault	This function is activated when a ground fault is detected in the inverter output circuit. If the ground-fault current is large, the overcurrent protection may be activated. This protective function is to protect the inverter. For the sake of prevention of accidents such as human damage and fire, connect a separate earth-leakage protective relay or an earth-leakage circuit breaker (ELCB).	EF	H103
Memory error	This function is activated when a memory error such as a data write error occurs. (The inverter memory uses a nonvolatile memory that has a limited number of rewritable times (100,000 to 1,000,000 times). Saving data with the full save function into the memory so many times unnecessarily will no longer allow the memory to save data, causing a memory error.)	Er 1	
Keypad communications error	This function is activated if a communications error occurs between the keypad and the inverter control circuit when the start/stop command given from the keypad is valid (Function code **F02** = 0). Note: Even if a keypad communications error occurs when the inverter is being driven via the control circuit terminals or the communications link, the inverter continues running without displaying any alarm or issuing an alarm output (for any alarm).	Er2	F02
CPU error	This function is activated if a CPU error occurs.	Er3	
Network error	This function is activated if a communications error occurs due to noise or other reason when the inverter is being driven via a T-Link, SX-bus, E-SX bus, CC-Link, or field bus.	Er4	o30, o31, H107, E01-E14, E15-E28
RS-485 communications error	This function is activated: if an RS-485 communications error occurs when the inverter is being driven via the RS-485 and Function code **H32** is set to any of "0" through "2"; or if Function code **H38** is set within the range of 0.1 to 60.0 (s) and the communications link breaks for the specified period or longer.	Er5	H32, H33, H38, H107

*1 Available when the ROM version is H1/2 0021 or later.

Item	Explanation	Display	Related function code
Operation error	This function is activated: • If two or more network options (T-Link, SX-bus, E-SX bus, and CC-Link) are mounted. • If the SW configuration is the same on two or more PG options. • If auto tuning (Function code **H01**) is attempted when any of the digital input signals BX, STOP1, STOP2 and STOP3 is ON. • If auto tuning is selected with Function code **H01** but the (FWD) key on the keypad is not pressed within 20 seconds.	Er-6	H01
Output wiring fault	This function is activated if the wires in the inverter output circuit are not connected during auto-tuning.	Er-7	H01
A/D converter error	This function is activated if an error occurs in the A/D converter circuit.	Er-8	
Speed not agreed	This function is activated if the deviation between the speed command (reference speed) and the motor speed (detected or estimated speed) becomes excessive. The detection level and detection time can be specified with function codes.	Er-9	E43, E44, E45, H108, H149
UPAC error *1	This function is activated: if the UPAC option hardware fails; if a communications error with main unit controller occurs; or the backup battery is run out.	Er-A	
Inter-inverter communications link error	This function is activated if a communications error occurs in the inverter-to-inverter communications link using a high-speed serial communication terminal block (option).	Er-b	H107
Hardware error	This function is activated upon detection of an LSI failure on the printed circuit board.	Er-H	
Mock alarm	An alarm can be simulated by inputting an external signal (FTB), by operating the keypad, or by using FRENIC-VG Loader.	Err	E01-E14 H108, H142
Start delay	This function is activated when the torque current command value exceeds the specified level (**H140**) and the detected or estimated speed value drops below the specified stop speed (**F37**), and then the state is kept for the specified duration (**H141**). The detection level and detection time can be specified with function codes.	LOC	H108, H140, H141
Under voltage	This function is activated if the DC intermediate circuit voltage drops to the insufficient voltage detection level or below for reasons such as a drop in the power supply voltage. Note that, if **F14** is set to 3, 4 or 5, no alarm is output even if the direct intermediate circuit voltage drops. (Auto-restart after momentary power failure) ■ **Under voltage detection level** • 400V series: 360 Vdc • 690V series: 470 Vdc	LU	F14
NTC thermistor wire break error	This function is activated if the thermistor wire breaks when the NTC thermistor is selected with Function code **P30**/**A31**/**A131** for motor M1/M2/M3. This function works even at extremely low temperatures (approx. -30°C or below).	nrb	P30, A31, A131, H106
Overcurrent	This function stops the inverter output when the output current to the motor exceeds the overcurrent level of the inverter. When a synchronous motor is controlled, the function is also activated if the current output to the synchronous motor exceeds the overcurrent protection level (P44, P64, P164).	OC	
Heat sink overheat	This function is activated if the temperature surrounding the heat sink (that cools down the IGBTs) increases due to stopped cooling fans or other reason.	OH1	

*1 Available when the ROM version is H1/2 0021 or later.

Item	Explanation	Display	Related function code
External alarm	This function stops the inverter with the protective function by digital input signal (THR). Connecting an alarm contact of external equipment such as a braking unit or braking resistor to the input terminal to which the THR signal is assigned activates this function according to the contact signal status. The diode rectifier (RHD) can be protected from overheating by connecting the alarm output (for any alarm) to the diode rectifier (RHD) to the input terminal to which the THR signal is assigned.	OH2	E01-E14, H106
Inverter internal overheat	This function is activated if the temperature surrounding the control printed circuit board increases due to poor ventilation inside the inverter or other reason.	OH3	
Motor overheat	This function is activated if the temperature detected by the NTC thermistor integrated in a dedicated motor for motor temperature detection exceeds the motor overheat protection level (Function code **E30**).	OH4	E30, H106
Motor 1 overload	This function is activated by the electronic thermal overload protection if the motor 1 current (inverter output current) exceeds the operation level specified by Function code **F11**.	OL1	F11, H106
Motor 2 overload	This function is activated by the electronic thermal overload protection if the motor 2 current (inverter output current) exceeds the operation level specified by Function code **A33**.	OL2	A33, H106
Motor 3 overload	This function is activated by the electronic thermal overload protection if the motor 3 current (inverter output current) exceeds the operation level specified by Function code **A133**.	OL3	A133, H106
Inverter overload	This function is activated if the output current exceeds the overload characteristic of the inverse time characteristic. It stops the inverter output depending upon the heat sink temperature and switching element temperature calculated from the output current.	OLU	F80
Output phase loss	This function detects a break in inverter output wiring during running and stops the inverter output. (Available under vector control for IM with a speed sensor.)	OPL	H103, P01 A01, A101
Overspeed	This function is activated if the motor speed (detected or estimated speed) exceeds 120% (adjustable with Function code H90) of the maximum speed (F03/A06/A106).	OS	H90
Overvoltage	This function is activated if the DC intermediate circuit voltage exceeds the overvoltage detection level for reasons such as a rise in the power supply voltage, or increase in braking power from the motor. Note that the inverter cannot be protected from excessive voltage (high voltage, for example) supplied by mistake. ■ **Overvoltage detection level** • 400V series: 820 Vdc • 690V series: 1230 Vdc	OU	
PG wire break	This function is activated if a wire breaks in the PA/PB circuit on the PG terminal or in the PGP/PGM power supply circuit. It does not work under vector control without a speed sensor or under V/f control. This function is also activated if the use of the PG interface card (OPC-VG1-PG, OPC-VG1-PMPG) is attempted with PG signal disconnection or incorrect wiring.	PG	H104
E-SX bus tact synchronization error	This error occurs when the tact cycle of the E-SX bus of the MICREX-SX SPH3000 and the inverter control cycle are out of synchronization with each other.	Er-E	H108
Toggle abnormality error	The inverter monitors 2-bit signals of toggle signal 1 TGL1 and toggle signal 2 TGL2 which are sent from the PLC. When the inverter receives no prescribed change pattern within the time specified by **H144**, this error occurs.	Er-F	H107

Item	Explanation	Display	Related function code
Light alarm (warning)	This function displays "L-AL" on the keypad if a failure or warning registered as a light alarm occurs. It outputs the light alarm signal on the Y terminal but it does not issue an alarm output (for any alarm) (30A/B/C), so the inverter continues to run. **<u>Light alarm objects that can be registered (selectable individually)</u>** Motor overheat (OH4), Motor overload (OL1 to OL3), NTC thermistor wire break error (nrb), External alarm (OH2), RS-485 communications error (Er5), Network error (Er4), Toggle abnormality error (ArF), Mock alarm (Err), DC fan lock (dFA), Speed mismatch (Er9), E-SX error (ArE), Motor overheat early warning (MOH), Motor overload early warning (MOL), Lifetime alarm (LiF), Heat sink overheat early warning (OH), Inverter overload early warning (OL), Battery life expired (BaT), Start delay (LOC) Light alarm objects can be checked on the keypad.	L-AL	H106-H111
Surge protection	This function protects the inverter against surge voltages which might appear between one of the power lines, using surge absorbers connected to the main circuit power terminals (L1/R, L2/S, L3/T) and control power terminals (RO, TO).	—	
Functional safety card error [*1]	Protective function for functional safety cards. 📖 For more information, refer to the functional safety card instruction manual (INR-SI47-1541).	SiF Si-F	

*1 Available when the ROM version is H1/2 0021 or later.

Note: All protective functions are automatically reset if the control power voltage drops to a level at which inverter control circuit operation can no longer be sustained.

- The inverter retains the latest and the last 10 alarm codes and the latest and the last three pieces of alarm detailed information. However if the DC voltage between main circuit input terminals P(+), N(-) is lower than necessary level, alarm information will not be saved.
- Stoppage due to a protective function can be reset by the RST key on the keypad or turning OFF and then ON between the X terminal (to which RST is assigned) and the CM. This action is invalid if the cause of an alarm is not removed.
- If there are multiple alarms, the inverter cannot reset until the causes of all the alarms are removed. (The causes of alarms not removed can be checked on the keypad.)
- When an alarm categorized as a light alarm occurs, the 30A/B/C does not operate.

2.3 Motor specifications

2.3.1 Dedicated motor specifications (induction motor with a sensor)

2.3.1.1 Standard specifications for three-phase 400V series

Dedicated motor rated output (kW)		30	37	45	55	75	90	110	132	160	200	220	250	280	300	315	355	400
Applicable motor type (MVK_)		8187A	8207A	8208A	9224A	9254A	9256A	9284A	9286A	528KA	528LA	531FA	531GA	531HA	535GA	535GA	535HA	535JA
Moment of inertia of rotor [kg•m^2]		0.34	0.41	0.47	0.53	0.88	1.03	1.54	1.77	1.72	1.83	2.33	2.52	2.76	5.99	5.99	6.53	7.18
Rotor GD^2 [kg•m^2]		1.34	1.65	1.87	2.12	3.52	4.12	6.16	7.08	6.88	7.32	9.32	10.08	12.34	23.96	23.96	26.12	28.72
Rated speed /Max. speed [r/min]		1500/3000			1500/2400		1500/2000											
Vibration		V10 or less			V15 or less													
Cooling fan	Voltage [V]	—			400 V/50 Hz, 400, 440 V/60 Hz					380,400,415 V/50 Hz, 400,440 V/60 Hz								
	Number of phases/poles	Three-phase, 4P																
	Input power [W]	150/210			80/ 120	270/390				2200		3700						
	Current [A]	0.38/0.39 to 0.4			0.39/ 0.4, 0.4	1.0/1.0,1.0				4.6/4.3,4.1		7.8/7.1,7.6						
Approx.mass [kg]		235	280	296	380	510	570	710	760	1270	1310	1630	1685	1745	2230	2230	2310	2420

2.3.1.2 Common specifications

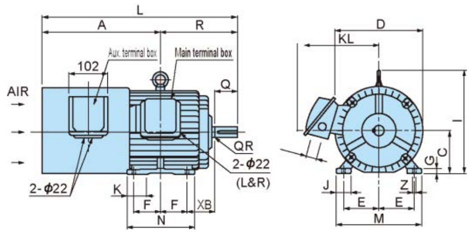
Item	Explanation
Insulation class, number of poles	Class F, 4P
Terminal structure	Main terminal box (lug type): Main circuit terminals x 3 or x 6, NTC thermistor terminal x 2 (for MVK8 series) or x 3 (for MVK9 and MVK5 series; including one spare) Auxiliary terminal box (terminal block): Pulse encoder (PGP, PGM, PA, PB, SS), cooling fan (FU, FV, FW)
Mounting method	Foot mounted with bracket (IMB3), Note: Contact your Fuji Electric representative for other mounting.
Degree of protection, cooling method	IP44, totally enclosed forced-ventilation system with cooling fan motor. A cooling fan blows air over the motor toward the drive-end.
Installation location	Indoors, 1000 m or less in altitude.
Ambient temperature, humidity	-10 to +40°C, 90% RH or less (no condensation)
Finishing color	Munsell N5
Standard conformity	MVK8 series: JEM1466 or JEC-2137-2000 MVK9 or MVK5 series: JEC-2137-2000
Standard accessories	Pulse encoder (1024 P/R, +15 V, complementary output), NTC thermistor(s) (1 or 2), and cooling fan

Note 1: For applicable motors of 55 kW or above, the torque accuracy is ±5%. When higher accuracy is required, contact your Fuji Electric representative.

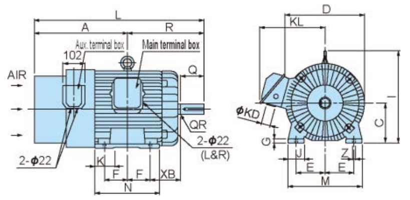
Note 2: For dedicated motors other than 4-pole ones with the base speed of 1500 r/min, contact your Fuji Electric representative.

2.3.1.3 External dimensions of dedicated motors

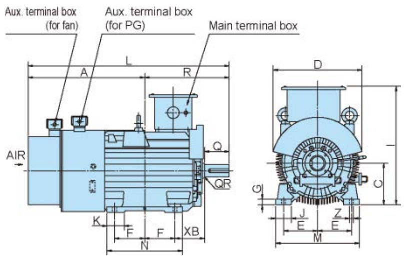
■ **Figure A**



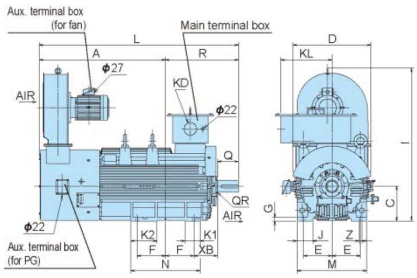
■ **Figure B**



■ **Figure C**



■ **Figure D**



Motor rated output [kW]	Motor type	Fig.	Dimensions [mm]																			Shaft extension [mm]						Approx. mass [kg]
			A	C	D	E	F	G	I	J	K	K1	K2	KD	KL	L	M	N	R	XB	Z	Q	QR	S	T	U	W	
30	MVK8187A	A	454	180	376	139.5	139.5	20	428	75	75	-	-	60	305	824.5	350	330	370.5	121	14.5	110	1.5	55m6	10	6	16	235
37	MVK8207A	B	490	200	411	159	152.5	25	466	80	85			80	364	915.5	390	360	425.5	133	18.5	140	2	60m6	11	7	18	280
45	MVK8208A																											296
55	MVK9224A		723	225	445	178	143		515		95				391	1155	436	366	432	149				65m6				380
75	MVK9254A	C	693.5	250	545	203	155.5	30	743	100	120				106	1157	506	411	463.5	168	24			75m6	12	7.5	20	510
90	MVK9256A		711.5				174.5									1194		449	483.5									570
110	MVK9284A		764	280	605	228.5	184	35	798						203	1308	557	468	544	190		170		85m6	14	9	22	710
132	MVK9286A		789.5				209.5									1359		519	569.5									760
160	MVK528JA	D	1015.5		628		228.5	30	1234	125	-	120	210	102	413	1604	560	557	588.5				1					1230
200	MVK528LA																											1350
220	MVK531FA		1073	315	689	254	254	36	1425	150		140	240			1713	630	648	640	216	28		2	95m6			25	1690
250	MVK531GA																											1750
280	MVK531HA																											1820
300	MVK535GA		1111	355	778	305	355		1510	160		180	330			1956	730	890	845	280		210		100m6	16	10	28	2230
315																												
355	MVK535HA																											2310
400	MVK535JA																											2420

Note 1: The MVK9224A (55 kW) has an auxiliary terminal box for fan, in addition to the configuration shown in Figure B.

Note 2: Dimensional tolerance of rotary shaft height C

C ≤ 250 mm: 0 to -0.5 mm, C > 250 mm: 0 to 1.0 mm

2.3.2 Dedicated motor specifications (synchronous motor with a sensor)

2.3.2.1 Standard specifications for three-phase 400V series

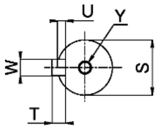
Dedicated motor rated output [kW]	30	37	45	55	75	90	110	132	160	200	220	250	280	300
Applicable motor type (GNF)	2139A	2165A	2167A	2185A	2187A	2207A	2224B	2226B	2254B	2256B	2284B		2286B	
Moment of inertia of rotor ([kg•m^2]	0.090	0.153	0.191	0.350	0.467	0.805	0.882	0.994	1.96	2.22	2.89		3.24	
Rotor GD^2 [kg•m^2]	0.360	0.610	0.763	1.401	1.868	3.220	3.53	3.98	7.84	8.88	11.6		13.0	
Base speed/Max. speed (r/min)	1500/2000													
Rated current [A]	57/54	72	83	100	135	158	198	232	273	340	369	420	480	520
Vibration	V10 or less													
Cooling fan: Voltage [V] Frequency [Hz]	200 to 240 V 50/60 Hz	400 to 420 V/50 Hz, 400 to 440 V/60 Hz					380,400,415/400,415,440,460 V 50/60 Hz							
Cooling fan: Number of phases/ poles	Three-phase, 2P	Three-phase, 4P												
Cooling fan: Input power [W]	54 to 58/ 70 to 78	90/120		150/210			80/120		270/390					
Cooling fan: Current [A]	0.18/ 0.22 to 0.21	0.27/ 0.24 to 0.25		0.38/ 0.39 to 0.4			0.36,0.38,0.41 /0.4,0.4,0.4,0.4		0.95,0.95,1/1,1,1,1					
Approx.mass [kg]	127	170	192	247	325	420	520	580	760	810	1020		1080	

2.3.2.2 Common specifications

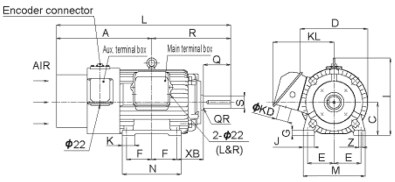
Item	Explanation
Insulation class, number of poles	Class F, 6P
Terminal structure	Main terminal box (lug type): Main circuit terminals x 3 or x 6, NTC thermistor terminal x 2 or x 3 (for 110 kW or higher; including one spare) Auxiliary terminal box (terminal block): Cooling fan (FU, FV, FW)
	Pulse encoder (connector type)
Rotation direction	CCW when viewed from the drive side
Mounting method	Legs mounted (IMB3) Note: Contact your Fuji Electric representative for other mounting.
Overload resistance	150% for 1 minute
Time rating	S1
Degree of protection, Cooling method	IP44, Totally enclosed forced-ventilation system with cooling fan motor. A cooling fan blows air over the motor toward the drive-end.
Installation location	Indoors, 1,000 m or less in altitude
Ambient temperature, humidity	-10 to +40°C, 90% RH or less (no condensation)
Noise	30 kW to 90 kW: 80 dB (A) or less at 1 m apart, 110 to 300 kW: 90 dB (A) or less at 1 m apart
Vibration resistance	6.86 m/s^2 (0.7G)
Finishing color	Munsell N1.2
Standard conformity	JEM 1487:2005
Standard built-in parts	Pulse encoder (1024 P/R, +5 VDC, A, B, Z, U, V, W line driver output), one NTC thermistor (Two for 110 kW or above) and cooling fan

2.3.2.3 External dimensions of dedicated motors

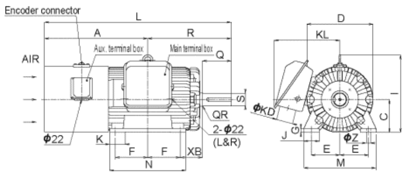
Shaft extension



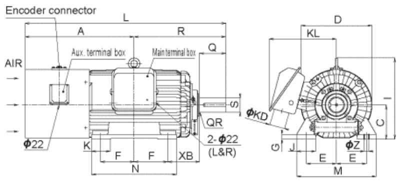
■ **Figure A**



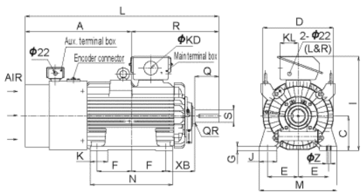
■ **Figure B**



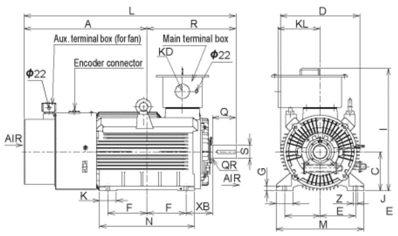
■ **Figure C**



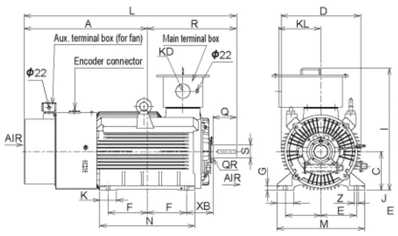
■ **Figure D**



■ **Figure E**



■ **Figure F**



Motor rated output [kW]	Motor type	Flame no.	Fig.	Dimensions [mm]																	Shaft extension [mm]							Approx. mass [kg]
				A	C	D	E	F	G	I	J	K	KD	KL	L	M	N	R	XB	Z	Q	QR	S	T	U	W	Y	
30	GNF2139A	132Hh	A	424.5	132	272	108	140		311	45	50	60	247	782.5	250	313	358		14.5	110	1.5	55m6	10	6	16	M10X20	127
37	GNF2165A	160Lg		470.5	160	319	139.5	127	20	376	75	75		320	845.5	350	300	375	108				60m6					170
45	GNF2167A	160Jg	B	501				157.5							906.5		370	405.5		18.5				11	7	18		192
55	GNF2185A	180Lg		510	180	375	159	139.5		428	80	85		356	910.5	390	330	400.5	121		140	2	65m6				M12X25	247
75	GNF2187A	180Jg	C	576				177.5	25			100			1061.5	420	450	485.5					75m6	12	7.5	20		325
90	GNF2207A	200Jg		618.5	200	410	178	200		549			80	107	1126.5	450	479	508	168									420
110	GNF2224B	225Kg	D	711	225	446	203		28	628	100			142	1249	506	526	538		24			85m6			22		520
132	GNF2226B	225Hg		761				250							1349		626	588										580
160	GNF2254B	250Hg	E	829	250	508	228.5		32	763				203	1469	557	677											760
200	GNF2256B					505						120									170	1		14	9		M20×35	810
220	GNF2284B							280										640	190				95m6			25		1020
250																												1020
280		280Jf	F	881	280	570	254		35	878	120		102	303	1521	628	680			28								1080
300	GNF2286B																											1080

Note 1: Models of 110 kW output or above are exclusive to direct connection. For indirect connection, contact your Fuji Electric representative.

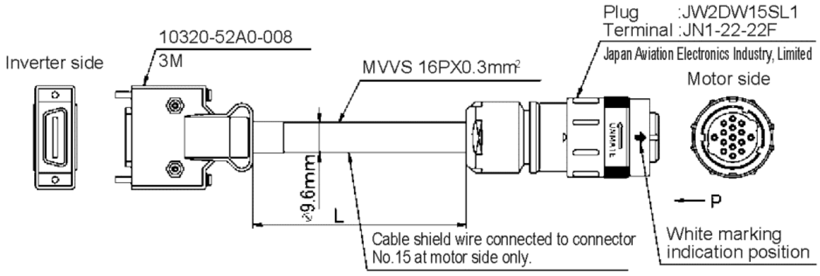
Note 2: Dimensional tolerance of rotary shaft height C
C ≤ 250 mm: 0 to -0.5 mm, C > 250 mm: 0 to 1.0 mm

2.3.2.4 Exclusive cables for inverter connection

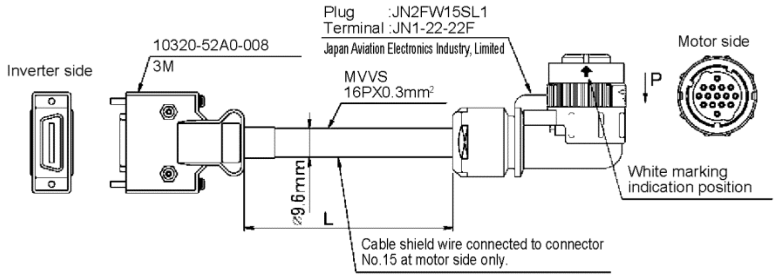
Item	Wiring length (L dimension)	Motor side plug shape: Straight plug	Motor side plug shape: Right-angle plug	Remarks
Cable type	5 m	CB-VG1-PMPG-05S	CB-VG1-PMPG-05A	
	15 m	CB-VG1-PMPG-15S	CB-VG1-PMPG-15A	
	30 m	CB-VG1-PMPG-30S	CB-VG1-PMPG-30A	
	50 m	CB-VG1-PMPG-50S	CB-VG1-PMPG-50A	

Cable configuration diagram

<Straight plug>



<Right-angle plug>



Wiring table pin arrangement

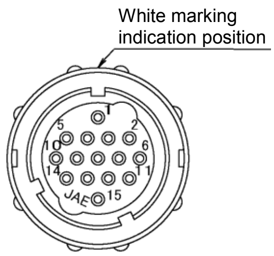
• Wiring table

Motor side connector #	Inverter side connector #	Function
1	9 or 20	Power +5 V
2	10 or 19	0V common
3	3	A-phase
4	2	A-phase reversed
5	5	B-phase
6	4	B-phase reversed
7	-	Z-phase *1
8	-	Z-phase reversed *1
9	8	Magnetic pole position F0
10	7	Magnetic pole position* F0
11	13	Magnetic pole position F1
12	12	Magnetic pole position* F1
13	15	Magnetic pole position F2
14	14	Magnetic pole position* F2
15	-	Shielded wire

*1 For the PG card (OPC-VG1-PMPG), Z phase or Z phase reversed signals are not required.

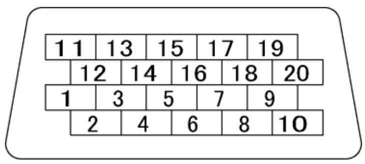
• Pin arrangement

Motor side Connector arrangement

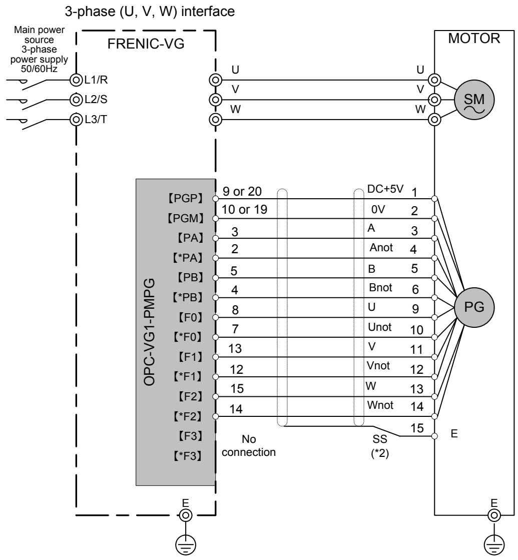


Viewed from P in the above figure

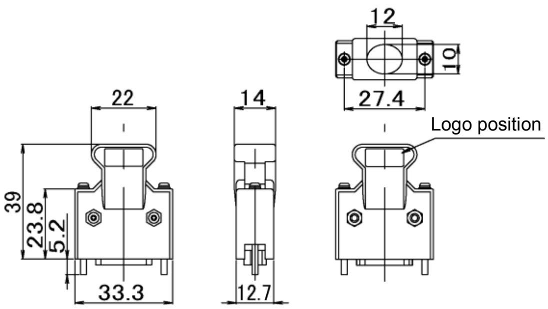
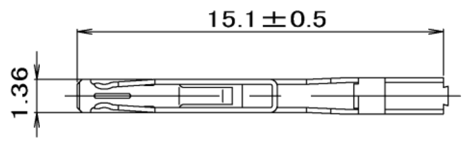
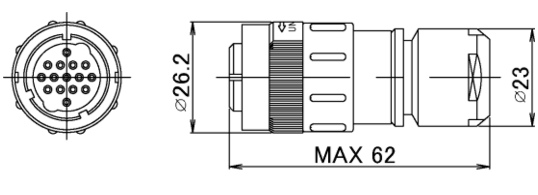
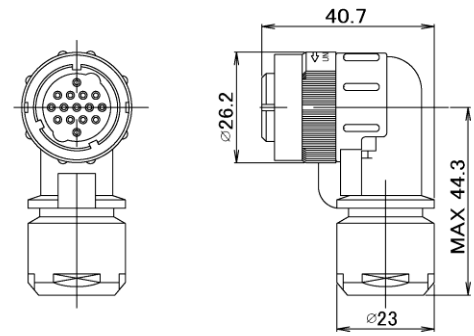
Optional OPC-VG1-PMPG connector arrangement



Inside the connector

Item	Specifications (Structure)
Connection example	 *2 When the customer prepares the inverter connection cable, the shield (SS) of the PG shielded wire should be connected to CN15 at the motor side. For inverter side, no connection is required.

Reference: Connectors and contact terminals recommended
The following specifications are recommended for customers who produce inverter connection cables.

At the inverter side connector: 10320-52F0-008 Sumitomo 3M Co., Ltd.	At the motor side connector contact terminal: JN1-22-22F-PKG100 Japan Aviation Electronics Industry, Limited
	 Max. applicable wire size: AWG20 (Outer dia. of coated cable: φ1.5 mm or less)
At the motor side connector: JN2DW15SL (Straight plug connector) Japan Aviation Electronics Industry, Limited	At the motor side connector: JN2FW15SL1 (Angle plug connector) Japan Aviation Electronics Industry, Limited
	

Note 1: The following specifications are recommended for PG shielded wires.

Type	Braided, shielded wires Twisted-pair cable (Outer dia.: Approx. φ10)
Number of cores	14 or more
Dia. of lead	0.2 to 0.3 mm^2
Outer dia. of coated cable	Max. φ1.5 mm

Note 2: The PKG in contact terminal models denotes that 100 terminals are packed in bulk.

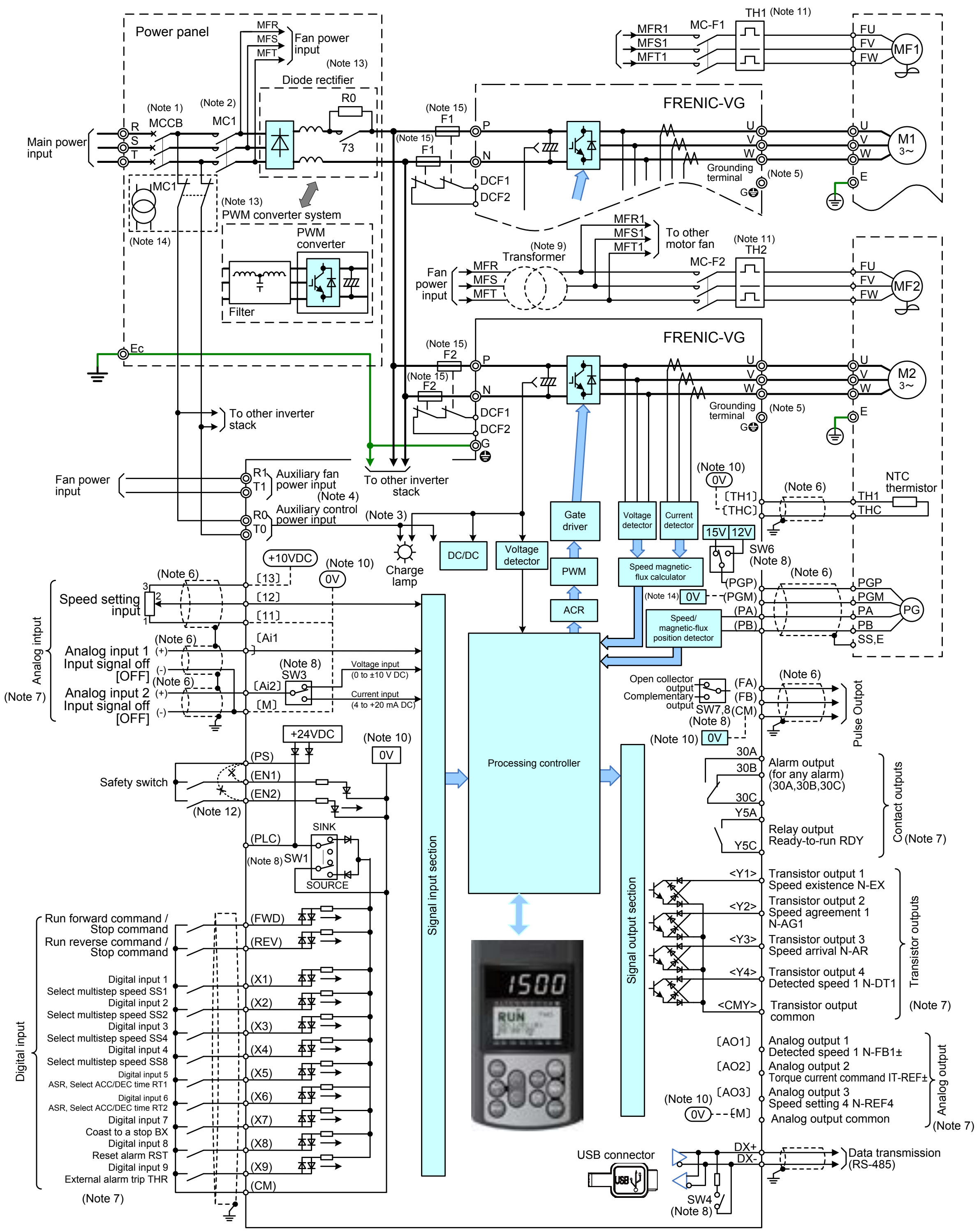
Note 3: Joint with contact terminals should be presoldered.

2.4 Connection diagrams and terminal functions

2.4.1 Connection diagrams

2.4.1.1 Standard stack

The connection example of the inverter (standard stack) is shown below.



(Note 1) For wiring protection, install the recommended circuit breaker (MCCB) or earth leakage breaker (ELCB) (with an overcurrent protection feature) on the input side (i.e., the primary side) of the PWM converter or diode rectifier. Ensure that the circuit breaker capacity is equivalent to or lower than the recommended capacity.

(Note 2) Aside from the MCCB or the ELCB, install the recommended electromagnetic contactor (MC) as necessary as it will be used when disconnecting the power supply from the PWM converter or diode rectifier. Connect a surge absorber in parallel when installing a coil such as an MC or solenoid near the inverter.

(Note 3) To retain an alarm output signal issued on inverter's programmable output terminals by the protective function or to keep the keypad alive even if the main power has shut down, connect these terminals to the power supply lines. Without power supply to these terminals, the inverter can run.

(Note 4) Connect the fan power supply terminals to power source when capacity of inverter is above 90 kW.

(Note 5) A grounding terminal for a motor. It is recommended that the motor be grounded via this terminal for suppressing inverter noise.

(Note 6) For wiring enclosed with [ ], use twisted or shielded wires. In principle, the shielded sheath of wires should be connected to ground. If the inverter is significantly affected by external induction noise, however, connection to (0V) (【M】, 【11】, 【THC】), [0V] (【CM】) may be effective to suppress the influence of noise. Keep the control circuit wiring away from the main circuit wiring as far as possible. (recommended: 10 cm or more). When crossing the control circuit wiring with the main circuit wiring, set them at right angles.

(Note 7) The connection diagram shows factory default functions assigned to digital input terminals [X1] to [X9], transistor output terminals [Y1] to [Y4], relay contact output terminals [Y5A/C], analog output terminal [AO1] to [AO3], and analog input terminals [Ai1] and [Ai2].

(Note 8) Slide switches on the control printed circuit board (control PCB).

(Note 9) The motor cooling fan voltage differs from motor to motor. Add a transformer as needed.

(Note 10) (0V) (【M】, 【11】, 【THC】), [0V] (【CM】) are insulated inside the inverter unit.

(Note 11) Use the auxiliary contact (manual reset) of the thermal relay to trip the MCCB or MC.

(Note 12) Jumper bars are mounted between safety terminals [EN1]/[EN2] and [PS] by factory default. To use the safety function, remove the jumper bars before connection of safety devices.

(Note 13) Diode rectifiers and PWM converter types are available for use as the inverter power supply (converter). Additionally, selection of recommended peripherals matching the converter to be used is necessary. Refer to "Chapter 6 Converter System" for details.

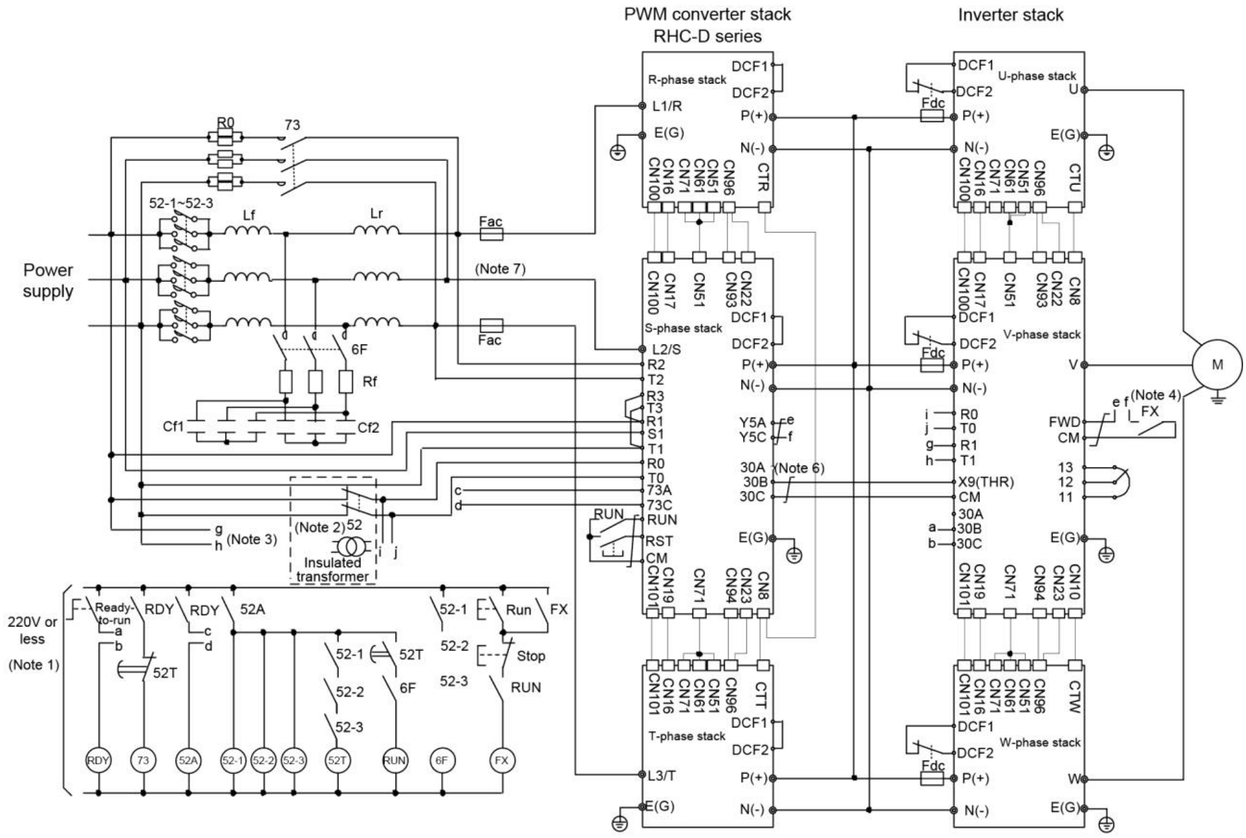
(Note 14) When used in combination with a PWM converter, be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the power supply electromagnetic contactor (MC1). This is not necessary if used in combination with a diode rectifier. When using the product with a non-grounded power supply, it is necessary to install an insulated transformer. For more information, refer to "6.3.15-(5)" in Chapter 6.

(Note 15) Be sure to use the fuse (F1, F2). Use the fuses on the P (+) side for the 400V series or on both the P (+) and N (-) sides for the 690V series.

2.4.1.2 Phase-specific stack

The following diagram shows the connection example of the phase-specific stack type, 630 to 800 kW (400V series) inverter. A single phase-specific stack consists of 3 units of the standard stack (4-frame size). Connections required in this case include stack-to-stack connections in addition to the connections described in "2.4.1.1 Standard stack". (The following example assumes that they are connected to a PWM converter.)

* Stack-to-stack connection cables (signal wires) are bundled with the product.



(Note 1) Connect a step-down transformer to ensure that the sequence circuit voltages are exactly the same as shown in the connection diagram.

(Note 2) When used in combination with a PWM converter, be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the power supply electromagnetic contactor (52). This is not necessary if used in combination with a diode rectifier. When using the product with a non-grounded power supply, it is necessary to add an insulated transformer. For more information, refer to "6.3.15-(5)" in Chapter 6.

(Note 3) Be sure to connect the power supply for the inverter's AC fan to the main power directly (not via contact b of #73 or #52) so that the power can be fed through terminals R1 and T1.

(Note 4) Create a sequence in which the PWM converter gets ready for operation before the run signal is input to the inverter.

(Note 5) Set the timer for 52T to 1 second.

(Note 6) Configure one of the inverter's terminals X1 to X9 for use by the external alarm (THR).

(Note 7) Ensure correct phase sequence when connecting wires to terminals L1/R, L2/S, L3/T, R2, T2, R1, S1, and T1.

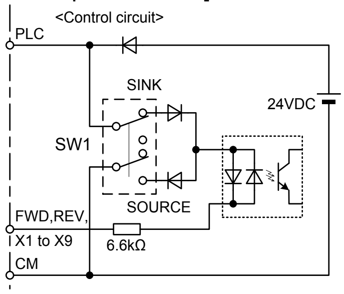
2.4.2 Terminal functions

This section describes terminal functions of the inverter.

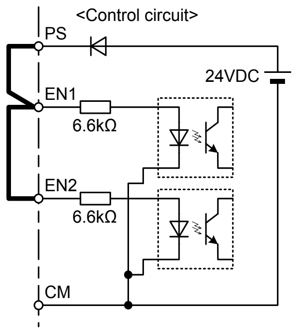
2.4.2.1 Terminal functions

Symbol		Name	Functions
Main circuit	U, V, W	Inverter output terminal	Connects a three-phase motor. For the stack type, one terminal connects to one phase (one stack).
	P (+), N (-)	DC input terminal	To be used for connection to the DC link bus. Connect to the diode rectifier or PWM converter stack output terminals P (+) and N (-).
	R0, T0	Auxiliary control power input	Connects the same AC power lines as the main power input for a backup of the control circuit power supply. For information on terminal ratings, refer to "4.5.3-(4) Control power auxiliary input terminals R0 and T0" in Chapter 4.
	R1, T1	Auxiliary fan power input	To be used for an auxiliary power input to AC cooling fans in the inverter (90 kW or higher). No connection is required for a 75 kW or lower inverter. For information on terminal ratings, refer to "4.5.3-(5) Fan power auxiliary input terminals R1 and T1 (R3 and T3 on the converter side)" in Chapter 4.
	DCF1 DCF2	Inputs for detection of fuse blown	Terminals for detecting a blowout of the DC fuse connected to the inverter main input power supply. When the circuit between terminals [DCF1] and [DCF2] is OFF, the inverter detects the blowout of the DC fuse. Remove the shorted piece and connect the DC fuse microswitch to use.
Grounding	⏚ G	Grounding for inverter	Grounding terminal for inverter chassis.
Analog input	13	Power supply for potentiometer	Power supply for a speed command potentiometer (Variable resistor: 1 to 5 kΩ). The potentiometer of 1/2 W rating or more should be connected. Specifications: 10 VDC, 10 mA max.
	12	Voltage input for speed setting	The speed is commanded according to the external analog voltage input. Specifications • Reverse operation with ± signals: 0 to ±10 VDC/0 to maximum speed The maximum input is ±15 VDC; however, the voltage out of the range of ±10 VDC is regarded as ±10 VDC. (Upper limit: ±10 VDC) • Input impedance: 10 kΩ
	Ai1 Ai2	Analog input 1 Analog input 2	(1) Analog input voltage from external equipment. Possible to assign various signal functions (Input signal off, Auxiliary speed setting 1, Torque limiter *), selected with Function codes E49 and E50 to these terminals. (2) Only for terminal [Ai2], the input is switchable between voltage and current with the SW3 configuration. (3) To use terminal [Ai2] for current input speed setting (N-REFC), turn SW3 to the I position, set F01 or C25 to "9" and set E50 to "26." After that, check that the current input is normal on the I/O check screen*. * For more information, refer to the separate volume "Unit Type Function Code Edition" (24A7-☐-0019). Specifications • Voltage input: 0 to ±10 VDC, Input impedance: 10 kΩ The maximum input is ±15 VDC; however, the voltage out of the range of ±10 VDC is regarded as ±10 VDC. (Upper limit: ±10 VDC) • Current input (only on [Ai2]): Input impedance 250 Ω The maximum input is 30 mADC; however, the current out of the range of 20 mADC is regarded as 20 mADC. (Upper limit: 20 mADC)
	11, M	Analog input common	Common for analog input signals ([12], [Ai1] and [Ai2]). Isolated from other control circuit common terminals [CM], [CMY] and [PGM].

<table>
<tr><th colspan="2">Symbol</th><th>Name</th><th>Functions</th></tr>
<tr><td rowspan="8">Digital input</td><td>FWD</td><td>Run forward/stop command</td><td>When terminals [FWD] and [CM] are closed, the motor runs in the forward direction; when they are opened, the motor decelerates to a stop.*1</td></tr>
<tr><td>REV</td><td>Run reverse/stop command</td><td>When terminals [REV] and [CM] are closed, the motor runs in the reverse direction; when they are opened, the motor decelerates to a stop.*1</td></tr>
<tr><td>X1
X2
X3
X4
X5
X6
X7
X8
X9</td><td>Digital input 1
Digital input 2
Digital input 3
Digital input 4
Digital input 5
Digital input 6
Digital input 7
Digital input 8
Digital input 9</td><td>(1) Various signals such as "Coast to a stop," "External alarm trip," and "Select multistep speed" can be assigned to these terminals by setting Function codes E01 to E09.*2
(2) It is possible to switch the operation mode of each terminal with Function code E14. *2
When short-circuited: ON (Active ON)
When short-circuited: OFF (Active OFF)
*1 Input mode, i.e. SINK/SOURCE, is changeable by using SW1. For the location of SW1, refer to "2.4.2.2 Setting up the slide switches".
*2 For more information on setting the functions, refer to "4.3 Function code details" in Chapter 4 of the separate volume "Unit Type Function Code Edition" (24A7-□-0019).

[General-purpose digital input circuit specifications]


<table>
<tr><th colspan="2">Item</th><th>Minimum</th><th>Maximum</th></tr>
<tr><td rowspan="2">Operating voltage (SINK)</td><td>ON level</td><td>0 V</td><td>2 V</td></tr>
<tr><td>OFF level</td><td>22 V</td><td>27 V</td></tr>
<tr><td rowspan="2">Operating voltage (SOURCE)</td><td>ON level</td><td>22 V</td><td>27 V</td></tr>
<tr><td>OFF level</td><td>0 V</td><td>2 V</td></tr>
<tr><td colspan="2">Operating current in ON state (with an input voltage of 0 V)</td><td>—</td><td>4.5 mA</td></tr>
<tr><td colspan="2">Allowable leak current in the OFF state</td><td>—</td><td>0.5 mA</td></tr>
</table></td></tr>
<tr><td>EN1
EN2</td><td>Input terminal for safety function</td><td>When [EN1]-[PS] or [EN2]-[PS] is opened (OFF), the switching element of the inverter main circuit turns OFF and the inverter output transistor stops its operation.
(1) When not using the safety function, short the circuit between [EN1]-[PS] and [EN2]-[PS] with jumper bars. (Factory default: Shorted with jumper bars. Keep the short bars connected.)
(2) The input mode of terminals [EN1] and [EN2] is fixed at SOURCE. It cannot be switched to SINK.

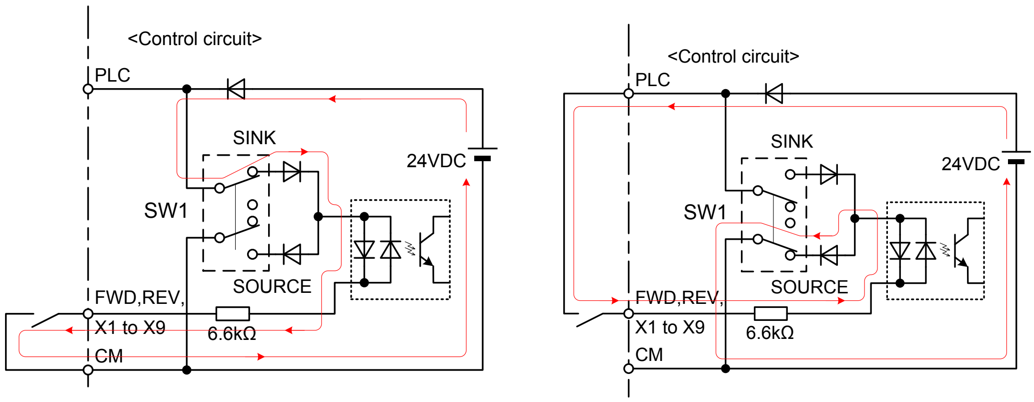
Terminal EN circuit specification


<table>
<tr><th colspan="2">Item</th><th>Minimum</th><th>Maximum</th></tr>
<tr><td rowspan="2">Operating voltage□ (SOURCE)</td><td>ON level</td><td>22 V</td><td>27 V</td></tr>
<tr><td>OFF level</td><td>0 V</td><td>2 V</td></tr>
<tr><td colspan="2">Operating current in ON state□ (with an input voltage of 0 V)</td><td>—</td><td>4.5 mA</td></tr>
<tr><td colspan="2">Allowable leak current in the OFF state</td><td>—</td><td>0.5 mA</td></tr>
</table></td></tr>
<tr><td>PS</td><td>[EN] terminal power</td><td>Power terminal exclusive to terminals [EN1] and [EN2].
Rated voltage: +24 VDC (based on terminal [CM])</td></tr>
<tr><td>PLC</td><td>PLC signal power</td><td>(1) Connects to PLC (Programmable Logic Controller) output signal power supply. Rated voltage: +24 VDC (Allowable voltage fluctuation range: +22 to +27 VDC), Maximum 100 mA
(2) This terminal is also used to supply power to the load connected to the transistor output terminals. Refer to "transistor output" described later in this table for more information.</td></tr>
<tr><td>CM</td><td>Digital input common</td><td>Common terminals for digital input signals
Electrically isolated from terminals [11], [M] and [CMY].</td></tr>
</table>

<table>
<tr><th colspan="2">Symbol</th><th>Name</th><th>Functions</th></tr>
<tr><td rowspan="2">Digital input</td><td></td><td colspan="2">

■ Using a relay contact to turn any of [FWD], [REV] and [X1] to [X9] ON or OFF

Figure 2.4.2-1 shows two examples of a circuit configuration using a relay contact. In circuit (a), the slide switch SW1 is turned to SINK and in circuit (b), to SOURCE.
This terminal section operates on minute current, so use a minute load relay. Using a general load relay may cause malfunction.
(Recommended product: Fuji control relay Model HH54PW)



(a) With the switch turned to SINK (b) With the switch turned to SOURCE

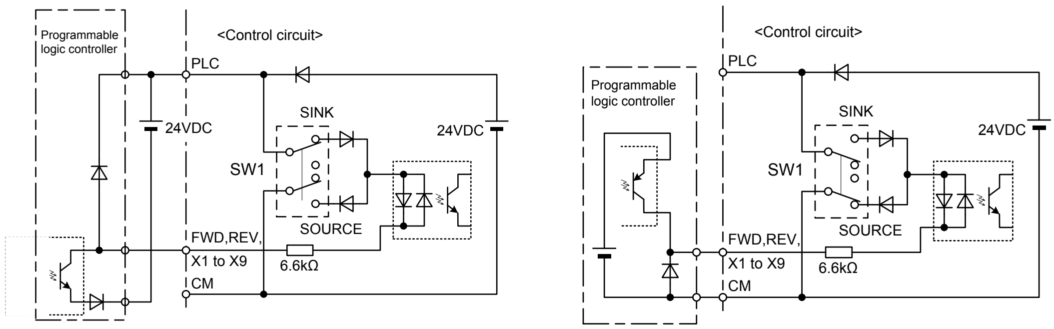
Figure 2.4.2-1: Circuit configuration using a relay contact

</td></tr>
<tr><td>Tip</td><td colspan="2">

■ Using a programmable logic controller (PLC) to turn any of [FWD], [REV] and [X1] to [X9] ON or OFF

Figure 2.4.2-2 shows two examples of a circuit configuration using a programmable logic controller (PLC). In circuit (a), the slide switch SW1 is turned to SINK and in circuit (b), to SOURCE.
Circuit (a) uses an external power supply. When using this type of circuit, observe the following.

- Connect the + node of the external power supply (which should be isolated from the PLC's power) to terminal [PLC] of the inverter.
- Do not connect terminal [CM] of the inverter to the common terminal of the PLC.



(a) With the slide switch turned to SINK and an external power supply being used

(b) With the switch turned to SOURCE

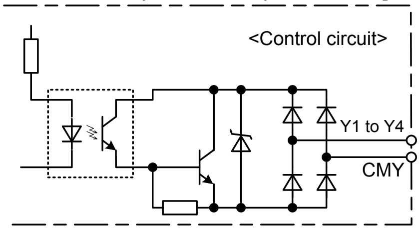
Figure 2.4.2-2: Circuit configuration using a PLC

For details about the slide switch configuration, refer to "2.4.2.2 Setting up the slide switches".

</td></tr>
<tr><td rowspan="2">Analog output</td><td>Ao1
Ao2
Ao3</td><td>Analog output 1
Analog output 2
Analog output 3</td><td>Output of monitor signals with analog DC voltage. Various signals such as "Detected speed," "Speed setting," and "Torque current command" can be assigned to these terminals by setting Function codes E69 to E71. For more information, refer to "4.3 Function code details" in Chapter 4 of the separate volume "Unit Type Function Code Edition" (24A7-☐-0019).
Specifications
• Voltage output: 0 to ±10 VDC, Connectable impedance: Min. 3 kΩ
• Gain adjustment range: 0 to ±100 times</td></tr>
<tr><td>M</td><td>Analog output
Common terminals</td><td>Common terminals for analog output signals ([Ao1], [Ao2] and [Ao3]).
Isolated from other control circuit common terminals [CM], [CMY] and [PGM].</td></tr>
</table>

<table>
<tr><th colspan="2">Symbol</th><th>Name</th><th>Functions</th></tr>
<tr><td rowspan="2">Transistor output</td><td>Y1
Y2
Y3
Y4</td><td>Transistor output 1
Transistor output 2
Transistor output 3
Transistor output 4</td><td>Various signals such as "inverter running," "Speed valid," and "Speed agreement" can be assigned to these terminals by setting Function codes E15 to E18.
For more information, refer to "4.3 Function code details" in Chapter 4 of the separate volume "Unit Type Function Code Edition" (24A7-☐-0019).
* It is possible to switch the operation mode for transistor output terminals [Y1]-[Y4] and [CMY] between "Active ON" (ON when the signal is output) and "Active OFF" (OFF when the signal is output).

[Transistor output circuit specification]



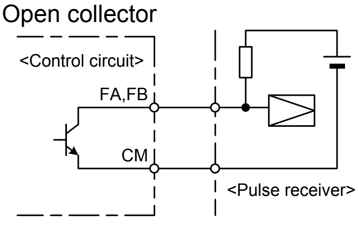
<table>
<tr><th colspan="2">Item</th><th>Maximum</th></tr>
<tr><td rowspan="2">Operating voltage</td><td>ON level</td><td>2 V</td></tr>
<tr><td>OFF level</td><td>27 V</td></tr>
<tr><td colspan="2">Operating load current in the ON state</td><td>50 mA</td></tr>
<tr><td colspan="2">Leakage current when OFF</td><td>0.1 mA</td></tr>
</table>

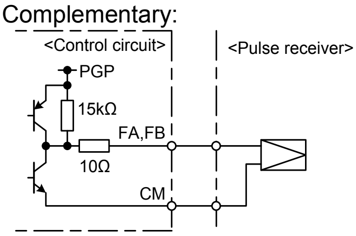
Figure 2.4.2-3: Transistor output circuit

Note 1: When a transistor output drives a control relay, connect a surge-absorbing diode across relay's coil terminals.
Note 2: Through terminal [PLC], power can be supplied to the relay. Short-circuit between terminals [CMY] and [CM] in this case.
[Terminal PLC specifications] 24 VDC, Allowable voltage fluctuation range: 22 to 27 VDC, 100 mA max.</td></tr>
<tr><td>CMY</td><td>Transistor output common</td><td>Common terminal for transistor output signals.
Electrically isolated from terminals [CM], [11], [M], and [PGM].</td></tr>
<tr><td rowspan="3">Contact output</td><td>Y5A
Y5C</td><td>General-purpose relay output</td><td>(1) The relay contact (1a) selects and outputs the same various signals as those from terminals [Y1] to [Y4].
(2) It is possible to switch the operation mode for these terminals with Function code E28.
• When ON signal is issued, [Y5A]-[Y5C] is short-circuited (Excited: "Active ON").
• When ON signal is issued, [Y5A]-[Y5C] is opened (Not excited: "Active OFF").</td></tr>
<tr><td>30A
30B
30C</td><td>Alarm output (for any alarm)</td><td>(1) Outputs a contact signal (relay contact, 1C) when the protective function stops the inverter.
(2) It is possible to switch the operation mode for these terminals with Function code F36.
• When ON signal is issued, [30A]-[30C] is short-circuited (Excited: "Active ON").
• When ON signal is issued, [30A]-[30C] is opened (Not excited: "Active OFF").</td></tr>
<tr><td></td><td></td><td>[Contact output specification]
Contact rating: 250 VAC 0.3 A cosφ=0.3, 48 VDC 0.5 A (resistance load)</td></tr>
</table>

Note

- The contact outputs (terminals Y5A/C, 30A/B/C) are mechanical contacts. Frequent ON/OFF operations cannot be permitted.
  The guideline for the life of relay contacts is 200,000 times if turned ON/OFF at 1 second intervals at rated load. Signals turned ON/OFF at high frequency should be output from terminals Y1 to Y4.
  Furthermore, even if using an AC power supply, the contact life may be shorter with loads for which the contact current direction is fixed (loads with half-wave rectifier circuit, etc., e.g., timers, power supply devices for motor electromagnetic brakes).
  In cases such as this, instead of connecting the load directly to the contact output terminals, connect a control relay, etc. (separately installed) which satisfies load conditions to the contact output terminals, and then connect to the load via this relay.

<table>
<tr><th colspan="2">Symbol</th><th>Name</th><th>Functions</th></tr>
<tr><td rowspan="2">Communication</td><td>DX+
DX-</td><td>RS-485 communications ports 2 (Terminal block)</td><td>Input/output terminals to transmit data through the RS-485 communications link between the inverter and a computer or other equipment such as a PLC.
(For setting of the terminating resistor, refer to "2.4.2.2 Setting up the slide switches".</td></tr>
<tr><td>USB connector</td><td>USB port</td><td>A USB port connector (mini B) that connects an inverter to a computer.
Using FRENIC-VG Loader (inverter support software) running on the computer supports editing the function codes, transferring them to the inverter, verifying them, test-running the inverter and monitoring the inverter running status.
In addition, using an optional software enables traceback operation.</td></tr>
<tr><td rowspan="5">Speed detection</td><td>PA
PB</td><td>Pulse generator 2-phase signal input</td><td>The PG interface uses a complementary output mode.
[PA]: Input terminal for A phase of the pulse generator
[PB]: Input terminal for B phase of the pulse generator
When 12 V power supply is in use: H level ≥ 9 V, L level ≤ 1.5 V
When 15 V power supply is in use: H level ≥ 12 V, L level ≤ 1.5 V
Input pulse frequency: 100 kHz or below, Duty: 50±10%
Wiring length: 100 m or less
(Note) False detection may occur due to noise. Make the wiring length as short as possible and take sufficient noise control measures.</td></tr>
<tr><td>PGP</td><td>Pulse generator power output terminal</td><td>Output terminals of power supply of pulse generator.
The output voltage is switchable between 12 V and 15 V with the slide switch SW6 on control print circuit board.
• +15 Vdc ±10%, maximum current: 270 mA (default status: 15V)
• +12 Vdc ±10%, maximum current: 270 mA
(For the output voltage switch SW6, refer to "2.4.2.2 Setting up the slide switches".)</td></tr>
<tr><td>PGM</td><td>Common terminal</td><td>Common terminal for pulse generator power/signal. Electrically isolated from terminals [11], [M] and [CMY]. Not electrically isolated from terminal [CM], but not equivalent voltage.</td></tr>
<tr><td>FA
FB</td><td>Pulse generator output</td><td>(1) The signal divided to 1/n from the original pulse generator signal is output. n is programmable switch with Function code E29.
(2) Switchable between open collector and complementary (equivalent to the voltage on terminal [PGP]) transistor outputs.
Default status: open collector
(For switching, refer to "2.4.2.2 Setting up the slide switches".)
Open collector


<table>
<tr><th colspan="2">Item</th><th>Maximum</th></tr>
<tr><td rowspan="2">Operating voltage</td><td>ON level</td><td>2 V</td></tr>
<tr><td>OFF level</td><td>Indefinite (dependent on the receiving side)</td></tr>
<tr><td colspan="2">Operating load current in the ON state</td><td>15 mA</td></tr>
<tr><td colspan="2">Rated voltage</td><td>15 V</td></tr>
</table>
Complementary:


<table>
<tr><th colspan="2">Item</th><th>Minimum</th><th>Maximum</th></tr>
<tr><td rowspan="2">Operating voltage</td><td>High level</td><td>PGP-3V</td><td>—</td></tr>
<tr><td>Low level</td><td>—</td><td>2 V</td></tr>
<tr><td colspan="2">Operating current in the ON state</td><td>—</td><td>20 mA</td></tr>
<tr><td colspan="2">Allowable leak current in the OFF state</td><td>—</td><td>0.5 mA</td></tr>
</table></td></tr>
<tr><td>CM</td><td>Common terminal</td><td>Common terminal for pulse generator output [FA] and [FB].</td></tr>
<tr><td rowspan="2">Temperature detection</td><td>TH1</td><td>NTC/PTC thermistor connection</td><td>Monitors the motor temperature with NTC or PTC thermistor.
For a PTC thermistor, the motor overheat protection level can be specified with Function code E32.</td></tr>
<tr><td>THC</td><td>Common terminal</td><td>Common terminal for NTC and PTC thermistors.
Electrically isolated from terminals [CM], [CMY] and [PGM].</td></tr>
</table>

2.4.2.2 Setting up the slide switches

Switching the slide switches (see Figure 2.4.2-4: Location of the slide switches on the control PCB) located on the PCB allows you to customize the operation mode of input/output terminals such as analog outputs.

To access the slide switches, remove the front cover so that you can see the control PCB. (Open also the keypad enclosure.)

📖 For information on removing the front cover and opening/closing the keypad case, refer to "4.2.2.2 Procedure for removing and attaching the front cover" in Chapter 4.

Table2.4.2-1: Function of each slide switch

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SW1</td><td>Switches the service mode of the digital input terminals between SINK and SOURCE.
• This switches the input mode of digital input terminals [X1] to [X9], [FWD] and [REV] to be used as the SINK or SOURCE mode.
• Factory default: SINK</td></tr>
<tr><td>SW2</td><td>Reserved for particular manufacturers.</td></tr>
<tr><td>SW3</td><td>Switches the input mode of the terminal [Ai2]
between voltage and current.
<table><tr><th>Input form</th><th>SW3</th></tr><tr><td>Voltage input (Factory default)</td><td>V position</td></tr><tr><td>Current input</td><td>I position</td></tr></table>Terminal Ai2 is available as a current input terminal only when the speed setting is <N-REFC>.
📖 Refer to Chapter 4 of the separate volume "Unit Type Function Code Edition" (24A7-☐-0019).</td></tr>
<tr><td>SW4</td><td>Switches the terminating resistor of RS-485 communications port 2 on the terminal block ON and OFF.
• If the inverter is connected to the RS-485 communications network as a terminating device, turn the switch to ON.</td></tr>
<tr><td>SW5</td><td>Reserved for particular manufacturers.</td></tr>
<tr><td>SW6</td><td>Switches the output voltage of terminal [PGP] between 12 V and 15 V.
Select the voltage level that matches the power voltage of the pulse encoder to be connected.
<table><tr><th>Output voltage</th><th>SW6</th></tr><tr><td>12 V</td><td>12 V</td></tr><tr><td>15 V (Factory default)</td><td>15 V</td></tr></table></td></tr>
<tr><td>SW7
SW8</td><td>Switches the output mode of terminals [FA] and [FB] between open collector output and complementary output.
<table><tr><th>Output form</th><th>SW7
(Terminal [FA])</th><th>SW8
(Terminal [FB])</th></tr><tr><td>Open collector output (Factory default)</td><td>1</td><td>1</td></tr><tr><td>Complementary output</td><td>2</td><td>2</td></tr></table></td></tr>
</table>

The following diagram shows the location of slide switches on the control PCB for the input/output terminal configuration.

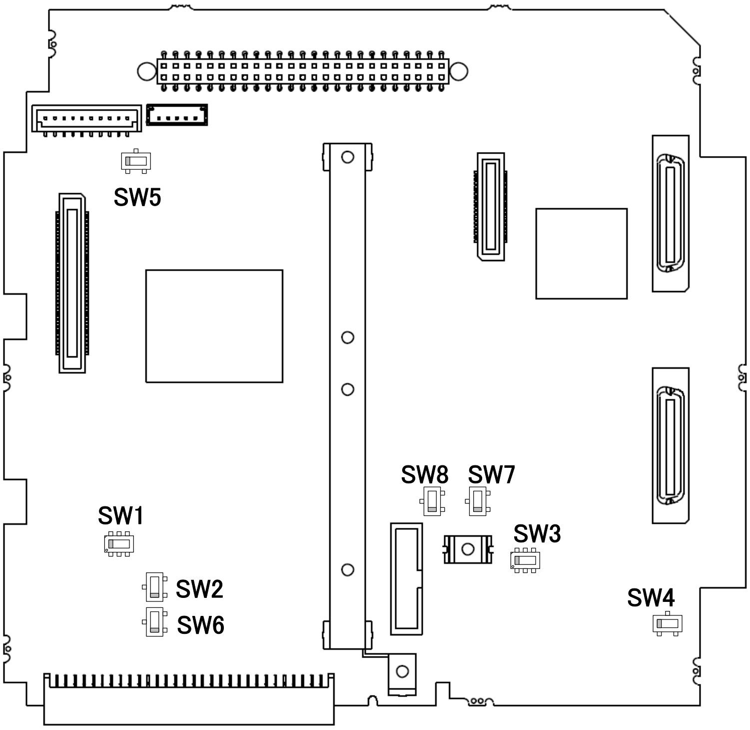


Figure 2.4.2-4: Location of the slide switches on the control PCB

	SW1	SW2	SW3	SW4	SW5	SW6	SW7 SW8
Factory default	SINK		V	OFF		15V	1
–	SOURCE		I	ON		12V	2

Note (1) Use a pointed tool (such as the tip of tweezers) to move the switch. Be careful not to touch other electronic components. Push the slider firmly to the edges as the connection is open when the slider is in the intermediate position. SW2 and SW5 are switches for the manufacturer, so please do not move the positions.

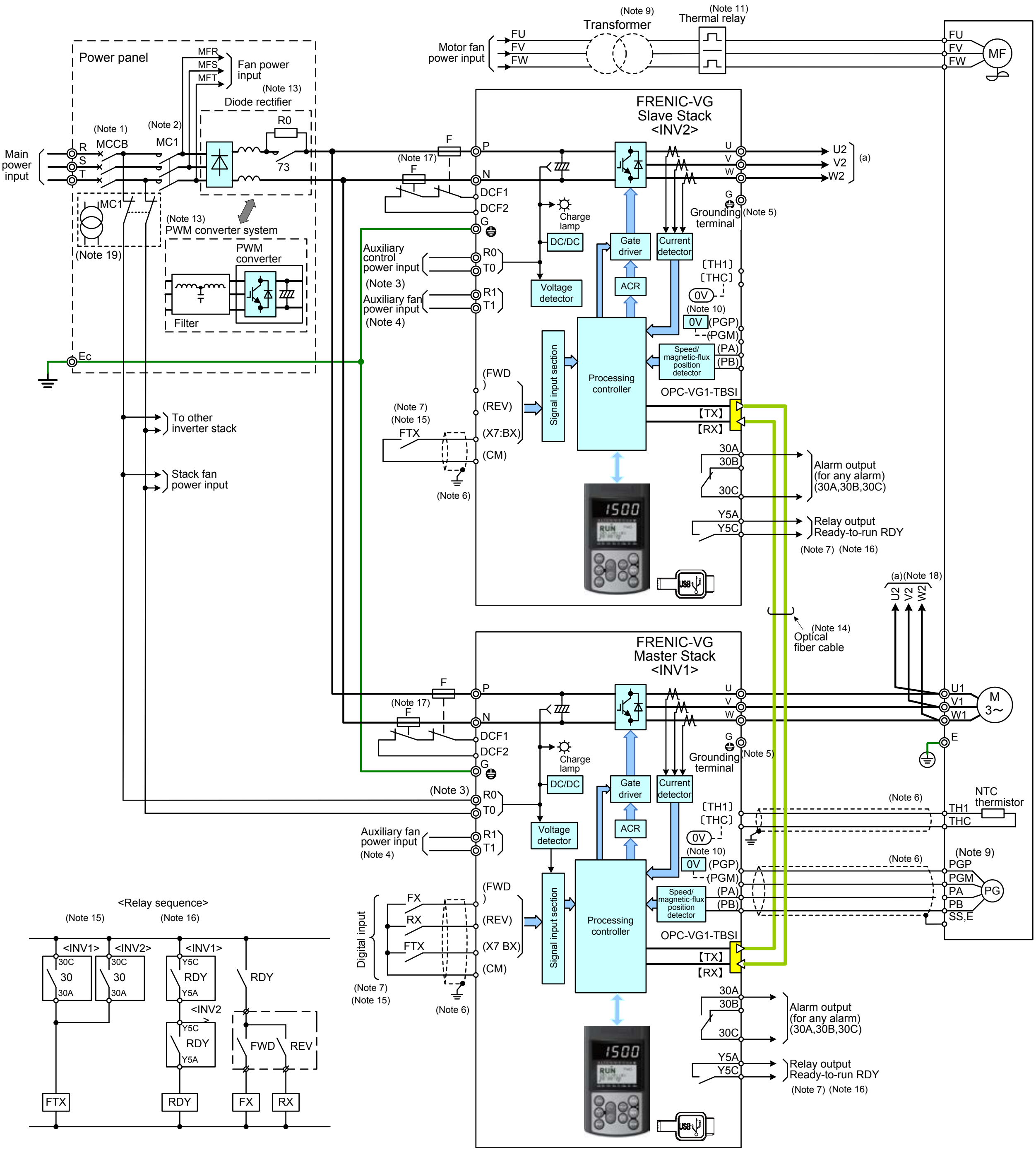
(2) When moving the switches, check that the direct intermediate circuit voltage between the P (+) and N (-) terminals of the major circuit has fallen to a safe voltage (+25 VDC or lower) using a tester after **confirming that the LED monitor and the charge lamp have turned off** and 10 minutes have elapsed from power off.

2.4.3 Multi-drive system connection diagrams

2.4.3.1 Direct parallel connection

In direct parallel connection, two or more inverter units drive one single-winding motor. Up to three inverter units can be connected in direct parallel connection.

For more information, refer to "9.4 Direct parallel connection system" in Chapter 9.



(Note 1) For wiring protection, install the converter-specific recommended circuit breaker (MCCB) or earth leakage breaker (ELCB) (with an overcurrent protection feature) on the input side (i.e., the primary side) of the converter. Ensure that the circuit breaker capacity is equivalent to or lower than the recommended capacity.

(Note 2) Aside from the MCCB or the ELCB, install the converter-specific recommended electromagnetic contactor (MC) as necessary as it will be used when disconnecting the power supply from the converter. Connect a surge absorber in parallel when installing a coil such as an MC or solenoid near the inverter.

(Note 3) To retain an alarm output signal issued on inverter's programmable output terminals by the protective function or to keep the keypad alive even if the main power has shut down, connect these terminals to the power supply lines. Without power supply to these terminals, the inverter can run.

(Note 4) Connect to the fan power supply terminals for cases above 90 kW.

(Note 5) A grounding terminal for a motor. It is recommended that the motor be grounded via this terminal for suppressing inverter noise.

(Note 6) For wiring enclosed with [ ], use twisted or shielded wires. In principle, the shielded sheath of wires should be connected to ground. If the inverter is significantly affected by external induction noise, however, connection to 0V (【M】, 【11】, 【THC】), 0V (【CM】) may be effective to suppress the influence of noise. Keep the control circuit wiring away from the main circuit wiring as far as possible (recommended: 10 cm or more). When crossing the control circuit wiring with the main circuit wiring, set them at right angles.

(Note 7) The connection diagram shows factory default functions assigned to digital input terminals [X1] to [X9], transistor output terminals [Y1] to [Y4], relay contact output terminals [Y5A/C], analog output terminal [AO1] to [AO3], and analog input terminals [Ai1] and [Ai2].

(Note 9) The motor cooling fan voltage differs from motor to motor. Add a transformer as needed.

(Note 10) 0V (【M】, 【11】, 【THC】), 0V (【CM】) are insulated inside the inverter unit.

(Note 11) Use the auxiliary contact (manual reset) of the thermal relay to trip the MCCB or MC.

(Note 13) Available converters include diode rectifiers and PWM converter types. Additionally, selection of recommended peripherals matching the converter to be used is necessary. Refer to "Chapter 6 Converter System" for details.

(Note 14) Direct parallel connection requires the optional high-speed serial communication support terminal block (OPC-VG1-TBSI). The option comes with an optical cable (5 m).
If the optical cable in use is bent (at a curvature of 35 mm or smaller), an alarm (Inter-inverter communications link error: Er-b) may occur. Lay the optical cable at a curvature of 35 mm or greater.

(Note 15) For the safety, configure the sequence circuit that causes all inverters running in direct parallel connection to coast to a stop (BX signal) when an inverter failure (heavy alarm) occurs. Do not assign BX signal via the communications link.

(Note 16) Configure the circuit that inputs a run command after the inverter ready-to-run signals on all inverters running in direct parallel connection are established. A run command and reset signal are valid only when they are entered to the master inverter. (There is no problem with them if entered via the communications link.)

(Note 17) Be sure to use the fuse (F). Use the fuses on the P (+) side for the 400V series or on both the P (+) and N (-) sides for the 690V series.

(Note 18) When a motor is run in a direct parallel connection system, there is a restriction on the wiring length between the inverter and motor.

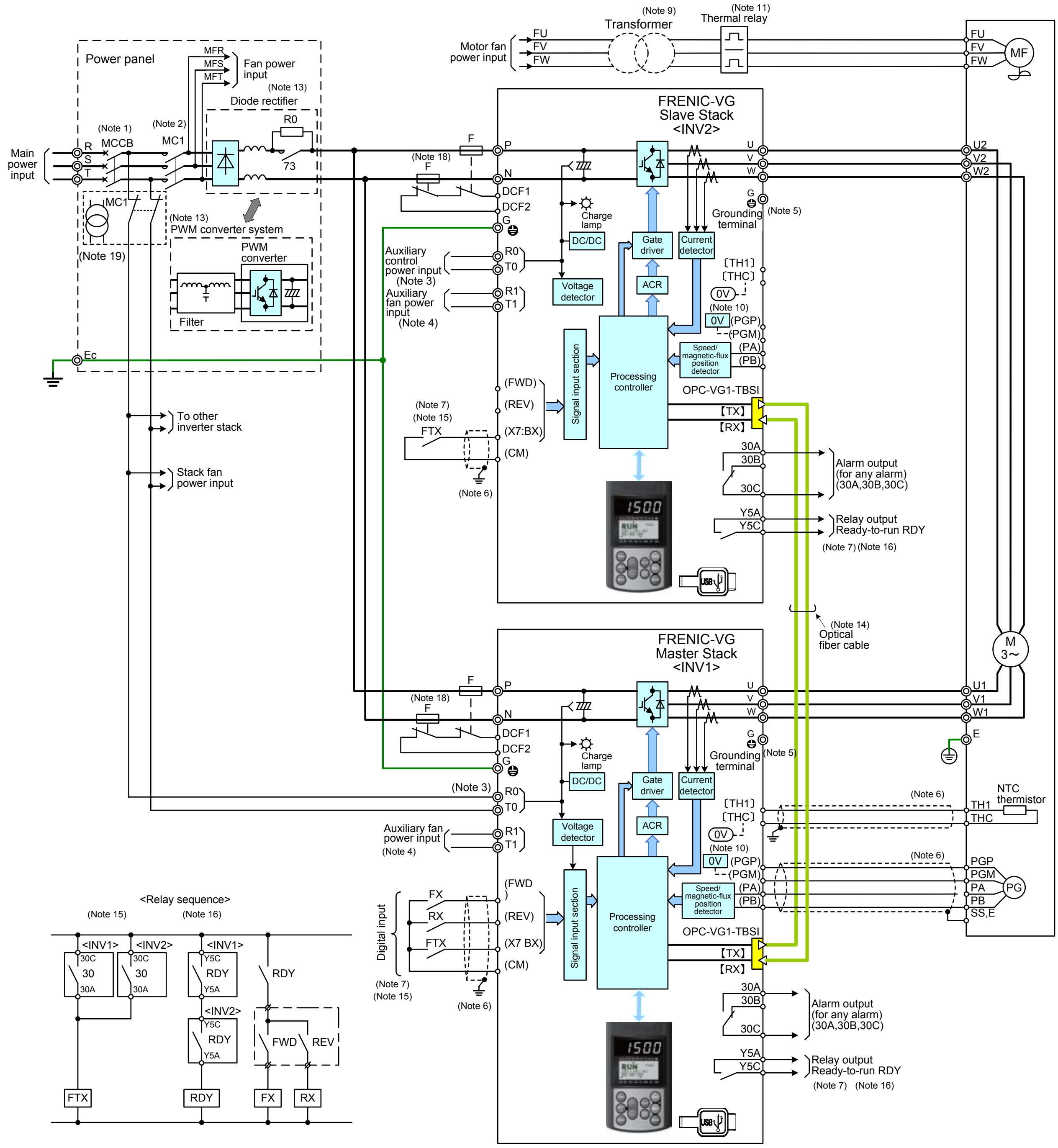
Note Refer to "9.4.8 Wiring inductance" and ensure that the wiring length between the inverter and motor is greater than the minimum wiring length.

(Note 19) When used in combination with a PWM converter, be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the power supply electromagnetic contactor (MC1). This is not necessary if used in combination with a diode rectifier. When using the product with a non-grounded power supply, it is necessary to add an insulated transformer.
For more information, refer to item (5) in section "6.3.15".

2.4.3.2 Multiwinding motor drive

Multiwinding motor drive system controls a special motor having more than one winding.

An inverter unit per motor winding is required. Generally, this system applies when VG7 or older inverter series are updated. (Vector control with a speed sensor is the only system which can be applied.)



(Note 1) For wiring protection, install the converter-specific recommended circuit breaker (MCCB) or earth leakage breaker (ELCB) (with an overcurrent protection feature) on the input side (i.e., the primary side) of the converter. Ensure that the circuit breaker capacity is equivalent to or lower than the recommended capacity.

(Note 2) Aside from the MCCB or the ELCB, install the converter-specific recommended electromagnetic contactor (MC) as necessary as it will be used when disconnecting the power supply from the converter. Connect a surge absorber in parallel when installing a coil such as an MC or solenoid near the inverter.

(Note 3) To retain an alarm output signal issued on inverter's programmable output terminals by the protective function or to keep the keypad alive even if the main power has shut down, connect these terminals to the power supply lines. Without power supply to these terminals, the inverter can run.

(Note 4) Connect to the fan power supply terminals for cases above 90 kW.

(Note 5) A grounding terminal for a motor. It is recommended that the motor be grounded via this terminal for suppressing inverter noise.

(Note 6) For wiring enclosed with [ ], use twisted or shielded wires. In principle, the shielded sheath of wires should be connected to ground. If the inverter is significantly affected by external induction noise, however, connection to (0V) (【M】, 【11】, 【THC】), [0V] (【CM】) may be effective to suppress the influence of noise. Keep the control circuit wiring away from the main circuit wiring as far as possible (recommended: 10 cm or more). When crossing the control circuit wiring with the main circuit wiring, set them at right angles.

(Note 7) The connection diagram shows factory default functions assigned to digital input terminals [X1] to [X9], transistor output terminals [Y1] to [Y4], relay contact output terminals [Y5A/C], analog output terminal [AO1] to [AO3], and analog input terminals [Ai1] and [Ai2].

(Note 9) The motor cooling fan voltage differs from motor to motor. Add a transformer as needed.

(Note 10) (0V) (【M】, 【11】, 【THC】), [0V] (【CM】) are insulated inside the inverter unit.

(Note 11) Use the auxiliary contact (manual reset) of the thermal relay to trip the MCCB or MC.

(Note 13) Available converters include diode rectifiers and PWM converter types. Additionally, selection of recommended peripherals matching the converter to be used is necessary. Refer to "Chapter 6 Converter System" for details.

(Note 14) Multiwinding motor drive requires the optional high-speed serial communication support terminal block (OPC-VG1-TBSI). The option comes with an optical cable (5 m).

(Note 15) For the safety, configure the sequence circuit that causes all inverters driving a multiwinding motor to coast to a stop (BX signal) when an inverter failure (heavy alarm) occurs. Do not assign BX signal via the communications link.

(Note 16) Configure the circuit that inputs a run command after the inverter ready-to-run signals on all inverters driving a multiwinding motor are established. A run command and reset signal are valid only when they are entered to the master inverter. (There is no problem with them if entered via the communications link.)

(Note 18) Be sure to use the fuse (F). Use the fuses on the P (+) side for the 400V series or on both the P (+) and N (-) sides for the 690V series.

(Note 19) When used in combination with a PWM converter, be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the power supply electromagnetic contactor (MC1). This is not necessary if used in combination with a diode rectifier. When using the product with a non-grounded power supply, it is necessary to add an insulated transformer.
For more information, refer to item (5) in section "6.3.15".

2.5 External dimensions

2.5.1 List of the FRENIC-VG's external dimensions

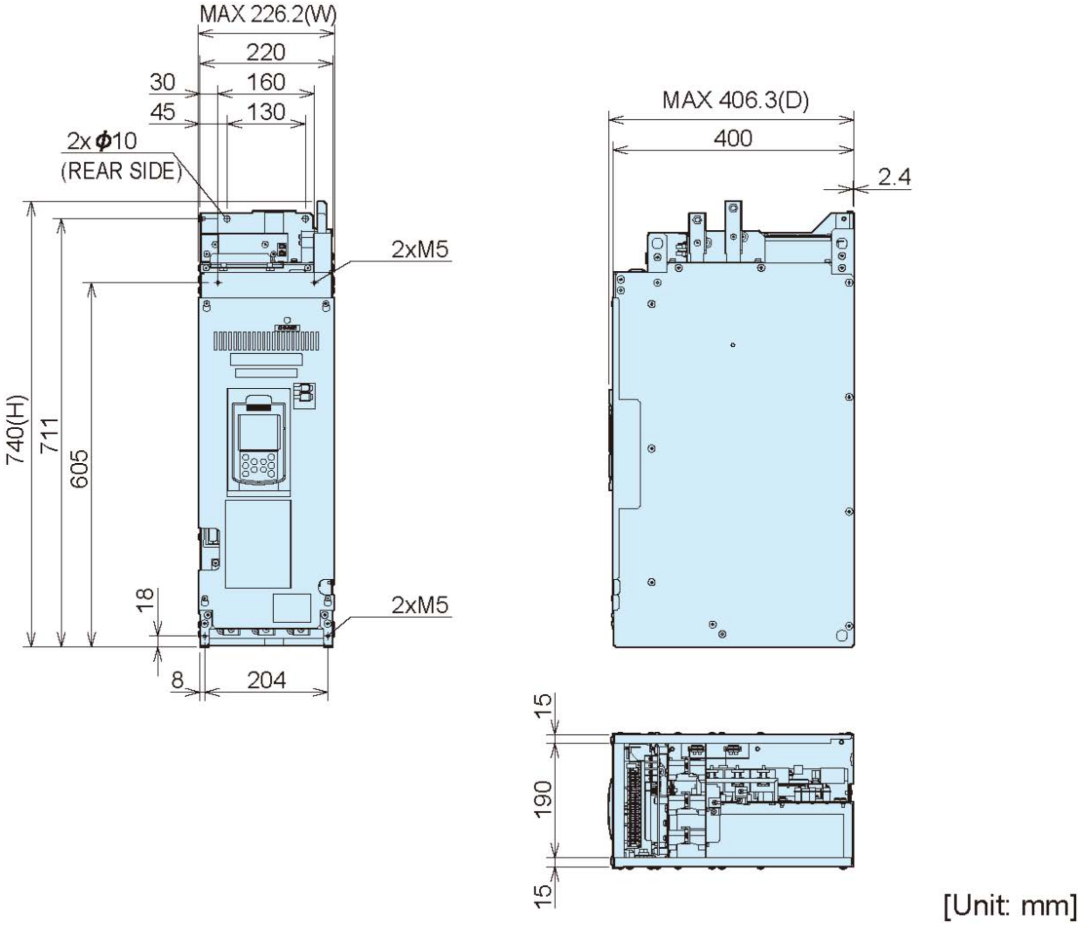
■ **3-phase 400V series**

Standard stack capacity [kW]	Dimensions [mm] W	H	D	Approx. mass [kg]	Figure	Remarks
FRN**30**SVG1S-4☐	226.2	740	406.3	30	A	
FRN**37**SVG1S-4☐						
FRN**45**SVG1S-4☐						
FRN**55**SVG1S-4☐		880		37	B	
FRN**75**SVG1S-4☐						
FRN**90**SVG1S-4☐				45		
FRN**110**SVG1S-4☐						
FRN**132**SVG1S-4☐		1100	567.3	95	C	
FRN**160**SVG1S-4☐						
FRN**200**SVG1S-4☐						
FRN**220**SVG1S-4☐		1400		125	D	
FRN**250**SVG1S-4☐				135		
FRN**280**SVG1S-4☐						
FRN**315**SVG1S-4☐						
FRN**630**BVG1S-4☐				135×3	E	A set of three stacks constitutes a single inverter unit.
FRN**710**BVG1S-4☐						
FRN**800**BVG1S-4☐						

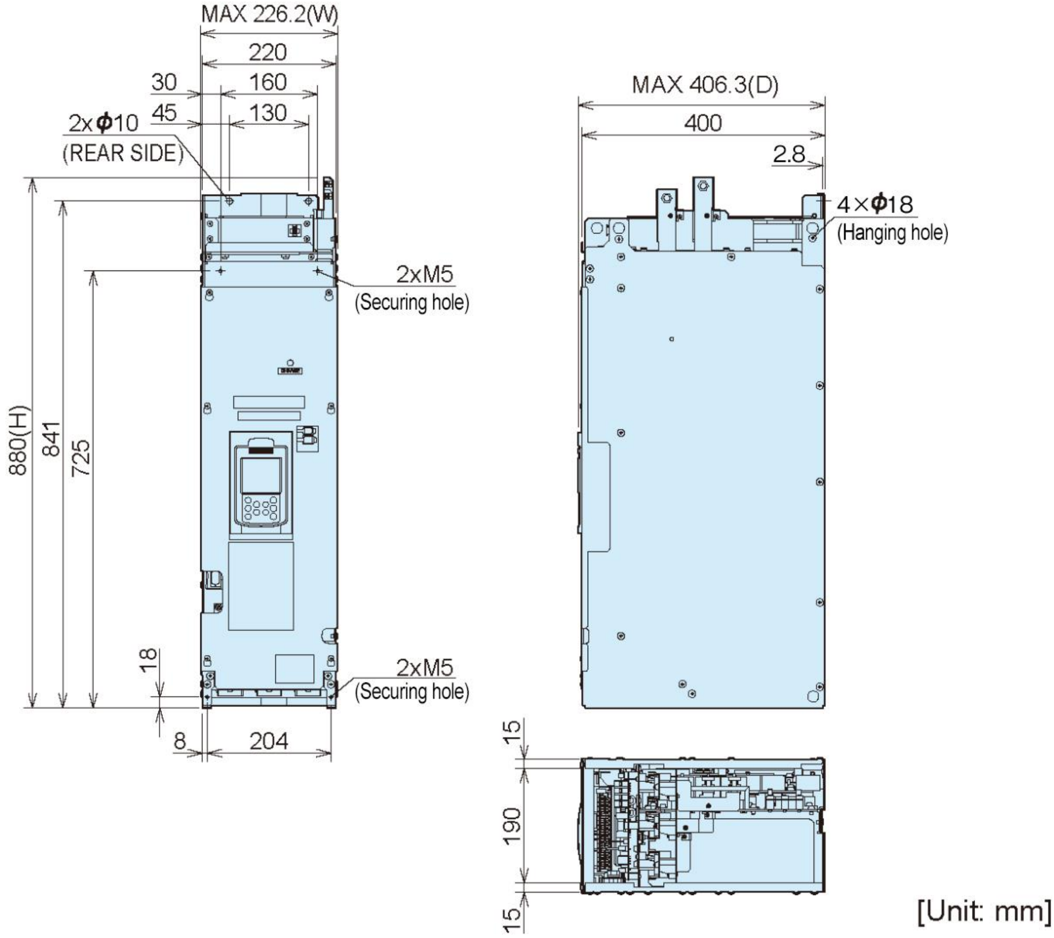
■ **3-phase 690V series**

Standard stack capacity [kW]	Dimensions [mm] W	H	D	Approx. mass [kg]	Figure	Remarks
FRN**90**SVG1S-69☐	226.2	880	406.3	45	F	
FRN**110**SVG1S-69☐						
FRN**132**SVG1S-69☐		1100	567.3	95	C	
FRN**160**SVG1S-69☐						
FRN**200**SVG1S-69☐						
FRN**250**SVG1S-69☐		1400		135	D	
FRN**280**SVG1S-69☐						
FRN**315**SVG1S-69☐						
FRN**355**SVG1S-69☐						
FRN**400**SVG1S-69☐						
FRN**450**SVG1S-69☐						

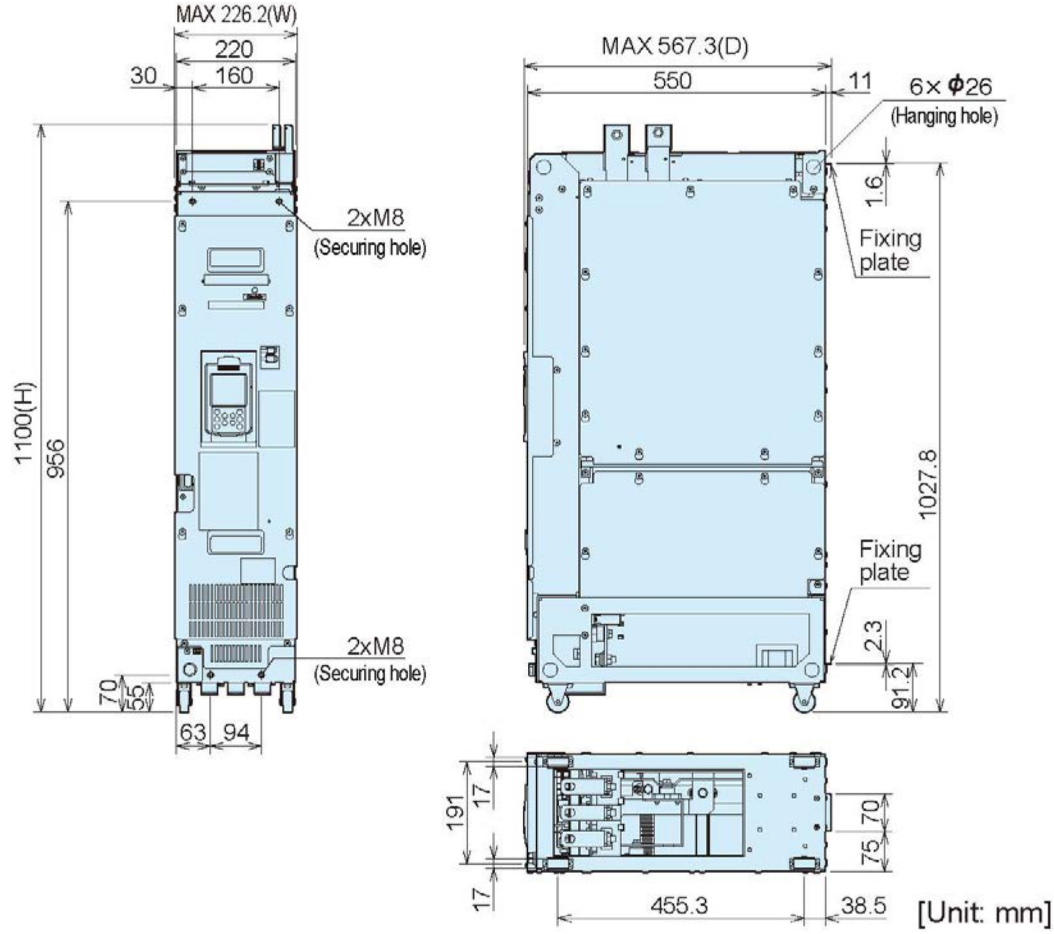
2.5.1.1 Figure A (1-frame size: FRN30SVG1S-4☐ to 45SVG1S-4☐)



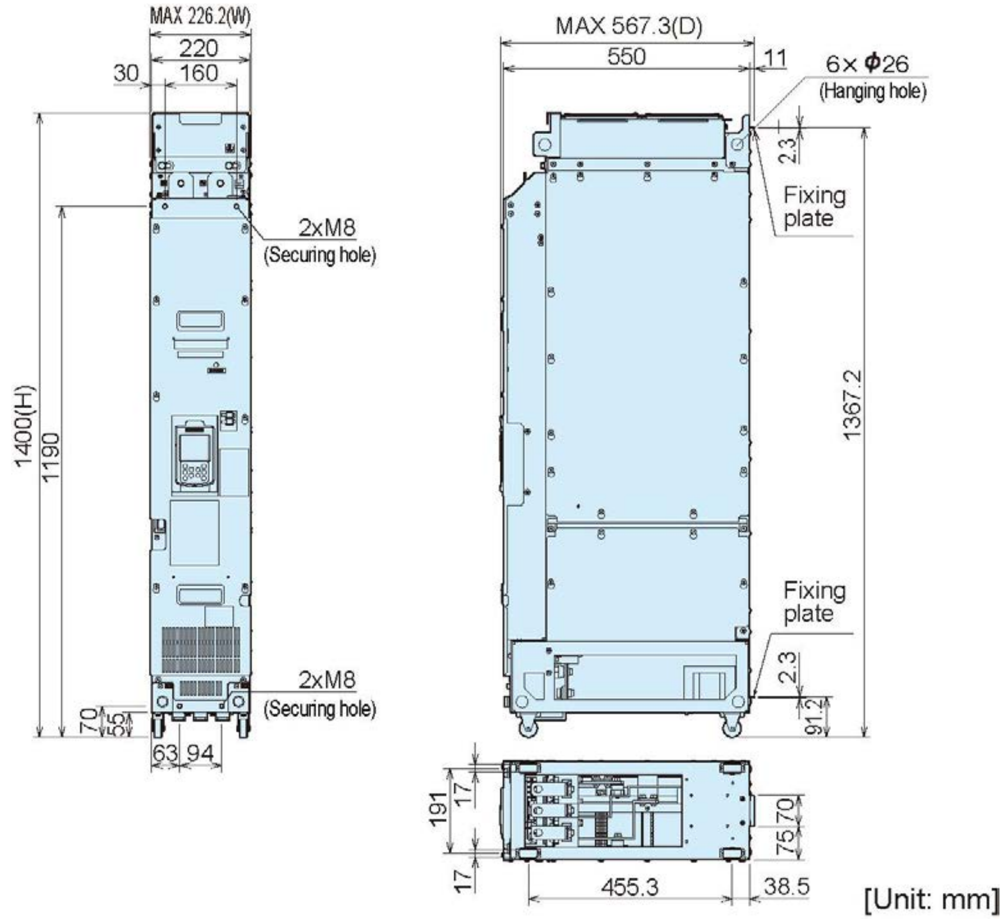
2.5.1.2 Figure B (2-frame size: FRN55SVG1S-4☐ to 110SVG1S-4☐)



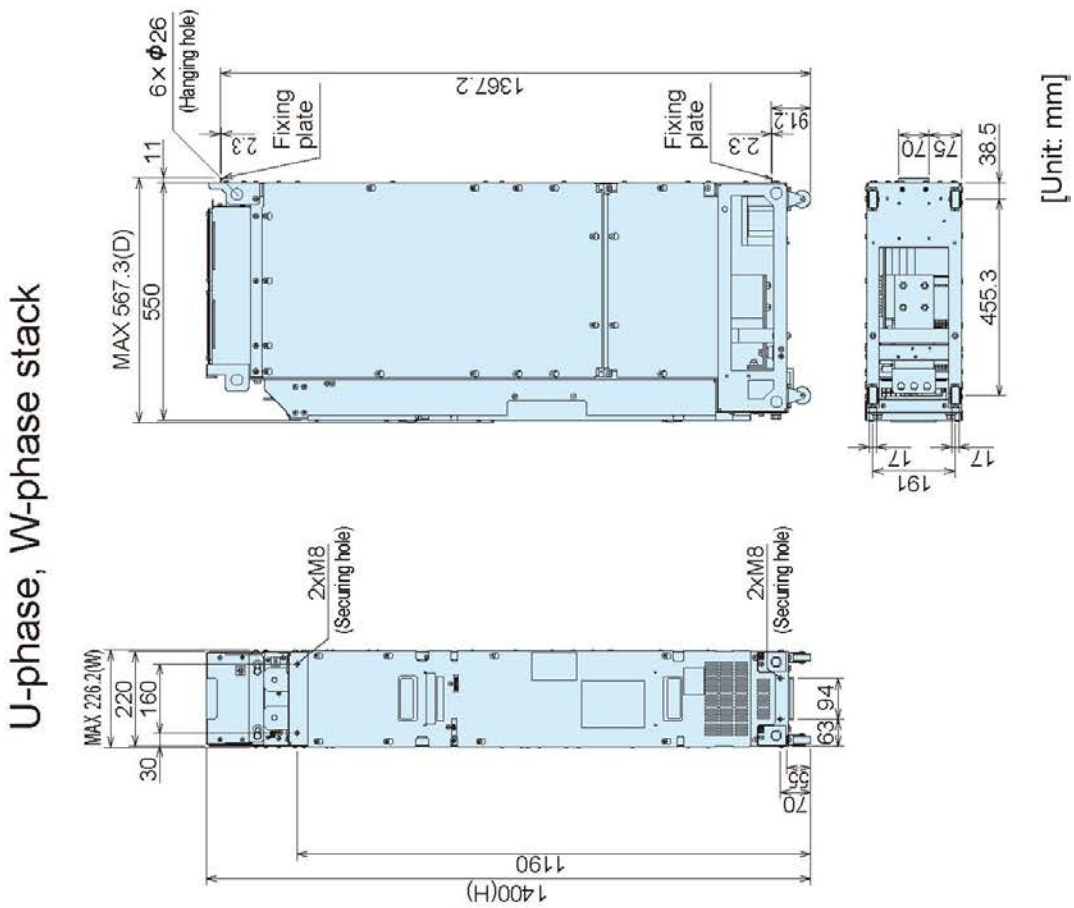
2.5.1.3 Figure C (3-frame size: FRN132SVG1S-4☐ to 200SVG1S-4☐, FRN132SVG1S-69☐ to FRN200SVG1S-69☐)

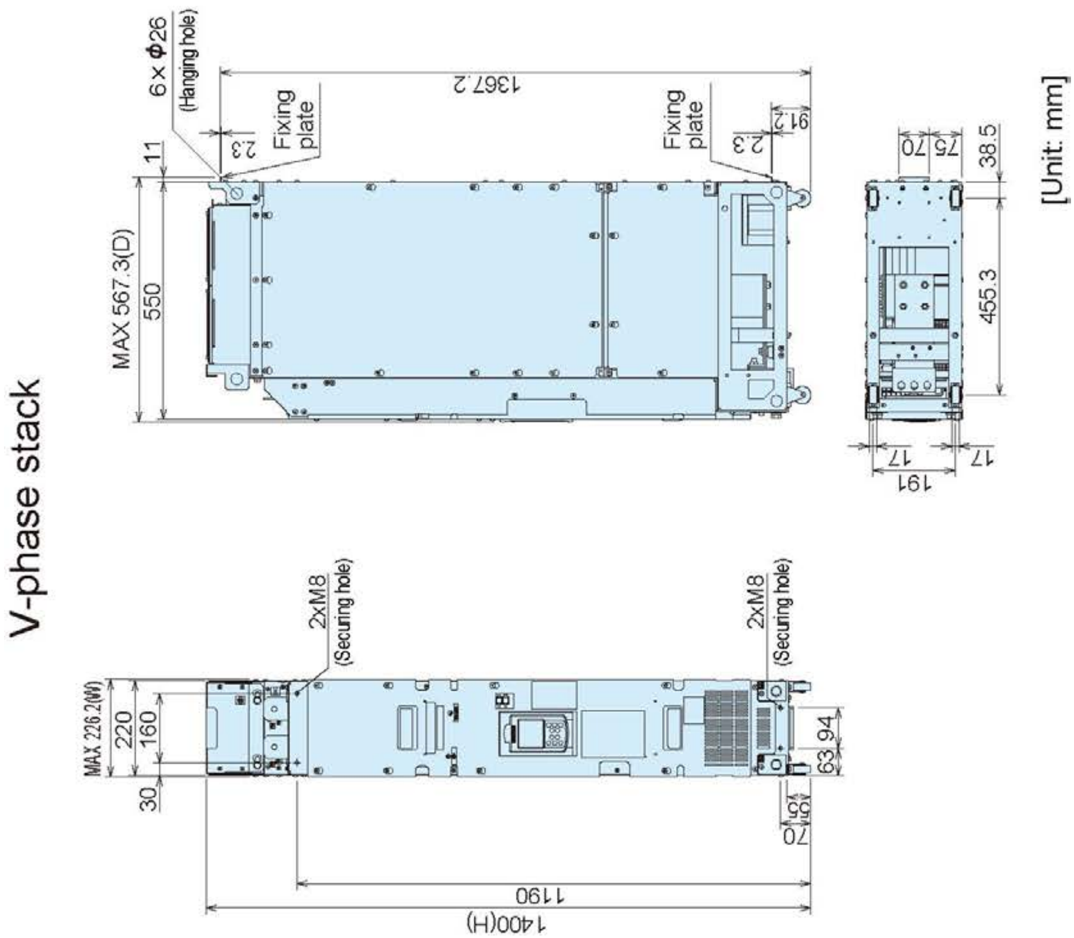


2.5.1.4 Figure D (4-frame size: FRN220SVG1S-4☐ to 315SVG1S-4☐, FRN250SVG1S-69☐ to FRN450SVG1S-69☐)

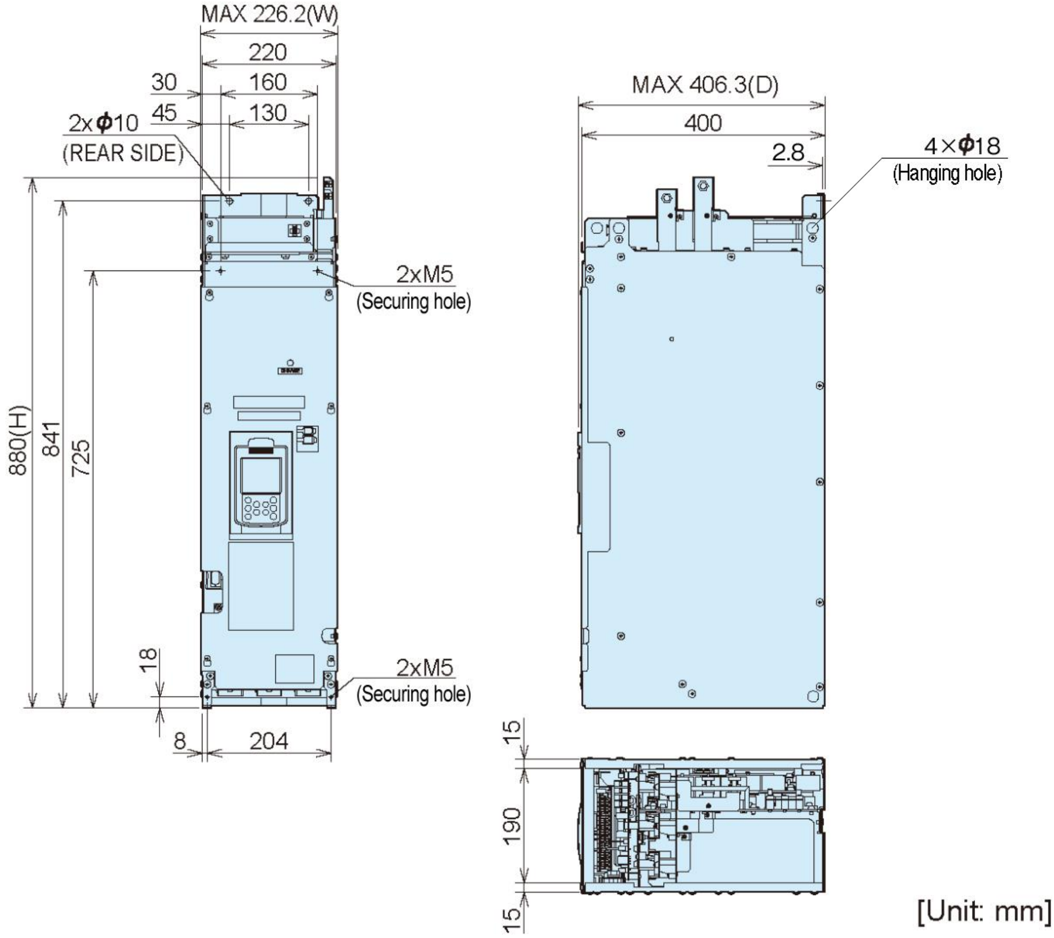


2.5.1.5 Figure E (4-frame size: FRN630BVG1S-4□ to 800BVG1S-4□)





2.5.1.6 Figure F (2-frame size: FRN90SVG1S-69□ to 110SVG1S-69□)



2.6 Generated loss

The following table shows inverter generated losses.

F26: Motor operating sound (carrier frequency) is 2 [kHz]. (The carrier frequency is fixed at 2 kHz.)

Power-based series	Type	Generated loss [W]	
		MD spec	LD spec
3-phase 400V	FRN30SVG1S-4☐	550	700
	FRN 37SVG1S-4☐	700	850
	FRN 45SVG1S-4☐	800	1000
	FRN55SVG1S-4☐	1100	1450
	FRN75SVG1S-4☐	1400	1600
	FRN90SVG1S-4☐	1700	2000
	FRN110SVG1S-4☐	2050	2400
	FRN132SVG1S-4☐	2200	2650
	FRN160SVG1S-4☐	2550	3100
	FRN200SVG1S-4☐	3050	3350
	FRN220SVG1S-4☐	3550	3950
	FRN250SVG1S-4☐	3950	4350
	FRN280SVG1S-4☐	4300	4750
	FRN315SVG1S-4☐	4850	5350
	FRN 630BVG1S-4☐	9300	10600
	FRN710BVG1S-4☐	10350	11350
	FRN800BVG1S-4☐	11400	14150
3-phase 690V	FRN90SVG1S-69☐	1600	1950
	FRN110SVG1S-69☐	2100	2400
	FRN132SVG1S-69☐	2150	2500
	FRN160SVG1S-69☐	2400	3050
	FRN200SVG1S-69☐	3200	3500
	FRN250SVG1S-69☐	4100	4500
	FRN280SVG1S-69☐	4450	4950
	FRN315SVG1S-69☐	4900	5400
	FRN355SVG1S-69☐	3550	3950
	FRN400SVG1S-69☐	4050	4500
	FRN450SVG1S-69☐	4550	—

Chapter 3 Transportation and Storage

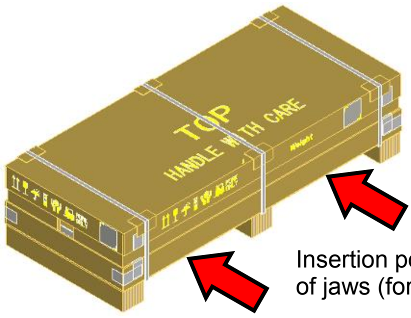
3.1 Transportation

This section explains the transportation and storage of the FRENIC-VG and converters.

3.1.1 Transportation in packed state

The packing form varies according to the type or order of the FRENIC-VG or converter.

<Transportation in pile>



Transportation in pile: **Up to 3 packages** can be loaded

<Vertical packing: Wood frame package>

Transportation in pile: Not available

Figure 3.1-1: External appearance of package

Note 1) When you transport the package, place it on a pallet and hoist the pallet, or lift it using a fork lifter or a hand lifter, etc.

Note 2) Be sure not to transport the product by hooking wires to a crane as the product is stored in a cardboard or a wood frame. It will lead to the drop of the product.

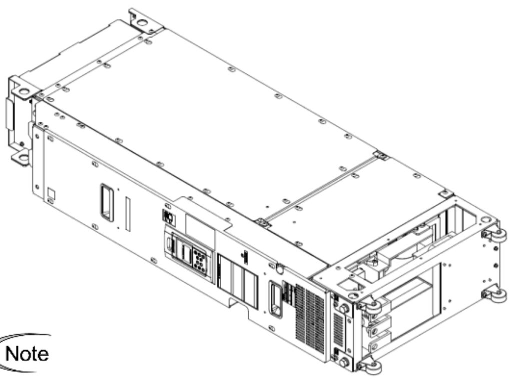
3.1.2 Transportation in unpacked state

3.1.2.1 Transportation

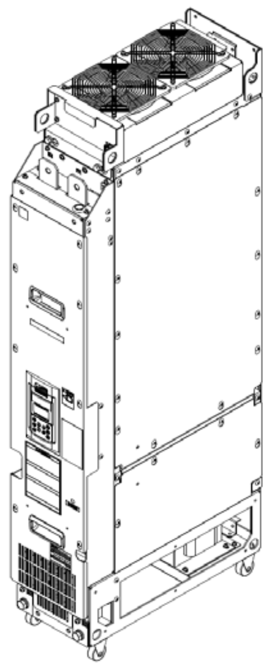
This section explains the transportation of the unpacked product.

Be sure to transport the product in the state shown in Figure 3.1-2.

(a) FRENIC-VG laid sideways



(b) FRENIC-VG in its upright position



Note

(1) You can transport the product after laying it down sideways, i.e., with the left side face down (when viewed from the front) as shown in (a).

(2) Alternatively, you can transport the product while keeping it upright as shown in (b). In this case, however, you should take care not to topple it.
As far as possible, lay the product sideways as shown in (a) or put it in a cabinet before transporting it.

Figure 3.1-2: Transportation state for unpacked product

3.1.2.2 General caution

Before you start operating a crane, be sure to check the following:

(1) Use a crane with the sufficient capacity for the weight of the cabinet.

(2) Visually check that the hanging rings (eye bolts) are not loosened and/or cracked and that the screw sections are not bent and/or broken.

(3) Be sure to check the wires and ropes before using them. Do not use the wires and ropes listed below:

a) Those through which large current such as short-circuit current flowed

b) Those with external flaws such as spark marks and fire ball marks

c) Those of which wires are disconnected

d) Those which are significantly rusted

e) Those which are clearly abraded

f) Those of which the core steel is exposed or of which the twist is deformed

g) Those which are kinked (These wires and ropes are not acceptable even if they are repaired)

(4) If a wire comes into contact with any corner, cover the corner with a buffer material so that it will not be damaged or scratched.

(5) Upon loading and unloading, be sure not to suddenly move up and down the product. In addition, pay attention to the front and back, and left and right directions so that the product will not come into contact with any objects.

(6) During transportation, be careful not to drop and/or fall the product by vibration and at a curve.

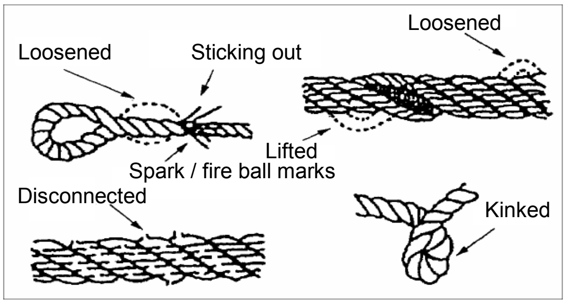


Figure 3.1-3: Unacceptable wires/ropes

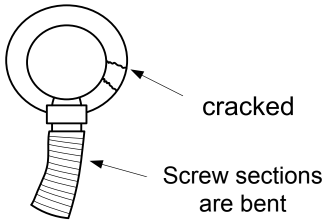


Figure 3.1-4: Unacceptable hanging ring (eye bolt)

3.1.2.3 Work procedure for lifting by crane

The work procedure to follow when you use a crane is explained below.

Raising from the laying state

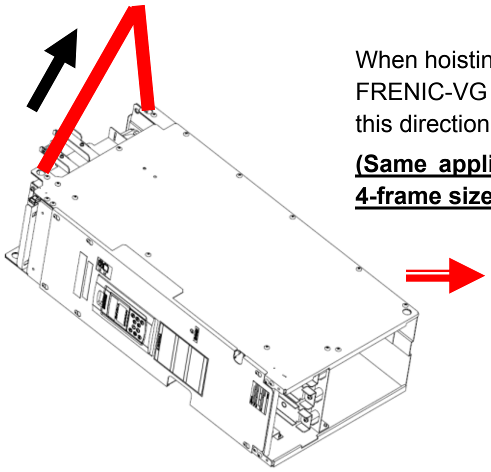
1-frame, 2-frame sizes

When raising the unit from the horizontal position, attach wire ropes to two points on the FRENIC-VG's upper section and slowly pull up using the crane.

Note: When pulling up, exercise caution as the **bottom side may slide**.

When raising the unit, face the front of the product and attach wire ropes to two points on the right side, as in the figure on the right.

(In the package, the right side of the product's front faces the top.)



When hoisting the unit, FRENIC-VG may slide in this direction.

(Same applies to 3-frame, 4-frame sizes)

3-frame, 4-frame sizes

When raising the unit from the horizontal position, place braces between the bar terminals and casters, and ensure that the unit is horizontal when mounted on the braces.

To ensure that the casters do not contact the ground, use braces with a height of 60 mm or higher. Next, attach wire ropes to two points on the FRENIC-VG's upper section and slowly pull up using the crane.

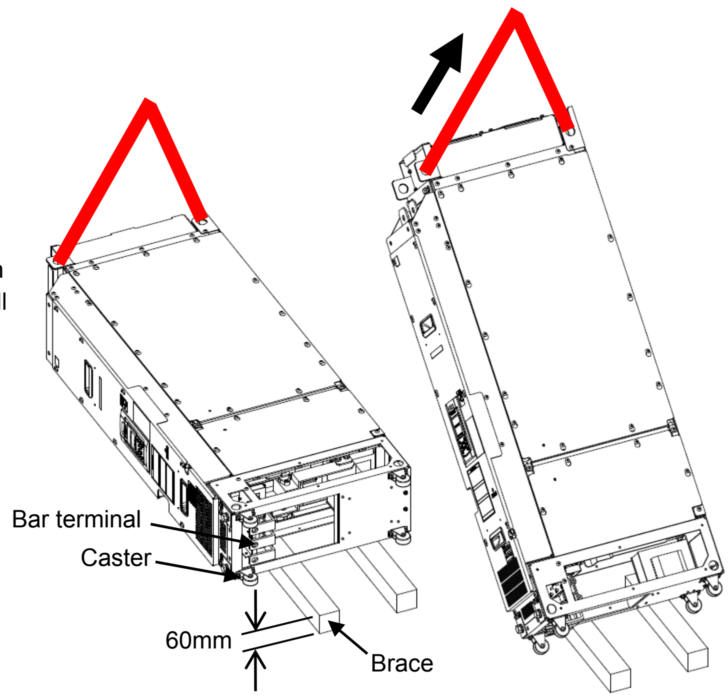
Note: If the unit is stood up without using braces, a load will be applied to the casters, causing damage.

Furthermore, when standing the unit up, ensure that the bar terminals and casters do not contact the braces.

When pulling up, exercise caution as the bottom side may slide.

When raising the unit, face the front of the product and attach wire ropes to two points on the right side, as shown in the figure on the right.

(In the package, the right side of the product's front faces the top.)



Lifting in the installed condition

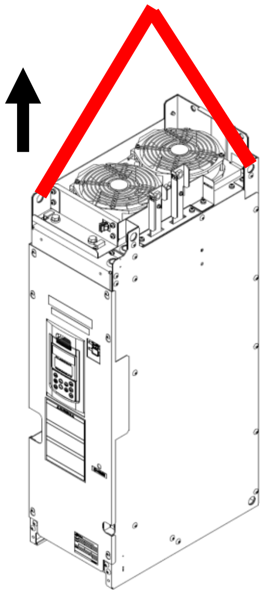
Lift the FRENIC-VG as follows when it is installed on a cabinet.

1-frame, 2-frame sizes

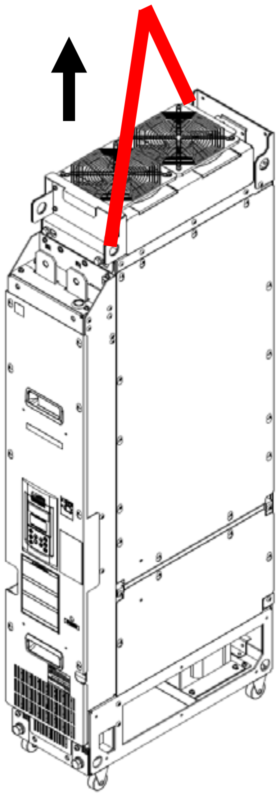
Hook wires onto the front left and two rear right locations (viewed from the front) as shown on the right.

3-frame, 4-frame sizes

Hook wires onto the front right and two rear right locations (viewed from the front) as shown on the right.



1-frame, 2-frame sizes



3-frame, 4-frame sizes

Lifting in the horizontal condition

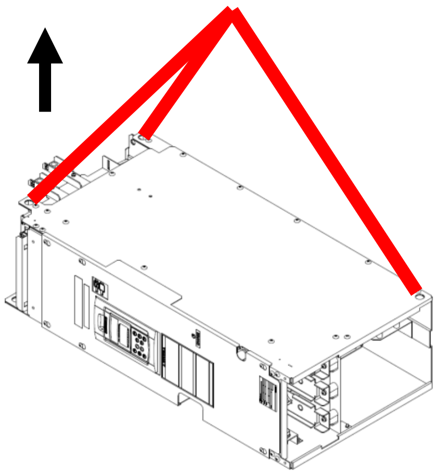
Transport the FRENIC-VG in its horizontal condition as follows.

1-frame, 2-frame sizes

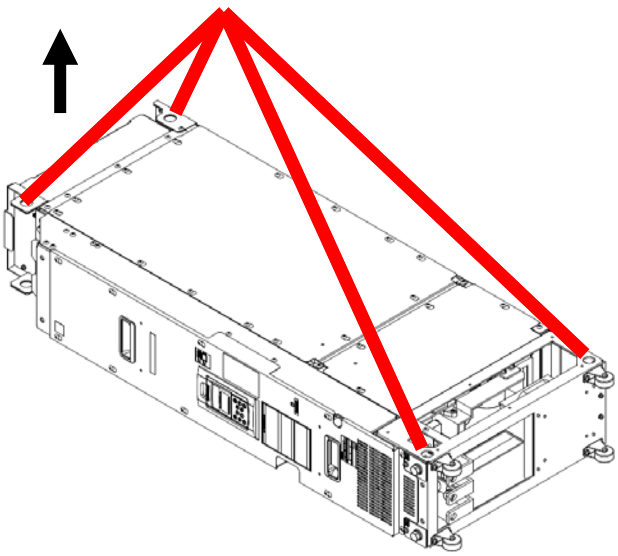
Hook wires onto the three locations shown below.

3-frame, 4-frame sizes

Hook wires onto the four locations shown below.



1-frame, 2-frame sizes



3-frame, 4-frame sizes

3.1.3 Transportation after assembling the product into a cabinet

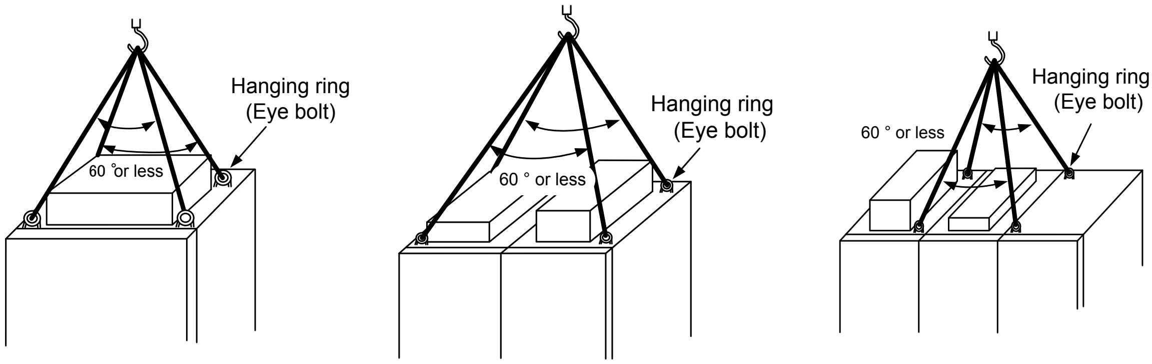
When you transport the FRENIC-VG, be extremely careful not to apply vibration and shock to it.

In the case of long distance transportation, do not transport the product using rollers, and be sure to transport it by lifting with a crane and the like.

3.1.3.1 Crane operation

When you transport the product using a crane or other heavy equipment, clear obstacles on the transportation route and follow the instructions given in "3.1.2.2 General caution".

(1) Figure 3.1-5 illustrates the methods of hooking wires. If there is only a single panel, use the method (a). Use the method (b) for 2 panels, and the method (c) for 3 panels.



(a) For single panel (b) For 2 panels (c) For 3 panels

Figure 3.1-5: How to hook wires

(2) As shown in Figure 3.1-5, hook a wire to each hanging ring. Be sure not to hook a single wire as shown in Figure 3.1-6. The hanging angle must be 60° or less.

(3) Firstly, lift the product by approx. 30 mm to confirm the safety (the tension of wires and hanging angle, etc.) and verify that the cabinet is not tilted. Then, lift the product for transportation.

(4) When you lift down the cabinet, be sure to slowly lift it down in parallel with the floor.

(5) When anchors are attached, remove them before installation in principle.
Such anchors as shown in Figure 3.1-8 can be removed after installation.

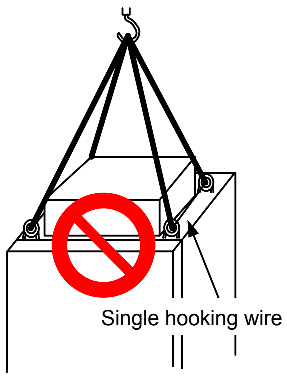


Figure 3.1-6: Incorrect hooking of wires

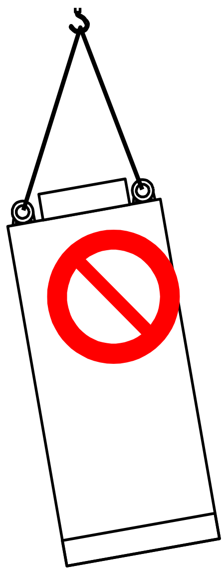


Figure 3.1-7: Tilt of cabinet (bad example)

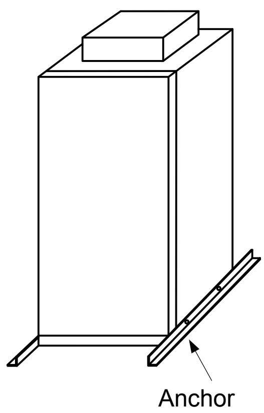


Figure 3.1-8: Anchor

3.1.3.2 Transportation on rollers

When you transport the product on rollers, follow the procedure given below:

(1) Check the transportation route and clear obstacles.

(2) Give the workers clear instructions and signs for the work procedure and work method.

(3) In a place where the floor might get scratched, install protection plates in the traveling direction. As shown in Figure 3.1-9, protection plates must be placed as sprints or in the shape of "ハ".

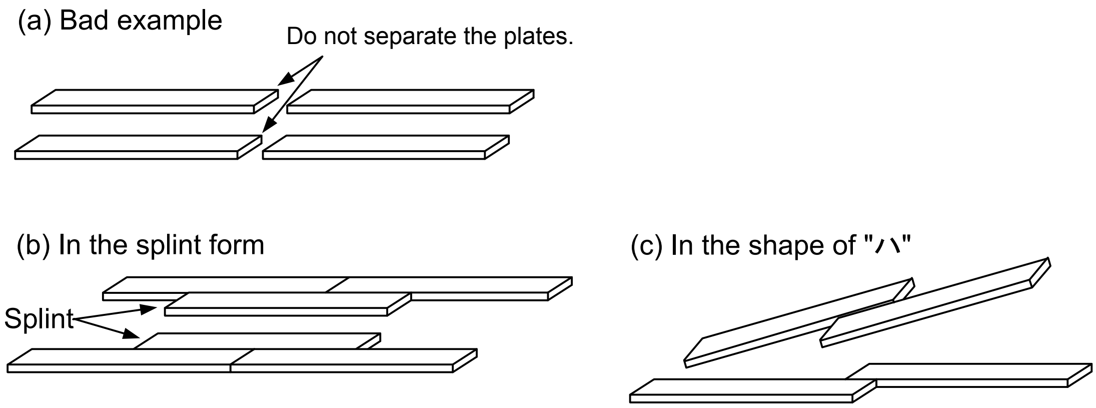


Figure 3.1-9: Layout of protection plates (protection of floor)

(4) Install rollers of which the diameter is approx. 50 mm and of which the length is 300 mm longer than the cabinet to the bottom of the cabinet, and slowly move the product following the instructions given below as checking the safety.

a) There must be always 3 or more rollers so that the cabinet will not tilt.

b) The rollers must protrude by 150 mm or more from the both ends of the cabinet during transportation.

c) Use a hammer to correct and cut rollers.

(5) When the traveling direction is changed, shift the protection plates little by little to the new direction as shown in Figure 3.1-11.

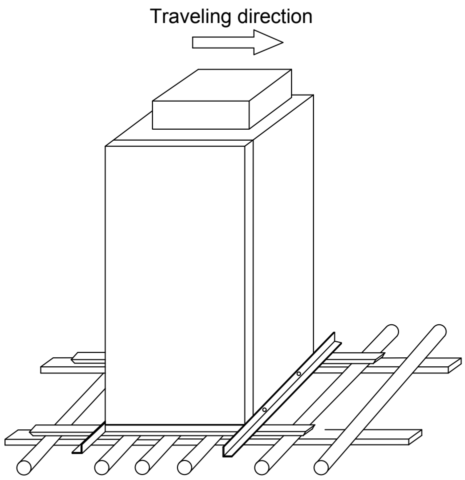


Figure 3.1-10: Transportation on rollers

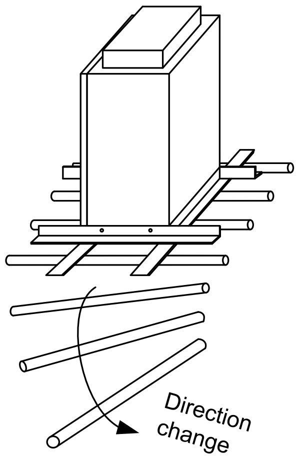


Figure 3.1-11: Change of transportation direction

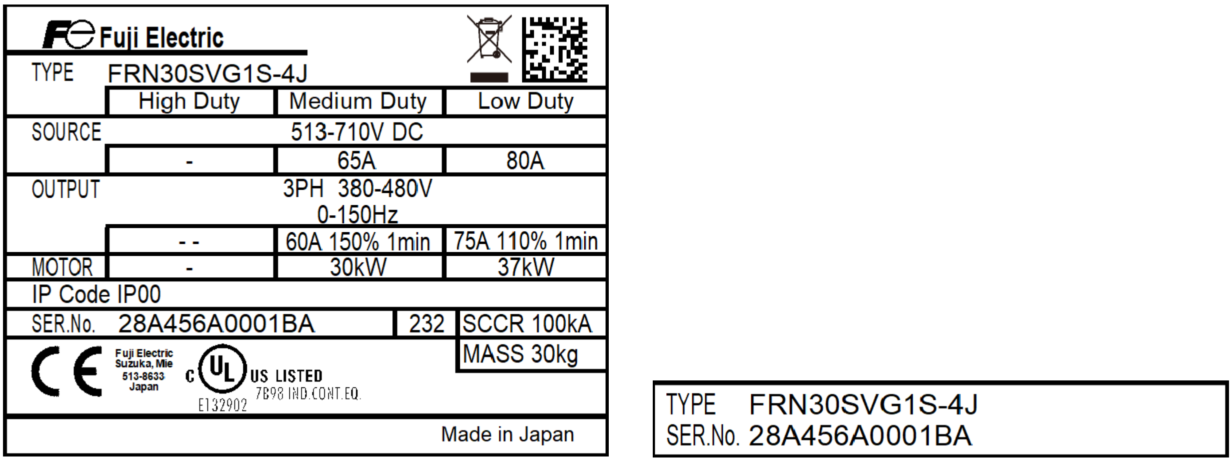
3.2 Check before use

Unpack the package and check the following:

An inverter and the following accessories are contained.

Accessories
- Instruction manual
- CD-ROM (containing the FRENIC-VG User's Manual, FRENIC-VG Loader software (free version), and FRENIC-VG Loader Instruction Manual)

The inverter has not been damaged during transportation—there should be no dents or parts missing. The main and sub nameplates are attached to the inverter as shown in Figure 3.3-1 to -4. Check these nameplates to see that the inverter is exactly the type you ordered.



(a) Main Nameplate (b) Sub Nameplate

Figure 3.2-1: Nameplate

TYPE: Inverter stack

FRN 160 S VG 1 S – 4□

Indication	Series name
FRN	FRENIC series

Indication	Nominal applied motor
30	30kW
37	37kW
45	45kW
≀	≀
450	450kW
630	630kW
≀	≀
800	800kW

Indication	Inverter structure
S	Standard stack type
B	Phase-specific stack type

Indication	Shipping destination/Instruction Manual
J	Japanese
E	English
C	Chinese

Indication	Voltage class
4	400 V class series
69	690 V class series

Indication	Structure
S	Standard type

Indication	Development series
1	1 series

Indication	Applicable area
VG	High performance vector control

The FRENIC-VG is available in two drive modes depending upon the inverter capacity: Medium Duty (MD) and Low Duty (LD) modes. Specifications in each mode are printed on the main nameplate.

Medium Duty: MD mode designed for medium duty load applications.
Overload capability: 150% for 1 min. Continuous ratings = Capacity of inverters

Low Duty : LD mode designed for light duty load applications.
Overload capability: 110% for 1 min. Continuous ratings = One rank or two ranks higher capacity of inverters

SOURCE : Input voltage, input current

OUTPUT : Number of output phases, rated output voltage, output frequency range
: Rated output capacity, rated output current, rated overload current

IP Code : IP protection level

SCCR : Short-circuit capacity

MASS Mass of the product in kilogram

SER.No. : Production number 2 8 A 4 5 6 A 0 0 0 1 BA 2 3 2

- 3 2 — Week of production: nth week of production when the first week of January is "01".
- 2 — Production year: Last digit of the year
- BA — Product version

: Mark of conformity with European standards

: Mark of conformity with UL Standards and CSA Standards (cUL-listed for Canada)

: Mark of conformity with WEEE Directive

If you suspect the product is not working properly or if you have any questions about your product, contact your Fuji Electric representative.

3.3 External views

3.3.1 Overall external views

■ **3-phase 400V series**

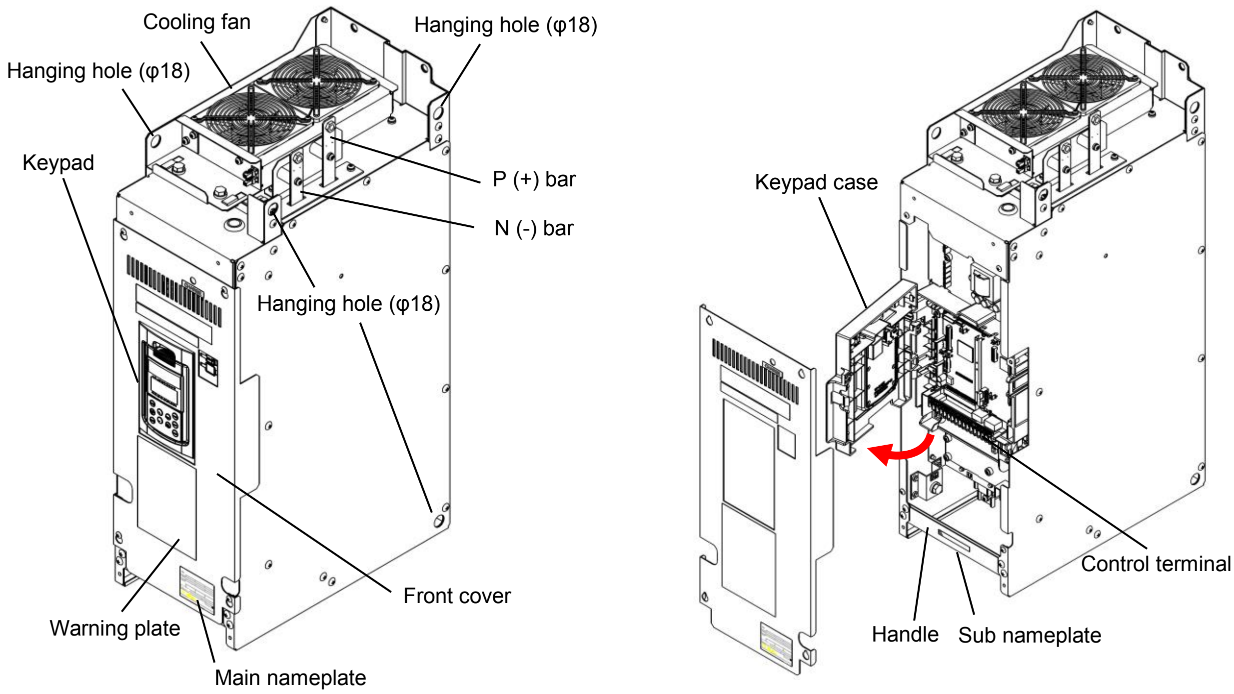


Figure 3.3-1: FRN30-45SVG1S-4☐ (Frame 1)

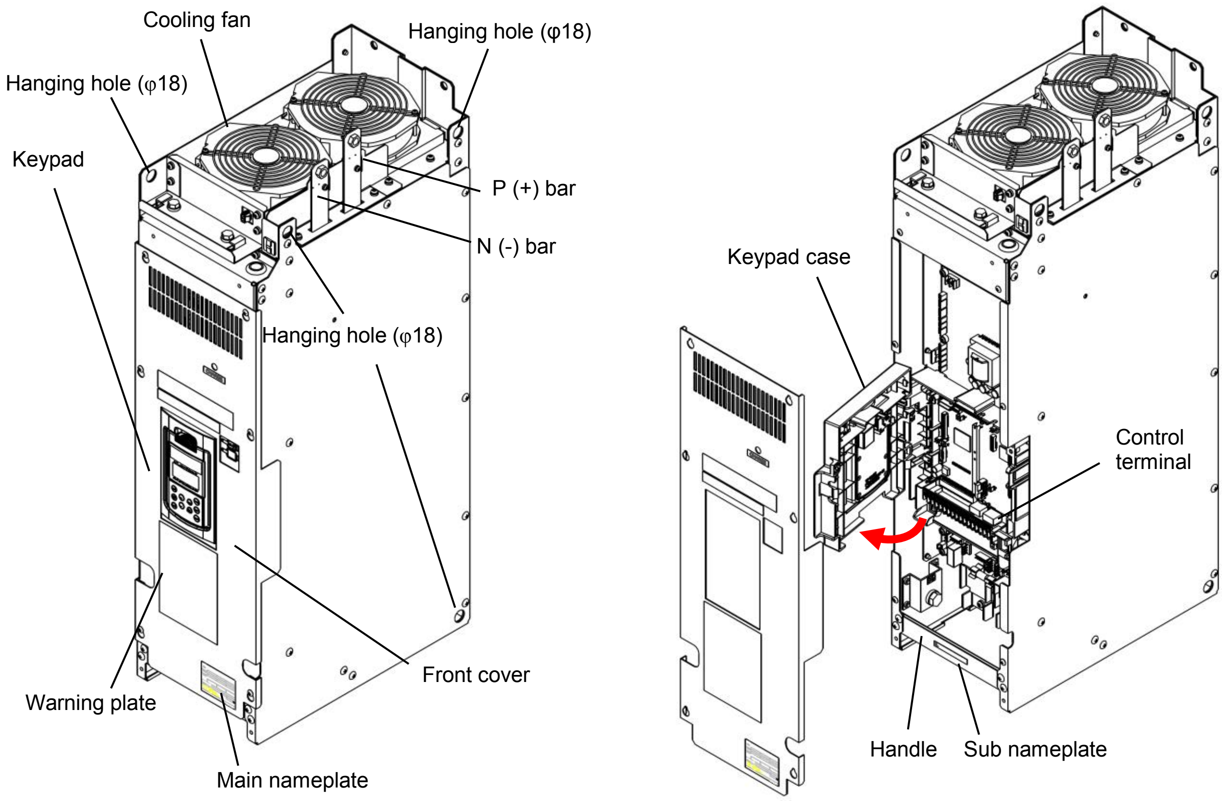


Figure 3.3-2: FRN55-110SVG1S-4☐ (Frame 2)

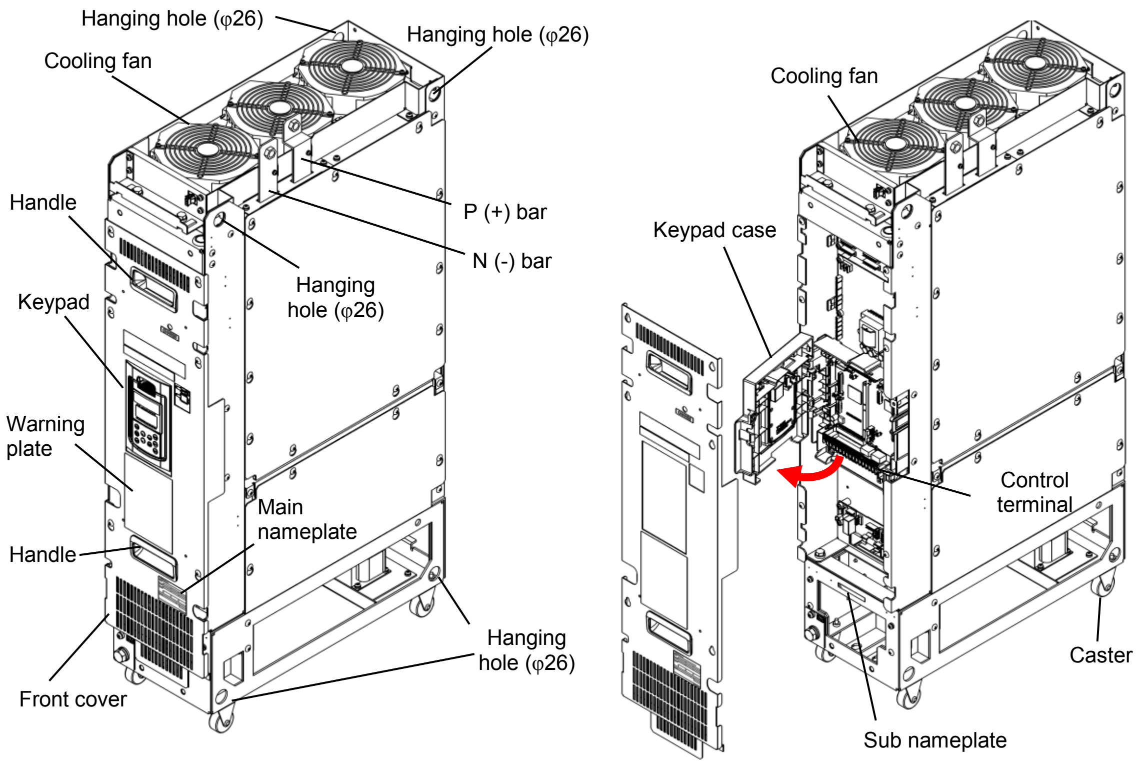


Figure3.3-3: FRN132-200SVG1S-4□ (Frame 3)

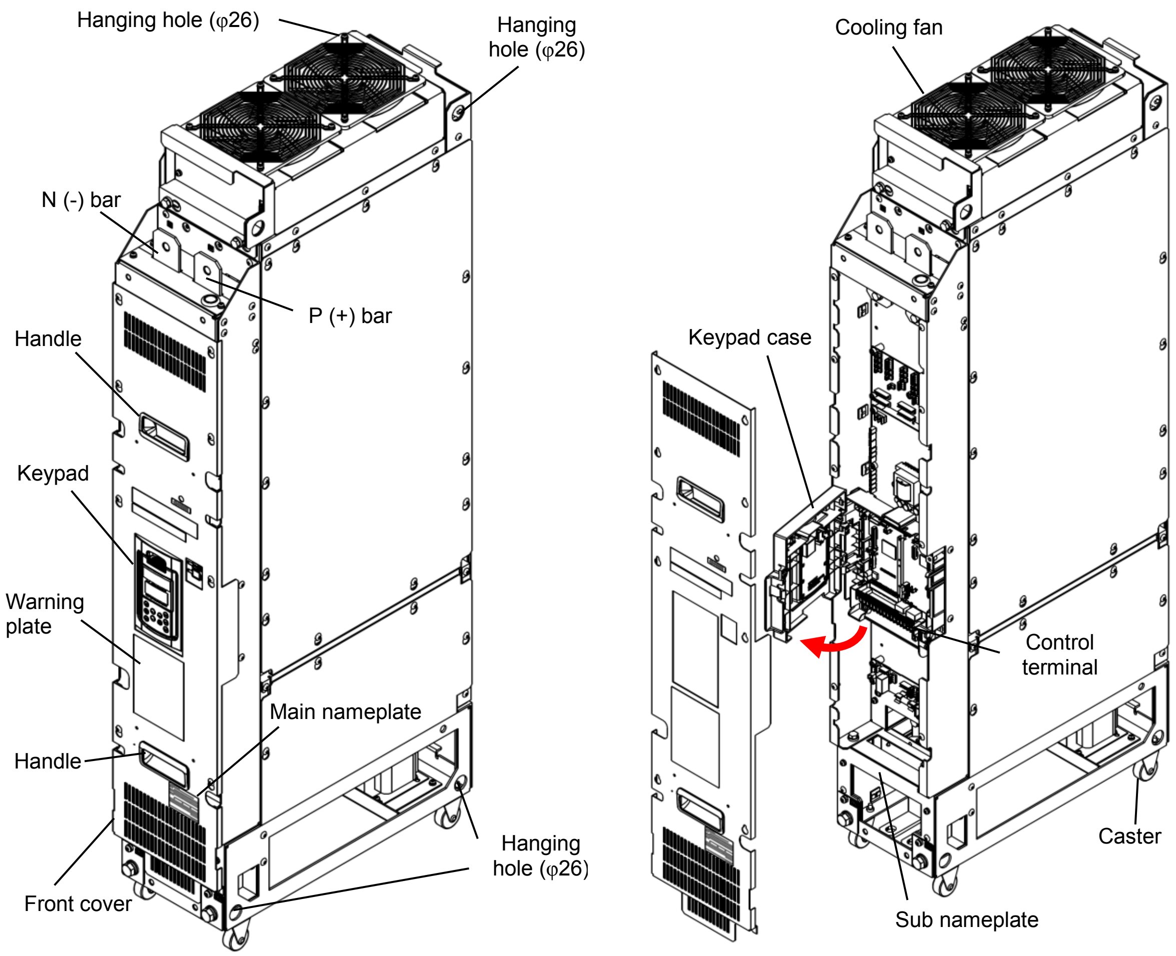
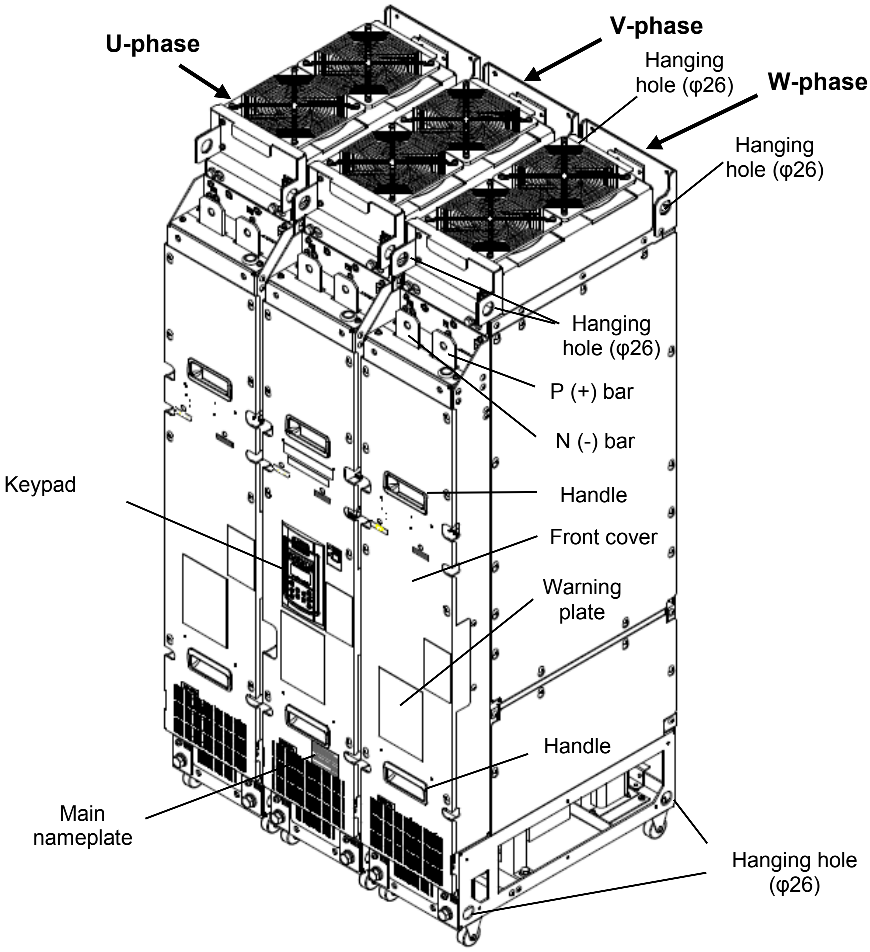


Figure3.3-4: FRN220-315SVG1S-4□ (Frame 4)



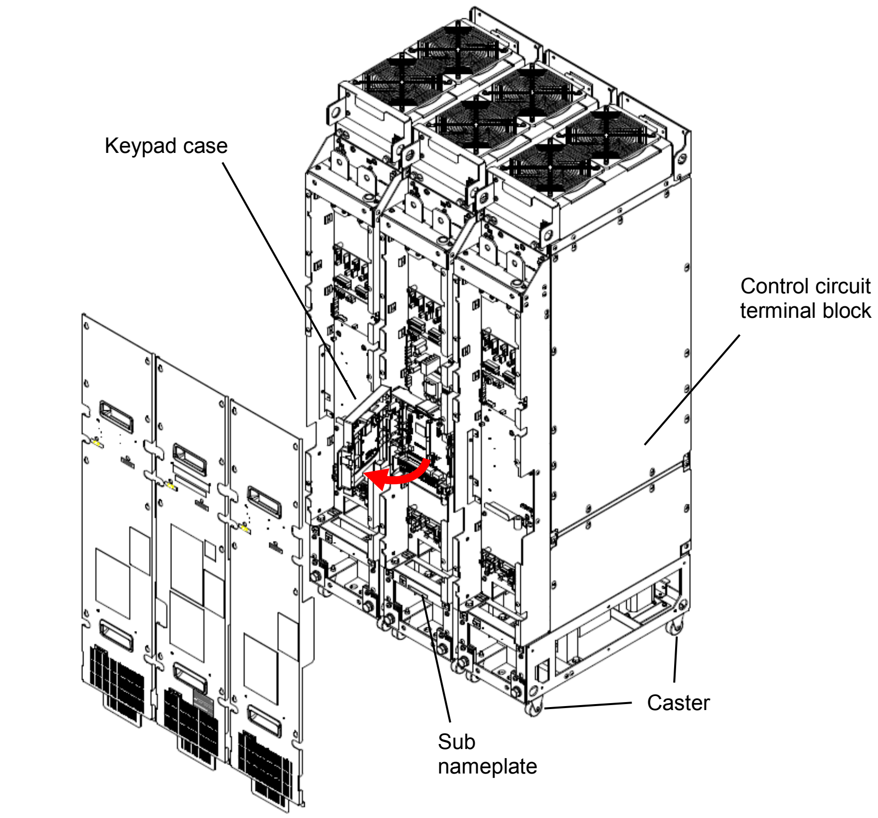


Figure 3.3-5: FRN630-800BVG1S-4□ (Frame 4)

■ **3-phase 690V series**

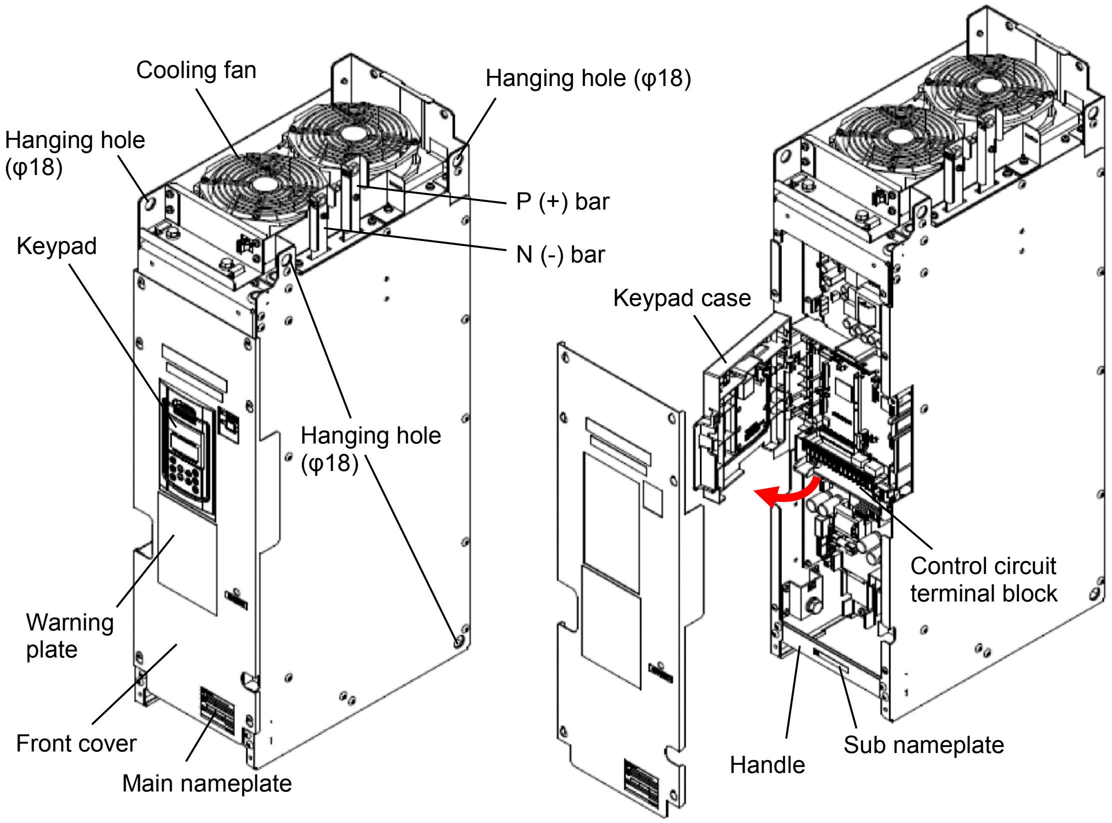


Figure 3.3-6: FRN90-110SVG1S-69□ (Frame 2)

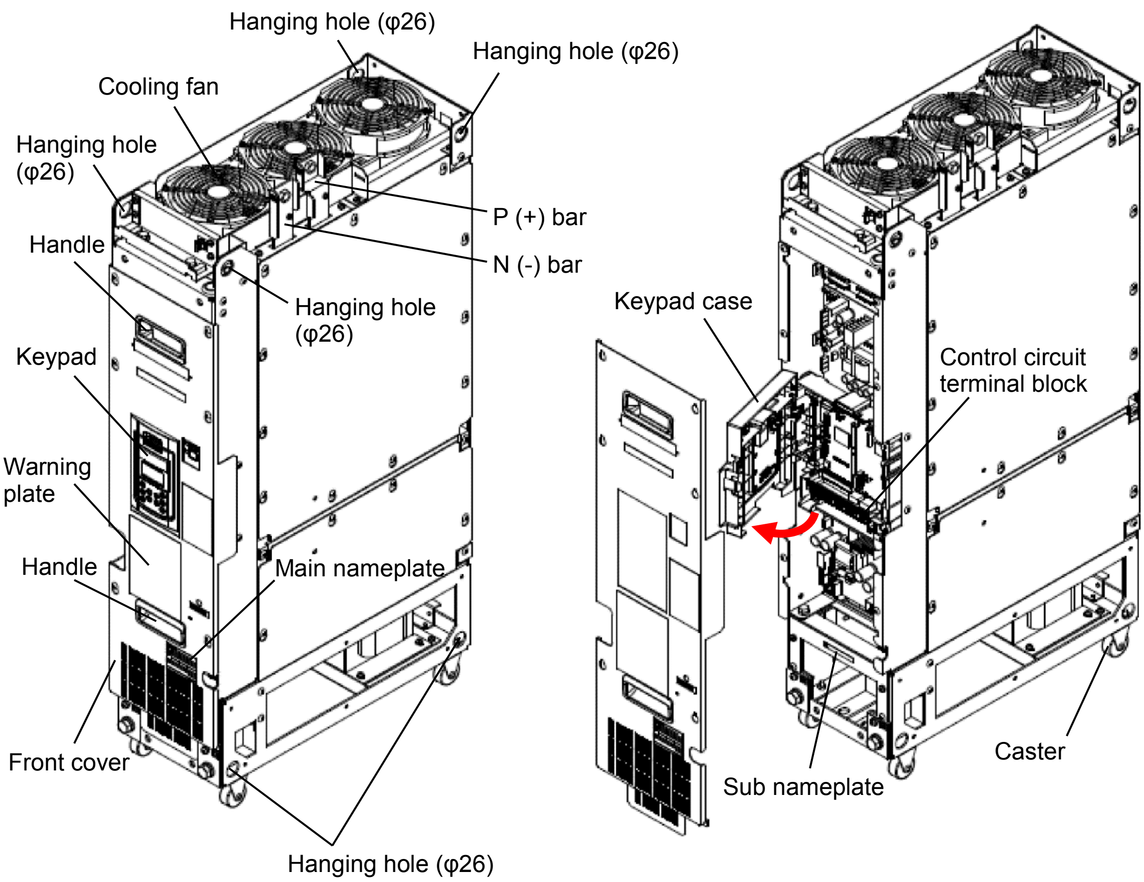


Figure 3.3-7: FRN132-200SVG1S-69□ (Frame 3)

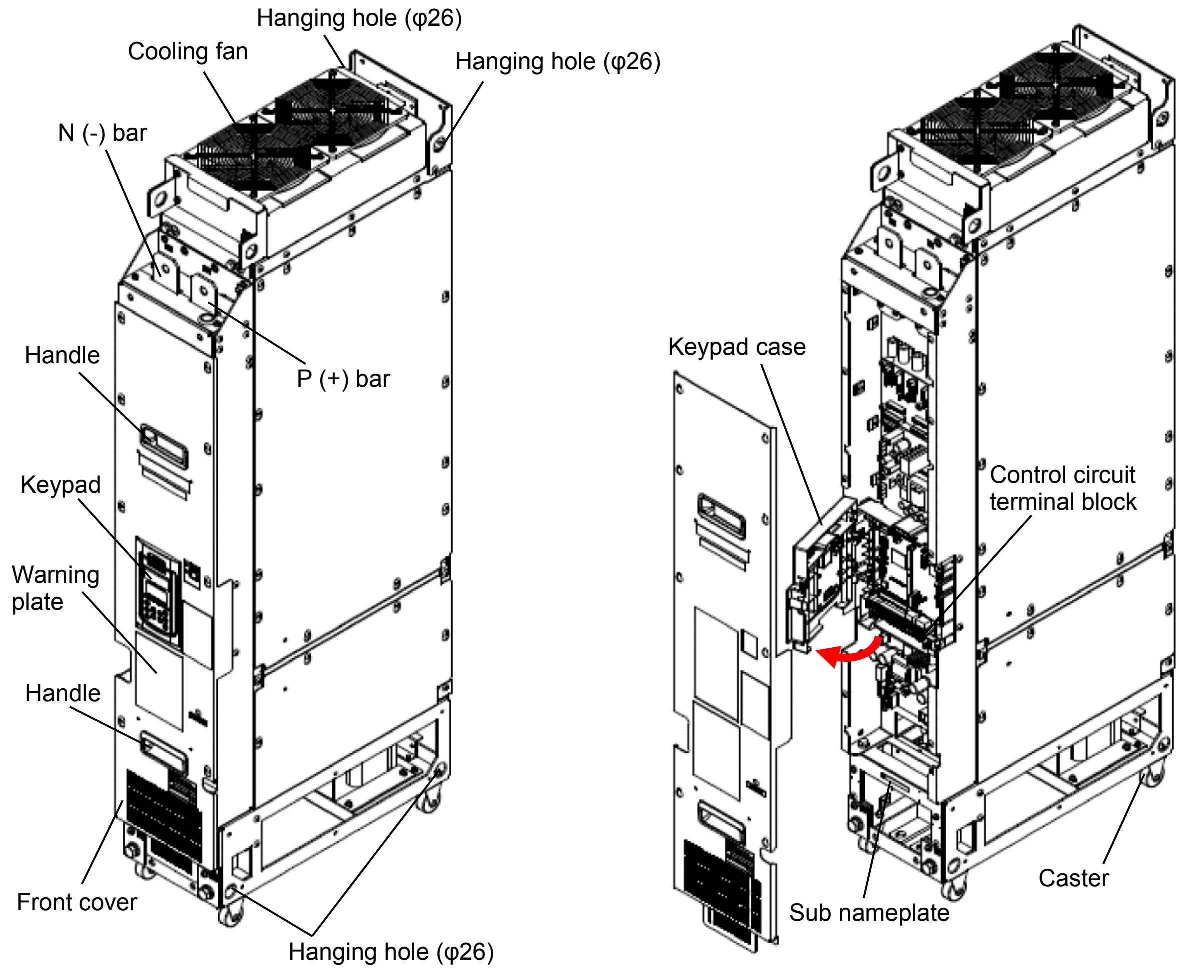


Figure 3.3-8: FRN250-450SVG1S-69□ (Frame 4)

3.3.2 Warning plate and warning label

Figure 3.3-9: Warning plate and warning label

3.4 Environment for transportation / temporary storage

This section explains the environment for transportation and temporary storage after purchase.

Carefully note that the storage environment requirements differ depending on whether the product is stored temporarily or for a long time.

3.4.1 Transportation / temporary storage

Environment requirements for transportation and temporary storage are listed below.

Table 3.4-1: Transportation / temporary storage environment

<table>
<tr><td>Item</td><td colspan="2">Explanation</td></tr>
<tr><td>Storage temperature (Note 1)</td><td>-25 to + 70°C</td><td rowspan="2">Avoid use in environments where abrupt changes in temperature may cause condensation or freezing.</td></tr>
<tr><td>Relative humidity</td><td>5 to 95% (Note 2)</td></tr>
<tr><td>Atmosphere</td><td colspan="2">Avoid exposure to dust, direct sunlight, corrosive gases, flammable gas, oil mist, steam, water droplets and vibration.
Avoid exposure to excessive salt content. (0.01 mg/cm^2 or less per year)</td></tr>
<tr><td rowspan="2">Atmospheric pressure</td><td colspan="2">86 to 106 kPa (during storage)</td></tr>
<tr><td colspan="2">70 to 106 kPa (during transportation)</td></tr>
</table>

(Note 1) Assuming comparatively short time storage, e.g., during transportation or the like.

(Note 2) Even if the humidity is within the specified requirements, avoid such places where the product will be subjected to sudden changes in temperature that will cause condensation or freeze to form.

Points to note for temporary storage

(1) Do not leave the product directly on the floor.

(2) If the environment does not satisfy the specified requirements listed in Table 3.4-1, wrap the product in an airtight vinyl sheet or the like for storage.

(3) If the product is to be stored in a high-humidity environment, put a drying agent (such as silica gel) in the airtight package described in (2) above.

3.4.2 Long-term storage

You should store the product in the conditions given below if you do not use it for an extended period.

(1) The storage site must satisfy the requirements specified for temporary storage.
However, for storage exceeding three months, the surrounding temperature range should be within the range from -10 to 30°C. This is to prevent electrolytic capacitors in the product from deterioration.

(2) The package must be airtight to protect the product from moisture. Add a drying agent (such as silica gel) inside the package to maintain the relative humidity inside the package within 70%.

(3) If the product has been installed to the equipment or cabinet at construction sites where it may be subjected to humidity, dust or dirt, then temporarily remove the product and store it in the environment specified in Table 3.4-1.

Precautions for storage over 1 year

If the product has not been powered on for a long time, the property of the electrolytic capacitors may deteriorate. Power the product on once a year and keep the product powering on for 30 to 60 minutes. Do not connect the product to the load circuit (secondary side) or run it.

For details, see the "Long-Term Storage Manual" (SI47-1741□).

Handling of drying agent

Drying agent type: Use Silica-Gel Type A Class 1.

Take out drying agent from the package and put it in a cloth bag. Clearly write “Drying Agent” on the bag and hang the bag above the control devices such as the electromagnetic switch and inverter using a cord. Hang the bag in a way that it does not contact the control devices. (If the control devices contact the bag over the long time, they will be rusted by moisture absorbed by the drying agent.)

Calculate the necessary quantity of the drying agent W [kg] using the equation given below:

$$W = N \bullet A \bullet M \quad [kg]$$

N: The reference quantities of the drying agent is shown in the table below. These values are applicable when polyethylene film is used as a moisture-proof packing material.

Relative humidity at storage site	Reference quantity of drying agent: N [kg/m^2 • month]
70% RH or less	0.05
71 to 90% RH	0.25

A: Surface area of moisture-proof packing material [m^2]; internal area of control panel and operation panel

M: Effective period (in months) of the drying agent. It is recommended to put the drying agent for 6 months.

When you open the package after storage, be sure to remove the drying agent.
(If you power on the inverter as the drying agent is left inside, it might be melted.)

Chapter 4 Installation and Wiring

4.1 Precautions for installation

This section describes precautions about the installation environment, power supply system, and wiring of stack type inverters (FRENIC-VG and converters), and connections of peripheral equipment. Strictly observe the following precautions when handling stacks.

4.1.1 Installation environment

Install your stack type inverter in a location that complies with the installation environment requirements specified in "2.2.1 Installation environment and conformity with standards" in Chapter 2.

The product is basically designed to be installed in cabinets. It is recommended that they be installed in cabinets for safety reasons. To install the product in a special environment exceeding the specified range of specifications, it is necessary to design cabinets suitable for the environment, examine where stacks should be installed, and derate output.

📖 For further information, see "Chapter 12 Cabinet Construction" of this manual.

Special environment	Possible problems	Examples of measures	Major applications
Corrosive gas, such as a sulfidizing gas	A corrosive gas, such as a sulfidizing gas, may cause the parts inside the stack type inverter to corrode, resulting in a malfunction.	Either of the following measures may be necessary: • Mount the product in a cabinet of hermetic structure (IP6X level) or using an air purge mechanism. • Place the product in a location free of the effect of such gases.	Paper manufacturing, sewage disposal, sludge treatment, tire manufacturing, gypsum manufacturing, metal processing, particular processes of textile manufacturing, etc.
Much conductive dust or foreign material (e.g. metal powder, cutting chips, carbon fiber, carbon dust)	If conductive dust or foreign material enters the product, it may cause a short circuit or another problem inside.	Either of the following measures may be necessary: • Mount the product in a cabinet of hermetic structure. • Place each product in a location free of the effect of conductive dust.	Wire drawing machines, general metal processing, extruding machines, printing machines, garbage incinerators, industrial waste treatment, etc.
Much fibrous dust or paper dust	Cooling efficiency may decrease due to the clogging of the cooling fin of the stack, or the electronic circuit may malfunction if fibrous dust or paper dust enters the product.	Any of the following measures against dust may be necessary. • Adopt a cabinet of hermetic structure capable of shutting out dust. • Adopt a cabinet design ensuring maintenance space for periodical cleaning of the cooling fin. • Perform periodical maintenance.	Textile manufacturing, paper manufacturing, etc.
High humidity or much dew condensation	In an environment where a humidifier is installed to ensure the quality of workpieces or in an air-conditioned environment without a dehumidifying function, humidity may reach a high level or dew condensation may occur, resulting in a short circuit inside the product or an electronic circuit malfunction.	• Such a measure as the installation of a space heater inside the cabinet may be necessary.	Outdoor installation, film manufacturing lines, pumps, food processing, etc.
Vibration or shock exceeding the specified level	A shock produced when a carrier runs over a rail joint, or a vibration or shock exceeding the specified level caused by blasting at a construction site may cause damage to the structure of the product.	• Cushioning material or another vibration absorbing material may be required for the product installation area to ensure safety.	Installation on a carrier or self-propelled machine, ventilation at construction sites, pressing machines, etc.
Fumigation in export packaging	Halogen compounds, including methyl bromide used for fumigation, may corrode some parts inside the stack type inverter.	• When exporting the stack type inverter in a cabinet, pack it in fumigated wooden crates. • When exporting the stack type inverter alone, use laminated veneer lumber (LVL).	Export to overseas countries

4.1.2 Required ventilation

When installing the stack type inverter in a cabinet of IP20 or equivalent protection level, it is necessary to fulfill the air volume required by the stack type inverter in addition to the observance of the working temperature range. If the required air volume cannot be fulfilled, the FRENIC-VG or converter will generate unusual heat and cause an overheat protection alarm trip.

The tables below show the required air volume per stack for each of the FRENIC-VG inverter and converter models (or, for 630 kW and over, the required air volume per three stacks). Calculate the required air volume based on the number of stacks to be installed in a cabinet, and set ventilation.

📖 For further information, see "Chapter 12 Cabinet Construction".

Table 4.1.2-1: Required air volumes of the FRENIC-VG (inverters)

Standard stack				Phase-specific stack	
Model (FRN)	Required air volume [m³/min]	Model (FRN)	Required air volume [m³/min]	Model (FRN)	Required air volume [m³/min]
30SVG1S-4☐	2.0	90SVG1S-69☐	5.8	630BVG1S-4☐	44.1
37SVG1S-4☐		110SVG1S-69☐		710BVG1S-4☐	
45SVG1S-4☐		132SVG1S-69☐	8.5	800BVG1S-4☐	
55SVG1S-4☐	1.5	160SVG1S-69☐			
75SVG1S-4☐		200SVG1S-69☐			
90SVG1S-4☐	5.8	250SVG1S-69☐	14.7		
110SVG1S-4☐		280SVG1S-69☐			
132SVG1S-4☐	8.5	315SVG1S-69☐			
160SVG1S-4☐		355SVG1S-69☐			
200SVG1S-4☐		400SVG1S-69☐			
220SVG1S-4☐	14.7	450SVG1S-69☐			
250SVG1S-4☐					
280SVG1S-4☐					
315SVG1S-4☐					

Table 4.1.2-2: Required air volumes of the converters

Standard stack							
Model (RHC)	volume [m³/min]	Model (RHF/RHD)	volume [m³/min]	Model (RHF/RHD)	volume [m³/min]	Model (RHF/RHD)	volume [m³/min]
RHC132S-4D☐	8.5	RHC132S-69D☐	8.5	RHF160S-4D☐	14.7	RHF160S-69D☐	14.7
RHC160S-4D☐		RHC160S-69D☐		RHF220S-4D☐		RHF220S-69D☐	
RHC200S-4D☐		RHC200S-69D☐		RHF280S-4D☐		RHF280S-69D☐	
RHC220S-4D☐	14.7	RHC250S-69D☐	14.7	RHF355S-4D☐		RHF355S-69D☐	
RHC280S-4D☐		RHC280S-69D☐		RHD200S-4D☐	8.5	RHF450S-69D☐	
RHC315S-4D☐		RHC315S-69D☐		RHD315S-4D☐	14.7	RHD220S-69D☐	
		RHC355S-69D☐				RHD450S-69D☐	
		RHC400S-69D☐					
		RHC450S-69D☐					

Phase-specific stack	
Model (RHC)	volume [m³/min]
RHC630B-4D☐	44.1
RHC710B-4D☐	
RHC800B-4D☐	

4.1.3 Installation direction and spacing to surroundings

The FRENIC-VG inverters and converters must be mounted only in the direction shown in Figure 4.1.3-1 (direction of the reading of the nameplate). For information on surrounding space, refer to Table 4.1.3-1 and Figure 4.1.3-2. Also, follow the space requirements shown in Table 4.1.3-1 when mounting stacks side by side.

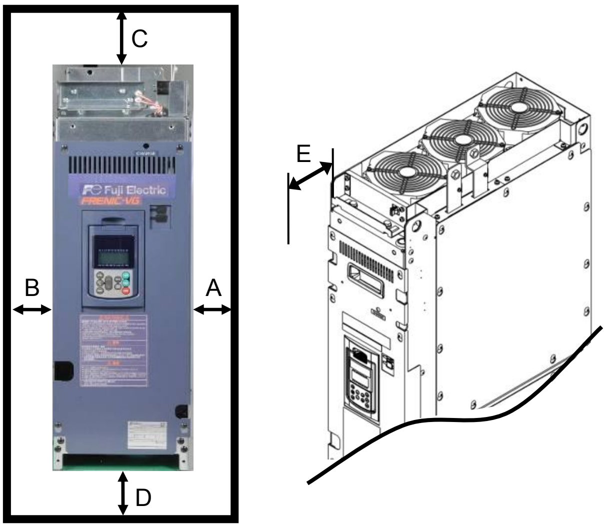


Figure 4.1.3-1 : Mounting direction and peripheral space requirements

Table 4.1.3-1: Surrounding space

Unit: mm

		A	B	C	D	E
Between stacks	Frame 1	10	10	300	350	50
	Frame 2					
	Frame 3					20
	Frame 4					20
Another appliance		20	20	—	350 (100)	50

Table 4.1.3-2: Frame size and capacity

Frame size	400V series	690V series
Frame 1	30 to 45 kW	—
Frame 2	55 to 110 kW	90 to 110 kW
Frame 3	132 to 200 kW	132 to 200 kW
Frame 4	220 to 315 kW 630 to 800 kW	250 to 450 kW

Note

(1) Stacks cannot be mounted on top of each other.

(2) Only a DC fuse (fuse designated by Fuji Electric) can be mounted in space C (above the exhaust fan of the stack).
A general appliance capable of working at a temperature of up to 70°C can be mounted in this space. In this case, mount it so that it does not block the exhaust fan of the stack.

(3) The stack has an air intake in the lower area. Keep about 60% of the 350-mm space in the lower area open. When installing an appliance in this space, keep a distance of at least 100 mm between it and the stack.

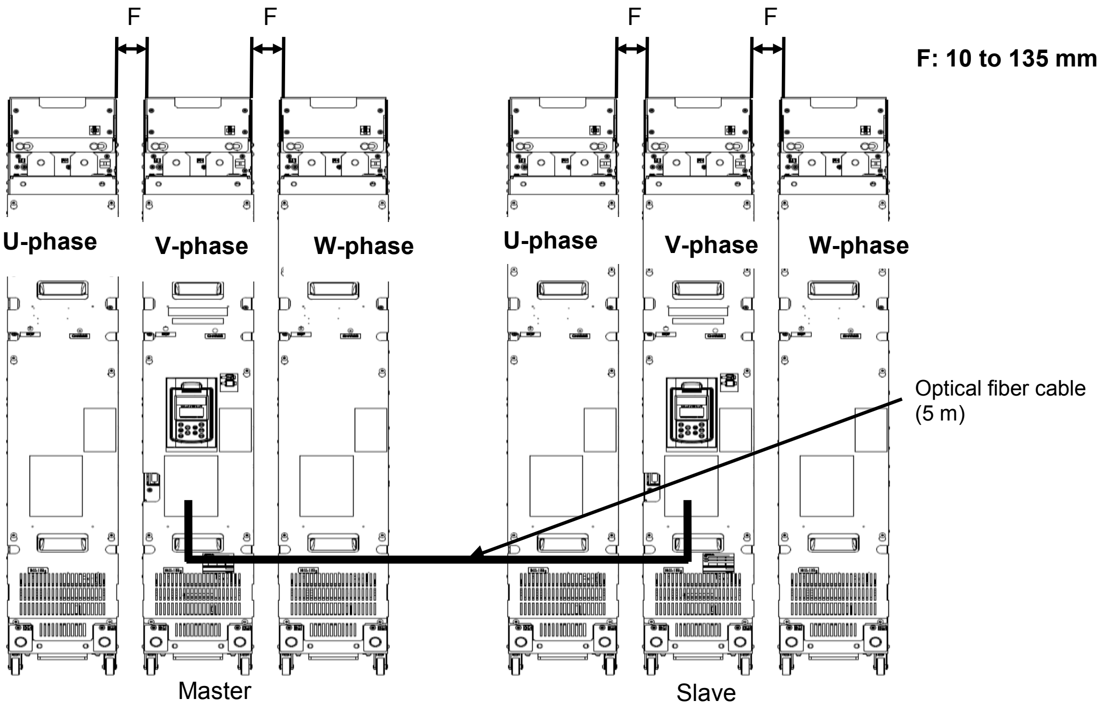


Figure 4.1.3-2: Spacing between phase-specific stacks (Frame 4: 630 to 800 kW)

Note (1) If space F exceeds 135 mm, the spacing between the stacks (U-phase, V-phase, and W-phase) is too large to connect the standard cable.

(2) When using direct parallel connection, connect the master and slave (or, for the phase-specific stack, V-phase) with the Optical fiber cable (5 m). Therefore, the master and slave must be installed within the distance at which they can be connected.

*The Optical fiber cable (5 m) comes standard with the optional high-speed serial communication support terminal block (OPC-VG1-TBSI).

4.1.4 Stack derating by ambient temperature

In cases where the ambient temperature exceeds 40°C, operation up to 55°C is possible if derating is considered. Carefully note that the derating curve differs depending on the product model.

Use the FRENIC-VG (inverter) 400V series 30 to 75kW and 630 to 800kW, and all capacities of RHF (filter stack) 400/690V series at ambient temperatures of up to 40 °C.

■ **FRENIC- VG (inverters)**

Standard stack				Phase-specific stack	
Model	Figure	Model	Figure	Model	Figure
FRN30SVG1S-4□	— (Not available)	FRN132SVG1S-4□	A	FRN630BVG1S-4□	— (Not available)
FRN37SVG1S-4□		FRN160SVG1S-4□	B	FRN710BVG1S-4□	
FRN45SVG1S-4□		FRN200SVG1S-4□	D	FRN800BVG1S-4□	
FRN55SVG1S-4□		FRN220SVG1S-4□			
FRN75SVG1S-4□		FRN250SVG1S-4□	A		
FRN90SVG1S-4□	D	FRN280SVG1S-4□	B		
FRN110SVG1S-4□		FRN315SVG1S-4□	D		
FRN90SVG1S-69□	C	FRN250SVG1S-69□	E		
FRN110SVG1S-69□	E	FRN280SVG1S-69□			
FRN132SVG1S-69□	C	FRN315SVG1S-69□			
FRN160SVG1S-69□	D	FRN355SVG1S-69□	B		
FRN200SVG1S-69□	E	FRN400SVG1S-69□	C		
—	—	FRN450SVG1S-69□	D		

■ **Converters**

Standard stack				Phase-specific stack	
Model	Figure	Model	Figure	Model	Figure
RHC132S-4D□	A	RHC220S-4D□	D	RHC630B-4D□	— (Not available)
RHC160S-4D□	B	RHC280S-4D□	B	RHC710B-4D□	
RHC200S-4D□	D	RHC315S-4D□	D	RHC800B-4D□	
RHD200S-4D□	D	RHD315S-4D□	D		
RHF160S-4D□	— (Not available)	RHF280S-4D□	— (Not available)		
RHF220S-4D□		RHF355S-4D□			
RHC132S-69D□	C	RHC250S-69D□	E		
RHC160S-69D□	D	RHC280S-69D□			
RHC200S-69D□	E	RHC315S-69D□			
—	—	RHC355S-69D□	B		
		RHC400S-69D□	C		
		RHC450S-69D□	D		
RHD220S-69D□	F	RHD450S-69D□	D		
RHF160S-69D□	— (Not available)	RHF280S-69D□	— (Not available)		
RHF220S-69D□		RHF355S-69D□			
—	—	RHF450S-69D□			

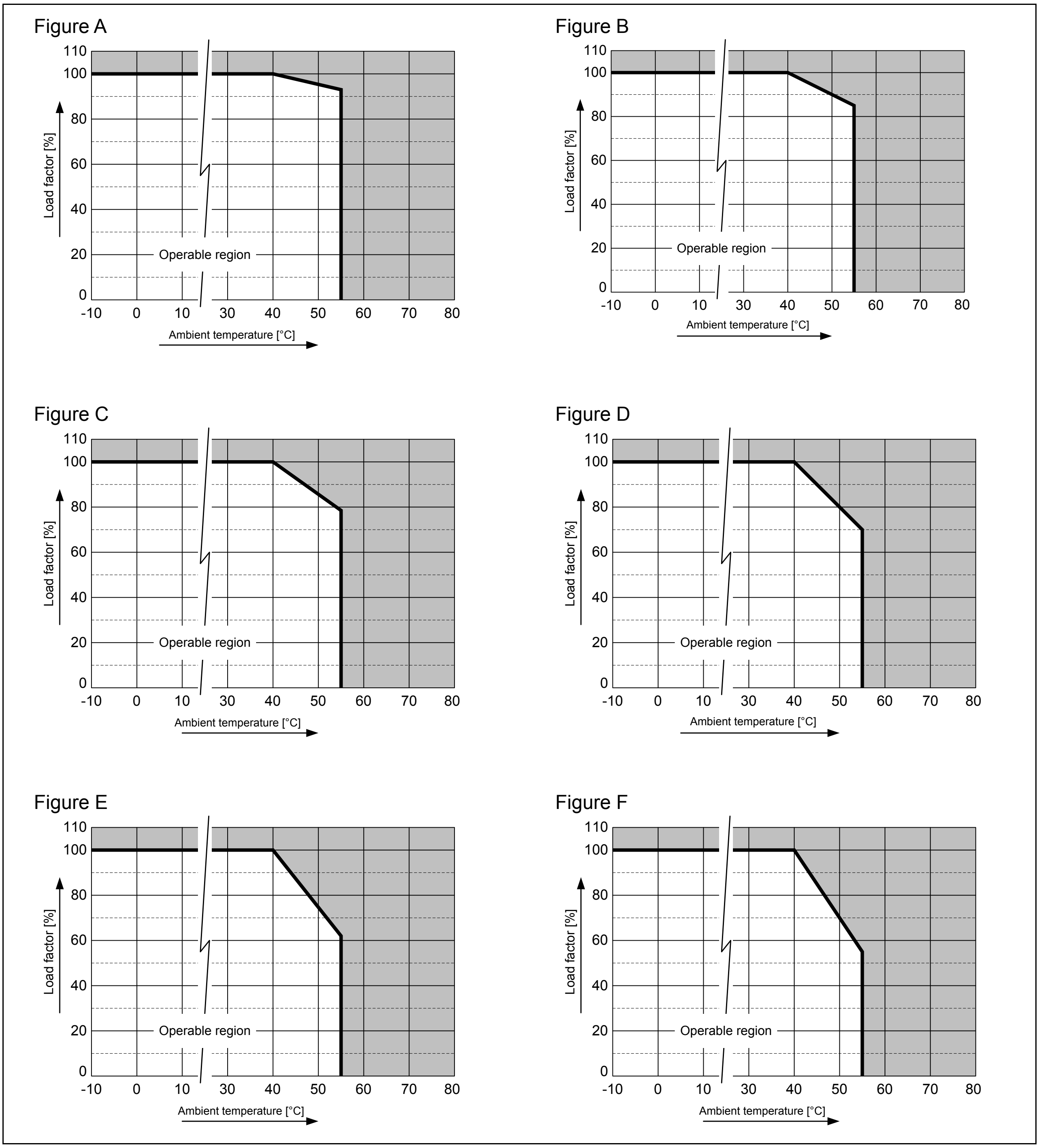


Figure 4.1.4-1: Derating curve

4.2 Installation

4.2.1 Fixation points and terminal positions

4.2.1.1 Frame 1 and 2 size stacks (400V: 30 to 110 kW, 690V: 90 to 110 kW)

[1] Fixation points (common to Frame 1 and 2 sizes)

For Frame 1 and 2 sizes (400V series: 30 to 45 kW [Frame 1], 55 to 110 kW [Frame 2]. 690V series: 90 to 110 kW [Frame 2]), there are two supporting points for installation. When installing them in cabinets, securely fix them at these supporting points.

📖 For setting of the terminating resistor, refer to "4.2.2 Installing stacks in cabinets".

<Points of mounting>

(1) Fixing hole in the upper area of the back face (2 x φ10: M8 screw or stud bolt)

(2) Tapped hole for fixation in the lower area of the front face (2 x M5-12 (up to 25) when the recommended plate thickness of the attachment for fixation is 2.3 mm)

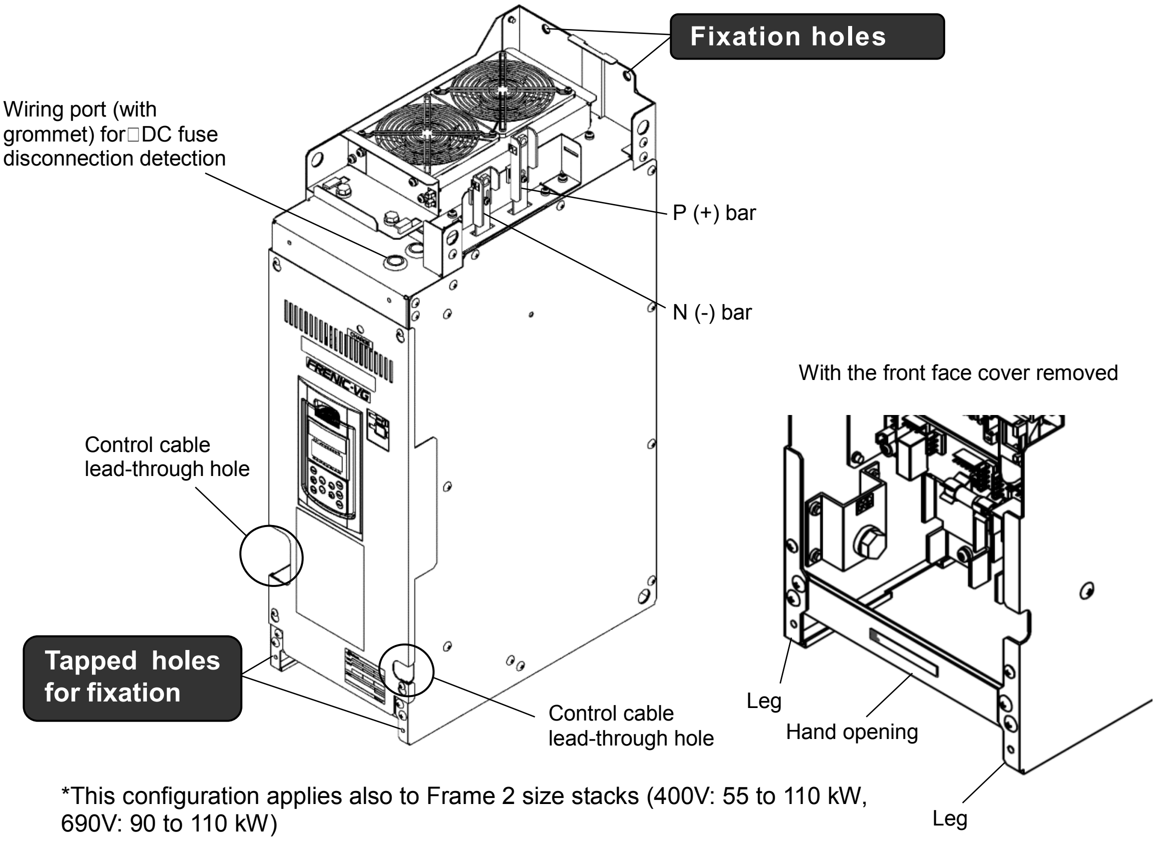


Figure 4.2.1-1: Fixation points for Frame 1 size (400V: 30 to 45 kW)

When using the tapped holes for fixation in the front face to fix the stack, make attachments for fixation from sheet metal.

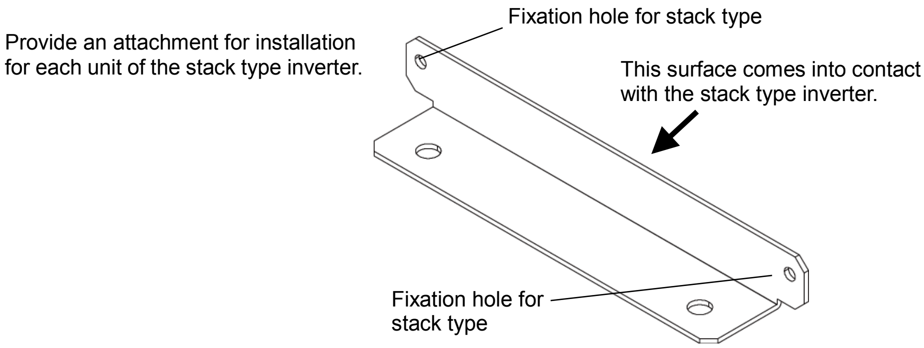


Figure 4.2.1-2: Attachment for fixing lower section (recommended)

<Dimensions for the attachment for fixing lower section>

The recommended dimensions of the attachment (front lower section) for fixing Frame 1 and 2 size (400V: 30 to 110 kW, 690V: 90 to 110 kW) stacks to the cabinet are shown below. This attachment should be used to fix the stacks individually.

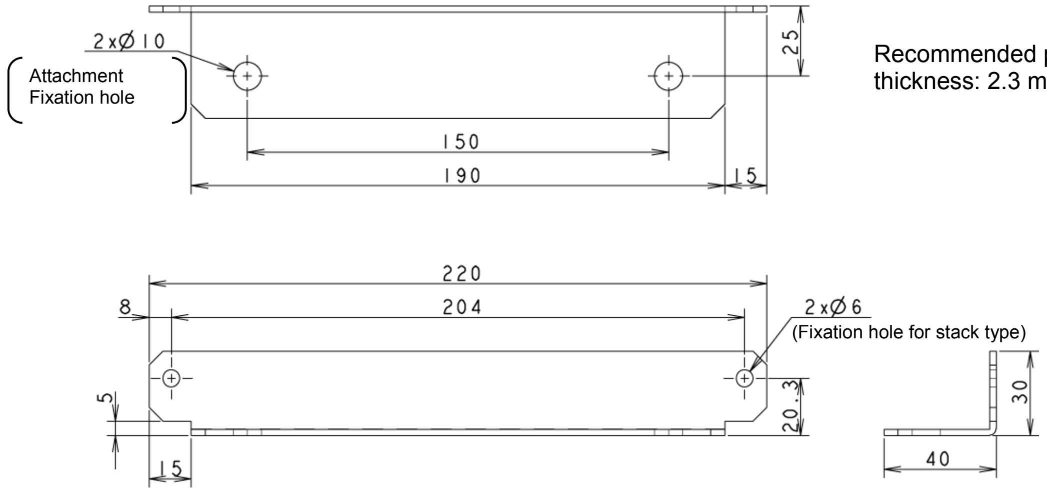
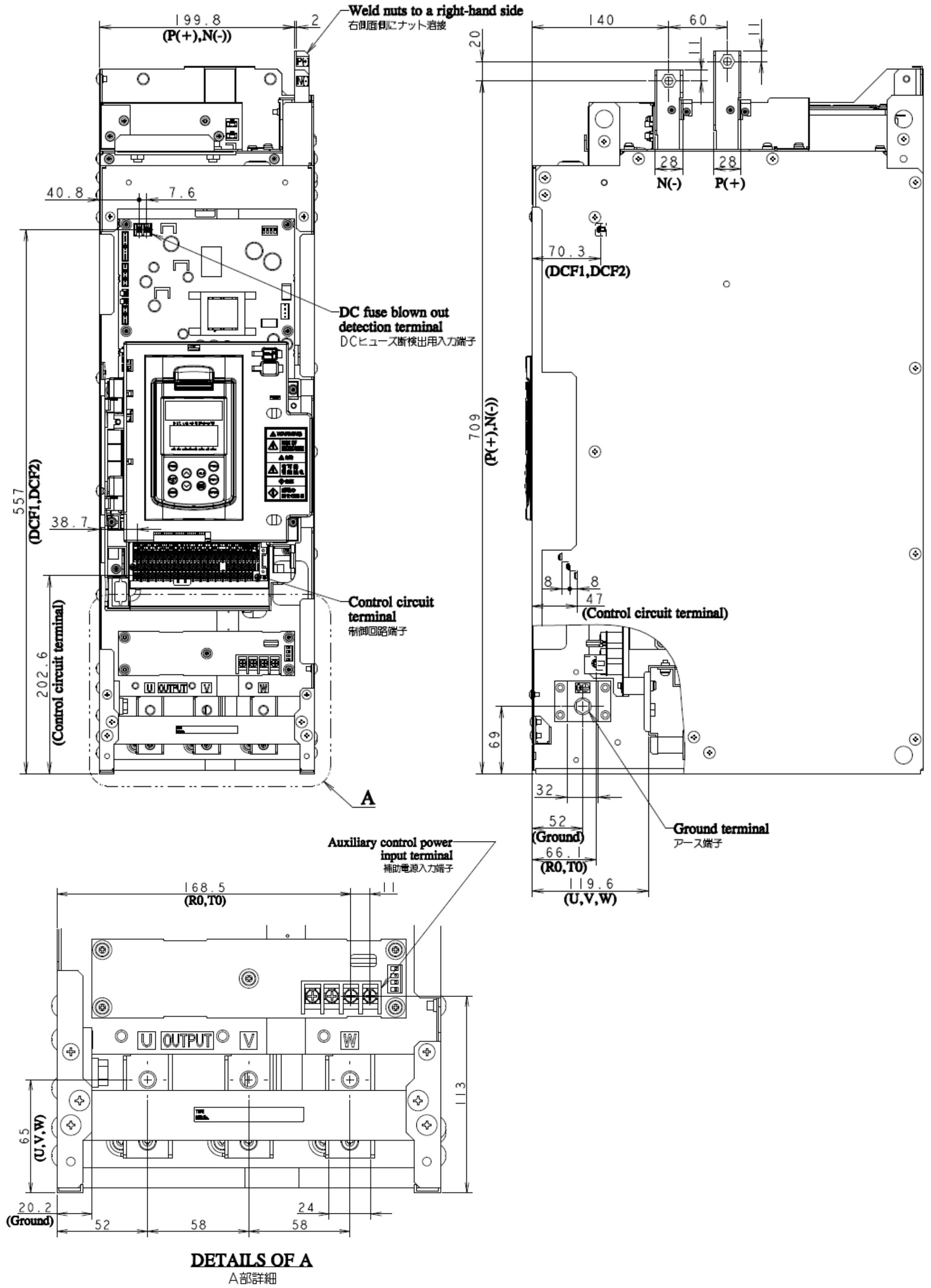


Figure 4.2.1-3: Shape of attachment for fixing lower section

[2] Terminal positions and screw sizes (main circuit terminals)

■ **Frame 1 size (400V:30 to 45 kW), models: FRN30SVG1S-4□ to FRN45SVG1S-4□**

Unit: [mm] <Internal front view> <Side face view: from the right side face>

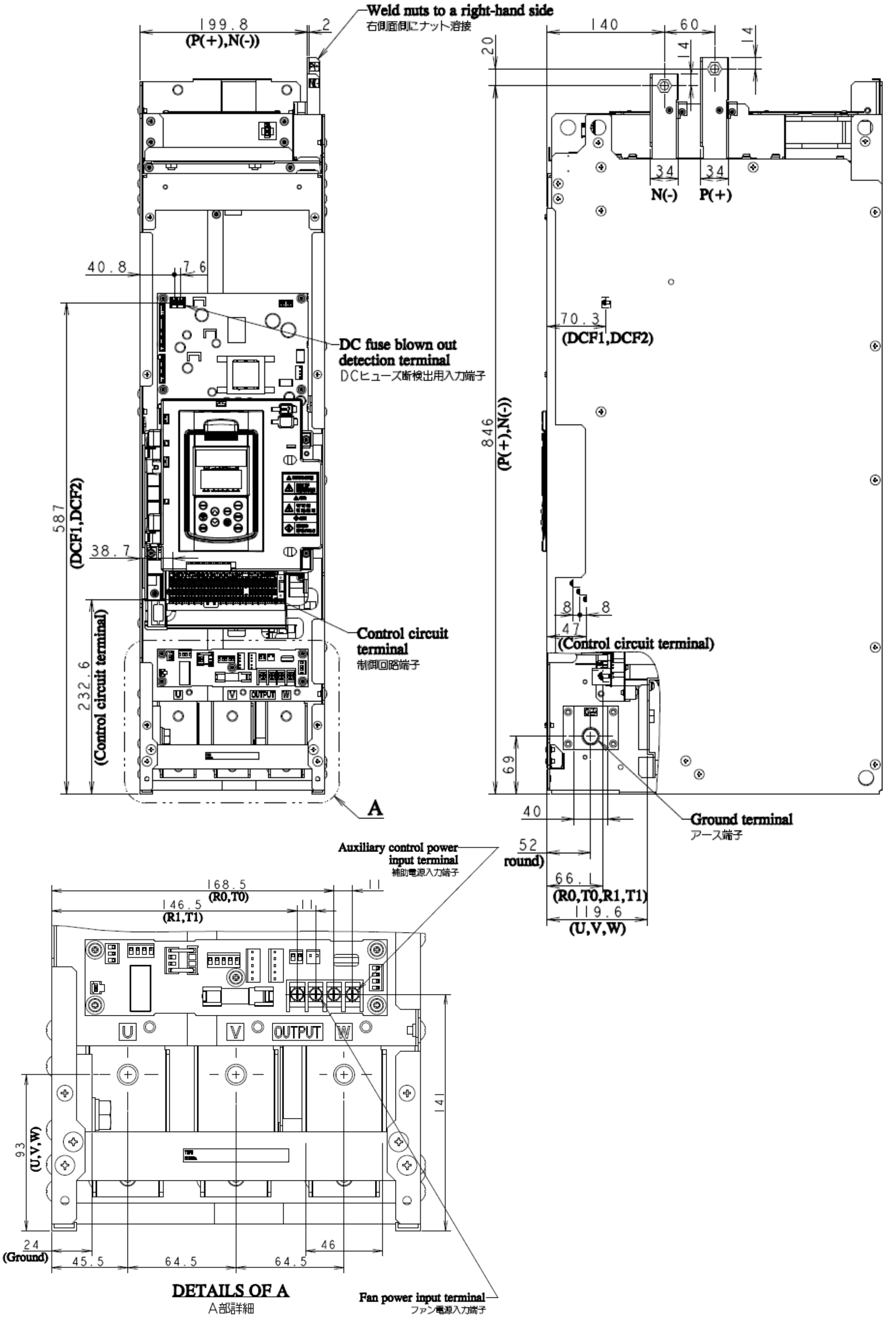


Terminal name	Terminal symbol	Screw size	Terminal tightening torque	Applicable crimped terminal size
Output terminal	U, V, W	M8	13.5 N·m	R60-8/MAX
DC input terminal	P(+), N(-)			
Grounding terminal	G			

Figure 4.2.1-4: Terminal positions for Frame 1 size (400V: 30 to 45 kW)

■ **Frame 2 size (400V:55 to 110 kW), models: FRN55SVG1S-4□ to FRN110SVG1S-4□**

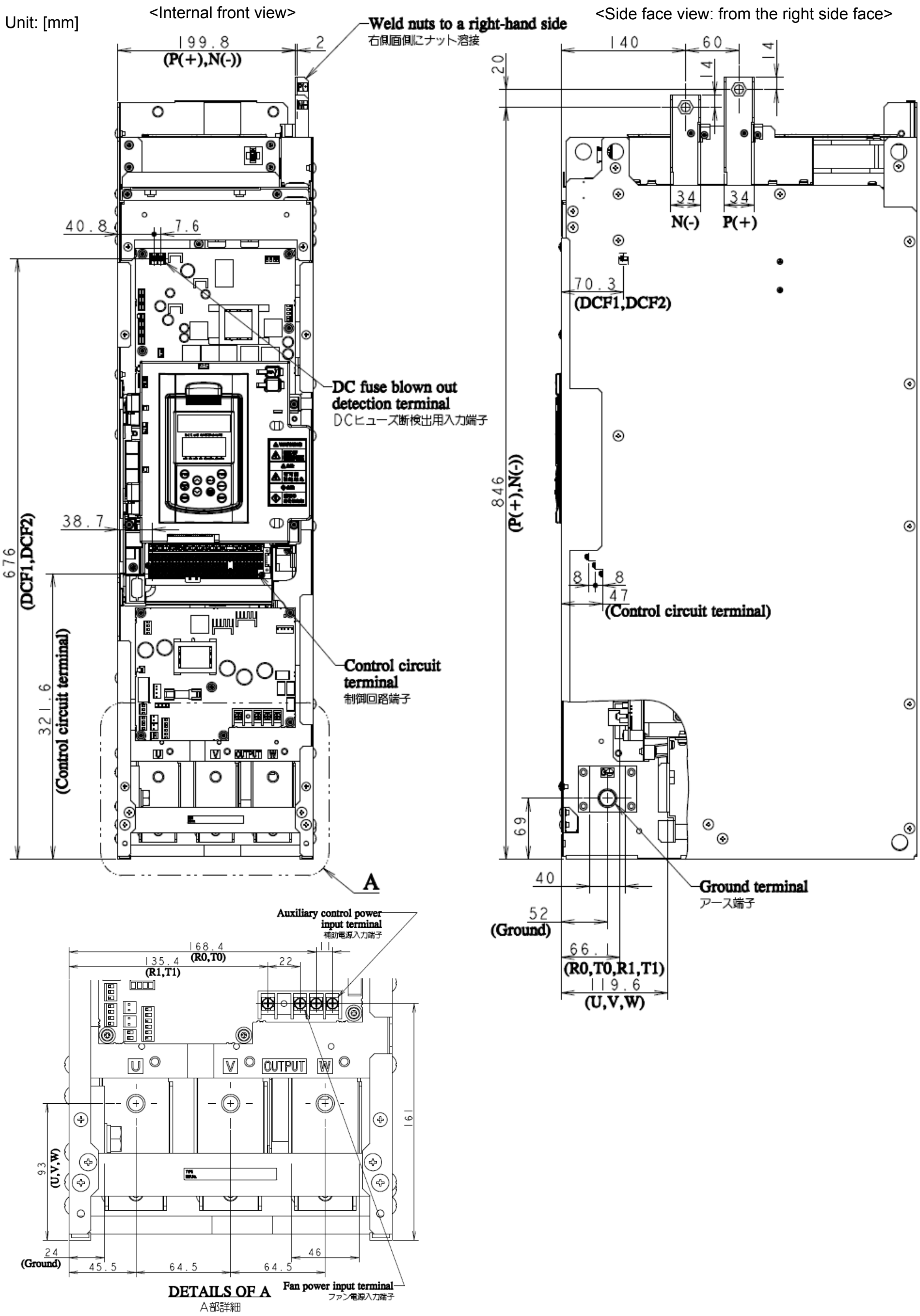
Unit: [mm] <Internal front view> <Side face view: from the right side face>



Terminal name	Terminal symbol	Screw size	Terminal tightening torque	Applicable crimped terminal size
Output terminal	U, V, W	M10	27 N·m	R150-10/MAX
DC input terminal	P(+), N(-)			
Grounding terminal	G			

Figure 4.2.1-5: Terminal positions for Frame 2 size (400V: 55 to 110 kW)

■ **Frame 2 size (690V:90 to 110 kW), models: FRN90SVG1S-69□ to FRN110SVG1S-69□**



Terminal name	Terminal symbol	Screw size	Terminal tightening torque	Applicable crimped terminal size
Output terminal	U, V, W	M10	27 N·m	R150-10/MAX
DC input terminal	P (+), N (-)			
Grounding terminal	G			

Figure 4.2.1-6: Terminal positions for Frame 2 size (690V: 90 to 110 kW)

4.2.1.2 Frame 3 size (400V: 132 to 200 kW, 690V: 132 to 200 kW)

[1] Fixation points

For Frame 3 size (400V series: 132 to 200 kW, 690V series: 132 to 200 kW), there are four supporting points for installation. When installing them in cabinets, securely fix them at these supporting points.

🕮 For setting of the terminating resistor, refer to "4.2.2 Installing stacks in cabinets".

<Points of mounting>

(1) Fixation plate provided in the upper area of the back face (with a set-in guide installed on the cabinet side)

(2) Fixation plate provided in the lower area of the back face (with a set-in guide installed on the cabinet side)

(3) Tapped hole for fixation in the upper area of the front face (2 x M8-25, when the recommended plate thickness of the attachment for fixation is 2.3 mm)

(4) Tapped hole for fixation in the lower area of the front face (2 x M8-25, when the recommended plate thickness of the attachment for fixation is 2.3 mm)

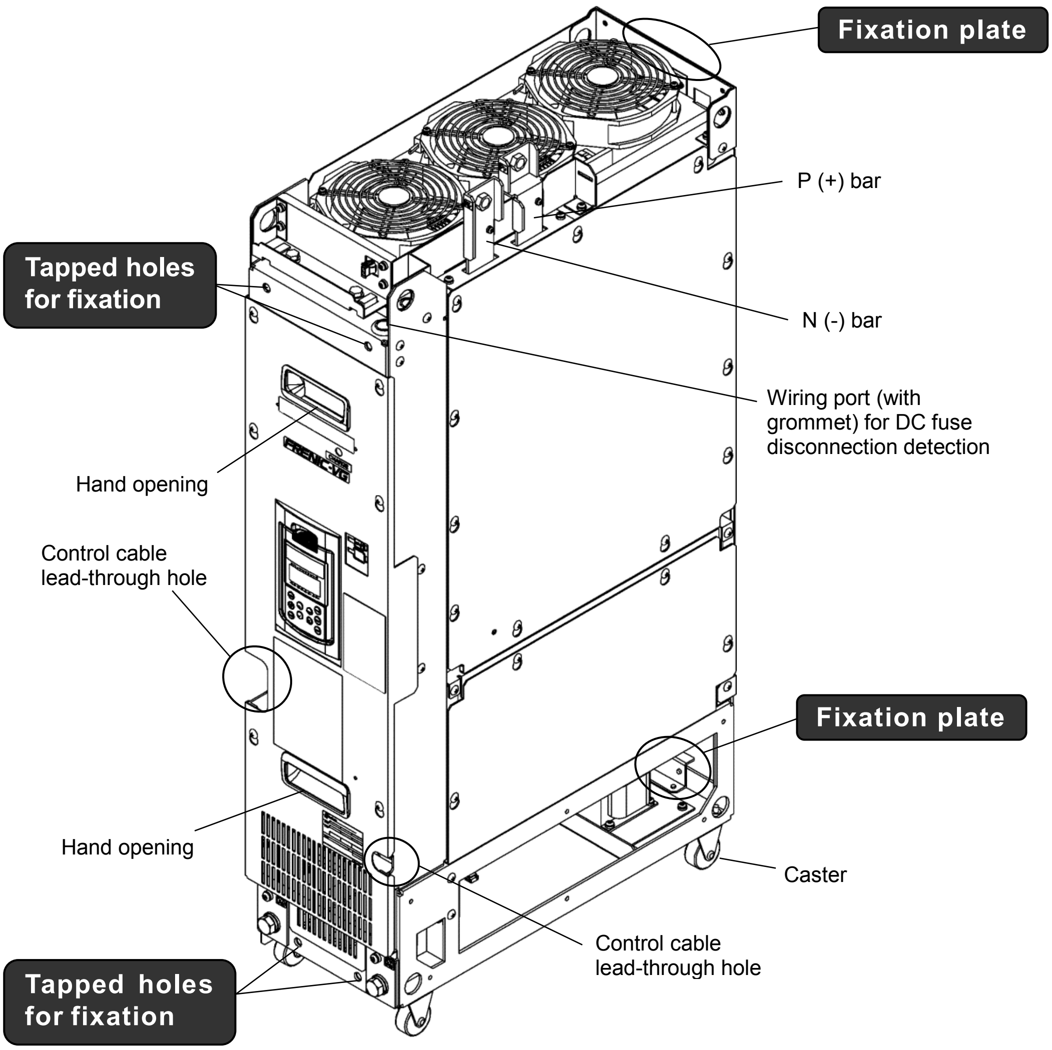


Figure 4.2.1-7: Fixation points for Frame 3 size (400V/690V: 132 to 200 kW)

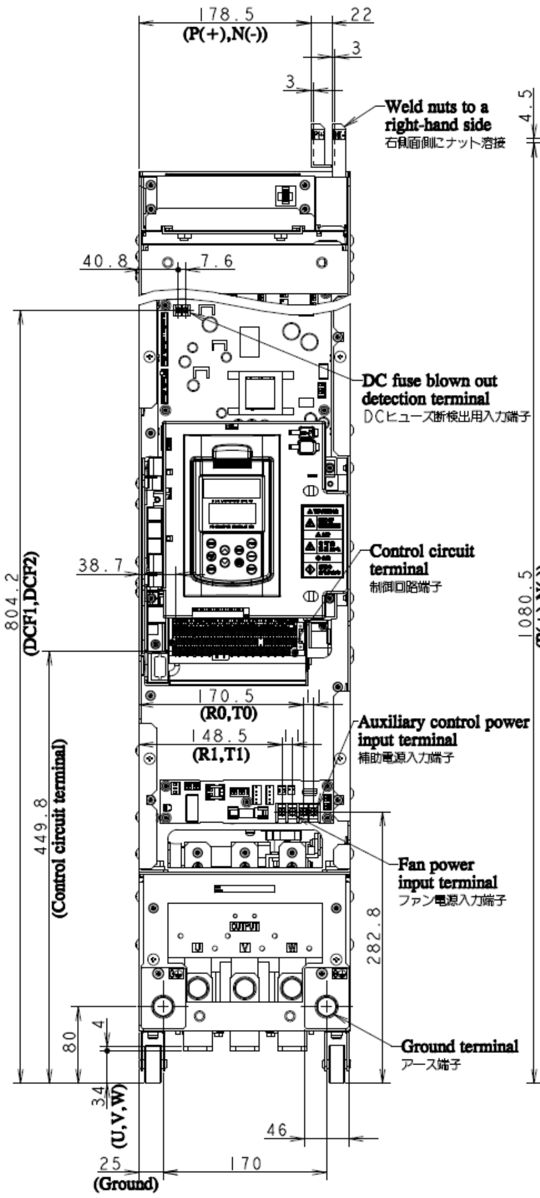
When using the tapped holes for fixation in the front face to fix the stack, make attachments for fixation from sheet metal.

🕮 Attachments for fixation of the same shape as the one shown in Figure 4.2.1-12: Attachment for fixing lower section (recommended) and Figure 4.2.1-13: Attachment for fixing upper section (recommended) can be used. (Refer to page 4-16.)

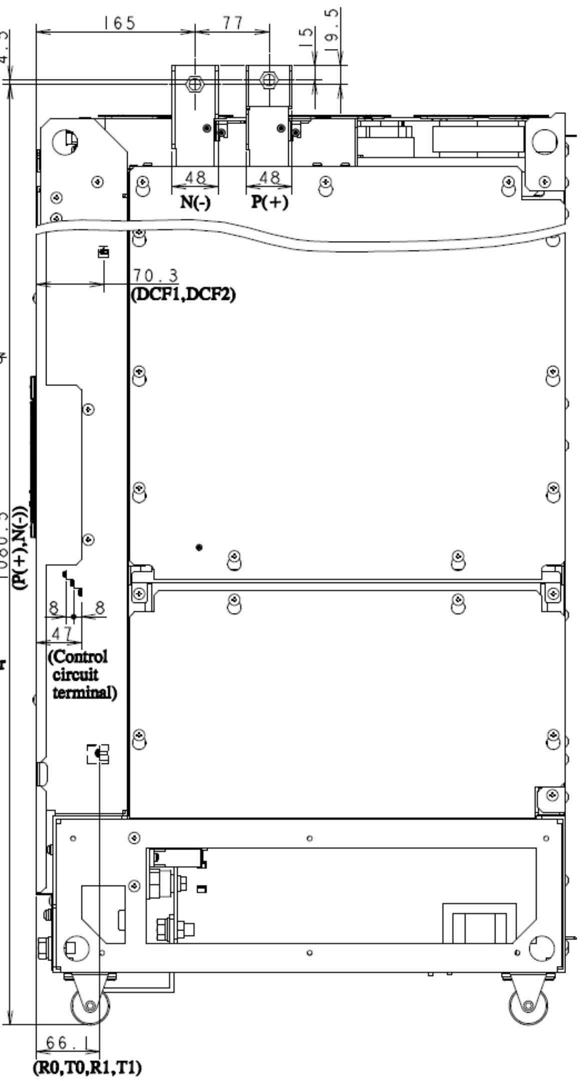
[2] Terminal positions and screw sizes (main circuit terminals)

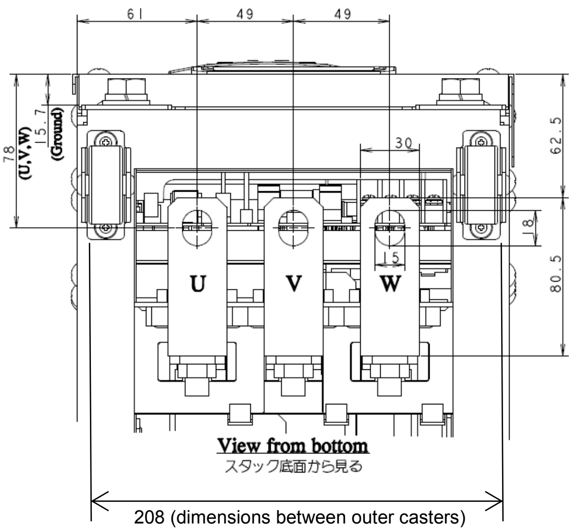
■ **Frame 3 size (400V:132 to 200 kW), models: FRN132SVG1S-4□ to FRN200SVG1S-4□**

<Internal front view>



<Side face view: from the right side face>





Note

To connect output terminals for Frame 3 size, use a relay bus bar provided on the cabinet side.

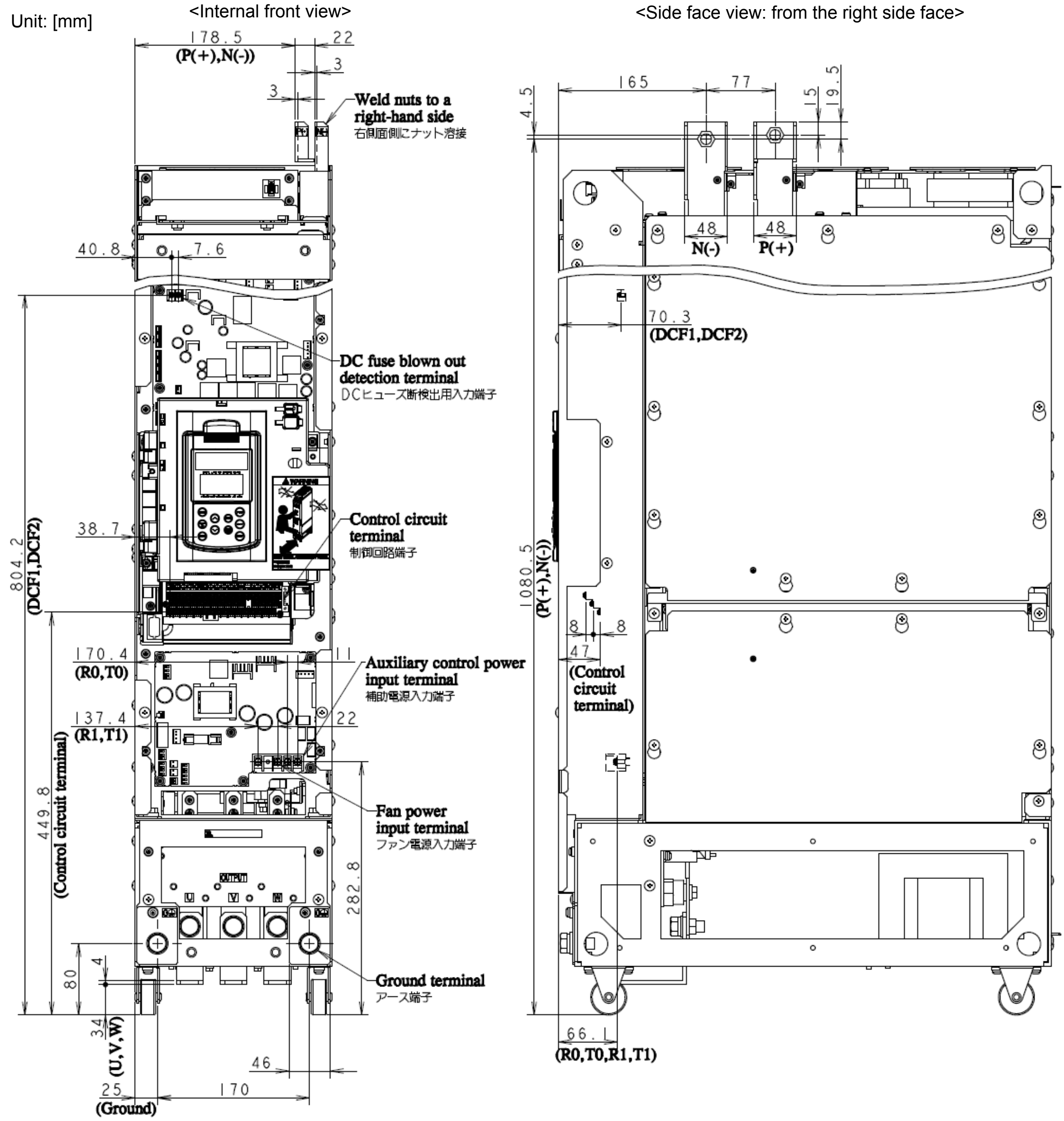
The relay bus bar should be fixed using an insulator.

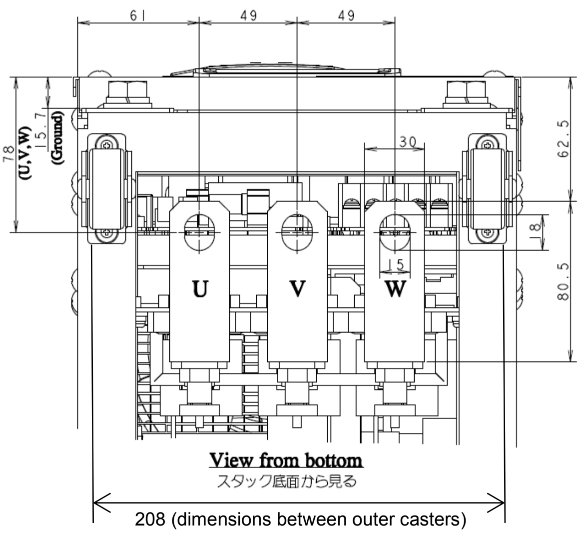
Terminal name	Terminal symbol	Bolt size	Terminal □tightening torque
Output terminal	U, V, W	M12	48 N·m
DC input terminal	P(+), N(-)		
Grounding terminal	G		

Figure 4.2.1-8: Terminal positions for Frame 3 size (400V: 132 to 200 kW)

■ **Frame 3 size (690V:132 to 200 kW), models: FRN132SVG1S-69□ to FRN200SVG1S-69□**

Unit: [mm]





Note

To connect output terminals for Frame 3 size, use a relay bus bar provided on the cabinet side.

The relay bus bar should be fixed using an insulator.

Terminal name	Terminal symbol	Bolt size	Terminal tightening torque
Output terminal	U, V, W	M12	48 N·m
DC input terminal	P(+), N(-)		
Grounding terminal	G		

Figure 4.2.1-9: Terminal positions for Frame 3 size (690V: 132 to 200 kW)

4.2.1.3 Frame 4 size (400V: 220 to 800 kW, 690V: 250 to 450 kW)

[1] Fixation points

For Frame 4 size (400V series: 220 to 800 kW, 690V series: 250 to 450 kW), there are four supporting points for installation. When installing them in cabinets, securely fix them at these supporting points.

For setting of the terminating resistor, refer to "4.2.2 Installing stacks in cabinets".

<Points of mounting>

(1) Fixation plate provided in the upper area of the back face (with a set-in guide installed on the cabinet side)

(2) Fixation plate provided in the lower area of the back face (with a set-in guide installed on the cabinet side)

(3) Tapped hole for fixation in the upper area of the front face (2 x M8-25, when the recommended plate thickness of the attachment for fixation is 2.3 mm)

(4) Tapped hole for fixation in the lower area of the front face (2 x M8-25, when the recommended plate thickness of the attachment for fixation is 2.3 mm)

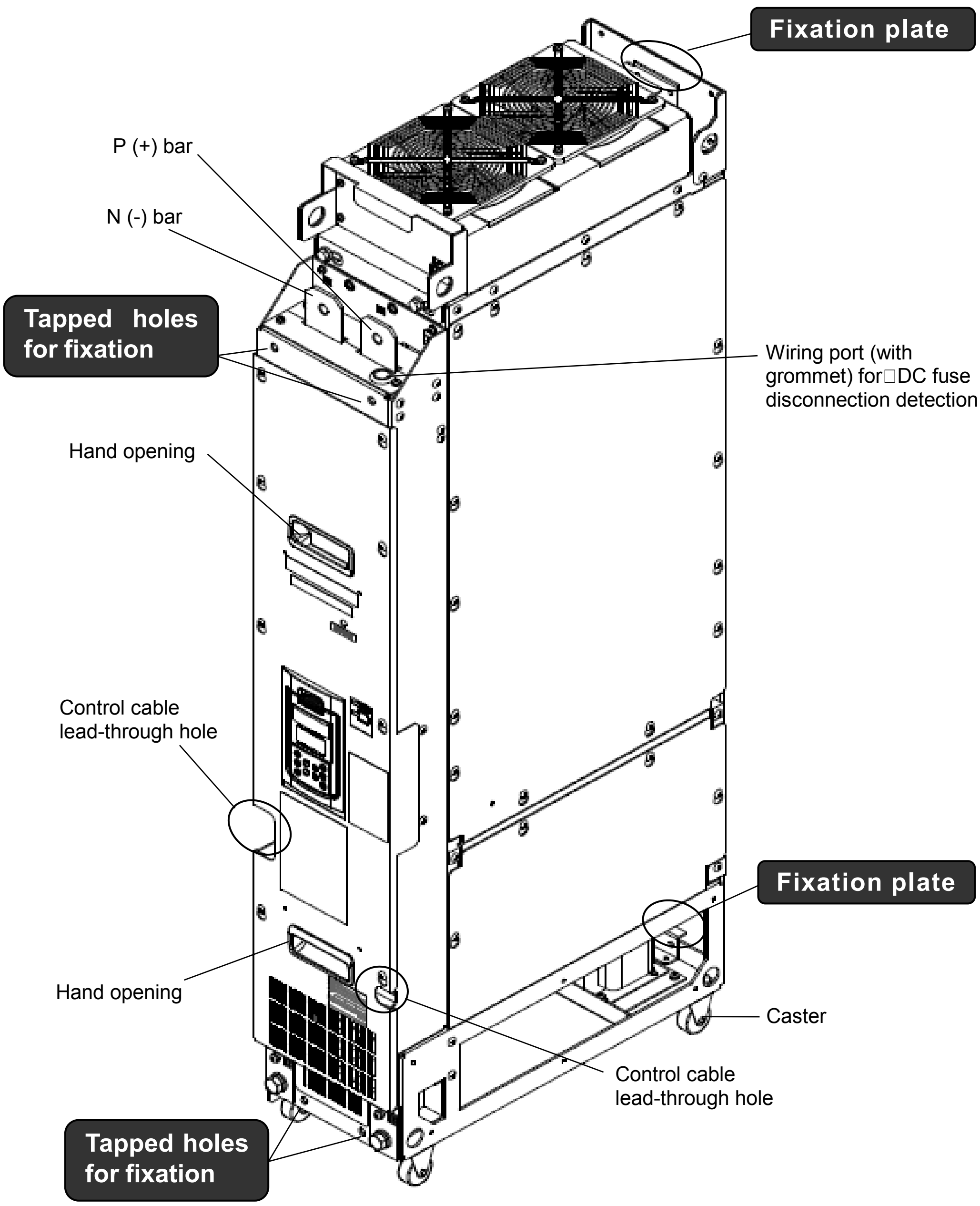


Figure 4.2.1-10: Fixation points for Frame 4 size (400V: 220 to 315 kW, 690V: 250 to 450 kW)

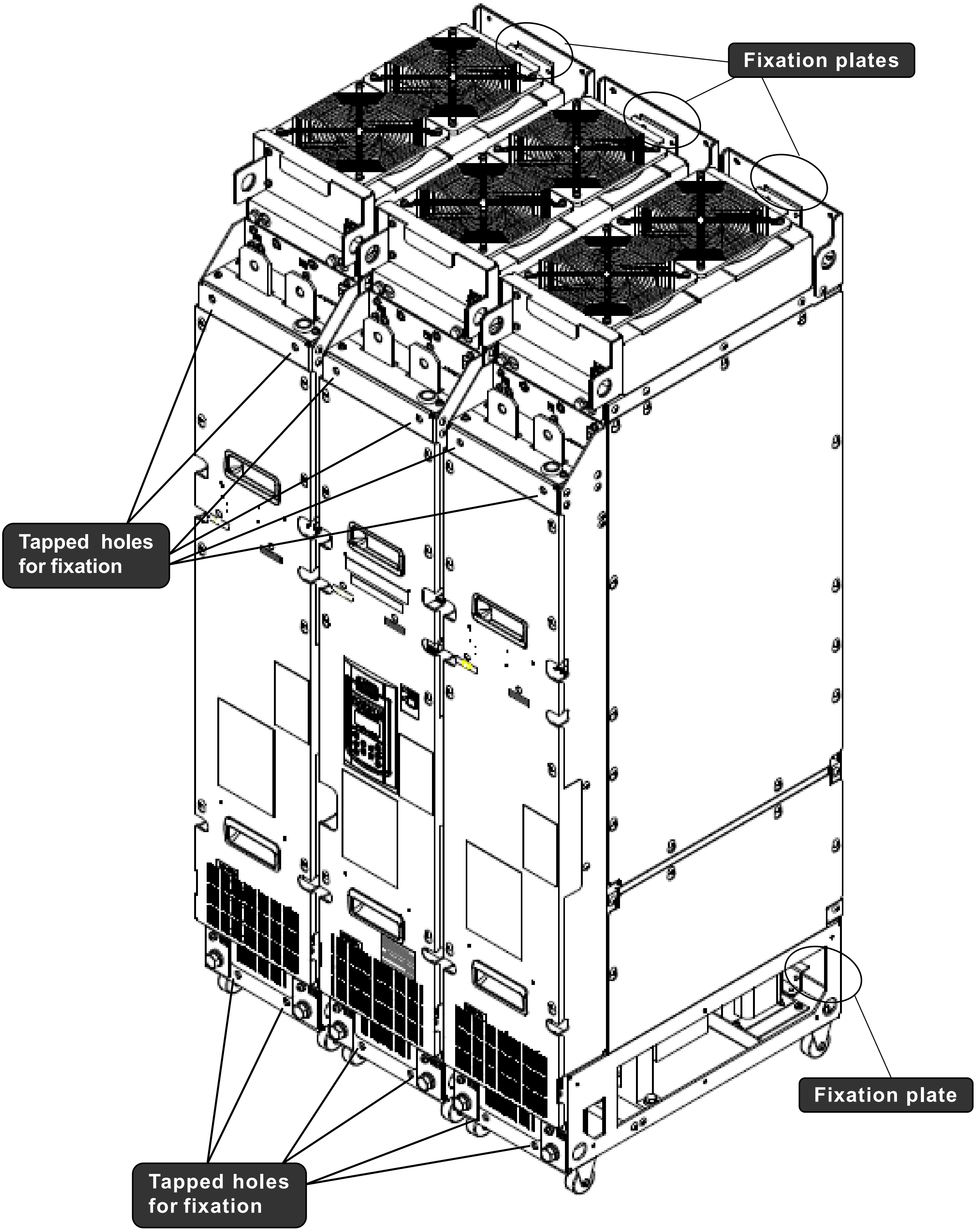
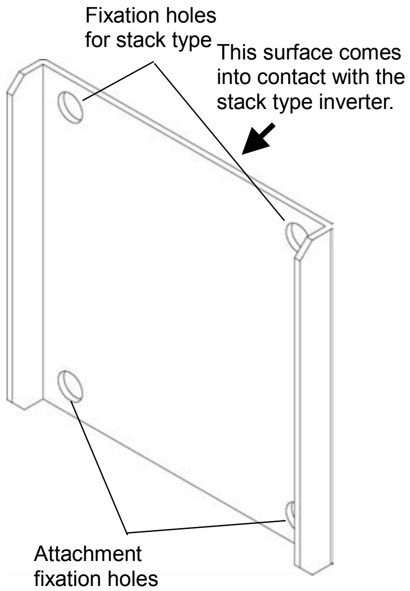


Figure 4.2.1-11: Fixation points for Frame 4 size (400V: 630 to 800 kW)

When using the tapped holes for fixation in the front face to fix the stack, make attachments for fixation from sheet metal.



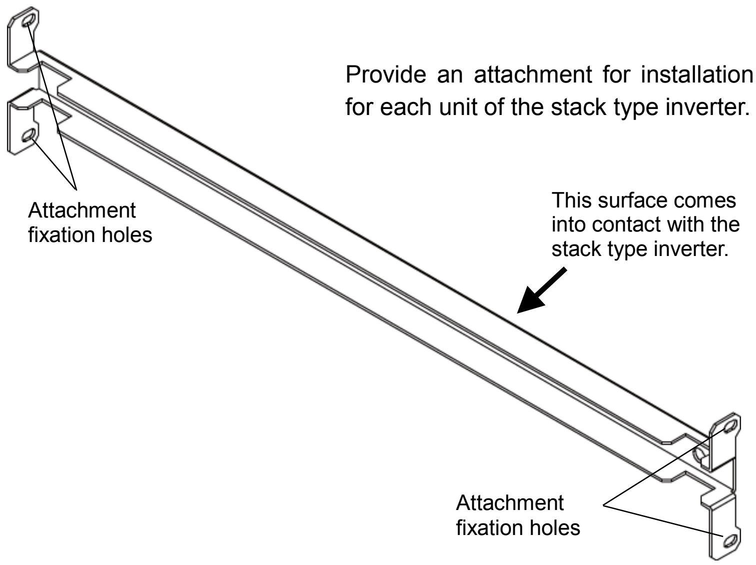


Figure 4.2.1-12: Attachment for fixing lower section (recommended)

Figure 4.2.1-13: Attachment for fixing upper section (recommended)

<Dimensions for the attachment for fixing lower section>

The recommended dimensions of the attachment (front lower section) for fixing Frame 3 and 4 size (400V: 132 to 800 kW, 690V: 132 to 450 kW) stacks to the cabinet are shown below. This attachment should be used to fix the stacks individually.

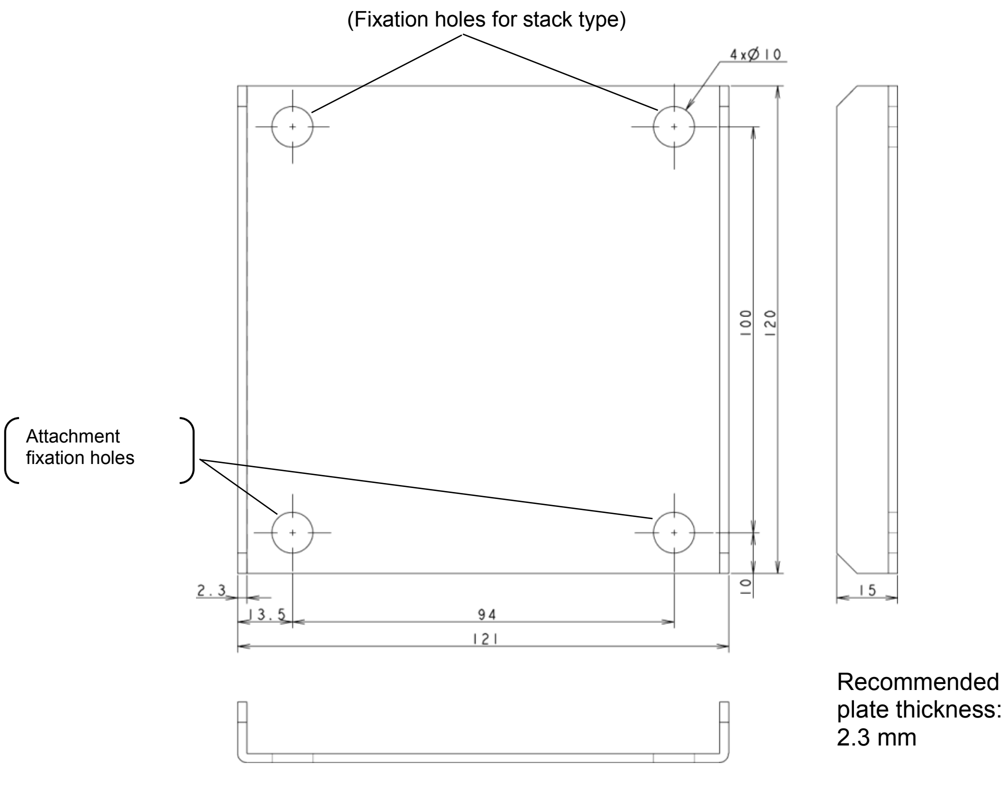


Figure 4.2.1-14: Attachment for fixing lower section

<Dimensions for the attachment for fixing upper section>

The recommended dimensions of the attachment (front upper section) for fixing Frame 3 and 4 size (400V: 132 to 800 kW, 690V: 132 to 450 kW) stacks to the cabinet are shown below. Using this attachment, fix the stack type inverters together before putting them in the cabinet.

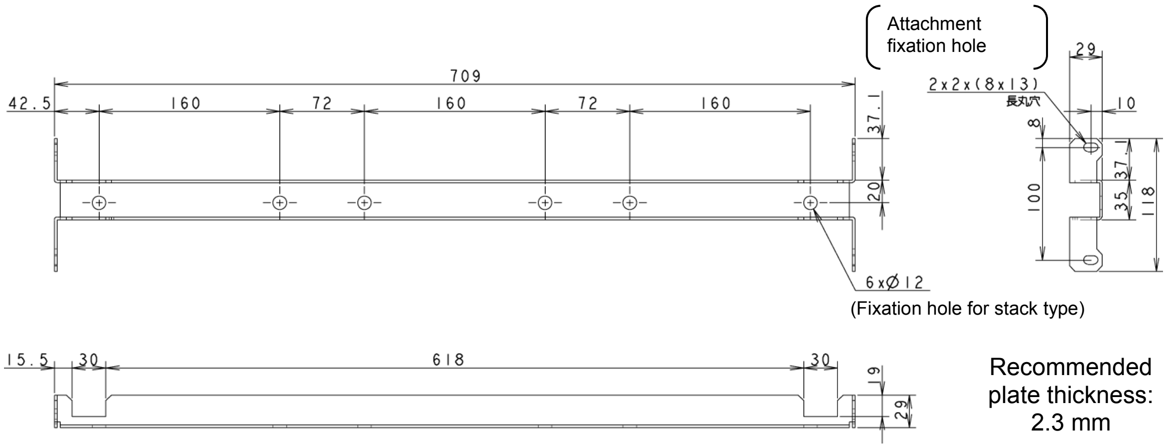


Figure 4.2.1-15: Attachment for fixing upper section

Note
(1) This attachment should be applied to cabinets with width 800 and flat steel sheets bent to 45 degrees.
(2) For stack type inverters, your design should be based on the horizontal spacing (clearance) of 12 mm (assuming the use of a cabinet with a width of 800).
(3) A height of 35 mm is recommended for surfaces in contact with stack type inverters. If this recommended value is exceeded, the keyholes on the surface cover will be hidden, making cover removal impossible.

<Position of the set-in guide hole for the back face lower fixation plate>

The following figure illustrates the position of the set-in guide hole for the attachment that supports the back face lower fixation plate for Frame 3 and 4 size (400V: 132 to 800 kW, 690V: 132 to 450 kW) stacks as well as the position of the screw clearance hole for stack type inverters.

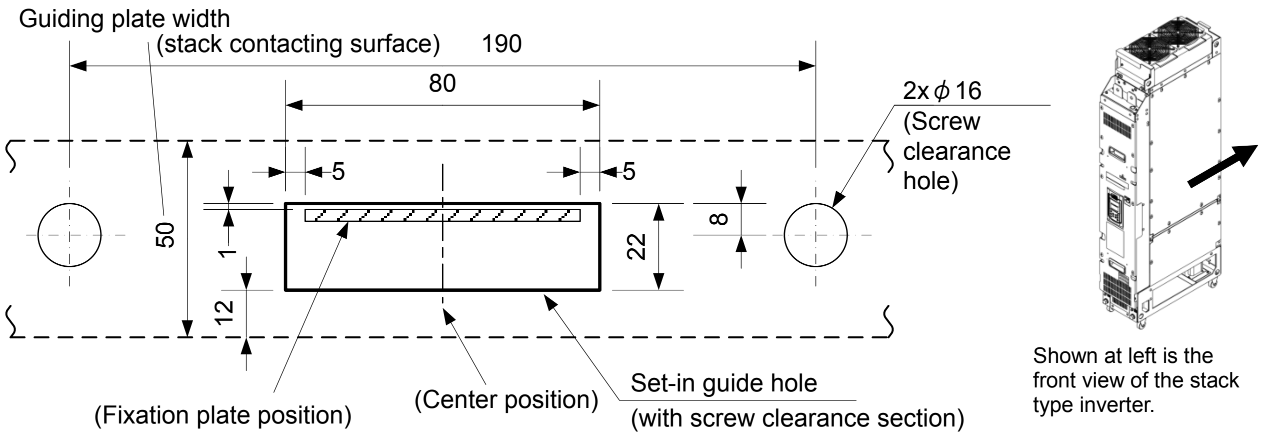


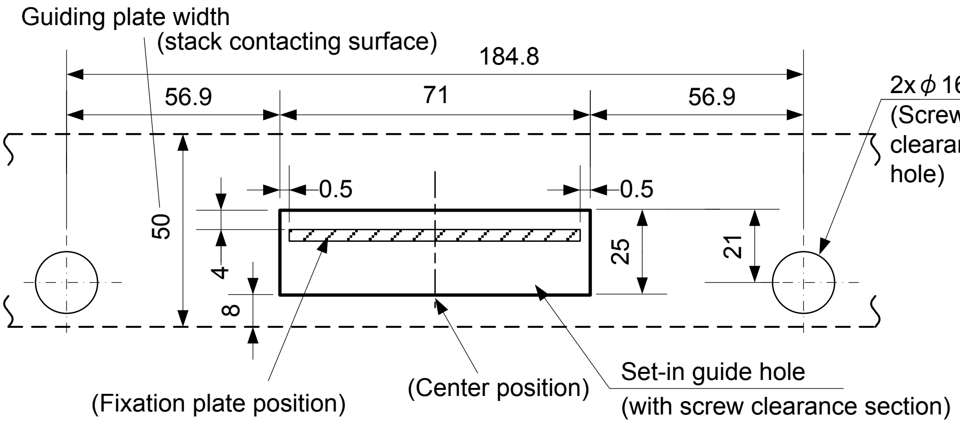
Figure 4.2.1-16: Positions of the set-in guide hole for the back face lower fixation plate and the screw clearance hole for stack type inverters

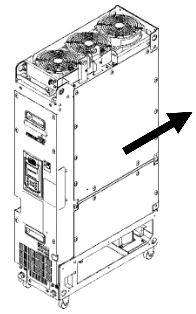
Note
(1) The figure above shows the dimensions for a single unit of stack type inverter.
(2) For stack type inverters, your design should be based on the horizontal spacing (clearance) of 12 mm (assuming the use of a cabinet with a width of 800).

<Position of the set-in guide hole for the back face upper fixation plate>

■ **Frame 3 size (400V: 132 to 200 kW, 690V: 132 to 200 kW)**

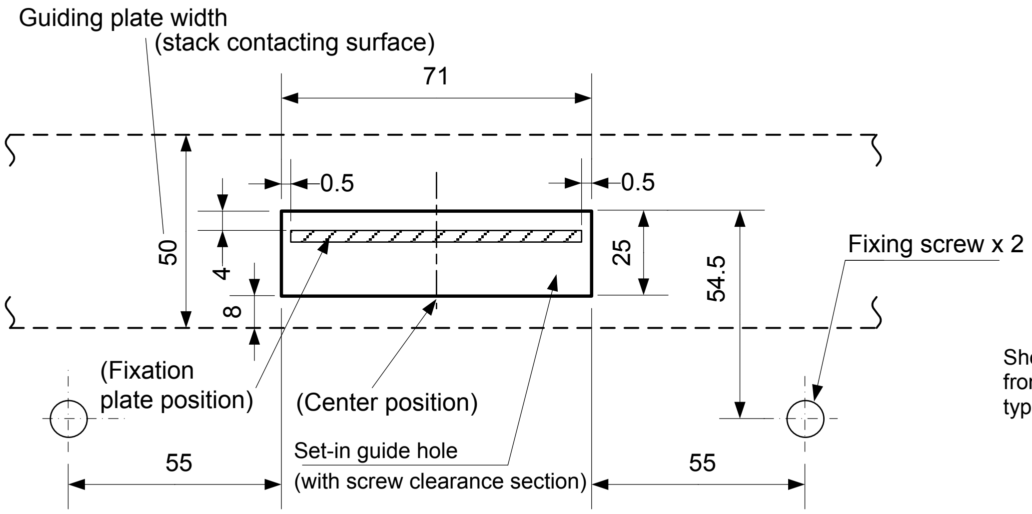
The following figure illustrates the positions of the set-in guide hole for the back face upper fixation plate and the screw clearance hole for stack type inverters.





■ **Frame 4 size (400V: 220 to 800 kW, 690V: 250 to 450 kW)**

The following figure illustrates the position of the set-in guide hole for the back face upper fixation plate.



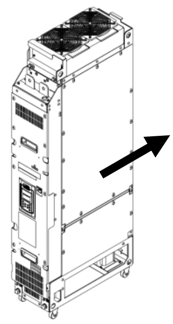
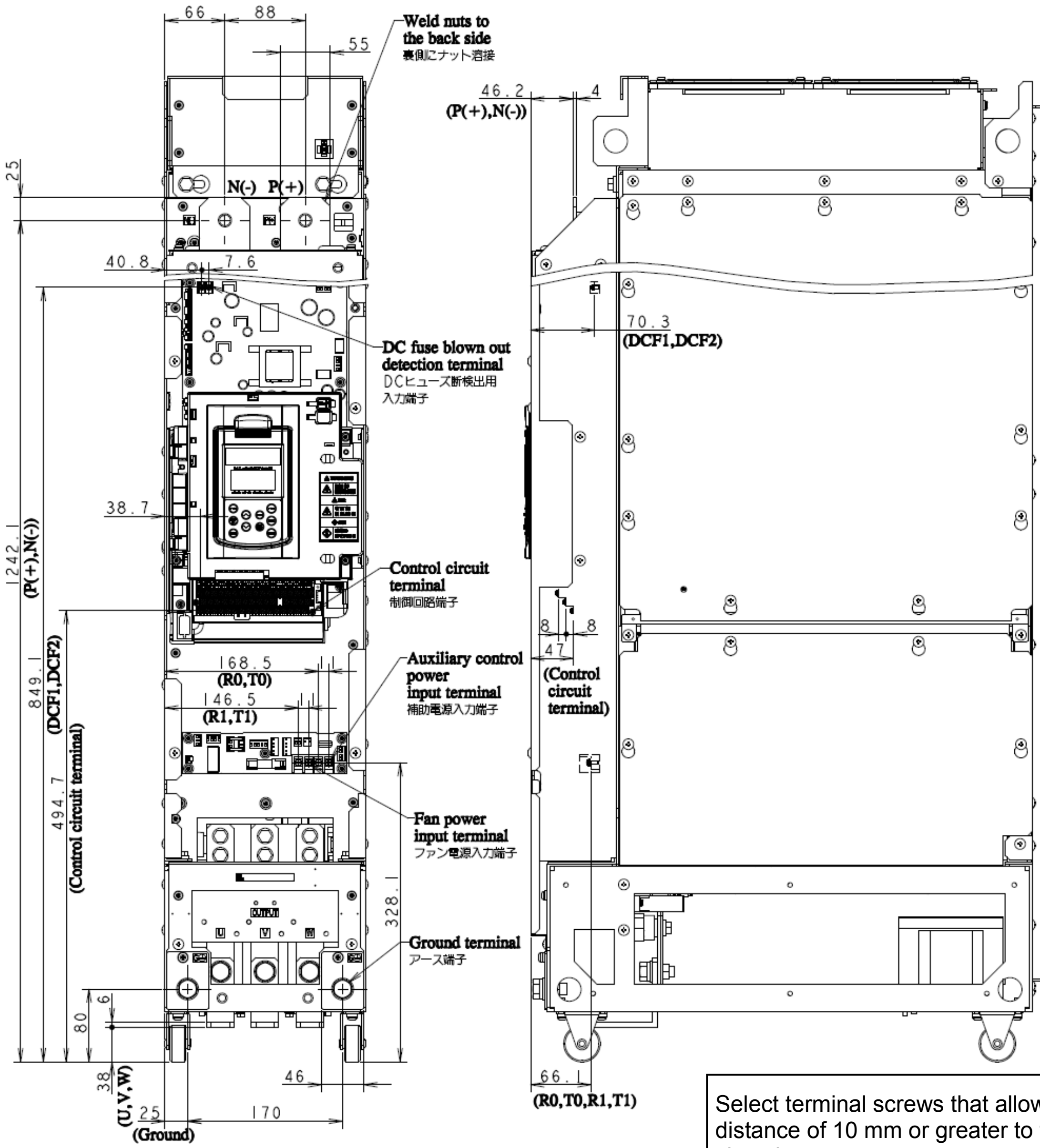


Figure 4.2.1-17: Set-in guide hole for the back face upper fixation plate

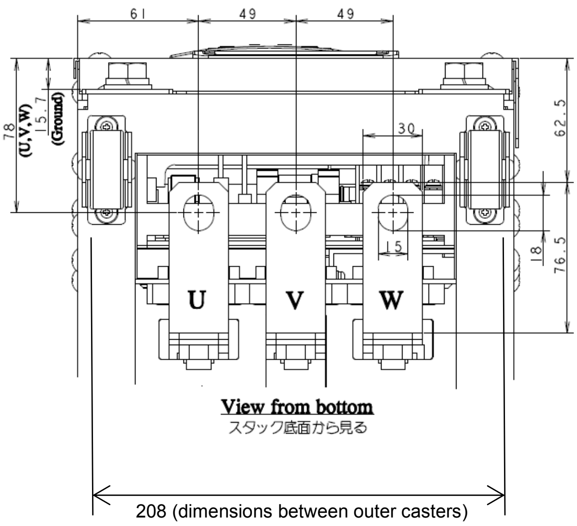
Note
(1) The figure above shows the dimensions for a single unit of stack type inverter.
(2) For stack type inverters, your design should be based on the horizontal spacing (clearance) of 12 mm (assuming the use of a cabinet with a width of 800).

[2] Terminal positions and screw sizes (main circuit terminals)

■ **Frame 4 size (400V:220 to 315 kW), models: FRN220SVG1S-4☐ to FRN315SVG1S-4☐**



Select terminal screws that allow for a distance of 10 mm or greater to the chassis.



Note

To connect output terminals for Frame 4 size, use a relay bus bar provided on the cabinet side.

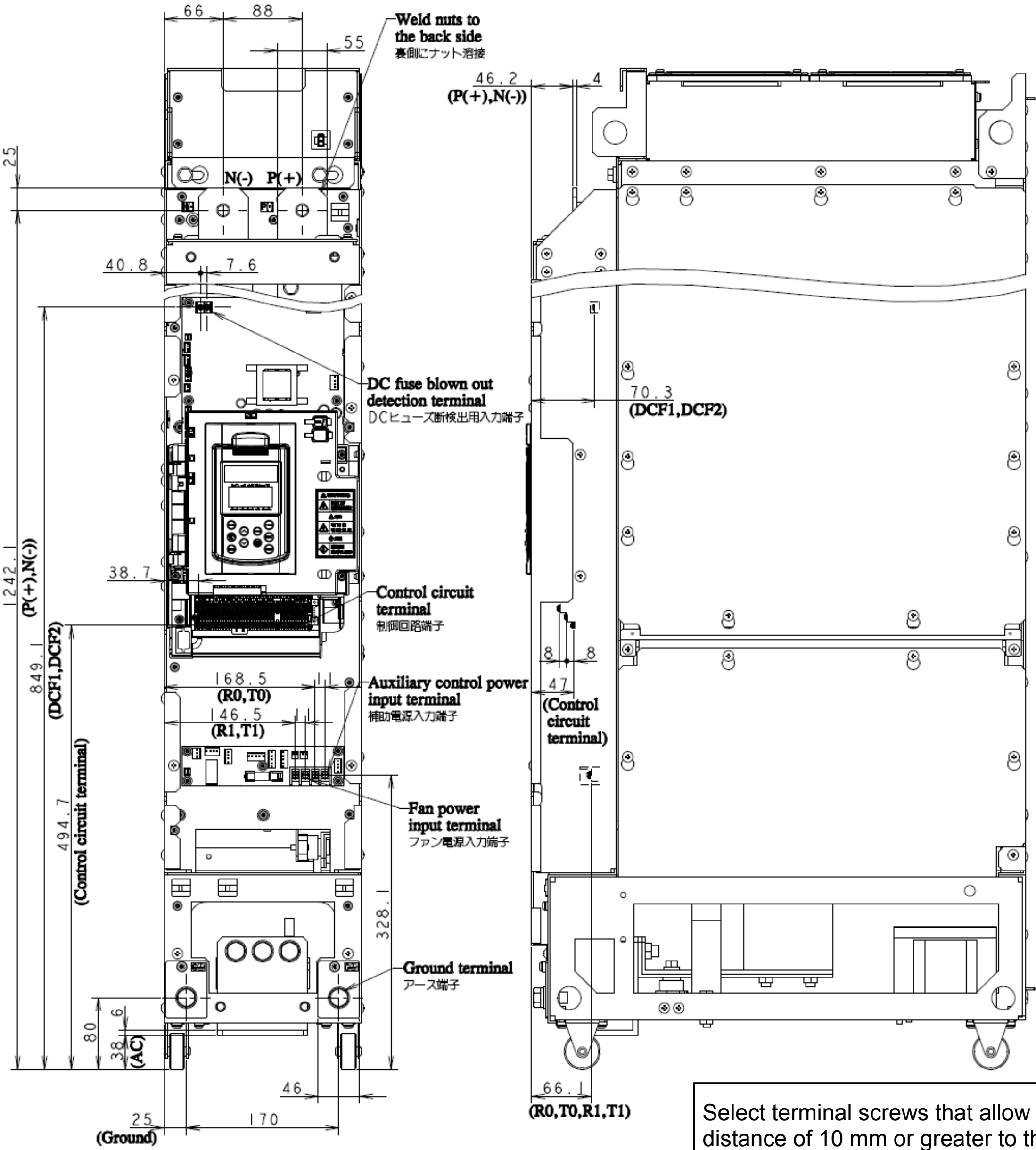
The relay bus bar should be fixed using an insulator.

Terminal name	Terminal symbol	Bolt size	Terminal tightening torque
Output terminal	U, V, W	M12	48 N·m
DC input terminal	P(+), N(-)		
Grounding terminal	G		

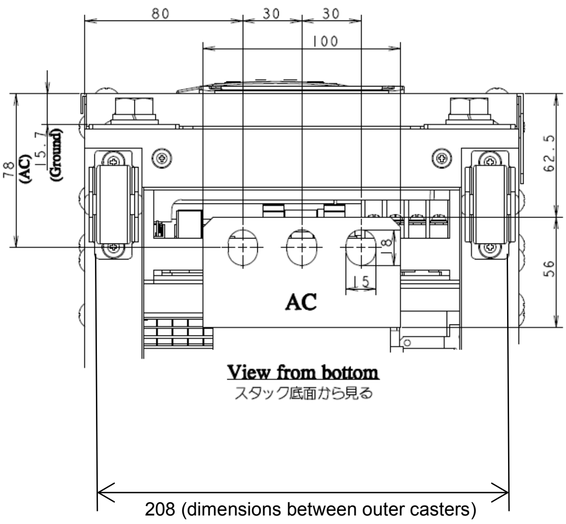
Figure 4.2.1-18: Terminal positions for Frame 4 size (400V: 220 to 315 kW)

■ Frame 4 size (400V: 630 to 800 kW), models: FRN630BVG1S-4□ to FRN800BVG1S-4□ (V-phase)

Unit: [mm] <Internal front view> <Side face view: from the right side face>



Select terminal screws that allow for a distance of 10 mm or greater to the chassis.



Note

To connect output terminals for Frame 4 size, use a relay bus bar provided on the cabinet side.

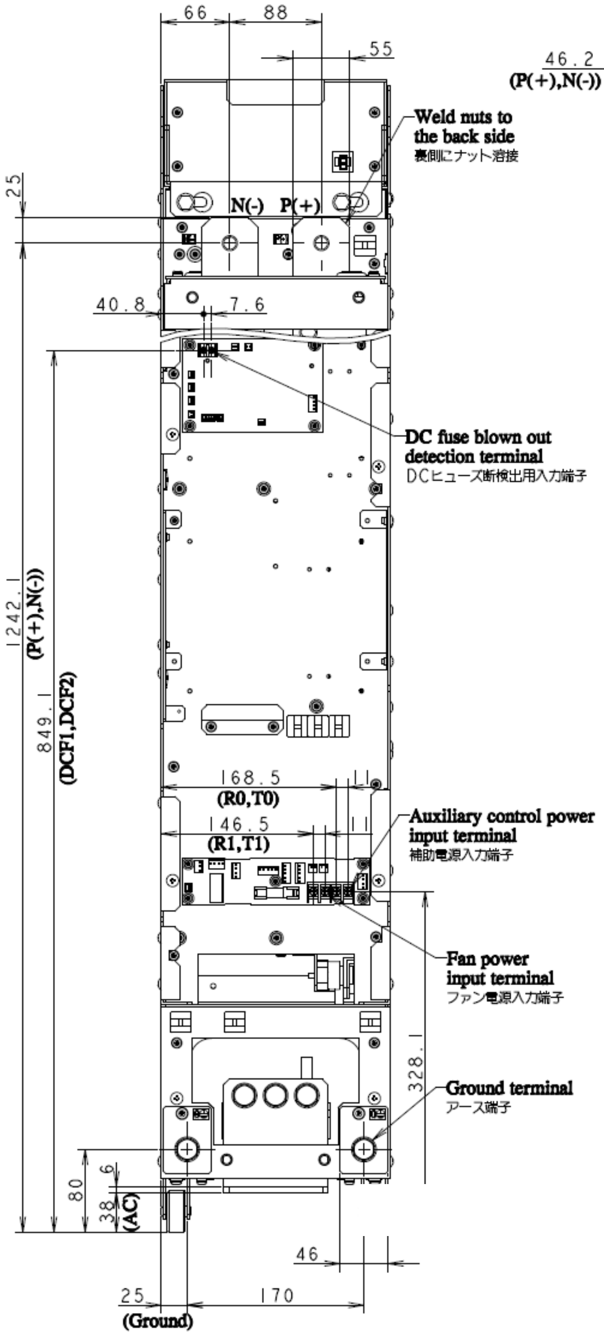
Terminal name	Terminal symbol	Bolt size	Terminal tightening torque
Output terminal	AC	M12	48 N·m
DC input terminal	P(+), N(-)		
Grounding terminal	G		

Figure 4.2.1-19: V-phase terminal positions for Frame 4 size (400V: 630 to 800 kW)

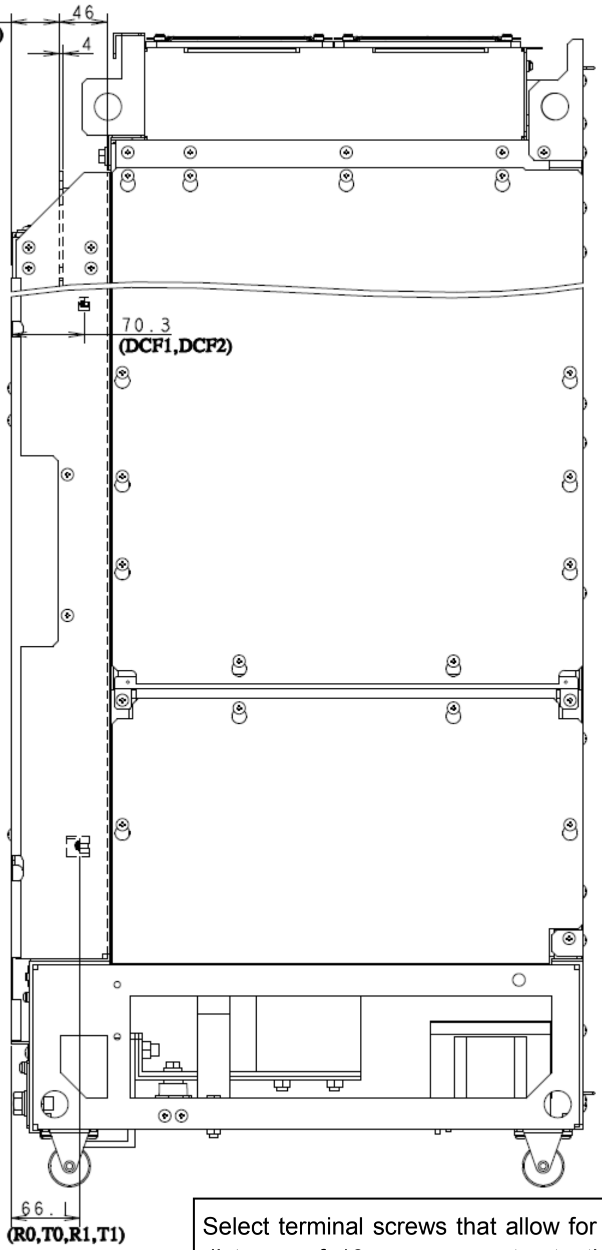
■ **Frame 4 size (400V: 630 to 800 kW), models: FRN630BVG1S-4☐ to FRN800BVG1S-4☐ (U- and W-phases)**

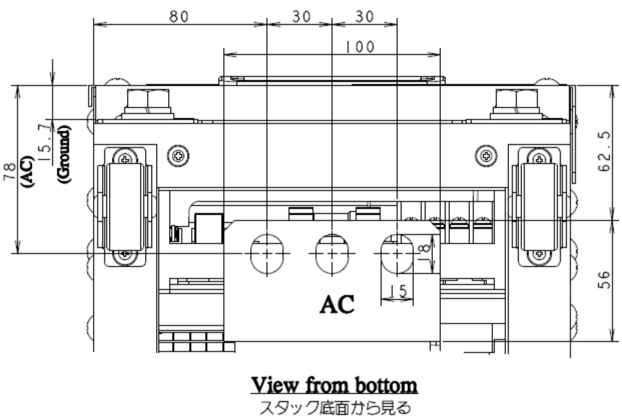
Unit: [mm]

<Internal front view>



<Side face view: from the right side face>





Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

Note

To connect output terminals for Frame 4 size, use a relay bus bar provided on the cabinet side.

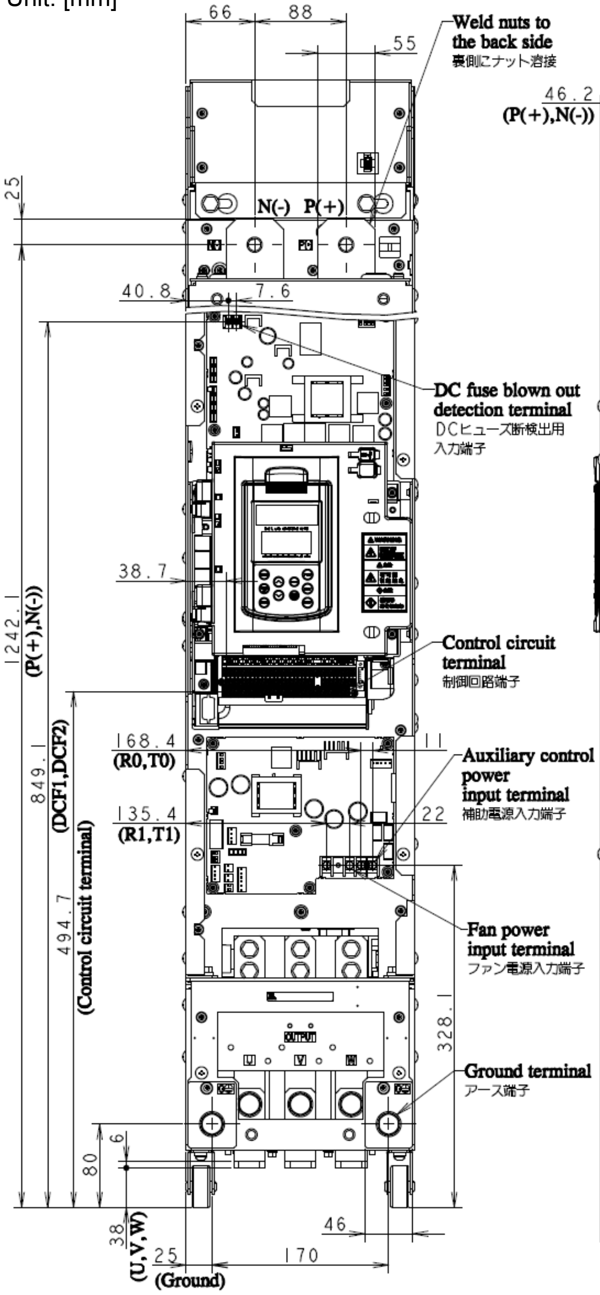
Terminal name	Terminal symbol	Bolt size	Terminal tightening torque
Output terminal	AC	M12	48 N·m
DC input terminal	P(+), N(-)		
Grounding terminal	⊕G		

Figure 4.2.1-20: U- and W-phase terminal positions for Frame 4 size (400V: 630 to 800 kW)

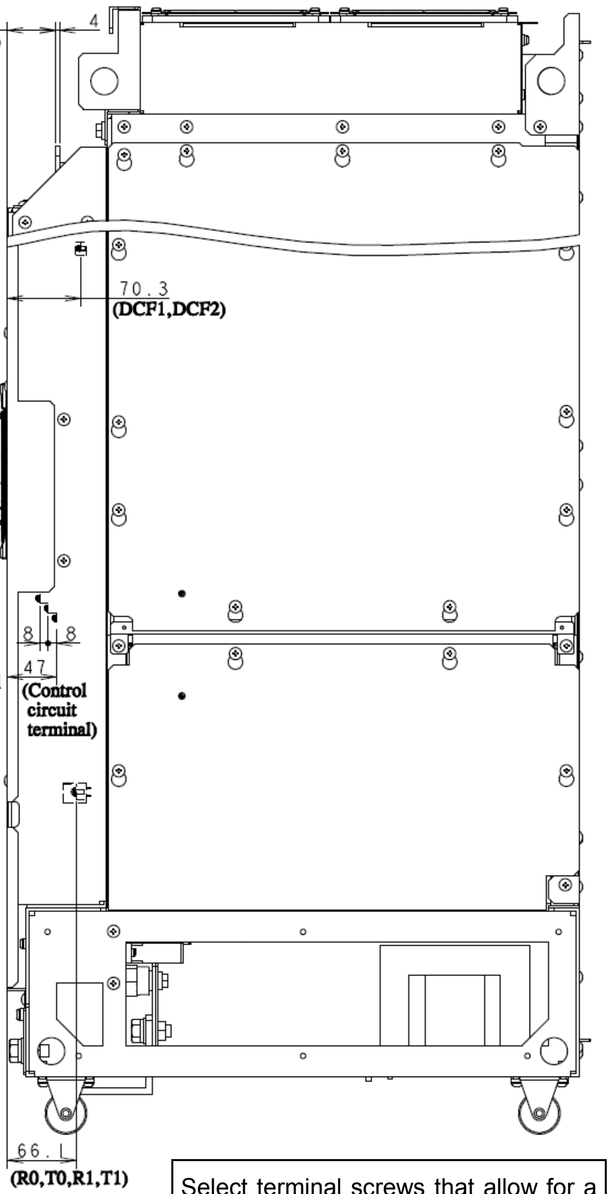
■ **Frame 4 size (690V: 250 to 450 kW), models: FRN250SVG1S-69□ to FRN450SVG1S-69□**

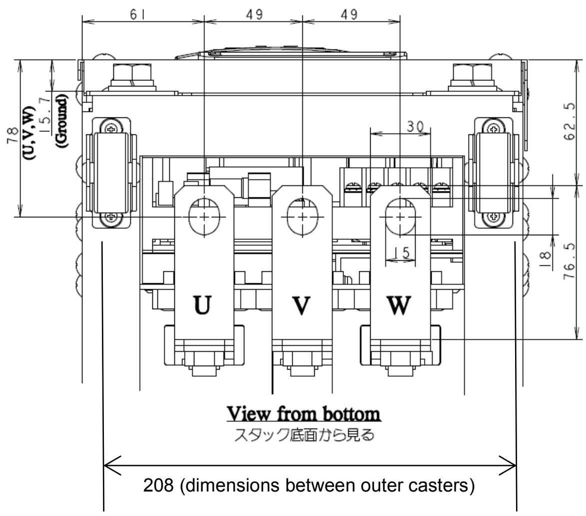
Unit: [mm]

<Internal front view>



<Side face view: from the right side face>





Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

Note

To connect output terminals for Frame 4 size, use a relay bus bar provided on the cabinet side.

The relay bus bar should be fixed using an insulator.

Terminal name	Terminal symbol	Bolt size	Terminal tightening torque
Output terminal	U, V, W	M12	48 N·m
DC input terminal	P(+), N(-)		
Grounding terminal	G		

Figure 4.2.1-21: Terminal positions for Frame 4 size (690V: 250 to 450 kW)

4.2.2 Installing stacks in cabinets

4.2.2.1 Precautions

(1) Circulation of exhaust air outside cabinets

Provide a cabinet adopting forced ventilation with an air intake in the lower area of the front door and an exhaust opening in the ceiling of the cabinet.
(Cabinet of IP20 or equivalent protection level)

Note that even if an exhaust opening is provided in the ceiling in the longitudinal direction as shown in Figure 4.2.2-1, most of the exhaust heat will be released from the front face when there is a wall or something behind the back face of the cabinet. If the exhaust area is small and exhaust heat is released only in the direction of the front face, exhaust air velocity will significantly increase.

On the other hand, air is introduced into the cabinet from the air intake, so that there is a possibility that it will be circulated through a route as shown in Figure 4.2.2-1.

To prevent exhaust heat released from the cabinet from being introduced through the air intake, consider the location of installation and increase the exhaust area of the exhaust opening.

Note: If air is circuited through a route as shown in the right figure, the inside temperature of the cabinet may increase, and the stack may cause an overheat trip.

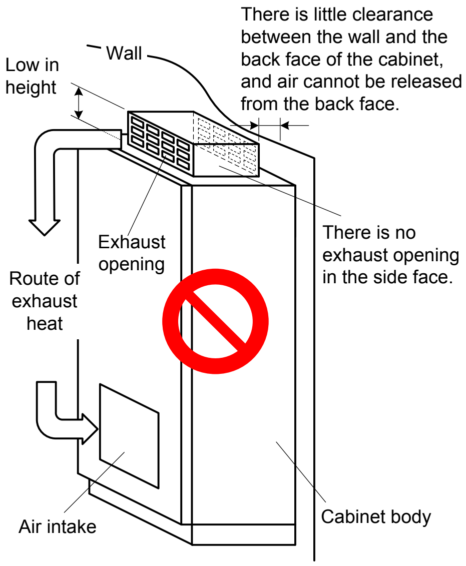


Figure 4.2.2-1: Example of heated exhaust intake (bad example)

(2) Partition of side faces of cabinet

When installing stacks side by side and connecting cabinets, install a partition plate between cabinets as shown in Figure 4.2.2-2.

In partition plates, open only a hole for passing the PN bar provided in the upper area of the cabinets. (Maintain an insulation distance between the PN bars and steel panel of each cabinet.)

Note: If no partition plate is installed between cabinets, exhaust air may circulate inside the cabinets and may not be completely released, which may result in an overheat trip of the stacks.

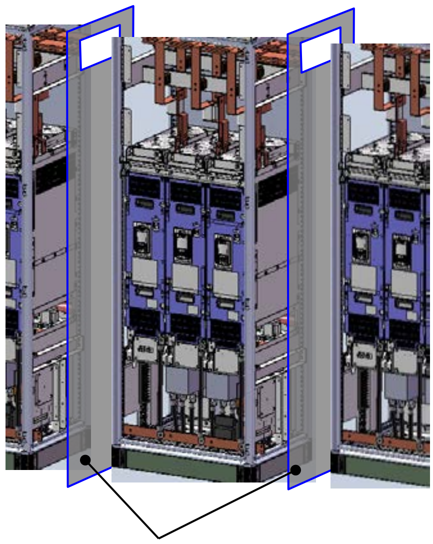


Figure 4.2.2-2: Example of installation of partition plates

(3) Circulation of exhaust air released from stacks inside cabinets

When maintaining a horizontal spacing (clearance) of 10 mm or over between stacks contained in the same cabinet, install a circulation prevention plate in a position close to the upper area of the stacks to prevent the ingress of exhaust air released from the stacks into the clearance.

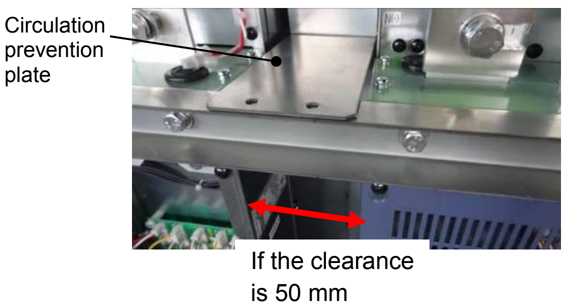


Figure 4.2.2-3: Example of installation of exhaust air circulation prevention plate

Note:
1) If a circulation prevention plate is not used, the stacks may cause an overheat trip.
2) If you mount the stacks on the cabinet side surfaces, similarly attach circulation prevention plates.

(4) Horizontal installation of stacks

Install stacks horizontally in cabinets in the direction shown in Figure 4.1.3-1 (on page 4-3).
If a stack is installed aslant, it may be distorted, or the casters may bend.

(5) Tightening torques

Tighten screws and bolts to the torques specified in Table 4.2.2-1.

If tightening torques are specified for the place or equipment, tighten them to the specified torques.

In addition, use screws and bolts in combination with a spring washer or flat washer.

Note (1) If the tightening torque applied to a conductive portion greatly deviates from the specified torque, the screw may become loose or the conductive portion will be separated, resulting in failure to maintain the normal contact state and unusual heat generation from the contact portion.

(2) Specified tightening torques are different between conductive portions (contact portion between bus bars or between a crimped terminal and an appliance terminal, etc.) and structures (steel panels and frames of cabinets, etc.).

Table 4.2.2-1: Tightening torques

[Unit: N·m]

Designation of screw	Conductive portion	Structure
M3	0.53±0.06	0.7±0.08
M3.5	0.88±0.11	1.2±0.14
M4	1.3±0.16	1.8±0.21
M5	2.7±0.32	3.5±0.42
M6	5±0.6	5.8±0.7
M8	12±1.4	13.5±1.6
M10	24±2.9	27±3.2
M12	40±4.8	48±5.8
M16	85±10.2	118±14

4.2.2.2 Procedure for removing and attaching the front cover

(1) Loosen the screws fastening the front cover (four screws for Frame 1; six for Frame 2: eight for Frame 3: ten for Frame 4).
Potbelly-shaped holes are used for the points of mounting of the front cover and allow the front cover to be removed without unfastening the screws.

(2) When the front cover is not provided with a hand opening, hold the right and left ends of the front cover with both hands, and slide and remove it.
When the front cover is provided with a hand opening, lift the hand opening, and slide and remove the front cover.

(3) Attach the front cover by reversing the removal procedure.

(4) To make the control terminal on the control PCB visible, open the keypad case.
The keypad case opens and closes on the left side.

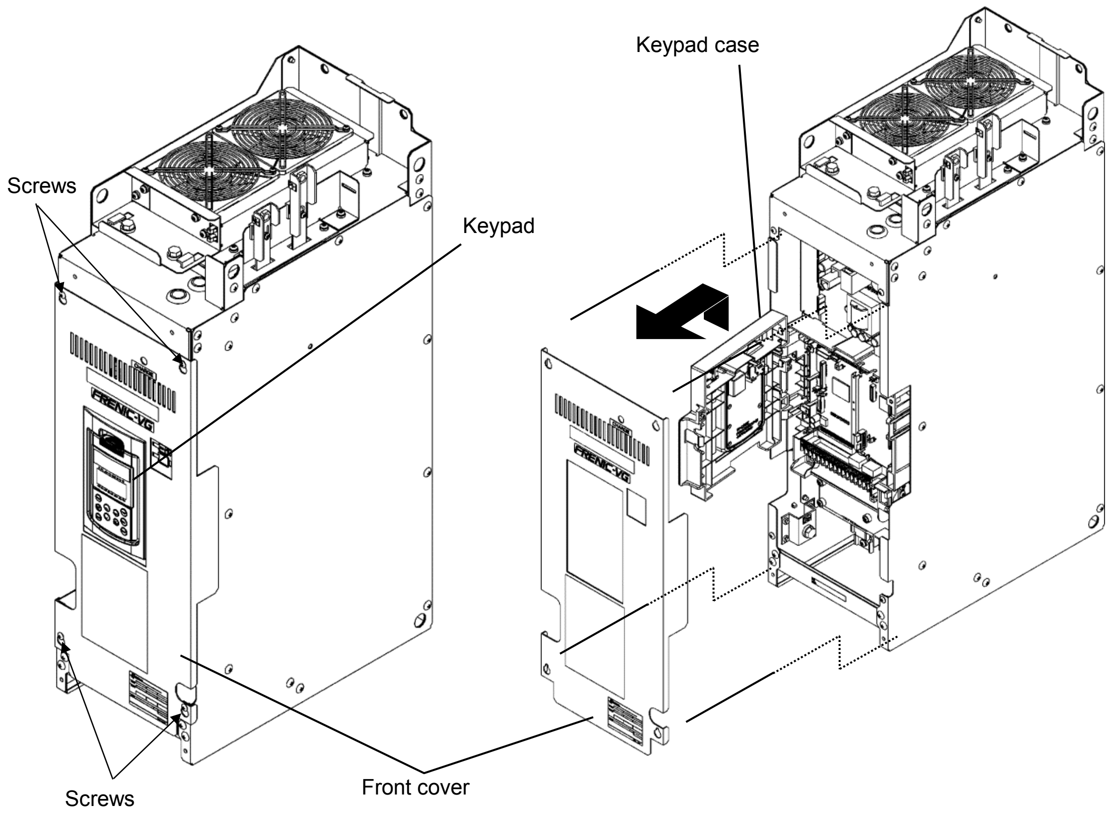


Figure 4.2.2-4: How to remove the front cover

4.2.2.3 Installing Frame 1 and 2 size stacks (400V: 30 to 110 kW, 690V: 90 to 110 kW)

(1) Installation procedure

To install in cabinets Frame 1 and 2 size stacks (400V series: 30 to 45 kW [Frame 1], 55 to 110 kW [Frame 2]. 690V series: 90 to 110 kW [Frame 2]), use the following procedure:

1) Place a stack on the stack installation frame. Then, push both side faces of the stack (area below the center) to the specified position.
2) Fix the stack with screws at the points of fixation on the further side. (M8 bolt x 2)
3) Using a fixation attachment, fix the stack with a screw (M5-12 to 25) at the point in the **lower area of the front face**.

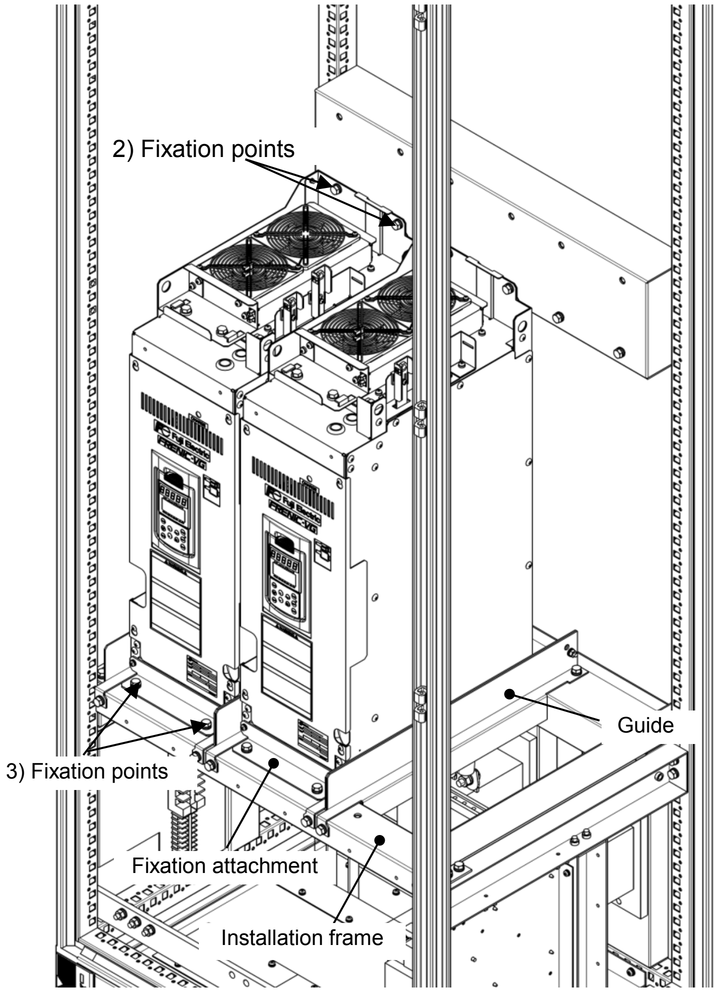


Figure 4.2.2-5: How to fix Frame 1 and 2 size stacks (400V: 30 to 110 kW, 690V: 90 to 110 kW) in a cabinet

Note

- Fix the stack in order of “points of fixation” (2), and (3) shown in the left figure.
- Carry out steps (3) mentioned above by making reference to **(3) Description**.

(2) Removal procedure

Remove the stack by reversing the "**(1) Installation procedure**" above.

When drawing out the stack, remove the front cover of the stack, and hold the hand opening provided in the lower area.

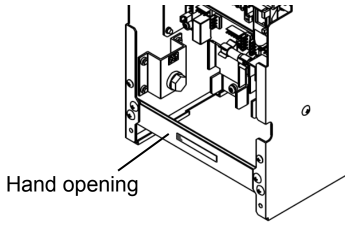


Figure 4.2.2-6: Position of hand opening

Note

(1) Frame 1 and 2 size (400V: 30 to 110 kW, 690V: 90 to 110 kW) stacks are not provided with casters, and the legs in the lower area of the stack rub against the cabinet when setting or drawing it out. If a painted steel panel is used on the cabinet side, the paint will come off from the rubbed area, and the area will get corroded. For this reason, it is advisable to use SUS panels or plated steel panels rather than painted steel panels. The legs of stacks that come into contact with cabinets use a plated steel panel (unpainted), and the cut face of the panel is chamfered so as not to cause damage to cabinets.

(2) Secure work space behind the back face to fix the stack at the points of fixation on the back face.

(3) Installing a **guide** for setting and drawing out stacks on the cabinet in advance ensures the smooth setting and draw-out of stacks.

(4) Create the fixation attachment on the front face of the stack according to the recommended dimensions. (See Figure 4.2.1-3 (on page 4-7).)
Design the cooling fan of the stack to be detached without removing this fixation attachment.

(5) The upper area of the stack is designed to attach a DC fuse. Lay out this area so that this DC fuse can be easily attached and detached.

(6) Do not fix the stack aslant.

(3) Description

1) Fixing the lower area of the front face of the stack (step 2 of "**(1) Installation procedure**").
Fix the lower area of the front face of each stack to be installed in a cabinet.
Temporarily fasten the fixation attachment to the stack and then to the frame of the cabinet. After the fixation attachment is temporarily fastened to the stack and the frame, securely tighten the temporarily fastened points of fixation.

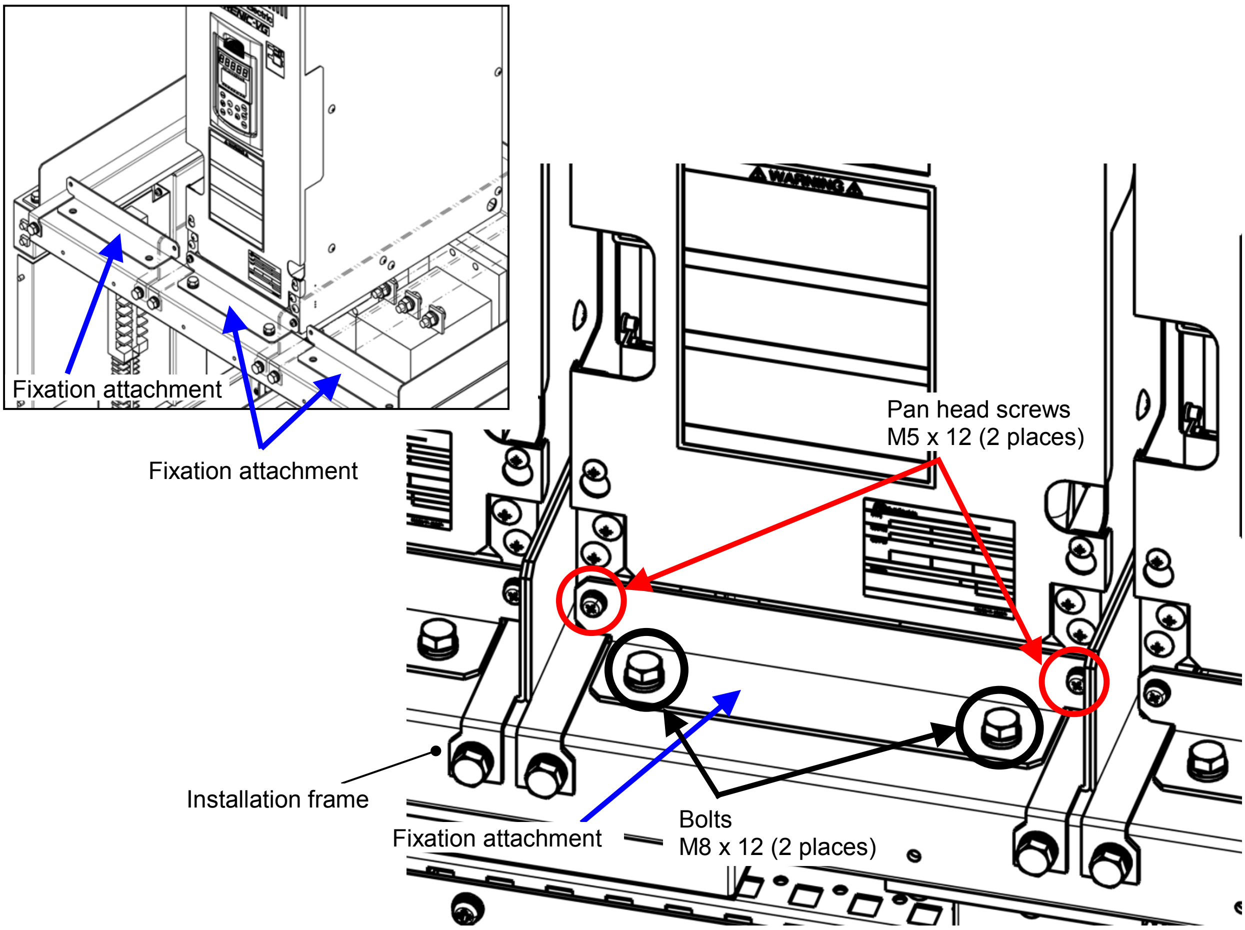


Figure 4.2.2-7: Fixing the front face lower area for Frame 1 and 2 size stacks (400V: 30 to 110 kW, 690V: 90 to 110 kW)

4.2.2.4 Installing Frame 3 and 4 size stacks (400V: 132 to 800 kW, 690V: 132 to 450 kW)

To install in cabinets Frame 3 and 4 size stacks (400V series: 132 to 200 kW [Frame 3], 220 to 800 kW [Frame 4]. 690V series: 132 to 200 kW [Frame 3], 250 to 450 kW [Frame 4]), use the following procedure:

When installing stacks of these frame sizes, attach a bus bar terminal, which relays the main circuit terminal in the lower area of the stacks, in advance.

(1) Installation procedure

Follow the procedure described below to install a stack in a cabinet.

1) Place a stack on the stack installation frame. Then, hold the hand opening, and push the stack until the fixation plate on the back face is fitted into the set-in guide.
2) Using a fixation attachment, fix the stack with a bolt (M8-16 bolt) at the point in the **lower area of the front face**.
3) Using a fixation attachment, fix the stack with a bolt (M8-16 bolt) at the point in the **upper area of the front face**.

Note Fix the stack in order of "points of fixation" (2) and (3) shown in the figure below.

(2) Removal procedure

Remove the stack by reversing "**(1) Installation procedure**" above. When drawing out the stack, remove the front cover of the stack, and hold the hand opening provided in the lower area.

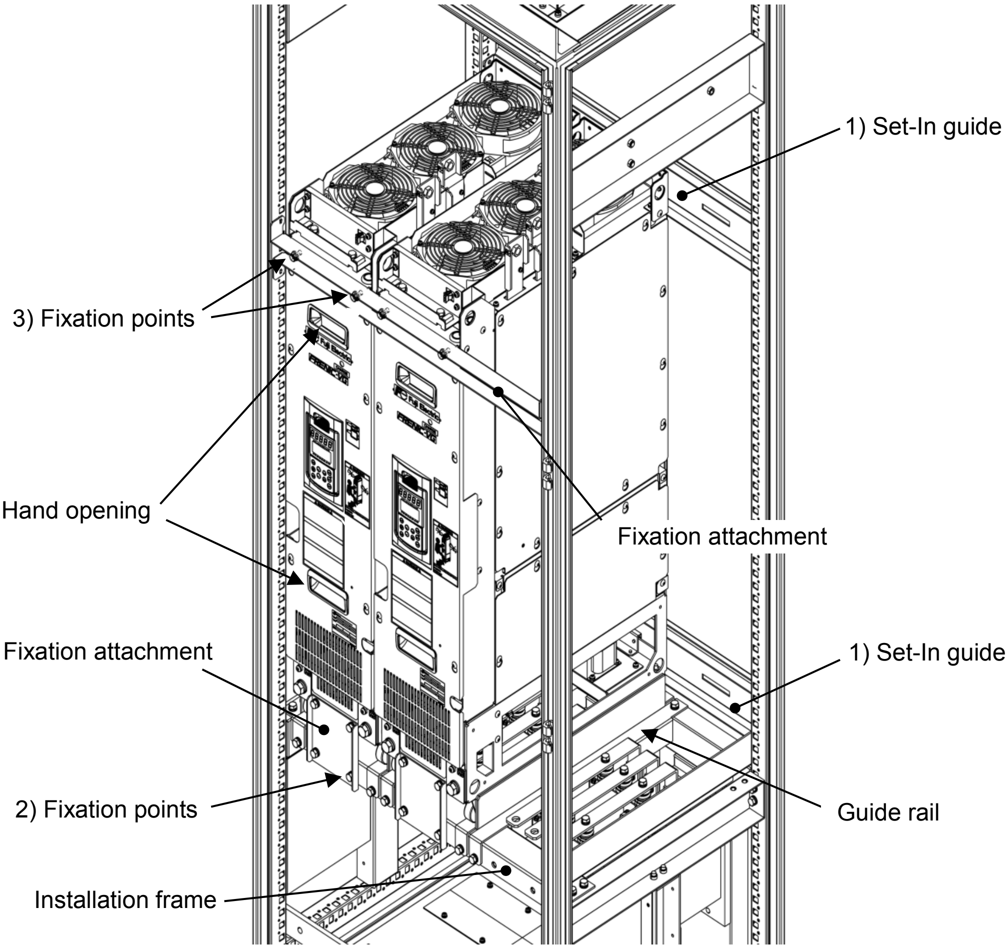


Figure 4.2.2-8: How to fix Frame 3 and 4 size stacks (400V: 132 to 800 kW, 690V: 132 to 450 kW) in a cabinet

Note
(1) Frame 3- and 4 size stacks (400V: 132 to 800 kW, 690V: 132 to 450 kW) are provided with casters. Install caster guides on the cabinet. If caster guides are painted, the paint may come off when setting or drawing out stacks. It is advisable to use SUS panels or plated steel panels.

(2) Create the fixation attachment on the front face of the stack according to the recommended dimensions. (See Figure 4.2.1-14 (on page 4-16) and Figure 4.2.1-15 (on page 4-17).)
Design the cooling fan of the stack to be detached without removing this fixation attachment.

(3) The upper area of the stack is designed to attach a DC fuse. Lay out this area so that this DC fuse can be easily attached and detached.

(4) Do not fix the stack aslant.

(3) Description

1) Guide rail

Caster outer perimeters for the respective inverter models are specified in the figures listed below. Install guide rails based on the specified perimeter according to the dimensions of the inverter used.

- 400V series, 132 to 200 kW ⇒ Figure 4.2.1-8 (page 4-12)
- 690V series, 132 to 200 kW ⇒ Figure 4.2.1-9 (page 4-13)
- 400V series, 220 to 315 kW ⇒ Figure 4.2.1-18 (page 4-19)
- 400V series, 630 to 800 kW ⇒ Figure 4.2.1-19 (page 4-20)
- 690V series, 250 to 450 kW ⇒ Figure 4.2.1-21 (page 4-22)

(A) Guide rail on back face

(B) Guide rail on front face

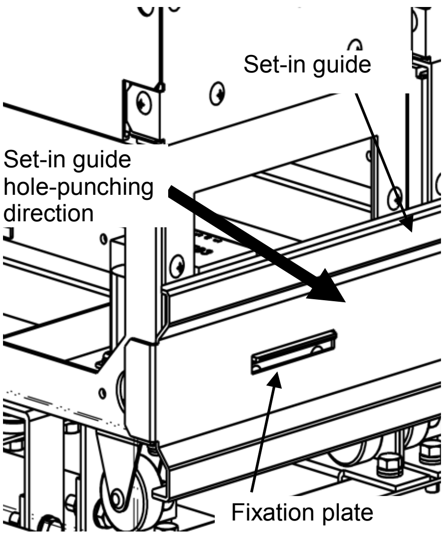
Figure 4.2.2-9: Examples of guide rails

2) Fixation plate set-in guide on the back face of the stack

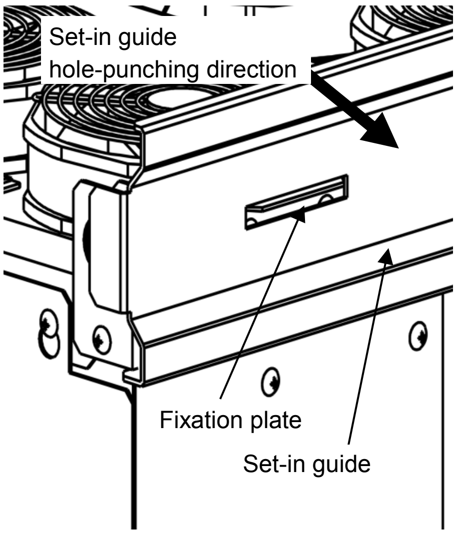
The relationship between the sizes of the holes in the set-in guide and the position of the stack fixation plate is shown in Figure 4.2.1-16 and Figure 4.2.1-17 (on pages 4-17 and 4-18). Note that size and the clearance are different between the upper and lower holes.

If it is possible to bend as the figure below, it is advisable to use a 2.3-mm-thick steel sheet to manufacture a set-in guide. When bending a steel sheet only in the vertical direction to manufacture a set-in guide, use a 3.2-mm-thick steel sheet.
Punch holes in the set-in guide in the directions specified in the figures below.

(A) Lower area of back face



(B) Upper area of back face



Steel plate shape recommended when t = 3.2 mm

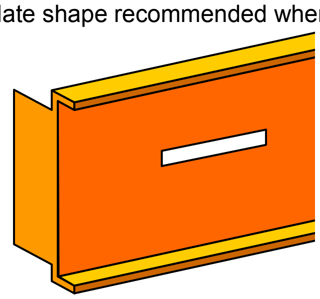


Figure 4.2.2-10: Overview of set-in guide for Frame 3 and 4 size stacks (400V: 132 to 800 kW, 690V: 132 to 450 kW)

3) Fixing the lower area of the front face of the stack (step 2 of "**(1) Installation procedure**")

Fix the lower area of the front face of each stack to be installed in a cabinet.

Temporarily fasten the fixation attachment to the stack and then to the frame of the cabinet.

After the fixation attachment is temporarily fastened to the stack and the frame, securely tighten the temporarily fastened points of fixation on the stack side.

Finally, pushing the stack in the direction of the back face, securely tighten temporarily fastened points of fixation on the cabinet side.

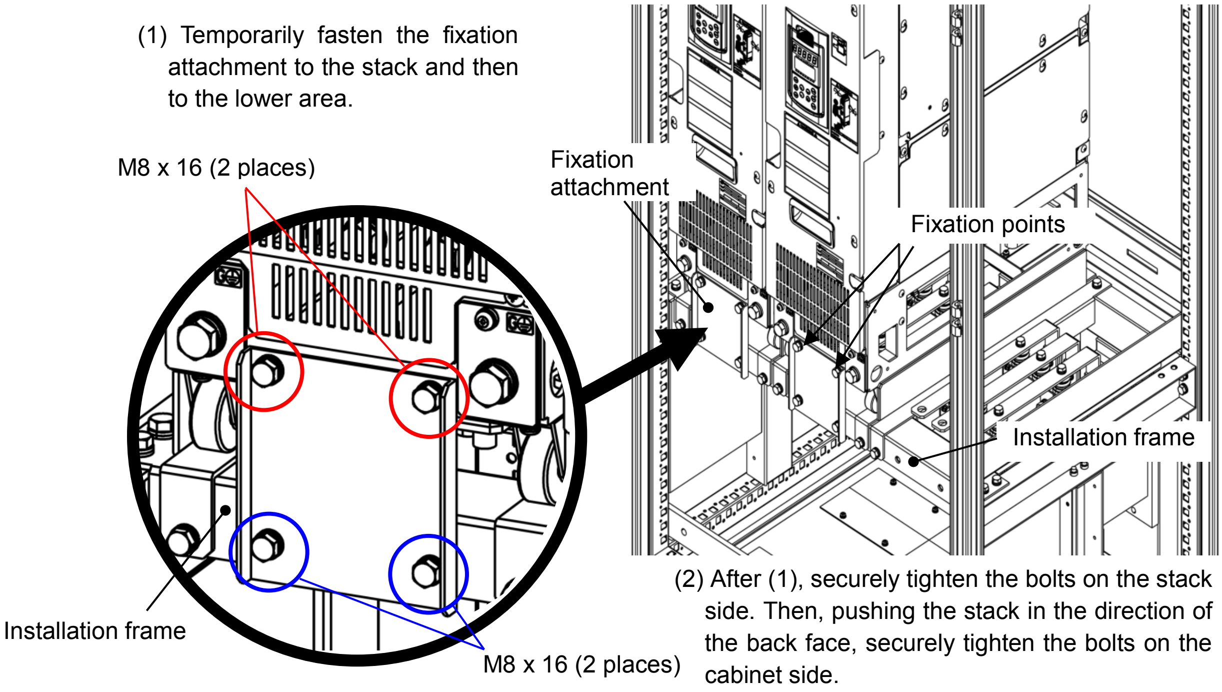


Figure 4.2.2-11: Fixing the front face lower area for Frame 3 and 4 size stacks
(400V: 132 to 800 kW, 690V: 132 to 450 kW)

4) Fixing the upper area of the front face (step 3 of "**(1) Installation procedure**")

The upper areas of the front faces of stacks are designed to collectively fix the stacks to be installed with a fixation attachment.

Temporarily fasten the fixation attachment to the frame of the cabinet, and fix each stack. Finally, pushing the stack in the direction of the back face, securely tighten the temporarily fastened points on the frame side.

Note Design this fixation attachment with a tolerance that presses it in the direction of the back face.

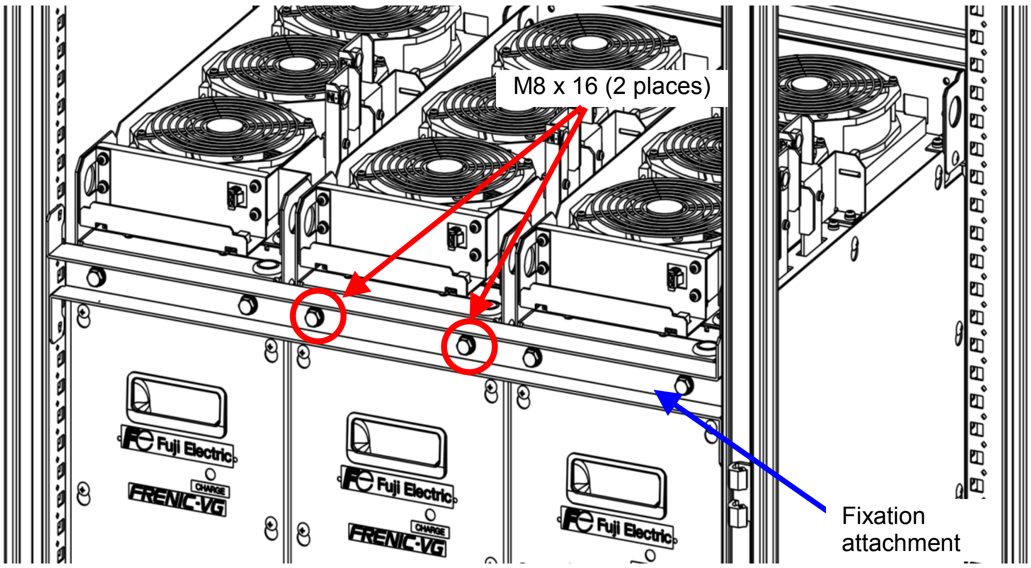


Figure 4.2.2-12: Fixing the front face lower area for Frame 3 and 4 size stacks
(400V: 132 to 800 kW, 690V: 132 to 450 kW)

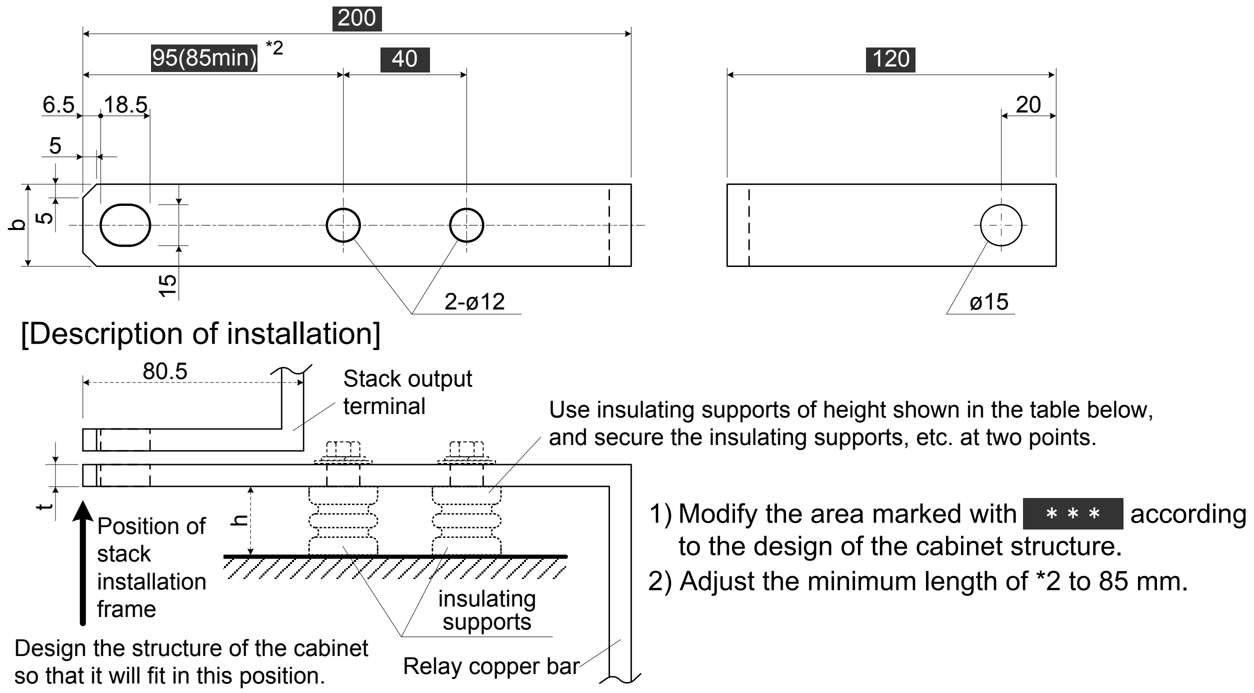
4.2.2.5 Connecting output terminals of Frame 3 and 4 size stacks (400V: 132 to 800 kW, 690V: 132 to 450 kW)

In Frame 3 and 4 size stacks (400V: 132 to 800 kW, 690V: 132 to 450 kW), connect a wire and etc. by connecting a relay copper bar to stack output terminal. This section describes relay copper bars.

Relay copper bars of the same shape are available for both Frame 3 and 4 size stacks.

Figure 4.2.2-13 shows the recommended size of a relay copper bar. Prepare a relay copper bar based on the figure, as well as an insulator for fastening this copper bar to the frame of the cabinet.

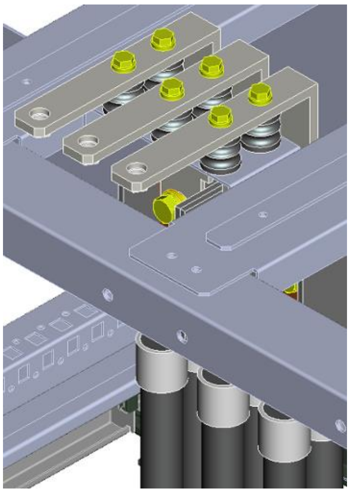
Note
(1) Connect a relay copper bar before installing a stack.
(2) When removing stack type inverters, loosen the stack type output terminal bolts, lift and then pull out to prevent the output terminals interfering with the relay copper bar.



Model	Voltage: *[V]	Model capacity: # [kW]	Relay copper bar size: t [mm]×b [mm]	Insulating support height: h [mm]
Inverters: FRN*SVG1S-# PWM converters: RHC*S-#D Diode rectifiers: RHD*S-#D	400	132 to 200	5×30	27 to 31
		220 to 315	10×30	26 to 30
		630 to 800	10×125	
	690	132 to 220	5×30	27 to 31
		250 to 450	10×30	26 to 30
Filter stacks: RHF*S-#D	400	160 to 220	5×30	34 to 38
		280 to 355	10×30	33 to 37
	690	160 to 220	5×30	34 to 38
		280 to 450	10×30	33 to 37

Figure 4.2.2-13: Recommended size of a relay copper bar, insulating supports

Connect the relay copper bar and output wiring before installing the stack.



The **clearance between the stack output terminal and the relay copper bar is 1 mm or greater. The stack output terminal is designed such that its vertical position can be adjusted.**

Fix the stack to the cabinet and then make connections as shown below.

The stack is designed to be installable in a cabinet without modification.

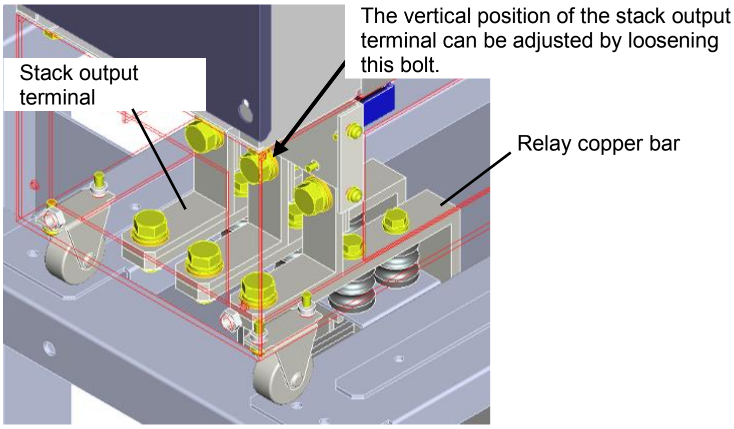


Figure 4.2.2-14: Precautions when connecting a relay copper bar

4.2.3 Connecting DC bus bars

A stack has DC bus bar connection terminals P (+) and N (-) in the upper area. By setting DC bus bars in the upper area of the cabinet side, the P (+) and N (-) terminals can be easily connected.

(1) For DC bus bars on the cabinet side, see "4.3 Basic configuration of cabinets".
(2) Select a bus bar size according to "4.4 Bus bars".

4.2.3.1 Connecting bus bars for Frame 1 to 3 size stacks (400V: 30 to 200 kW, 690V: 90 to 200 kW)

For Frame 1 to 3 size stacks (400V: 30 to 200 kW, 690V: 90 to 200 kW), the P (+) and N (-) terminals are attached on the right side of the stack.
(Refer to Figure 4.2.1-1 (on page4-6) and Figure 4.2.1-7 (on page 4-11).)

Since nuts are welded to the P (+) and N (-) terminals, position them so that the DC bus bars from the DC line will contact on the reverse side.
(Refer to Figure 4.2.3-1.)

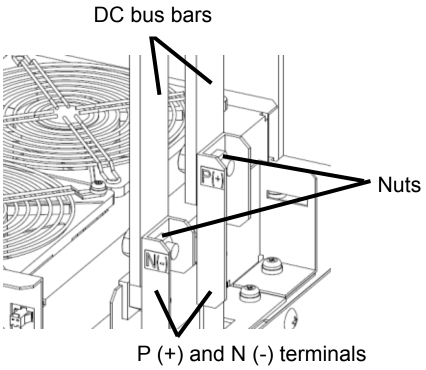
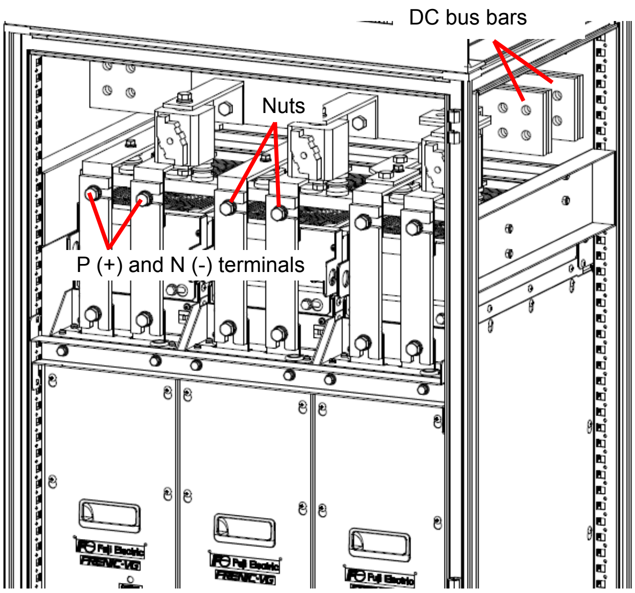


Figure 4.2.3-1: Examples of DC bus bar connections for Frame 1 to 3 size stacks

4.2.3.2 Connecting bus bars for Frame 4 size (400V: 220 to 800 kW, 690V: 250 to 450 kW)

For Frame 4 size stacks (400V: 220 to 800 kW, 690V: 250 to 450 kW), the P (+) and N (-) terminals are attached on the front side of the stack. (Refer to Figure 4.2.1-10 (on page 4-14).) Since nuts are welded to the backside of these terminals, position them so that the DC bus bars from the DC line will contact on the front side. (Refer to Figure 4.2.3-2.)



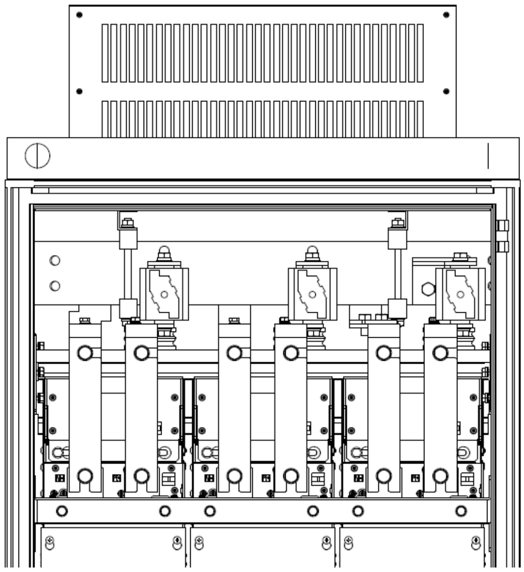


Figure 4.2.3-2: Examples of DC bus bar connections for Frame 4 size (400V: 220 to 800 kW, 690V: 250 to 450 kW)

4.3 Basic configuration of cabinets

The basic structure of a stack cabinet is designed to accommodate three stacks. Design the cabinet structure based on this basic structure.

4.3.1 Appearance of cabinets

The basic cabinet structure is as shown below.

Cabinet specifications

(1) Ambient temperature : -5 to 40°C (annual average temperature: 35°C), temperature at inlet of stack: 40°C (maximum value)

(2) IP protection level : IP20

(3) Maintenance and inspection : Only access to the front face

(4) Air intake : Provided with a dust collection filter (for coarse dust)

(5) Single swinging door : Handle type. The door is fixed at three points - upper, lower, and central points.

(6) Size : Overall length = 800 x 2560 x 630
Body = 2200 x 800 x 600 (+30), height of exhaust opening = 260, channel base = 100

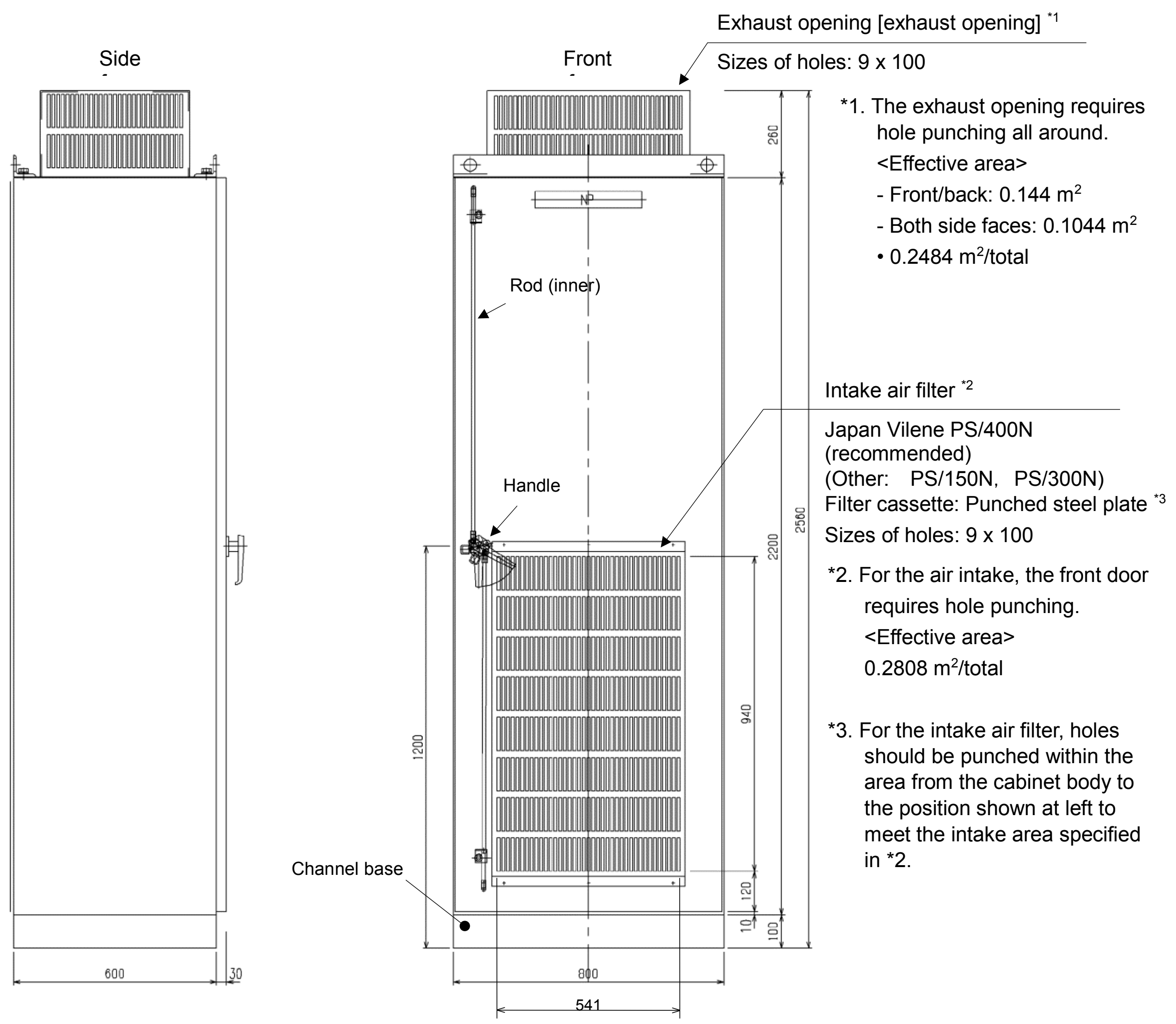


Figure 4.3.1-1: Appearance of cabinet

4.3.2 Internal layouts of cabinets

This section shows the internal layouts of cabinets, assuming the case where stack type inverters are used in conjunction with peripheral equipment (DCF: DC fuse) and a ACL (radio noise reducing zero-phase reactor) connected on the output side.

As a DC bus (DC bus bar), Cu x 100 (in two parallel rows) is adopted in consideration for connection of plural stacks and the low impedance of the PN bus.

4.3.2.1 Internal layout for Frame 1 size (400V: 30 to 45 kW)

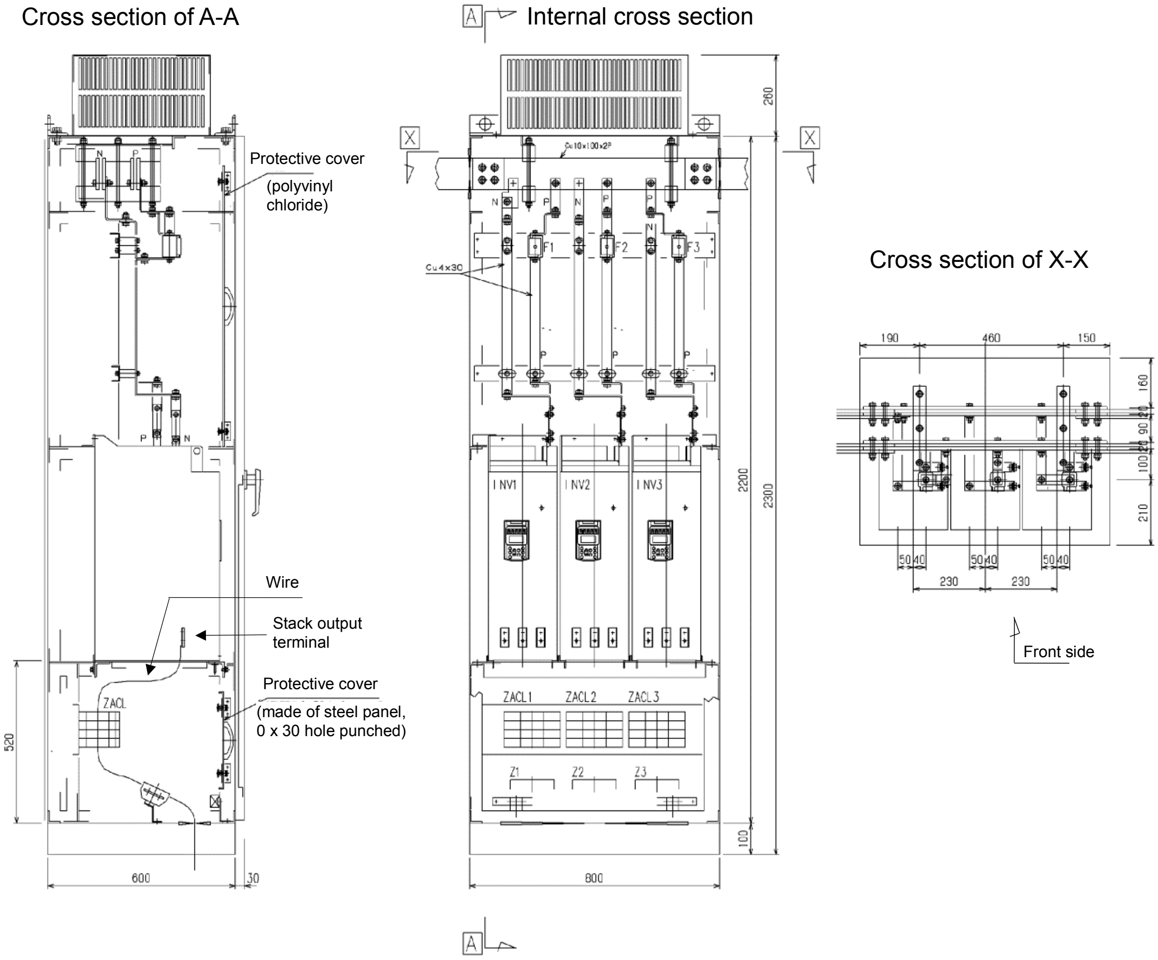


Figure 4.3.2-1: Example of internal layout for Frame 1 size (400V: 30 to 45 kW)

Components

■ **400V series**

Specifications	Model: FRN_		30SVG1S-4☐	37SVG1S-4☐	45SVG1S-4☐
	Rated current [A]	MD spec	60	75	91
		LD spec	75	91	112
DC fuse		F1-F3	Refer to "5.2.1.1 Fuses" in Chapter 5.		
Zero-phase reactor		ACL1-3	ACL-40B (x4)	ACL-40B (x4)	ACL-74B (x4)
External wire terminal		Z1-Z3	LT2E-080 (4pin)	LT2E-090 (4pin)	LT2E-150 (4pin)

Note

(1) The number of turns of the radio noise reducing zero-phase reactor (ACL) depends on the type and size of the wire to be used.
Thus, when this layout is applied, it is assumed that the wire is passed through the radio noise reducing zero-phase reactor only once.

(2) The external wire terminal block is selected based on the rated current of each inverter.
(Selection criteria: ambient temperature of 40°C and temperature rise of 30K.)

4.3.2.2 Internal layout for Frame 2 size (400V: 55 to 110 kW, 690V: 90 to 110 kW)

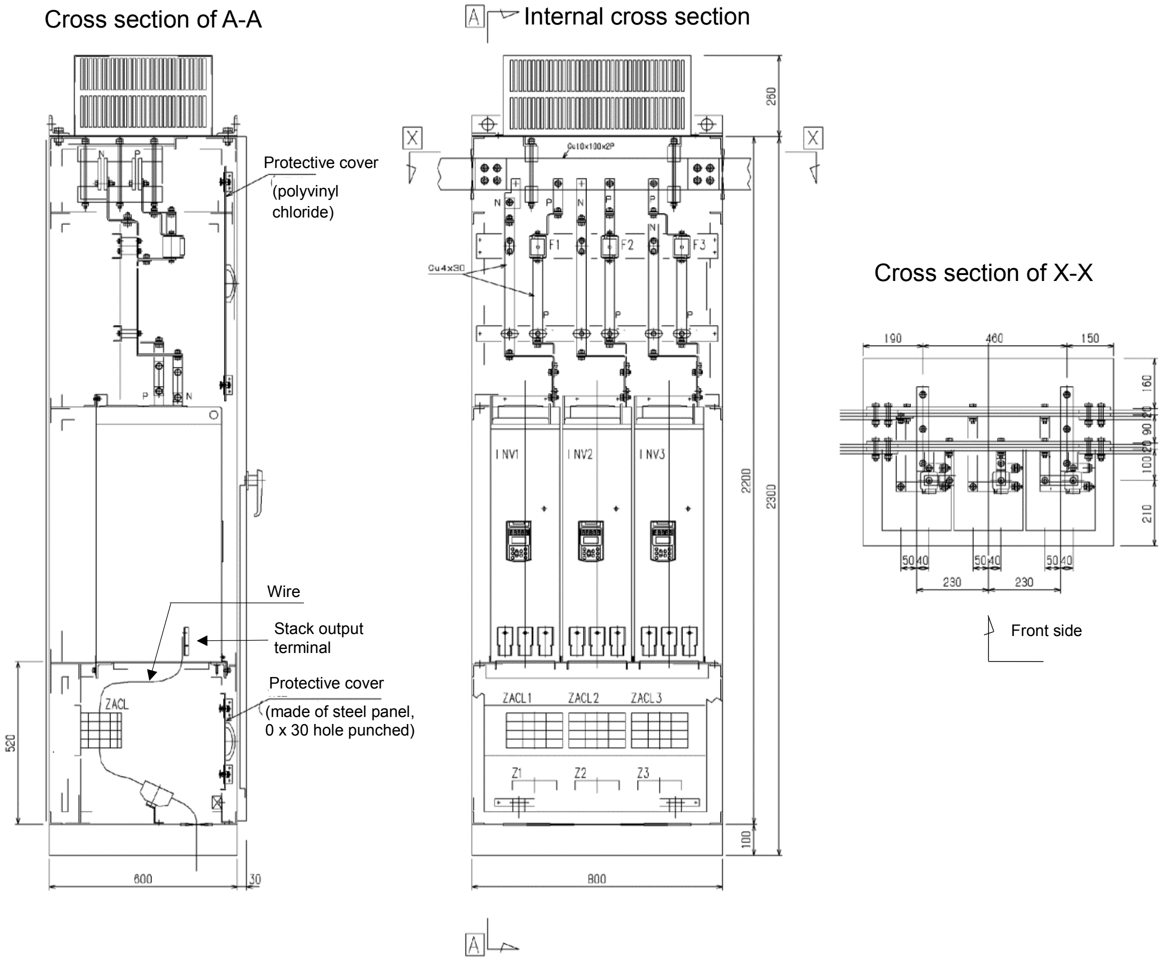


Figure 4.3.2-2: Internal layout for Frame 2 size (400V: 55 to 110 kW, 690V: 90 to 110 kW)

Components

■ **400V series**

Specifications	Model: FRN_		75SVG1S-4☐	90SVG1S-4☐	110SVG1S-4☐
	Rated current [A]	MD spec	150	176	210
		LD spec	176	210	253
DC fuse	F1-F3		Refer to "5.2.1.1 Fuses" in Chapter 5.		
Zero-phase reactor	ACL1-3		ACL-74B (x4)		
External wire terminal	Z1-Z3		LT2E-200 (4pin)	LT2E-300 (4pin)	

■ **690V series**

Specifications	Model: FRN_		90SVG1S-69☐	110SVG1S-69☐
	Rated current [A]	MD spec	100	130
		LD spec	130	140
DC fuse	F1-F3		Refer to "5.2.1.1 Fuses" in Chapter 5.	
Zero-phase reactor	ACL1-3		—	
External wire terminal	Z1-Z3		LT2E-150 (4pin)	

Note

(1) The number of turns of the radio noise reducing zero-phase reactor (ACL) depends on the type and size of the wire to be used.
Thus, when this layout is applied, it is assumed that the wire is passed through the radio noise reducing zero-phase reactor only once.

(2) The external wire terminal block is selected based on the rated current of each inverter.
(Selection criteria: ambient temperature of 40°C and temperature rise of 30K.)

4.3.2.3 Internal layout for Frame 3 size (400V: 132 to 200 kW, 690V: 132 to 200 kW)

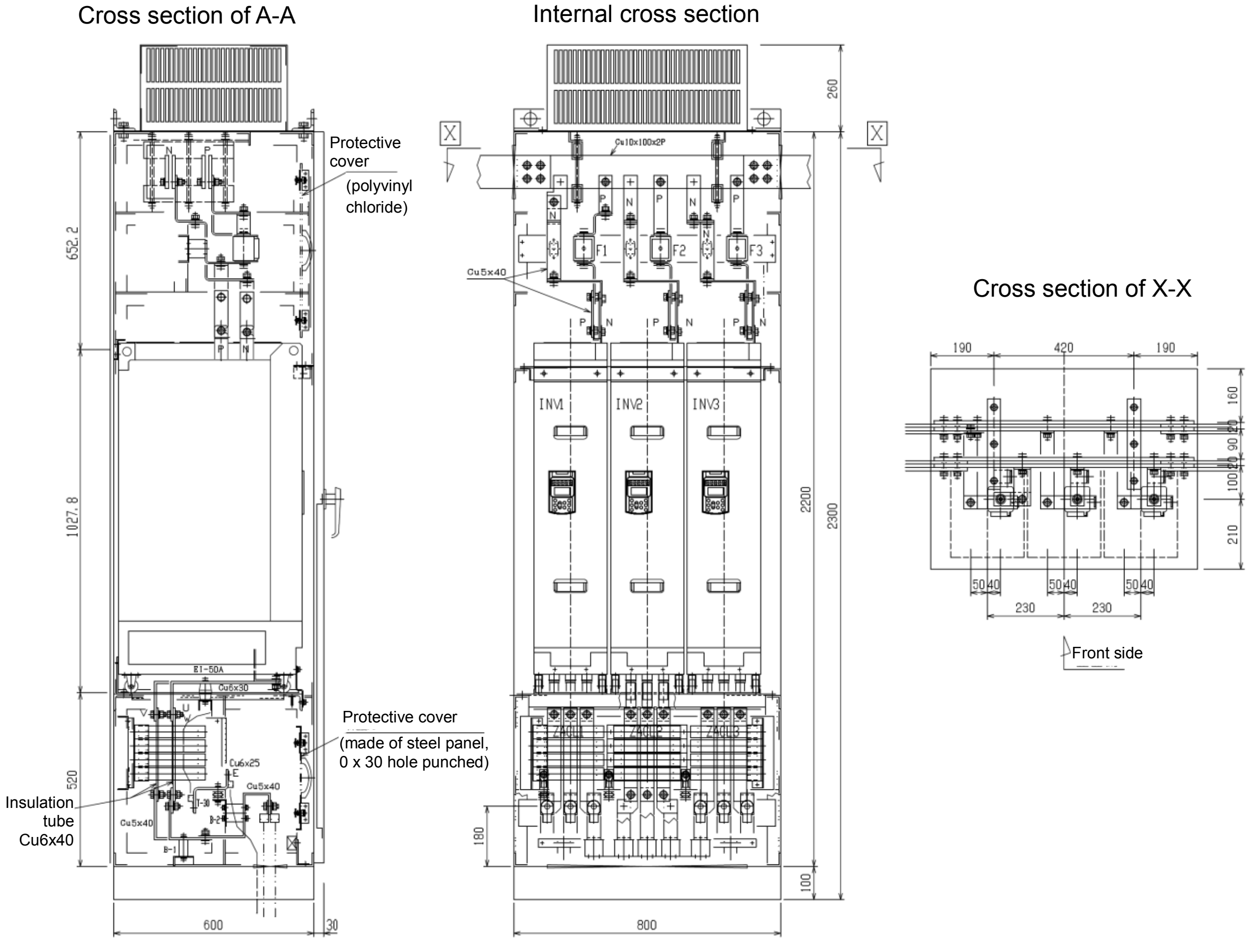


Figure 4.3.2-3: Internal layout for Frame 3 size (400V: 132 to 200 kW, 690V: 132 to 200 kW)

Components

■ **400V series**

Specifications	Model: FRN_		132SVG1S-4☐	160SVG1S-4☐	200SVG1S-4☐
	Rated current [A]	MD spec	253	304	377
		LD spec	304	377	415
DC fuse		F1-F3	Refer to "5.2.1.1 Fuses" in Chapter 5.		
Zero-phase reactor		ACL1-3	F200160PB (x4)		
External wire terminal		Z1-Z3	Cu5x30 (x3)		
		E	Cu6x25		

■ **690V series**

Specifications	Model: FRN_		132SVG1S-69☐	160SVG1S-69☐	200SVG1S-69☐
	Rated current [A]	MD spec	140	161	216
		LD spec	161	216	235
DC fuse		F1-F3	Refer to "5.2.1.1 Fuses" in Chapter 5.		
Zero-phase reactor		ACL1-3	—		
External wire terminal		Z1-Z3	Cu3x30 (x3)		
		E	Cu6x25		

Note (1) The number of turns of the radio noise reducing zero-phase reactor (ACL) depends on the type and size of the wire to be used. Thus, when this layout is applied, it is assumed that the wire is passed through the radio noise reducing zero-phase reactor only once.

(2) The external wire terminals are selected based on the rated current of each inverter. (Selection criteria: ambient temperature of 40°C and temperature rise of 30K.)

4.3.2.4 Internal layout for Frame 4 size (400V: 220 to 800 kW, 690V: 250 to 450 kW)

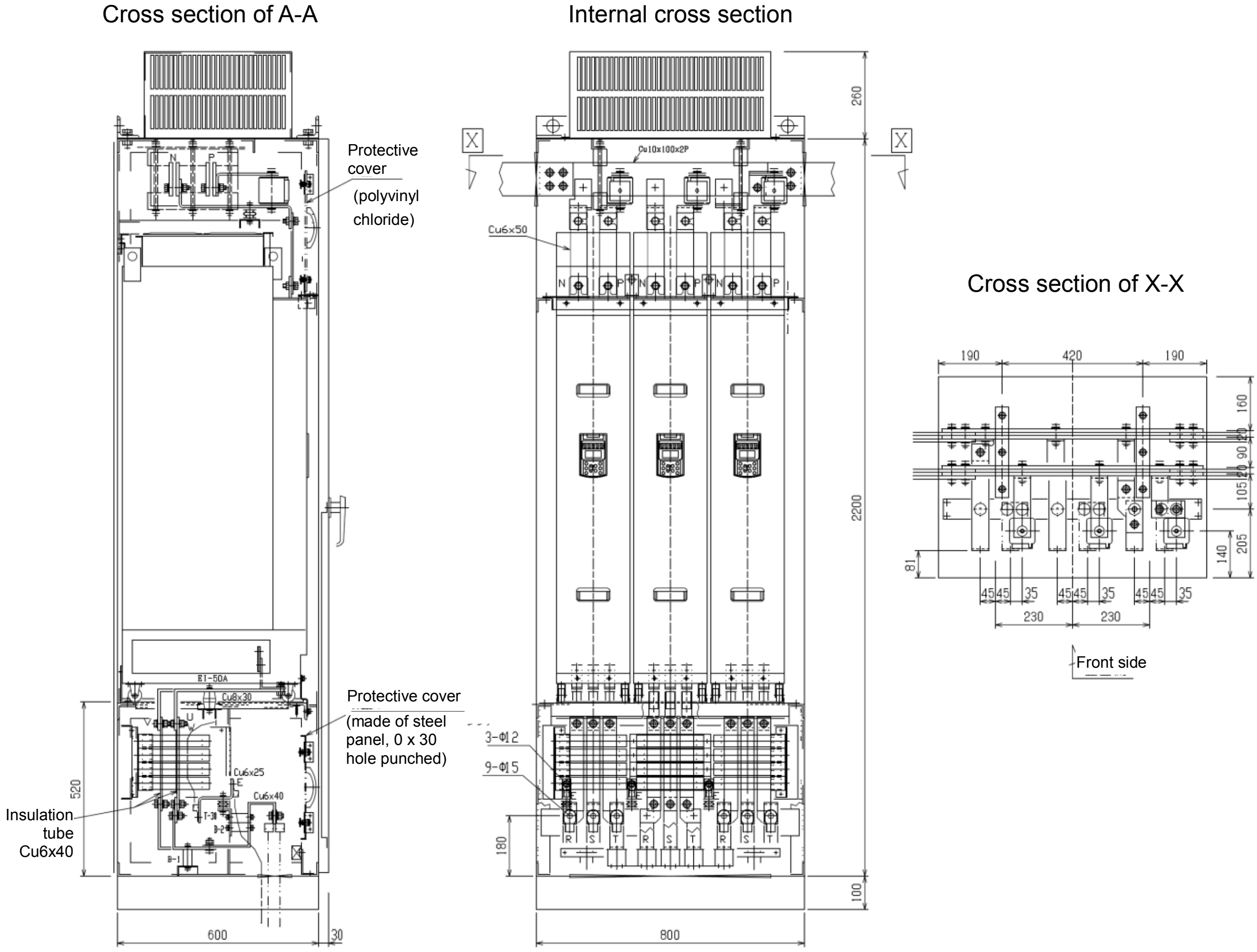


Figure 4.3.2-4: Internal layout for Frame 4 size (400V: 220 to 800 kW, 690V: 250 to 450 kW)

Components

■ **400V series**

Specifications	Model: FRN_		220SVG1S-4□	250SVG1S-4□	280SVG1S-4□	315SVG1S-4□
	Rated current [A]	MD spec	415	468	520	585
		LD spec	468	520	585	650
DC fuse		F1-F3	Refer to "5.2.1.1 Fuses" in Chapter 5.			
Zero-phase reactor		ACL1-3	F200160PB (x4)			
External wire terminal		Z1-Z3	Cu10x30 (x3)			
		E	Cu6x25			

Specifications	Model: FRN_		630BVG1S-4□	710BVG1S-4□	800BVG1S-4□
	Rated current [A]	MD spec	1170	1370	1480
		LD spec	1370	1480	1850
DC fuse		F1-F3	Refer to "5.2.1.1 Fuses" in Chapter 5.		
Zero-phase reactor		ACL1-3	F200160PB (x4)		
External wire terminal		Z1-Z3	Cu10x125 (x3)		
		E	Cu6x25		

■ **690V series**

Specifications	Model: FRN_		250SVG1S-69☐	280SVG1S-69☐	315SVG1S-69☐
	Rated current [A]	MD spec	265	295	330
		LD spec	295	330	365
DC fuse		F1-F3	Refer to "5.2.1.1 Fuses" in Chapter 5.		
Zero-phase reactor		ACL1-3	—		
External wire terminal		Z1-Z3	Cu5x30 (x3)		
		E	Cu6x25		

Specifications	Model: FRN_		355SVG1S-69☐	400SVG1S-69☐	450SVG1S-69☐
	Rated current [A]	MD spec	365	410	460
		LD spec	410	460	—
DC fuse		F1-F3	Refer to "5.2.1.1 Fuses" in Chapter 5.		
Zero-phase reactor		ACL1-3	—		
External wire terminal		Z1-Z3	Cu5x30 (x3)		
		E	Cu6x25		

Note

(1) The number of turns of the radio noise reducing zero-phase reactor (ACL) depends on the type and size of the wire to be used.
Thus, when this layout is applied, it is assumed that the wire is passed through the radio noise reducing zero-phase reactor only once.

(2) The external wire terminals are selected based on the rated current of each inverter.
(Selection criteria: ambient temperature of 40°C and temperature rise of 30K.)

4.4 Bus bars

Use a bus bar to connect DC bus bar connection terminals [P (+), N (-)] and output terminals (U, V, W). This section describes bus bars.

4.4.1 Materials and surface treatment of bus bars

Use bus bars made of any of the materials specified in JIS H3140 and subjected to any of the surface plating processes complying with JIS H0404.

Material of bus bars	: C1100BB	Copper (electric conductivity: 97%)	... JIS H3140
	: C1020BB		
Surface plating	: Ep-Cu/Sn3	Tin plating (plating thickness: 3 μm)	... JIS H0404
	: Ep-Cu/Sn-Pb(5-10)3	Tin lead alloy (plating thickness: 3 μm)	

4.4.2 Connection of bus bars (sizes of holes in bus bars, drilling pitches)

According to the size of bus bar, the number of connection holes and the hole pitch are specified as shown in Table 4.4.2-2.
Connect bus bars in any of the patterns shown in Table 4.4.2-1. If bus bars of different widths are used, connect them based on the bus bar of the smaller width.

Table 4.4.2-1: Connection patterns of bus bars

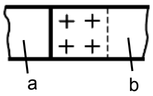
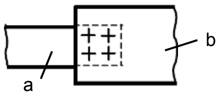
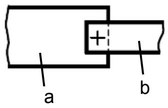
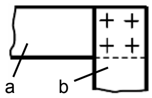
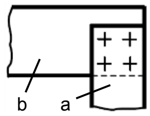
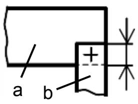
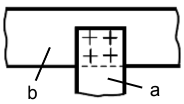
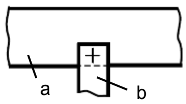
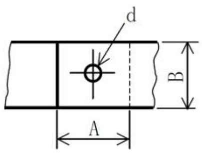
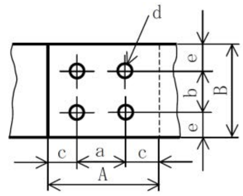
	a ＝ b	a < b	a > b
Straight connection			
L-branched connection			 Based on the smaller bus bar
T-branched connection			

Table 4.4.2-2: Connection of bus bars (relatively narrow bus bars) and bolt holes and pitches

Bus bar [mm]		Overlap dimension A x B [mm]	Size of hole [mm]					Applicable bolt	Effective contact area [mm²]	Application diagram
Thickness	Width (B)		a	b	c	e	d			
3 to 10 mm thickness	15	15×15	—	—	—	—	7	M6	187	 When the terminal of the mating appliance has two holes or when there is a possibility that the bus bar will rotate (slip out of position) because of the structure, two holes need drilled in the bus bar.
	20	20×20					10	M8	322	
	25	25×25							547	
	30	30×30	—	—	—	—	12	M10	787	
	40	40×40					15	M12	1423	
	50	50×50							2323	
	60	60×60					19	M16	3317	

Note
(1) Secure an effective contact area equal to or larger than the appropriate value specified in the table above.
(2) Set the contact surface pressure at 5 [N/mm^2] or over.
(3) The bearing surface pressure of the bolt shall not exceed 50 [N/mm^2] in order to prevent creep.
(4) The stress of the bolt shall not exceed the yield point of 226 N/mm^2 (bolt made of 4T).
(5) These specifications apply to up to three bus bars connected in parallel.
(6) The effective contact area means the area of the contact portion calculated by subtracting the area of the bolt hole (d).

Table 4.4.2-3: Connection of bus bars (wide bus bars) and bolt holes and pitches

Bus bar [mm]		Overlap dimension A x B [mm]	Size of hole [mm]					Applicable bolt	Effective contact area [mm^2]	Application diagram
Thickness	Width (B)		a	b	c	e	d			
10 mm thickness	75	75×75	40	40	17.5	17.5	15	M12	4919	
	80	80×80			20	20			5694	
	100	80×100		50		25			7294	

Note The precautions stated in Table 4.4.2-2 apply.

4.4.3 Connection methods and tightening torques

Connect bus bars using a bolt as shown in Figure 4.4.3-1. Use plural washers or belleville springs for bus bars that are connected in a frequently vibrating location or in which stress concentrates to prevent the bus bars from becoming loose.

In addition, comply with Table 4.2.2-1 "Tightening torques" (on page 4-24).

Note
(1) It is recommended that belleville springs, spring washers, and nuts be mounted on surfaces where they can be easily checked after tightening.
(2) Use bolts and nuts plated with Ep-Fe, Zn5, or CM2.

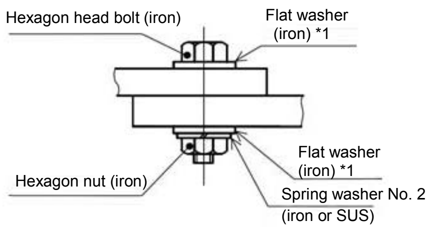


Figure 4.4.3-1: Example of connection of bus bar

4.4.3.1 Rated current of Cu bus bars

Rated currents of bus bars are as shown in Table 4.4.3-1 (on page 4-43). However, if the ambient temperature of the cabinet is higher than 40°C and in some other cases, the derating of the current must be considered.

[Current capacity of bus bars]

Bus bars are selected based on the assumption that the temperature is 70°C (ambient temperature = 40°C and temperature rise = 30K). If ambient temperature drops below 40°C, the value of temperature rise increases. Consider a correction factor according to Figure 4.4.3-3.

In addition, the reduction rate of the supplied current depends on the layout of bus bars. When supplying a large current, plan the current by making reference to Figure 4.4.3-2.

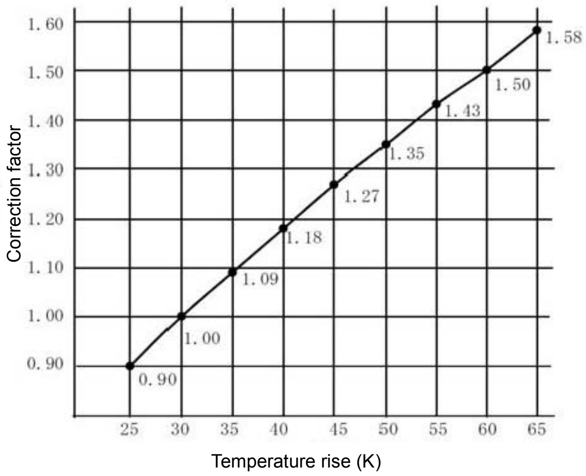


Figure 4.4.3-3: Temperature correction factor

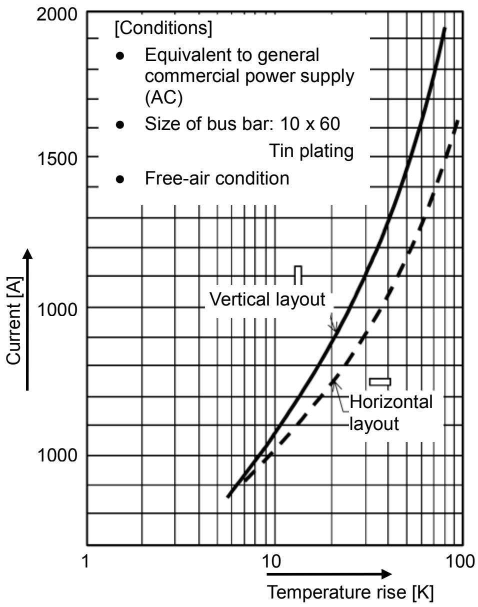


Figure 4.4.3-2: Derating in installation direction (reference)

Table 4.4.3-1: Rated currents of CU bus bars

Dimensions (mm) Thickness	Dimensions (mm) Width	Cross sectional area [mm²]	No parallel connection DC	No parallel connection AC (50/60Hz)	2 parallel rows When equal to thickness DC	2 parallel rows When equal to thickness AC (50/60Hz)	3 parallel rows When equal to thickness DC	3 parallel rows When equal to thickness AC (50/60Hz)
3	15	45	180	180				
	20	65	225	225				
	25	75	275	275				
	30	90	320	320				
4	25	100	325	325				
	30	120	380	375				
	40	160	485	480				
5	25	125	370	365				
	30	150	430	425				
	40	200	550	540				
	50	250	660	650				
	60	300	780	860				
	75	375	950	930	1920	1790		
6	25	150	410	410				
	30	180	480	470				
	40	240	610	600				
	50	300	730	720				
	60	360	860	840				
	75	450	1050	1010	2090	1910		
	80	480	1110	1070	2190	2000		
	100	600	1350	1280	2620	2330	3670	3060
8	25	200	500	490				
	30	240	570	560				
	40	320	720	700				
	50	400	860	840				
	60	480	1010	970				
	75	600	1220	1160	2390	2120		
	80	640	1290	1220	2510	2210		
	100	800	1580	1470	2990	2560	4230	3330
10	40	400	830	800	1730	1600		
	50	500	990	950	2010	1810		
	60	600	1150	1090	2280	2010		
	75	750	1390	1290	2680	2290		
	80	800	1460	1360	2810	2380		
	100	1000	1780	1620	3310	2730	4750	3490
	125	1250	2150	1930	3930	3160	5570	3960
	150	1500	2550	2260	4550	3590	6410	4450
12	125	1500	2390	2100	4290	3300	6140	4120
	150	1800	2800	2430	4930	3700	7000	4590
15	100	1500	2110	1920				
	150	2250	3160	2660	5510	3870	7900	4790
	175	2625	3550	2960	6080	4240	8660	5200
	200	3000	4070	3350	6850	4680	9680	5700

Note

(1) The selection conditions applied to this table are ambient temperature: 40°C and temperature rise: 30K.

(2) The layout of bus bars is a vertical layout.

(3) The material of bus bars is one complying with "4.4.1 Materials and surface treatment of bus bars" (on page 4-40).

4.5 Main circuit wires

This section describes the wire sizes for the inverter main circuit section.

Depending on the wiring method for the main circuit section, noise may be applied to the control circuit system, and the system may malfunction.

📖 See Chapter 7 "EMC Compatible Peripherals" and Appendix 5 "Proficient way to use inverters (on preventing electric noise)" and Appendix 6 "Grounding as noise countermeasure and ground noise".

4.5.1 Wire selection criteria

Unless otherwise required by a special application, use the wire types listed below.

<400V series>

- 600 V vinyl-insulated wire (IV wire)
  This is an insulated wire with a rated voltage of 600 V and a maximum permissible temperature of 60°C. It can be widely used for main circuits and control circuits inside cabinets or indoors.
  However, this wire is low in flexibility and permissible current and is not suitable for large-capacity applications.
- 600 V class 2 vinyl wire or 600 V polyethylene-insulated wire (HIV wire)
  This is an insulated wire with a rated current of 600 V and a maximum permissible temperature of 75°C. It is superior in flexibility to IV wires of the same class and permits a large current to flow.
  Thus, it is applicable to the main circuit sections inside cabinets or indoor.
- 600 V cross-linked polyethylene insulated wire (FSLC wire)
  This is an insulated wire with a rated current of 600 V and a maximum permissible temperature of 90°C. It is much superior in flexibility to IV wires of the same class and permits a large current to flow. Thus, it can be used not only for large-capacity applications but also for the reduction of the exclusive area of wires or the streamlining of work.
  For your reference, Board Lex manufactured by Furukawa Electric Co., Ltd. is equivalent to this wire.

<690V series>

Use wires rated at 1000 V or higher voltage. The maximum permissible temperature should be 70°C for PVC (polyvinyl chloride) or 90°C for XLPE (cross-linked polyethylene) or EP (ethylene-propylene rubber) according to IEC 60364-5-52: 2001(JIS C 60364-5-52: 2006).
(Examples of wires: NYY, NYCWY (70°C))

- IEC 60364-5-52：2001 Electrical installations of buildings - Part 5-52：Selection and erection of electrical equipment - wiring systems
- JIS C 60364-5-52:2006 "Electrical installations of buildings -- Part 5-52: Selection and erection of electrical equipment -- Wiring systems"

4.5.1.1 Overcurrent protectors and protection coordination

Select a wire size that does not burn out with an overcurrent.

- PWM converter input/output side : Time until a molded case circuit breaker (MCCB) causes an overcurrent trip, or time until the overcurrent protection function of a PWM converter stack starts to work.
- Diode rectifier input/outputs side : Time until a molded case circuit breaker (MCCB) causes an overcurrent trip.
- Inverter output side : Time until the overcurrent trip function of an inverter starts to work.

Figure 4.5.1-1 shows the operating characteristic of an MCCB. The right side of this operating characteristic curve is the operating range, and the left side is the non-operating range. Judging from this curve, the wire showing the characteristic ③ is a proper wire. (The wires with the characteristics ① and ② are improper.)

① Continuous domain

To prevent the MCCB from operating after the current exceeds the permissible current (continuously supplied current) of the wire. The following relationship must be fulfilled:

Permissible current of wire [A] > Rated current of MCCB [A]

② Short-time domain

Note that the short-time domain may intersect with the permissible current characteristic of the wire at a point close to the point of intersection of the time delay trip and instantaneous trip characteristics of an MCCB (portion Ⓐ in Figure 4.5.1-1).

To make it easy to consider the short-time domain of IV wires, combinations of the rated currents of the MCCB and protectable wire sizes are shown in Table 4.5.1-1.

Consider FSLC wires based on the short-time characteristic shown in Figure 4.5.1-2 and the operating characteristic curve of the MCCB. For the operating characteristic curve of the MCCB, see the catalog for it or engineering documents.

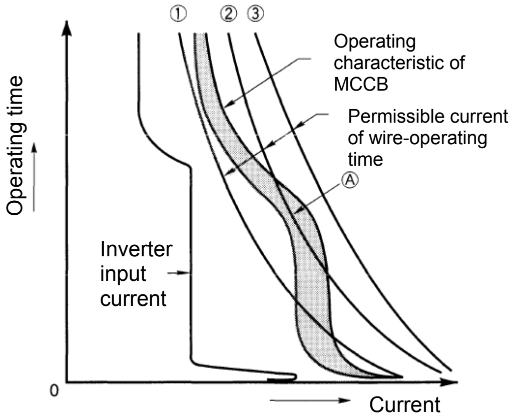


Figure 4.5.1-1: Protection coordination between MCCB and wire

Table 4.5.1-1: Sizes of 600 V vinyl insulated wires (IV wires) protectable in short-time domain

Rated current of MCCB [A] / Wire size [mm²]	15	20	30	40	50	60	75	100	125	150	175	200	225	250	300	350	400	500	600	700
2.0																				
3.5																				
5.5																				
8.0																				
14																				
22																				
38																				
60																				
100																				
150																				
200																				
250																				
325																				

Domain that can be protected

Note (1) The short-time permissible temperature of the wire is set at 100°C.

(2) Separately calculate an applicable wire size in case of a fault break.

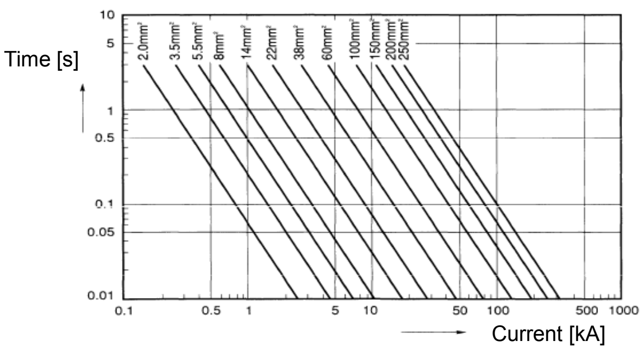


Figure 4.5.1-2: Short-time characteristics of 600 V cross-linked polyethylene insulated wires (FSLCs)

③ Short circuit domain

The square product $\left\{\int_{t1}^{t2} i^2 \times dt \ \text{ or } \ I^2(t2-t1)\right\}$ of the passing current (short circuit current) from t1 (at which a short circuit occurred) to t2 (at which the cutoff of the MCCB was completed) is called the "short-time capacity" of the wire or the "total cutoff" $I^2 \cdot t$ of the MCCB at the time of short circuit current cutoff. When the relationship between them is as shown below, the wire can be protected.

Short circuit current of wire	[kA^2s]	>	Total cutoff $I^2 \cdot x$ t at the time of short circuit current cutoff	[kA^2s]

Obtain the short circuit capacity of the wire from the catalogue for it or engineering documents. Calculate the total cutoff $I^2 \cdot t$ of the MCCB at the time of short circuit current cutoff using the equation given below.

Total cutoff of MCCB at the time of short circuit current cutoff: $I^2t = Is^2 \times t_{CB}[kA^2s]$

Is: Short circuit current passing through the MCCB, or the rated cutoff capacity [kA] of the MCCB when the short circuit current is unknown.

t_{CB}: Operating time of the MCCB corresponding to the short circuit current, or the operating time [s] of the MCCB at the rated cutoff capacity when the short circuit current is unknown.

Table 4.5.1-2: Short-time currents

Wire size □[mm^2]	Short-time capacity [kA^2s]	
	IV wire	FLSC wire
2.0	0.054	0.079
3.5	0.165	0.242
5.5	0.408	0.597
8.0	0.863	1.262
14	2.64	3.865
22	6.53	9.544
38	19.47	28.47
60	48.55	71.0
100	135	197.2
150	303	443.7
200	539	788.8
250	843	1232.5
325	1425	—

When the short-time characteristic curve of the wire is available, calculate the protectable time to the short circuit current and the operating time of the MCCB from this curve and the operating characteristic curve of the MCCB. The short circuit current passing through the wire and that passing through the MCCB are the same. Thus, compare the protectable time to the short circuit current of the wire with the operating time of the MCCB.

tw[s]>tC B[s]

tw: Protectable time to the short circuit current of the wire

Use Table 4.5.1-2 for the short-time capacity of the wire.
Obtain the operating time of the MCCB from the catalogue for it or engineering documents.

4.5.1.2 Voltage drop

Since the wiring distance inside a cabinet is short, it is unlikely that any problem will occur even if the wire size is determined based on the permissible current. However, it is necessary to check for a voltage drop when considering wiring, including external cables. The wire size is determined by its electric resistance, not its permissible current, if the wiring distance is long.

Calculate a voltage drop using the equation given below.

$$\Delta V = \frac{\sqrt{3} \times r \times \lambda \times I}{1000} \quad \cdots \quad \text{Equation 4.5.1-1}$$

ΔV : Voltage drop [V]
r : Resistance value corresponding to the conductor temperature [Ω/km]
λ : Wiring distance [m]
I : Passing current [A]

Calculate the value of r using the equation given below.

r＝K·r20

K: Temperature correction factor

r20: Conductor resistance value at 20°C [Ω]

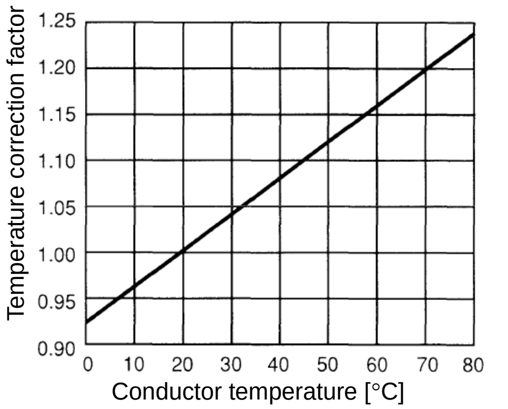


Figure 4.5.1-3: Temperature correction factor K

4.5.2 Recommended wire size

4.5.2.1 3-phase 400V series (MD spec)

Table 4.5.2-1: Recommended wire sizes (MD spec, ambient temperature: 40°C)

Standard load capacity [kW]	FRN□ VG1S	DC bus bars P (+), N (-)									Inverter output [U, V, W]					Grounding terminal [⏚G] [mm²]
		When PWM converter is used				When diode rectifier is used				Bus bar size [mm²]	Permissible temperature* [mm²]			Bus bar size [mm²]	Current [A]	
		Permissible temperature* [mm²]			Current [Adc]	Permissible temperature* [mm²]			Current [Adc]							
		60°C	75°C	90°C		60°C	75°C	90°C			60°C	75°C	90°C			
30	30S	14	8	5.5	55	14	8	8	65	t3×25 (75)	14	8	5.5	—	60	5.5
37	37S		14	8	68	22	14	14	80		22	14	8		75	8
45	45S	22		14	82	38	22		97				14		91	14
55	55S	38	22		101	38		22	119	t3×30 (90)	38	22			112	
75	75S	60	38	22	137	60	38	38	162		60	38	38		150	22
90	90S			38	164	100	60		195			60			176	
110	110S	100	60		201		100	60	238		100		60		210	
132	132S		100	60	241	150		100	286	t4×40 (160)	150	100		t5×30 (150)	253	38
160	160S	150		100	292	200	150		347				100		304	
200	200S	200	150		365	250	200	150	433		200	150			377	60
220	220S	250		150	402	325			476	t8×50 (400)	250		150	t10 ×30 (300)	415	
250	250S	325	200		457	2×200	250	200	541		325	200			468	
280	280S		250	200	512		325	250	606			250	200		520	
315	315S	2×200			576	2×250			682		2×200				585	
630	630B	—	—	—	1151	—	—	—	1365	t8×50 (400)	—	3×250	2×250	t10 ×125 (1250)	1170	150
710	710B	—	—	—	1298	—	—	—	1538		—	4×250	2×325		1370	
800	800B	—	—	—	1462	—	—	—	1733		—	4×325	3×325		1480	

*An "IV wire," a "600 V HIV insulated wire," and a "600 V cross-linked polyethylene insulated wire" were used at permissible temperatures of 60°C, 75°C, and 90°C, respectively, and the values represent aerial wiring.

Note
(1) The current values of the DC bus bar were calculated on the assumption that the converter (PWM converter or diode rectifier) supply voltage was 400 V AC.
(2) The grounding wire is cited from the permissible short circuit current defined in internal wire regulations.
(3) When using wires of 150 mm² or greater, use relay bus bars so that the wires can be connected. (The Frame 3 and 4 size inverters' output terminals are configured to connect wires by use of relay bus bars.)
(4) Use bus bars to connect to a DC line of 630 kW or greater. It is also recommended that the inverter output side be connected using a bus bar.

Table 4.5.2-2: Recommended wire sizes (MD spec, ambient temperature: 50°C)

Standard load capacity [kW]	FRN□ VG1S	DC bus bars P (+), N (-): When PWM converter is used – Permissible temperature* [mm²] 60°C	75°C	90°C	Current [Adc]	When diode rectifier is used – Permissible temperature* [mm²] 60°C	75°C	90°C	Current [Adc]	Bus bar size [mm²]	Inverter output [U, V, W]: Permissible temperature* [mm²] 60°C	75°C	90°C	Bus bar size [mm²]	Current [A]	Grounding terminal [⊜G] [mm²]
30	30S	22	8	5.5	55	22	14	—	60	t3×25	22	14	8	—	60	5.5
37	37S	38	14	8	68	38			75	(75)	38		14		75	8
45	45S		22	14	82	60	22		91			22			91	14
55	55S	60			101		38		112	t3×30	60	38	22		112	
75	75S	100	38	38	137	100	60		150	(90)	100	60	38		150	22
90	90S		60		164	150			176		150				176	
110	110S	150	100	60	201	200	100		210			100	60		210	
132	132S	200			241	250	150	t5×30	253	t4×40	200		100	t5×30	253	38
160	160S	250	150	100	292	325		(150)	304	(160)	250	150		(150)	304	
200	200S	325	200	150	365	2×200	250		377		325	200	150		377	60
220	220S	2×200			402	2×250		t10	415	t8×50	2×200			t10	415	
250	250S	2×250	250	200	457	2×325	325	×30	468	(400)	2×250	250		×30	468	
280	280S		325		512		2×200	(300)	520			325		(300)	520	
315	315S	2×325		250	576	3×325			585		2×325				585	
630	630B	—	—	—	1151	—	—	—	1170	t8×50	—	4×250		t10	1170	150
710	710B	—	—	—	1298	—	—	—	1370	(400)	—	4×325		×125	1370	
800	800B	—	—	—	1462	—	—	—	1480		—	5×325		(1250)	1480	

*An "IV wire," a "600 V HIV insulated wire," and a "600 V cross-linked polyethylene insulated wire" were used at permissible temperatures of 60°C, 75°C, and 90°C, respectively, and the values represent aerial wiring.

Note
(1) The current values of the DC bus bar were calculated on the assumption that the converter (PWM converter or diode rectifier) supply voltage was 400 V AC.

(2) The grounding wire is cited from the permissible short circuit current defined in internal wire regulations.

(3) When using wires of 150 mm^2 or greater, use relay bus bars so that the wires can be connected. (The Frame 3 and 4 size inverters' output terminals are configured to connect wires by use of relay bus bars.)

(4) Use bus bars to connect to a DC line of 630 kW or greater. It is also recommended that the inverter output side be connected using a bus bar.

4.5.2.2 3-phase 400V series (LD spec)

Table 4.5.2-3: Recommended wire sizes (LD spec, ambient temperature: 40°C)

Standard load capacity [kW]	FRN□ VG1S	DC bus bars [P (+), N (-)]									Inverter output [U, V, W]					Grounding terminal [⏚G] [mm²]
		When PWM converter is used				When diode rectifier is used				Bus bar size [mm²]	Permissible temperature* [mm²]			Bus bar size [mm²]	Current [A]	
		Permissible temperature* [mm²]			Current [Adc]	Permissible temperature* [mm²]			Current [Adc]							
		60°C	75°C	90°C		60°C	75°C	90°C			60°C	75°C	90°C			
37	30S	14	14	8	68	22	14	14	80	t3×25	22	14	8	—	75	8
45	37S	22		14	82	38	22		97	(75)			14		91	14
55	45S	38	22		101			22	119		38	22			112	
75	55S	60	38	22	137	60	38	38	162	t3 x 30	60	38	38		150	22
90	75S			38	164	100	60		195	(90)		60			176	
110	90S	100	60		201		100	60	238		100		60		210	
132	110S		100	60	241	150		100	286		150	100			253	38
160	132S	150		100	292	200	150		347	t4×40			100	t5×30	304	
200	160S	200	150		365	250	200	150	433	(160)	200	150		(150)	377	60
220	200S	250		150	402	325			476		250		150		415	
250	220S	325	200		457		250	200	541	t8 x 50	325	200		t10	468	
280	250S		250	200	512	2×200	325	250	606	(400)		250	200	×30	520	
315	280S	2×200			576	2×250			682		2×200			(300)	585	
355	315S	2×250	325	250	649	2×325	2x200	325	769		2×250	325	250		650	100
710	630B	—	—	—	1151	—	—	—	1538	t8×50	—	4×250	2×325	t10	1370	150
800	710B	—	—	—	1298	—	—	—	1733	(400)	—	4×325	3×325	×125	1480	
1000	800B	—	—	—	1462	—	—	—	2166		—	5×325	4×325	(1250)	1850	2×150

Table 4.5.2-4: Recommended wire sizes (LD spec, ambient temperature: 50°C)

Standard load capacity [kW]	FRN□ VG1S	DC bus bars [P (+), N (-)]									Inverter output [U, V, W]					Grounding terminal [⏚G] [mm²]
		When PWM converter is used				When diode rectifier is used				Bus bar size [mm²]	Permissible temperature* [mm²]			Bus bar size [mm²]	Current [A]	
		Permissible temperature* [mm²]			Current [Adc]	Permissible temperature* [mm²]			Current [Adc]							
		60°C	75°C	90°C		60°C	75°C	90°C			60°C	75°C	90°C			
37	30S	38	14	8	68	38	14	14	80	t3×25	38	14	14	—	75	8
45	37S		22	14	82	60	22		97	(75)		22			91	14
55	45S	60			101		38	22	119		60	38	22		112	
75	55S	100	38	38	137	100	60	38	162	t3 x 30	100	60	38		150	22
90	75S		60		164	150		60	195	(90)	150				176	
110	90S	150	100	60	201	200	100		238			100	60		210	
132	110S	200			241	250	150	100	286		200		100		253	38
160	132S	250	150	100	292	325		150	347	t4×40	250	150		t5×30	304	
200	160S	325	200	150	365	2×200	250		433	(160)	325	200	150	(150)	377	60
220	200S	2×200			402	2×250		200	476		2×200				415	
250	220S	2×250	250	200	457	2×325	325	250	541	t8×50	2×250	250	200	t10	468	
280	250S		325		512		2×200		606	(400)		325		×30	520	
315	280S	2×325		250	576	3×325		325	682		2×325		250	(300)	585	
355	315S	3×325	2×200	325	649	4×325	2×250	2×200	769		3×325	2×200	325		650	100
710	630B	—	3×325	2×325	1151	—	5×325	4×325	1538	t8×50	—	4×325	3×325	t10	1370	150
800	710B	—	4×325	3×325	1298	—	—		1733	(400)	—	5×325	4×325	×125	1480	
1000	800B	—	5×325	4×325	1462	—	—	—	2166		—	—	5×325	(1250)	1850	2×150

*An "IV wire," a "600 V HIV insulated wire," and a "600 V cross-linked polyethylene insulated wire" were used at permissible temperatures of 60°C, 75°C, and 90°C, respectively, and the values represent aerial wiring.

Note

(1) The current values of the DC bus bar were calculated on the assumption that the converter (PWM converter or diode rectifier) supply voltage was 400 V AC.

(2) The grounding wire is cited from the permissible short circuit current defined in internal wire regulations.

(3) When using wires of 150 mm² or greater, use relay bus bars so that the wires can be connected. (The Frame 3 and 4 size inverters' output terminals are configured to connect wires by use of relay bus bars.)

(4) Use bus bars to connect to a DC line of 630 kW or greater. It is also recommended that the inverter output side be connected using a bus bar.

4.5.2.3 3-phase 690V series (MD/LD spec)

Table 4.5.2-5: Recommended wire sizes (MD spec, ambient temperature: 40°C)

Standard load capacity [kW]	FRN□ VG1S	DC bus bars [P (+), N (-)]							Inverter output [U, V, W]				Ground-ing terminal [⏚G] [mm²]
		When PWM converter is used			When diode rectifier is used			Bus bar size [mm²]					
		Permissible temperature* [mm²]		Current [Adc]	Permissible temperature* [mm²]		Current [Adc]		Permissible temperature* [mm²]		Bus bar size [mm²]	Current [A]	
		70°C	90°C		70°C	90°C			70°C	90°C			
90	90S	35	25	95	50	35	114	t2×30	35	25	—	100	14
110	110S	50	35	117	70	50	139	(60)	50	35		130	22
132	132S	70	50	140			167	t3×45	70	50	t4×30	140	
160	160S		70	170	95	70	201	(135)			(120)	161	
200	200S	120		212	150	95	252		120	95		216	
250	250S	2×70	2×50	265	2×95	2×70	316	t4×50	2×70	2×50	t6×30	265	38
280	280S	2×95	2×70	297			352	(200)		2×70	(180)	295	
315	315S			334	2×120	2×95	396		2×95			330	
355	355S	2×120	2×95	376	2×150		446		2×120			365	60
400	400S	2×150		424	2×185	2×120	503			2×95		410	
450	450S	2×185	2×150	477	2×240	2×150	563		2×150	2×120		460	

Table 4.5.2-6: Recommended wire sizes (LD spec, ambient temperature: 40°C)

Standard load capacity [kW]	FRN□ VG1S	DC bus bars [P (+), N (-)]							Inverter output [U, V, W]				Ground-ing terminal [⏚G] [mm²]
		When PWM converter is used			When diode rectifier is used			Bus bar size [mm²]					
		Permissible temperature* [mm²]		Current [Adc]	Permissible temperature* [mm²]		Current [Adc]		Permissible temperature* [mm²]		Bus bar size [mm²]	Current [A]	
		70°C	90°C		70°C	90°C			70°C	90°C			
110	90S	50	35	117	70	50	139	t2×30	50	35	—	130	22
132	110S	70	50	140			167	t3×45	70	50		140	
160	132S		70	170	95	70	201	(135)			t4×30	161	
200	160S	120		212	150	95	252	t4×50	120	95	(120)	216	
220	200S		95	233		120	277	(200)				235	38
280	250S	2×95	2×70	297	2×95	2×70	352		2×70	2×70	t6×30	295	
315	280S			334	2×120	2×95	396		2×95		(180)	330	
355	315S	2×120	2×95	376	2×150		446		2×120			365	60
400	355S	2×150		424	2×185	2×120	503			2×95		410	
450	400S	2×185	2×150	530	2×240	2×150	563		2×150	2×120		460	

*A “PVC (polyvinyl chloride) wire” and an “XLPE (cross-linked polyethylene) wire” were used at permissible temperatures of 70°C and 90°C, respectively, and the wire sizes were selected based on the permissible current under the following conditions. If the use conditions are different, select the wire sizes based on use conditions that comply with IEC 60364-5-52:2001(JIS C 60364-5-52:2006).
Ambient temperature: 40°C, Multicore cable: 3 cores (conductor: copper), A single cable: aerial wiring, Two or more cables: electric duct wiring

Note

(1) The current values of the DC bus bar were calculated on the assumption that the converter (PWM converter or diode rectifier) input voltage was 690 V AC.

(2) When using wires of 150 mm² or greater, use relay bus bars so that the wires can be connected. (The frame 3 and 4 size inverters' output terminals are configured to connect wires by use of relay bus bars.)

(3) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

Table 4.5.2-7: Recommended wire size, domestic selection (MD spec., ambient temperature 40 °C)

Standard load capacity [kW]	FRN□ VG1S	DC bus bars [P (+), N (-)]: When PWM converter is used: Permissible temperature* [mm²] 70°C	DC bus bars: When PWM converter is used: Permissible temperature* [mm²] 90°C	DC bus bars: When PWM converter is used: Current [Adc]	DC bus bars: When diode rectifier is used: Permissible temperature* [mm²] 70°C	DC bus bars: When diode rectifier is used: Permissible temperature* [mm²] 90°C	DC bus bars: When diode rectifier is used: Current [Adc]	DC bus bars: Bus bar size [mm²]	Inverter output [U, V, W]: Permissible temperature* [mm²] 70°C	Inverter output [U, V, W]: Permissible temperature* [mm²] 90°C	Inverter output: Bus bar size [mm²]	Inverter output: Current [A]	Grounding terminal [⏚G] [mm²]
90	90S	14	14	95	22	22	114	t2×30 (60)	22	14	—	100	14
110	110S	22	22	117	38		139		38	22		130	22
132	132S	38		140		38	167	t3×45 (135)			t4×30 (120)	140	
160	160S		38	170	60		201			38		161	
200	200S	60	60	212	100	60	252		60	60		216	
250	250S	100		265		100	316	t4×50 (200)	100		t6×30 (180)	265	38
280	280S		100	297	150		352			100		295	
315	315S	150		334		150	396		150			330	
355	355S			376	200		446					365	60
400	400S		150	424			503			150		410	
450	450S	200		530	250	200	563		200			460	

Table 4.5.2-8: Recommended wire size, domestic selection (LD spec., ambient temperature 40 °C)

Standard load capacity [kW]	FRN□ VG1S	DC bus bars [P (+), N (-)]: When PWM converter is used: Permissible temperature* [mm²] 70°C	DC bus bars: When PWM converter is used: Permissible temperature* [mm²] 90°C	DC bus bars: When PWM converter is used: Current [Adc]	DC bus bars: When diode rectifier is used: Permissible temperature* [mm²] 70°C	DC bus bars: When diode rectifier is used: Permissible temperature* [mm²] 90°C	DC bus bars: When diode rectifier is used: Current [Adc]	DC bus bars: Bus bar size [mm²]	Inverter output [U, V, W]: Permissible temperature* [mm²] 70°C	Inverter output [U, V, W]: Permissible temperature* [mm²] 90°C	Inverter output: Bus bar size [mm²]	Inverter output: Current [A]	Grounding terminal [⏚G] [mm²]
110	90S	22	22	117	38	22	139	t2×30	38	22	—	130	22
132	110S	38		140		38	167	t3×45 (135)				140	
160	132S		38	170	60		201			38	t4×30 (120)	161	
200	160S	60	60	212	100	60	252	t4×50 (200)	60	60		216	
220	200S			233			277		100			235	38
280	250S	100	100	297	150	100	352			100	t6×30 (180)	295	
315	280S	150		334		150	396		150			330	
355	315S			376	200		446					365	60
400	355S		150	424			503			150		410	
450	400S	200		530	250	200	563		200			460	

*: The power supply voltage is 690 VAC.

Note (1) PVC was used for permissible temperature of 70 °C, and XLPE for permissible temperature of 90 °C.

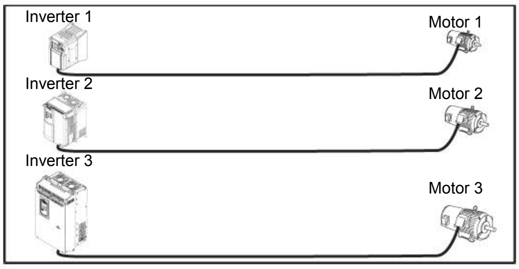
(2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

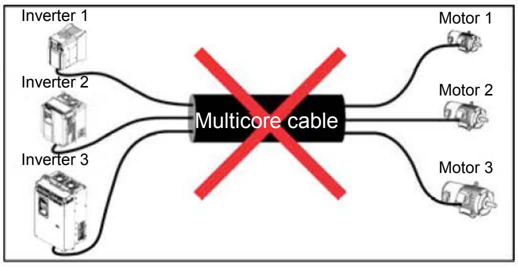
4.5.3 Wiring of main circuit and grounding terminals

(1) Inverter output terminals U, V, and W and terminal ⊕G for motor grounding

1) Connect the inverter output terminals U, V, and W to the terminals U, V, and W of the three-phase motor in the correct order of phases.
2) Connect the grounding wire of the output wires (U, V, and W) to the terminal (⊕G) for grounding.

Note When multiple combinations of inverters and motors exist, do not use multicore cables for the purpose of handling the wiring together.





(2) Terminal ⊕G for inverter grounding

This is the grounding terminal provided with the chassis (case) of the inverter. Do not fail to connect the grounding terminal for safety and as a measure against noise. Technical standards concerning electrical equipment make it mandatory to perform grounding work of metallic frames for electrical appliances to prevent electric shock or fire.

Connect the grounding terminal on the power supply side as described below.

1) According to technical standards concerning electrical equipment, connect the grounding terminal to a grounding pole to which class C grounding work was applied.
2) Connect a thick grounding wire having a large surface area along as short a route as possible.
3) For 132 to 450 kW stacks, follow Figure 4.5.3-1 and Figure 4.5.3-2 on the connections to grounding terminals.

Table 4.5.3-1: Grounding of appliances according to technical standards concerning electrical equipment

Type of grounding work	Grounding resistance
Class C grounding work	10 Ω or less

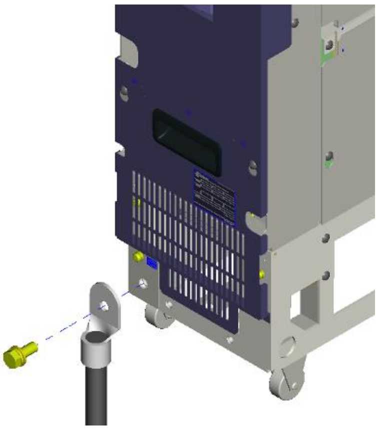


Figure 4.5.3-1: Example of grounding wiring for Frame 3 size (132 to 200 kW)

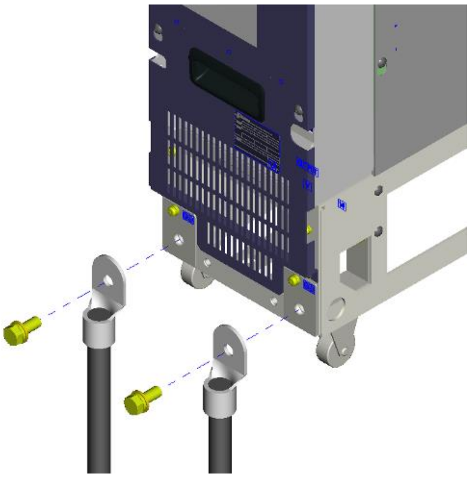


Figure 4.5.3-2: Example of grounding wiring for Frame 4 size (220 to 450 kW)

(3) Inverter DC bus bar connection terminals/converter output terminals P (+), N (-)

The inverter uses DC (direct current) input and the converter uses DC (direct current) output terminals.
Bus bar connections are assumed, but when connecting by electric lines, keep the distance between the stacks to **max. 2 m**.
When connecting to the DC bus bar by wires, keep the distance to **max. 2 m**.

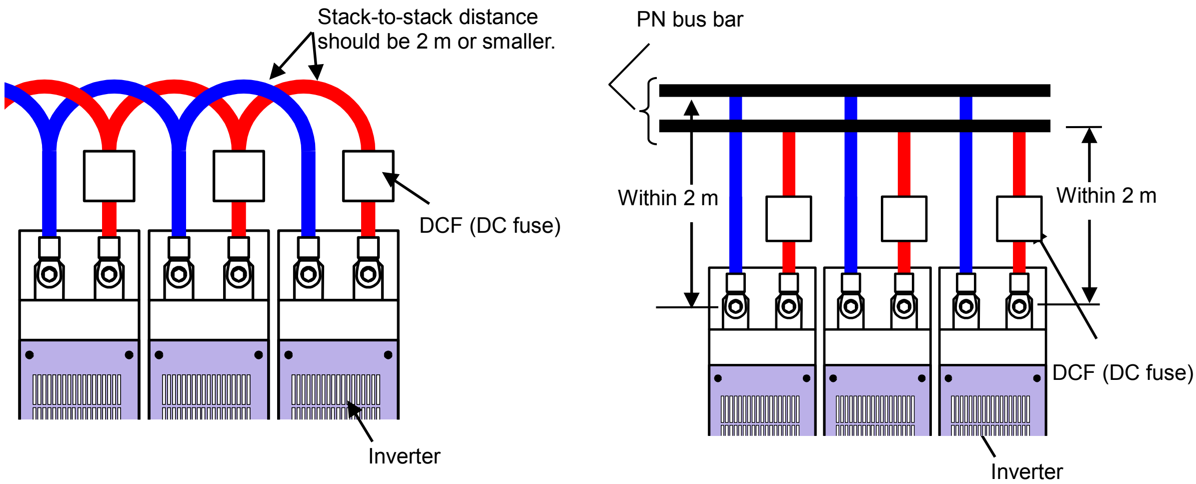


Figure 4.5.3-3: Restriction when connecting P (+) and N (-) terminals by electric lines

Note: When using long electric lines, route the P (+) and N (-) lines together and do not route beside control circuits.
(Do not route the P (+) and N (-) electric lines separately.)

(4) Control power auxiliary input terminals R0 and T0

The inverter can operate even if the power is not supplied to the control power auxiliary input terminals. However, if the main power to the inverter is turned off, the control power will also be shut down, and output signals of the inverter and the keypad will be no longer displayed.
To retain an alarm output signal to be issued when the protective function operates or keep the keypad displayed even if the main power to the inverter is shut down, connect the power to the control power auxiliary input terminals.
If a magnetic contactor (MC) is used on the input side of the inverter, connect the wire from the input (primary) side of the MC.

Terminal rating: 400V series: 380 to 480 V AC, 50/60 Hz, maximum current 0.5 A
690V series: 575 to 690 V AC, 50/60 Hz, maximum current 0.5 A

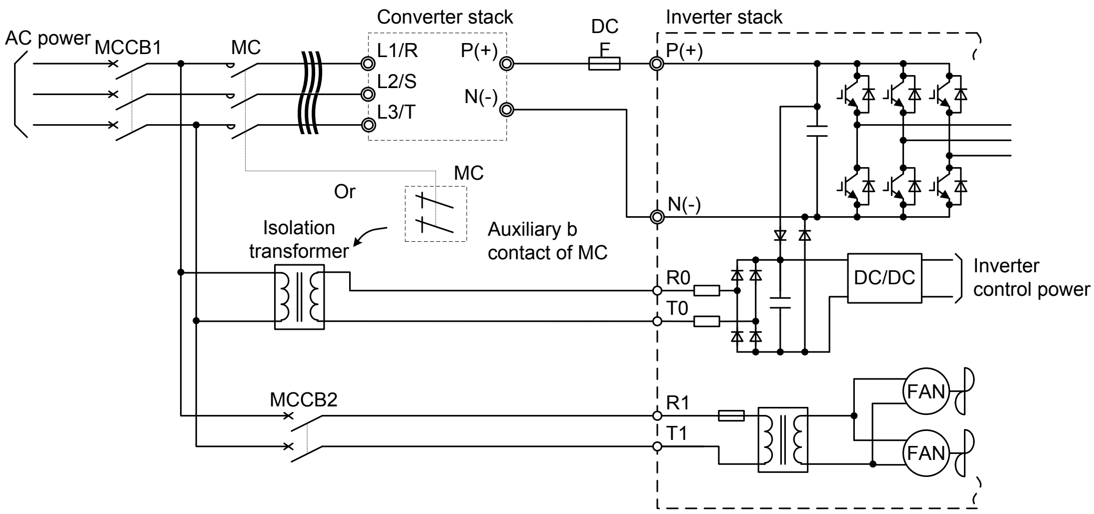


Figure 4.5.3-4: Connection of terminals R0 and T0

Terminal name	Recommended wire size [mm^2]
Control power auxiliary input terminals R0 and T0	2.0

Note: If wires of a larger size than a recommended wire size are used, they may not be inserted into the control cable lead-in hole in the front cover depending on the number of wires.

When connecting the FRENIC-VG to a PWM converter by connecting the power to the control power auxiliary input terminals (R0 and T0) of the FRENIC-VG, insert an isolation transformer or the auxiliary b contact of a magnetic contactor on the power supply side as shown in Figure 4.5.3-4.
When adding an isolation transformer, select the appropriate isolation transformer based on the sum of the required capacities of the FRENIC-VG and PWM converter, referring to the following tables:

■ **Required transformer capacity for the inverter (FRENIC-VG)**

Model	30S	37S	45S	55S	90S	110S	132S	160S	200S	220S	250S	280S	315S	355S	400S	450S	630B	710B	800B
FRN☐VG1S-4☐	200 VA													—			600 VA		
FRN☐VG1S-69☐	—				200 VA					—	200 VA						—		

■ **Required transformer capacity for the converter (RHC-D series)**

Model	132S	160S	200S	220S	250S	280S	315S	355S	400S	450S	500S	630B	710B	800B
RHC☐-4D☐	200VA				—	200VA		—				600VA		
RHC☐-69D☐	200VA			—	200VA						—			

(5) Fan power auxiliary input terminals R1 and T1

400V stacks with 90 kW or higher capacity and all 690V stacks are equipped with fan power supply terminals, so connect them to AC power supply. Switch the fan power supply switching connectors “U1” and “U2” according to the power supply specifications.

Terminal rating:

• 400V series: 380 to 440 VAC/50 Hz, 380 to 480 V/60 Hz, Maximum current: 1.0 A
(For phase-specific stacks, the maximum current is 3 times larger than above.)

• 690V series: 660 to 690 VAC, 50/60 Hz, maximum current 1.0A
575 to 600 VAC, 50/60 Hz, maximum current 1.0A

■ **Inverter (FRENIC-VG) - Rated capacity of terminals R1 and T1**

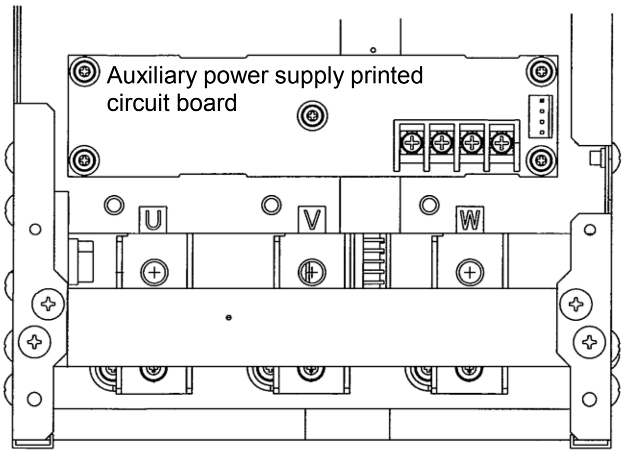
Model	90	110	132	160	200	220	250	280	315	355	400	450	630	710	800
FRN☐VG1S-4☐	100 VA					200 VA				—			600 VA		
FRN☐VG1S-69☐	100 VA					—	200 VA						—		

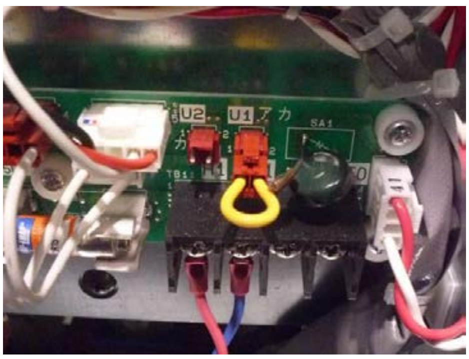
■ **Converter (RHC-D series) - Rated capacity of terminals R3 and T3**

Model	132S	160S	200S	220S	250S	280S	315S	355S	400S	450S	500S	630B	710B	800B
RHC☐-4D☐	100VA			200VA	—	200VA		—				600VA		
RHC☐-69D☐	100VA			—	200VA						—			

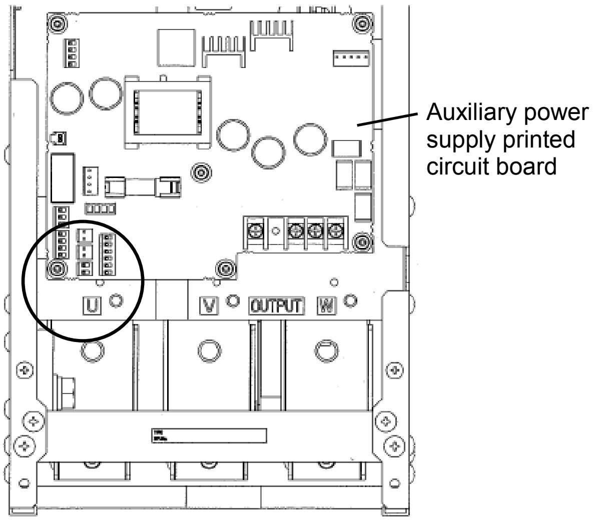
Fan power supply switching connectors are located on "Auxiliary power supply printed circuit board" attached to the lower section of the stack.

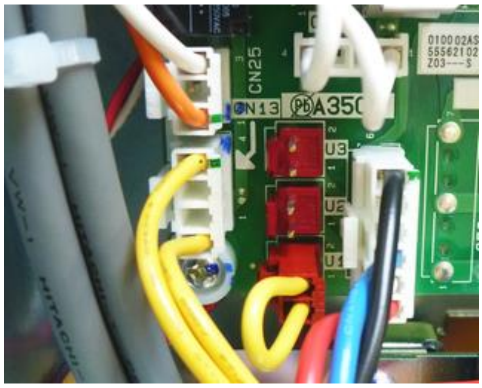
● 400V series (90 kW or higher)





- 690V series (all capacities)





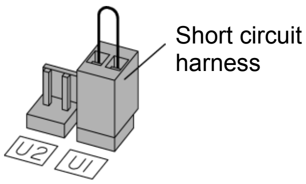
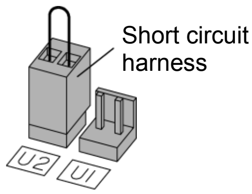
Configuration		
Applied voltage	400V series: 398 to 440 V/50 Hz, 430 to 480 V/60 Hz 690V series: 660 to 690 V, 50 Hz/60 Hz (Factory shipping state)	400V series: 380 to 398 V/50 Hz, 380 to 430 V/60 Hz 690V series: 575 to 600 V, 50 Hz/60 Hz

Figure 4.5.3-5: Description of fan power supply switching connector

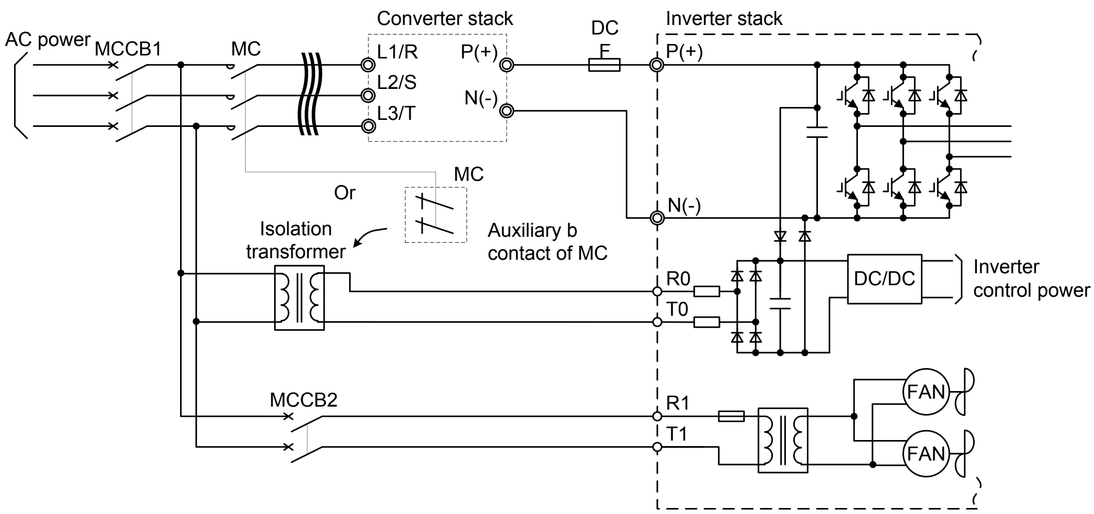


Figure 4.5.3-6: Connection of terminals R1 and T1

Terminal name	Recommended wire size [mm^2]
Fan power auxiliary input terminals R1 and T1	2.0

Note

- Terminals R1 and T1 are insulated from terminals R0, T0, P (+), and N (-). Thus, terminals R1 and T1 do not require an isolation transformer, unlike terminals R0 and T0.
  When inserting an MCCB2 in terminals R1 and T1 as shown in Figure 4.5.3-6, assign the auxiliary a contact of this MCBB2 to the operation interlock circuit of the inverter. When the MCCB2 is turned off, the cooling fan of the inverter will not run even if the inverter is in operation, and the inverter will cause an overheat trip.
- If wires of a larger size than a recommended wire size are used, they may not be inserted into the control cable lead-in hole in the front cover depending on the number of wires.

4.6 Control circuit

4.6.1 Screw specifications and recommended wire sizes

Table 4.6.1-1 shows the screw specifications and wire sizes for the wiring of the control circuit.

The control circuit terminal block is common regardless of the inverter capacity.

Table 4.6.1-1: Screw specifications and recommended wire sizes

Common terminal	Screw specifications		Recommended wire size [mm^2]
	Screw size	Tightening torque [N·m]	
Control circuit terminal	M3	0.7	1.25

Note: If wires of a larger size than a recommended wire size are used, they may not be inserted into the control cable lead-in hole in the front cover depending on the number of wires.

4.6.2 Control terminal layout

Figure 4.6.2-1 shows the control terminal layout.

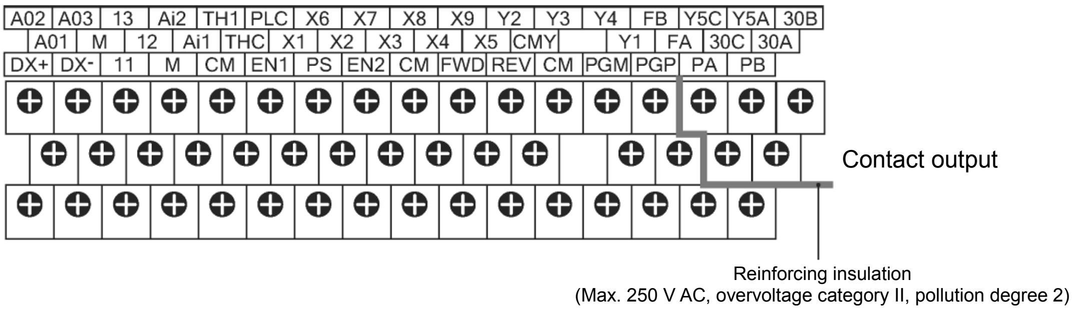


Figure 4.6.2-1: Control terminal layout

4.6.3 Control wire routes

In general, there are three control circuit wiring routes.

(1) DCF disconnection detection circuit wiring route. (The control wire is led into the stack from the upper area of the front face.)

(2) Route through which the control wire is led into the stack from the left side of the front cover.

(3) Route through which the control wire is led into the stack from the right side of the front cover.

If the control wire routed inside the stack comes into contact with any of the electronic parts inside the stack, the wire may burn out.
A binding fixture is attached to the inside of the stack. Bind the wire at the binding fixture.

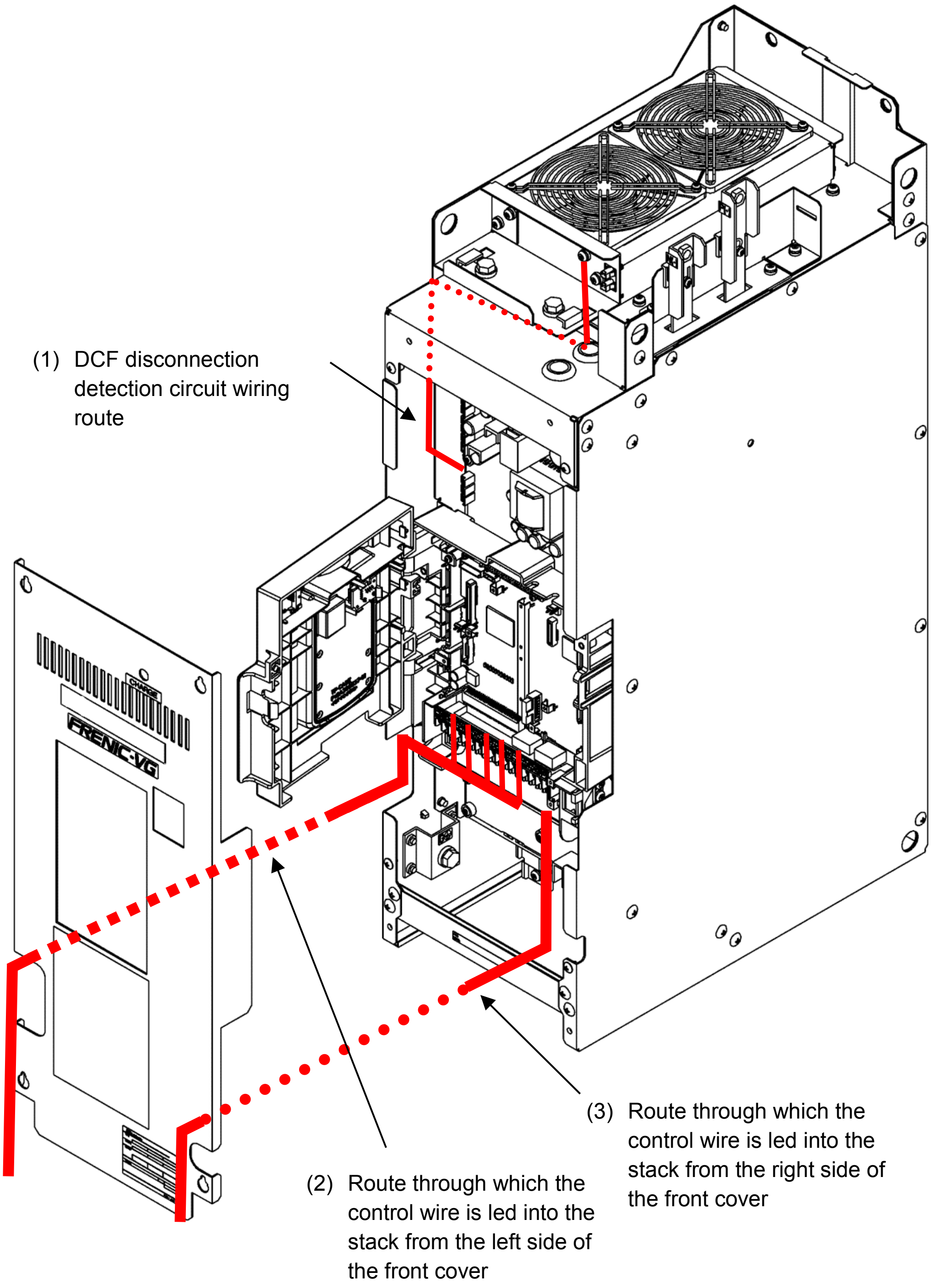


Figure 4.6.3-1: Control wire routes for Frame 1 size (400V: 30 to 45 kW) (example)

4.6.4 DCF disconnection detection circuit wiring route

Figure 4.6.4-1 shows the DCF disconnection detection circuit wiring route. On the PCB, aluminum electrolytic capacitors, high-voltage circuits, and heat sinks for cooling electronic parts are packaged.
If the wire comes into contact with any of these parts, the part may come off due to vibrations. For this reason, do not fail to fasten the wire using the binding band fixture. In addition, exercise care not to apply an excessive tension to the wire.

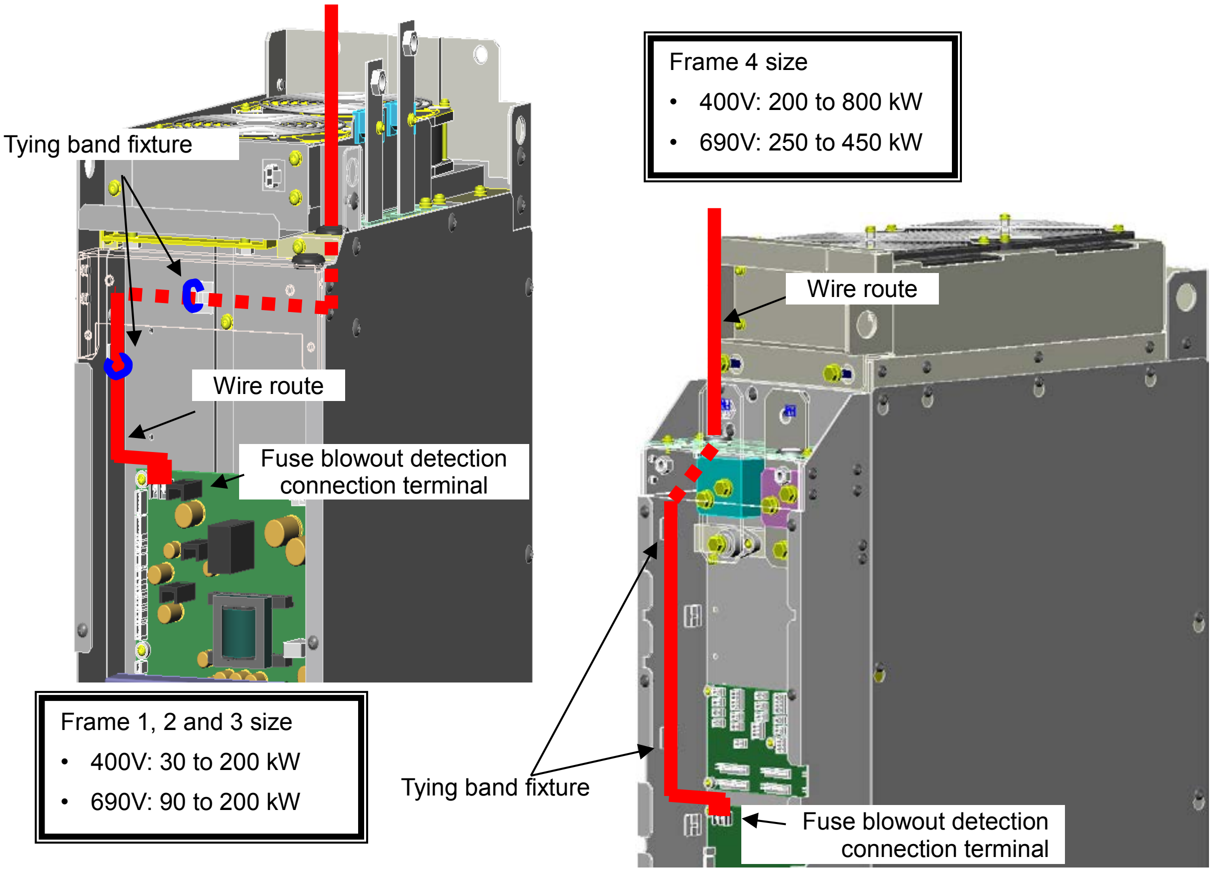
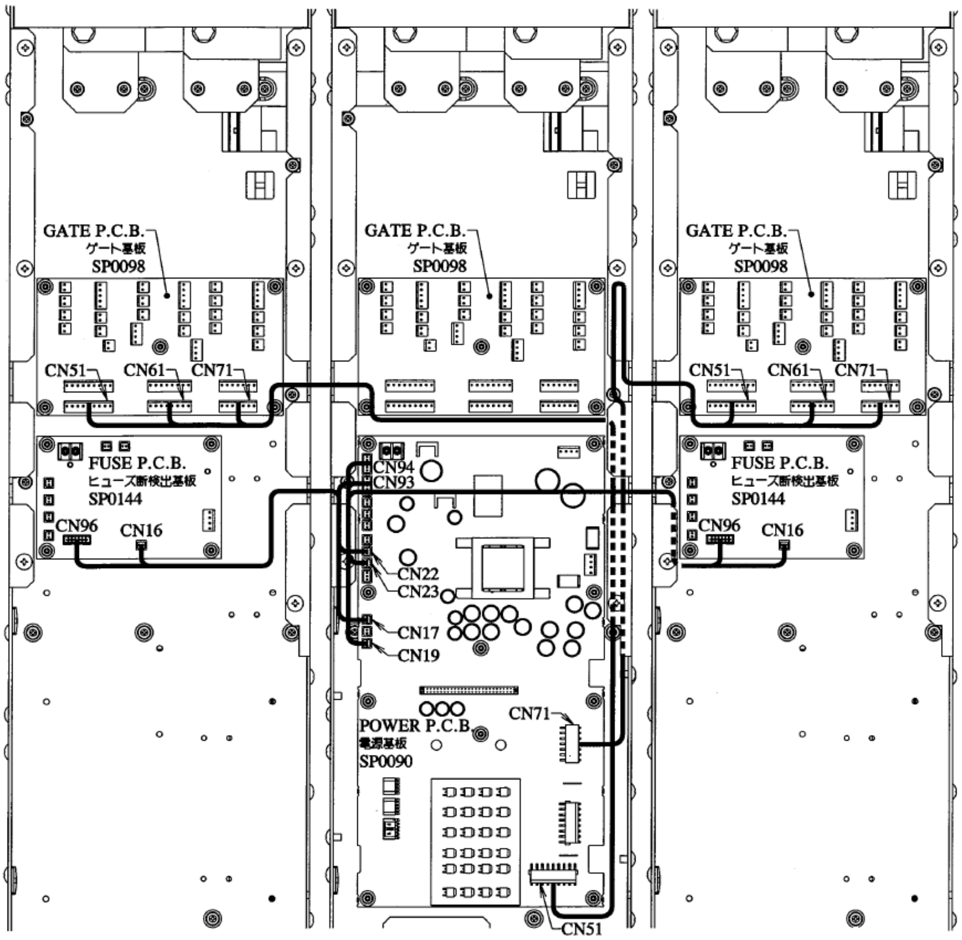


Figure 4.6.4-1: DCF disconnection detection circuit wiring route

4.6.5 Wiring between phase-specific stacks

After phase-specific stack inverters (FRN630BVG1S-4☐ to FRN800BVG1S-4☐) are installed, stack-to-stack wiring is required. To connect the stacks, use the wires that come with the product. For details, refer to Figure 4.6.5-1 to Figure 4.6.5-3.

- Applicable inverter models: FRN630BVG1S-4☐ to FRN800BVG1S-4☐
- Applicable PWM converter models; RHC630B-4D☐ to RHC800B-4D☐



U-phase (R-phase) **V-phase (S-phase)** **W-phase (T-phase)**

*The inverter has U-, V-, and W-phases. The PWM converter has R-, S-, and T-phases.

Figure 4.6.5-1: Gate, fuse disconnection alarm, and inverter overheat protection wires connected between phase-specific stacks

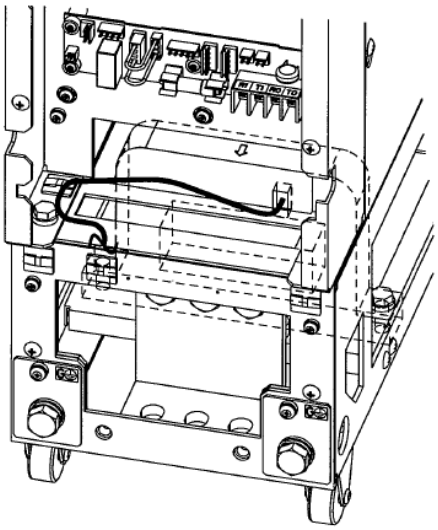
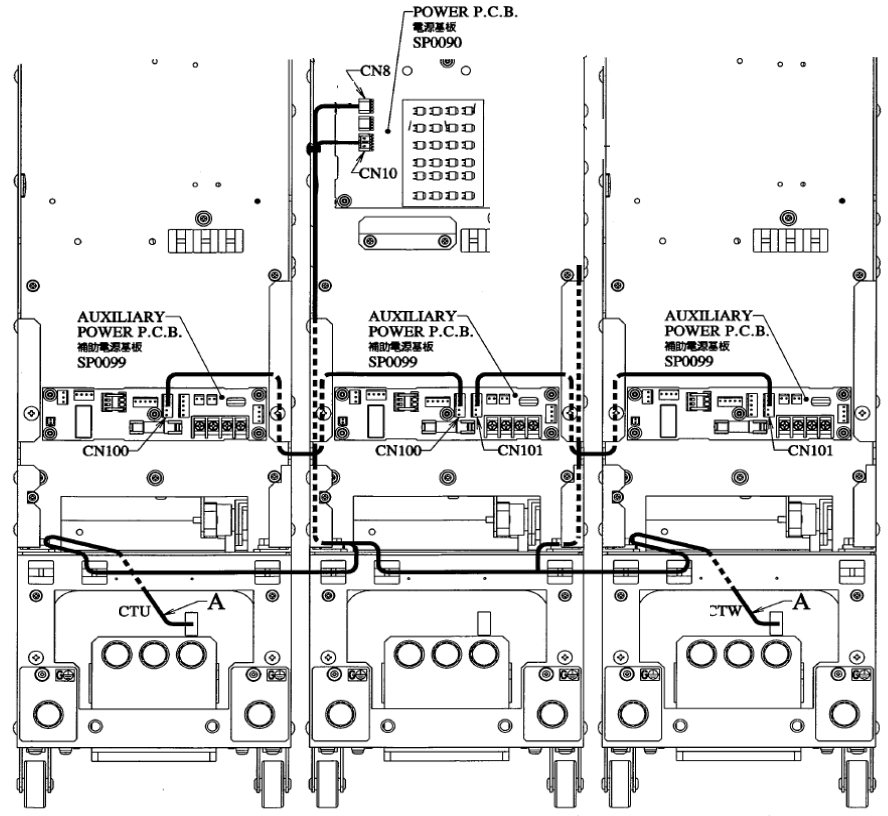


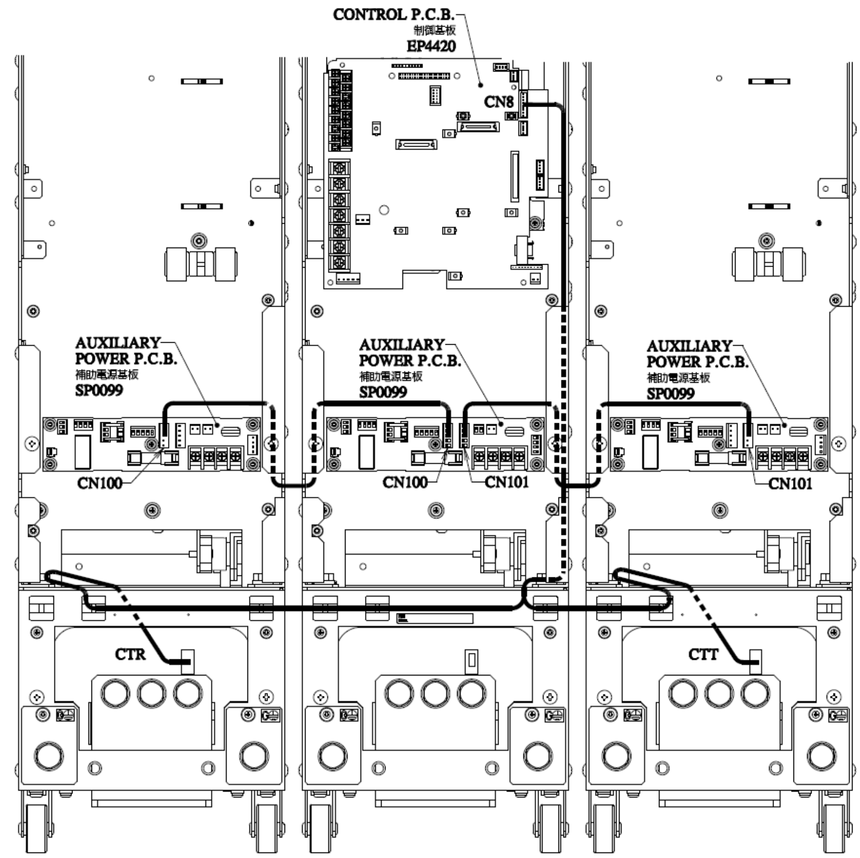
Figure 4.6.5-2: Auxiliary power supply and CT (current detection) wires connected between phase-specific stacks

[Inverter]



U-phase **V-phase** **W-phase**

[PWM converter]



(R-phase) **(S-phase)** **(T-phase)**

Figure 4.6.5-3: Details of CT (portion A) wiring route between phase-specific stacks

4.7 Mounting and connecting the keypad

The keypad can be mounted in the following patterns:

- Attaching the keypad to the inverter body (state at the time of the delivery of the inverter)
- Mounting the keypad on the door of the cabinet and remote-operating it (Refer to 4.7.2.2 Mounting the keypad on the door of the cabinet.)
- Remote-operating the keypad in your hand

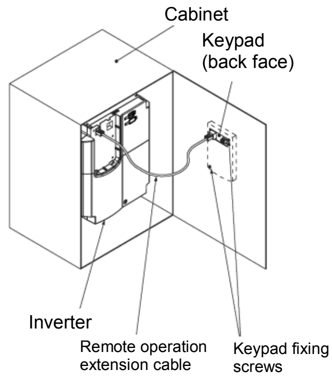


Figure 4.7.1-1: Example of installing keypad

4.7.1 Parts required for mounting and connecting the keypad

Use a keypad extension cable produced by Fuji Electric or a commercially available LAN cable (straight) to connect the keypad and the inverter. When mounting the keypad on the door of the cabinet, fix it with screws from the inside face of the door.
The parts required for mounting and connecting the keypad are not attached to the inverter. Prepare them yourself.

Part name	Model	Remarks
Keypad extension cable *1	CB-1S, CB-3S, CB-5S	Available in three different lengths: 5 m, 3 m, 1 m. The number in each model indicates the length of the cable.
Keypad fixing screw	M3 x 12 *2	Two fixing screws are required.

*1 When using a commercially available LAN cable, select a straight cable (within 20 m) for 10BASE-T/100BASE-TX complying with the category 5 specification of ANSI/TIA/EIA-568A of the U.S.

<Recommended LAN cables>
Manufacturer: Sanwa Supply Inc.
Model : KB-10T5-01K (1 m)
: KB-STP-01K (1 m) – Shielded cable (with improved noise resistance). Use this cable to make the inverter compliant with EMC Directives.

*2 When mounting the keypad on the cabinet, use fixing screws of proper length for the thickness of the steel panel. When the thickness of the steel panel is 1.2 to 2.3 mm: Use M3 x 12 screws. (When the thickness of the steel panel is 1 mm, use M3 x 10 screws.)

4.7.2 Installation procedure

After the wiring of the inverter is completed, mount the keypad according to the procedure described below. Before mounting the keypad, turn off the power to the inverter. The procedure described here proceeds on the assumption that the inverter used is a unit type, but is also applicable to stack type inverters.

4.7.2.1 How to mount and remove the keypad on/from the inverter

(1) Holding down the hook marked with an **arrow** shown in the figure below, pull the keypad toward you and remove it.

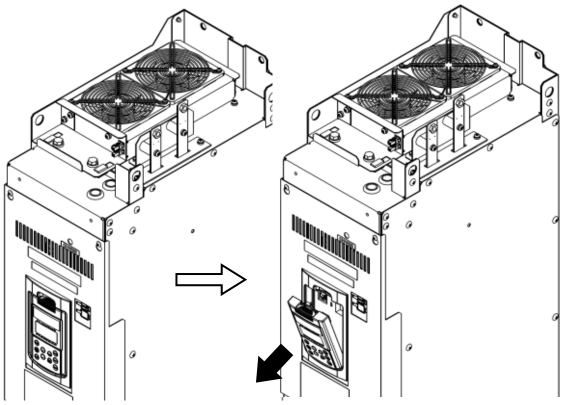


Figure 4.7.2-1: Removing the keypad

(2) Set the keypad on the latches shown in the figure below. Push the keypad in the direction of the terminal cover (arrow (1)) into the case of the inverter (arrow (2)).

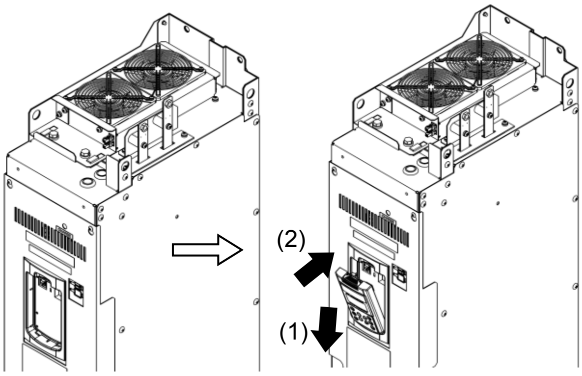


Figure 4.7.2-2: Mounting the keypad

4.7.2.2 Mounting the keypad on the door of the cabinet

(1) Cut the door of the cabinet on which the keypad will be mounted to the panel cutting dimensions shown in "4.7.2.3 External dimensions of the keypad" below.

(2) Mount the keypad as shown in Figure 4.7.2-3.

- Use M3 x 12 screws (thickness of the door: 2.3 mm).
- Tightening torque: 0.7 N·m

(3) Connect the RJ-45 connector of the keypad and the RJ-45 connector (modular jack) of the inverter using the keypad extension cable or a commercially available LAN cable (straight).
(Refer to Figure 4.7.2-4.)

Note: The cable may get caught between the door and the cabinet and get damaged when the door opens or closes. Fasten the cable with a tying part, such as INSULOK.

However, do not tie the cable more than necessary.

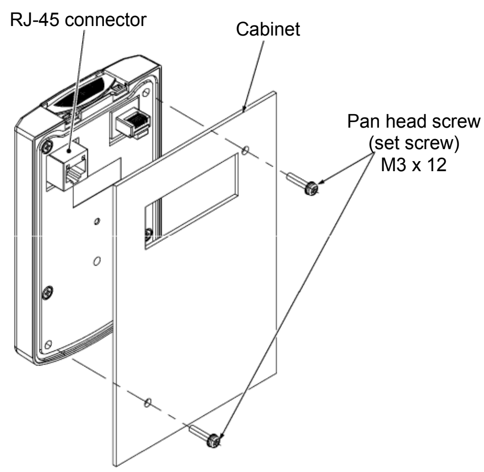


Figure 4.7.2-3: Mounting the keypad

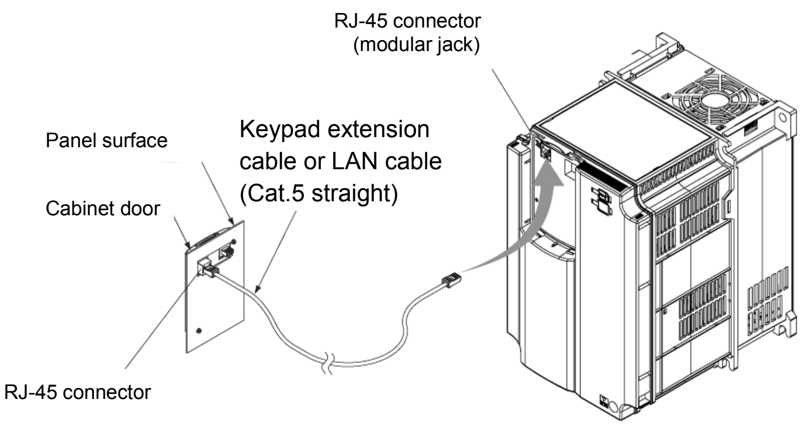
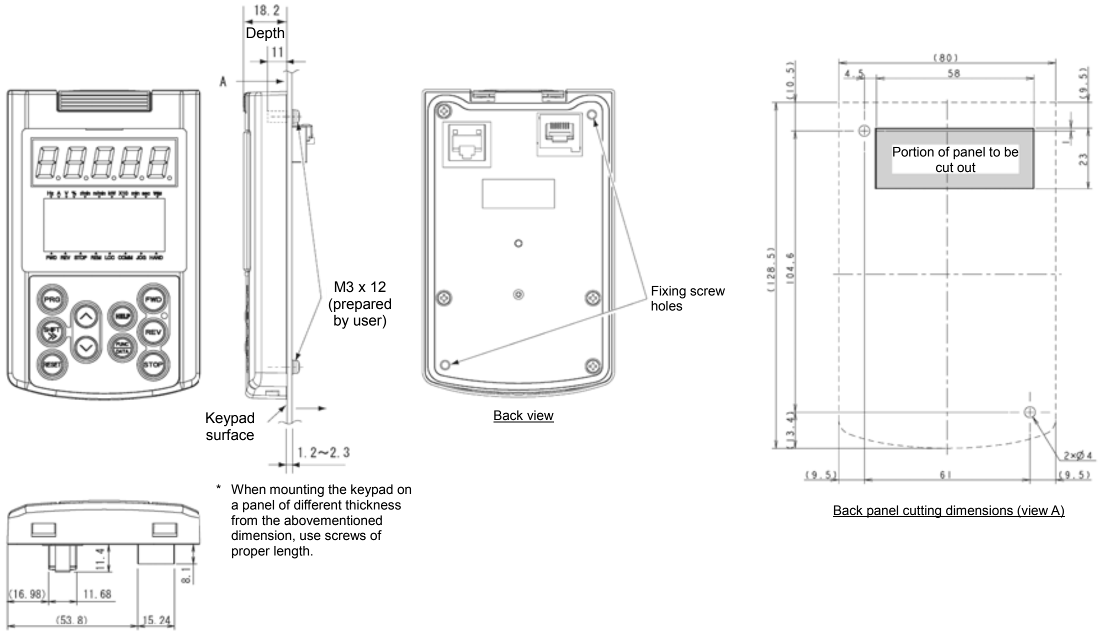


Figure 4.7.2-4: Connecting the keypad and the inverter

4.7.2.3 External dimensions of the keypad

The outside dimensions of the keypad are shown in the figure below. When mounting the keypad on the door of the cabinet, cut the door to the dimensions specified in the figure.



4.8 Connecting FRENIC-VG Loader

To use the FRNIC-VG Loader software that runs on a personal computer, it can be connected in the two ways described below. Select either connection method according to the usage of the equipment.

(1) Using the USB connector (mini type B) on the front panel of the stack inverter, connect a personal computer and an inverter.

(2) Using the RS-485 communications ports of the inverter control terminal, connect a personal computer and multiple inverters (up to 31 inverters can be connected) in a multidrop configuration.

📖 For more information on FRENIC-VG Loader, refer to "FRENIC-VG Loader Instruction Manual (INR-SI47-1588 (WPS-VG1-STR), INR-SI47-1616 (WPS-VG1-PCL))."

Note
- The RJ-45 connector for keypad connection is designed exclusively for keypad communication. It cannot be connected for RS-485 communication or to FRENIC-VG Loader.
- Do not connect an inverter to the LAN port of the personal computer, an Ethernet hub, or a telephone line. The inverter or the unit to which the inverter is connected may get damaged.

4.8.1 Connecting a USB

A USB cable connection port (closed by a plastic cover) is provided on the right side of the keypad.
A USB connector appears from under the cable connection port cover. Insert a USB cable into the port.

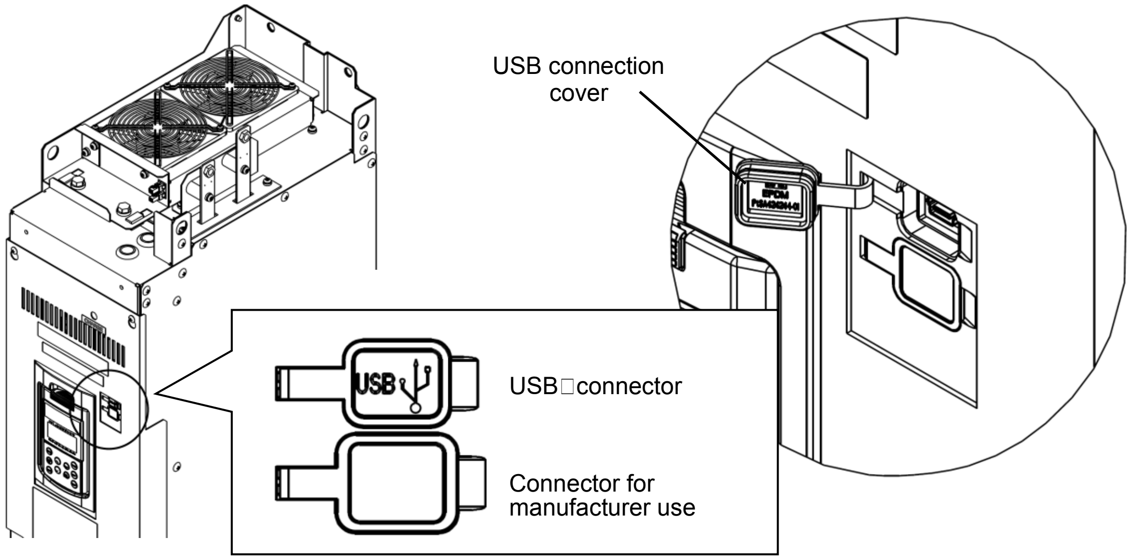


Figure 4.8.1-1: Connecting a USB cable

Note
- The connector below the USB connector is reserved for manufacturer use and cannot be used.
- A USB cable is not attached to inverters or the FRNIC-VG Loader software (CD-ROM). Prepare one yourself.

4.8.2 Using the RS-485 communications ports

4.8.2.1 Terminal specifications of the RS-485 communications ports

Connect the RS-485 communications ports to the terminals for RS-485 communication [DX+, DX-: half-duplex system (two-wire system)] on the control circuit terminal block. In addition, a terminating resistor is contained (for switching). Set it according to the connection configuration.

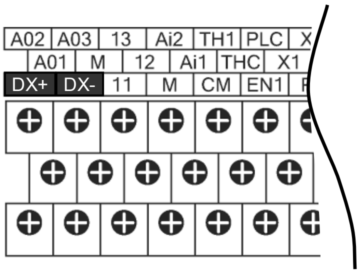


Figure 4.8.2-1: RS-485 terminals (part of control terminal block)

Terminal symbol	Description	Remarks
DX-	RS-485 communication data (-)	112-Ω terminating resistor contained Switch connection/disconnection by operating the SW4[*1].
DX+	RS-485 communication data (+)	

*1 For details of the SW4, see "2.4.2.2 Setting up the slide switches" in Chapter 2.

*2 There is no grounding terminal for shielding. Ground the shielded wire to the host unit.

4.8.2.2 RS-485 converter

Standard personal computers are not provided with an RS-485 communications port but are provided with an RS-232C or USB communications port.
To prevent this problem, use an RS-232C/RS-485 converter or USB/RS-485 converter. Note that the inverter will not properly function if a converter other than a recommended one that underwent a communication performance check is used.

Recommended converters (System Sacom Industry Corp.)

Name	Model	Remarks
RS-232C/RS-485 converter	KS-485PTI	
USB/RS-485 converter	USB-485I RJ45-T4P	A converter fixture (UTK-01) is available.

Website of System Sacom Industry Corp.: http://www.sacom.co.jp/

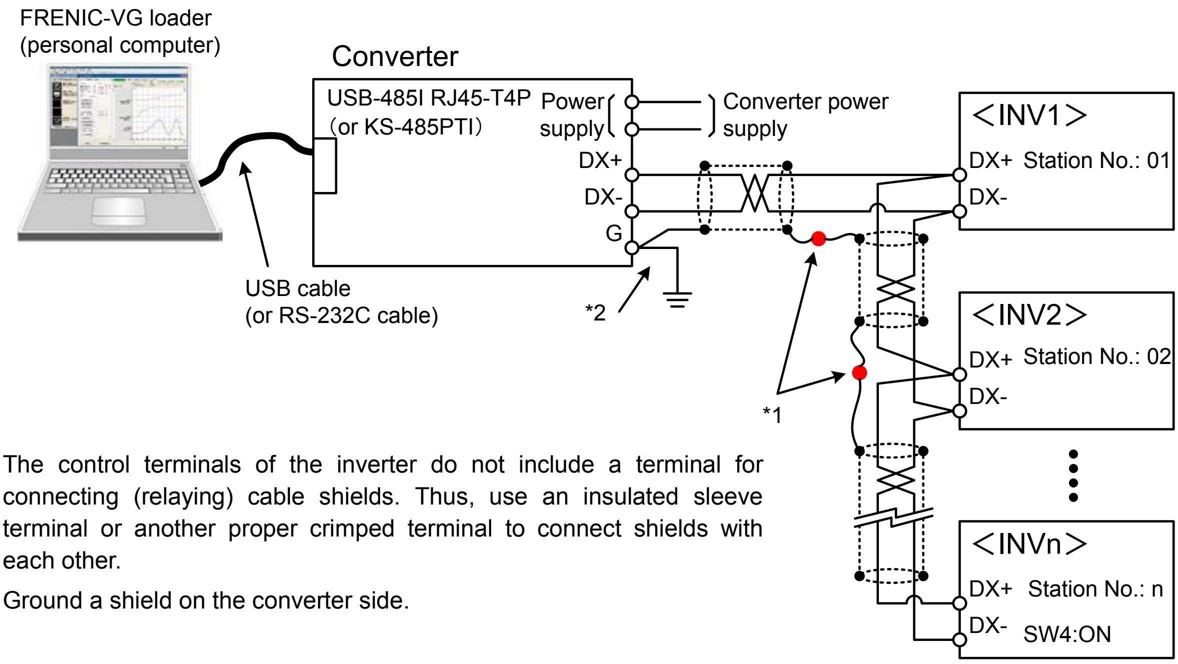
4.8.2.3 Cables

Use twisted-pair shielded cables of 0.5 mm^2 (0.3 to 1.25 mm^2) [AWG20 (AWG16 to AWG22)].

Recommended cables

- AWM2789 cable for long-distance connection (Furukawa Electric Co., Ltd. standard specification: DTS5023) 2-pair product
- Cat. 5E-compatible cable (Cat. 5 cable provided with a shield) when using a LAN cable

Website of Furukawa Electric Co., Ltd.: http://www.furukawa.co.jp/



*1 The control terminals of the inverter do not include a terminal for connecting (relaying) cable shields. Thus, use an insulated sleeve terminal or another proper crimped terminal to connect shields with each other.

*2 Ground a shield on the converter side.

Figure 4.8.2-2: Connection diagram

Note

- Maximum wiring length: 500 m (There is no restriction on the wiring distance between stations.)
- Provide the end unit with a terminating resistor. The recommended converters and inverters contain a terminating resistor. Set the terminating resistor to “Connect” using the appropriate selector switch or jumper switch.
- Even if FRENIC-VG Loader is not used, keep active the RS-485 communications line between the converter and the inverter. (If the converter is disconnected from the communications line, the communications line will serve as an antenna, and the converter will malfunction due to noise.)

4.8.3 Noise reduction

In some working environments, noise produced by an inverter may cause abnormal communication or malfunctions of the master's instrumentation units, converters, etc.

See Appendix 5 "Proficient way to use inverters (on electric noise)" in addition to this section.

Isolated converter : Use a recommended converter.

Twisted-pair shielded wire : Use a recommended wire.

Change of grounding : If an instrumentation unit and an inverter are grounded together, they may malfunction. Prepare grounding exclusively for instrumentation units. Use a large-size wire for grounding.

Reinforcement of converter power supply : Noise may propagate through the power supply for an instrumentation unit. It is recommended that an isolation transformer for power supply (TRAFY), noise cutting transformer, or LC filter be used.

Addition of inductance : By slipping a ferrite core over the signal circuit or using an LC filter, add inductance to the circuit to ensure high impedance against high-frequency noise.

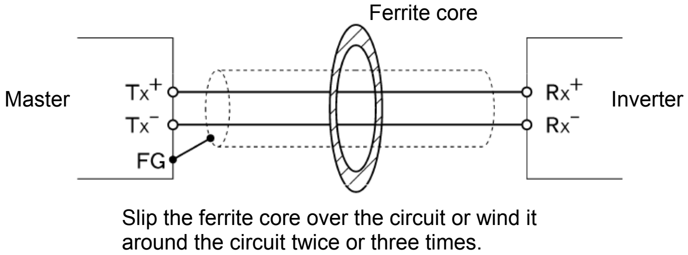


Figure 4.8.3-1: Example of setting of ferrite core

Filtering : Form a low-pass filter (LPF) by connecting capacitors to signal input/output terminals in parallel to prevent rigging or high-frequency noise.

<Filtering effect>

Filtering is a method for separating normal signals from rigging resulting from signal reflection or normal mode noise. In general, rigging has a higher frequency than signals and can, therefore, be separated by an LPF.

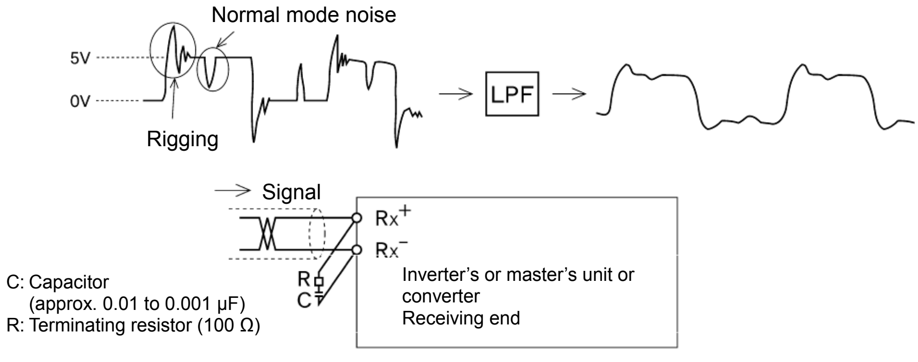


Figure 4.8.3-2: Description of effect of filtering

Note: Using an LC filter, ferrite core, or CR for filtering with a high damping rate for the communications line will make the waveform inactive and interrupt communication. (Communication error occurs.)

To continue communication with an inactive waveform, reduce the communication speed with H34 (communication speed setting function).

4.9 Dedicated lifter for stacks

4.9.1 Feature

(1) This is a dedicated lifter for transporting and replacing the FRENIC-VG series (stack type). It allows you to easily put a stack type inverter in the cabinet and take it out.
The lifter is available with the following products (stack type):

- FRENIC- VG series inverters (stack type)
- RHC-D series PWM converters
- RHD-D series diode rectifiers
- RHF-D series filter stacks

(2) The lifter pallet can be moved up and down (with a winching mechanism) and moved horizontally (with a ball screw mechanism) and can be easily aligned to the cabinet.

[Appearance]

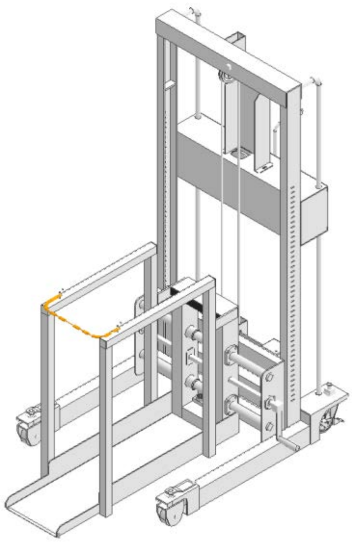


Figure 4.9.1-1: Appearance of the lifter

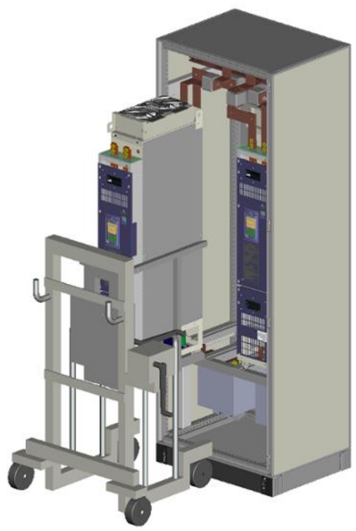


Figure 4.9.1-2: Example of using the lifter

(3) The lifter can be easily installed by use of the lifter fixture (SA430288-01), which is designed to fix the cabinet and lifter pallet.
This fixture allows easy installation even if the cabinet front face has no space to put the tip of the lifter pallet.

Note
- The lifter can be used without the fixture.
- The fixture must be fastened on the cabinet side.
- The fixture should be prepared by you.
- Design the cabinet so that the fixture can be attached.

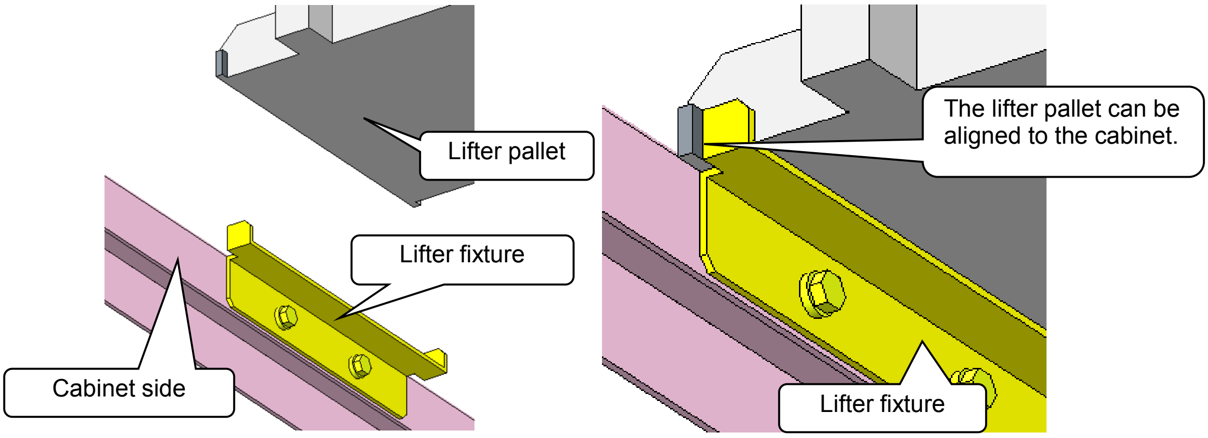


Figure 4.9.1-3: Example of using the lifter fixture

4.9.2 Specifications

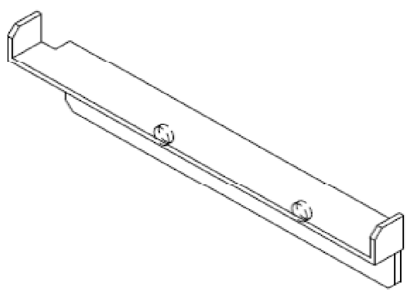
Item	Specifications	
Model	LFT-VG1	LFT-RHF450
Maximum load weight	250 [kg] (2450N)	280 [kg]（2744N）
External dimensions [mm]	702 (W) x 1254 (D) x 1450 (H)	
Lifting height [mm]	0 to 800	
Move up/down	Hand-wound: winching mechanism	
Move horizontally	Hand-wound: ball screw mechanism (rightward: 0 to 120 [mm], leftward: 0 to 120 [mm])	Hand-wound: ball screw mechanism (rightward: 0 to 65 [mm], leftward: 0 to 65 [mm])
Anti-fall device	With an anti-fall device (protection in case of broken wire rope)	
Front and rear wheels	Front wheels: 90-degree steerable Rear wheels: free type (with a stopper)	
Approximate weight	120 [kg]	125 [kg]
Finishing color	25-70B 5Y7/1, half-gloss	
Ambient temperatures	-10 to 50°C	
External dimensions	SA496984-01	SA497688-01

4.9.3 Securing the Lifter

When using a lifter, a lifter securing fixture may be used.

The fixture should be prepared by you as needed.

4.9.3.1 Lifter securing fixture (for SA430288-01_ LFT-VG1)



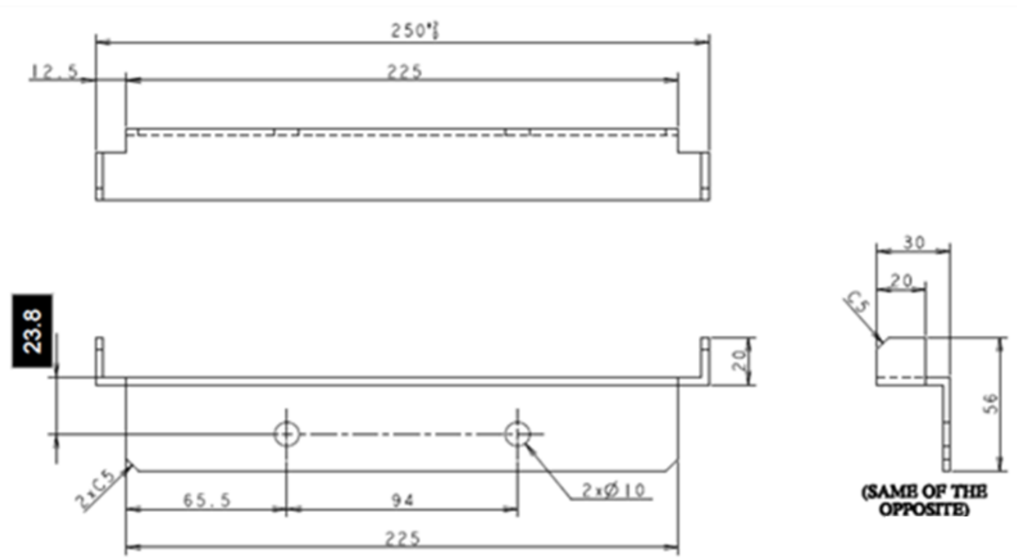
ISOMETRIC DRAWING

Material: SPHC, t3.2

Plating: Specification JIS Ep-Fe/Zn8/CM2-F

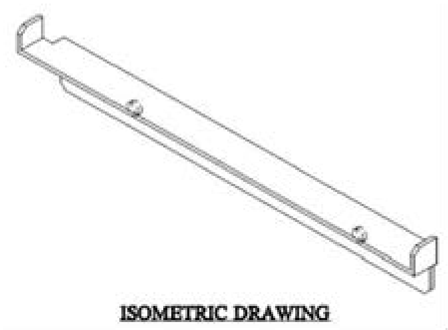
To be post-plated.

Unit: mm



Change * * * based on the structural design of the cabinet.

4.9.3.2 Lifter securing fixture (for SA433892-01_ LFT-RHF45)

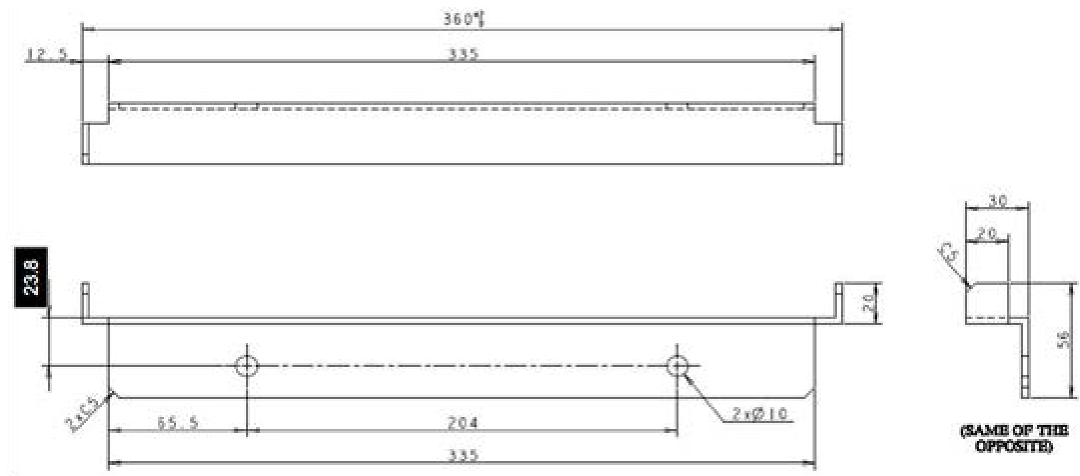


Material: SPHC, t3.2

Plating: Specification JIS Ep-Fe/Zn8/CM2-F

To be post-plated.

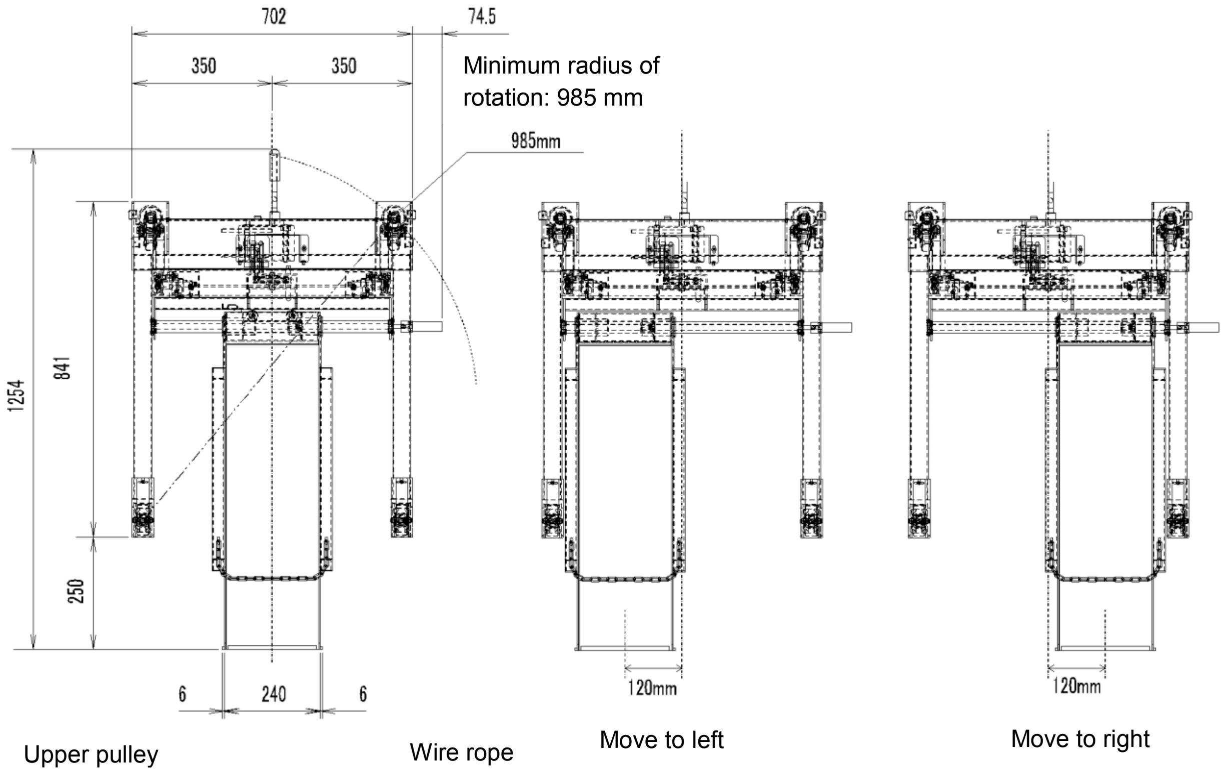
Unit: mm

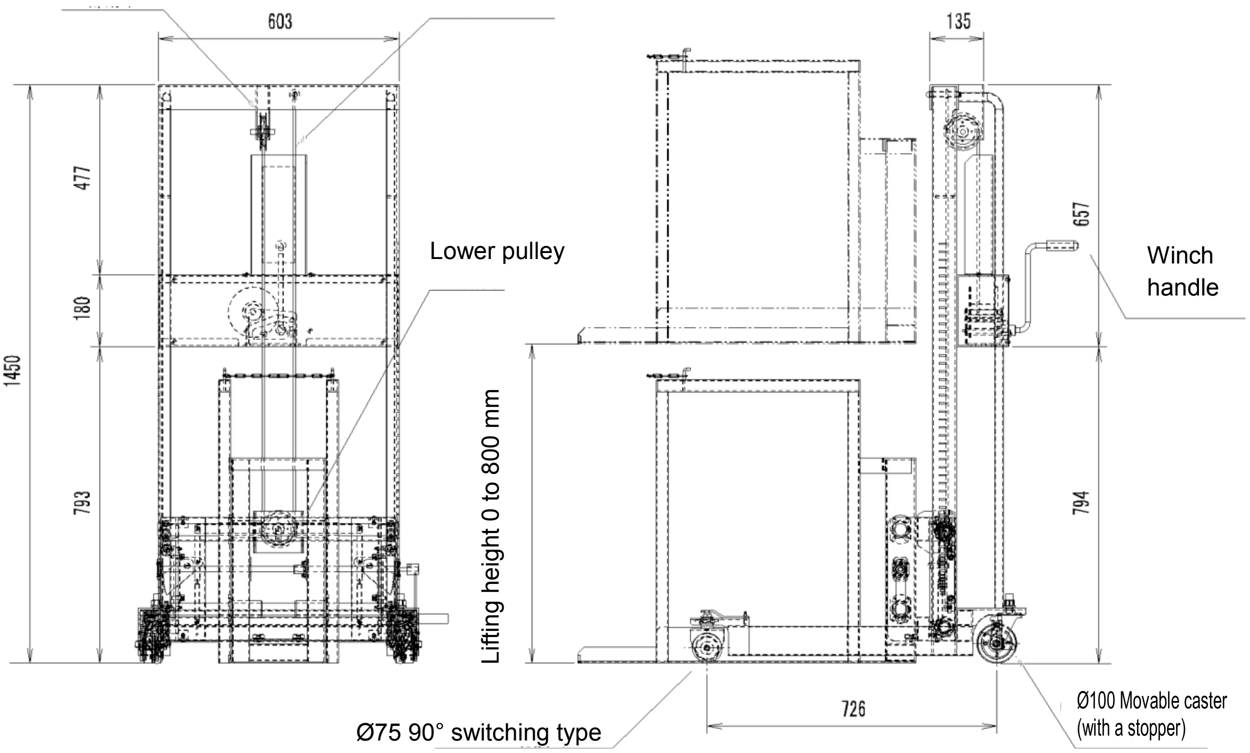


Change * * * based on the structural design of the cabinet.

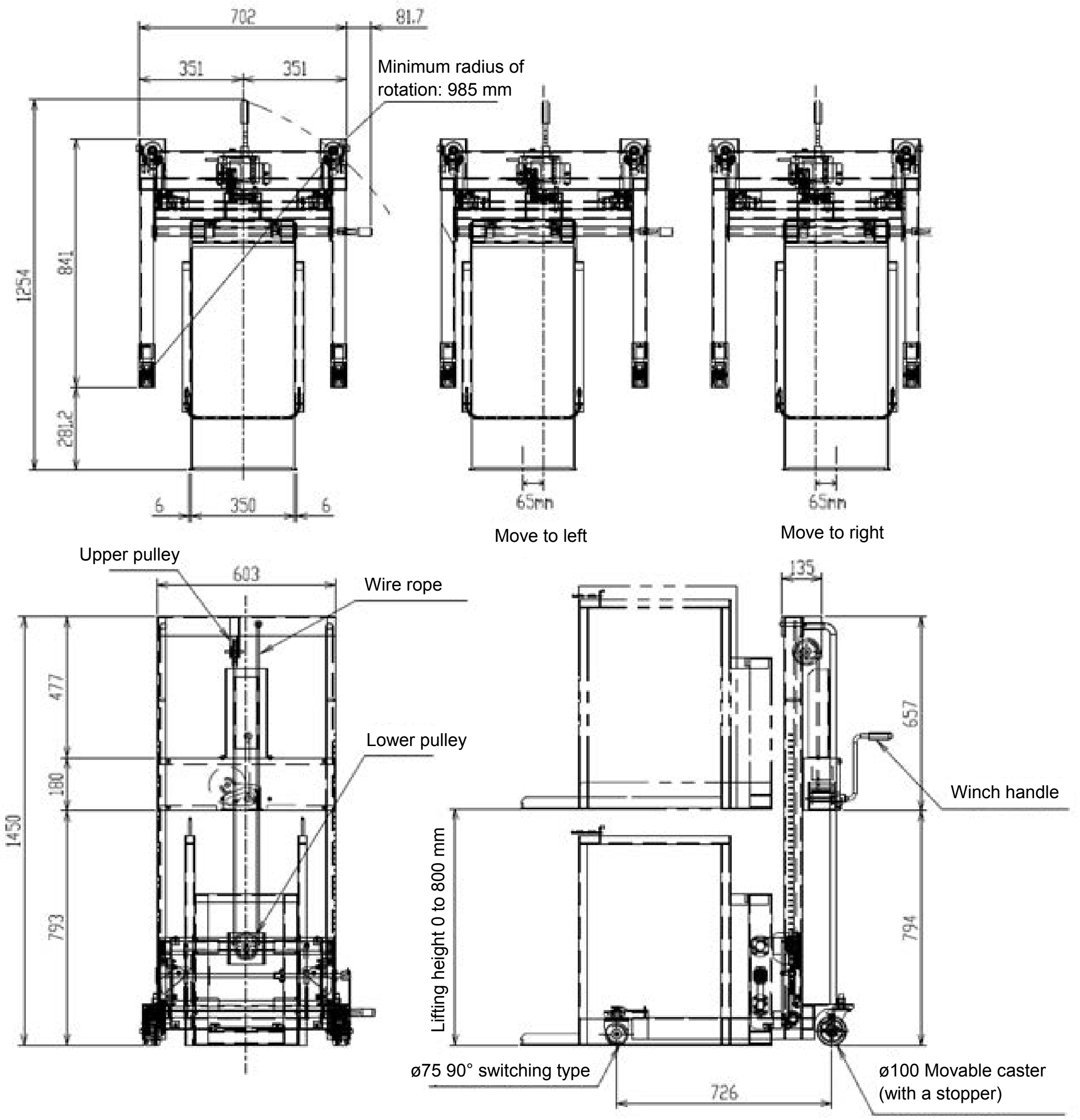
4.9.4 Lifter external dimensions

4.9.4.1 LFT-VG1 external dimensions





4.9.4.2 LFT-RHF450 external dimensions



Chapter 5 Peripherals

5.1 Precautions for use

Precautions for use including the selection and connectivity of inverter peripherals are described below.

5.1.1 Precautions in connecting main circuit peripherals

5.1.1.1 Fuses

Fuses have limited life. Fuji Electric recommends replacing these periodically. If the attachment of the fuse is inadequate, accidents can occur due to the impact of fuse melting, so fasten the fuse with the appropriate tightening torque.

5.1.1.2 Breakers/disconnectors (Molded Case Circuit Breaker: MCCB, Earth Leakage Circuit Breaker: ELCB)

An MCCB or ELCB cannot be used for the input (DC bus bar) and output sections of the inverter. (due to the characteristics of MCCB/ELCB)

- The output of the inverter has protective functions (overcurrent, ground fault, open phase, etc.), so no MCCB or ELCB is required. If an MCCB is used inevitably for the purpose of short protection, select a breaker with capacity which trips at a larger current than the rated inverter capacity. (An ELCB in particular cannot be used.) Protective coordination with the electric wire size should also be confirmed before the selection.
- To use as a disconnector, use the non-auto switch which detaches the overcurrent trip function.

5.1.1.3 Initial charging circuit

The common converter performs initial charging for the entire system at once. Refer to this chapter if initial charging circuit is to be inevitably implemented for each inverter. When the instructions in this chapter are not followed, peripherals may be adversely affected, resulting in damage in some cases.

5.1.1.4 Contactor (magnetic contactor)

For the contactor (electromagnetic contactor) attached to the DC bus bar and the output side, configure the sequence such that opening and closing operations are performed while the inverter is stopped (inverter output is cut off).

5.1.1.5 Motor overload protection

When connecting to and operating the motor on a 1:1 basis, use the electronic thermal function of the inverter. For the following cases, electronic thermal function cannot protect to maintain normal state, so attach thermistors (NTC / PTC) or thermal relays to the motor for protection.

- Applications where start and stop are frequent, where loading variation occurs frequently, and where very low speed operation is continuous.
- Motors other than the standard three phase motor is used (electronic thermal characteristics are different).

Do not use a thermal relay on the inverter's input (DC bus bar) side. The thermal relay will not function properly due to direct current voltage containing high frequency components.

5.1.2 Precautions for phase advancing capacitors

Do not attach phase advancing capacitors to the inverter output (secondary) side. When connected to inverter output, the phase advancing capacitors can burn and be damaged, or make the inverter trip from overcurrent due to the switching frequency of the inverter.

Attaching phase advancing capacitors to the power supply side does not improve the power factor because the inverter is capacitive.

When attaching the phase advancing capacitors to the power receiving side for other instruments, attach reactors which match the phase advancing capacitors.

5.1.3 Precautions for connecting control circuit instruments

PG amplifier (isolation amplifier)

In facilities where PG (pulse generator) is attached to motors to control vectors with long distance wiring, the stray capacitance of the long wires distort PG waveforms, making normal speed detection impossible. In these cases, attach isolation amplifiers (PG amplifiers) for pulse detection.

When PG amplifiers are attached, PG cut off detection protection function is disabled. Enable the inverter's speed mismatch detection function and use it to replace the PG cut off detection protection function.

5.1.4 Precautions for using synchronous motors

Be careful of the following matters when using synchronous motors.

(1) When using motors other than Fuji's standard synchronous motor (GNF2), please contact Fuji Electric.

(2) One inverter cannot operate multiple synchronous motors.

(3) Synchronous motors cannot be operated using direct input from commercial power supplies.

(4) Synchronous motors become a generator and a voltage is induced on the motor terminals when they are rotated. Disconnectors and contactors may be attached on inverter outputs for maintenance checkups. Exercise caution on the following points, especially when using contactors.

<Problem>

The following problems exist when using contactors (52-2) on inverter outputs and the instantaneous power failure restart mode.

(1) Tripping of inverter alarm, diode damage, and fuse (DCF) melting may occur.

(2) Welding, contact stain, and contact failure of the main contact points on contactor (52-2) may occur.

Synchronous motors become a generator (such as in the case of fans) when rotated from the load side, and the main circuit capacitors inside the inverter are charged via the inverter return flow diodes.

Even in the case when the inverter cuts off the gate from the inverter driven control state, the synchronous motors become a generator as in the above case, and charge the inverter.

Hence, when the synchronous motor is a generator, the voltage on the synchronous motor terminals is higher than the inverter intermediate voltage, and the contactor (52-2) is turned on, rush current flows in the route in Figure 5.1.4-1, causing the problems (1) and (2) above. (Similar phenomenon occurs when recovering from instantaneous power failure.)

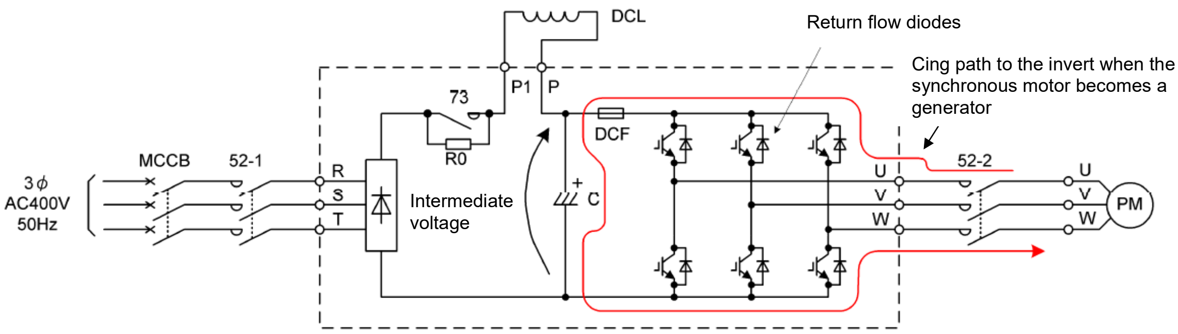


Figure 5.1.4-1: Path of rush current

Problem does not exist if 52-2 is still ON, but rush current flows in this path when it turns from OFF to ON. (The larger the voltage difference between the motor terminal voltage and the inverter intermediate voltage, the larger the rush current.)

<Countermeasure>

When driving synchronous motors, select instruments which can maintain open and close states for devices to be attached to the inverter output.

(1) Use of large switch (Non-auto switch of Fuji Electric's G-TWIN molded case circuit breaker series).

(2) Use of mechanical latches (e.g., systems which can turn contactors off only during alarms, such as SC-N**/VS) for the case of contactors.

5.2 Selection of peripherals

5.2.1 Main circuit

5.2.1.1 Fuses

To reduce secondary damage to other instruments in the event the inverter is damaged, install a fuse between the input (DC bus bar) and the inverter. The recommended connection for the 400V series is on the P side (+ side), but N side (- side) will provide the same protection without any problems.

For the 690V series, install fuses on both the P side (+ side) and N side (- side).

The FRENIC-VG contains fuse disconnection detection terminals, allowing detection of fuse disconnection. (Inverter alarm will trip.)

Purchase the microswitches for disconnection detection along with fuses.

Note: Fuses other than those in the “**Application list**” below cannot be used.

(1) Application list

Fuse manufacturer - Eaton: http://www.eaton.com/
*This product can be also purchased from Fuji Electric.

Table 5.2.1-1: Application list (400V series)

Voltage	Specifications	Motor rated capacity [kW]	Rated output [A]	Rated DC current [A]	Inverter type	Fuse				
						Type	Quantity	Fig.	Generated loss [W]	Approx. mass [kg]
400 V	MD	30	60	65	FRN30SVG1S-4□	170M3394-XA	1	A	45	0.38
		37	75	80	FRN37SVG1S-4□					
		45	91	97	FRN45SVG1S-4□	170M3395-XA	1		55	
		55	112	119	FRN55SVG1S-4□					
		75	150	162	FRN75SVG1S-4□	170M3396-XA	1		60	
		90	176	195	FRN90SVG1S-4□	170M3448-XA	1	B	70	
		110	210	238	FRN110SVG1S-4□					
		132	253	286	FRN132SVG1S-4□	170M4445-XA	1	C	85	0.58
		160	304	347	FRN160SVG1S-4□	170M5446-XA	1	D	110	0.90
		200	377	433	FRN200SVG1S-4□	170M6546-XA	1	E	125	1.25
		220	415	476	FRN220SVG1S-4□					
		250	468	541	FRN250SVG1S-4□	170M6547-XA	1		130	
		280	520	606	FRN280SVG1S-4□	170M6548-XA	1		135	
		315	585	682	FRN315SVG1S-4□	170M6500-XA	1	F	145	
		630	1170	1365	FRN630BVG1S-4□	170M7532	3	G	225	3
		710	1370	1538	FRN710BVG1S-4□	170M7633	3		235	
		800	1480	1733	FRN800BVG1S-4□					
	LD	37	75	80	FRN30SVG1S-4□	170M3394-XA	1	A	45	0.38
		45	91	97	FRN37SVG1S-4□					
		55	112	119	FRN45SVG1S-4□	170M3395-XA	1		55	
		75	150	162	FRN55SVG1S-4□	170M3396-XA	1		60	
		90	176	195	FRN75SVG1S-4□	170M3448-XA	1	B	70	
		110	210	238	FRN90SVG1S-4□					
		132	253	286	FRN110SVG1S-4□	170M4445-XA	1	C	85	0.58
		160	304	347	FRN132SVG1S-4□	170M5446-XA	1	D	110	0.9
		200	377	433	FRN160SVG1S-4□	170M6546-XA	1	E	125	1.25
		220	415	476	FRN200SVG1S-4□					
		250	468	541	FRN220SVG1S-4□	170M6547-XA	1		130	
		280	520	606	FRN250SVG1S-4□	170M6548-XA	1		135	
		315	585	682	FRN280SVG1S-4□	170M6500-XA	1	F	145	
		355	650	769	FRN315SVG1S-4□					
		710	1370	1538	FRN630BVG1S-4□	170M7633	3	G	235	3
		800	1480	1733	FRN710BVG1S-4□					
		1000	1850	2166	FRN800BVG1S-4□	170M7595	3		260	

Note 1) Rated DC current is calculated using a diode rectifier and assuming that the received power voltage is 400 VAC 50 Hz.

Table 5.2.1-2: Application list (690V series)

Voltage	Specifications	Motor rated capacity [kW]	Rated output [A]	Rated DC current [A]	Inverter type	Fuse				
						Type	Quantity	Fig.	Generated loss [W]	Approx. mass [kg]
690 V	MD	90	100	117	FRN90SVG1S-69□	170M3448-XA	2	B	70	0.38
		110	130	143	FRN110SVG1S-69□					
		132	140	169	FRN132SVG1S-69□					
		160	161	204	FRN160SVG1S-69□					
		200	216	254	FRN200SVG1S-69□	170M4445-XA	2	C	85	0.58
		250	265	315	FRN250SVG1S-69□	170M6546-XA	2	E	125	1.25
		280	295	355	FRN280SVG1S-69□					
		315	330	397	FRN315SVG1S-69□					
		355	365	446	FRN355SVG1S-69□	170M6547-XA	2		130	
		400	410	501	FRN400SVG1S-69□					
		450	460	561	FRN450SVG1S-69□					
	LD	110	130	143	FRN90SVG1S-69□	170M3448-XA	2	B	70	0.38
		132	140	169	FRN110SVG1S-69□					
		160	161	204	FRN132SVG1S-69□					
		200	216	254	FRN160SVG1S-69□					
		220	235	277	FRN200SVG1S-69□	170M4445-XA	2	C	85	0.58
		280	295	355	FRN250SVG1S-69□	170M6546-XA	2	E	125	1.25
		315	330	397	FRN280SVG1S-69□					
		355	365	446	FRN315SVG1S-69□					
		400	410	501	FRN355SVG1S-69□	170M6547-XA	2		130	
		450	460	561	FRN400SVG1S-69□					

(2) Connection diagram

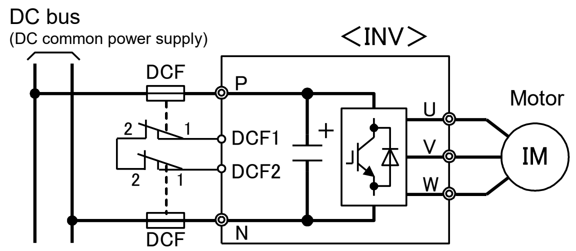


Figure 5.2.1-1: Fuse wire connection diagram

Figure 5.2.1-1 shows the connection diagram for the fuse and disconnection detection microswitch.

For the 400V series, install a fuse to the P side (+ side). (* The N side (- side) will also provide the same protection.)

For the 690V series, install fuses on both the P side (+ side) and N side (- side).

Connect microswitches to [DCF1, DCF2] terminals of the inverter. (These terminals support b contact output, and detect fuse disconnection when the contact is open.)

(3) How to install a fuse

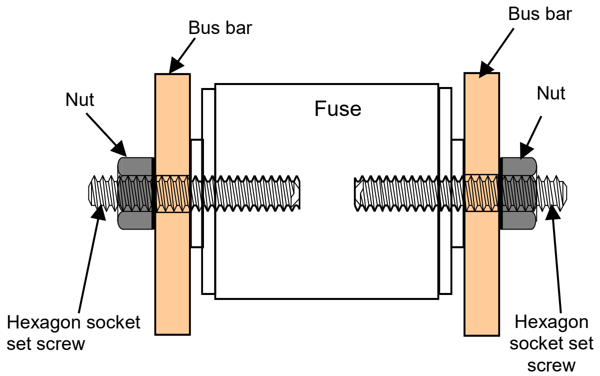


Figure 5.2.1-2: Installing a fuse

Figure 5.2.1-2 shows how to install a fuse. Install hexagon socket set screws into the fuse and fasten the bus bars with nuts.

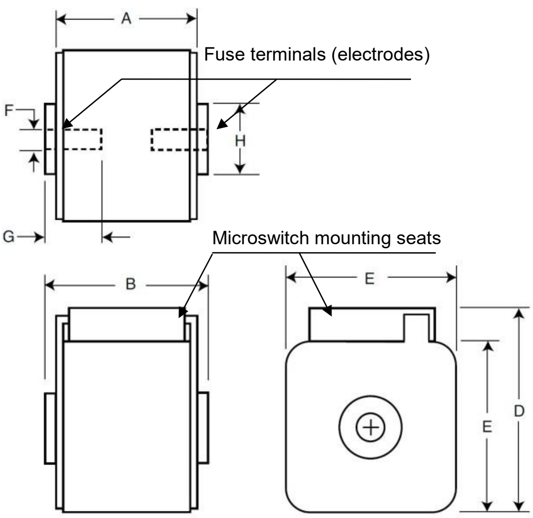
(4) External dimensions

Table 5.2.1-3: Fuse external dimensions table

Fig.	Dimensions (mm)						
	A	B	D	E	F	G	H
A	74	75	59	45	M8	5	φ17
B	80	81					
C	80	81	69	53		8	φ20
D			77	61	M10	10	φ24
E	81	83	92	76	M12		φ30
F		91					
G	-	106.6	120	105	M10	10	φ56

Note) Column H shows the fuse main circuit terminals.

■ **Figure A-F**



■ **Figure G**

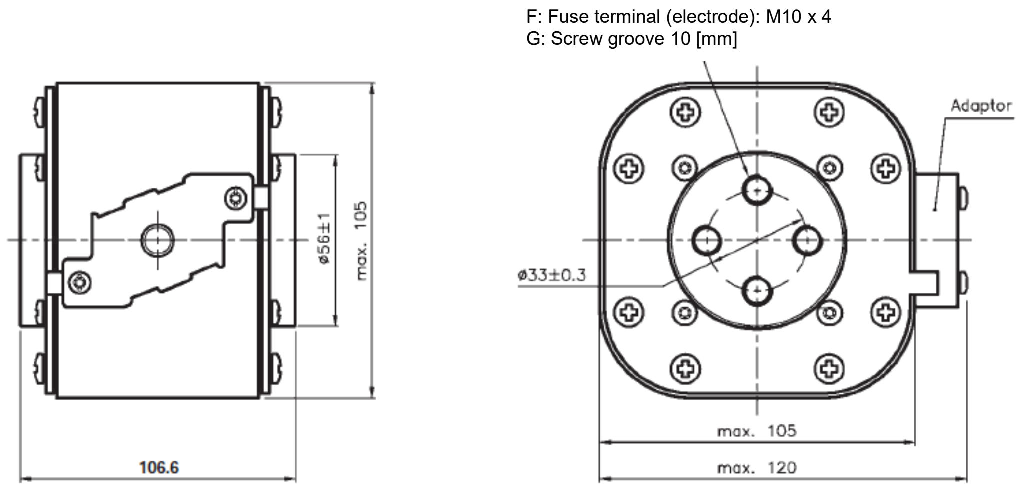


Figure 5.2.1-3: Fuse external shape

(5) Microswitch

Type: 170H3027

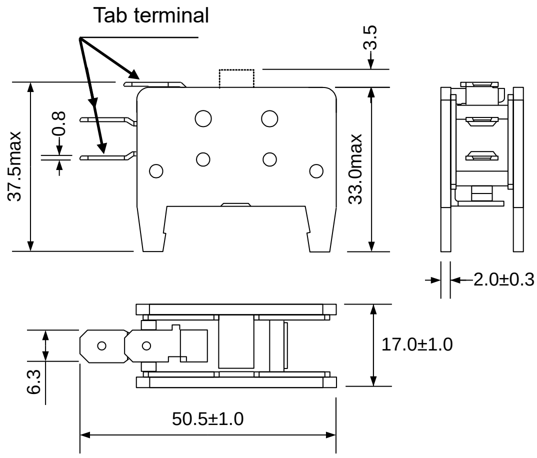


Figure 5.2.1-5: Microswitch external shape

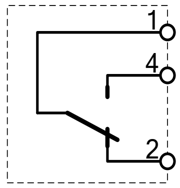


Figure 5.2.1-4: Microswitch contact structure

Note Install the microswitch to the fuse so that its tab terminals face down.

Press in the microswitch so that the claws for attaching the microswitch will hook onto the fuse body.

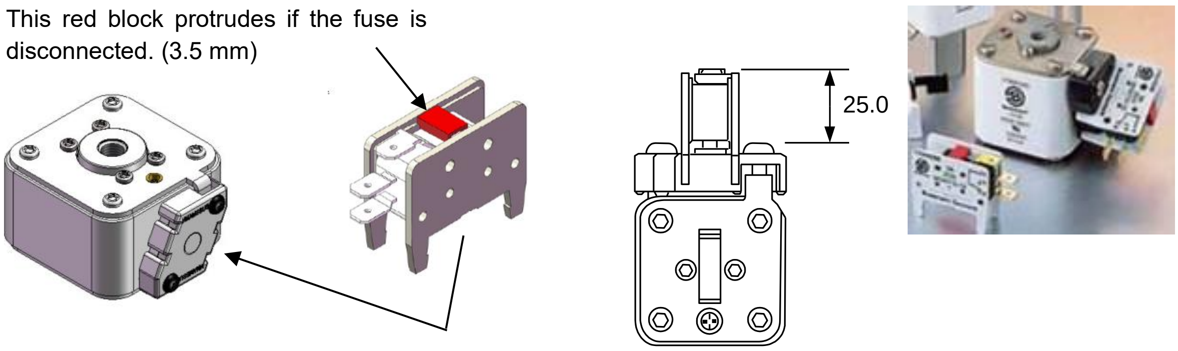


Figure 5.2.1-6: Installing a microswitch

5.2.2 Disconnectors and molded case circuit breakers for wiring (MCCB)

This section describes disconnectors and molded case circuit breakers for wiring (hereinafter referred to as "MCCBs") used in the inverter input/output circuit.

[Examples of use]
- Used to disconnect the inverter's input power supply from the converter before maintenance of the facilities
- Used to disconnect the inverter and motor from each other

When using an MCCB on the input (DC bus bar) and/or output side of the inverter, it is necessary to use a non-auto switch that excludes the overcurrent trip function.

<u>Inverter input side</u>

The opening and closing of the disconnector or MCCB installed on the inverter input side should be performed after confirming that both the converter and inverter charge lamps are off.

<u>Inverter output side</u>

Use of a non-auto switch is recommended when installing a disconnector or MCCB on the inverter output side. If MCCB is necessary for the purpose of short protection, use one that has larger capacity than the inverter rated capacity. In this case, also consider <u>protective coordination with the electric wire</u>.

* Normally, protective coordination with the electric wire is achieved with the inverter's protective functions (overcurrent, ground fault, open phase, etc.). However, if the user's facility standards require protective coordination with MCCBs as a rule, that rule should be followed.

(1) Application list

Use the combinations in the following table.

Table 5.2.2-1: Application list

Voltage	Motor rating		Inverter type (FRN)		Diode rectifier		PWM converter		Inverter output side MCCB*2
	Capacity [kW]	Capacity [kW]	MD Spec	LD Spec	Input current [Adc]*1	MCCB*2	Input current [Adc]*1	MCCB*2	
400V	30	60	30SVG1S-4□	-	65	400AF	56.3	400AF	400AF
	37	75	37SVG1S-4□	30SVG1S-4□	80		68.8		
	45	91	45SVG1S-4□	37SVG1S-4□	97		82.9		
	55	112	55SVG1S-4□	45SVG1S-4□	119		102		
	75	150	75SVG1S-4□	55SVG1S-4□	162		138		
	90	176	90SVG1S-4□	75SVG1S-4□	195		161		
	110	210	110SVG1S-4□	90SVG1S-4□	238		197		
	132	253	132SVG1S-4□	110SVG1S-4□	286		235		
	160	304	160SVG1S-4□	132SVG1S-4□	347	630AF	285		
	200	377	200SVG1S-4□	160SVG1S-4□	433		355	630AF	630AF
	220	415	220SVG1S-4□	200SVG1S-4□	476		386		
	250	468	250SVG1S-4□	220SVG1S-4□	541	800AF	440		
	280	520	280SVG1S-4□	250SVG1S-4□	606		491		
	315	585	315SVG1S-4□	280SVG1S-4□	682		552	800AF	800AF
	355	650	-	315SVG1S-4□	769		625		
	630	1170	630BVG1S-4□	-	1365	-	1102	-	-
	710	1370	710BVG1S-4□	630BVG1S-4□	1538	-	1243	-	-
	800	1480	800BVG1S-4□	710BVG1S-4□	1733	-	1400	-	-
	1000	1850	-	800BVG1S-4□	2166	-	1750	-	-
690V	90	100	90SVG1S-69□	-	117	-	96	-	-
	110	130	110SVG1S-69□	90SVG1S-69□	143	-	118	-	-
	132	140	132SVG1S-69□	110SVG1S-69□	169	-	140	-	-
	160	161	160SVG1S-69□	132SVG1S-69□	204	-	170	-	-
	200	216	200SVG1S-69□	160SVG1S-69□	254	-	212	-	-
	220	265	-	200SVG1S-69□	277	-	231	-	-
	250	295	250SVG1S-69□	-	315	-	261	-	-
	280	330	280SVG1S-69□	250SVG1S-69□	355	-	293	-	-
	315	365	315SVG1S-69□	280SVG1S-69□	397	-	329	-	-
	355	410	355SVG1S-69□	315SVG1S-69□	446	-	373	-	-
	400	460	400SVG1S-69□	355SVG1S-69□	501	-	418	-	-
	450	100	450SVG1S-69□	400SVG1S-69□	561	-	470	-	-

- Instruments in the table are products of Fuji Electric Co., Ltd. (http://www.fujielectric.co.jp/fcs/).
  For information on available non-auto switch series, see the catalog of Fuji Electric's G-TWIN breakers for high-voltage DC circuits.
  Refer to catalogs and information from Fuji Electric Co., Ltd. for external dimensions and installation methods.
- Columns marked with *1 show the inverter input current (DC) values when the individual converters are applied.
  For the diode rectifiers, the diode rectifier input voltage is equivalent to 3φ 400 VAC 50 Hz.
- For MCCBs with *2, it is recommended to use a non-auto switch.

(2) Connection diagram

1) MCCBs on the inverter input side

When installing an MCCB (non-auto switch) on the DC bus bar, refer to the catalog of Fuji Electric's "breakers for high-voltage DC circuits". When operating an MCCB (non-auto switch), take the following precautions if applicable:

① When diode converters are used, always confirm that the input power supply is cut off before operating.

② When using PWM converters, always confirm that the input power supply is cut off and that both charge lamps for the inverter and converter are unlit before operating.

③ Add the state where the inverter input side MCCB is closed (ON) as a turning-on interlock condition for the main power input MCCB.

2) MCCBs on the inverter output side

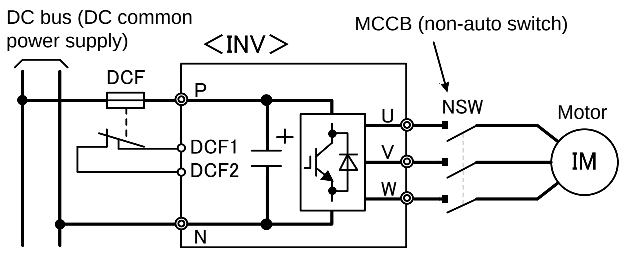


Figure 5.2.2-1: Example of an MCCB connected to the inverter output side

When connecting an MCCB (non-auto switch) on the inverter output side, wire it as shown in Figure 5.2.2-1. Take the following precautions if applicable:

① Operate the opening and closing of the MCCB when the inverter is suspended.

② Add the state where the inverter output side MCCB is closed (on) as a condition to start the inverter.

Note: In the connection shown in Figure 5.2.2-1, do not operate the MCCB while the inverter is running. Doing so would activate the inverter's protective functions.

5.2.2.1 Contactor (magnetic contactor)

This section describes the contactors (magnetic contactors) used in the inverter output circuits.

[Examples of use]
- Used to disconnect the inverter from the input power supply converter before facility maintenance, etc.
- Used to disconnect the inverter and motor from each other
- Used to switch from commercial power supply operation to inverter-based operation

Perform the opening and closing of the contactor attached to the inverter output side **while the inverter is suspended (i.e.. in free run state)**.

Note
- Do not attach main circuit surge absorption units (Fuji Electric SZ-ZM□, etc.) to the contactors.
- The inverter will be damaged if commercial power supply is connected to the inverter output side (secondary side). Interlock the commercial power supply side contactor and the inverter output side contactor to prevent simultaneous ON state.
- When using the instantaneous power failure restart function, connect the connection confirmation signal of the inverter output side contactor to the inverter's general purpose contact input terminal (X terminal) and set the [IL: interlock function] for the X terminal.

📖 For more information, refer to Chapter 4 of the separate volume "Unit/Function Codes Edition" (24A7-□-0019).

(1) Application list

Use the combinations in the following table.

Table 5.2.2-2: Application list

Voltage	Motor rating		Inverter type (FRN)		Inverter output side MC
	Capacity [kW]	Current (A)	MD Spec	LD Spec	
400V	30	60	30SVG1S-4□	-	SC-N2
	37	75	37SVG1S-4□	30SVG1S-4□	SC-N2S
	45	91	45SVG1S-4□	37SVG1S-4□	SC-N3
	55	112	55SVG1S-4□	45SVG1S-4□	SC-N4
	75	150	75SVG1S-4□	55SVG1S-4□	SC-N5
	90	176	90SVG1S-4□	75SVG1S-4□	SC-N7
	110	210	110SVG1S-4□	90SVG1S-4□	SC-N8
	132	253	132SVG1S-4□	110SVG1S-4□	
	160	304	160SVG1S-4□	132SVG1S-4□	SC-N11
	200	377	200SVG1S-4□	160SVG1S-4□	SC-N12
	220	415	220SVG1S-4□	200SVG1S-4□	
	250	468	250SVG1S-4□	220SVG1S-4□	SC-N14
	280	520	280SVG1S-4□	250SVG1S-4□	
	315	585	315SVG1S-4□	280SVG1S-4□	
	355	650	-	315SVG1S-4□	
	630	1170	630BVG1S-4□	-	612CM *1
	710	1370	710BVG1S-4□	630BVG1S-4□	616CM *1
	800	1480	800BVG1S-4□	710BVG1S-4□	
	1000	1850	-	800BVG1S-4□	-
690V	90	100	90SVG1S-69□	-	SC-N3
	110	130	110SVG1S-69□	90SVG1S-69□	SC-N4
	132	140	132SVG1S-69□	110SVG1S-69□	SC-N5
	160	161	160SVG1S-69□	132SVG1S-69□	SC-N7
	200	216	200SVG1S-69□	160SVG1S-69□	SC-N8
	220	235	-	200SVG1S-69□	
	250	265	250SVG1S-69□	-	SC-N11
	280	295	280SVG1S-69□	250SVG1S-69□	
	315	330	315SVG1S-69□	280SVG1S-69□	
	355	365	355SVG1S-69□	315SVG1S-69□	SC-N12
	400	410	400SVG1S-69□	355SVG1S-69□	
	450	460	450SVG1S-69□	400SVG1S-69□	SC-N14

*1. Aichi Electric Works Co., Ltd.

Note Instruments in the table are products of Fuji Electric Co., Ltd. (http://www.fujielectric.co.jp/fcs/).
Refer to catalogs and information from Fuji Electric Co., Ltd. for external dimensions and installation methods.

5.2.2.2 Initial charging circuit

Inverters do not have a built-in initial charging circuit. If the system configuration requires an initial charging circuit, configure it using the steps described in this section.

(1) Application list

Use the combinations in Table 5.2.2-3.

Table 5.2.2-3: Application list

Voltage	Inverter type	Diode rectifier						PWM converter
		Input current [A][*1]		MC type (73)		Charging resistor type (R0)	Quantity	
		MD Spec	LD Spec	MD Spec	LD Spec			
400V	FRN30SVG1S-4☐	65	80	SC-N1	SC-N1	HF5C5504(80W 7.5Ω)	1	Contact Fuji Electric.
	FRN37SVG1S-4☐	80	97	SC-N1	SC-N2			
	FRN45SVG1S-4☐	97	119	SC-N2	SC-N2			
	FRN55SVG1S-4☐	119	162	SC-N2	SC-N2S			
	FRN75SVG1S-4☐	162	195	SC-N2S	SC-N3			
	FRN90SVG1S-4☐	195	238	SC-N3	SC-N3	HF5C5504(80W 7.5Ω)	2 (Parallel)	
	FRN110SVG1S-4☐	238	286	SC-N3	SC-N4			
	FRN132SVG1S-4☐	286	347	SC-N4	SC-N5	HF5C5504(80W 7.5Ω)	3 (Parallel)	
	FRN160SVG1S-4☐	347	433	SC-N5	SC-N7			
	FRN200SVG1S-4☐	433	476	SC-N7	SC-N7			
	FRN220SVG1S-4☐	476	541	SC-N7	SC-N8	HF5C5504(80W 7.5Ω)	4 (Parallel)	
	FRN250SVG1S-4☐	541	606	SC-N8	SC-N8			
	FRN280SVG1S-4☐	606	682	SC-N8	SC-N10	HF5C5504(80W 7.5Ω)	6 (Parallel)	
	FRN315SVG1S-4☐	682	769	SC-N10	SC-N11			
690V	FRN90SVG1S-69☐	117	143	SC-N2	SC-N2S	HF5C5504(80W 7.5Ω)	2 (Series)	
	FRN110SVG1S-69☐	143	169	SC-N2S	SC-N2S			
	FRN132SVG1S-69☐	169	204	SC-N2S	SC-N3	HF5C5504(80W 7.5Ω)	4 (2 series, 2 parallel)	
	FRN160SVG1S-69☐	204	254	SC-N3	SC-N4			
	FRN200SVG1S-69☐	254	277	SC-N4	SC-N4			
	FRN250SVG1S-69☐	315	355	SC-N4	SC-N5	HF5C5504(80W 7.5Ω)	6 (2 series, 3 parallel)	
	FRN280SVG1S-69☐	355	397	SC-N5	SC-N5			
	FRN315SVG1S-69☐	397	446	SC-N5	SC-N7			
	FRN355SVG1S-69☐	446	501	SC-N7	SC-N8			
	FRN400SVG1S-69☐	501	561	SC-N8	SC-N8			
	FRN450SVG1S-69☐	561	-	SC-N8	-			

Note

- Instruments in the table are products of Fuji Electric Co., Ltd. (http://www.fujielectric.co.jp/fcs/).
  Refer to catalogs and information from Fuji Electric Co., Ltd. for external dimensions and installation methods.
- Regarding the column marked with *1, the input voltage is equivalent to 3φ 400 VAC 50 Hz when a diode rectifier is used.
- Contact your Fuji Electric representative for information on the 400V series 630 to 800 kW models and the 690V series.

(2) Connection diagram, external dimensions of charging resistors

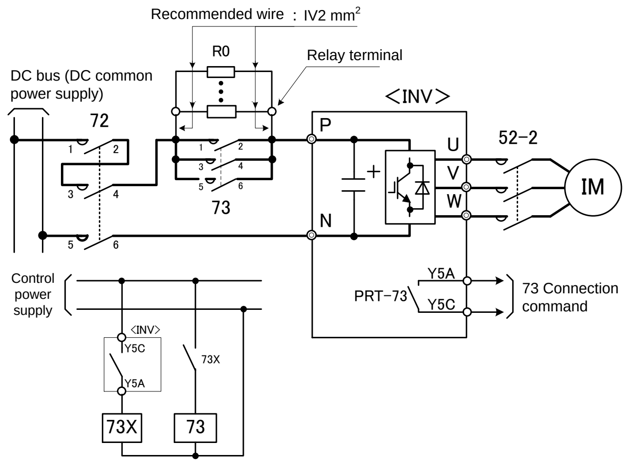


Figure 5.2.2-2: Example of connection of DC bus side disconnector

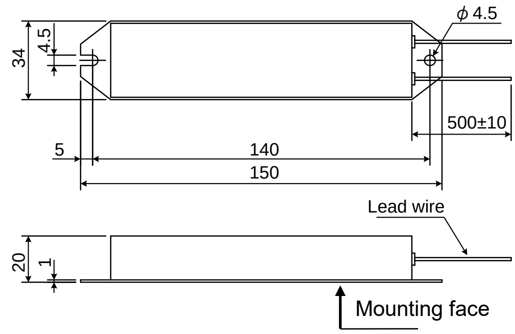


Figure 5.2.2-3: External dimensions of charging resistor

① Use a 3-phase parallel terminal board (SZ-SP□), which is a contactor option, to connect the initial charging contactor (73).

② Install the main section of the charging resistor with approximately 10 mm spacing from other resistors, other instruments, and structural parts.

③ When using multiple charging resistors, connect them in parallel. IV2 mm^2 is recommended for the relay wires.

④ Contact your Fuji Electric representative for information on the charging resistor (R0) when configuring the system with PWM converters.
Depending on the system configuration, the configuration of the charging resistor may need to be reconsidered.

Note: Use the charging circuit up to once an hour. Repeating initial charging too often may cause failures in the charging resistor.

5.2.2.3 Thermal relays

The inverter contains the electronic thermal function for motor protection. However, the electronic thermal function cannot detect an overload on individual motors when one inverter drives multiple motors. In this case, use thermal relays for overload protection of the motors.

(1) Application list

The following is an application list of thermal relays for Fuji's standard motors. However, applications may differ from this table depending on use conditions. In conditions that require more than one minute of start-up time, the setup should be reconsidered. For the 690V series, selected appropriate thermal relays based on the rated current of the motor used.

Table 5.2.2-4: Application list

Voltage	Motor		Standard thermal relay [TR-☐], 2E thermal relay [TK-☐] types										
	Capacity (kW)	Current [A]	0N 0NH	5-1N 5-1NH	N2 N2H	N3 N3H	N5 N5H	N6 N6H	N7 N7H	N8 N8H			
400 V	0.4	1.2	0.8-1.2 (0.8)										
	0.75	1.8	1.4-2.2 (1.4)										
	1.5	3.3	2.8-4.2 (2.8)										
	2.2	4.6	4-6 (4)										
	3.7	7.5	6-9 (6)										
	5.5	11		9-13 (9)									
	7.5	15		12-18 (12)									
	11	21			18-26 (18)								
	15	28			24-36 (36)								
	18.5	34			28-40 (28)								
	22	39				34-50 (50)							
	30	54				45-65 (45)							
	37	66					53-80 (53)						
	45	80					65-95 (65)						
	55	99						85-125 (85)					
	75	134							110-160 (110)				
	90	160								125-185 (125)			
	110	192											
	132	229											
	160	278											
	200	343											

Note

- Instruments in the table are products of Fuji Electric Co., Ltd. (http://www.fujielectric.co.jp/fcs/).
  Refer to catalogs and information from Fuji Electric Co., Ltd. for external dimensions and installation methods.
- The tripping characteristic curves for thermal relays differ between cold start and hot start.
  Configure after confirming the overload current and time of the motor at hot start.
  However, if starts/stops are frequent and the start-up current of the motor is large, the thermal relay may trip mistakenly. Consider the use depending on the mechanical application.

(2) Precautions for use

Ambient temperature compensation characteristics

Thermal relays regulate current referencing ambient temperature of 20°C. The operating current varies by ambient temperature change, increasing current at low temperature and decreasing current at high temperature. The operating characteristic compensates for the deficiency.

Hence, the set point of the current may need to be adjusted depending on use conditions. When the operating temperature differs widely from 20°C, use "Figure 5.2.2-4" as a rough guideline to calculate the set point current after compensation.

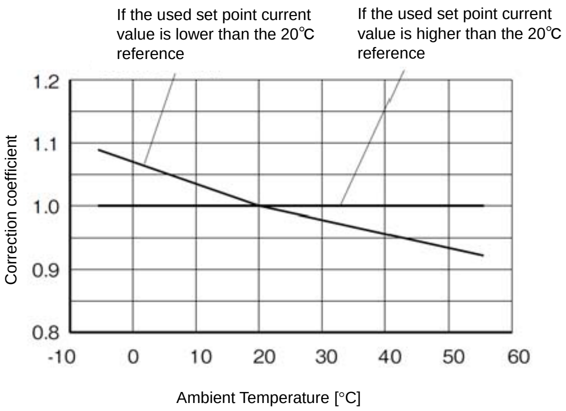


Figure 5.2.2-4: Operating temperature correction coefficient

$$\frac{\textbf{Set point current value at 20°C}}{\textbf{Correction coefficient for installation condition (cabinet internal temperature)}} = \textbf{Set point value of thermal relay}$$

Installation on the inverter output side

If thermal relay is selected according to the motor rated current, it may cause trip mistakenly. Reference the following to implement countermeasures.

Principles for selection (example)

① Measure the current of the installed circuit with thermal relay, and select the rated current for the thermal relay. For current measurement, use a clamp meter (HIOKI made: 3284/200 A, 3285/2000 A equivalent products).

② Confirm that the current is within the motor's allowable heat characteristics.

Countermeasures for mistaken trips

① Install an OFL filter (OFL-□□-4A).

② Increase the set point value on the thermal relay adjustment dial.

③ Install at a location distant from the inverter wiring (close to the motor).

④ Attach a temperature sensor to the motor for motor temperature protection, without installing a thermal relay.

Note • Do not use delay type thermal relays or those above N10 type because they falsely trip more readily compared to standard types.
For protection of loads with long start times (loads with large inertia) and motors with large capacity (over 90 kW), attach temperature sensors to motors to implement temperature protection.

(3) Connection diagram

For large capacity motors, use instrument transformers (CT) and thermal relays in combination.

Refer to Figure 5.2.2-5.

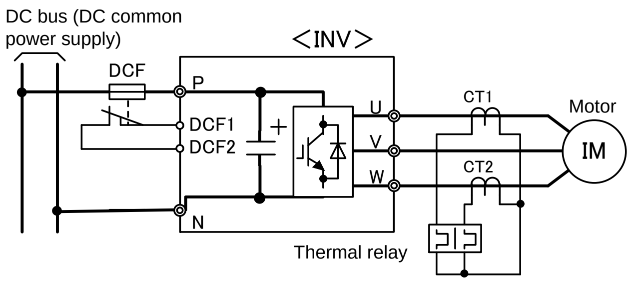


Figure 5.2.2-5: Example of thermal relay connection with large current

5.2.2.4 Output transformer

Typical transformers cannot be connected to the inverter output side for the following reasons.

When transformers are needed, contact your Fuji Electric representative.

(1) Inverter output voltages contain direct current components accompanying slightly unbalanced IGBT switching. These direct current components cause bias magnetism.

(2) If the torque boost is set for increasing motor torque at low frequencies, the V/f ratio increases, resulting in higher magnetic flux density. This causes overexcitation of the transformer, causing magnetic saturation of the magnetic core and overheating.

(3) Because surge voltage accompanying IGBT switching occurs, enhancement of insulation matching surge voltage is necessary.

* Transformers (special) can be used only when the control method is V/f control. (Do not use a transformer when vector control is in use.)

5.2.2.5 Main circuit monitoring instrument

"6.2.12.9 Receiving power supply monitor" in Chapter 6 shows meters that can be attached to the inverter output side.

Refer to "6.2.12.9 Receiving power supply monitor" in Chapter 6.

5.3 Control circuit

5.3.1 Backup battery

When saving trace back memory or using calendar functions while the inverter is not powered, batteries are needed for memory storage. This inverter contains the battery in the standard package, so attach the battery when using the above features.

Table 5.3.1-1: Battery specifications

Model	OPK-BP * When battery runs out, purchase this model.
Battery voltage / capacity	3.6 V-1100 mAh
Classification	Thionyl chloride lithium battery
Replacement cycle	5 years (operating temp: 60°C, inverter not powered)

Units: [mm]

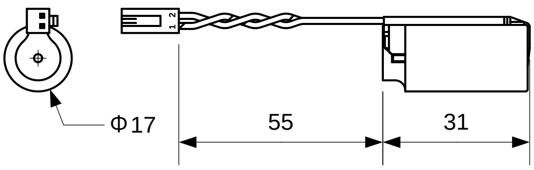


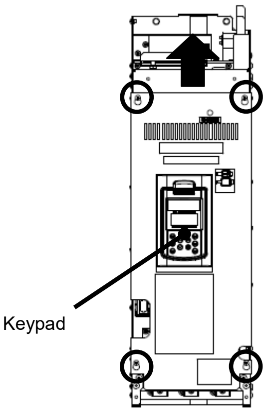
Figure 5.3.1-1: External dimensions of the battery

5.3.1.1 Procedures for installing/replacing the battery

Battery installation steps are described below.

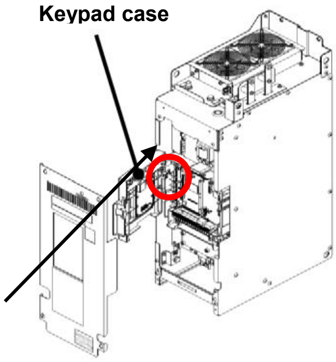
📖 For information on how to set the date/time, refer to Section 3.4. 4.12 in Chapter 3 of the separate volume "Unit/Function Codes Edition" (24A7-☐-0019).

(1) Remove the front cover.



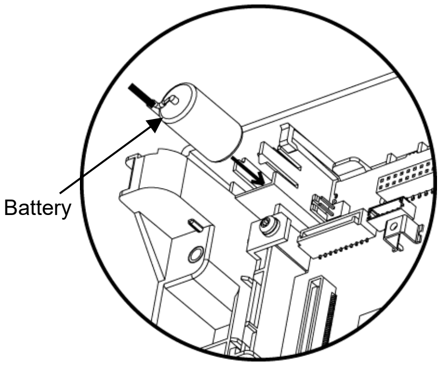
(2) Open the keypad case and remove connectors CN5 and CN8 on the control print circuit board.

(3) Remove the keypad case.

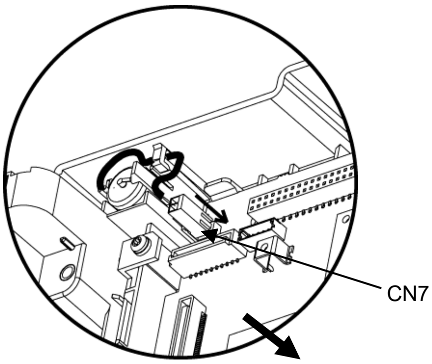


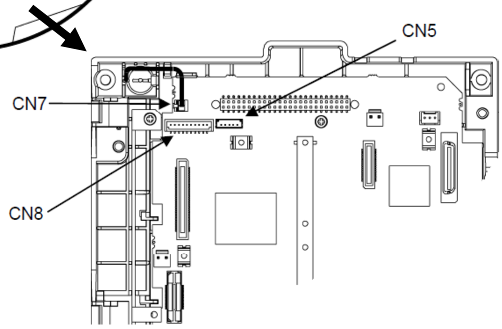
Connectors CN5 and CN8 are located on the upper left side, viewed from the front side of the control print circuit board.

(4) Attach the battery into the battery holder near the upper left side of the control circuit board.



(5) Insert firmly the lead wire connector of the battery into connector CN7 on the control print circuit board.





The above completes the battery installation.
For battery replacement, remove the battery in the reverse order. Then install the new battery, following the steps.

Figure 5.3.1-2: Battery replacement steps

5.3.1.2 Overseas and aerial transportation of battery (lithium metal battery)

Exercise caution on the following items when transporting the battery (lithium metal battery) by itself, by packaging it with other instruments, or by embedding it into instruments.

(1) Transportation of lithium metal battery by embedding it into instruments
When transporting control boards with more than five inverters containing batteries, attach a label as shown in Figure 5.3.1-3 and prepare transportation documents.

(2) Transportation of lithium metal battery by packaging it with instruments
Attach a label as shown in Figure 5.3.1-3 and prepare a certificate of conformance to drop test in the transportation material.
For air transport, the number of batteries which can be bundled is limited to two additional to the number required for instrument operation.

For details, contact the transportation company.

Dimensions
120 x 110 mm

Figure 5.3.1-3: Label to attach to package exterior

5.3.2 PG amplifier (insulating converter)

When the motor speed cannot be normally detected due to distorted PG waveforms resulting from the long wiring to the pulse generator (PG) for motor speed detection, use a PG amplifier that corrects and amplifies PG waveforms.

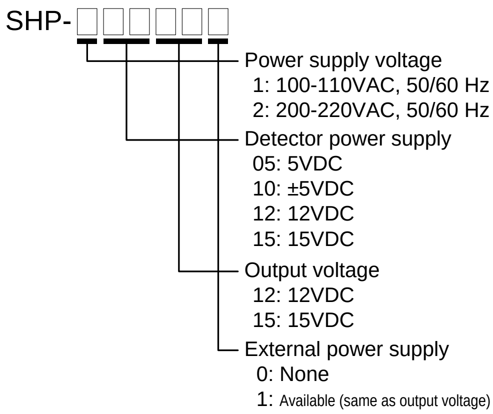
5.3.2.1 Recommended pulse amplifier model

- SHP-115150 (FAITH product)
- SHC-215150 (FAITH product)

The only difference between the above products is in the control power supply specifications of the PG amplifier.
PG voltage of the standard vector motor type is 15 V.

Contact your Fuji Electric representative when purchasing these products.

Type number nomenclature



5.3.2.2 External dimensions

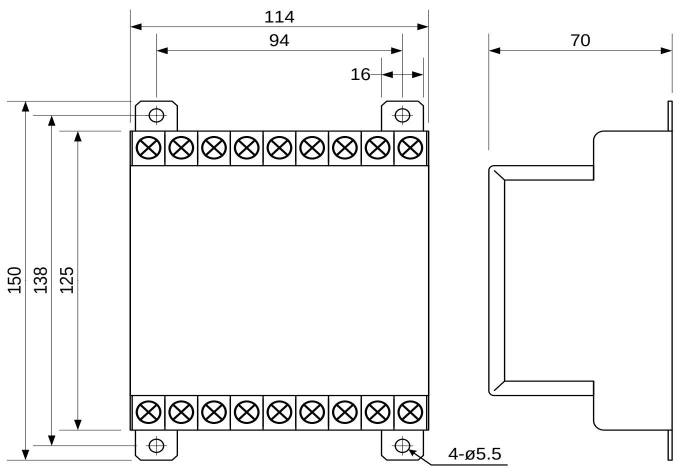


Figure 5.3.2-1: External dimensions of the PG amplifier

- Steel closed box (IP20 equivalent)
- Paint color: Cream color (Munsell 5Y7/1)
- Approx. mass: 1 kg
- Position approx. 10 mm away from instruments such as control relays and structural parts. Also, position more than 100 mm away from the main circuit instruments and wiring.

5.3.2.3 Specifications and terminal description

(1) Specifications

<table>
<tr><th colspan="2">Item</th><th>Specifications</th></tr>
<tr><td colspan="2">Maximum input frequency</td><td>100 kHz</td></tr>
<tr><td colspan="2">Isolation between input and output signals</td><td>Isolator using photo coupler</td></tr>
<tr><td colspan="2">Input interface</td><td>Voltage input (input impedance: 500 kΩ)</td></tr>
<tr><td></td><td>Signal levels*</td><td><table><tr><th></th><th>H level</th><th>L level</th></tr><tr><td>SHP-□05□□</td><td>3.5 to 18 V</td><td>0 to 0.8 V</td></tr><tr><td>SHP-□10□□</td><td>3.5 to 6 V</td><td>-1 to -6 V</td></tr><tr><td>SHP-□12□□</td><td>8 to 18 V</td><td>0 to 1 V</td></tr><tr><td>SHP-□15□□</td><td>8 to 18 V</td><td>0 to 1 V</td></tr></table></td></tr>
<tr><td colspan="2">Phase of input and output signals</td><td>Same phase</td></tr>
<tr><td colspan="2">Delay between input and output signals</td><td>500nS</td></tr>
<tr><td colspan="2">Output interface</td><td>Complementary (loading impedance over 500 Ω)</td></tr>
<tr><td></td><td>Signal level</td><td>H= over 10 V, L= below 1 V (loading impedance 10 kΩ)</td></tr>
<tr><td colspan="2">External power supply for PG*</td><td>5 VDC, 12 V, 15 V</td></tr>
<tr><td colspan="2">Control power supply*</td><td>100-110 VAC, 200-220 VAC, 50/60 Hz</td></tr>
<tr><td colspan="2">Withstand voltage</td><td>1500 VAC/1 minute (between input and output terminals, between power terminal and casing)</td></tr>
<tr><td colspan="2">Insulated resistance</td><td>100 MΩ or higher (500 VDC, between all terminals and casing)</td></tr>
<tr><td colspan="2">Operating temperature, humidity</td><td>0 to 50°C, 35 to 85% Rh (avoid condensation)</td></tr>
<tr><td colspan="2">Storage temperature, humidity</td><td>-10 to 60°C, 35 to 85% Rh (avoid condensation)</td></tr>
<tr><td colspan="2">Power consumption</td><td>Approximately 7 VA</td></tr>
</table>

Specifications marked with * in the table are determined by the model.

(2) Terminal description

<table>
<tr><th>Terminal No.</th><th>Terminal description</th></tr>
<tr><td>1</td><td>N.C</td></tr>
<tr><td>2</td><td>N.C</td></tr>
<tr><td>3</td><td>A-phase input (+ side)</td></tr>
<tr><td>4</td><td>A-phase input (- side, common side)</td></tr>
<tr><td>5</td><td>B-phase input (+ side)</td></tr>
<tr><td>6</td><td>B-phase input (- side, common side)</td></tr>
<tr><td>7</td><td>PG power supply (+ side)</td></tr>
<tr><td>8</td><td>PG power supply (common side)</td></tr>
<tr><td>9</td><td>-5 V terminal</td></tr>
<tr><td>11</td><td>A-phase output (- side, common side)</td></tr>
<tr><td>12</td><td>A-phase output (+ side)</td></tr>
<tr><td>13</td><td>B-phase output (- side, common side)</td></tr>
<tr><td>14</td><td>B-phase output (+ side)</td></tr>
<tr><td>15</td><td>External power supply (+ side)</td></tr>
<tr><td>16</td><td>External power supply (- side, common side)</td></tr>
<tr><td>17</td><td>Earthing terminal</td></tr>
<tr><td>18</td><td rowspan="2">AC power supply input</td></tr>
<tr><td>19</td></tr>
</table>

5.3.2.4 Precautions for connection and specifications

(1) Connection diagram

Connect the wiring as shown in Figure 5.3.2-2.

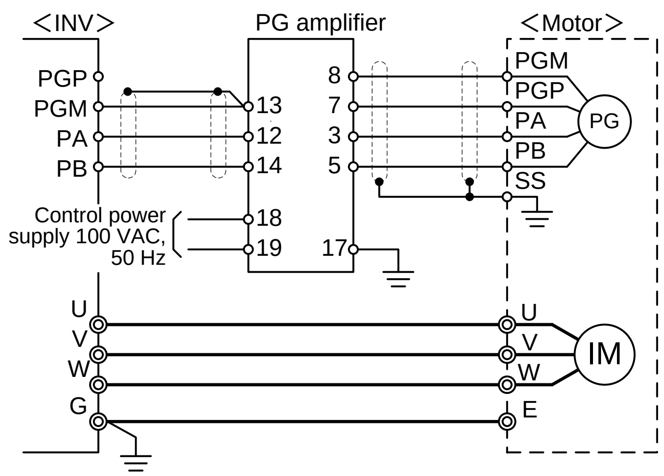


Figure 5.3.2-2: Connection diagram

① Connect the grounding terminal of the PG amplifier to the same ground connection as the inverter. (Connect to the common ground bus when housed inside a cabinet.)

② For the pulse signals, use shielded lines between the motor and the PG amplifier, and between the PG amplifier and the inverter.

- Inside cabinet: MVVS-3 over 0.3 mm^2 core
- Outside cabinet: CVVS-4 over 2 mm^2 core

③ Connect the shield of the shield line between the motor and PG amplifier to the SS (E) terminal dedicated for motor signals.

(2) Precautions for use

When the PG amplifier is used, "PG cut off" detection (PG), one of the inverter protective functions, becomes unavailable because the connection to the inverter's terminal "PGP" is lost. Therefore, configure to use the speed mismatch alarm function [E45] instead of the PG cut off function in the function code setup.
In addition, disable the PG cut off alarm function (PG) with function code [H104].

📖 For information on how to set the date/time, refer to Section 3.4. 4.12 in Chapter 3 of the separate volume "Unit/Function Codes Edition" (24A7-☐-0019)For information on how to set the date/time, refer to "Chapter 4 Control and Operation" of the separate volume "Unit/Function Codes Edition" (24A7-☐-0019).

5.4 Inverter options

This section contains an overview of control options and the restrictions on installation in inverters.

📖 For information on how to set the date/time, refer to Section 3.4. 4.12 in Chapter 3 of the separate volume "Unit/Function Codes Edition" (24A7-J-0019)For information on how to set the date/time, refer to "Chapter 6 Control Options" of the separate volume "Unit/Function Codes Edition" (24A7-J-0019).

5.4.1 Option list

Category	Name	Type	Switch functions using SW	Specifications
Analog card (for A port only)	Synchronous interface	OPC-VG1-SN		Synchronous interface circuit for dancer control
	Aio extension card	OPC-VG1-AIO		Ai 2 points + Ao 2 points extension card
Digital 8 bit (for A or B port only)	Di interface card	OPC-VG1-DI	OPC-VG1-DIA	16 bit Di binary or BCD 4 digits + sign used for speed command, torque command, torque current command setup. (Setting must be switched depending on which port is used)
			OPC-VG1-DIB	
	Dio extension card	OPC-VG1-DIO	OPC-VG1-DIOA	Function selection Di x 4bits + function selection Do x 8bits extension
			OPC-VG1-DIOB	UPAC I/O extension Di x 16 bits + Do x 10 bits
	T link interface card	OPC-VG1-TL		T link interface card
	CC-Link interface card	OPC-VG1-CCL		This interface card supports CC-Link
	PG interface card	OPC-VG1-PG	OPC-VG1-PG (SD)	+5 V line driver type encoder interface (A, B, Z signals) (500 kHz) Used for motor speed, line speed, position command, and position detection.
			OPC-VG1-PG (LD)	
			OPC-VG1-PG (PR)	
			OPC-VG1-PG (PD)	
		OPC-VG1-PGo	OPC-VG1-PGo (SD)	Open collector type encoder interface (A, B, Z signals) (100 kHz) Used for motor speed, line speed, position command, and position detection.
			OPC-VG1-PGo (LD)	
			OPC-VG1-PGo (PR)	
			OPC-VG1-PGo (PD)	
		OPC-VG1-SPGT		17 bit high resolution ABS encoder interface
	PMPG interface card for driving synchronous motor	OPC-VG1-PMPG		Supports +5 V line driver output / A, B, position of magnetic pole (max. 4 bits)
		OPC-VG1-PMPGo		Supports open collector output / A, B, position of magnetic pole (max. 4 bits)
Field bus interface card (for C port only)	PROFIBUS-DP interface card	OPC-VG1-PDP (*1)		PROFIBUS-DP interface card
	DeviceNet interface card	OPC-VG1-DEV (*2)		DeviceNet interface card
Digital 16 bit (for D port only)	SX bus interface card	OPC-VG1-SX		SX bus interface card
	E-SX bus interface card	OPC-VG1-ESX		E-SX bus interface card
	User Programmable Application Card	OPC-VG1-UPAC (*1)		Used for inverter control from customized software created by the user
	PROFINET-IRT interface card	OPC-VG1-PNET (*3)		Supports PROFINET-RT and IRT
Safety card (for E port only)	Functional safety card	OPC-VG1-SAFE (*1)		Functional safety standard compatible card
Control circuit terminal (for F port only)	High speed serial communication supported terminal board	OPC-VG1-TBSI (*1)		Used for multiplexed systems such as multi-winding motor driving and direct parallel systems
Loader	Inverter support loader	WPS-VG1-STR		CD-ROM (free) for Windows
		WPS-VG1-PCL		CD-ROM (paid version) for Windows

(*1) Available when the ROM version is H1/2 0021 or later.
(*2) Available when the ROM version is H1/2 0030 or later.
(*3) Available with FRENIC-VG types with PROFINET support (i.e., type numbers that end with "PN").

5.4.2 Restrictions on mounting control option cards and others

5.4.2.1 Mountable ports

Control options are restricted by function on the ports which can be mounted (attachment section). Refer to Table 5.4.2-1 Option mounting port and Figure 5.4.2-1 Option mounting locations.

Table 5.4.2-1: Option mounting port

CN	Port	Category	Pattern 1	Pattern 2	Pattern 3
3	A	Digital 8bit, analog card	1	1	1
2	B	Digital 8bit	1	0	0
6	C	Field bus interface card	0	0	1
10	D	Digital 16bit	1	1	0
16	E	Safety card	0	1	1
1	F	Control circuit terminal	1	1	1

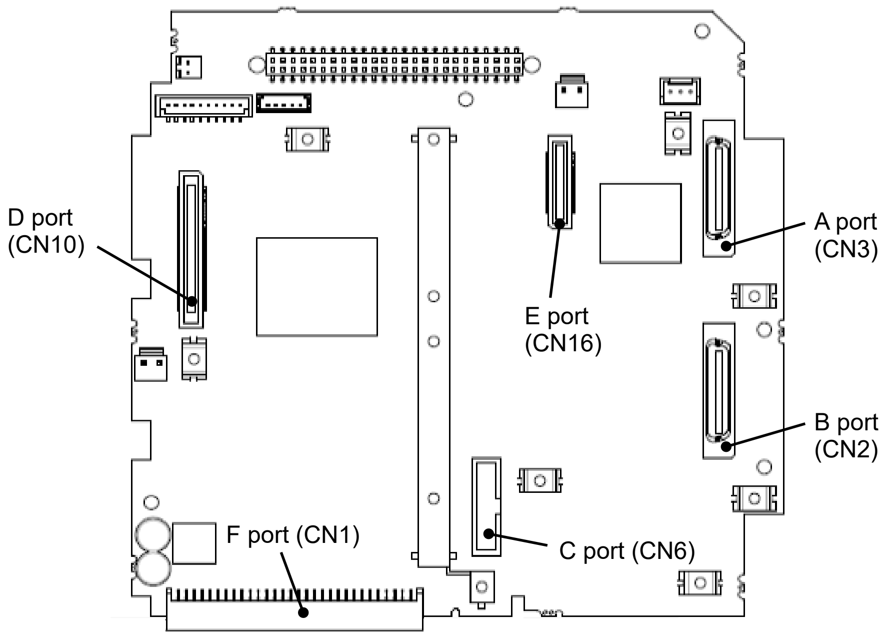


Figure 5.4.2-1: Option mounting locations

5.4.2.2 Restrictions when mounting control options

Some combinations of control option digital cards (8 bit and 16 bit) cannot be mounted together, due to their functions. Construct the system in accordance with Table 5.4.2-2 " Control options which can be mounted together".

Table 5.4.2-2: Control options which can be mounted together
OK: Can be mounted together NG: Cannot be mounted together

Model OPC-VG1 -□□□□	SN	AIO	DI	DIO	TL	CCL	PG/PGo	PMPG/PMPGo	SPGT	TBSI *7	SX	ESX	UPAC	PNET	PDP	DEV	SAFE	TBSI *8
SN	NG																	
AIO	NG	NG																
DI *1	OK	OK	OK															
DIO *1	OK	OK	OK	OK														
TL	OK	OK	OK	OK	NG													
CCL	OK	OK	OK	OK	NG	NG												
PG/PGo *1 *2	OK	OK	OK	OK	OK	OK	*3											
PMPG/PMPGo *4	OK	OK	OK	OK	OK	OK	*3	NG										
SPGT *5	*6	*6	OK	OK	OK	OK	NG	NG	NG									
TBSI *7	OK	OK	OK	OK	OK	OK	OK	OK	OK	NG								
SX	OK	OK	OK	OK	OK	NG	OK	OK	OK	NG	NG							
ESX	OK	OK	OK	OK	NG	NG	OK	OK	OK	NG	NG	NG						
UPAC	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	NG	NG	NG					
PNET	OK	OK	OK	OK	NG	NG	OK	OK	OK	NG	NG	NG	NG	NG				
PDP	OK	OK	OK	OK	NG	NG	OK	OK	OK	NG	NG	NG	NG	NG	NG			
DEV	OK	OK	OK	OK	NG	NG	OK	OK	OK	NG	NG	NG	NG	NG	NG	NG		
SAFE	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	NG	
TBSI *8	OK	OK	OK	OK	OK	OK	OK	OK	OK	NG	OK	OK	OK	OK	OK	OK	*6	NG

As shown above, certain combinations of communication related option cards (such as the OPC-VG1-TL and the OPC-VG1-CCL) cannot be mounted together. An attempt to mount such cards together will result in an operation procedure alarm (Er-6).

*1 The use method for OPC-VG1-DI, DIO, PG, and PGo can be selected by the setup of the SW on the print board. Two cards of OPC-VG1-DI, DIO, PG, and PGo each can be mounted, but an operation procedure alarm (Er-6) will be activated if the setup of the 2 cards determining the use method becomes identical.

*2 When using the OPC-VG1-PG for motor speed detection, inputs from main control print circuit board terminals (PA and PB) are not available.

*3 When two cards of OPC-VG1-PG/PGo and/or OPC-VG1-PMPG/PMPGo are mounted, the following restrictions apply:

	VG1-PG/PGo(SD) VG1-PMPG/PMPGo	VG1-PG/PGo(LD)	VG1-PG/PGo(PR)	VG1-PG/PGo(PD)
VG1-PG/PGo(SD) VG1-PMPG/PMPGo	NG			
VG1-PG/PGo(LD)	OK	NG		
VG1-PG/PGo(PR)	OK	NG	NG	
VG1-PG/PGo(PD)	OK	NG	NG	NG

*4 When OPC-VG1-PMPG is attached, the available terminals change depending on the control method selected. When the vector control with speed sensor for induction motor is selected, terminals (PA and PB) of the main control print circuit board are available.
When the vector control with speed sensor for synchronous motor is selected, OPC-VG1-PMPG is available.

*5 The OPC-VG1-SPGT can only be mounted on B port.

*6 When this combination is needed, contact your Fuji Electric representative.

*7 Restrictions when TBSI is used in as a part of SIU system.

*8 Restrictions when TBSI is used for multi-winding motor drive or direct parallel system.

Chapter 6 Converter System

(Diode Rectifier, PWM Converter, Filter Stack, Braking System)

6.1 Multi-converter system

A converter that converts AC power to DC power is separately required to use the FRENIC-VG stack type inverters. For this purpose, two versions of stack type converts (i.e., diode rectifiers and PWM converters) are available to support your system configuration needs.

A converter may also be connected to more than one inverter via DC bus bars, to conserve energy more efficiently by transferring regenerative energy of the inverter, while reducing the capacity of the converter at the same time.

In addition, unit type PWM converters (RHC-C series) are also available for use in combination with the FRENIC-VG stack type inverters.

This chapter describes two different versions of stack type converters (i.e., diode rectifiers and PWM converters), filter stacks (RHF-D series), and braking systems (braking unit + braking resistor).

Converter type	Description	Max. output capacity*1
Diode rectifier Stack type RHD-D series	• AC power is converted to DC power by diode rectifier, which is then supplied to inverter. • Supply of high capacity power is enabled by parallel connection. • Equipped with DC reactor for input power factor improvement (reduction of the harmonic currents). On the other hand, reduction of harmonic currents generated by 12-pulse rectifier is also made possible by installing a power transformer. • By connecting a braking unit and a braking resistor (DBR), it may also be made to convert regenerative energy from motor (electric power energy) to thermal energy, for processing of regenerative energy.	400V series • 1450 kW (MD spec) • 1640 kW (LD spec) 690V series • 2000 kW (MD spec) (📖 Refer to Section 6.2.)
High-efficiency power regeneration PWM converter Stack type RHC-D series Unit type RHC-C series	• IGBT is driven by PWM control to convert AC power to DC power, which is then supplied to inverter. • Supply of high capacity power is enabled by parallel connection. • Use of PWM control makes it possible to greatly reduce the harmonic current of the AC power supply. (The power factor is controlled at approximately "1".) • The regenerative energy is returned to the AC power. The regenerative energy is applicable to a large load.	RHC-D series (Transformer parallel system) 400V series • 2400 kW (MD spec) • 3000 kW (LD spec) 690V series • 1200 kW (MD, LD spec) (📖 Refer to Section 6.3.)
Filter stack Stack type RHF-D series *Dedicated to use with the RHC-D*2	• This filter stack is dedicated to use with the RHC-D series high-efficiency power regeneration PWM converters. • All peripherals (filter, booster, charging circuits, etc.) required to run a PWM converter are packaged in a single unit. • It is possible to save wiring work and installation space for peripherals. • Built on the same stack design and shape as inverters and PWM converters, these products effectively help reduce the panel size.	(📖 Refer to Section 6.4.)
Braking system (braking unit) (braking resistor)	• These products provide a braking system that consumes regenerative energy from a motor as thermal energy by use of a resistor. (thus achieving high braking performance). • Braking unit: BU□□□-4C Standard rating at duty cycle of 10%ED. Can be increased to duty cycle of 30%ED Max. by installing the optional fan unit (BU-F). • Braking resistor: DB□□V-□□ Two standard types are available: duty cycle 10%ED and 20%ED.	(📖 Refer to Section 6.5.)

*1 The Max. output capacity values are based on the assumption that the respective converters are connected in parallel. The number of connectable units varies depending on the converter.

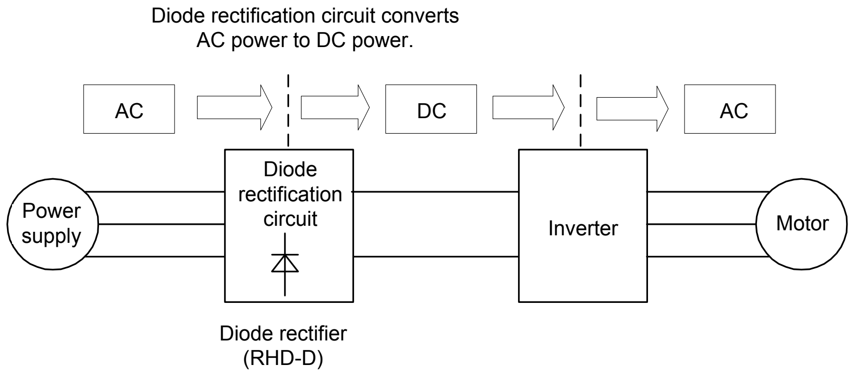
*2 Cannot be used with unit type PWM converters (RHC-C series).

6.2 Diode rectifiers (RHD-D series)

6.2.1 Features

■ Converter type

Diode rectifier converts AC power to DC power, and then supplies DC power to inverter.

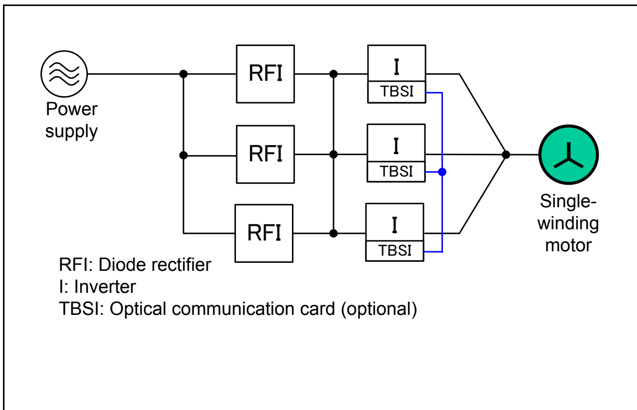


■ Substantial applicable capacity

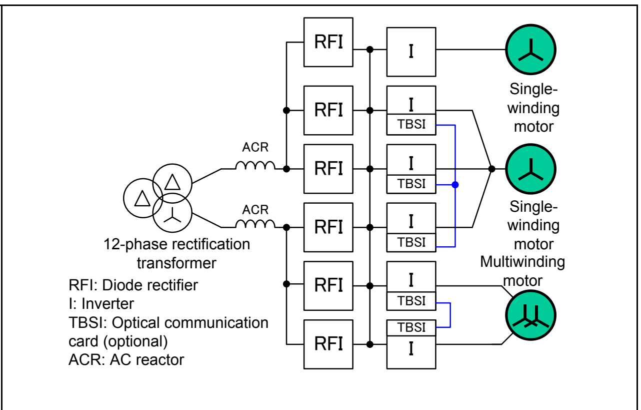
A high capacity system can be constructed by connecting diode rectifiers in parallel.
(12-phase rectification + parallel connection (using 6 units of diode rectifiers))

- 400V series: 1450 kW (MD spec) or 1640 kW (LD spec) (at supply voltage of 400 V)
- 690V series: 2000 kW (MD spec) (at supply voltage of 690 V)

<Example of constructing a high capacity system>



3 units connected in parallel



12-phase rectification (6 units in all)

Note: To connect multiple diode rectifiers in parallel (so that all of them have the same output), ensure that they all have the same capacity.

■ Reduction of harmonic currents

The RHD-D series diode rectifiers are equipped with a built-in DC reactor for reduction of the harmonic currents. Further reduction of harmonic currents is made possible by creating a 12-phase rectification system in combination with a power transformer, when connecting more than one unit in parallel.

■ Braking device

A discharging resistor braking device (that consists of a braking unit and braking resistor) is available an externally mounted option. You can select the capacity based on the required regenerative energy amount, thereby constructing a compact system.

6.2.2 Standard specifications

6.2.2.1 3-phase 400V series

Model				RHD200S-4D☐	RHD315S-4D☐
MD Spec	Output	Continuous capacity [kW] *1		227	353
		Nominal applied inverter/motor capacity *1		200	315
		Overload rating		150% of the continuous rating for 1 minute	
		Voltage		513 to 679 VDC (variable according to input voltage and load)	
	Max. connection capacity [kW] *1 *2			600	945
	Min. connection capacity [kW] *1			110	180
	Required power supply capacity [kVA]			248	388
LD spec	Output	Continuous capacity [kW] *1		247	400
		Nominal applied inverter/motor capacity *1		220	355
		Overload rating		110% of the continuous rating for 1 minute	
		Voltage		513 to 679 VDC (variable according to input voltage and load)	
	Max. connection capacity [kW] *1 *2			600	1065
	Min. connection capacity [kW] *1			110	180
	Required power supply capacity [kVA]			271	435
Input power	Main power supply Number of phases, voltage, and frequency			3-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz	
	Fan power supply auxiliary input Number of phases, voltage, and frequency		400 V input	Single-phase, 380 to 440 V/50 Hz, 380 to 480 V/60 Hz *3	
			200 V input	Single-phase, 200 to 220 V/50 Hz, 200 to 230 V/60 Hz *4	
	Allowable fluctuation			Voltage: +10 to -15% (inter-phase unbalance rate: within 2% *5) Frequency wave number: +5% to -5%	
Approx. mass [kg]				125	160
Enclosure				IP00	
Common Specifications				🕮Refer to "2.2.1 Installation environment and conformity with standards" in Chapter 2.	

*1 Reduction of capacity is required for supply voltage under 400 V. Reduction of capacity is also required when multiple units are connected.

*2 Due to the restriction of the initial charging circuit, this is the total capacity of inverters that can be connected. However, the capacity of inverters that can be run at the same time is limited to the continuous capacity. This shows the total capacity of inverters that can be connected. However, the capacity of inverters that can be run in driving mode at the same time is the continuous capacity.

*3 For 380 to 398 V/50 Hz or 380 to 430 V/60 Hz power supply, switching of converter internal terminals (U1, U2) is required.

*4 200 V power supply can also be used. For details, refer to "6.2.4 Terminal functions".

*5 $$\text{Interphase unbalance rate}(\%) = \frac{\text{Max. voltage[V] - Min. voltage[V]}}{\text{3 - phase average voltage}} \times 67$$

6.2.2.2 3-phase 690V series

Model			RHD220S-69D□	RHD450S-69D□
MD Spec	Output	Continuous capacity [kW]*1	252	504
MD Spec	Output	Nominal applied inverter/motor capacity*1	220	450
MD Spec	Output	Overload rating	150% of the continuous rating for 1 minute	
MD Spec	Output	Voltage	776 to 1091 VDC (variable according to input voltage and load)	
MD Spec	Max. connection capacity [kW] *1 *2		660	1350
MD Spec	Min. connection capacity [kW] *1		132	250
MD Spec	Required power supply capacity [kVA]		270	549
LD spec	Output	Continuous capacity [kW]*1	280	-
LD spec	Output	Nominal applied inverter/motor capacity*1	250	-
LD spec	Output	Overload rating	110% of the continuous rating for 1 minute	
LD spec	Output	Voltage	776 to 1091 VDC (variable according to input voltage and load)	
LD spec	Max. connection capacity [kW] *1 *2		750	-
LD spec	Min. connection capacity [kW] *1		132	-
LD spec	Required power supply capacity [kVA]		308	-
Input power	Main power supply Number of phases, voltage, and frequency		3-phase, 575 to 690 V/50 Hz, 60 Hz	
Input power	Fan power supply auxiliary input Number of phases, voltage, and frequency	690 V input	Single-phase, 660 to 690 V, 50 Hz/60 Hz, 575 to 600 V, 50 Hz/60 Hz*3	
Input power	Fan power supply auxiliary input Number of phases, voltage, and frequency	200 V input	Single-phase, 200 to 220 V/50 Hz, 200 to 230 V/60 Hz *4	
Input power	Allowable fluctuation		Voltage: +10 to -15% (inter-phase unbalance rate: within 2% *5) Frequency wave number: +5% to -5%	
Approx. mass [kg]			125	160
Enclosure			IP00	
Common Specifications			🕮Refer to "2.2.1 Installation environment and conformity with standards" in Chapter 2.	

*1 This specification applies when the supply voltage is 690 V. Reduction of capacity is required for supply voltage under 690 V. Reduction of capacity is also required when multiple units are connected.

*2 Due to the restriction of the initial charging circuit, this is the total capacity of inverters that can be connected. However, the capacity of inverters that can be run at the same time is limited to the continuous capacity. This shows the total capacity of inverters that can be connected. However, the capacity of inverters that can be run in driving mode at the same time is the continuous capacity.

*3 For 690 V series 575 to 600 V, 50 Hz/60 Hz power supply, switching of converter internal terminals (U1, U2) is required.

*4 200 V power supply can also be used. For details, refer to "6.2.4 Terminal functions".

*5 $$\text{Interphaseunbalance rate}(\%) = \frac{\text{Max. voltage[V] - Min. voltage[V]}}{\text{3 - phase average voltage}} \times 67$$

6.2.3 Basic connection diagrams

6.2.3.1 When a diode rectifier and an inverter are connected on a 1:1 basis

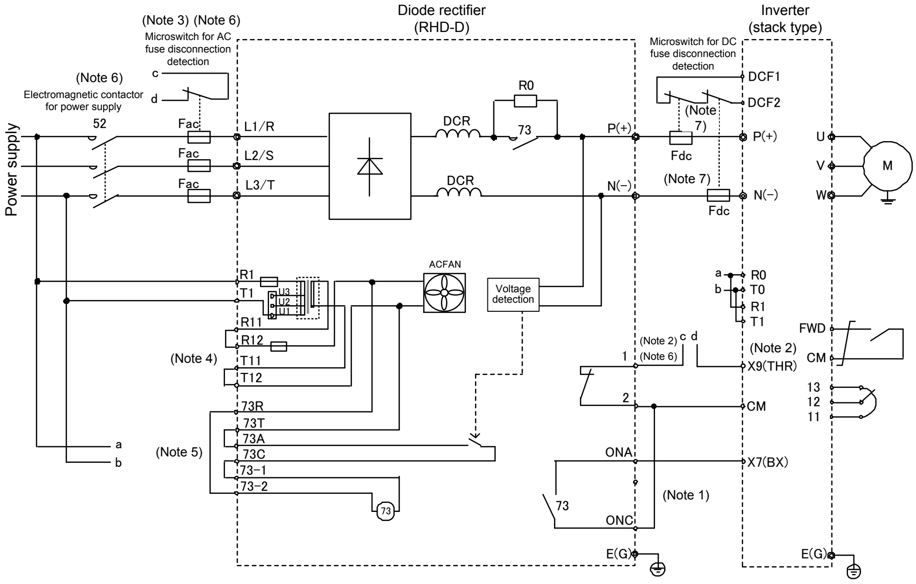


Figure 6.2.3-1: Basic connection diagram (when a diode rectifier and an inverter are connected on a 1:1 basis)

Note 1) Construct a sequence in which the "Coast to a stop" command is input to the inverter until the initial charging of the diode rectifier is completed. Assign the "Coast to a stop" command (BX) to one of the inverter's terminals X1 to X9. Use function code E14 to configure the b-contact input so that input occurs on the b-contact. In this connection configuration, the motor will be in "coast to a stop" state when an instantaneous power failure occurs. Therefore, when using the circuit for purposes such as vertical transportation, provide an external interlock circuit.

Note 2) The overheat signal of the diode rectifier is output. Make sure to connect one of the inverter's terminals X1 to X9 to external alarm (THR). Use function code E14 to configure the b-contact input so that input occurs on the b-contact.

Note 3) When using microswitches for AC fuse disconnection detection, assign external alarm (THR) to one of the inverter's terminals X1 to X9, and connect all of the microswitches in series. Use function code E14 to configure the b-contact input so that input occurs on the b-contact.

Note 4) When inputting 200 VAC as the fan power supply, remove jumper wires from between terminals R11 and R12 and from between terminals T11 and T12, and then connect the input to terminals R12 and T12.

Note 5) The control signal and drive power supply for the charging circuit contactor (73) can be input from the outside. To do so, make the wiring as illustrated in Figure 6.2.3-2. Additionally, contactors 73A and 73C can also be used for the external sequence circuit.

Note 6) When connecting multiple diode rectifiers, use the electromagnetic contactor for power supply (52) at the same time. Furthermore, connect overheat signal outputs (1, 2), charging circuit operation signals (ONA, ONB, ONC), and AC fuse blow detection microswitch output in series between each stack.

Note 7) For the 400V series, connect "Fdc" (fuse) to either the P (+) side or N (-) side.
For the 690V series, connect "Fdc" (fuse) to both the P (+) and N (-) sides.
(Use two microswitches and connect them in series.)

⚠WARNING

- Be sure to assign the inverter digital input terminal (X1 to X9) to the external alarm (THR), and to connect the diode rectifier overheat signal outputs (1, 2).
- Be sure to stop the inverter when the overheat signal is output.

Risk of fire, accident

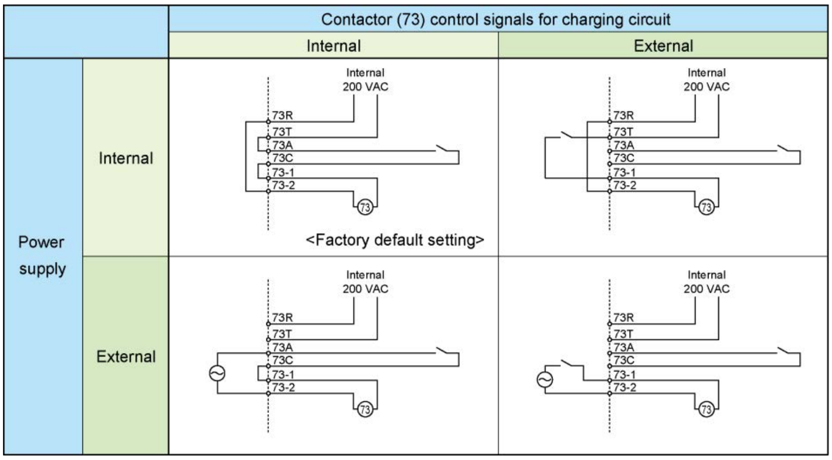


Figure 6.2.3-2: Control signal connection for the charging circuit contactor (73)

6.2.3.2 When connecting multiple diode rectifiers

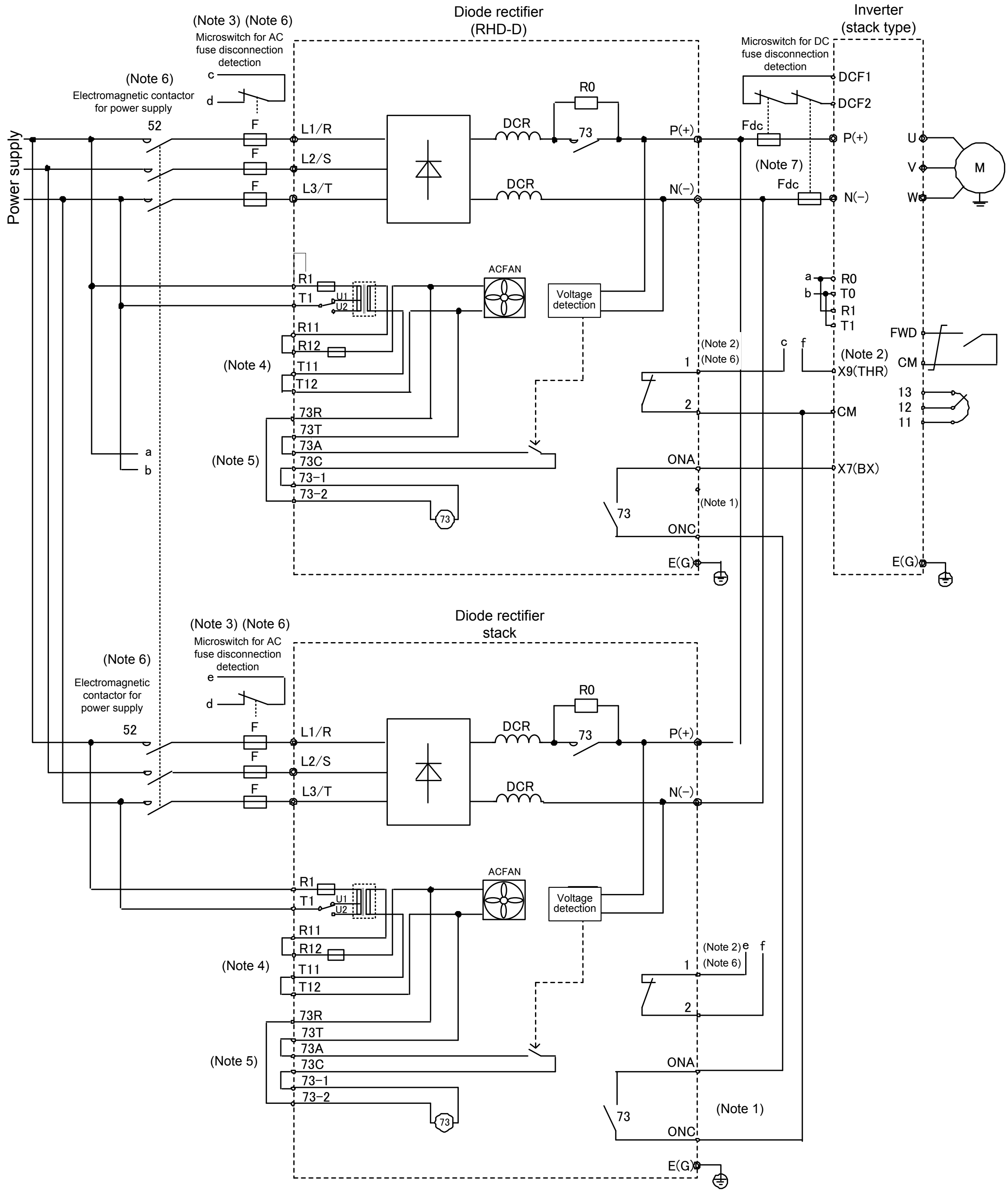


Figure 6.2.3-3: Basic connection diagram (with two diode rectifiers connected in parallel)

* When connecting multiple diode rectifiers, use the electromagnetic contactor for power supply (52) at the same time. Furthermore, connect overheat signal outputs (1, 2), charging circuit operation signals (ONA, ONC), and AC fuse blow detection microswitch output in series between each stack.

6.2.4 Terminal functions

Terminal symbol		Name	Specifications
Main circuit	L1/R, L2/S, L3/T	Main power input	Connect to a 3-phase power supply.
	P (+), N (-)	Converter output	Connect to inverter power input terminals P(+) and N(-).
	E(G)	Converter grounding	Grounding terminal for the chassis (case) of the diode rectifier.
	R1, T1	Fan power input (400V series: when 400 V is input) (690V series: when 690 V is input)	To be used as supply input of AC cooling fan of inside the diode rectifier. Internal switching connector needs to be changed to meet supply voltage. 📖Refer to "4.5.3 (5) Fan power auxiliary input terminals R1 and T1" in Chapter 4.
	R11, R12 T11, T12 *1	Fan power input (when 200 V is input)	To be used when inputting 200 VAC as the power to the AC cooling fan inside the diode rectifier. When inputting 200 VAC as the fan power supply, remove jumper wires from between terminals R11 and R12 and from between terminals T11 and T12, and then connect the input to terminals R12 and T12.
	73R 73T	Power supply for charging circuit	Driving supply of charging circuit contactor. Not to be used as power supply for an external circuit.
	U1, U2 *2	Supply voltage switching terminal	Change the terminal connection depending on the power supply connected to the fan power input terminals. (Refer to Figure 6.2.4-2.)
Input signals	73-1 73-2	Charging circuit contactor Control input	Control signal input for charging circuit contactor Control signal may also be input externally.* 3 <Coil rated capacity> • 400V series At power on ... 200 V/50 Hz: 390 VA, 220 V/60 Hz: 460 VA At power hold ... 200 V/50 Hz: 28.6 VA, 220 V/60 Hz: 28.8 VA • 690V series At power on ... 200 V/50 Hz: 470 VA, 220 V/60 Hz: 500 VA At power hold ... 200 V/50 Hz: 40.0 VA, 220 V/60 Hz: 39.0 VA
Output signals	73A *4 73C	Control signal output for charging circuit	Control signal for charging circuit Contact rating: 250 VAC 0.5 A cos φ=0.3, 30 VDC 0.5 A
	ONA ONC	Charging circuit operation signal	Auxiliary contact output for charging circuit contactor To be used as signal for operational check of charging circuit. Contact rating: 24 VDC 3 A * Min. working voltage/current: 5 VDC 3 mA
	1 2	Overheat signal output	Signal is output when internal parts of diode rectifier are overheated. Contact rating: 24 VDC (max. 27 V), max. 0.3A/max. 6W * Min. usage voltage, current: 1 VDC, 0.1mA

*1 Terminals R11, R12, T11, and T12 are 200 V power terminals and their withstand voltage is 2000 VAC for 1 minute.

*2 Terminals U1 and U2 can be switched as shown in Figure 6.2.4-2.

*3 Refer to Figure 6.2.3-2 for connection method.
Contactor should be powered after completion of initial charging. Do not open contactor while inverter is in operation. This poses a risk of damaging the initial charging circuit.

*4 Refer to Figure 6.2.4-1 for timing chart of output signal, and DC PN voltage at signal output.

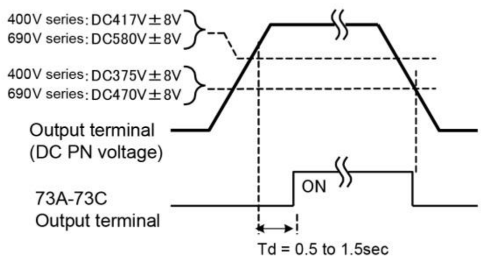


Figure 6.2.4-1: 73A - 73C signal timing chart

⚠WARNING

- Be sure to assign the inverter digital input terminal (X1 to X9) to the external alarm (THR), and to connect the diode rectifier overheat signal outputs (1, 2).
- Be sure to stop the inverter when the overheat signal is output.

Risk of fire, accident

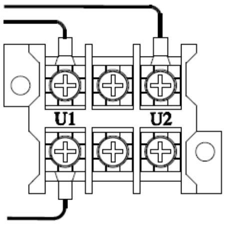
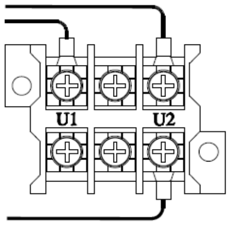
Configuration		
Applied Voltage	400V series: 398 to 440 V/50 Hz, 430 to 460 V/60 Hz 690V series: 660 to 690 V, 50 Hz/60 Hz (Factory default)	400V series: 380 to 398 V/50 Hz, 380 to 430 V/60 Hz 690V series: 575 to 600 V, 50 Hz/60 Hz

Figure 6.2.4-2: Supply voltage switching terminals

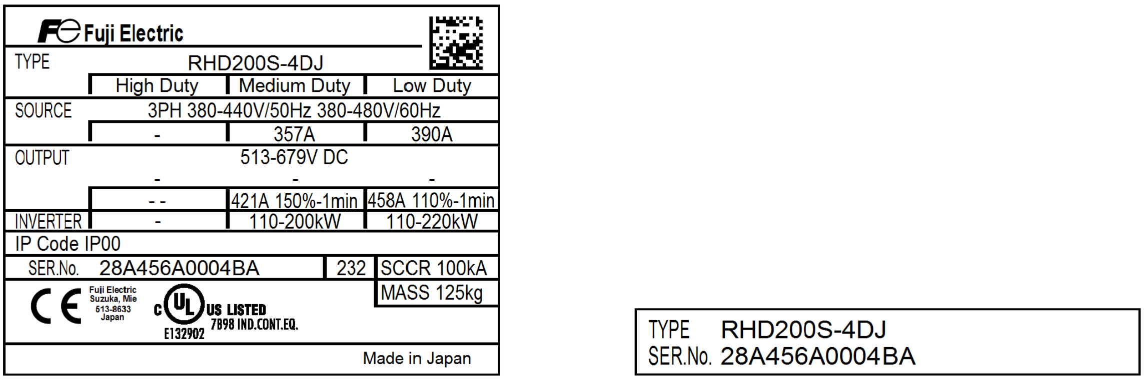
6.2.5 Check before use

Unpack the package and check the following:

Check that you have properly received the product main unit and the following accessories.

Accessories   Instruction manual

Check that the inverter has not been damaged during transportation—there should be no dents or parts missing. The main and sub nameplates are attached to the main unit. The main nameplate is located on the front face of the main unit (as shown in Figure 6.2.6-2 and Figure 6.2.6-3). Check these main nameplates to see that the inverter is exactly the type you ordered.



(a) Main Nameplate   (b) Sub Nameplate

Figure 6.2.5-1: Nameplate

TYPE: Diode rectifier (RHD-D)

RHD 200 S - 4 D □

Indication	Series name
RHD	Diode rectifier

Indication	Standard applicable rated capacity
200	200kW
220	220kW
315	315kW
450	450kW

Indication	Inverter structure
S	Standard stack type

Indication	Voltage class
4	400 V class series
69	690 V class series

Indication	Development series
D	D series

Indication	Shipping destination/Instruction Manual
J	Japanese
E	English
C	Chinese

The diode rectifier may be used by selecting either MD spec/LD spec, depending on the applicable load. Specifications in each mode are printed on the nameplate.

Medium Duty : MD spec: designed for medium duty overload applications. Overload current rating: 150% for 1 min., Continuous rating capacity = Capacity of inverters
Low Duty : LD spec: designed for light duty overload applications. Overload current rating: 110% for 1 min., Continuous rating capacity = One rank or two ranks higher capacity of inverters
SOURCE : Power supply rating (MD spec, LD spec)
OUTPUT : Output rating (MD spec, LD spec)
IP Code : IP protection grade
SCCR : Short-circuit capacity
MASS : Mass
SER.No. : Production number   2 8 A456A0004BA

- 2: Production year (Last digit of the year)
- 8: Production month — 1 to 9: January to September; X, Y, or Z: October, November, or December
- A456A0004BA: Serial number of production lot

If you suspect the product is not working properly or if you have any questions about your product, contact your Fuji Electric representative.

📖 Refer to Chapter 3 "Transportation and Storage of Stack" for information on transportation and long-term storage of diode rectifiers.

📖 Refer to Chapter 4 "Installation and Wiring" for information on installation of diode rectifiers.
For information on the main circuit wire sizes, refer to "6.2.13 Recommended wire size".

📖 For more details, refer to the Instruction Manual. (400V: INR-SI47-1786, 690V: INR-SI47-1852)

6.2.6 External views

6.2.6.1 Warning label and falling warning label

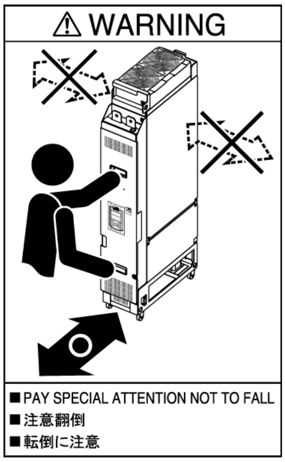


Figure 6.2.6-1: Warning label and falling warning label

6.2.6.2 Appearance

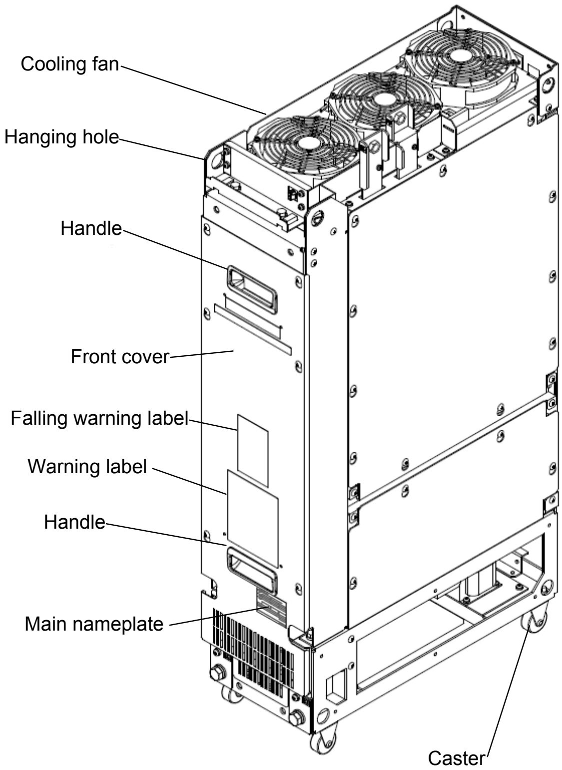


Figure 6.2.6-2: Frame 3 size
(RHD200S-4D☐, RHD220S-69D☐)

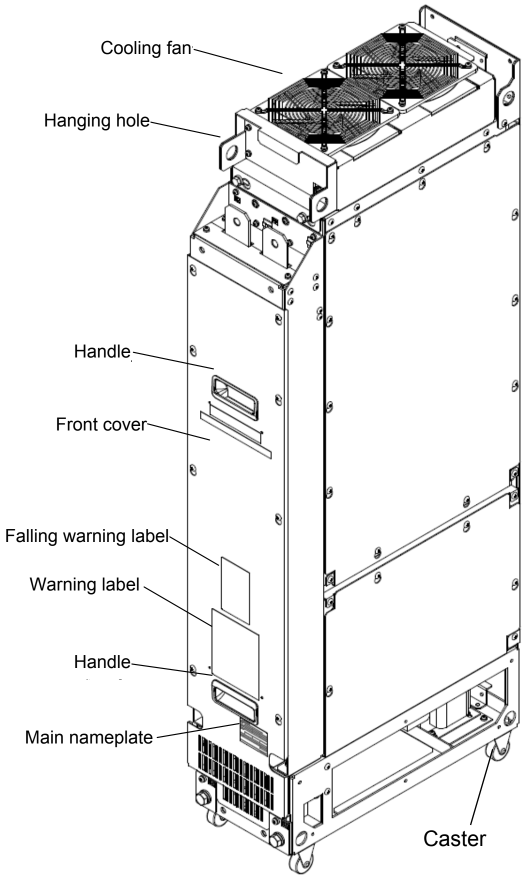


Figure 6.2.6-3: Frame 4 size
(RHD315S-4D☐, RHD450S-69D☐)

6.2.7 External dimensions

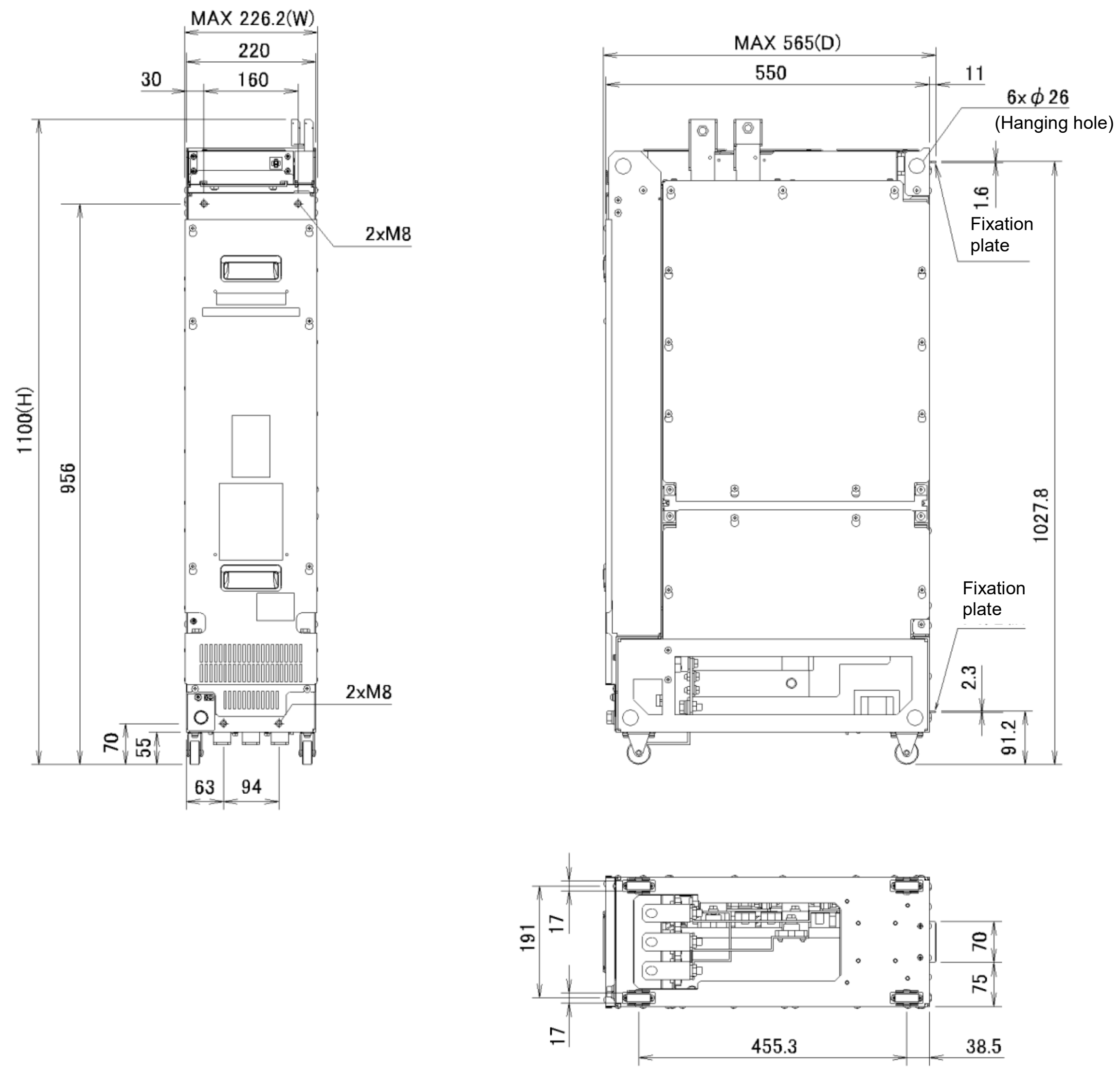
6.2.7.1 List of external dimensions - RHD-D series (stack type)

Unit: [mm]

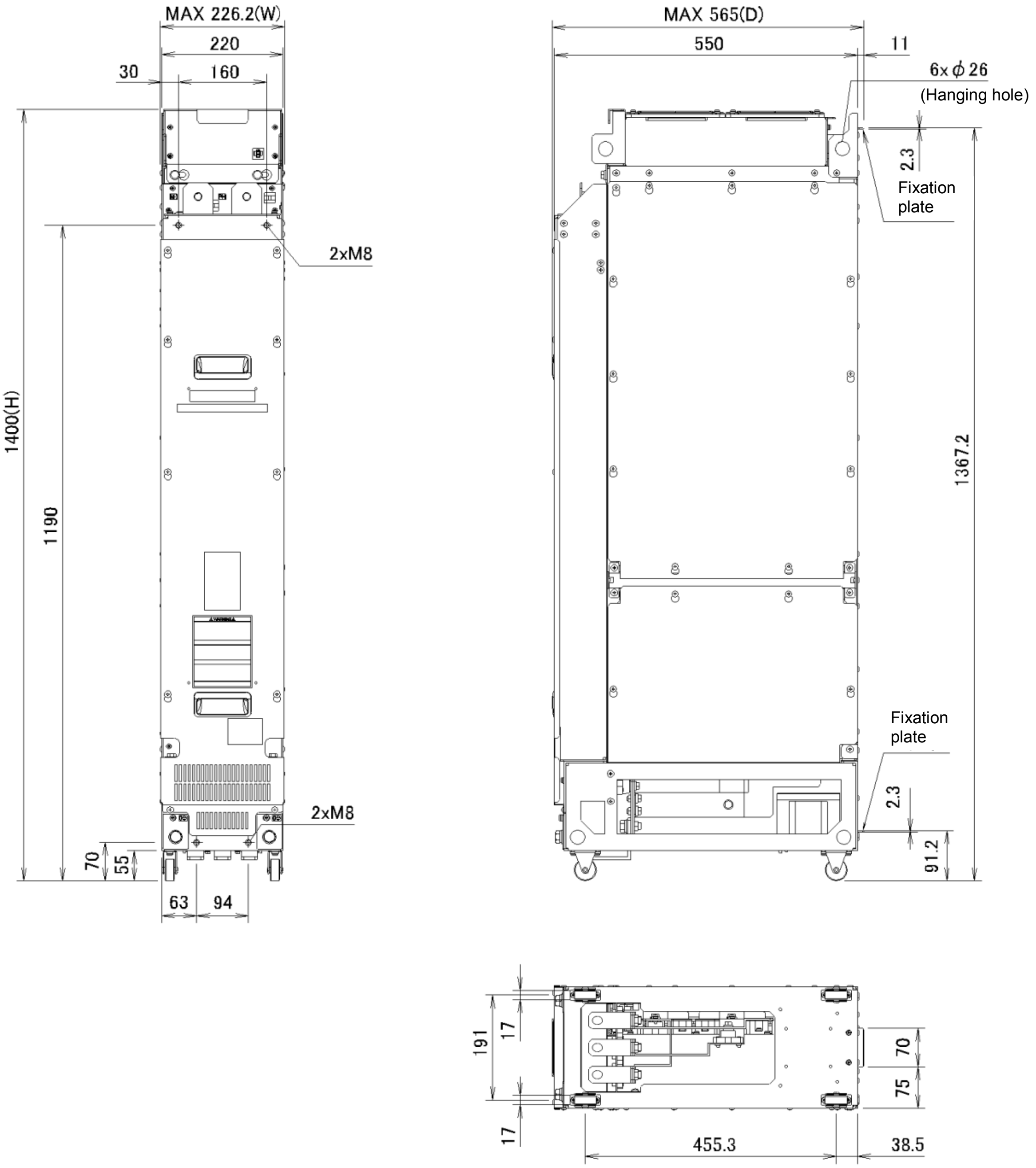
Power-based series	Model	Figure	W	H	D	Approx. mass [kg]	Remarks
400V	RHD200S-4D□	A	226.2	1100	565	125	Frame 3 size
	RHD315S-4D□	B	226.2	1400	565	160	Frame 4 size
690V	RHD220S-69D□	A	226.2	1100	565	125	Frame 3 size
	RHD450S-69D□	B	226.2	1400	565	160	Frame 4 size

6.2.7.2 External dimensions

(1) Figure A (Frame 3 size: RHD200S-4D□, RHD220S-69D□)



(2) Figure B (Frame 4 size: RHD315S-4D□, RHD450S-69D□)



6.2.8 Terminal positions

6.2.8.1 Main circuit terminals

Unit: [mm]

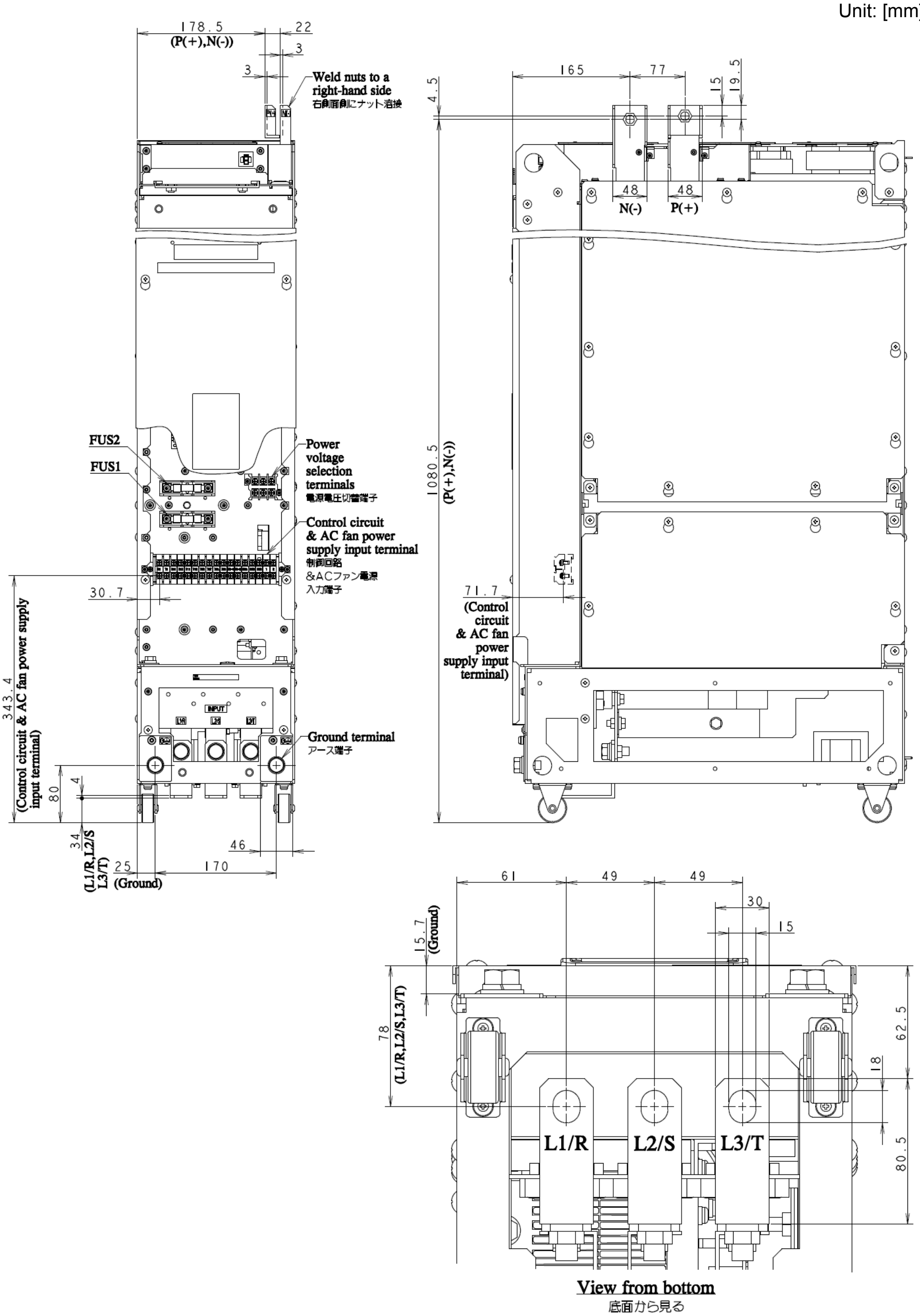


Figure 6.2.8-1: Frame 3 size (RHD200S-4D☐, RHD220S-69D☐)

Unit: [mm]

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

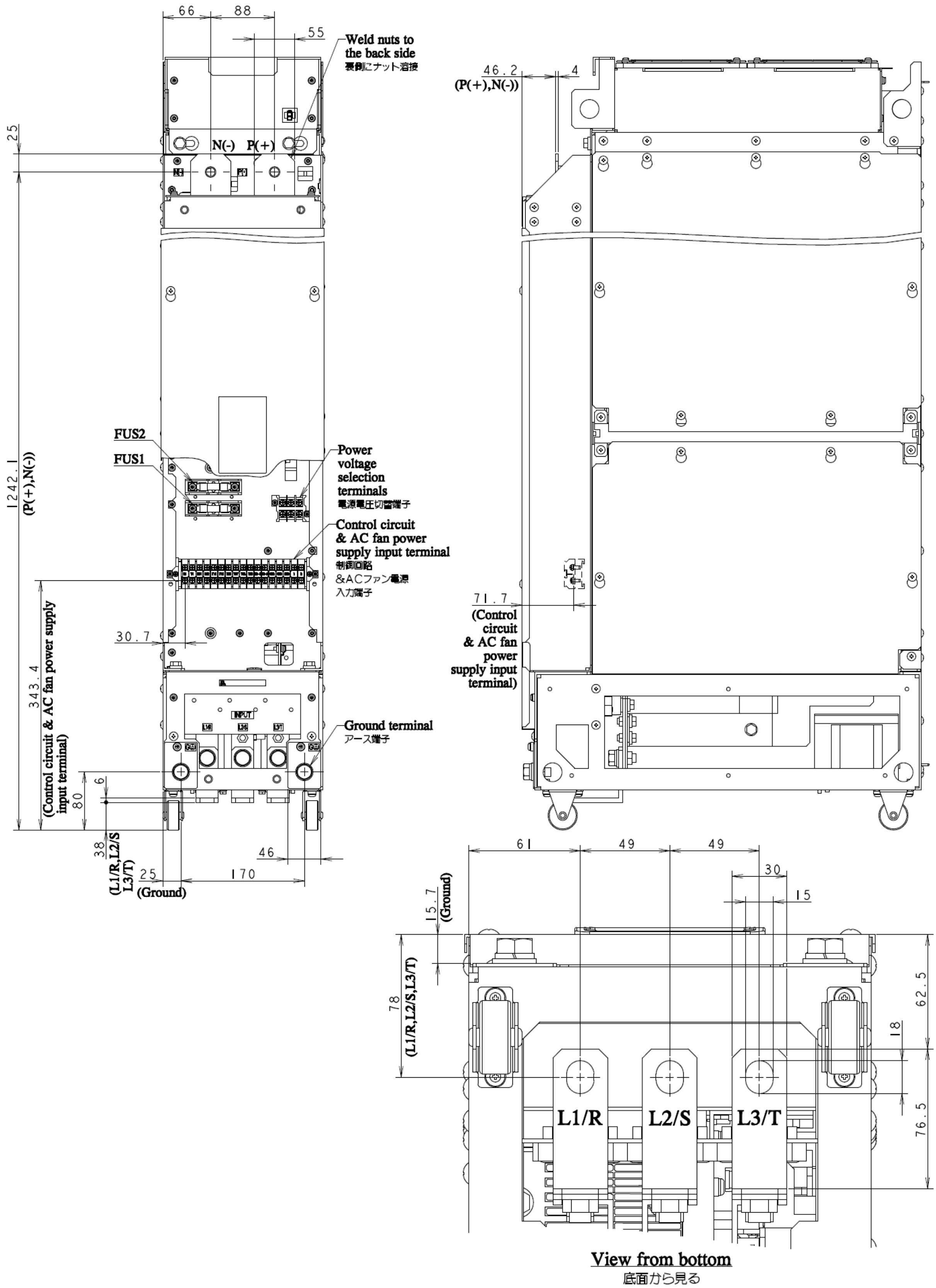


Figure 6.2.8-2: Frame 4 size (RHD315S-4D☐, RHD450S-69D☐)

6.2.8.2 Control circuit terminal

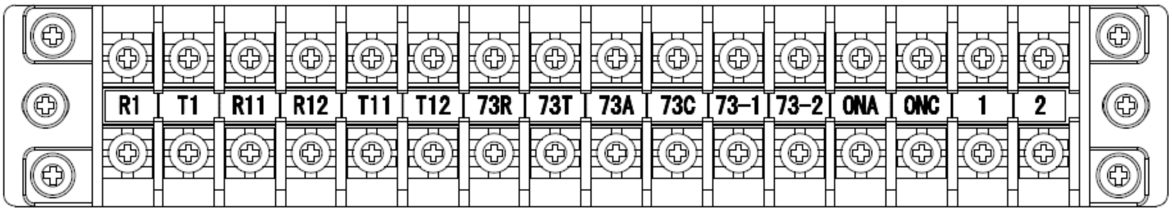
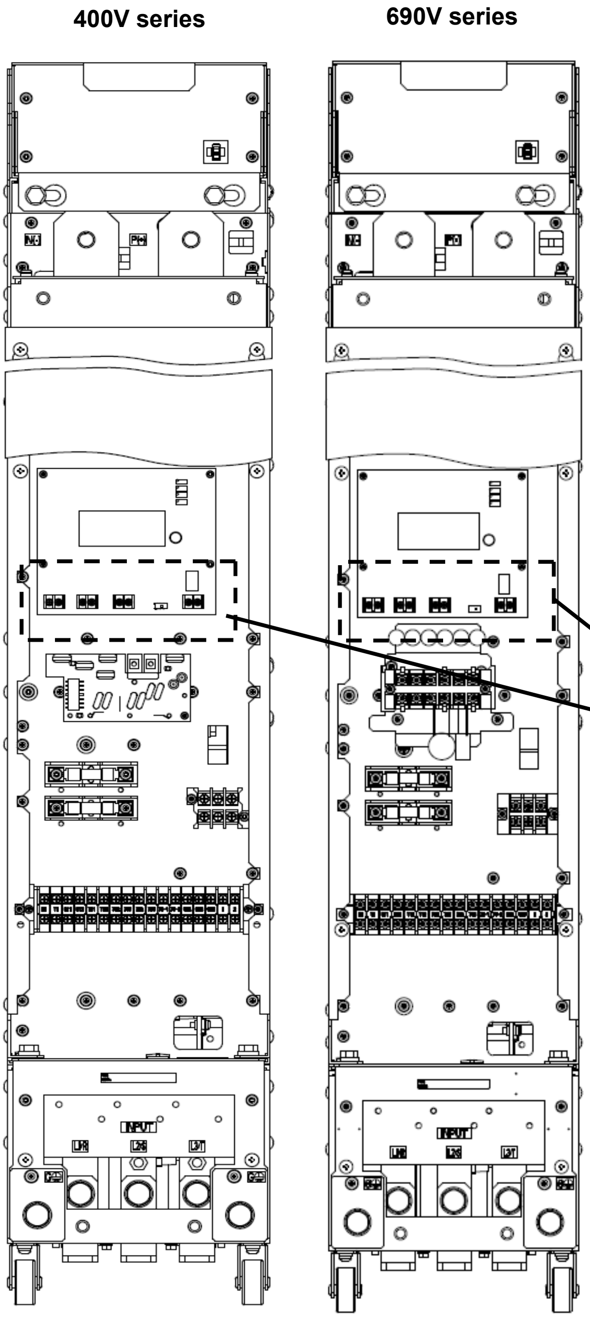
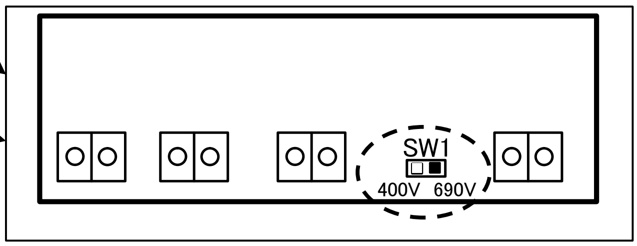


Figure 6.2.8-3: Control terminal layout

6.2.8.3 Switch 1





Do not change Switch 1 from the factory default.

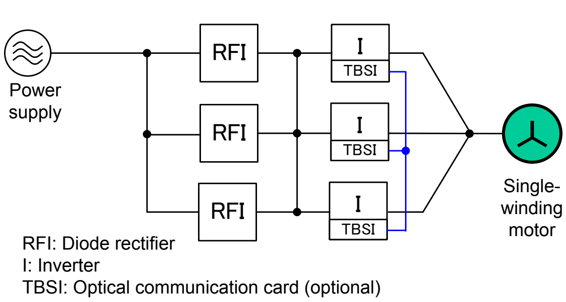
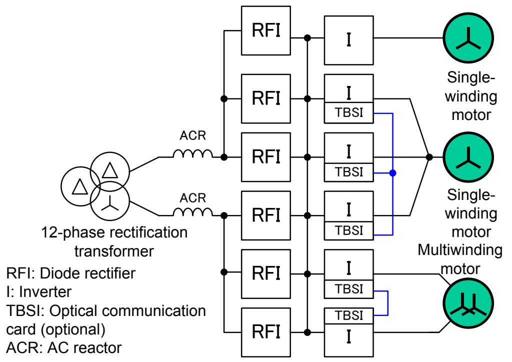
Note: Make sure that Switch 1 is set to the factory default before turning on the power.

	Setting of Switch 1
400V series	400 V
690V series	690 V

Figure 6.2.8-4: Switch 1 layout

6.2.9 Multi-unit connection (capacity expansion)

A high capacity system can be constructed by connecting diode rectifiers (RHD-D) in parallel.
There are two methods of capacity expansion: parallel connection and 12-phase rectification.

Parallel connection method	12-phase rectification method
Up to three diode rectifiers can be connected in parallel to the same power supply system.	Up to six diode rectifiers (two sets of three rectifiers connected in parallel) by use of a 12-phase rectification transformer. Connect an AC reactor (ACR) to the secondary side of the 12-phase rectification transformer.
<Nominal applied inverter/motor capacity> • 400V series: (at supply voltage of 400 V) 850 kW for MD spec or 950 kW for LD spec • 690V series: (at supply voltage of 690 V) 1200 kW for MD spec	<Nominal applied inverter/motor capacity> • 400V series: (at supply voltage of 400 V) 1450 kW for MD spec or 1640 kW for LD spec • 690V series: (at supply voltage of 690 V) 2000 kW for MD spec
 Figure 6.2.9-1: 3 units connected in parallel	 Figure 6.2.9-2: 12-phase rectification and parallel connection

(Note 1) To connect multiple diode rectifiers so that all of them have the same output, ensure that they all have the same capacity.

(Note 2) The maximum applied capacity is calculated on the assumption that the capacity reduction compensation factor based on the supply voltage is 100%. For information on how to accurately calculate the capacity based on the use conditions, refer to "6.2.9.1 Parallel connection method" to "6.2.9.4 Example of calculating the nominal applied inverter/motor capacity".

6.2.9.1 Parallel connection method

(1) Output capacity reduction

Up to three diode rectifiers (RHD-D) can be connected in parallel. Parallel connection requires reduction of the output capacity. Use the reduction rates shown in Table 6.2.9-1, calculate and consider the output capacity.
(The reduction rates shown apply to the 400V series at supply voltage of 400 V and to the 690V series at supply voltage of 690 V.)

Table 6.2.9-1: Output capacity reduction rates for the parallel connection method

Number of sets connected in parallel	Output capacity reduction rate
2 parallel sets	92 [%]
3 parallel sets	92 [%]

(2) Precautions for connecting rectifiers

1) Ensure that all the diode rectifiers (RHD-D) have the same wiring length (portion A) from the power supply to their input terminal.
2) Ensure that all the diode rectifiers (RHD-D) have the same wiring length (portion B) from their output terminal to the DC bus bar.
3) The wiring length for portion C should be within 500 mm. Also, the wiring length for portion C1 should be equal to that for portion C2.

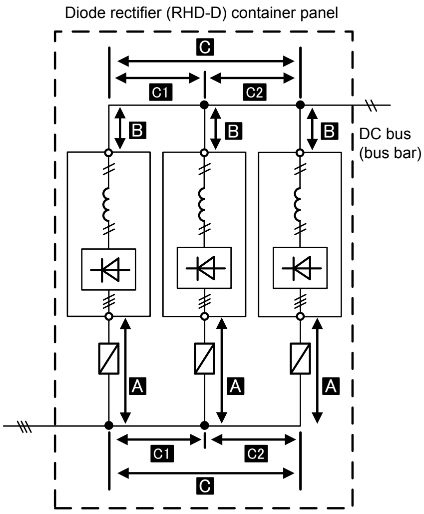


Figure 6.2.9-3: Precautions for parallel connection

6.2.9.2 12-phase rectification method

(1) Output capacity reduction

Output capacity reduction (applicable to the 400V series at supply voltage of 400 V and to the 690V series at supply voltage of 690 V)

Up to six diode rectifiers (RHD-D) can be connected by use of a 12-phase rectification transformer in combination with parallel connection. Whether or not combined with parallel connection, 12-phase rectification requires reduction of the output capacity. Use the reduction rates shown in Table 6.2.9-2, and calculate and consider the output capacity.
(The reduction rates shown apply to the 400V series at supply voltage of 400 V and to the 690V series at supply voltage of 690 V.)

Table 6.2.9-2: Output capacity reduction rates for the 12-phase rectification method

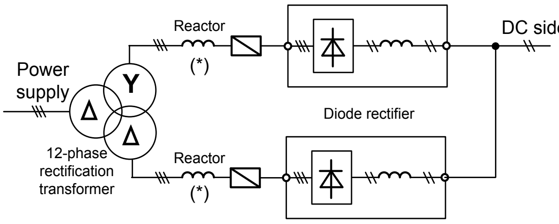
Configuration	400V series	690V series
12-phase rectification	87%	77%
12-phase rectification combined with parallel connection	77%	70%

(2) Precautions for connecting rectifiers

Ensure that the 12-phase rectification transformer meets the specifications in Table 6.2.9-3.

Table 6.2.9-3: 12-phase rectification transformer specifications

Characteristics	400V Series	690V Series
No-load voltage difference (voltage transformation ratio) between Δ and Y	1.5 V or lower	3.0 V or lower
%X	4% or higher	
Unbalance rate between Δ and Y (%X)	10% or lower	
%R	1% or higher	
Unbalance rate between Δ and Y (%R)	10% or lower	



(*) If the supply voltage includes 5th and/or 7th order components, a reactor is required on the secondary side of the 12-phase rectification transformer.
This reactor must have an inductance equivalent to 10% or higher of the required power capacity of the diode rectifiers.
In addition, the variation in inductance must not exceed 10%.

6.2.9.3 Capacity reduction compensation based on the supply voltage

When capacity reduction is required for parallel connection and/or 12-phase rectification, the reduction rate can be mitigated based on the supply voltage. To calculate the compensation factor based on the supply voltage, use the formula given below.

However, if (reduction rate) x (compensation factor) is higher than 100%, use 100% as the upper limit.

$$\text{Compensation factor}(\%) = \frac{\text{Supply voltage}[V]}{400[V]}$$

(*) Even when the supply voltage is lower than 400 V, use the formula above to reduce the capacity (in the case of the 400V series).

6.2.9.4 Example of calculating the nominal applied inverter/motor capacity

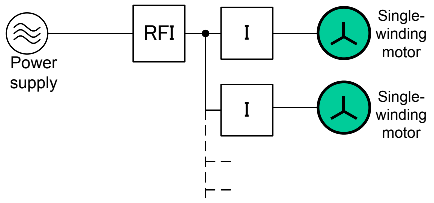
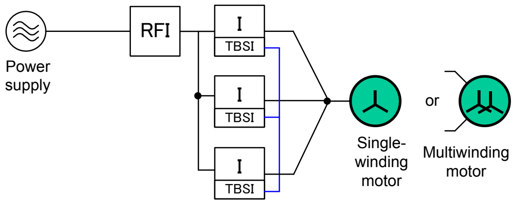
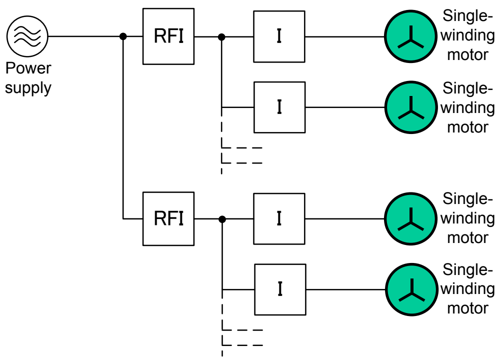
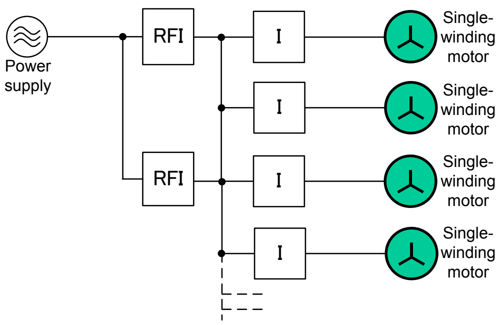
The nominal applied inverter/motor capacity can be calculated using the formula below.

Nominal applied inverter/motor capacity[kW]
= (Stack capacity[kW]) x (number of units) x (parallel connection degression rate [12 - phase rectification reduction rate])
x(supply voltage compensation factor)

	Conditions	Parallel connection reduction rate	12-phase rectification reduction rate	Supply voltage compensation factor	Nominal applied inverter/motor capacity
Example 1	Supply voltage : 440 V Stacks used : RHD315-4D (MD) x 6 units Connection method : 3 parallel sets x 12-phase rectification	77%		110% (440 V/400 V)	1600 kW (MD) (315×6×77%×110%)
Example 2	Supply voltage : 480 V Stacks used : RHD200-4D(MD) x 2 units Connection method : 12-phase rectification	-	87%	120% (480 V/400 V)	400 kW (MD) (200 x 2 x 100%) (Note 1)
Example 3	Supply voltage : 380 V Stacks used : RHD315-4D (LD) x 3 units Connection method : 3 parallel sets	92%	-	95% (380 V/400 V)	930 kW (LD) (355×3×92%×95%)

(Note 1) 87% x 120%=104.4%. Hence, use 100%, the upper limit.

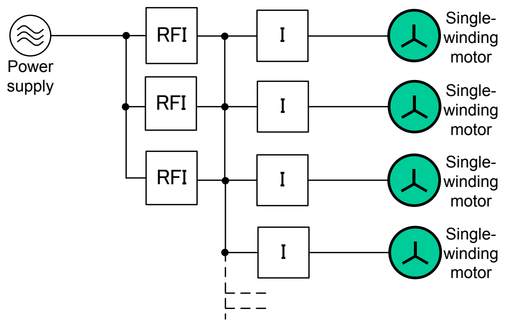
6.2.10 System configuration examples

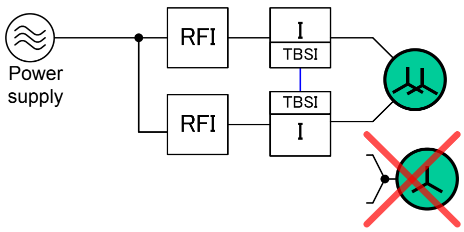
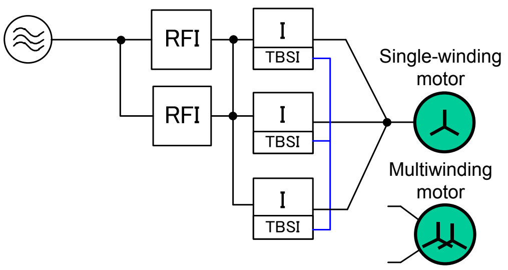
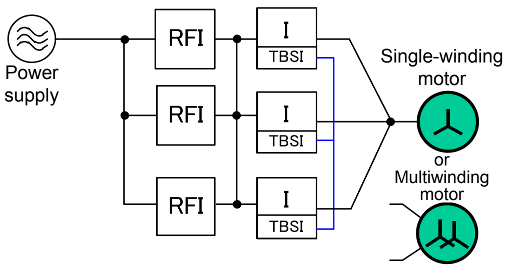
No.	System configuration diagram (Symbols in diagram) RFI: Diode rectifier I: Inverter, TBSI: Optical communication card (optional)	Diode rectifier configured system Capacity expansion method	Diode rectifier configured system Number of connected units	Inverter configured system Capacity expansion method	Inverter configured system Number of connected units	Remarks* • Applied inverter/motor capacity • Precautions
1		-	1	-	Multiple	[Applied capacity] <400V series> • MD: up to 315 kW • LD: up to 355 kW <690V series> • MD: up to 450 kW
2		-	1	Direct parallel	3 (Max)	
				Multi-winding driving	6 (Max)	
3		Parallel connection	2	-	Multiple	When used without connecting (sharing) each RFI output. [Applied capacity] <400V series> • MD: up to 315 kW • LD: up to 355 kW <690V series> • MD: up to 450 kW
			3			
4		Parallel connection	2	-	Multiple	When used by connecting (sharing) each RFI output. [Applied capacity] <400V series> • MD: up to 579 kW • LD: up to 653 kW <690V series> • MD: up to 828 kW

* The nominal applied inverter/motor capacity is calculated on the assumption that the capacity reduction compensation based on the supply voltage is 100%. For information on how to accurately calculate the capacity based on the use conditions, refer to "6.2.9.1 Parallel connection method" to "6.2.9.4 Example of calculating the nominal applied inverter/motor capacity".

(Note 1) To connect multiple diode rectifiers so that all of them have the same output, ensure that they all have the same capacity.

(Note 2) When using direct parallel connection and multi-winding driving systems, ensure that all the inverters have the same capacity.

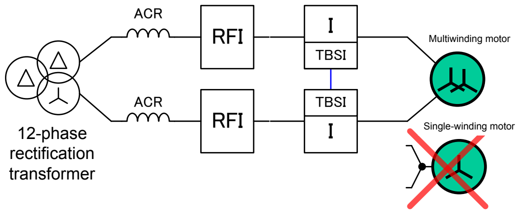
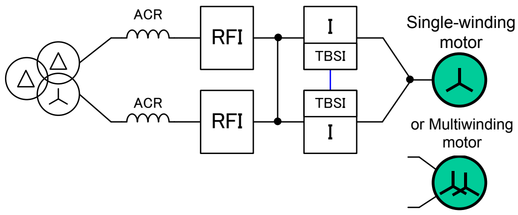
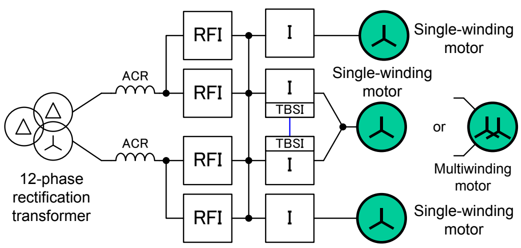
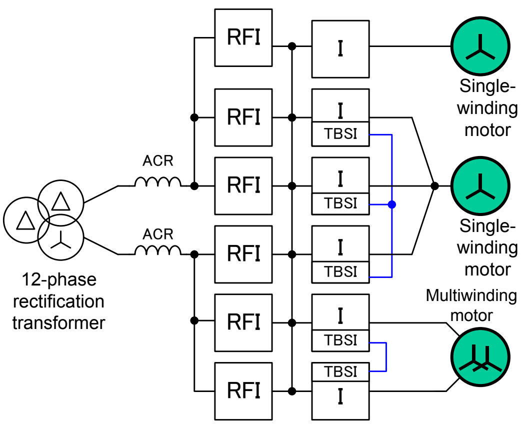
<table>
<tr><th rowspan="2">No</th><th rowspan="2">System configuration diagram
(Symbols in diagram)
RFI: Diode rectifier
I: Inverter, TBSI: Optical communication card (optional)</th><th colspan="2">Diode rectifier configured system</th><th colspan="2">Inverter configured system</th><th rowspan="2">Remarks*
• Applied inverter/motor capacity
• Precautions</th></tr>
<tr><th>Capacity expansion method</th><th>Number of connected units</th><th>Capacity expansion method</th><th>Number of connected units</th></tr>
<tr><td>5</td><td>
</td><td>Parallel connection</td><td>3</td><td>-</td><td>Multiple</td><td>When used by connecting (sharing) each RFI output.

[Applied capacity]
<400V series>
• MD: up to 869 kW
• LD: up to 979 kW
<690V series>
• MD: up to 1240 kW</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">
</td><td rowspan="2">Parallel connection</td><td>2</td><td rowspan="2">Multi-winding driving</td><td rowspan="2">6 (Max)</td><td rowspan="2">[Applied capacity]
When using 3 units of RFI
<400V series>
• MD: up to 945 kW
• LD: up to 1065 kW
<690V series>
• MD: up to 1350 kW</td></tr>
<tr><td>3</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">
</td><td rowspan="2">Parallel connection</td><td rowspan="2">2</td><td>Direct parallel</td><td>3 (Max)</td><td rowspan="2">[Applied capacity]
<400V series>
• MD: up to 579 kW
• LD: up to 653 kW
<690V series>
• MD: up to 828 kW</td></tr>
<tr><td>Multi-winding driving</td><td>6 (Max)</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">
</td><td rowspan="2">Parallel connection</td><td rowspan="2">3</td><td>Direct parallel</td><td>3 (Max)</td><td rowspan="2">[Applied capacity]
<400V series>
• MD: up to 869 kW
• LD: up to 979 kW
<690V series>
• MD: up to 1240 kW</td></tr>
<tr><td>Multi-winding driving</td><td>6 (Max)</td></tr>
</table>

* The nominal applied inverter/motor capacity is calculated on the assumption that the capacity reduction compensation based on the supply voltage is 100%. For information on how to accurately calculate the capacity based on the use conditions, refer to "6.2.9.1 Parallel connection method" to "6.2.9.4 Example of calculating the nominal applied inverter/motor capacity".

(Note 1) To connect multiple diode rectifiers so that all of them have the same output, ensure that they all have the same capacity.

(Note 2) When using direct parallel connection and multi-winding driving systems, ensure that all the inverters have the same capacity.

No	System configuration diagram (Symbols in diagram) RFI: Diode rectifier I: Inverter, TBSI: Optical communication card (optional)	Diode rectifier configured system: Capacity expansion method	Diode rectifier configured system: Number of connected units	Inverter configured system: Capacity expansion method	Inverter configured system: Number of connected units	Remarks* • Applied inverter/motor capacity • Precautions
9		12-phase rectification	2	Multi-winding driving	6 (Max)	[Applied capacity] <400V series> • MD: up to 548 kW • LD: up to 617 kW <690V series> • MD: up to 783 kW
10		12-phase rectification	2	Direct parallel	3 (Max)	[Applied capacity] <400V series> • MD: up to 548 kW • LD: up to 617 kW <690V series> • MD: up to 783 kW
				Multi-winding driving	6 (Max)	
11		12-phase rectification	4	Direct parallel	3 (Max)	[Applied capacity] When using 3 units of RFI <400V series> • MD: up to 970 kW • LD: up to 1093 kW <690V series> • MD: up to 1386 kW
				Multi-winding driving	6 (Max)	
12		12-phase rectification	6	Direct parallel	3 (Max)	[Applied capacity] <400V series> • MD: up to 1450 kW • LD: up to 1640 kW <690V series> • MD: up to 2000 kW
				Multi-winding driving	6 (Max)	

* The nominal applied inverter/motor capacity is calculated on the assumption that the capacity reduction compensation based on the supply voltage is 100%. For information on how to accurately calculate the capacity based on the use conditions, refer to "6.2.9.1 Parallel connection method" to "6.2.9.4 Example of calculating the nominal applied inverter/motor capacity".

(Note 1) To connect multiple diode rectifiers so that all of them have the same output , ensure that they all have the same capacity.

(Note 2) When using direct parallel connection and multi-winding driving systems, ensure that all the inverters have the same capacity.

6.2.11 Generated loss

The Table 6.2.11-1 shows diode rectifier generated losses.

Table 6.2.11-1: Diode rectifier generated losses

Power-based series	Model	Generated loss [W]	
		MD spec mode	LD spec mode
400V	RHD200S-4D□	1650	1900
	RHD315S-4D□	2550	3250
690V	RHD220S-69 D□	1200	1450
	RHD450S-69D□	2450	-

6.2.12 Peripherals

6.2.12.1 AC fuse for diode rectifier

This is an AC fuse used for protecting a diode rectifier.

Use the inverter's fuse disconnection detection terminals to implement the detection of fuse disconnection. Purchase microswitches along with fuses.

* Fuse other than the types listed in "**Application table**" may not be used.

(1) Application table

Fuse manufacturer: Eaton website: http://www.eaton.com/

*This product can be also purchased from Fuji Electric.

Table 6.2.12-1: Application table

Voltage	Specifications	Nominal applied motor capacity [kW]	Diode rectifier model	AC Fuse			
				Model	Fig.	Generated loss [W]	Approx. mass [kg]
400 V	MD	200	RHD200S-4D□	170M6547	E	130	1.25
		315	RHD315S-4D□	170M6500	F	145	
	LD	220	RHD200S-4D□	170M6547	E	130	1.25
		355	RHD315S-4D□	170M6500	F	145	
690 V	MD	220	RHD220S-69D□	170M6497	F	130	1.25
		450	RHD450S-69D□	170M6501	F	150	
	LD	250	RHD220S-69D□	170M6497	F	130	1.25

(2) External dimensions

For information on fuse external dimensions and installation steps, refer to "5.2.1.1 Fuses" in Chapter 5.

(3) Microswitch

Model: 170H3027 * For details, refer to "5.2.1.1 Fuses" in Chapter 5.

(4) Connection diagram

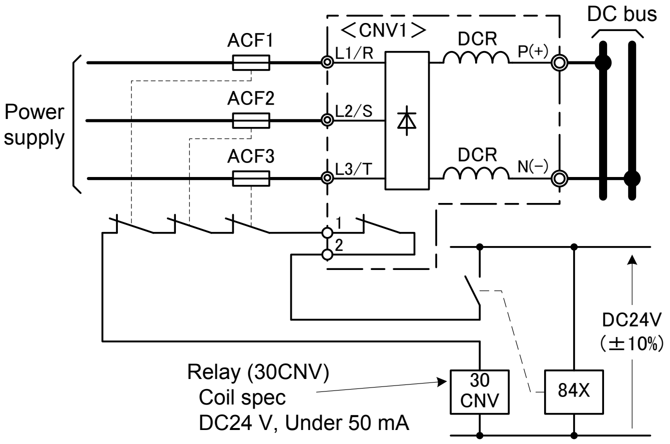


Figure 6.2.12-1: Fuse wire connection diagram

Use the relay sequence shown in Figure 6.2.12-1.

When using multiple inverters, abnormality signals for the microswitches and diode rectifiers (CNV1) associated with the AC fuses (ACF1 to ACF3) should be input to the relay (30CNV).

Connect this relay contact (30CNV) to one of terminals X1 to X9 on each inverter.

Assign "Coast to a stop" (BX) or external alarm (THR) to the inverter side.

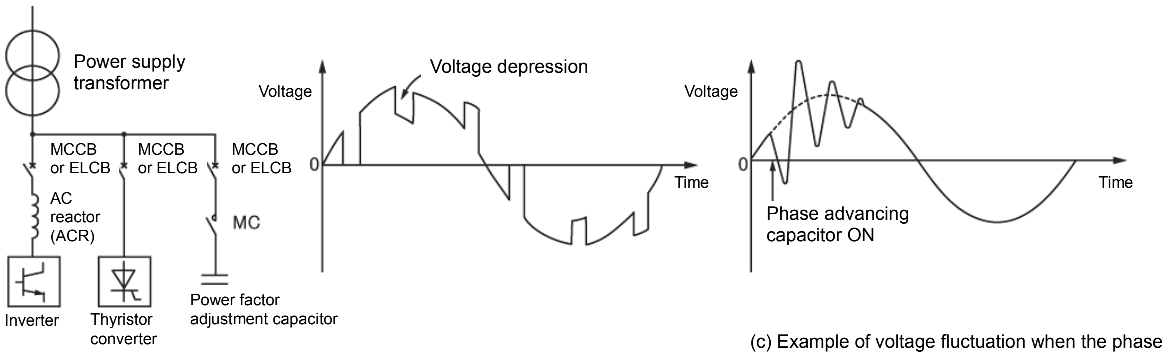
If you choose to assign BX, make this a self-holding circuit (to be cancelled by reset PBS, etc.) as necessary.

6.2.12.2 AC reactor (ACR: alternate current reactor)

An AC reactor is used for the purpose of preventing load allocation of diode rectifiers from becoming unbalanced when connected in parallel. It is also used when the supply voltage is unstable (extreme inter-phase voltage unbalance).

(1) Applied example

When there are thyristor-driven loads or when phase-advancing capacitors are turned ON or OFF in the same power supply system



(a) Connection example

(b) Example of voltage depression by thyristor converter

(c) Example of voltage fluctuation when the phase advancing capacitor is turned ON.

Figure 6.2.12-2: Description of receiving power supply

When the inter-phase unbalance rate of the inverter power supply exceeds 2%

$$\text{Interphase unbalance rate}(\%) = \frac{\text{Max. voltage(V) - Min. voltage(V)}}{\text{3-phase average voltage(V)}} \times 67$$

When connecting diode rectifiers in parallel

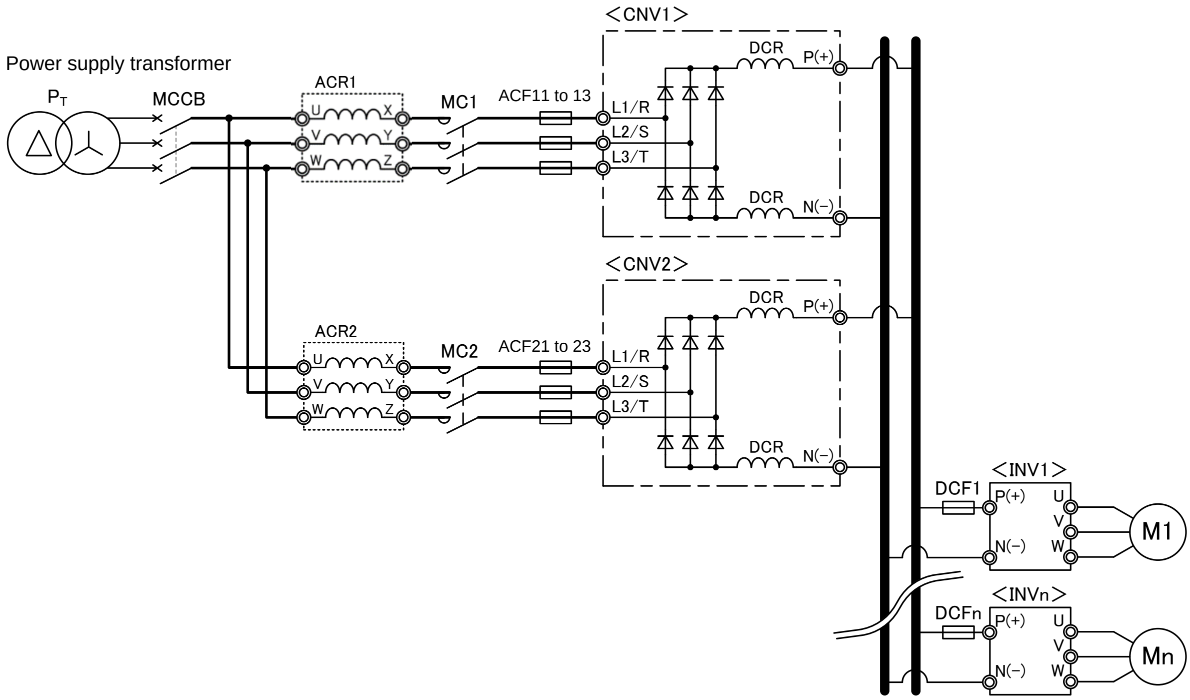


Figure 6.2.12-3: Configuration with two converters

Note 1) The diode rectifier and AC reactor used should be of the identical type.

Note 2) The contactor and AC reactor may be arranged in the opposite order of arrangement shown in this diagram.

Note 3) The wiring from MCCB to diode rectifiers (CNV1, CNV2) should be made the same length whenever possible.

(2) AC reactor specifications

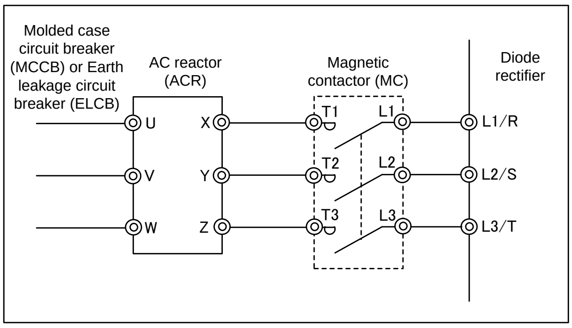


Figure 6.2.12-4: AC reactor (ACL) and connection example

Table 6.2.12-2: List of AC reactor specifications

Power supply system	Reactor model	Rated current [A]	Reactance [mΩ/phase]		Winding resistance [mΩ]	Generated loss [W]	Approx. mass [kg]	Dimensions								
			50 Hz	60 Hz				Figure	W	W1	D	D1	D2	G	H	J
400 V	ACR4-110	250	16.7	20	0.523	60.3	24	A	250	100	136	105	202	M8 (9.5×18)	245	M12
	ACR4-132	270	20.8	25	0.741	119	32		250	100	146	115	207	M8 (10×16)	250	M12
	ACR4-220	561	10	12	0.236	107	40		320	120	150	110	240	M10 (12×20)	300	M12
	ACR4-280	825	6.67	8	0.144	108	52		380	130	150	110	260	M10 (12×20)	300	M12
	ACR4-355	825	6.67	8	0.144	245	52		380	130	150	110	260	M10 (12×20)	300	M12
	ACR4-450	950	6.67	8	0.136	473	95	B	460	155	290	230	200	M12 (φ15)	490	4×M12
	ACR4-530	1100	5.75	6.9	0.0824	340	100	C	480	155	420	370		M12 (15×25)	380	4×M12
	ACR4-630	1300	4.87	5.84	0.0713	422	110		510	170	420	370	-	M12 (15×25)	390	4×M12

Note 1) Generated losses listed in the above table are calculated under the conditions shown below.

- The power supply is 3-phase 400 VAC, 50 Hz and the inter-phase voltage unbalance ratio is 0%.
- The power supply capacity is "500 kVA" or "a capacity 10 times larger than the rated capacity of the inverter", whichever is larger.
- For the load motor, a 4-pole standard motor is used at full load (100%).

Note 2) For information on AC reactors other than listed above, refer to "8.5.4 AC reactor (ACR)" in Chapter 8 of the separate volume "Unit Type Function Code Edition" (24A7-☐-0019).

<Common>

Withstand voltage: 2500 VAC for 1 min. (Insulation class: Class H)

Insulation resistance: 100 MΩ (1000 V-Megger)

Ambient temperature: -20 to 50°C

Humidity: 90% Rh or less

Indoor altitude 1000 m or less

<External dimensions>

Figure A

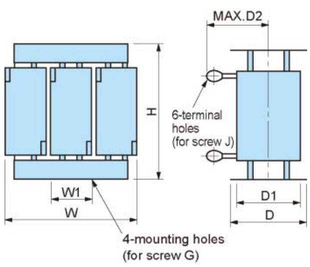


Figure B

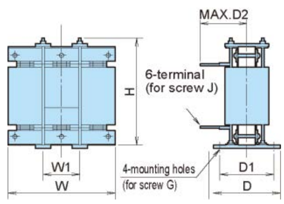


Figure C

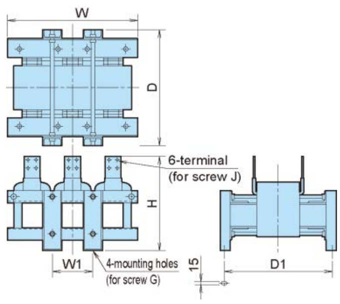


Figure 6.2.12-5: External dimensions of AC reactor (ACL)

6.2.12.3 Use of molded case circuit breakers (MCCBs)

A molded case circuit breaker (MCCB) protects the main circuit terminals (L1/R, L2/S, L3/T) of a converter (inverter) and is mainly used to protect the wiring from overload and short-circuiting to prevent a secondary accident after breakage of an inverter.

The degree of inverter protection generally depends on the overcurrent and overload protection functions built in the inverter.

📖 Equipment selection list for each converter model

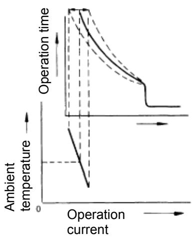
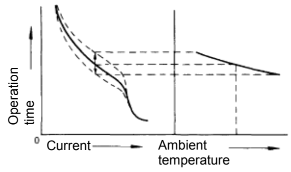
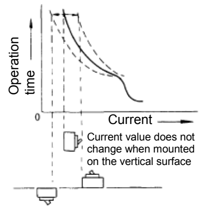
- Diode rectifiers: Refer to "6.2.12.6 List of equipment (MCCB and MC)".
- PWM converters: Refer to "6.3.12.3 Input power supply circuit (MCCB, ELCB)".

Note
- The modeled case circuit breakers (MCCBs) used for converters (including diode rectifiers and PWM converters) should be those for general wiring.
- Motor protection breakers may not be used for converters and inverters because they are rated to meet conditions for full-voltage starting.

(1) Overcurrent tripping method

The overcurrent tripping devices should be a thermal-electromagnetic type, full electromagnetic type, or **electronic type with higher harmonics prevention measures taken (RMS value detection method)**.

Table 6.2.12-3: Comparison of current tripping operations

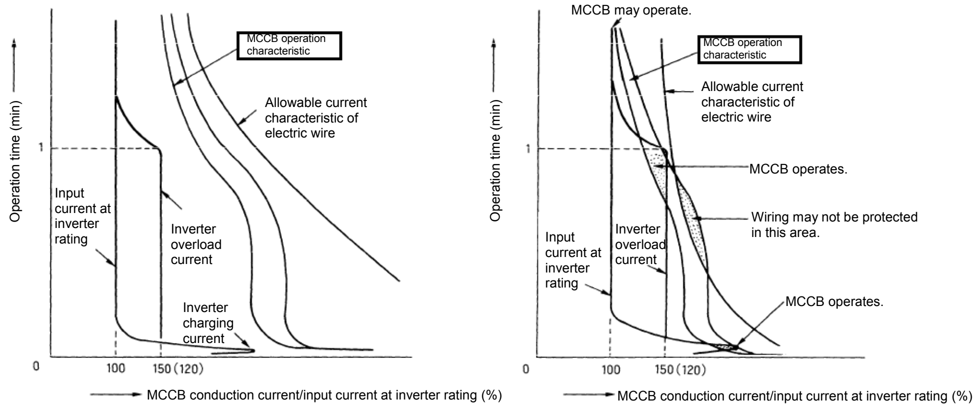
Comparison item	Thermal-electromagnetic type	Full electromagnetic type	Electronic type
Effect of ambient temperature	A bimetal is used. A bimetal has the property that changes the shape by the temperature. Therefore, the effect of the temperature is not large, but the temperature may affect the internal components, causing the rated current to change. * When the overcurrent relay is equipped with an ambient temperature compensation device, the rated current rarely changes. 	The rated current does not change. However, as the viscosity of the silicon oil in the dash pod changes, the operation time changes. 	A current detection circuit detects the conduction current. The temperature drift of the electronic device exists, but it does not affect greatly.
Effect of mounting posture	The impact is small. (Almost non-change.)	Since the weight of the plunger in the dash pod affects the operation, the operation current value changes depending on the mounting posture. 	The impact is small. (Almost non-change.)

(2) Rated voltage

The rated voltages stated in the catalog or technical reference of the MCCB are the applicable maximum voltages.

(3) Rated current

1) An appropriate MCCB should be selected that does not operate (trip) by either the input current or overload current during motor operation and protects the wires reliably. The MCCB operation characteristic curve shown in Figure 6.2.12-6 becomes the boundary line. The right portion shows that the MCCB operates while the left portion shows that it does not operate. Therefore, select an appropriate MCCB so that the right position shows the allowable current of the wire along the MCCB operation characteristic curve while the left portion shows the current during converter/inverter operation.



(a): Correct selection example (b): Incorrect selection example

Figure 6.2.12-6: How to select the rated current of molded case circuit breaker (MCCB)

2) The rated current stated in the catalog or technical reference of the MCCB shows the value at an operating temperature of 40°C. When storing the MCCB in a cabinet, the temperature coefficient (which should be reduced to 0.85 to 0.95 during operation depending on the MCCB) should be taken into consideration according to the set temperature inside the cabinet.

$$\text{Rated current when using INV} = \text{Rated current of MCCB} \times \frac{1}{\text{Temperature correction coefficient } (0.85 \text{ to } 0.95)}$$

(4) Rated breaking current

Select an appropriate MCCB with the ability to break the short-circuit current. This is called full capacity breaking method.

In addition to this method, a cascade breaking method is also available that breaks the short-circuit current in cooperation with the breaker of the power supply if the breaking capacity of the MCCB for the inverter is insufficient. (However, there are restrictions on the combinations of breakers and protectors.)

When the short-circuit current value is unknown, calculate it while referring to the references shown below:

- Fuji auto breaker technical reference (EH150□)
- Technical description catalog "Short-circuit current calculation method (CY002)."

The value of the MCCB output terminal should be used as the short-circuit current value that becomes the reference.

If the short-circuit current is calculated with the value of the converter input terminal, the calculated value becomes small when the wiring is long since the impedance of the wire is taken into consideration. As a result, the breaking capacity becomes insufficient if a short-circuit accident occurs in the main circuit terminal of the MCCB.
(Refer to Figure 6.2.12-7.)

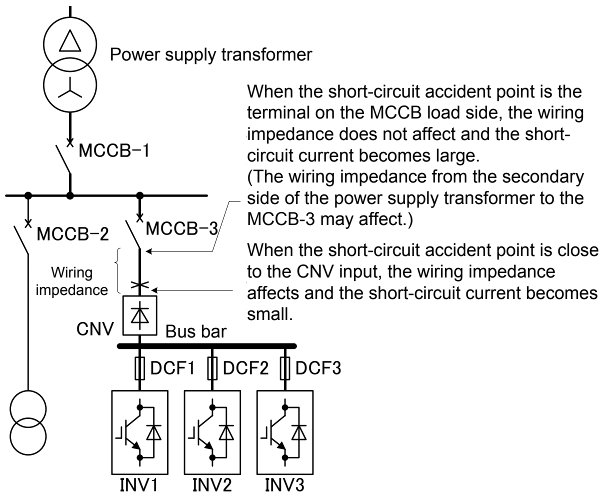
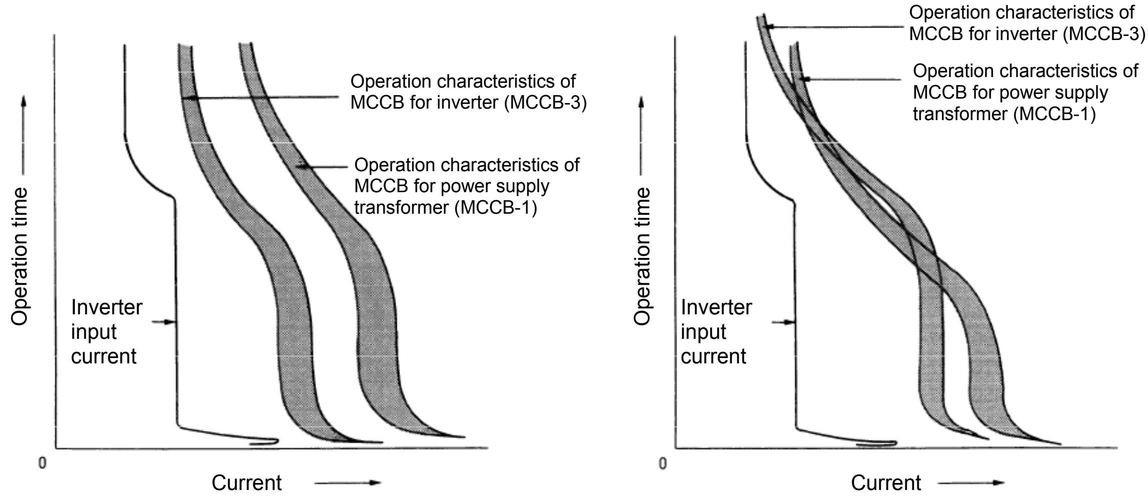


Figure 6.2.12-7: Accident point and short-circuit current

(5) Selective tripping coordination

This selective tripping coordination means a relationship where only the breaker on the power supply side closest to the accident point operates and upstream breakers do not operate. This relationship needs to be established in both the overload and short-circuit areas. The selective tripping coordination is used when the reliable power supply is required for the power supply system with an important load.

For example, if a short-circuit accident occurs at point X in Figure 6.2.12-7, the short-circuit current flows to the MCCB-1 and MCCB-3.
If the MCCB-1 is tripped by this short-circuit current, a power failure also occurs in the load of the MCCB-2. Therefore, to satisfy the selective tripping coordination, it is necessary to combine the MCCBs so that the tripping operation of the MCCB-3 is completed before the MCCB-1 operates in all ranges of the overcurrent protective area. (Refer to Figure 6.2.12-8.)



(a): Example of a good combination (b): Example of a bad combination

Figure 6.2.12-8: Selective tripping coordination

Table 6.2.12-4: List of Fuji Electric's MCCB (G-TWIN series) models: extracted from G-TWIN catalog (EH130☐)

Series/Applications			Standard													Global
Specifications			For general wiring		For motor protection	For primary side of transformer	Momentary breaking type		Non-auto switch (1)	With earth leakage alarm	With ZCT	With single-phase 3-wire neutral line open-phase protection (2)	Class 2 heat resistant type (3)	Distribution panel module (4)	Momentary fixing type for general wiring (5)
Frame (A)	Basic name	Rated braking capacity Icu(kA) AC230V/ AC440V(JIS)	Momentary fixed type	Momentary adjustable type			Momentary fixed type	Momentary adjustable type							
32	BW32	2.5/1.5	BW32AAG		BW32AAM									BW32AFC	
		5/2.5	BW32SAG		BW32SAM	BW32SAT	BW32SAQ		BW32SAS						
50	BW50	2.5/1.5	BW50AAG											BW50AFC	
		5/2.5	BW50EAG		BW50EAM	BW50EAT				BW50EAL		BW50EAN	BW50EAH		
		10/7.5	BW50SAG		BW50SAM	BW50SAT	BW50SAQ		BW50SAS				BW50SAH		
		25/10	BW50RAG		BW50RAM										BW50RAGU
		125/65	BW50HAG												
63	BW63	5/2.5	BW63EAG		BW63EAM		BW63EAQ								
		10/7.5	BW63SAG		BW63SAM		BW63SAQ		BW63SAS						
		25/10	BW63RAG												
100	BW100	5/1.5	BW100AAG											BW100AFC	
		25/10	BW100EAG		BW100EAM	BW100EAT			BW100EAS	BW100EAL		BW100EAN	BW100EAH		BW100EAGU
125	BW125	50/30	BW125JAG		BW125JAM	BW125JAT	BW125JAQ		BW125JAS	BW125JAL	BW125JAZ				BW125JAGU
		100/50	BW125RAG		BW125RAM		BW125RAQ		BW125RAS	BW125RAL	BW125RAZ				BW125RAGU
		125/65	BW125HAG												
250	BW250	36/18	BW250EAG		BW250EAM	BW250EAT			BW250EAS	BW250EAL		BW250EAN	BW250EAH		BW250EAGU
		50/30	BW250JAG		BW250JAM		BW250JAQ			BW250JAL	BW250JAZ				BW250JAGU
		100/50	BW250RAG		BW250RAM	BW250RAT	BW250RAQ		BW250RAS	BW250RAL	BW250RAZ				BW250RAGU
		125/65	BW250HAG												
400	BW400	50/30	BW400EAG	BW400EAA		BW400EAT			BW400EAS	BW400EAL		BW400EAN	BW400EAH		BW400EAGU
		85/36	BW400SAG	BW400SAA						BW400SAL	BW400SAZ				BW400SAGU
		100/50	BW400RAG	BW400RAA		BW400RAT	BW400RAQ	BW400RAB	BW400RAS	BW400RAL	BW400RAZ				BW400RAGU
		125/70	BW400HAG	BW400HAA			BW400HAQ	BW400HAB							BW400HAGU
630	BW630	50/36	BW630EAG	BW630EAA		BW630EAT			BW630EAS	BW630EAL					
		100/50	BW630RAG	BW630RAA		BW630RAT	BW630RAQ	BW630RAB	BW630RAS	BW630RAL	BW630RAZ				BW630RAGU
		125/70	BW630HAG	BW630HAA			BW630HAQ	BW630HAB							BW630HAGU
800	BW800	50/36	BW800EAG	BW800EAA					BW800EAS	BW800EAL					
		100/50	BW800RAG	BW800RAA			BW800RAQ	BW800RAB	BW800RAS	BW800RAL	BW800RAZ				BW800RAGU
		125/70	BW800HAG	BW800HAA			BW800HAQ	BW800HAB							BW800HAGU

(Note 1) The rated breaking capacity is not described since the model is a switch.
(Note 2) The product is dedicated to the single-phase 3-wire circuit. Icu at 100 VAC/ 200 VAC becomes as follows. BW50EAN: 5 kA, BW100EAN: 25 kA, BW250EAN: 35 kA, BW400EAN: 50 kA.
(Note 3) The specifications of class 2 heat resistant type is different from the value listed above table. For details, refer to the list of Fuji heat resistant type equipment catalog (No. AH060).
(Note 4) The product is not applicable to the 400 V-circuit.
(Note 5) For details about UL ratings, refer to the list of specifications (page 20).

6.2.12.4 Use of earth leakage circuit breakers (ELCBs)

To protect work personnel from an electric shock, prevent fire caused by earth leakage, or maintain the electric facilities, an earth leakage circuit breaker (ELCB) should be used instead of an MCCB to prevent such accidents. When using an ELCB with a converter or an inverter, the ELCB may function by the leakage current caused by high frequency switching operations.

- The overcurrent protective function of an ELCB is the same as an MCCB.
  Refer to "6.2.12.3 Use of molded case circuit breakers (MCCBs)".
- For information on the equipment used for each diode rectifier model, refer to "6.2.12.6 List of equipment (MCCB and MC)".

(1) Rated current sensitivity

As a rule, to aim at prevention of electric shock accidents, a product with high sensitivity and high-speed operation should be used. To aim at prevention of fire caused by earth leakage or damage to the unit, a product with medium sensitivity can be used. Additionally, the sensing time may need to be changed according to the wiring distance or motor capacity.

When the current sensitivity to be used is defined in a legally controlled place (an ELCB with high sensitivity and high-speed operation is used), investigate whether or not unnecessary operation is performed by continuous leakage current. In other cases, determine an appropriate ELCB in the manner shown below.

Table 6.2.12-5: Examples of current sensitivity selection standards

Current sensitivity		Operating conditions
High sensitivity type	15 mA	Place where the risk of an electric shock accident is very high (moistened place, etc.)
	30 mA	Place where a human body needs to be protected even when touching any electrically live line. Movable or transportable grounding wire may be cut. However, when the ELCB has a large capacity, it may malfunction. Unit installation work is difficult. (15 mA: Refer to Article 28 of the Electrical Equipment Technical Standards.)
Medium sensitivity type	100 mA	Protection from an electric shock accident caused by earth leakage in a circuit where units are installed securely. (For details about unit grounding resistance, refer to Table 6.2.12-8.) Protection from fire caused by earth leakage When the high sensitivity type ELCB is used, it malfunctions.
	200 mA	
	500 mA	
	1000 mA	
	3000 mA	

(2) Operation time and grounding resistance

According to Article 19 of the Electrical Equipment Technical Standards, the grounding resistance is relaxed as shown in "Table 6.2.12-6" when an earth leakage circuit breaker (ELCB) is connected. Additionally, when the grounding resistance of the grounding work for prevention of electric shock accident conforms to Table 6.2.12-8 and the operation time is 0.1 sec. or less (high-speed type), an ELCB with medium sensitivity can be used according to the relationship with allowable human body contact voltage (Table 6.2.12-7).

Table 6.2.12-6: Grounding and the grounding resistance of electrical equipment according to Electrical Equipment Technical Standards

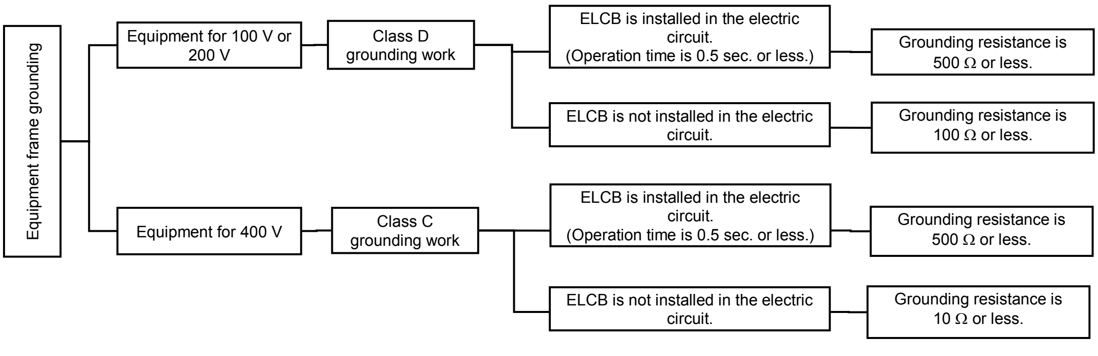


Table 6.2.12-7: Allowable contact voltage

(From low-voltage protective circuit guideline)

Class	Contact status	Allowable contact voltage
Class 1	Most part of human body is in the water.	2.5 V or lower
Class 2	Human body is moistened significantly. Metallic electric machine unit is always in contact with a part of human body from the structural aspect.	25 V or lower
Class 3	In cases other than classes 1 and 2, the risk is high when the contact voltage is applied in the normal human body status.	50 V or lower
Class 4	In cases other than classes 1 and 2, the risk is low even when the contact voltage is applied in the normal human body status. There is no risk to apply any contact voltage.	No limit.

Table 6.2.12-8: Protective grounding resistance values

ELCB current sensitivity [mA]	Grounding resistance [Ω]	
	Moistened or other place with a high risk of an electric shock.	Other places
30	500	500
50	500	500
75	333	500
100	250	500
150	166	333
200	125	250
300	83	166
500	50	100
1,000	25	50

(3) Continuous leakage current

When an earth leakage circuit breaker (ELCB) is connected to the inverter input side, the inverter output side also becomes the protective area as illustrated in Figure 6.2.12-9.

Therefore, the high-frequency charging/discharging current that flows through the wiring on the inverter output side or static capacitance to the earth of the motor becomes the continuous leakage current. This may cause the ELCB to operate.

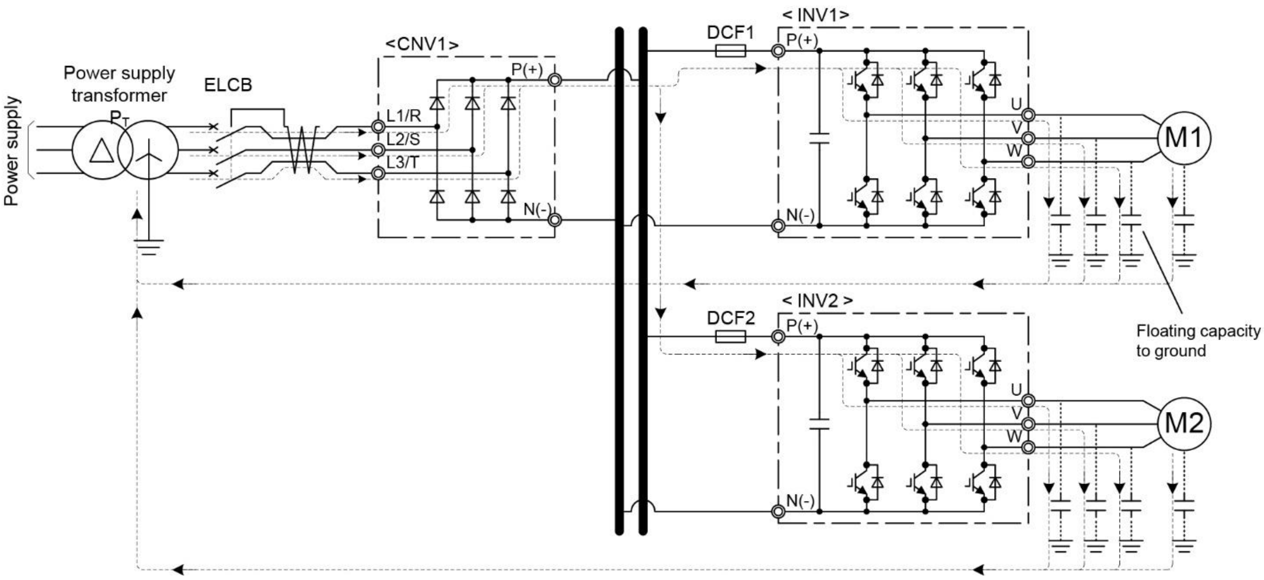
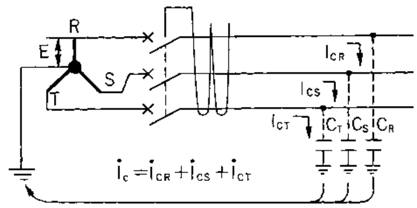
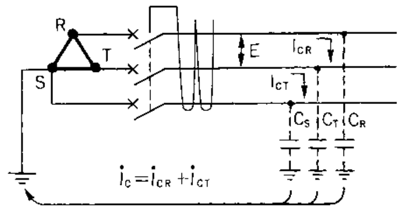
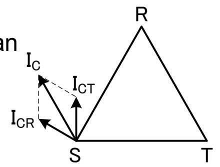
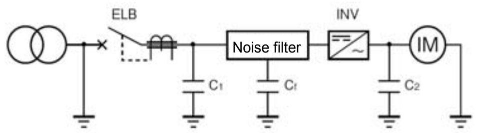


Figure 6.2.12-9: Leakage current transmission route

The level of the leakage current that flows the ELCB may vary depending on the power supply transformer (and also depending on the transformer grounding). The following summarizes the leakage current calculation methods.

Table 6.2.12-9: Grounding method and continuous leakage current

Kind of system		Leakage current to the static capacitance to the earth (overview)
Neutral point grounding		When the static capacitance to the earth of each phase of the electric circuit is balanced, the following Equation is established in the steady status $\dot{I}_C = \dot{I}_{CR} + \dot{I}_{CS} + \dot{I}_{CT} = 0$ and no leakage current flows. Actually, the distribution line of each phase does not have the same conditions or the contacts become uneven when the switch is turned ON or OFF. This may cause the leakage current to flow through the static capacitance to the earth of a specific phase. Therefore, the zero phase current of the leakage current that flows through the static capacitance to the earth for at least one phase needs to be taken into consideration. $I_{\Delta n} \geqq 10 \times 2\pi f \times (C_1 + C_2) \times V_C$ ·············· Equation 6.2.12-1
S-phase grounding		The leakage current flows through the static capacitance to the earth of a phase other than the grounding phase. $\dot{I}_C = \dot{I}_{CR} + \dot{I}_{CT}$ The vector of each leakage current is illustrated in the figure on the right.  $I_{\Delta n} \geqq 10 \times \sqrt{3} \times 2\pi f \times (C_1 + C_2) \times V_C$ ·········· Equation 6.2.12-2



Vc: Grounding voltage of main circuit
f: Power supply frequency [Hz]
Ct: Static capacitance to the earth between ELB and INV (For one phase of cable)
Cf: Static capacitance of noise filter (For one phase)
C2: Static capacitance to the earth between INV and motor (For one phase of cable)

Figure 6.2.12-10: Leakage current model diagram

Table 6.2.12-10

Leakage current (3-ϕ 200 VAC, 60 Hz) per km when the CV wires are used in wiring through the metal conduit pipes (tightly in contact with the grounding).

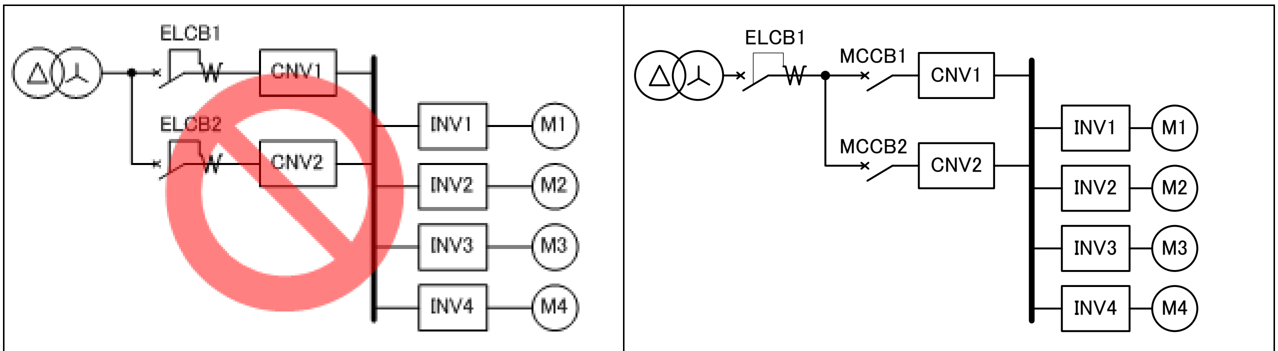
Wire size [mm^2]	Static capacitance [uF]	Leakage current [mA]
5.5	0.250	33
8	0.276	36
14	0.341	45
22	0.353	46
38	0.450	59
60	0.457	60
100	0.444	57
150	0.531	68
200	0.496	65
250	0.547	71
315	0.616	80

As the rated current sensitivity is summarized as described above, it can be investigated and calculated from the contents. Actually, it is very difficult to calculate the leakage current according to the inverter or motor grounding method, or cables to be used, etc.

Therefore, Fuji Electric summarizes the relationship between the rated current sensitivity and wiring distance on the output side in Table 6.2.12-11 from the data based on the actual machine test with an inverter and a motor combined.

(4) ELCB installation place

Install the ELCB on the converter input side (primary side: L1/R, L2/S, L3/T). Since the voltage and frequency on the converter output side or inverter output side (secondary side) do not meet the ELCB specifications, the ELCB does not operate correctly. (Do not use.) Normal operation may not be attained by installing an ELCB on the input side of each converter when more than one converter is connected in parallel to the same supply system. (Refer to Figure 6.2.12-11.)



(a) Bad installation example

(b) Good installation example

Figure 6.2.12-11: ELCB installation place

(5) Settings on the inverter side

An appropriate ELCB is selected under conditions that the inverter carrier frequency is 1 kHz or more and that the operation frequency is 60 Hz or less. When the carrier frequency is set to a level less than 1 kHz, it is greatly redundant by the fundamental current. So, the safety factor that is twice larger than the normal level should be used.

(6) Applicable category of rated current sensitivity of ELCB

Table 6.2.12-11: Applicable category of rated current sensitivity of ELCB

Power-based series	Standard application motor (kW)	Wiring distance/current sensitivity					
		10 m	30 m	50 m	100 m	200 m	300 m
	3.7						
	5.5						
	7.5	30 mA					
	11			100 mA			
	15						
	18.5						
	22				200 mA		
	30						
	37						
	45					500 mA	
	55						
	75						
	90						
400V	110						
	132						1000 mA
	160						
	200						
	220						
	250						
	280						
	315						
	355						3000 mA
	400						(Special)
	450						
	500						
	630						
	710						

Note

(1) The list above is obtained when Fuji Electric’s earth leakage circuit breaker or earth leakage relay applies to the test setup.

(2) The rated current of the standard application motor is the numeric values for Fuji Electric’s standard motor (4-pole, 400 VAC, 50 Hz).

(3) The power supply grounding is calculated when the neutral point grounding is performed with 400 V class Y-connection.

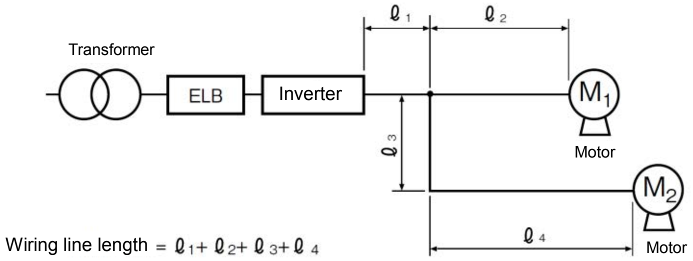
(4) The values listed above are calculated based on the static capacitance to the earth when 3-core 600 V cross linked-polyethylene-insulated wire (CV wire) is used in a wiring through metal conduit pipes (tightly in contact with the grounding). When the wire has a static capacitance to the earth smaller than that of the CV wire, the wiring distance can be made longer in reverse proportion to the decrease ratio of the static capacitance to the earth.

(5) The values listed above are calculated with the metal conduit pipe wiring (tightly in contact with the grounding). When the static capacitance to the earth is small by separating the wire from the grounding, the wiring distance can be made longer.

(6) The wiring distance is the total distance from the inverter to the motor. Therefore, when multiple motors are connected to one inverter, the wiring length becomes the total wiring length.

$\lambda_M = \lambda_1 + \lambda_2 + \lambda_3 + \lambda_4$

λ_M : Total wiring length



(7) Enhanced model for inverter

Fuji Electric’s G-TWIN series earth leakage circuit breaker (ELCB) standard models are designed to be applied to inverter circuits. However, when the static capacitance to the earth is large due to the wiring length or noise filter, the leakage current becomes large and the ELCBs do not function correctly.

To suppress this unnecessary operation, an enhanced model for inverters is available that provides an earth leakage detection circuit improved in terms of frequency characteristics.
(In particular, a grounding capacitor with a large static capacitance is used for the noise filter.)

When placing an order, specify "-01065" at the end of the model.

The enhanced model for inverters can detect a ground fault on the secondary side of the inverter at an operation frequency of 120 Hz or less.

However, **<u>Fuji Electric’s inverters are equipped with the ground fault detection and output phase loss protective functions</u>**.

Additionally, when using the Y-connection neutral point grounding method, the current sensitivity becomes dull in response to a ground fault on the secondary side of the inverter. For this reason, the protective grounding of the load (class C and D grounding) should be 10 Ω or less.

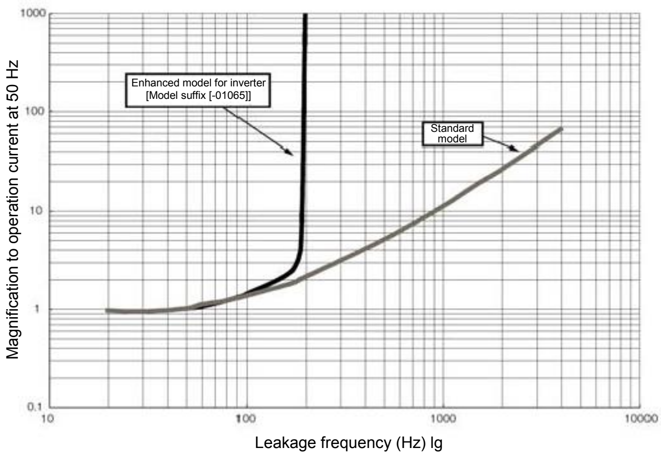


Figure 6.2.12-12: Frequency characteristics of the enhanced model for inverters

Table 6.2.12-12: List of Fuji Electric's ELCB (G-TWIN series) models - extracted from G-TWIN Catalog (EH130☐)

Specifications / Series/Applications			Standard				Global
			For general wiring Momentary fixed type	For motor protection	With single-phase 3-wire neutral line open-phase protection (1)	For resistance welding machine	Momentary fixing type for general wiring (2)
Frame (A)	Basic name	Rated braking capacity Icu(kA) AC230V/ AC440V(JIS)					
32	EW32	2.5/-	EW32AAG				
		2.5/1.5	EW32EAG	EW32EAM			
		5/2.5	EW32SAG	EW32SAM			
50	EW50	2.5/-	EW50AAG				
		5/2.5	EW50EAG	EW50EAM	EW50EAN		
		10/7.5	EW50SAG	EW50SAM			
		25/10	EW50RAG				EW50RAGU
		125/65	EW50HAG				
63	EW63	5/2.5	EW63EAG	EW63EAM			
		10/7.5	EW63SAG	EW63SAM			
		25/10	EW63RAG				
100	EW100	5/-	EW100AAG				
		25/10	EW100EAG	EW100EAM	EW100EAN		EW100EAGU
125	EW125	50/30	EW125JAG	EW125JAM			EW125JAGU
		100/50	EW125RAG	EW125RAM			EW125RAGU
		125/65	EW125HAG				
250	EW250	36/18	EW250EAG	EW250EAM	EW250EAN		
		50/30	EW250JAG	EW250JAM			EW250JAGU
		100/50	EW250RAG	EW250RAM		EW250RAW	EW250RAGU
		125/65	EW250HAG		EW400EAN		
400	EW400	50/30	EW400EAG				EW400SAGU
		85/36	EW400SAG			EW400RAW	EW400RAGU
		100/50	EW400RAG				EW400HAGU
		125/70	EW400HAG				
630	EW630	50/36	EW630EAG				EW630RAGU
		100/50	EW630RAG				
		125/70	EW630HAG				
800	EW800	50/36	EW800EAG				
		100/50	EW800RAG				
		125/70	EW800HAG				

(Note 1) The product is dedicated to the single-phase 3-wire circuit. Icu at 100 VAC/ 200 VAC becomes as follows. EW50EAN: 50 kA, BW100EAN: 25 kA, BW250EAN:35 kA, EW400EAN:50 kA
(Note 2) For details about UL ratings, refer to the list of specifications (page 34).

Table 6.2.12-13: List of Fuji Electric's ELCB (G-TWIN series) current sensitivities

Specifications	Rated current sensitivity [mA]
High-speed type	15
	30
	50 (EW50RAG-3P and EW100EAGU-3P only)
	100
	100/200 or 100/200/500 setting can be switched.
Time delay type	100/200/500 setting can be switched. (EW100EA D only)
High-speed/time delay type	100/200/500/1000 setting can be switched.

Some models provide the ability to switch different current sensitivity and operating time settings although available only in particular frame sizes.

🕮 Refer to the G-TWIN Catalog (EH130☐).

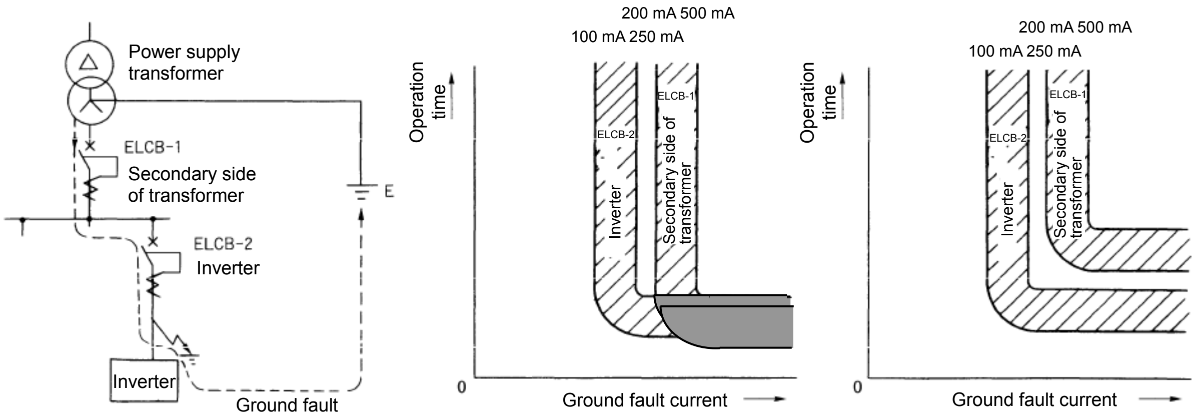
(8) Ground fault protection coordination

As the period of time from detection of a ground fault to the operation of the ELCB is shorter, the earth leakage protection characteristics become more excellent. However, it is necessary to consider the ground fault protection coordination in the same manner as the selective tripping coordination for the overcurrent protection.

The ground fault protection coordination performs the selective tripping coordination between the upstream (power supply side) and downstream (load side) ground fault protection devices. If a ground fault accident occurs on the downstream side, only this ground fault device is tripped and the upstream ELCBs do not operate.

For example, even though ELCB-1 and ELCB-2 with different rated current sensitivity and the same operation time are used as illustrated in" Figure 6.2.12-13", both ELCBs may operate if a ground fault accident exceeding 500 mA occurs. (Shaded portion ▭ in the figure.)

When a model with a slow operation time (time delay type) is applied to the upstream ELCB-1, the coordination can be established. Therefore, the ground fault protection coordination needs a combination of ELCBs with not only different rated current sensitivity, but also different operation time.



(a) Example of ground fault

(b) Example of protection coordination not established

(c) Example of protection coordination established

Figure 6.2.12-13: Ground fault protection coordination of earth leakage circuit breaker (ELCB)

(9) Model applicable to different voltage

Fuji Electric's standard earth leakage circuit breaker can be used for a circuit with a voltage of up to 440 V. If the circuit voltage exceeds this level, use a special voltage earth leakage circuit breaker. When placing an order, specify "-C5" at the end of the model.

Table 6.2.12-14: Fuji Electric’s ELCB (G-TWIN series) models applicable to different voltage - extracted from G-TWIN Catalog (EH130☐)

Model		EW125JAG	EW125RAG	EW250EAG	EW250JAG	EW250RAG	EW400EAG	EW400SAG	EW400RAG	EW400HAG	EW630EAG	EW630RAG	EW630HAG	EW800EAG	EW800RAG	EW800HAG
Number of poles		3P、4P	3P、4P	3P	3P、4P	3P、4P	3P	3P	3P、4P	3P、4P	3P	3P	3P	3P	3P	3P
Rated operation AC voltage (V)		380-500		230-500			230-500				230-500			230-500		
Operable AC voltage range (V)		160-550		160-550			160-550				160-550			160-550		
Rated impulse withstand voltage Uimp (V)		6		6			6				6			6		
Rated current Io (A)		15,20,30,40,50, 60,75,100,125		125,150,160,175, 200,225,250			250,300,350,400				500,600,630			700,800		
Rated frequency (Hz)		50-60		50-60			50-60				50-60			50-60		
Rated current sensitivity (mA)		30, 100/200/500/1000 切替		30、100/200/500/1000切替			30、100/200/500/1000切替				100/200/500/1000切替			100/200/500/1000切替		
Rated braking capacity (kA) IEC60947-2 JIS C8201-2-2 Ann1,2 Icu/Ics	AC500V	8/4	10/5	5/3	8/4	10/5	18/9	20/10	36/18	42/21	20/10	36/18	42/21	20/10	36/18	42/21
	AC440V	30/15	50/25	18/9	30/15	50/25	30/15	36/18	50/25	70/35	36/18	50/25	70/35	36/18	50/25	70/35
	AC380V	30/15	50/25	18/9	30/15	50/25	30/15	36/18	50/25	70/35	36/18	50/25	70/35	36/18	50/25	70/35
	AC230V	–	–	36/18	50/25	100/50	50/25	85/43	100/50	125/63	50/25	100/50	125/63	50/25	100/50	125/63

Model		EW125JAGU	EW125RAGU	EW250JAGU	EW250RAGU	EW400SAGU	EW400RAGU	EW400HAGU
Number of poles		3P	3P	3P	3P	3P	3P	3P
Rated operation voltage	IEC	380-500		230-500		230-500		
	UL	240-480		240-480		240-480		
Operable AC voltage range		160-550		160-550		160-550		
Rated impulse withstand voltage Uimp (kV)		6		6		6		
Rated current Io (A)		15,20,30,40,50,60,75,100,125		125,150,160,175,200,225,250		250,300,350,400		
Rated frequency (Hz)		50-60		50-60		50-60		
Rated current sensitivity (mA)		30、100/200/500/1000切替		30、100/200/500/1000切替		30、100/200/500/1000切替		
Rated braking capacity (kA) IEC60947-2 JIS C8201-2-2 Ann1,2 Icu/Ics	AC500V	15/8	36/18	18/9	36/18	20/10	36/18	42/21
	AC440V	30/15	50/25	30/15	50/25	36/18	50/25	70/35
	AC380V	30/15	50/25	30/15	50/25	36/18	50/25	70/35
	AC230V	–	–	50/25	100/50	85/43	100/50	125/63
Rated braking capacity (kA) UL489 CAN/CSA C22.2 No.5	480V	30	50	30	50	35	50	65
	240V	50	100	50	100	50	100	100

6.2.12.5 Use of electromagnetic contactor for power supply circuit

An electromagnetic contactor (MC) to be installed on the input side of the converter is used for the purposes shown below.

- The inverter is separated from the power supply by operation of the converter or inverter protective function or external signal.
- The stop command cannot be input due to circuit trouble and the emergency stop needs to be activated.
- The inverter needs to be separated from the power supply if molded case circuit breaker (MCCB) connected to the power supply side cannot be turned OFF when starting the maintenance and inspection work of the inverter. (In this case, it is recommended to add an interlock mechanism, such as manual switch to the operation circuit of the MC.)

Note Do not turn ON or OFF the electromagnetic contactor on the input side (primary side) frequently. Doing so may cause an inverter failure (faulty wiring may occur in the charging circuit). When it is necessary to frequently turn ON or OFF the electromagnetic contactor, do not exceed the frequency of once per 30 minutes. To maintain an inverter service life of 10 years or longer, turn ON or OFF the electromagnetic contactor once per hour.

If it is required to start or stop the operation frequently, perform this operation using the "FWD" or "REV" signal of the control circuit terminals or the FWD, REV, or STOP key on the keypad.

6.2.12.6 List of equipment (MCCB and MC)

Table 6.2.12-15: List for selection of Molded Case Circuit Breakers (MCCBs), Earth Leakage Circuit Breakers (ELCBs), and Electromagnetic Contactors (MCs)

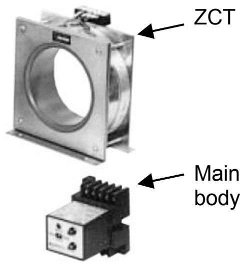
Voltage	Nominal applied motor capacity [kW]	Diode rectifier model	Specifications	MCCB, ELCB	MC
400 V	200	RHD200S-4D☐	MD	500AT	SC-N12
	315	RHD315S-4D☐		700AT	SC-N14
	220	RHD200S-4D☐	LD	500AT	SC-N12
	355	RHD315S-4D☐		800AT	SC-N14
690 V	220	RHD220S-69D☐	MD	300AT	SC-N11
	450	RHD450S-69D☐		600AT	SC-N14
	250	RHD220S-69D☐	LD	350AT	SC-N11

Note
(1) Install the MCCB or ELCB on the input side of the converter.
(2) This table selects an appropriate MCCB or ELCB under conditions that the temperature inside the cabinet is 50°C or less. Select installation environment conditions by considering the correction coefficient (0.85 to 0.93) according to the ambient temperature conditions. To select a specific model, consider the short-circuit breaking capacity of the equipment.
(3) When selecting an electromagnetic contactor (MC), it is assumed that the wire type to be connected is HIV wire (allowable temperature is 75°C). When using other wires, select an electromagnetic contactor (MC) again by considering the terminal block size and wire size.
(4) To prevent any consequential accident if the converter is broken, use an appropriate MCCB or ELCB with the rated current shown in the table above.
Do not use any MCCB or ELCB with a rated current larger than the required level.

6.2.12.7 Use of earth leakage detector (earth leakage relay)

This section describes an earth leakage relay that eliminates the breaking performance of the earth leakage circuit breaker and contains an earth leakage detection function.

The following shows recommended earth leakage relays (Fuji Electric).



RRD type	This earth leakage relay has the same frequency characteristics of the leakage current as the standard type of Fuji Electric's ELCB. There are two types of ZCTs available: the through type and the bus bar integrated type. An earth leakage of up to approx. 3000 A can be detected. Additionally, the high-speed type and the time delay type are also provided. Rated current sensitivity : Switching is possible. (100/200 mA, 200/500 mA, 500/1000 mA) Rated non-operation current : Rated current sensitivity x 50% or switching is possible.
EL type	This earth leakage relay has the same frequency characteristics of the leakage current as Fuji Electric's enhanced ELCB model for inverters ("-01065" is attached to the end of the model). 📖 Figure 6.2.12-12 Refer to "Frequency characteristics of the enhanced model for inverters". The ZCT is only available in the through type and applicable to approximately 1200 A (three wires, HIV or FLSC wires, are passed through). The high-speed type and the time delay type are provided. Rated current sensitivity : 30 mA, Switching is possible. (100/200 mA, 200/500 mA, 500/1000 mA) Rated non-operating current : Rated current sensitivity x 50%

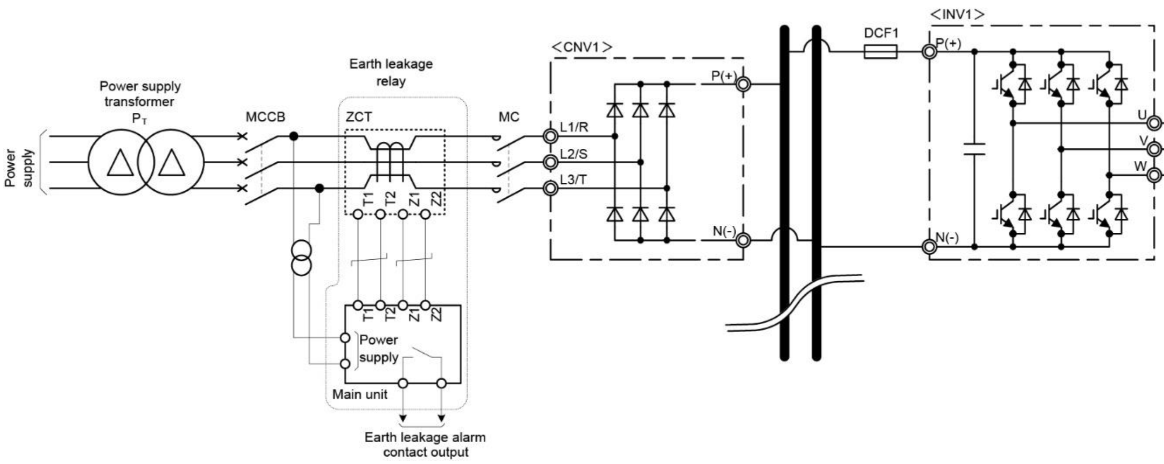


Figure 6.2.12-14: Basic circuit configuration diagram

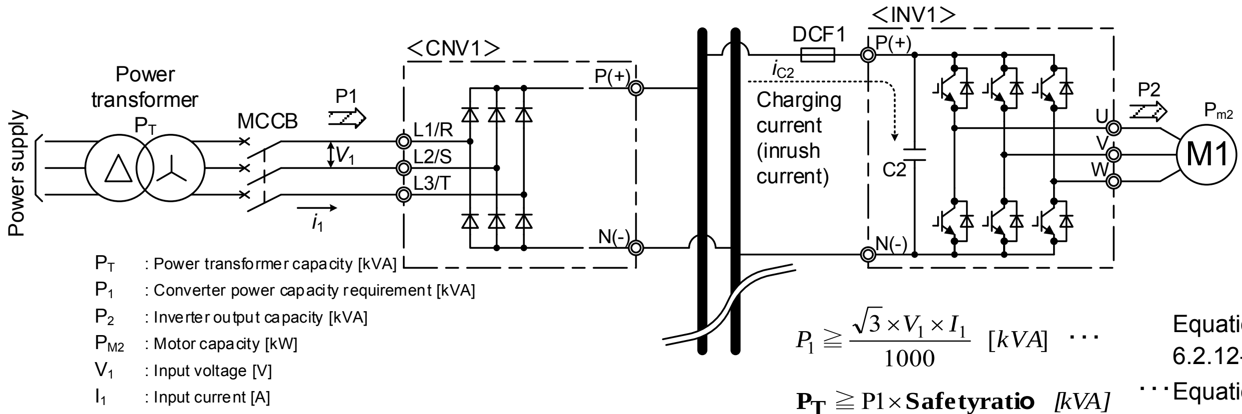
Note
(1) For details about specifications, refer to Fuji Electric's earth leakage relay catalog.
(2) Place the main unit 10 cm or more far from the power system (particularly, large current system) equipment or wires.
If the main unit is put close to such equipment, the external magnetic field may adversely affect it.
(3) When necessary, pass or connect the neutral wires in the circuit. However, do not pass or connect the class C or D grounding wire.
(4) The signal cable between the relay and ZCT [Z1 and Z2 terminals] should be a twist pair cable with a cross-sectional area of 0.3 to 2 mm^2 and its length is 10 m or less.
(5) Make the wiring of the signal cable 10 cm or more far from other power cables [control power supply and test circuit (T1 and T2 terminals), etc.].

6.2.12.8 Power supply transformer (power receiving transformer)

When specifying a power supply transformer capacity on the input side, required power supply capacity of the converter (diode rectifier or PWM converter) and voltage drop when the power is turned ON should be taken into consideration.

(1) Transformer capacity

The following shows a simple calculation method to calculate the transformer capacity from the required power supply capacity of the converter. However, when determining the transformer capacity, the calculated value should be multiplied by the safety ratio. Additionally, when the power supply to the control circuit is supplied from this transformer, the power supply capacity of the control circuit should be also added.



$$P_1 \geqq \frac{\sqrt{3} \times V_1 \times I_1}{1000} \quad [kVA] \quad \cdots \quad \text{Equation 6.2.12-3}$$

$$\mathbf{P_T} \geqq \text{P1} \times \textbf{Safetyratio} \quad [kVA] \quad \cdots \quad \text{Equation 6.2.12-4}$$

Figure 6.2.12-15: Circuit configuration

(2) Voltage drop

When the wiring distance to the load is short like transformer to be installed inside the cabinet, the voltage drop can be calculated simply from the percent impedance of the transformer.

When the power is turned ON, the charging (rush) current flows into the smoothing capacitor of the converter and the voltage largely drops in the transient status.

However, for this voltage drop, an initial charging circuit is normally provided in the converter to suppress the rush current. Additionally, this rush current is set to a level that is the rated current of the inverter or less.

When large capacity equipment is installed in the converter, inverter, or other AC power supply system, the voltage drop must be taken into consideration when selecting a transformer.

$$\Delta V = \%Z_t \times \frac{n \times P_1}{P_T} \quad [\%] \quad \cdots \quad \text{Equation 6.2.12-5}$$

- ΔV : Voltage drop in transient status [V]
- $\%Z_T$: Percent impedance of transformer [%]
- n : Current magnification in transient status
- P_1 : Required power supply capacity of inverter [kVA]
- P_T : Capacity of transformer to be used [kVA]

The current magnification (n) in the transient status is set to a value 4 times larger than the inverter input current I1. Actually, the current magnification may become 20 times larger than the inverter input current I1. However, since this symptom occurs within a short time (several ms), there are normally no problems.

This transient voltage drop that occurs when the power is turned ON does not adversely affect the inverter itself, but it affects the unit connected to the same power supply transformer as the inverter. To avoid the effects on such units, the following relationship must be satisfied.

Allowable lower limit voltage of unit [V] < Vn ··· Equation 6.2.12-6

$$Vn < Vo \times \frac{1 - \Delta V}{100} \quad [V] \quad \cdots \quad \text{Equation 6.2.12-7}$$

- Vn: Transformer output voltage in transient status [V]
- Vo: Transformer voltage in no-load status [V]

If this $\%Z_T$ is pointed out as a problem, this is solved when the $\%Z_T$ is made larger than the calculated transformer capacity value. Additionally, a transformer with $\%Z_T$ specified is prepared to solve the problem, but this transformer may become a special product.

The $\%Z_T$ of the general transformer has the trend shown below.

- $\%Z_T$ is small in the oil transformer.
- $\%Z_T$ is large in the molded transformer.

When the transformer is commonly used by other power load, select an appropriate transformer by considering the operating conditions, such as system impedance and load.

If the power supply voltage decreases to a level lower than the allowable lower limit voltage of the inverter, the inverter does not operate correctly and the protective function may operate. In particular, when starting a large capacity motor, a large voltage drop occurs by the start current.

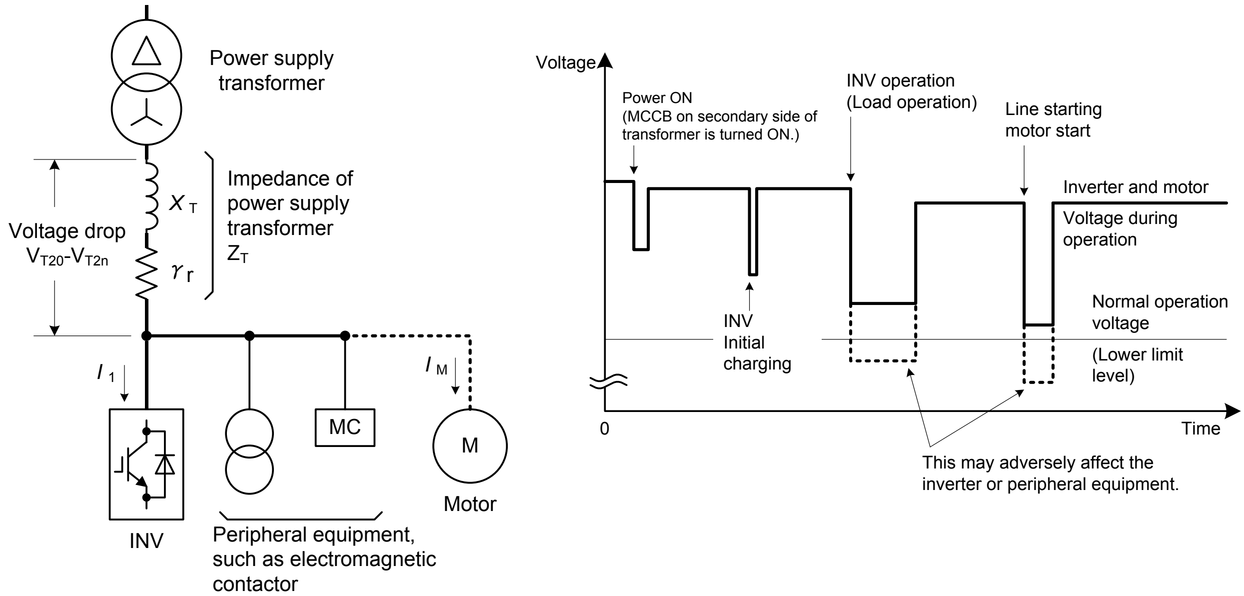
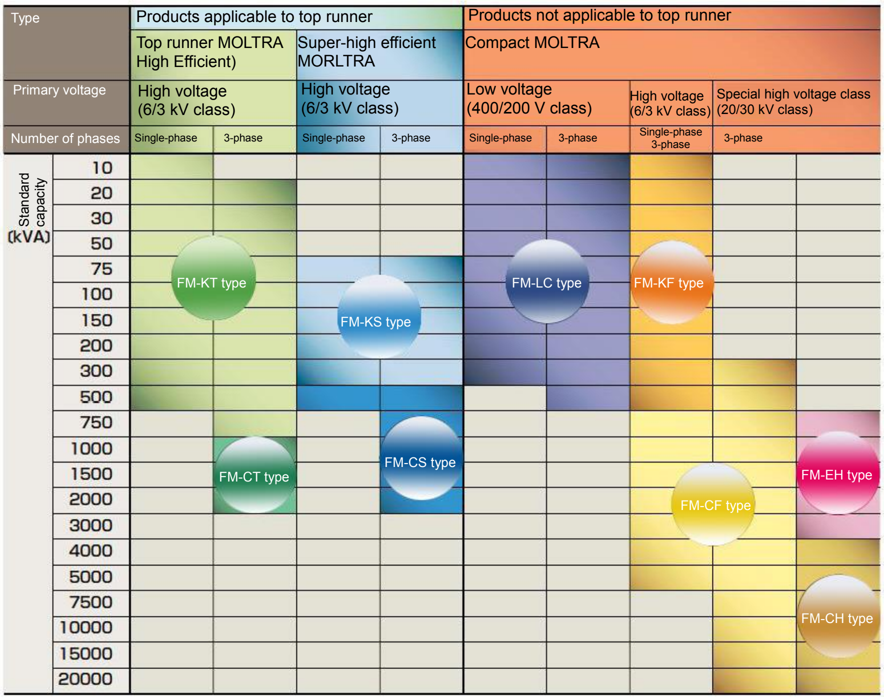


Figure 6.2.12-16: Secondary fluctuation of transformer

(3) Other items

1) In the V-connection transformer, since the inter-phase balance of the power supply impedance is not balanced when viewed from the converter, the unbalance of the input current of each phase becomes large. So, use a 3-phase transformer for the power supply transformer.
2) When a three-winding transformer with a phase difference between the secondary (delta connection) and tertiary (star connection) windings is used to drive multiple inverters, the harmonic current on the primary side is reduced. Note that the harmonic current of the secondary and tertiary windings is not reduced. To reduce the second and tertiary harmonic currents, connect the DC reactor (DCR).
   (This reduces the harmonic current close to the fundamental wave current components.)
3) To ensure the safety and prevent noise propagation, use a two-winding type or three-winding type transformer with the grounding terminal. When noise resistance or surge resistance is required, use a static shield type transformer.

<Reference: Fuji Electric's molded transformer: Extracted from catalog TC76-7V.>



<Reference: Fuji Electric's molded transformer: Extracted from catalog TC76-7V.>

☐ Model (Series)		KT-CT type KS-CS type KF-CF type CH-EH type LC type
☐ Heat resistant class		Standard Class B Class F Class H
■ Number of phases		Single-phase 3-phase Scott connection
■ Frequency (Hz)		50 60 50/60
■ Rated capacity (kVA)		
■ Primary voltage	Rated voltage (V)	210 420 3300 6600 11000 22000 33000
	Tap voltage	Standard ± 2.5, 5.0% tap
	Insulation	Standard ⅄ △
■Secondary voltage	Voltage (V)	R210-105 210 420 (50 Hz) 440 (60 Hz) 3300 6600
	Insulation	Standard ⅄ ⅄(With neutral point) △ Delta connection Delta transformer
☐ Cooling		Standard Natural cooling Wind cooling
■ Wheels		Provided None
☐ Accessories (options)		Contact prevention plate Dial thermometer Protective case
☐ Order quantity		
☐ Desired delivery time		
Other remarks		
Operating environment		The operating environment conforms to the following normal conditions defined in JEC-2200. If the operating environment is other than that shown below, specify it separately. (1) Ambient temperature: Max. temperature 40°C (Average temperature during day time is 35°C. Annual average temperature is 20°C or less.) Min. temperature -5°C (2) Altitude: 1000 m or less (3) Circuit voltage waveform: The voltage waveform of the circuit connected to the transformer is almost the sine waveform. (4) Circuit voltage balance: The voltage of the 3-phase circuit connected to the transformer is almost balanced.

Describe desired specifications or enclose a desired specification by a circle in the table. ■ shows absolutely required items.

Note: The guarantee of this product covers only the purchased product and delivered single product. Consequential damages (damages or losses of machine and equipment and losses of profits) resulting from the malfunction are expected from the guarantee.

<Reference: Fuji Electric's oil transformer: Extracted from catalog TC77g.>

Standard specification series products

■Specifications

Type		Transformer with standard specifications (JIS product series)				
Standard conformity		JIS C 4304 (2005)				
Number of phases		Single-phase	3-phase			
Rated frequency		50 or 60 Hz				
Rated primary voltage		6600V				
Tap voltage		R6600/F6300/6000 V(50 kVA or less) F6750/R6600/F6450/F6300/6150 V(75 kVA or more)				
Rated secondary voltage		210/105V	210V			420V(50Hz), 440V(60Hz)
Connection		Dedicated to single-phase 3-wire	YyO	Yd1	DdO	Dyn11
Rated capacity [kVA]	10					
	20					
	30	FHE-SS	FHE-SS			
	50					
	75					
	100	FHE-SSA				
	150			FHE-SSA		
	200					
	300	FHE-SS				
	500					
	750				FHE-SS	
	1000					
	1500				RSB-SS	RSB-SS
	2000					
Oil deterioration prevention method		Air sealed type (1000 KVA or less)				Oil sealed type (1500 KVA or more)
Standard paint color		Munsell color notification N5.5, full gloss (500 KVA or less)			Munsell color notification N7, full gloss (750 KVA or more)	
Insulation strength		Withstand voltage Primary 6600 V: 22 kV, Secondary 210 V: 2 Kv Secondary 400 V class: 4 kV, Lightning impulse withstand voltage Primary 6600 V: Switch the CN13, CN14, section 60 kV				

Note 1) Transformer with specifications other than those described above can also be manufactured. Contact Fuji Electric separately. 2) Tap-less transformer is also manufactured.

6.2.12.9 Receiving power supply monitor

(1) Transformer for instrument (VT)

■ **Converter stack input side**

General VT for 50/60 Hz can be used.

■ **Inverter output side**

The output voltage waveform of the inverter is a square wave (rectangular wave).

The output waveform on the secondary side of the transformer for instrument (VT) is a pulse shape distorted waveform. The voltage cannot be measured correctly and the iron core of the VT is saturated magnetically, possibly causing burning. Additionally, when the inverter is operated at a low speed, the frequency becomes low and the voltage becomes close to the DC voltage. In this case, the VT may be burnt.

Therefore, the VT should not be connected to the output side of the inverter.

Table 6.2.12-16: Fuji Electric's coil molded transformer

Model	CD32□-○1	CD34□-○1	CD36□-○1
Rating	220/110V, 440/110V		
Rated load	15VA	50VA	100VA
Accuracy class	1.0･1P	3.0･3P	1.0･1P
Rated frequency	50/60Hz		
Withstand voltage	220 V product: 2 kV, 440 V product: 4 kV		

□: F (Primary side with fuse), N (without fuse)

○: 2 or 4 (Rated primary voltage specifications)

Note: Avoid short-circuiting the secondary side of the VT or short-circuiting with a low impedance. (An excessive current flows to the secondary winding of the VT, causing burning of the secondary winding. This may lead to the insulation breakage of the primary winding. Finally, inter-phase short-circuit may result.)

(2) Current transformer for instrument (CT)

■ **Converter stack input side**

General CT for 50/60 Hz can be used. However, since harmonic components are included, a larger rated load is taken.

■ **Inverter output side**

As a current including a large amount of high frequency and harmonic components may flow, the iron core loss increases. An allowance 10 times larger than the rated load should be given.

CT rated load [VA] ≥ 10 x (rated load of instrument + wire load) [VA]

The wire load should be calculated from Figure 6.2.12-17.

$$P\lambda = r \times \lambda \times \frac{I}{1000} [VA] \quad \cdots\cdots\cdots\cdots \quad \text{Equation 6.2.12-8}$$

$P\lambda$: Wire load [VA]

r : Resistance value of wire [Ω/km]

λ : Wiring distance of wire (round trip distance) [m]

I : Rated secondary current of CT [A]

Note Do not open the secondary side of the CT.
If the secondary side is open while the primary current flows, a high voltage is produced to flow the secondary current according to the CT ratio.

Therefore, the insulation of the secondary winding is broken to produce a short-circuit, possibly resulting in burning.

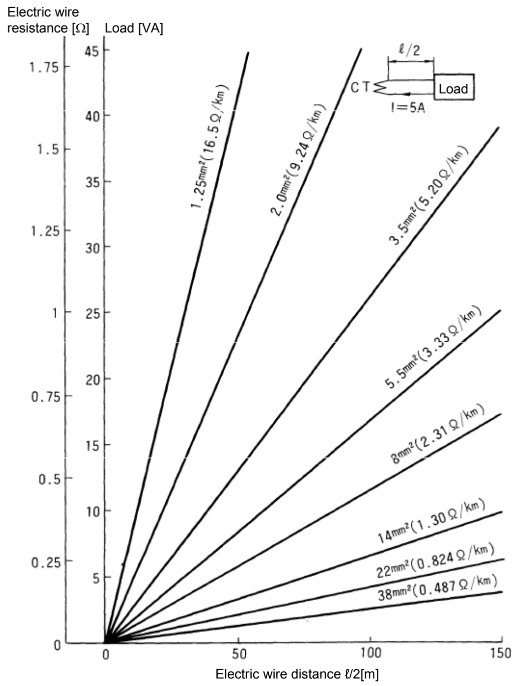


Figure 6.2.12-17: Wire load of circuit

Table 6.2.12-17: Fuji Electric's molded current transformer

Product name	Round window through type			With primary winding			Square window through type	
Model	CC3L1	CC3L2	CC3L3	CC3P1	CC3P2	CC3P3	CC3M2	CC3M3
Rated primary current	10 to 750 A			5 to 50 A			150 to 750 A	200 to 6,000 A
Rated secondary current	5 A or 1 A							
Rated load	5 VA	15 VA	40 VA	5 VA	15 VA	40 VA	15 VA	40 VA
Rated overcurrent strength	40							
Max. voltage	1,150 V							
Error class	1.0 class							
Rated frequency	50/60 Hz							
Insulation method	Double-molding (*1)							

(*1) Epoxy molding is used to insulate a rated primary current of 5,000 or 6,000 A.

(3) Voltmeter

■ **Converter input side**

The waveform is distorted by the effect of the harmonic. However, since the commercial power supply is measured, "a moving-iron type" or "rectifier type voltmeter" should be used.

■ **Inverter output side**

The output voltage including high-frequency components is measured. "A rectifier type voltmeter" should be used that indicates a value close to the r.m.s. value of the fundamental wave.

(4) Ammeter

■ **Converter input side**

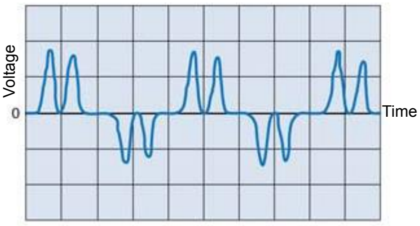
Since the harmonic current with a high peak value called "rabbit's ear" is measured, "a moving-iron type" or "r.m.s. value response type (RMS type)" should be used that indicates the general r.m.s. value including harmonic components.

■ **Inverter output side**

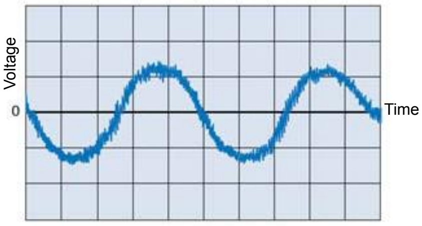
A current with the harmonic components superimposed on the fundamental wave current is measured. The current cannot be measured accurately in all frequency areas. The following models can be used conditionally.

Area of 20 Hz or more: Moving-iron type, rectifier type, r.m.s. value rectifier type,

: R.m.s. value response type (RMS type)



Input current waveform (primary side)



Output current waveform (secondary side)

Figure 6.2.12-18: Current waveform

(5) Frequency meter and wattmeter (watt-hour meter)

■ **Inverter output side**

General purpose analog output terminal of the inverter should be used.

As a value ranging from 0 to 10 VDC (4-20 mA DC) is output, a meter with the scale plate used for the DC voltmeter should be used.

Fuji Electric Technica's analog meter

● **Panel meter**

Product name	Model	Operation principle	Inverter	
			Primary side	Secondary side
AC ammeter	FS-□ type	Moving-core type	○	△ (Note) 1, 2
AC voltmeter	FS-□ type	Moving-core type	○	×
AC ammeter	FR-□ type	Rectifier type	×	△ (Note) 1
AC voltmeter	FR-□ type	Rectifier type	○	×
Single-phase wattmeter	FR-□ W1 type	Converter type	○	×
Single-phase 3-wire wattmeter	FR-□ W2 type	Converter type	○	×
3-phase wattmeter	FR-□ W3 type	Converter type	○	×
3-phase reactive power meter	FR-□ V3 type	Converter type	○	×
3-phase balanced power factor meter	FR-□ FP3 type	Converter type	×	×
3-phase unbalanced power factor meter	FR-□ PFU type	Converter type	×	×
Frequency meter	FR-□ F type	Converter type	○	×

● **Wide angle meter**

Product name	Model	Operation principle	Inverter	
			Primary side	Secondary side
AC ammeter	SWR-□ type	RMS value rectifier type	×	△ (Note) 1
AC voltmeter	SWR-□ type	RMS value rectifier type	○	×
AC ammeter	SWRA-□ type	RMS value response type	○	△ (Note) 1
AC voltmeter	SWRA-□ type	RMS value response type	○	×
Single-phase wattmeter	SWC-□ type	Converter type	○	×
Single-phase 3-wire wattmeter	SWC1-□ type	Converter type	○	×
3-phase wattmeter	SWC2-□ type	Converter type	○	×
3-phase 4-wire wattmeter	SWC3-□ type	Converter type	○	×
3-phase reactive power meter	SWC2-□ type	Converter type	○	×
3-phase 4-wire reactive power meter	SWC3-□ type	Converter type	○	×
3-phase balanced power factor meter	SWA1-□ type	Converter type	×	×
3-phase unbalanced power factor meter	SWA2-□ type	Converter type	×	×
3-phase 4-wire power factor meter	SWA4-□ type	Converter type	×	×
Frequency meter	SWP1-□ type	Converter type	○	×

Note Carefully check the following on the inverter output side.

(1) When the operation frequency is less than 20 Hz, the indication may fluctuate.

(2) When the inverter is operated at a carrier frequency of 5 kHz or more, overcurrent loss produced in the metallic part inside the moving-iron type instrument increases, possibly causing burning.

(3) When monitoring in a low speed area, it is recommended to use the analog output of the inverter stack.

(6) Multi-meter

The following introduces multi-meters that monitor the electric power in the input power supply system of the converter. Two kinds of multi-meters are recommended as multi-meters to be mounted in the cabinet. Investigate an appropriate multi-meter suitable for the purpose.

<u>**PPMC□□□□3-□ (Fuji Electric)**</u>

Features

- This multi-meter is compact and lightweight with front panel dimensions of 48 x 96 mm and easy to install on individual equipment or power distribution panel.
- The current input signal is intended for the general purpose CT (secondary side, 1 A, 5 A). An appropriate selection suitable for the application can be made.
- The RS485 interface can be built-in.
  Communication/function software: Dedicated data collection software is available.
- Data for an extended period of time can be recorded into a SD card. The data stored in the SD card can be loaded onto the personal computer and can be edited using Excel.

<u>**UM03-ARA3□ (F-MPC04S series products: Fuji Electric FA Components & Systems)**</u>

Features

- This multi-meter is compact and lightweight with front panel dimensions of 48 x 96 mm and easy to install on individual equipment or power distribution panel.
- Dedicated CT is used. When monitoring a large capacity, this can be made in a combination with general purpose CT.
- The RS-485 is built-in as standard function. The same communication cable as the F-MPC series product can be used.
- A wide variety of output functions suitable for preventive maintenance can be selected.
  Power alarm/current pre-alarm output (provided as standard), electric energy pulse signal (provided as standard), earth leakage alarm, earth leakage pre-alarm output (model with leakage current measurement function only)
- The rush current of the welding machine, etc. can be measured.
  All cycles of the voltage and current are sampled at a high speed to perform the calculation.

Monitor measurable items

Measurement contents	PPMC	UM03	Remarks
Voltage	○	○	
Current	○	○	
Harmonic current	×	○*1	
Leakage current	×	○*2	
Active power	○	○	
Reactive power	○	○	
Power factor	○	○	
Electric energy	○	○	
Reactive energy	○	○	
Frequency	○	○	

*1 The total harmonic current of only R/T phase can be measured. The total of 3rd, 5th, and 7th harmonic currents is measured.

*2. The measurement is possible only when the model is specified.

📖 For details, refer to relevant catalog or technical reference.

6.2.13 Recommended wire size

The wire size of the main circuit is calculated based on the Equation below.

$$I_{AC} = \frac{P_M}{\sqrt{3} \times Vin \times \cos\vartheta \times \eta_{CNV} \times \eta_{INV} \times \eta_M} [A] \cdots \quad \text{Equation 6.2.13-1}$$

$$I_{DC} = \sqrt{\frac{3}{2}} \times I_{AC} [A] \cdots\cdots\cdots\cdots \quad \text{Equation 6.2.13-2}$$

- I_{AC} : Converter input current [A]
- *IDC* : Converter output current [A]
- P_M : Motor capacity [kW]
- Vin : Converter input voltage [A]
- cos θ : Input power factor
- η_{CNV} : Converter efficiency
- η_{INV} : Inverter efficiency
- η_M : Motor efficiency

Note The structure from the converter output to the DC bus bar should be designed to cover it with the bus bar.

Additionally, when using the wire, the wiring length must be **2 m or less**.

6.2.13.1 3-phase 400V series

(1) Ambient temperature: 40°C

Nominal applied motor capacity [kW]	RHD□-4D□	Specifi-cations	Main input: L1/R, L2/S, L3/T					Output: P(+), N(-)					Grounding wire [mm²] (Note 2)	Control wire [mm²]
			Wire size (Permissible temperature) (Note 1)			Bus bar size [mm²]	Current [A]	Wire size (Permissible temperature) (Note 1)			Bus bar size [mm²]	Current [Adc]		
			60°C	75°C	90°C			60°C	75°C	90°C				
200	200S	MD	200	150	100	t5x30	357	250	200	150	t4x40	421	38	1.25
315	315S		2x200	250	200	t10x30	559	2x250	325	250	t8x50	654	60	
220	200S	LD	250	150	150	t5x30	390	325	200	150	t4x40	458	60	1.25
355	315S		2x200	325	250	t10x30	628	2x325	2x200	325	t8x50	741	100	

(2) Ambient temperature: 50°C

Nominal applied motor capacity [kW]	RHD□-4D□	Specifi-cations	Main input: L1/R, L2/S, L3/T					Output: P(+), N(-)					Grounding wire [mm²] (Note 2)	Control wire [mm²]
			Wire size (Permissible temperature) (Note 1)			Bus bar size [mm²]	Current [A]	Wire size (Permissible temperature) (Note 1)			Bus bar size [mm²]	Current [Adc]		
			60°C	75°C	90°C			60°C	75°C	90°C				
200	200S	MD	325	150	150	t5x30	357	2x200	250	150	t4x40	421	38	1.25
315	315S		—	325	250	t10x30	559	—	2x200	325	t8x50	654	60	
220	200S	LD	2x200	200	150	t5x30	390	2x250	250	200	t4x40	458	38	1.25
355	315S		2x325	2x200	250	t10x30	628	—	2x250	2x200	t8x50	741	60	

The power supply voltage is 400 VAC.

(Note 1) An "IV wire," a "600 V HIV insulated wire," and a "600 V cross-linked polyethylene insulated wire" were used at permissible temperatures of 60°C, 75°C, and 90°C, respectively, and the values represent aerial wiring.

(Note 2) The grounding wire is cited from the permissible short circuit current defined in internal wire regulations.

6.2.13.2 3-phase 690V series

(1) Ambient temperature: 40°C (IEC standard)

Nominal applied motor capacity [kW]	RHD□ -69D□	Specifi- cations	Main input: L1/R, L2/S, L3/T				Output: P(+), N(-)				Ground- ing wire [mm²]	Control wire [mm²]
			Wire size (Permissible temperature) (Note 1)		Bus bar size [mm²]	Current [A]	Wire size (Permissible temperature) (Note 1)		Bus bar size [mm²]	Current [Adc]		
			70°C	90°C			70°C	90°C				
220	220S	MD	120	95	t5x30	226	150	120	t4x40	277	22	1.25
450	450S		2x150	2x120	t10x30	460	2x240	2x150	t8x50	561	38	
250	220S	LD	150	95	t5x30	258	185	150	t4x40	315	60	

The power supply voltage is 690 VAC.

(Note 1) A "PVC (polyvinyl chloride) wire" and an "XLPE (cross-linked polyethylene) wire" were used at permissible temperatures of 70°C and 90°C, respectively, and the wire sizes were selected based on the permissible current under the following conditions. If the use conditions are different, select the wire sizes based on use conditions that comply with IEC 60364-5-52:2001(JIS C 60364-5-52:2006).
Ambient temperature: 40°C, Multicore cable: 3 cores (conductor: copper), A single cable: aerial wiring, Two or more cables: electric duct wiring

(Note 2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

(2) Ambient temperature: 40°C (domestic selection)

Nominal applied motor capacity [kW]	RHD□ -69D□	Specifi cations	Main input: L1/R, L2/S, L3/T				Output: P(+), N(-)				Ground- ing wire [mm²]	Control wire [mm²]
			Wire size (Permissible temperature) (Note 1)		Bus bar size [mm²]	Current [A]	Wire size (Permissible temperature) (Note 1)		Bus bar size [mm²]	Current [Adc]		
			75°C	90°C			75°C	90°C				
220	220S	MD	60	60	t5x30	226	100	60	t4x40	277	22	1.25
450	450S		200	150	t10x30	460	200	150	t8x50	561	60	
250	220S	LD	100	60	t5x30	258	100	100	t4x40	315	38	

The power supply voltage is 690 VAC.

(Note 1) PVC was used for permissible temperature of 70 °C, and XLPE for permissible temperature of 90 °C.

(Note 2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

6.3 High-efficiency power regeneration PWM converter

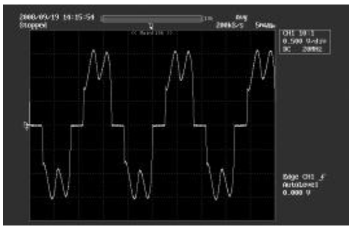
6.3.1 Features

■ **Compliant with the harmonic wave suppression guidelines**

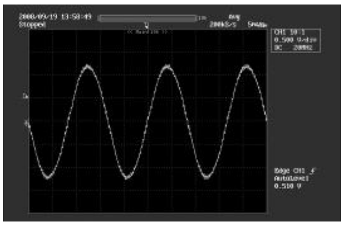
The current on the power supply side is converted into the sine waveform by the PWM control to greatly reduce the harmonic current. When this converter is combined with the inverter, the conversion coefficient Ki stated in "Japanese Guideline for Suppressing Harmonics by Customers Receiving High Voltage or Special High Voltage" issued by the Agency for Natural Resources and Energy of the Ministry of Economy, Trade, and Industry is handled as zero (0) (no harmonic is produced).

Comparison of input current waveforms

<Without PWM converter>



<With PWM converter>



■ **Power supply equipment capacity can be reduced.**

Since the current with the same phase as the power supply phase voltage is flowed by the power factor control, the operation with a power factor of almost "1" can be made.

Therefore, the power supply transformer capacity can be reduced or the unit can be made compact when compared to the standard type inverter.

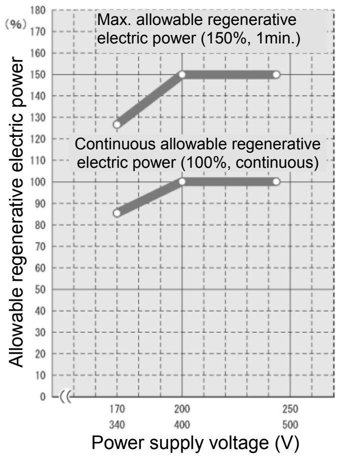
■ **Braking performance is improved significantly.**

All of the regenerative energy generated by highly frequent acceleration and deceleration operations or the lift are returned to the power supply side. This ensures the energy saving.

Additionally, as the current waveform of the regenerative energy also becomes the sine waveform, this does not cause any trouble in the power supply system. The following describes the regenerative performance.

Unit type	• Continuous regenerative rating	: 100%
	• Regenerative rating for 1 min.	: 150% (CT spec) : 120% (VT spec)
Stack type	• Continuous regenerative rating	: 100%
	• Regenerative rating for 1 min.	: 150% (MD spec) : 110% (LD spec)

Allowable regenerative electric power characteristics



■ **Protective and maintenance functions are enhanced.**

(1) Use of trace back (option) function makes it possible to easily analyze the cause of the alarm trip.

(2) The past alarm contents (memory for past ten alarms) can be checked using the segment LED.

(3) If a momentary power failure occurs, the gate is shut down and the operation is immediately restarted after the power has been recovered.

(4) A warning signal, such as overload, fin overheat, or service life is used to give an alarm before the converter is tripped.

■ **Network functions are enhanced**

This PWM converter can be connected to Fuji Electric’s network systems, such as SX bus, T-Link, CC-Link (optional). The RS-485 is provided as standard. (Unit type: RHC-C only)

■ **Applicable capacity are enhanced**

(1) Two models, unit type (RHC-C) and stack type (RHC-D), are available. An appropriate model for the system can be selected.

(2) Use of high-speed serial card (OPC-VG7-SI□) (optional) makes it possible to perform the parallel operation of the PWM converters. As the power supply transformer is used for the input power supply, up to six parallel operations can be performed.

- Transformer-less parallel system: 3-parallel operation (stack type 400 V) ⇒ MD spec: 2400 kW, LD spec: 3000 kW)
- Insulated parallel system with a transformer: 6-parallel operation (stack type 400 V) ⇒ MD spec: 4800 kW, LD spec: 6000 kW)

Note: Use of the transformer-less parallel system with the unit type (RHC-C) requires the product dedicated to transformer-less parallel systems (RHC□-4CR) as well as the optical link option card for parallel systems (OPC-VG7-SIR).

This section is focused on the RHC-D series (stack type) PWM converters.
For more information on the stack and unit types, refer to the separate volume instruction manual.

📖 For details on the unit type, refer to the RHC-C Instruction Manual (INR-HF51746c).
For details on the stack type, refer to the RHC-D Instruction Manual (INR-SI47-1722).

6.3.2 Standard specifications

The standard specifications described here include those for the RHC-C series (unit type) as well.

6.3.2.1 3-phase 400V series (RHC-C: unit type)

Item			Standard specifications																		
Model			RHC□-4C																		
			30	37	45	55	75	90	110	132	160	200	220	280	315	355	400	500	630		
CT mode	Applicable inverter capacity (kW)		30	37	45	55	75	90	110	132	160	200	220	280	315	355	400	500	630		
	Output	Continuous capacity (kW)	36	44	53	65	88	103	126	150	182	227	247	314	353	400	448	560	705		
		Overload rating	150% of the continuous rating for 1 minute																		
		Voltage	640 to 710 VDC (variable according to input power voltage) *1																		
	Required power supply capacity (kVA)		38	47	57	70	93	111	136	161	196	244	267	341	383	433	488	610	762		
	Carrier frequency *2		Standard 15 kHz				Standard 10 kHz											Standard 6 kHz			
VT mode	Applicable inverter capacity (kW)		37	45	55	75	90	110	132	160	200	220	280	315	355	400	500				
	Output	Continuous capacity (kW)	44	53	65	88	103	126	150	182	227	247	314	353	400	448	560				
		Overload rating	120% of the continuous rating for 1 minute																		
		Voltage	640 to 710 VDC (variable according to input power voltage) *1																		
	Required power supply capacity (kVA)		47	57	70	93	111	136	161	196	244	267	341	383	433	488	610				
	Carrier frequency *2		Standard 10 kHz				Standard 6 kHz														
Input power	Number of phases, voltage, and frequency		3-phase, 380 to 440 V/50 Hz, 380 to 460 V/60 Hz *3																		
	Allowable voltage and frequency fluctuation		Voltage: -15 to +10%, Frequency; ±5%, Voltage unbalance ratio; 2% or less *4																		

*1 When the power supply voltage is 400 V, 440 V, and 460 V, the output voltage is approx. 640 VDC, 686 VDC and 710 VDC, respectively.

*2 When the OPC-VG7-SIR is installed (to provide a transformer-less parallel system), the carrier frequency is automatically set to 5kHz.

*3 When the power supply voltage is 380 to 398 V/50 Hz or 380 to 430 V/60 Hz, the tap switching inside the PWM converter is required.
When the power supply voltage is less than 400 V, the capacity needs to be reduced.

*4 Inter-phase unbalance rate [%] = (Max. voltage [V] - Min. voltage [V])/3-phase average voltage x 67

6.3.2.2 3-phase 400V/690V series (RHC-D: stack type)

Item			Standard specifications																	
Model			RHC☐S-4D☐						RHC☐B-4D☐ *1			RHC☐S-69D☐								
			132	160	200	220	280	315	630	710	800	132	160	200	250	280	315	355	400	450
MD mode	Applicable inverter capacity (kW)		132	160	200	220	280	315	630	710	800	132	160	200	250	280	315	355	400	450
MD mode	Output	Continuous capacity (kW)	150	182	227	247	314	353	705	795	896	150	182	227	280	314	353	400	448	504
MD mode	Output	Overload rating	150% of the continuous rating for 1 minute																	
MD mode	Output	Voltage	640 to 710 VDC (variable according to input power voltage) *2									895 to 1073 VDC (variable according to input power voltage) *3								
MD mode	Required power supply capacity (kVA)		161	196	244	267	341	383	762	858	967	161	196	244	304	341	383	433	488	549
MD mode	Carrier frequency *3		5kHz						5kHz			5kHz								
LD mode	Applicable inverter capacity (kW)		160	200	220	—	315	355	710	800	1000	132	160	200	250	280	315	355	400	
LD mode	Output	Continuous capacity (kW)	182	227	247	—	353	400	795	896	1120	160	200	220	280	315	355	400	450	
LD mode	Output	Overload rating	110% of the continuous rating for 1 minute																	
LD mode	Output	Voltage	640 to 710 VDC (variable according to input power voltage) *2									895 to 1073 VDC (variable according to input power voltage) *3								
LD mode	Required power supply capacity (kVA)		196	244	267	—	383	433	858	967	1210	196	245	267	341	383	433	488	549	
LD mode	Carrier frequency *3		5kHz						5kHz			5kHz								
Input power	Number of phases, voltage, and frequency		3-phase, 380 to 440 V/50 Hz, 380 to 460 V/60 Hz *5											3-phase, 3-wire type, 660 to 690 V, 50Hz/60Hz 3-phase, 3-wire type, 575 to 600 V, 50Hz/60Hz *6								
Input power	Allowable voltage and frequency fluctuation		Voltage: -15 to +10%, Frequency; ±5%, Voltage unbalance ratio; 2% or less *7											Voltage: -15 to +10%, Frequency; ±5%, Voltage unbalance ratio; 2% or less *7								

*1 The RHC☐B-4D consists of three stacks per set.

*2 When the power supply voltage is 400 V, 440 V, and 460 V, the output voltage is approx. 640 VDC, 686 VDC and 710 VDC, respectively.

*3 The output voltage is 895 VDC when the power supply voltage is 575 V, and 1073 VDC when the power supply voltage is 690 V.

*4 When the OPC-VG7-SIR is installed (to provide a transformer-less parallel system), the carrier frequency is automatically set to 2.5 kHz.

*5 When the power supply voltage is 380 to 398 V/50 Hz or 380 to 430 V/60 Hz, the tap switching inside the PWM converter is required.
When the power supply voltage is less than 400 V, the capacity needs to be reduced.

*6 The tap inside the converter must be switched when the power supply voltage is 575 to 600 V / 50Hz or 575 to 600 V / 60Hz.
The capacity must be reduced when the power supply voltage is less than 690 V.

*7 Inter-phase unbalance rate [%] = (Max. voltage [V] - Min. voltage [V])/3-phase average voltage x 67

6.3.3 Common specifications

Item		Specifications
Control	Control method	AVR constant control with DC ACR minor
	Start/stop operation	Starts the rectification when the power is turned ON after connection. Starts boosting when it receives the run signal (RUN-CM short-circuit or run command from the communication). After that, the converter is ready to run.
	Running status signal	Running, power running, regenerative operation, ready-to-run, alarm output (for any alarm), etc.
	Overload rating switching	Unit type CT spec: 150% of overload rating for 1 min. VT spec: 120% of overload rating for 1 min. Either rating is selected. (CT spec is fixed when the capacity is 500 kW or more.) Stack type MD spec: 150% of overload rating for 1 min., LD spec: 110% of overload rating for 1 min. Either rating is selected.
	Carrier frequency	Unit type: 5 kHz to 15 kHz (The setting range may vary depending on the capacity.) Stack type: Fixed at 5 kHz *1
	Input power factor	0.99 or more (at full load) *2
	Input harmonic current	Conversion coefficient Ki can be set to zero (0) according to the harmonics suppressing guideline by METI.
	Restart after momentary power failure	Shuts down the gate when the voltage level reaches the under-voltage level if a momentary power failure occurs, and the PWM converter is automatically restarted after the power recovers.
	Power limiting control	Controls the power to the preset limit value or less.
Display	Alarm display (protective functions)	Refer to "Table 6.3.10-1 List of alarm displays and protective operations".
	Alarm history	Saves and displays the alarm history data for past ten alarms. Saves and displays the detailed contents of the trip cause for past one alarm.
	Monitor	Displays the input power, input current in RMS, input voltage in RMS, DC intermediate current, and power supply frequency.
	Load factor	Allows the user to measure the load factor with the keypad.
	Display language	Allows the user to specify or refer to function codes in any of the three languages: Japanese, English, and Chinese.
	Charging lamp	Lights up when the main circuit capacitor is charged. For the stack type, it lights up when only the auxiliary control power input is active.
Structure/environment		🕮 Unit type: Refer to the RHC-C Instruction Manual (INR-HF51746c). 🕮 Stack type: Refer to "2.2.1 Installation environment and conformity with standards" in Chapter 2.

*1 When the OPC-VG7-SIR is installed (to provide a transformer-less parallel system), the carrier frequency is automatically set to 2.5 kHz.

*2 When the power supply voltage is 420 V (400V series) or higher, or 630 V or higher (690V series), and the operating load is 50% or higher, the power factor for the power supply drops to approx. 0.95 (only during regenerative operation).

6.3.4 Control options

Control options shown below can be used for the PWM converter.

Category	Model	Name	Specifications
Analog card	OPC-VG7-AIO	Aio extension card	Extension card for analog signal output x 2 points
Digital card (Applicable to 8-bit bus.)	OPC-VG7-DIO	Dio extension card	Extension card for digital output (Y terminal) x 8 points This card is used when DIOA is set.
	OPC-VG7-TL	T link interface card	For Fuji Electric’s private link: T-Link communication
	OPC-VG7-CCL	CC-Link interface card	For CC-Link communication
	OPC-VG7-SI	Optical link card for parallel system	For converter parallel operation (for insulated parallel system with a transformer)
	OPC-VG7-SIR	Optical link card for parallel system	For converter parallel operation (for transformer-less parallel system) The special version (RHC□-4CR) is required when this system is applied to the unit type (RHC-C). (The stack type can be used with the standard type.)
Digital card (Applicable to 16-bit bus.)	OPC-VG7-SX	SX bus interface card	SX bus interface card

Allowable option combinations

Category	Max. number of mountable cards				Remarks
	Example 1	Example 2	Example 3	Example 4	
Analog card	1	1	0	0	Analog (1 card) + digital (1 card) or digital (2 cards) (It is impossible to mount the TL and CCL at the same time.)
Digital card (Applicable to 8-bit bus.)	1	—	2	2	
Digital card (Applicable to 16-bit bus.)	—	1	0	1	It is possible to mount this card and the TL or SI□ at the same time. It is impossible to mount this card and the CCL at the same time.

Note Take great care since there are restrictions on mounting of option card.

For more information, refer to the RHC-C instruction manual (INR-HF51746c) and the RHC-D Instruction Manual (INR-SI47-1722).

	AIO	TR	DIO	TL	CCL	SI	SIR	SX	PDP
AIO	NG								
TR	OK	NG							
DIO	OK	OK	NG						
TL	OK	OK	OK	NG					
CCL	OK	OK	OK	NG	NG				
SI	OK	OK	OK	OK	OK	NG	NG		
SIR	OK	OK	OK	OK	OK	NG	NG		
SX	OK	OK	OK	OK	NG	OK	OK	NG	
PDP	OK	OK	OK	NG	NG	OK	OK	NG	NG

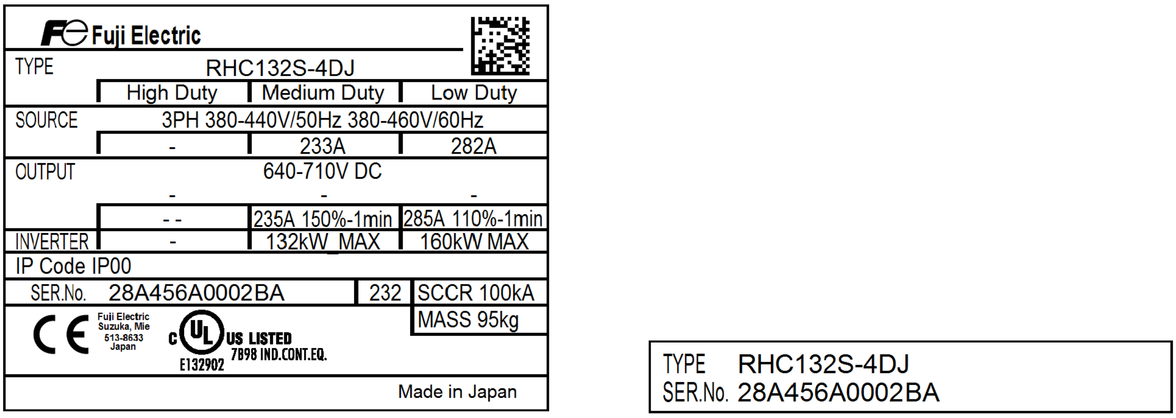
6.3.5 Check before use

Unpack the package and check the following:

Check that you have properly received the product main unit and the following accessories.

Accessories   Instruction manual

The inverter has not been damaged during transportation—there should be no dents or parts missing. The main and sub nameplates are attached to the main unit. The main nameplate is located on the front face of the main unit (as shown in Figure 6.3.6-2 and Figure 6.3.6-3). Check these main nameplates to see that the inverter is exactly the type you ordered.



(a) Main Nameplate   (b) Sub Nameplate

Figure 6.3.5-1: Nameplate

TYPE: PWM converter (RHC-D)

RHC 160 S - 4 D□

Indication	Series name
RHC	PWM converter

Indication	Standard applicable rated capacity
132	132kW
≀	≀
800	800kW

Indication	Inverter structure
S	Standard stack type
B	Phase-specific stack type

Indication	Shipping destination/Instruction Manual
J	Japanese
E	English
C	Chinese

Indication	Development series
D	D series

Indication	Voltage class
4	400 V class series
69	690 V class series

The PWM converter (RHC-D) is available in two drive modes depending upon the applied load: Medium Duty (MD) spec and Low Duty (LD) spec modes.
Specifications in each spec are printed on the nameplate.

Medium Duty : MD spec: designed for medium duty overload applications. Overload current rating: 150% for 1 min., Continuous rating capacity = Capacity of inverters
Low Duty : LD spec mode: designed for light duty overload applications. Overload current rating: 110% for 1 min., Continuous rating capacity = One rank or two ranks higher capacity of inverters
SOURCE : Power supply rating (MD spec, LD spec)
OUTPUT : Output rating (MD spec, LD spec)
IP Code : IP protection grade
SCCR : Short-circuit capacity
MASS : Mass
SER.No. : Production number   2 8 A456A0002BA

Production year (Last digit of the year) — 2
Production month — 8   1 to 9: January to September; X, Y, or Z: October, November, or December
Serial number of production lot — A456A0002BA

If you suspect the product is not working properly or if you have any questions about your product, contact your Fuji Electric representative.

📖 Refer to Chapter 3 "Transportation and Storage of Stack" for information on transportation and long-term storage of PWM converters.

📖 Refer to Chapter 4 "Installation and Wiring" for information on installation of PWM converters.
For information on the main circuit wire sizes, refer to "6.3.15.2 Wire size".

6.3.6 External views

6.3.6.1 Warning label and falling warning label

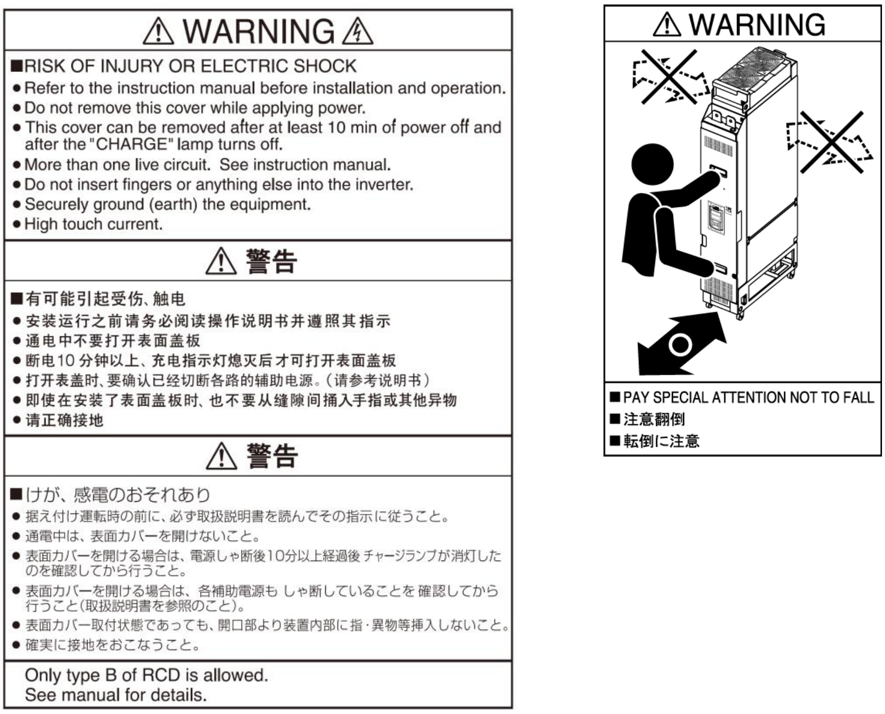


Figure 6.3.6-1: Warning label and falling warning label

6.3.6.2 Appearance

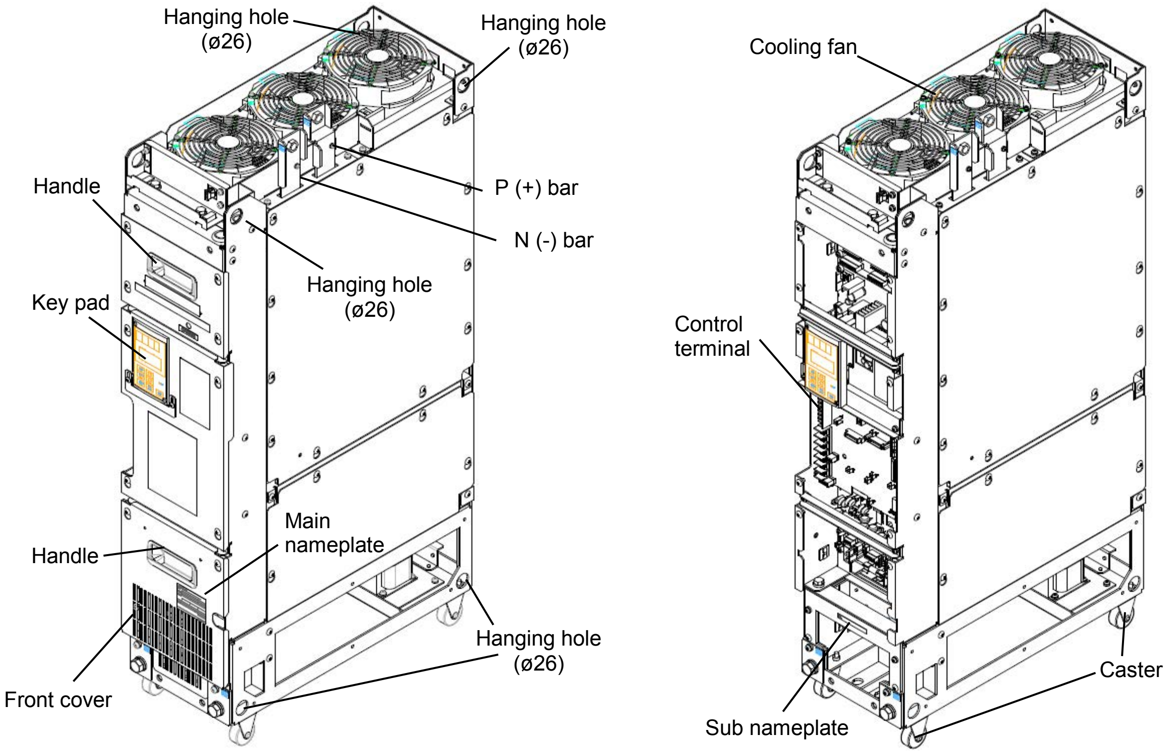


Figure 6.3.6-2: Frame 3 size (RHC132S to RHC200S-4D☐)

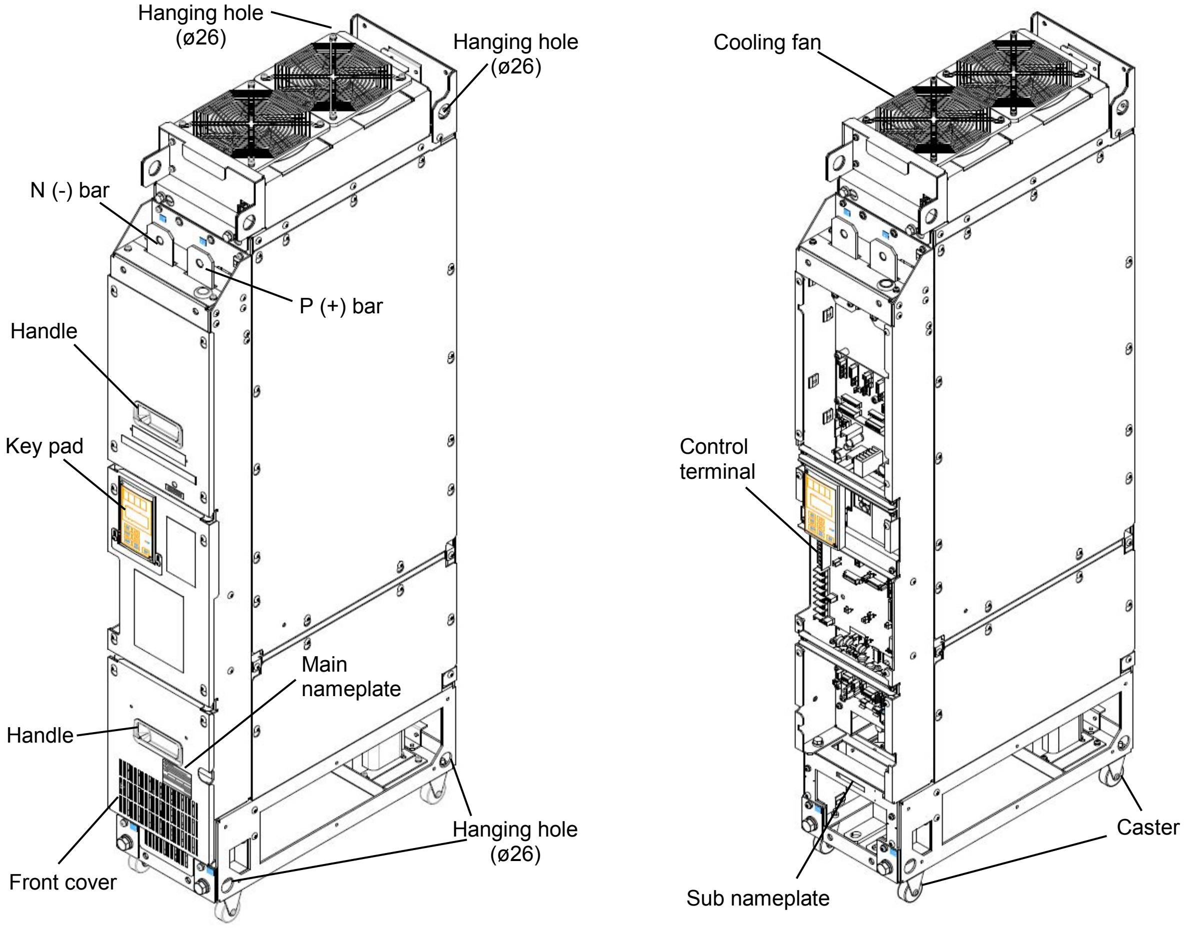


Figure 6.3.6-3: Frame 4 size (RHC220S to RHC315S-4D☐)

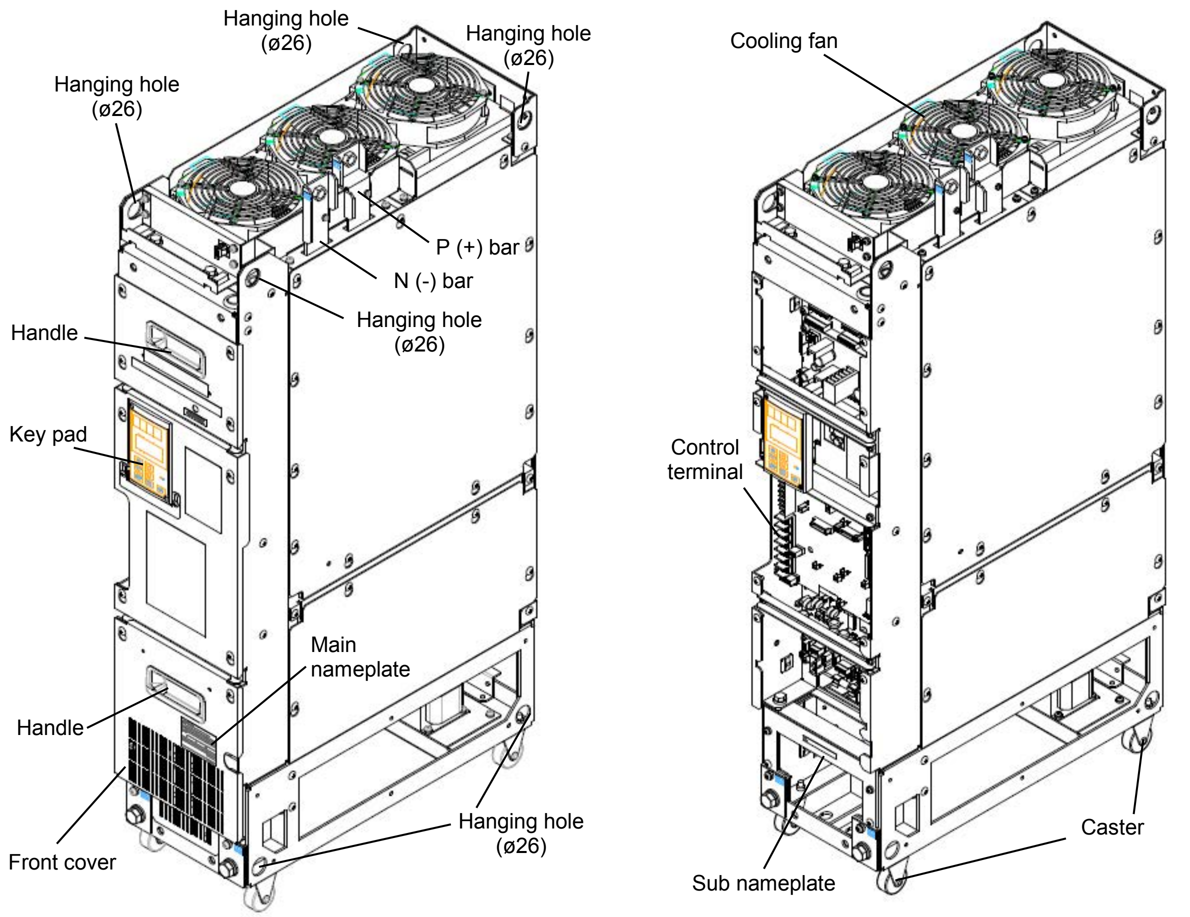


Figure 6.3.6-4: Frame 3 size (RHC132S to RHC200S-69D☐)

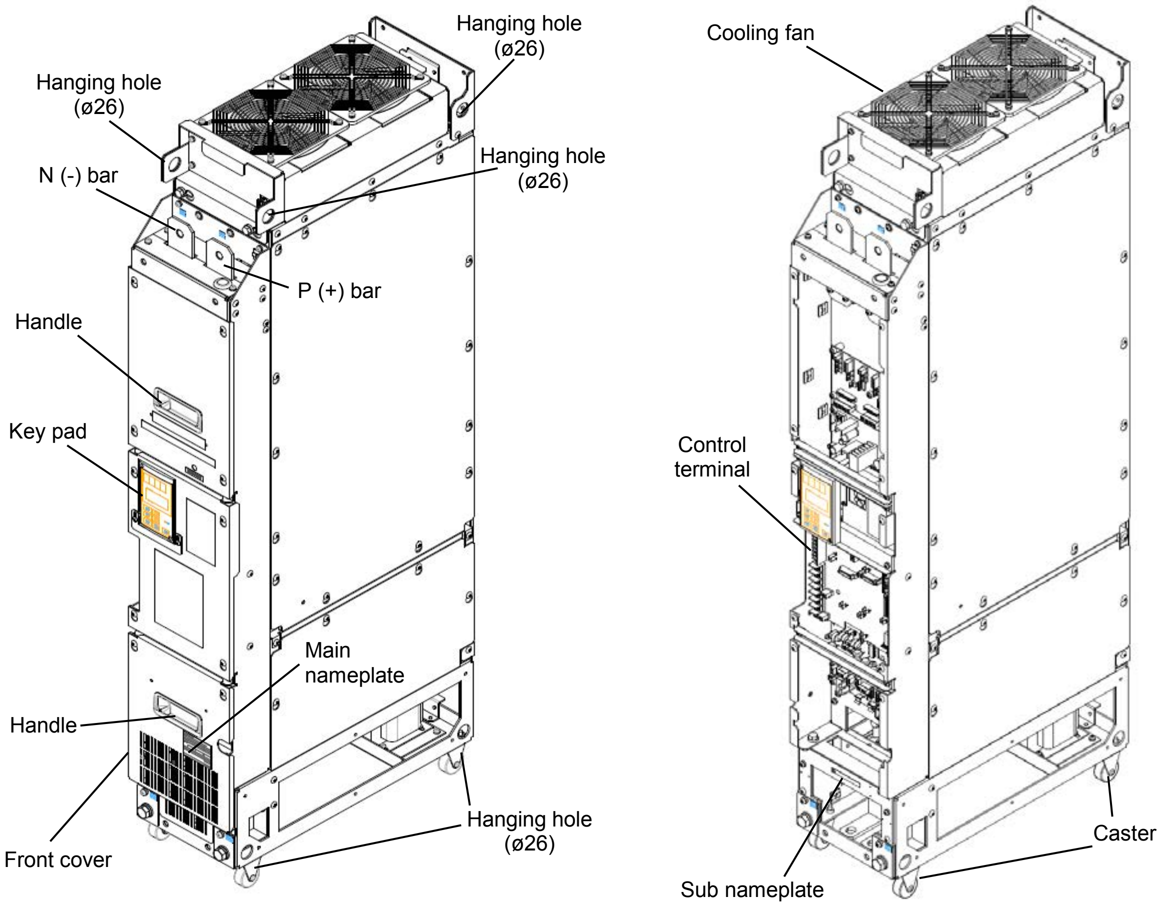
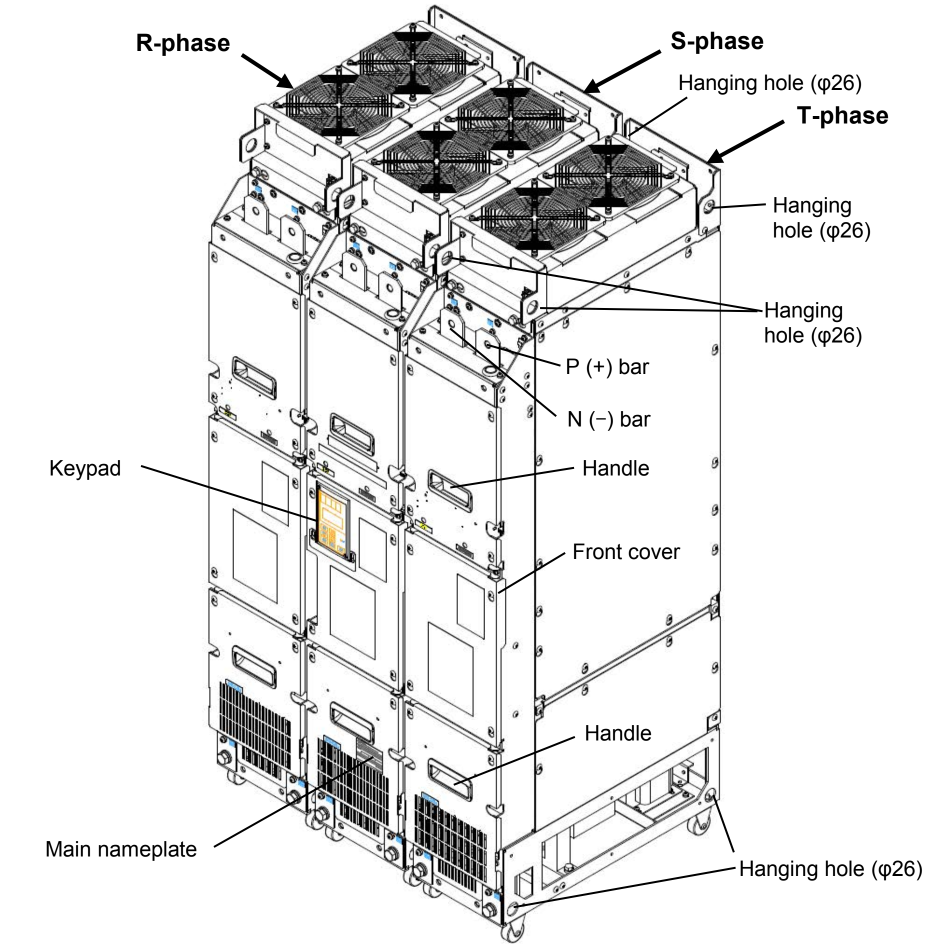


Figure 6.3.6-5: Frame 4 size (RHC250S to RHC450S-69D☐)

For phase-specific stacks, the keypad can be installed to the S-phase stack only.



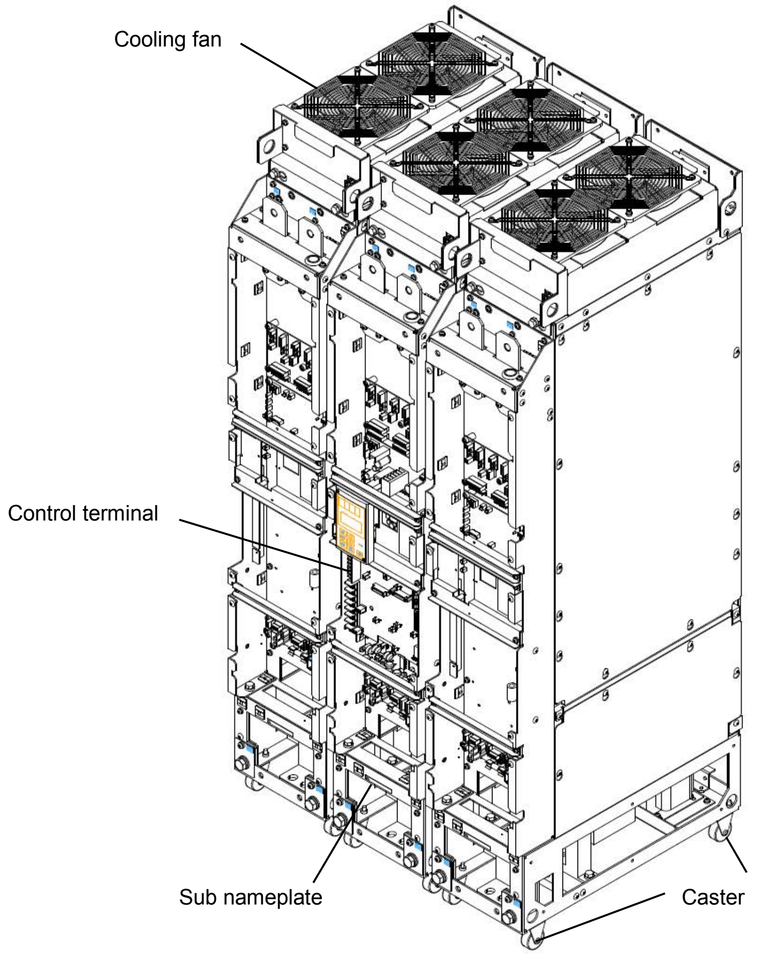
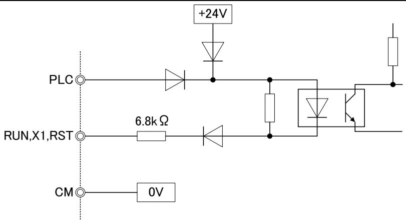


Figure 6.3.6-6: Frame 4 size (RHC630B to RHC800B-4D☐)

6.3.7 Terminal functions

Category	Terminal symbol	Terminal name	Specifications
Main circuit	L1/R, L2/S, L3/T	Main power input	Connect to 3-phase power supply via dedicated reactor, etc.
	P(+), N(-)	Converter output	Connect to inverter power input terminals P(+) and N(-).
	E(G)	Earthing terminal	Grounding terminal for the chassis (case) of the PWM converter.
	R0, T0	Auxiliary control power input	Connect to the backup terminal of the power supply for the control power supply and the same power supply system as the main power input. For information on terminal ratings, refer to "4.5.3 (4) Auxiliary control power input and fan power input".
	R1, S1, T1	For voltage detection Synchronous power supply input	Voltage detection terminals used to control the inside of the PWM converter. These terminals are connected to the power supply sides of the dedicated filter.
	R2, T2	Control monitor input	(400V series) Connection terminal for AC fuse disconnection detection. No connection is required when the filter stack (RHF-D) is used. (690V series) There are no R2 or T2 terminals.
	R3,T3	Fan power input	(400V series) Connection terminals for the AC cooling fan inside the stack. Connect these terminals to the same power supply system as the main power input. Jumper wires are connected between R1 and R3 and between T1 and T3 when the product is shipped from the factory. Remove the jumper wires and wire these terminals independently when the fan power supply is used individually. For information on how to connect the terminals, refer to the PWM converter (RHC-D) instruction manual. For information on terminal ratings, refer to "6.3.15.1-(5) Auxiliary control power input (R0, T0) and fan power input (CNV: R3, T3 INV: R1, T1)". (690V series) There are no R3 or T3 short-circuit wires. If using a separate fan power supply, switch the tap inside the converter, and connect the fan power supply to the R3 and T3 terminals. Refer to the PWM converter (RHC-D) instruction manual for information on the connection method.

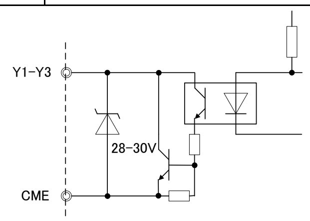
Category	Terminal symbol	Terminal name	Specifications
Input signals	[RUN]	Start/stop command	When the portion between the RUN and CM is turned ON, the converter performs boosting. The converter stops when this portion is turned OFF.
	[RST]	Alarm reset command	If an alarm stop occurs, remove the cause of the alarm. When the portion between the RST and CM is turned ON, the protective function in operation is cancelled to restore the operation.
	[X1]	Digital input	The following function can be assigned to terminal X1. 0: External alarm [THR], 1: Current limit cancellation [LMT-CCL], 2: 73 answer back [73ANS], 3: Current limit switching [I-LIM], 4: Option DI [OPT-DI]
	[CM]	Digital input common	Common terminal for the digital input signals
	[PLC]	PLC signal power	Connect the PLC output signal power supply. (Rated voltage 24 V (22 to 27 V) DC)



Item		min.	typ.	max.
Operating voltage	ON level	0 V	—	2 V
	OFF level	22 V	22 V	27 V
Operating current in the ON state		—	3.2 mA	4.5 mA
Allowable leak current in the OFF state		—	—	0.5 mA

Category	Terminal symbol	Terminal name	Specifications
Input signals	[DCF1] [DCF2]	Input for DC fuse disconnection detection	This terminal is intended to connect the microswitch for DC fuse blow detection in the case the converter output is protected with a DC fuse. It supports the b-contact output. 24 VDC 12 mA Typ

Category	Terminal symbol	Terminal name	Specifications
Output signals	[AO1]	Analog output	This terminal can be configured to output the signal selected from the following. 0: Input power [PWR], 1: Input current in RMS [I-AC], 2: Input voltage in RMS [V-AC], 3: DC intermediate voltage [V-DC], 4: Power supply frequency [FREQ], 5: +10 V test [P10], 6: -10 V test [N10] Specifications: 0 to ±10 VDC, connectable impedance: Min. 3 kΩ When the OPC-VG7-AIO option is used, up to two AO extension functions (A04, A05) can be added. * Ai functions cannot be used.
	[M]	Analog output common	
	[Y1] [Y2] [Y3]	Transistor output	This terminal can be configured to output the signal selected from the following. 0: Running [RUN], 1: Ready-to-run [RDY], 2: Power supply current limiting [IL], 3: Service life warning [LIFE], 4: Cooling fin overheat warning [PRE-OH], 5: Overload warning [PRE-OL], 6: Driving [DRV], 7: Regenerative operation running [REG], 8: Current limit warning [CUR], 9: Momentary stop restarting [U-RES], 10: Power supply frequency synchronizing [SY-HZ], 11: Alarm contents 1 [AL1], 12: Alarm contents 2 [AL2], 13: Alarm contents 4 [AL4], 14: Option DO [OPT-DO] When the OPC-VG7-DIO option is used, up to eight DO outputs (Y11 to Y18) can be added. * Di functions cannot be used.
	[CME]	Transistor output common	Common terminal for the transistor output signals. Electrically isolated from terminal CM.



Item		min.	typ.	max.
Operating voltage	ON level	—	1 V	2 V
	OFF level	—	24 V	27 V
Operating current in the ON state		—	—	50 mA
Allowable leak current in the OFF state		—	—	0.1 mA

Note (1) When connecting a relay, connect a surge-absorbing diode to both ends of the exciting coil.

(2) For PWM converters, it is not possible to drive a relay by use of terminal PLC although that is possible with the FRENIC-VG.

Category	Terminal symbol	Terminal name	Specifications
Output signals	[30A] [30B] [30C]	Alarm output (for any alarm)	Outputs the signal if the converter protective function operates to activate the alarm stop. (Contact: 1C, In the case of an error, portion between 30A and 30C: ON) (Contact capacity: 250 VAC, 0.3 A cos φ = 0.3)
	[Y5A] [Y5C]	Relay output	Signals that can be selected with these terminals are similar to those with Y1 to Y3 terminals. (Contact capacity: 250 VAC, 0.3 A cos φ = 0.3)
	[73A] [73C]	Charging circuit control output	Control output for external charging circuits. These terminals can be used to output operation signals for the electromagnetic contactor for charging circuit. (Contact capacity: 250 VAC, 5 A Max.)

Note

- The contact outputs (terminals Y5A/C, 30A/B/C, 73A/C) are mechanical contacts. Frequent ON/OFF operations cannot be permitted. Signals turned ON/OFF at high frequency at terminal Y5A/C should be output from terminals Y1 to Y3.

  Furthermore, even if using an AC power supply, the contact life may be shorter with loads for which the contact current direction is fixed (loads with half-wave rectifier circuit, etc., e.g., timers, power supply devices for motor electromagnetic brakes).

  In cases such as this, instead of connecting the load directly to the contact output terminals, connect a control relay, etc. (separately installed) which satisfies load conditions to the contact output terminals, and then connect to the load via this relay.

6.3.8 Communication specifications

Item		Specifications
General communication specifications		Run information, running status, function code monitor function (polling), RUN, RST, and X1 can be controlled (selected). (* Function codes other than "S" codes cannot be written.)
Network (option)	T link	Option to be used: OPC-VG7-TL Performs the T link communication with the T link module of the MICREX-F or MICREX-SX.
	SX bus	Option to be used: OPC-VG7-SX Performs the SX bus connection with the MICREX-SX.
	CC-Link	Option to be used: OPC-VG7-CCL Performs the connection with the CC link master unit.
Optical communication * (option)		Option to be used: OPC-VG7-SI, OPC-VG7-SIR Use of this option makes it possible to perform the load allocation control of the parallel multiplex system.

6.3.9 Basic connection diagrams

6.3.9.1 List of basic connection diagrams

How to wire the filter circuits and sequence units differs depending on the inverter used in conjunction with the PWM converter capacity. From Table 6.3.9-1, select the appropriate basic connection diagram.

Table 6.3.9-1: List of basic connection diagrams for PWM converters (RHC-D series)

Basic connection diagrams	Filter circuit	PWM converter *2		Inverter	Recommended *3
		Specifi-cations	Model		
1	Configuration of peripherals *1	MD	RHC132S-4D☐ to RHC220S-4D☐	Stack type	
		LD	RHC132S-4D☐ to RHC200S-4D☐		
2	Configuration of peripherals *1	MD	RHC280S-4D☐ to RHC315S-4D☐	Stack type	
		LD	RHC280S-4D☐ to RHC315S-4D☐		
3	Configuration of peripherals *1	MD	RHC630B-4D☐ to RHC800B-4D☐	Stack type	○
		LD	RHC630B-4D☐ to RHC800B-4D☐		
4	Filter stack (RHF-D series) RHF160S-4D☐ to RHF355S-4D☐	MD	RHC132S-4D☐ to RHC315S-4D☐	Stack type	○
		LD	RHC132S-4D☐ to RHC315S-4D☐		
	RHF160S-69D☐ to RHF450S-69D☐	MD	RHC132S-69D☐ to RHC450S-69D☐		
		LD	RHC132S-69D☐ to RHC400S-69D☐		

*1 The peripherals are those shown in "6.3.12.2 List of peripherals with no filter stack used".

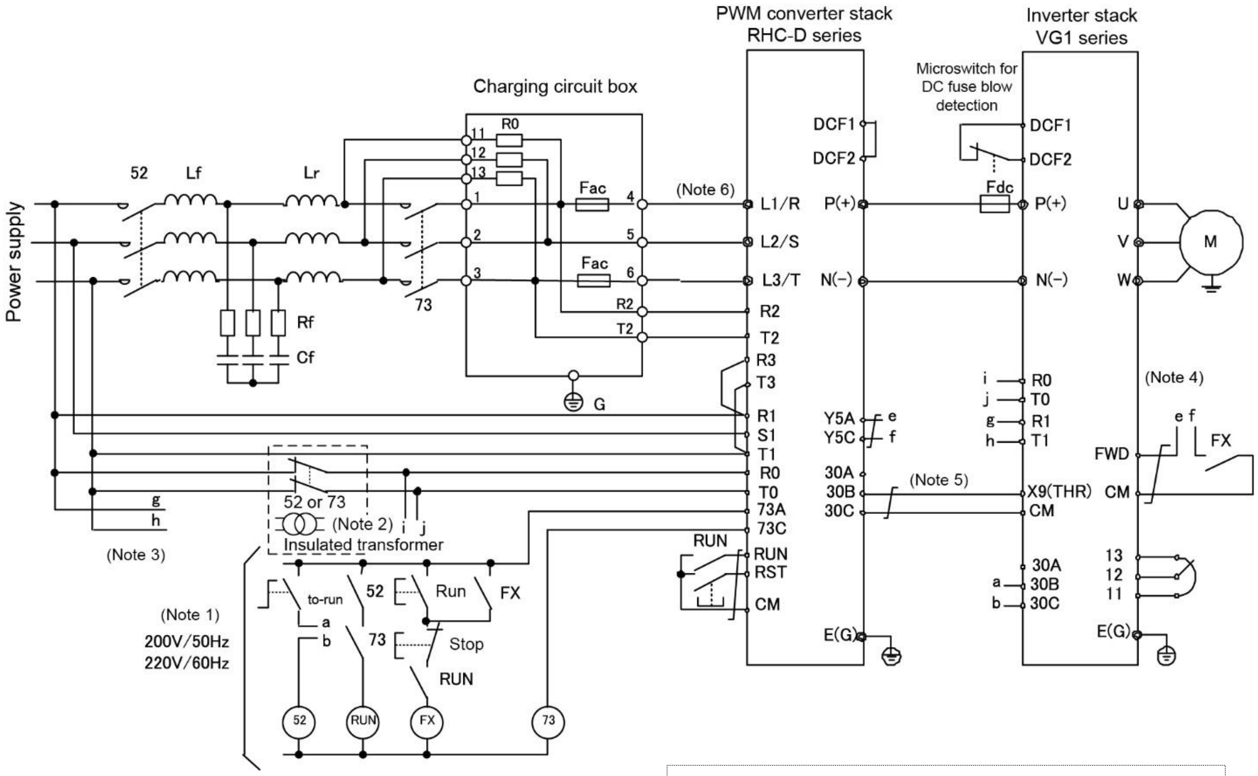
*2 A single unit of PWM converter is used.

*3 This means recommended basic connections.
RHC630B-4D☐ to RHC800B-4D☐
Configuration with peripherals is recommended.
RHC132S-4D☐ to RHC315S-4D☐
RHC132S-69D☐ to RHC450S-69D☐
Use of filter stack is recommended. When using a single PWM converter or using an insulated parallel system with a transformer (where multiple PWM converters are run in parallel), the filter circuit can be configured with peripherals. This is not possible, however, when using a transformer-less parallel system (where multiple PWM converters are run in parallel). Use a filter stack when using a transformer-less parallel system.

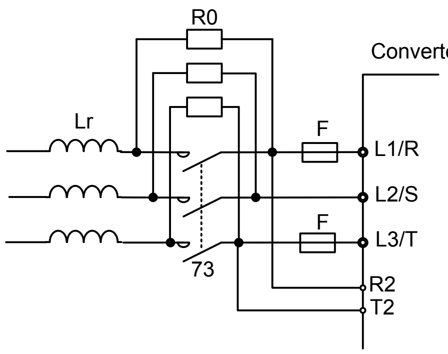
6.3.9.2 Basic connection diagram 1

■ **RHC132S-4D☐ to RHC220S-4D☐ (MD spec)**

■ **RHC132S-4D☐ to RHC200S-4D☐ (LD spec)**



When the charging circuit box is not used.



Symbol	Equipment name
Lr	Pressurizing reactor
Lf	Reactor for filter
Cf	Capacitor for filter
Rf	Resistor for filter
R0	Charging resistor
Fac	AC fuse
Fdc	DC fuse
73	Electromagnetic contactor for charging circuit
52	Electromagnetic contactor for power supply

(Note 1) Connect a step-down transformer to ensure that the sequence circuit voltages are exactly the same as shown in the connection diagram.

(Note 2) Be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the charging circuit electromagnetic contactor (73) or power supply electromagnetic contactor (52). When using the product with a non-grounded power supply, it is necessary to add an insulated transformer. For more information, refer to "6.3.15-(5)" in Chapter 6.

(Note 3) Be sure to connect the power supply for the inverter's AC fan to the main power directly (not via contact b of #73 or #52) so that the power can be fed through terminals R1 and T1.

(Note 4) Create a sequence in which the PWM converter gets ready for operation before the run signal is input to the inverter.

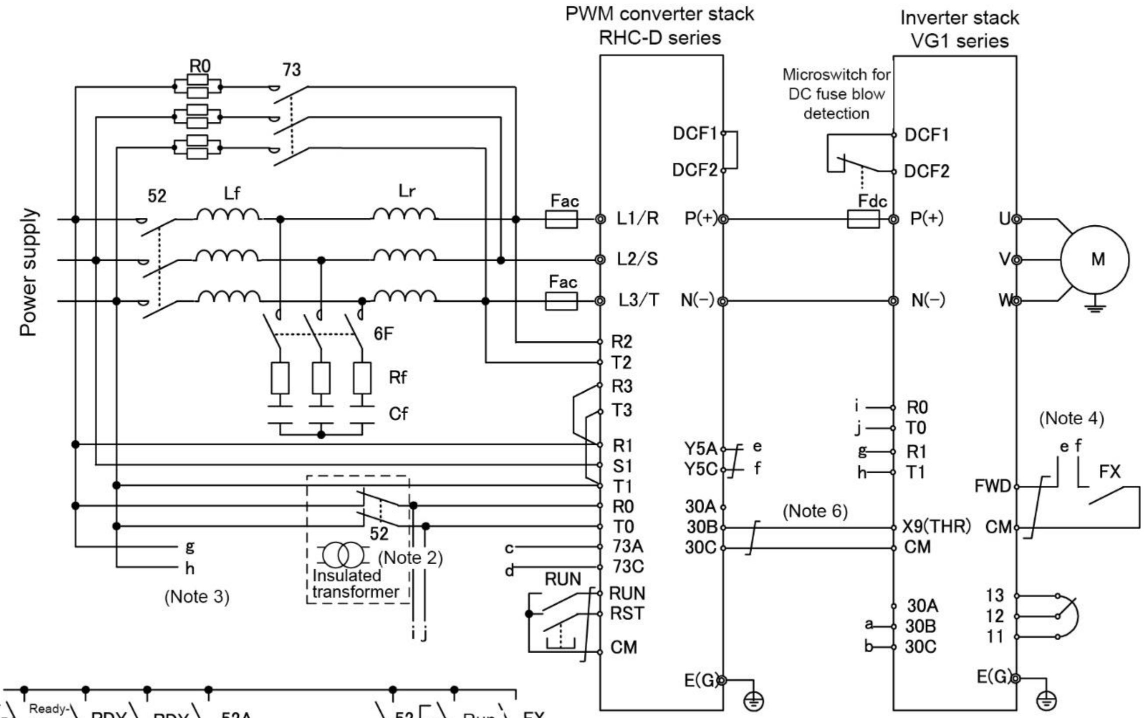
(Note 5) Configure one of the inverter's terminals X1 to X9 for use by the external alarm (THR).

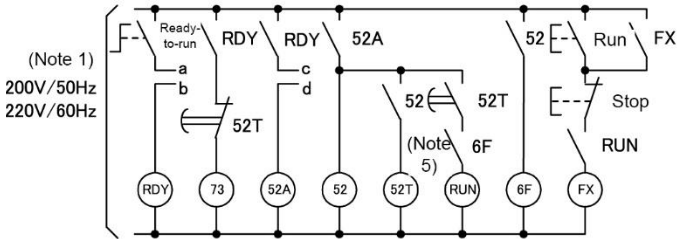
(Note 6) Ensure correct phase sequence when connecting wires to terminals L1/R, L2/S, L3/T, R2, T2, R1, S1, and T1.

6.3.9.3 Basic connection diagram 2

■ **RHC280S-4D☐ to RHC315S-4D☐ (MD spec)**

■ **RHC280S-4D☐ to RHC315S-4D☐ (LD spec)**





Symbol	Equipment name
Lr	Pressurizing reactor
Lf	Reactor for filter
Cf	Capacitor for filter
Rf	Resistor for filter
R0	Charging resistor
Fac	AC fuse
Fdc	DC fuse
73	Electromagnetic contactor for charging circuit
52	Electromagnetic contactor for power supply
6F	Filter circuit electromagnetic contactor

(Note 1) Connect a step-down transformer to ensure that the sequence circuit voltages are exactly the same as shown in the connection diagram.

(Note 2) Be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the power supply electromagnetic contactor (52). When using the product with a non-grounded power supply, it is necessary to add an insulated transformer. For more information, refer to "6.3.15-(5)" in Chapter 6.

(Note 3) Be sure to connect the power supply for the inverter's AC fan to the main power directly (not via contact b of #52) so that the power can be fed through terminals R1 and T1.

(Note 4) Create a sequence in which the PWM converter gets ready for operation before the run signal is input to the inverter.

(Note 5) Set the timer for 52T to 1 second.

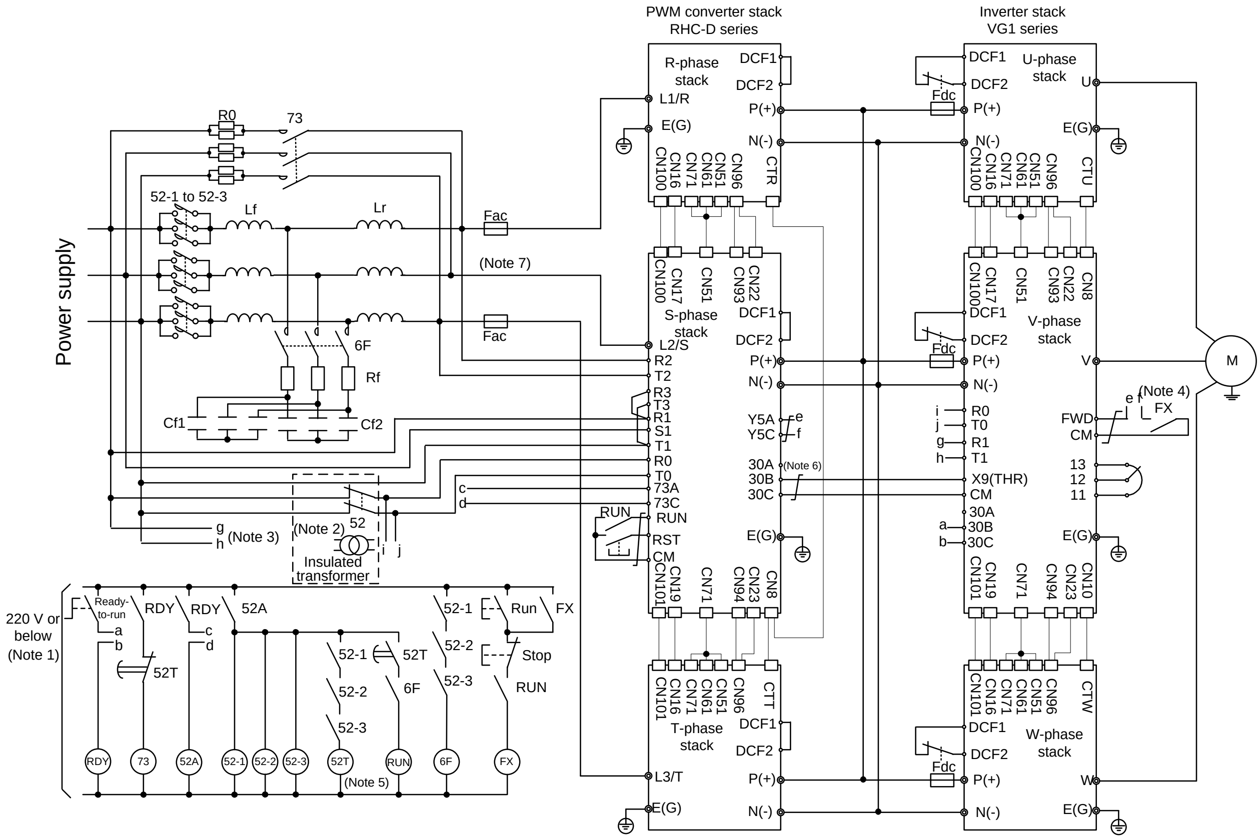
(Note 6) Configure one of the inverter's terminals X1 to X9 for use by the external alarm (THR).

(Note 7) Ensure correct phase sequence when connecting wires to terminals L1/R, L2/S, L3/T, R2, T2, R1, S1, and T1.

6.3.9.4 Basic connection diagram 3

■ **RHC630B-4D☐ to RHC800B-4D☐ (MD spec)**

■ **RHC630B-4D☐ to RHC800B-4D☐ (LD spec)**



Symbol	Equipment name
Lr	Pressurizing reactor
Lf	Reactor for filter
Cf	Capacitor for filter
Rf	Resistor for filter
R0	Charging resistor
Fac	AC fuse
Fdc	DC fuse
73	Electromagnetic contactor for charging circuit
52	Electromagnetic contactor for power supply
6F	Filter circuit electromagnetic contactor

(Note 1) Connect a step-down transformer to ensure that the sequence circuit voltages are exactly the same as shown in the connection diagram.

(Note 2) Be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the power supply electromagnetic contactor (52). When using the product with a non-grounded power supply, it is necessary to add an insulated transformer. For more information, refer to "6.3.15-(5)" in Chapter 6.

(Note 3) Be sure to connect the power supply for the inverter's AC fan to the main power directly (not via contact b of #52) so that the power can be fed through terminals R1 and T1.

(Note 4) Create a sequence in which the PWM converter gets ready for operation before the run signal is input to the inverter.

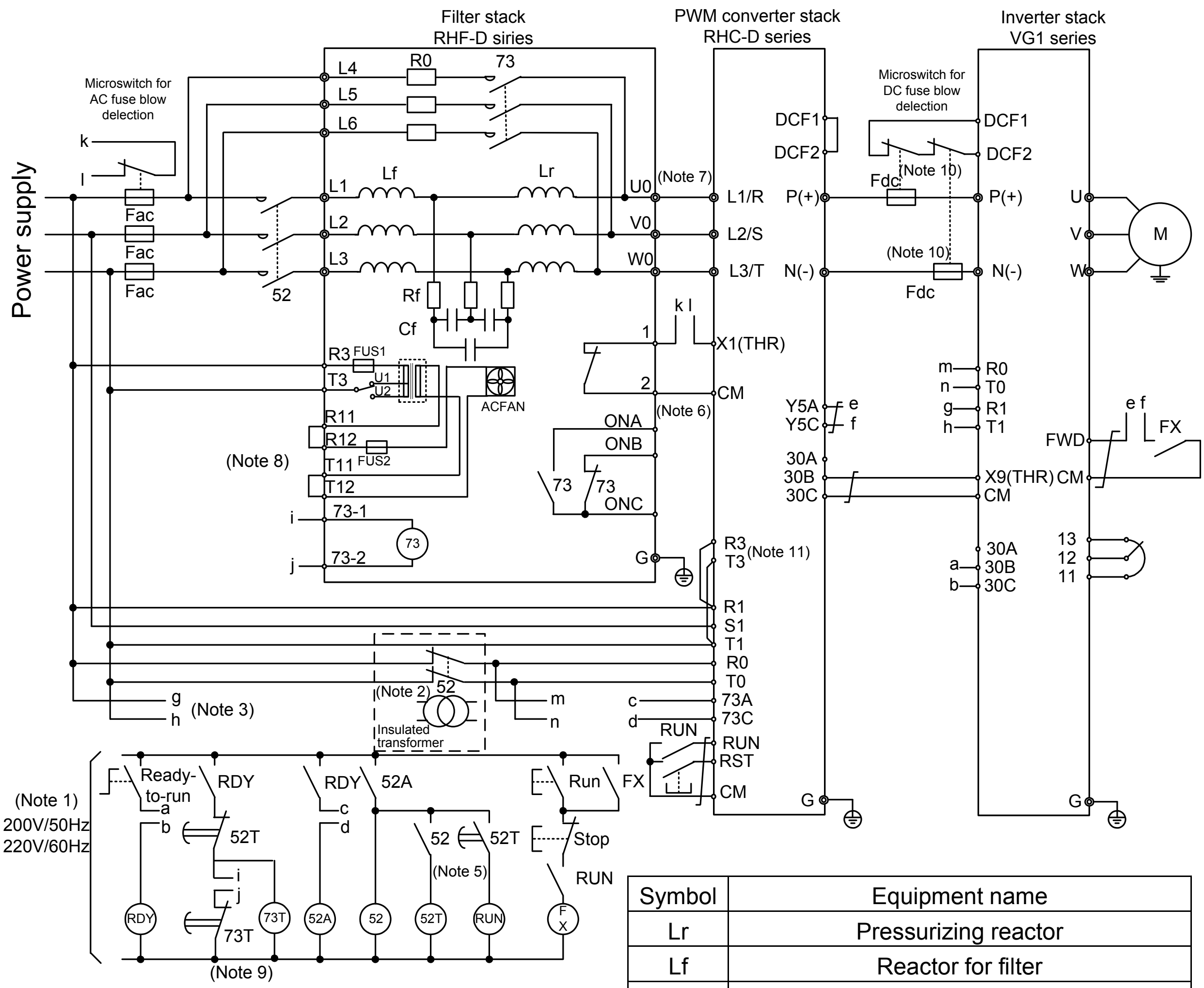
(Note 5) Set the timer for 52T to 1 second.

(Note 6) Configure one of the inverter's terminals X1 to X9 for use by the external alarm (THR).

(Note 7) Ensure correct phase sequence when connecting wires to terminals L1/R, L2/S, L3/T, R2, T2, R1, S1, and T1.

6.3.9.5 Basic connection diagram 4

- RHC132S-4D☐ to RHC315S-4D☐ (MD spec)
- RHC132S-4D☐ to RHC315S-4D☐ (LD spec)
- RHC132S-69D☐ to RHC450S-69D☐ (MD spec)
- RHC132S-69D☐ to RHC400S-69D☐ (LD spec)



Symbol	Equipment name
Lr	Pressurizing reactor
Lf	Reactor for filter
Cf	Capacitor for filter
Rf	Resistor for filter
R0	Charging resistor
Rf	Resistor for filter
Fac	AC fuse
Fdc	DC fuse
73	Electromagnetic contactor for charging circuit
52	Electromagnetic contactor for power supply

(Note 1) Connect a step-down transformer to ensure that the sequence circuit voltages are exactly the same as shown in the connection diagram.

(Note 2) Be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the power supply electromagnetic contactor (52). When using the product with a non-grounded power supply, it is necessary to add an insulated transformer. For more information, refer to "6.3.15-(5)" in Chapter 6.

(Note 3) Be sure to connect the power supply for the inverter's AC fan to the main power directly (not via contact b of #52) so that the power can be fed through terminals R1 and T1.

(Note 4) Create a sequence in which the PWM converter gets ready for operation before the run signal is input to the inverter.

(Note 5) Set the timer for 52T to 1 second.
When using microswitches for AC fuse disconnection detection, assign external alarm (THR) to the PWM converter's terminal X1, and connect all of the microswitches in series.

(Note 6) Be sure to assign the PWM converter digital input terminal (X1) to the external alarm (THR), and to connect the filter stack overheat signal outputs (1, 2). Set contact b input with function code E14 to input with contact b. Furthermore, connect the microswitch for AC fuse blow detection to the digital input terminal (X1) in series with all microswitches and the overheat signal outputs (1, 2).

(Note 7) Ensure correct phase sequence when connecting wires to terminals L1/R, L2/S, L3/T, R2, T2, R1, S1, and T1.

(Note 8) When inputting 200 VAC as the fan power supply, remove jumper wires from between terminals R11 and R12 and from between terminals T11 and T12, and then connect the input to terminals R12 and T12. Note that these terminals are dedicated to the internal fan power supply. Do not use them for any other purposes.

(Note 9) Be sure to set the timer for 73T to 5 seconds.

(Note 10) For the 400V series, connect "Fdc (fuse)" to the P (+) side. No "Fdc (fuse)" is required at the N (-) side. For the 690V series, connect "Fdc (fuse)" to the P (+) side and N (-) side.
Furthermore, use two microswitches and connect them in series.

(Note 11) With the 690V series, there are no R3 or T3 short-circuit wires.

⚠WARNING

- Be sure to assign the PWM converter digital input terminal (X1) to the external alarm (THR), and to connect the filter stack overheat signal outputs (1, 2).
- Be sure to stop the PWM converter and inverter when the overheat signal is output. Furthermore, shut off electromagnetic contactors 52 and 73.

Risk of fire, accident

6.3.10 Protective functions

If an error occurs in the PWM converter, the protective function operates to immediately stop (trip) the PWM converter and display the alarm code on the keypad. If the protective function operates, check and remove the cause, and then replace any defective parts. When a reset command is input after that, the operation of the protective function is cancelled, and then the converter operation can be restarted.
For details about alarm contents, refer to Table 6.3.10-1.

6.3.10.1 List of alarm codes

Table 6.3.10-1: List of alarm displays and protective operations

Alarm name	Display	Operation contents
AC fuse blown	ACF	Operates if the external AC fuse of PWM converter is blown due to short-circuiting or breakage of internal circuits.
AC overcurrent	AOC	Operates if the momentary value of the AC current exceeds the overcurrent detection level due to short-circuiting or ground fault of the power supply circuit.
AC insufficient voltage	ALV	Operates if the AC power supply voltage drops to the insufficient voltage detection level or less during PWM converter operation. No alarm is output when "F02: Restart Mode after Momentary Power Failure (Mode selection)" is set to "1" (Restart). AC insufficient voltage detection level (400V system: 176 Vrms, 690V series: 350 Vrms)
AC input current error	ACE	Operates if the deviation between the PWM converter current command value and input AC power supply detection value exceeds the input current error detection level. No alarm is output when "F02: Restart Mode after Momentary Power Failure (Mode selection)" is set to "1" (Restart).
AC overvoltage	AOV	Operates if the AC power supply voltage exceeds the AC overvoltage detection level. AC overvoltage detection level (400V system: AC 552 Vrms, 690V series: 828 Vrms)
DC overvoltage	dOV	If the regenerative energy from the motor is equal to or greater than the PWM converter braking capability, this function is activated activated if the DC intermediate circuit voltage rises and exceeds the DC overvoltage detection level. DC overvoltage detection level (400V system: DC 800 Vdc, 690V series: 1230 Vdc)
DC fuse blown	dCF	Operates if the DC fuse is blown by short-circuit or breakage of the internal circuit when the DC fuse is installed in the PWM converter output.
DC insufficient voltage	dLV	This function is activated if the DC intermediate circuit voltage drops to the insufficient voltage detection level or below due to a drop in the power supply voltage during PWM converter operation. No alarm is output when "F02: Restart Mode after Momentary Power Failure (Mode selection)" is set to "1" (Restart). DC insufficient voltage detection level (400V system: 371 Vdc, 690V series: 540 Vrms)
Input open-phase	LPV	This function operates when powered ON and is connected to L1/R, L2/S, or L3/T of the main power supply input of the main circuit. If an open-phase or 3-phase power supply voltage unbalance occurs in the 3-phase power supply, it is necessary to power ON again (power ON reset) in order to reset the alarm.
Synchronous power supply frequency error	FrE	Operates if any of the following occurs. • Power supply frequency detection value is beyond the range of 46 to 54 Hz or 56 to 64 Hz (only when powered ON). • Frequency is ±15% or more of the reference frequency (50/60 Hz). • Value three times larger than the standard deviation of the power supply frequency (3 σ) detects 5 Hz or more (when the run command is input). No alarm is output when "F02: Restart Mode after Momentary Power Failure (Mode selection)" is set to "1" (Restart).

Alarm name	Display	Operation contents
Charging circuit error	PbF	This function operates when "73 answer back" [73ANS] is selected in the X1 function selection. The function also operates if X1 is not input (electromagnetic contactor for charging circuit bypass is closed) within 0.5 sec. after the charging circuit control output [73A] signal of the PWM converter has operated. The alarm is reset by switching the X1 function selection or powering ON again (power ON reset).
Cooling fin overheat	OH1	Operates if the temperature around the cooling fins that cool the semiconductor elements of the main circuit increases due to cooling fan stop.
External alarm	OH2	Performs the PWM converter alarm stop operation by the external signal input (THR).
Overheat inside converter	OH3	Operates if the temperature around the control PCB increases due to poor ventilation inside the PWM converter.
Converter overload	OLU	Operates if the AC power supply current exceeds the overload level shown in Figure 6.3.10-1. MD mode: 150%/60 sec. LD mode: 110%/60 sec.
Memory error	Er1	Operates if an error occurs in the memory, such as a data write error.
Keypad communication error	Er2	Operates if the keypad transmission error occurs.
CPU error	Er3	Operates if the CPU error occurs.
Network unit error	Er4	Operates if a transmission error occurs due to noise during PWM converter operation through T-Link, SX bus, or CC-Link. Operates if a PLC unit error, communication faulty wiring, or option failure occurs.
Operation error	Er6	Operates if multiple network options (T-Link, SX bus, or CC-Link) are installed.
A/D converter error	Er8	Operates if an error occurs in the A/D converter circuit.
Optical network error	Erb	Operates if a transmission error occurs in the communication between the PWM converters using the high-speed serial card (OPC-VG7-SI, OPC-VG7-SIR). * High-speed serial card: This card is required to configure the parallel operation of the PWM converters.

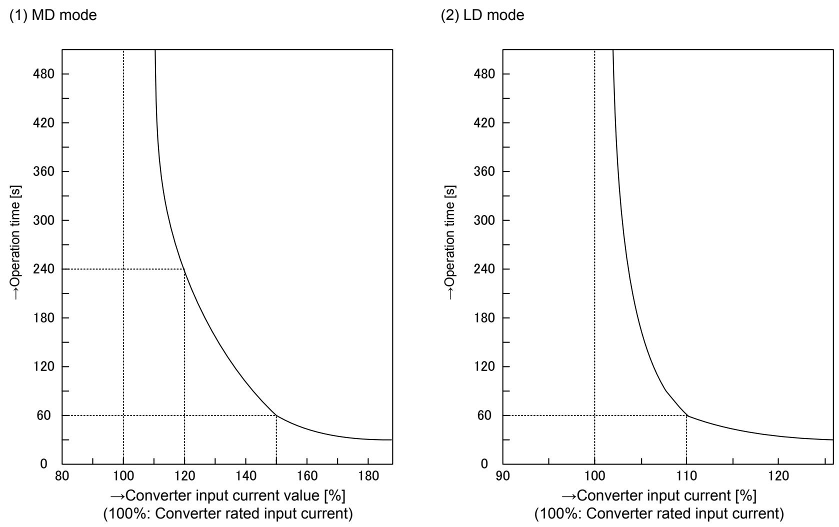
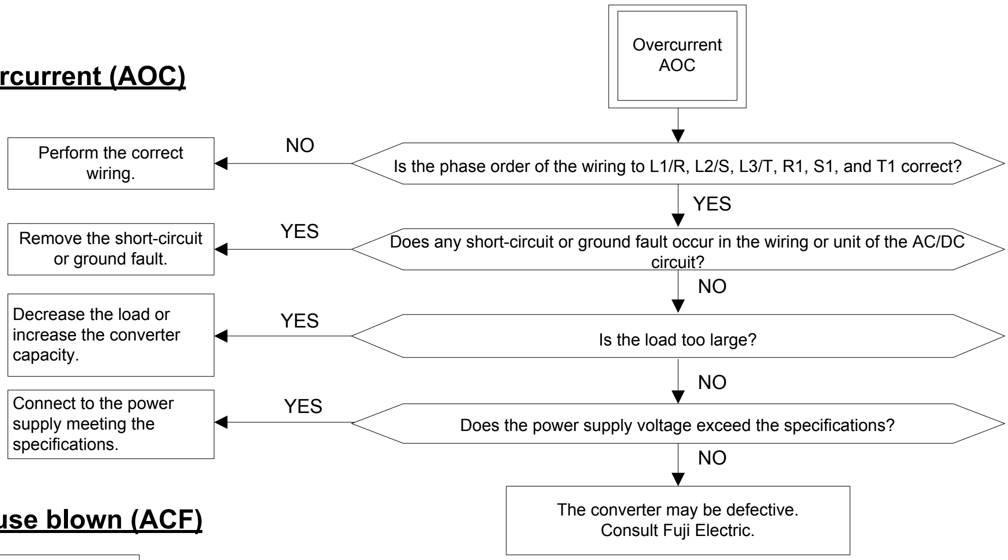


Figure 6.3.10-1: Overload trip time

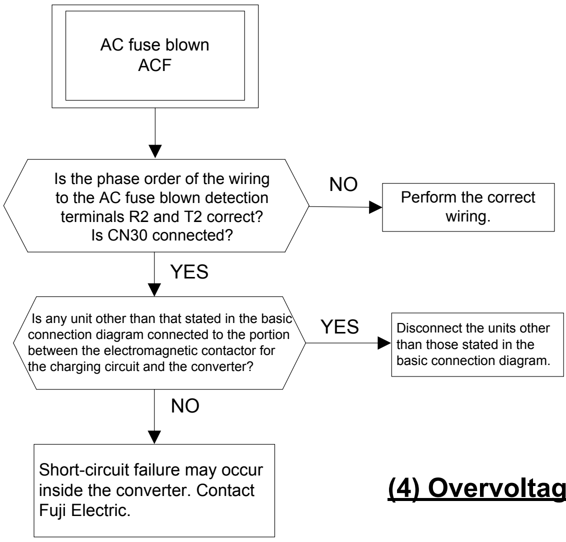
6.3.10.2 Troubleshooting

(1) If the protective function operates [PWM converter main unit]

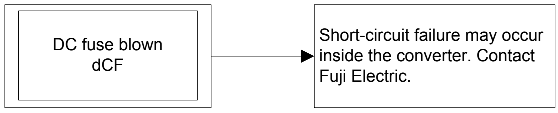
(1) Overcurrent (AOC)



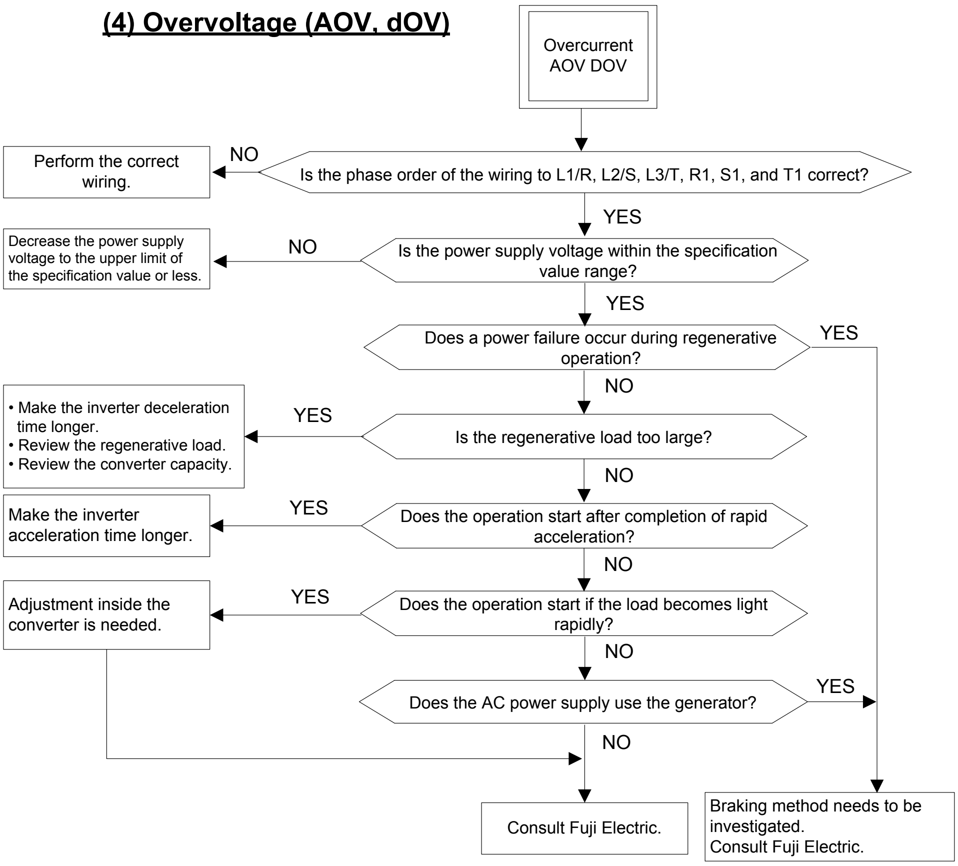
(2) AC fuse blown (ACF)



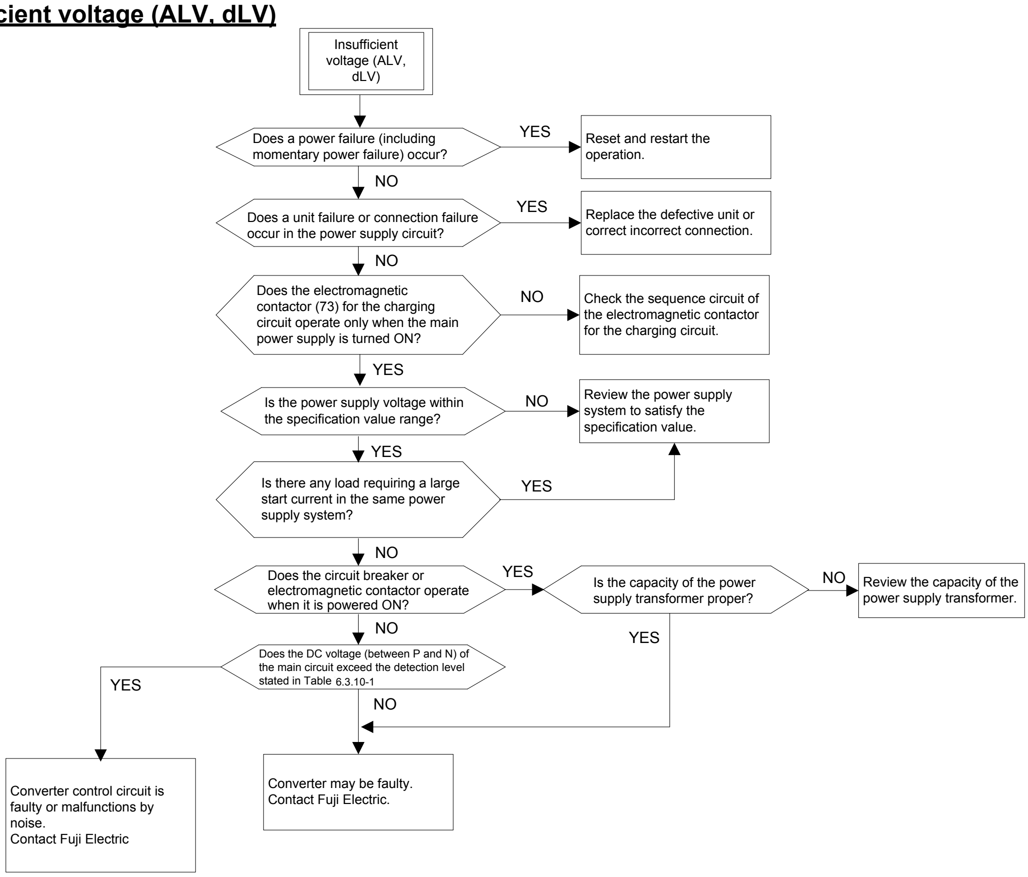
(3) DC fuse blown (dCF)



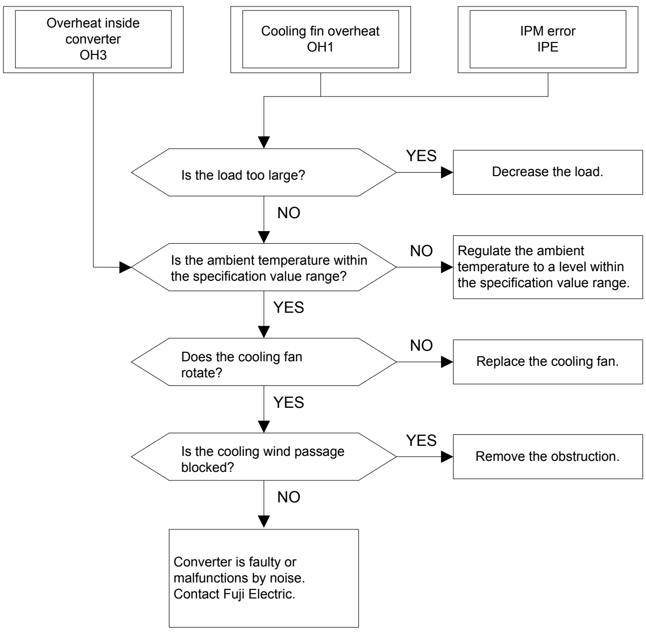
(4) Overvoltage (AOV, dOV)



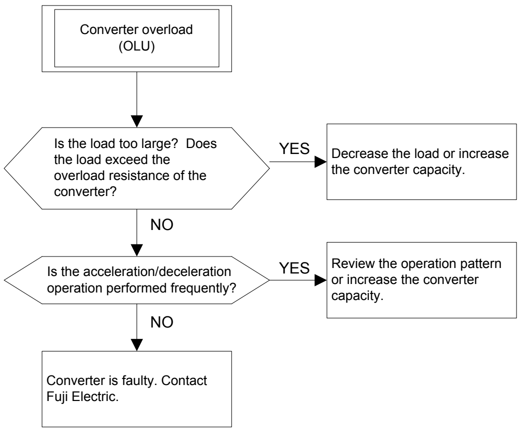
(5) Insufficient voltage (ALV, dLV)



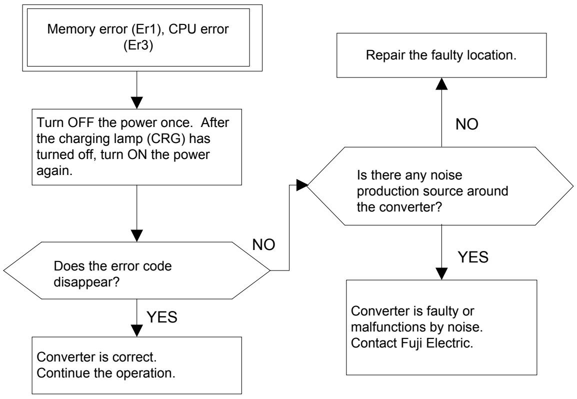
(6) Overheat inside converter (OH3), cooling fin overheat (OH1), IPM error (IPE)



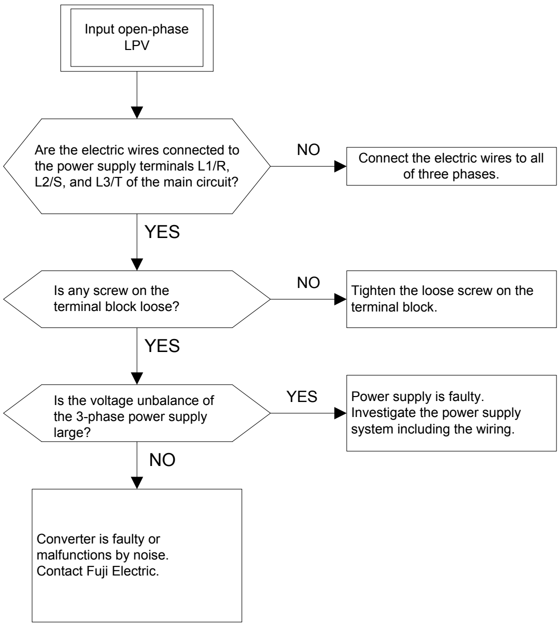
(7) Converter overload (OLU)



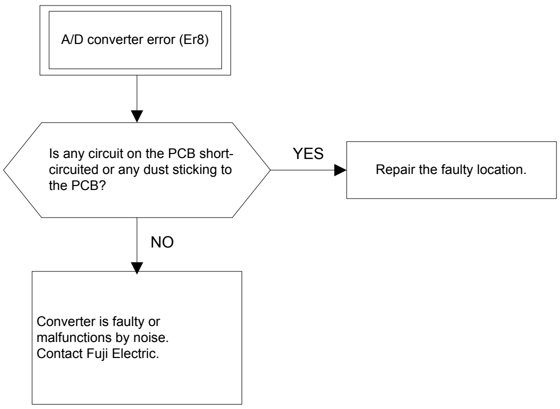
(8) Memory error (Er1), CPU error (Er3)



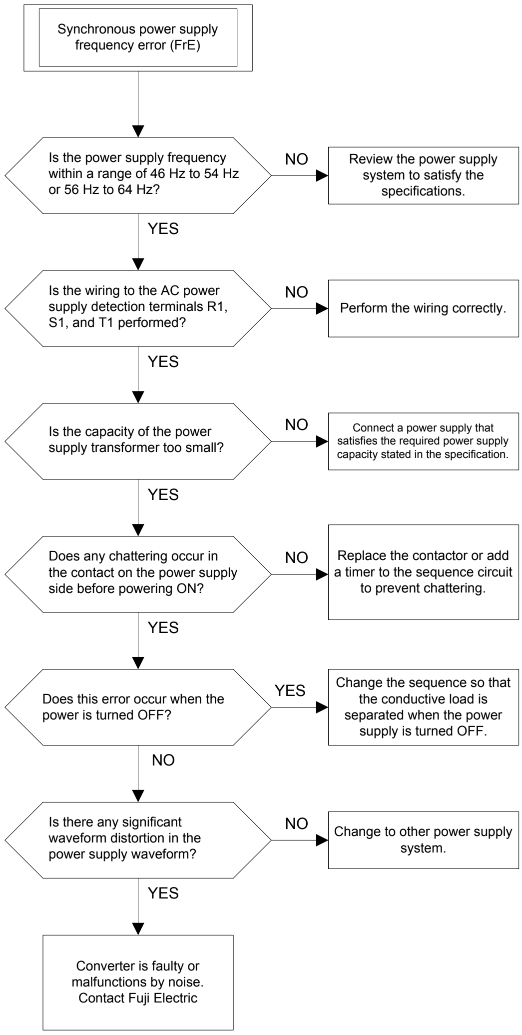
(9) Input open-phase (LPV)



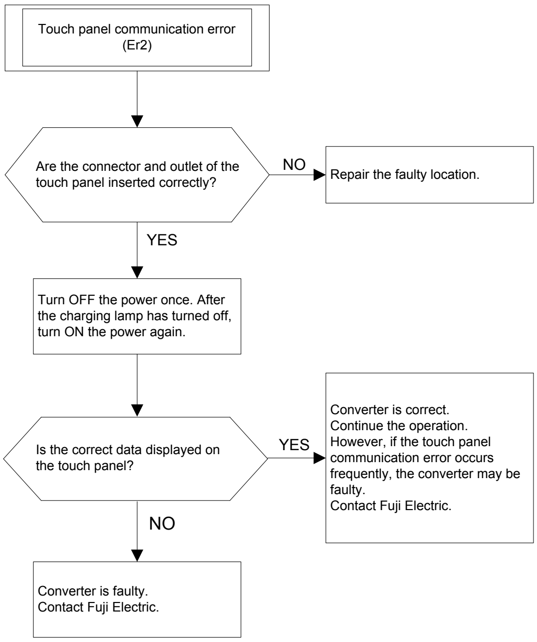
(10) A/D converter error (Er8)



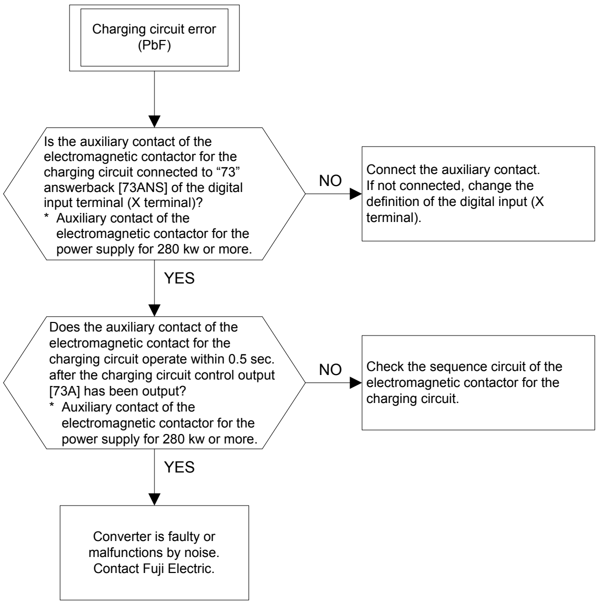
(11) Synchronous power supply frequency error (FrE)



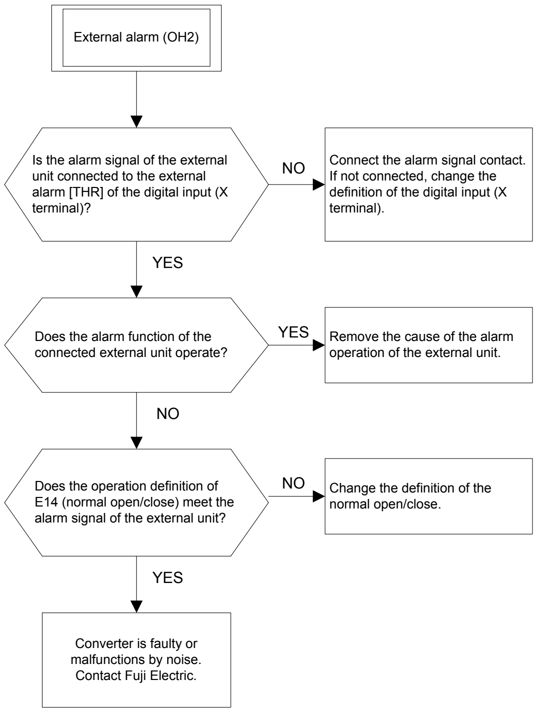
(12) Touch panel communication error (Er2)



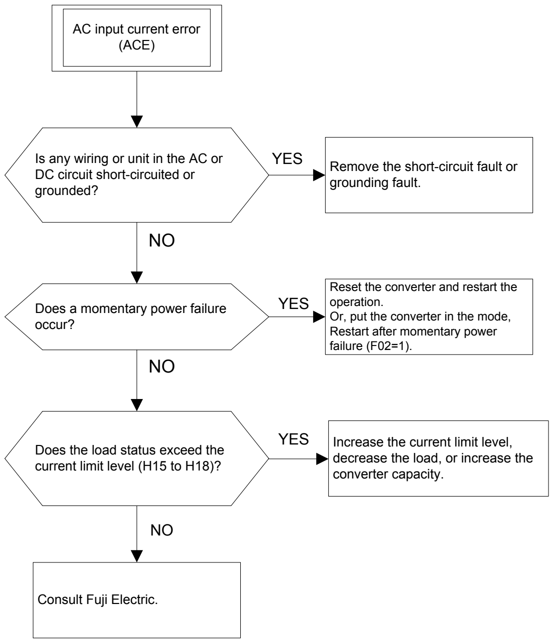
(14) Charging circuit error (PbF)



(13) External alarm (OH2)



(15) AC input current error (ACE)



(2) If the protective function operates [Network option: Network error (Er4)]

<T-Link: OPC-VG7-TL>

The T-Link option provides two kinds of alarms, light alarm and heavy alarm, according to the failure level.

Item	Light alarm	Heavy alarm	
Cause	• Noise is applied to the communication line. • Address is duplicated. (Setting mistake of RSW 1 and 2)	• Communication line is disconnected. Power to MICREX (PLC) is shut down (OFF).	T-Link option hardware is faulty (breakage or defect).
Reset method	Resolve the cause of the alarm (automatic resolution by restoring the communication), and give the reset command (reset from the keypad, [RST], or communication).		Remove the cause of the hardware failure and reset the power supply (power ON reset).
Failure state control	Alarm may occur only when the run command is sent from the T-Link. Alarm can be controlled with function codes H02 and H03.	Momentary Er4 alarm	

<SX bus: OPC-VG7-SX>

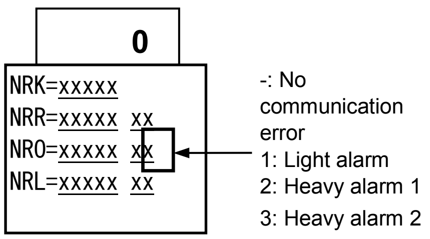
The SX bus option provides two kinds of alarms, light alarm and heavy alarm, according to the failure level.

Item	Light alarm	Heavy alarm 1	Heavy alarm 2
Cause	Communication data error due to noise application to the communication line.	• All master units are failed. • Disconnection is detected. • SX bus power supply is shut down.	• Option hardware failure • Option mounting failure
Reset method	Resolve the cause of the alarm (automatic resolution by restoring the communication), and give the reset command (reset from the keypad, [RST], or communication).		Remove the cause of the hardware failure and reset the power supply (power ON reset).
Failure state control	Alarm may occur only when the run command is sent from the SX bus. Alarm can be controlled with function codes H02 and H03.	Momentary Er4 alarm	
Keypad display (Communication error code)	1	2	3

Note (1) If any heavy alarm 1 occurs, reset also the power supply to the MICREX-SX (power ON reset) depending on the CPU status.

(2) The communication error code of a light alarm or heavy alarm can be checked on the Maintenance Information Communication Status screen on the keypad. To display the Communication Status screen, press the **PRG** key on the Operation Mode screen to change to the Menu screen, use the **∧** or **∨** key to move the arrow mark at the left end of the screen to "5. Maintenance", and then press the **FUNC/DATA** key.

After that, press the **∨** key three times to display the following screen.



<CC-Link: OPC-VG7-CCL>

The CC-Link option provides two kinds of alarms, light alarm and heavy alarm, according to the error level.

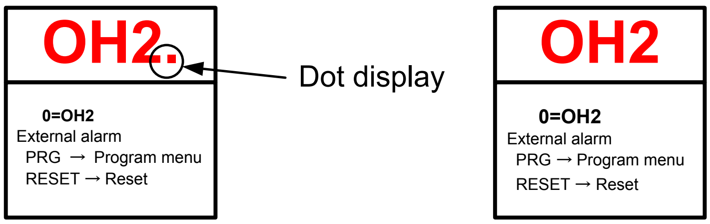
Item	Light alarm (operation in the case of communication line error)	Heavy alarm (operation in the case of option error)
Cause	• Master unit is failed. • Disconnection is detected. • Communication data error (Noise is applied to the communication line.)	• Option hardware error • Option mounting failure
Reset method	After the cause of the alarm has been removed (automatic release by resetting communication), give the reset.	Remove the cause of the hardware failure and reset the power supply (power ON reset).
Alarm output control	• Error is detected only in the CC-Link operation mode. • Alarm output method if an error is detected can be controlled with function codes H02 and H03.	Momentary Er4 alarm
Communication error code	01	02

(3) If the protective function operates [Parallel system: OPC-VG7-SI/OPC-VG7-SIR is used.]

1) Parallel system alarm display

If an alarm occurs in the master or slave (PWM converter) unit (protective function operates) during parallel system operation, all units enter the alarm mode and the operations of all converters stop.
At the same time, the alarm code showing the cause of the alarm No. 1 is displayed on the LED displays of the keypads of all units. According to this alarm code display, a unit in which the alarm occurred can be judged.

Additionally, even when multiple alarms occur at the same time, the cause of only alarm No. 1 is displayed as alarm caused by other station. Furthermore, the alarm history display is the normal alarm display.



Alarm occurs in the other station.
(Alarm trip caused by other station)

Alarm occurs in its own station
(Alarm trip caused by its own station)

2) Link error among converter links (Erb)

If the optical cable has any faulty wiring or the connector drops during PWM converter operation, the protective function operates by the link error among converters (Erb). (All stacks operate at the same time.) When the PWM converter alarm output is used as external alarm conditions of the inverter, the inverter is tripped by the alarm and stops in the coast-to-a-stop mode.

Even when the reset command (any of the keypad, terminal block, and communication system, etc.) is input without the cause of the alarm reset, the alarm state cannot be cancelled. Be sure to investigate the cause of the alarm, and then reset it.

<Troubleshooting "Erb">

If the "Erb" alarm occurs, the following causes may be considered. Check the causes.

- The optical cable is not connected or inserted into the connector completely. ➔ Insert the cable securely into the optical connector.
- The optical cable is bundled or bent with a bending radius of 35 mm or less. ➔Bend the optical cable to a specified level.
- The connection plugs of the optical cable do not meet the connector colors (gray and blue) of the PCB. ➔Match the connector colors on the cable side with those on the PCB side.
- The optical cable connection is not formed as a loop. ➔ Be sure to loop back the signal from the master.

3) Operation procedure error (Er6)

If the station number of this optical communication option is set incorrectly or if the same communication option card is installed in the inverter, the protective function operates.
This function provides preventive measures so that unstable operation caused by illegal operation is not performed.

<Troubleshooting "Er6">

- The optical link option hardware station number SW1 setting is set to 6 or more.
- The optical link option hardware number SW1 setting is higher than H13 "Number of parallel system slave stations". ➔Make the setting correctly.
- Two optical link options are installed. ➔ Install only one optical link option.

4) Reset process

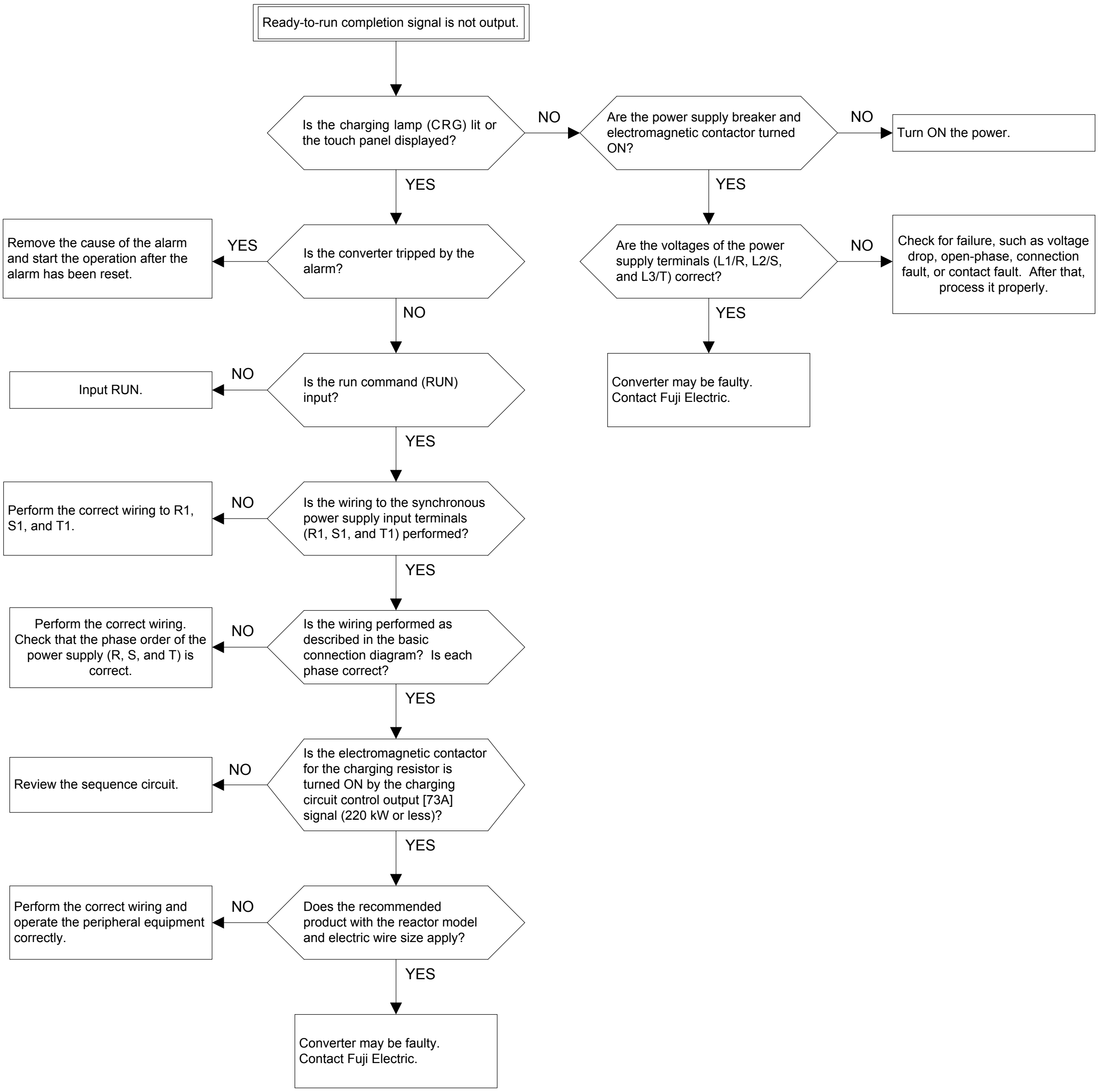
All stations are reset at the same time by the reset command of the master (slave) unit under conditions that the cause of the alarm is reset.

	Master alarm status	Slave alarm status	Reset target
Reset command from master unit	Valid	Valid	All units
Reset command from slave unit	Valid	Valid	All units

Chapter 6 Converter System

(4) Ready-to-run of PWM converter is not completed.

The PWM converter outputs the ready-to-run signal [RDY] that is the inverter operation condition after the run command [RUN] has been input.
The following describes the troubleshooting if the ready-to-run completion signal is not output after the run command has been input.



6.3.11 List of function codes

Table 6.3.11-1: List of function codes

Function	Function code No.	Function code Name		Data range	Min. unit	Unit	Factory default value	
Basic functions	F00	Data protection		0 to 1	1	—	0	
	F01	Harmonic filter selection		0 to 1			0	
	F02	Restart after momentary power failure (operation selection)		0 to 1			0	
	F03	Current rating switching		0 to 1			0	
	F04	LED monitor (display selection)		0 to 5			0	
	F05	LCD monitor (display selection)		0 to 2			2	
	F06	LCD monitor (language selection)		0 to 2			0	
	F07	LCD monitor (contrast adjustment)		0 to 10			5	
	F08	Carrier frequency		5			5	
Terminal functions	E01	X1 function selection		0 to 4	1	—	4	
	E02	Y1 function selection		0 to 14	1	—	0	
	E03	Y2 function selection					2	
	E04	Y3 function selection					3	
	E05	Y5 function selection					1	
	E06	Y11 function selection	OPC-VG7-DIO option function	0 to 14	1	—	0	
	E07	Y12 function selection					0	
	E08	Y13 function selection					0	
	E09	Y14 function selection					0	
	E10	Y15 function selection					0	
	E11	Y16 function selection					0	
	E12	Y17 function selection					0	
	E13	Y18 function selection					0	
	E14	I/O function normally open/closed		0000 to 007F			0000	
	E15	RHC overload warning level		50 to 105%	1	%	80	
	E16	Cooling fan ON/OFF control		0 to 1	1	—	0	
	E17	Output during current limiting (hysteresis width)		0 to 30%	1	%	10	
	E18	AO1 function selection		0 to 10	1	—	1	
	E19	AO4 function selection	OPC-VG7-AIO option function				0	
	E20	AO5 function selection					0	
	E21	AO1 gain setting		-100.00 to 100.00 (multiplication)	0.01	(multipli-cation)	1.00	
	E22	AO4 gain setting	OPC-VG7-AIO option function				1.00	
	E23	AO5 gain setting					1.00	
	E24	AO1 bias setting		-100.0 to 100.0%	0.1	%	0.0	
	E25	AO4 bias setting	OPC-VG7-AIO option function				0.0	
	E26	AO5 bias setting					0.0	
	E27	AO1-5 filter setting		0.000 to 0.500s	0.001	s	0.010	

Note (1) The settings of the functions in the shaded portions in the list can be changed during operation. Other functions should be set after the operation has been stopped.

Function	Function code No.	Function code Name		Data range	Min. unit	Unit	Factory default value	
High performance functions	H01	Station address	Built-in RS-485 function	0 to 255	1	—	1	
	H02	Operation selection in case of error	Communication option common function	0 to 3	1	—	3	
	H03	Timer operation time		0.01 to 20.00s	0.01	s	2.00	
	H04	Transmission speed	Built-in RS-485 function	0 to 4	1	—	2	
	H05	Data length selection		0 to 1			0	
	H06	Parity bit selection		0 to 2			0	
	H07	Stop bit selection		0 to 1			0	
	H08	Communication faulty wiring time		0.0 to 60.0s	0.1	s	60.0	
	H09	Response interval time		0.00 to 1.00s	0.01	s	0.05	
	H10	Protocol selection		0 to 3	1	—	0	
	H11	TL transmission format	OPC-VG7-TL function	0 to 1	1	—	0	
	H12	Parallel system	OPC-VG7-SI□ function	0 to 1			0	
	H13	Number of parallel system slave stations		1 to 5			1	
	H14	Alarm data deletion		0 to 1			0	
	H15	Power supply current limit (drive 1)		0 to 150%	1	%	150	
	H16	Power supply current limit (drive 2)					150	
	H17	Power supply current limit (braking 1)		-150 to 0%			-150	
	H18	Power supply current limit (braking 2)					-150	
	H19	Current limit warning (level)		-150 to 150%			100	
	H20	Current limit warning (timer)		0 to 60s	1	s	0	
User application functions	U01	Reserved for particular manufacturers.	OPC-VG7-SX option function	-32768 to 32767	1	—	0	
	U02	SX bus station number monitor		-32768 to 32767	1	—	0	
	U03	DC fan alarm cancellation		0000 to FFFF	1	—	0000	
	U04	AVR control response		-32768 to 32767	1	—	0	
	U05	DC voltage commend value selection		-32768 to 32767	1	—	0	
	U06	Reserved for particular manufacturers.		-32768 to 32767	1	—	0	
	U07	Reserved for particular manufacturers.		-32768 to 32767			0	
	U08	Reserved for particular manufacturers.		-32768 to 32767			0	
	U09	Reserved for particular manufacturers.		-32768 to 32767			0	
	U10	Reserved for particular manufacturers.		-32768 to 32767			0	

Note

(1) U01 and U06 to U10 are function codes that are reserved for the manufacturer. Do not change them from the factory default values.

(2) U codes to be displayed on the keypad are USER P1 to USER P10.

(3) The settings of the functions in the shaded portions in the list can be changed during operation. Other functions should be set after the operation has been stopped.

6.3.12 Configuration of peripherals

6.3.12.1 Configuration for the RHF-D series filter stacks

(1) In the case of MD

Power-based series	PWM converter model	Filter stack		MCCB/ELCB rated current [A]	Electro-magnetic contactor		AC Fuse		Microswitch	
		Model	Quantity		Model	Quantity	Model	Quantity	形式	Quantity
3-phase 400V	RHC132S-4D□	RHF160S-4D□	1	300	SC-N8	1	170M5446	3	170H3027	3
	RHC160S-4D□	RHF160S-4D□	1	350	SC-N11	1	170M6546	3		
	RHC200S-4D□	RHF220S-4D□	1	500	SC-N12	1	170M6547	3		
	RHC220S-4D□	RHF220S-4D□	1	500	SC-N12	1	170M6547	3		
	RHC280S-4D□	RHF280S-4D□	1	600	SC-N14	1	170M6499	3		
	RHC315S-4D□	RHF355S-4D□	1	700	SC-N14	1	170M6500	3		
3-phase 690V	RHC132S-69D□	RHF160S-69D□	1	175	SC-N6	1	170M5447	3		
	RHC160S-69D□	RHF160S-69D□	1	200	SC-N7	1				
	RHC200S-69D□	RHF220S-69D□	1	250	SC-N8	1	170M5448	3		
	RHC250S-69D□	RHF280S-69D□	1	300	SC-N8	1	170M6548	3		
	RHC280S-69D□	RHF280S-69D□	1	350	SC-N11	1				
	RHC315S-69D□	RHF355S-69D□	1	400	SC-N11	1				
	RHC355S-69D□	RHF355S-69D□	1	500	SC-N12	1	170M6500	3		
	RHC400S-69D□	RHF450S-69D□	1	500	SC-N12	1				
	RHC450S-69D□	RHF450S-69D□	1	600	SC-N14	1				

∗ For information on peripherals for RHC630B to 800B-4DJ, refer to "6.3.12.2 List of peripherals with no filter stack used".

(2) In the case of LD

Power-based series	PWM converter model	Filter stack		MCCB/ELCB rated current [A]	Electro-magnetic contactor		AC Fuse		Microswitch	
		Model	Quantity		Model	Quantity	Model	Quantity	Model	Quantity
3-phase 400V	RHC132S-4D□	RHF160S-4D□	1	350	SC-N11	1	170M5446	3	170H3027	3
	RHC160S-4D□	RHF220S-4D□	1	500	SC-N12	1	170M6546	3		
	RHC200S-4D□	RHF220S-4D□	1	500	SC-N12	1	170M6547	3		
	RHC280S-4D□	RHF355S-4D□	1	700	SC-N14	1	170M6499	3		
	RHC315S-4D□	RHF355S-4D□	1	800	SC-N14	1	170M6500	3		
3-phase 690V	RHC132S-69D□	RHF160S-69D□	1	200	SC-N7	1	170M5447	3		
	RHC160S-69D□	RHF220S-69D□	1	250	SC-N8	1				
	RHC200S-69D□	RHF220S-69D□	1	300	SC-N8	1	170M5448	3		
	RHC250S-69D□	RHF280S-69D□	1	350	SC-N11	1	170M6548	3		
	RHC280S-69D□	RHF355S-69D□	1	400	SC-N11	1				
	RHC315S-69D□	RHF355S-69D□	1	500	SC-N12	1				
	RHC355S-69D□	RHF450S-69D□	1	500	SC-N12	1	170M6500	3		
	RHC400S-69D□	RHF450S-69D□	1	600	SC-N14	1				

∗ For information on peripherals for RHC630B to 800B-4DJ, refer to "6.3.12.2 List of peripherals with no filter stack used".

Note: The "MCCB (ELCB) rated current" column shows the recommended rated current values at panel temperatures 50°C or lower.

* Since the ambient temperature is 40°C, the installation environment standards for MCCBs or ELCBs have been selected taking into account the correction coefficient depending on the temperature conditions (0.90 for 800AF or lower; 0.85 for 1000AF or higher). To select a specific model, consider the short-circuit breaking capacity of the equipment.

Refer to "6.2.12.3 Use of molded case circuit breakers (MCCBs)" and "6.2.12.4 Use of earth leakage circuit breakers (ELCBs)".

6.3.12.2 List of peripherals with no filter stack used

Note: When configuring a transformer-less parallel system with RHC132S-4D☐ to RHC315S-4D☐, use the RHF-D series filter stacks to implement an input filter. You cannot implement a filter circuit by use of peripherals.

(1) In the case of MD

Applied motor capacity [kW]	RHC-D model	Charging circuit contactor (73)	Quantity	Main contactor (52)	Quantity
132	RHC132S-4D☐	SC-N8	1	SC-N8	1
160	RHC160S-4D☐	SC-N11	1	SC-N11	1
200	RHC200S-4D☐	SC-N12	1	SC-N12	1
220	RHC220S-4D☐				
280	RHC280S-4D☐	SC-N3	1	SC-N14	1
315	RHC315S-4D☐				
630	RHC630B-4D☐			SC-N12	3
710	RHC710B-4D☐	SC-N4	1		
800	RHC800B-4D☐			SC-N14	3

Applied motor capacity [kW]	RHC-D model	Pressurizing reactor (Lr)	Quantity	Resistor for filter (Rf)	Quantity	Reactor for filter (Lf)	Quantity	Capacitor for filter (Cf)	Quantity	Contactor for filter circuit (6F)	Quantity
132	RHC132S-4D☐	LR4-160C	1	RF4-160C	1	LFC4-160C	1	CF4-160C	1	—	—
160	RHC160S-4D☐										
200	RHC200S-4D☐	LR4-220C	1	RF4-220C	1	LFC4-220C	1	CF4-220C	1		
220	RHC220S-4D☐										
280	RHC280S-4D☐	LR4-280C	1	RF4-280C	1	LFC4-280C	1	CF4-280C	1	SC-N4	1
315	RHC315S-4D☐	LR4-315C	1	RF4-315C	1	LFC4-315C	1	CF4-315C	1		
630	RHC630B-4D☐	LR4-630C	1	RF4-630C	1	LFC4-630C	1	CF4-630C *1	1	SC-N7 *2	1
710	RHC710B-4D☐	LR4-710C	1	RF4-710C	1	LFC4-710C	1	CF4-710C *1	1	SC-N8	1
800	RHC800B-4D☐	LR4-800C	1	RF4-800C	1	LFC4-800C	1	CF4-800C *1	1		

*1 Two units of capacitors of the identical type will be delivered when an order is made for any of CF4-630C to CF4-800C for quantity = "1".

*2 When you apply OPC-VG7-SIR and use it in a transformer-less parallel system, change "(6F)" to "SC-N8".

(2) In the case of LD

Applied motor capacity [kW]	RHC-D model	Charging circuit contactor (73)	Quantity	Main contactor (52)	Quantity
160	RHC132S-4D☐	SC-N11	1	SC-N11	1
200	RHC160S-4D☐	SC-N12	1		
220	RHC200S-4D☐			SC-N12	1
315	RHC280S-4D☐	SC-N3	1	SC-N14	1
355	RHC315S-4D☐				
710	RHC630B-4D☐	SC-N4	1	SC-N12	3
800	RHC710B-4D☐			SC-N14	3
1000	RHC800B-4D☐			SC-N16	3

Applied motor capacity [kW]	RHC-D model	Pressurizing reactor (Lr)	Quantity	Resistor for filter (Rf)	Quantity	Reactor for filter (Lf)	Quantity	Capacitor for filter (Cf)	Quantity	Contactor for filter circuit (6F)	Quantity
160	RHC132S-4D☐	LR4-160C	1	RF4-160C	1	LFC4-160C	1	CF4-160C	1	—	—
200	RHC160S-4D☐	LR4-220C	1	RF4-220C	1	LFC4-220C	1	CF4-220C			
220	RHC200S-4D☐								1		
315	RHC280S-4D☐	LR4-315C	1	RF4-315C	1	LFC4-315C	1	CF4-315C	1	SC-N4	1
355	RHC315S-4D☐	LR4-355C	1	RF4-355C	1	LFC4-355C	1	CF4-355C *1	1		
710	RHC630B-4D☐	LR4-710C	1	RF4-710C	1	LFC4-710C	1	CF4-710C *1	1	SC-N8	1
800	RHC710B-4D☐	LR4-800C	1	RF4-800C	1	LFC4-800C	1	CF4-800C *1	1		
1000	RHC800B-4D☐	LR4-1000C	1	RF4-1000C	1	LFC4-1000C	1	CF4-1000C *1	1	SC-N11/SF	1

*1 Two units of capacitors of the identical type will be delivered when an order is made for any of CF4-630C to CF4-800C for quantity = "1".
Three units of capacitors of the identical type will be delivered when an order is made for any of CF4-1000C for quantity = "1".

6.3.12.3 Input power supply circuit (MCCB, ELCB)

PWM converter (400V series)			
Applicable capacity [kW]	MD spec	LD spec	MCCB/ELCB rated current [A]
132	RHC132S-4D☐	—	300
160	RHC160S-4D☐	RHC132S-4D☐	350
200	RHC200S-4D☐	RHC160S-4D☐	500
220	RHC220S-4D☐	RHC200S-4D☐	500
280	RHC280S-4D☐	—	600
315	RHC315S-4D☐	RHC280S-4D☐	700
355	—	RHC315S-4D☐	800
630	RHC630B-4D☐	—	1400
710	RHC710B-4D☐	RHC630B-4D☐	1600
800	RHC800B-4D☐	RHC710B-4D☐	1800
1000	—	RHC800B-4D☐	2200

Note The "MCCB (ELCB) rated current" column shows the recommended rated current values at panel temperatures 50°C or lower.

* Since the ambient temperature is 40°C, the installation environment standards for MCCBs or ELCBs have been selected taking into account the correction coefficient depending on the temperature conditions (0.90 for 800AF or lower; 0.85 for 1000AF or higher). To select a specific model, consider the short-circuit breaking capacity of the equipment.

Refer to "6.2.12.3 Use of molded case circuit breakers (MCCBs)" and "6.2.12.4 Use of earth leakage circuit breakers (ELCBs)".

6.3.13 Parallel system (capacity expansion)

A "parallel system" means that multiple PWM converters are connected in parallel to increase the total capacity of the converters. For example, when three 200 kW PWM converters are driven in parallel, this converter parallel system can produce an output power up to 600 kW or equivalent.

Controlling a parallel system requires the use of the optical link option card for parallel systems (OPC-VG7-SIR) so that each individual converter can be controlled in terms of synchronous behavior and load current balancing.

A parallel system is characterized by the following:

(1) If a PWM converter failure occurs during parallel operation of two PWM converters and one converter stops, the reduced capacity operation with the other remaining converter can be made (single converter operation).

(2) There are two kinds of parallel systems: transformer-less connection and transformer insulation connection. Select a desired system.

Note To connect PWM converters in parallel (so that all of them have the same output voltage), ensure that they all have the same capacity.

6.3.13.1 Transformer-less parallel system

In this system, the input to each PWM converter is not insulated by a transformer or the like and the PWM converters are connected to the same power supply system.

• Unit type is a dedicated product.
  (RHC☐-4CR * Standard equipment for the OPC-VG7-SIR)

• The OPC-VG7-SIR (option) allows the use of the stack type.

Table 6.3.13-1: Transformer-less parallel system control specifications

Item	Specifications	
	Unit	Stack
Applicable converter	CT spec only	MD spec, LD spec
Max. number of converters connected in parallel	3 units (Master: 1 unit, Slave: 2 units)	
Output voltage	Fixed at 710 VDC	
Carrier frequency	5 kHz	2.5 kHz
Input power supply *1	3-phase 380 to 440 V 50/60 Hz	
Input power factor	Approx. 0.94 (30% or more load)	

*1 When the input power supply voltage is less than 400 V, the capacity needs to be reduced.

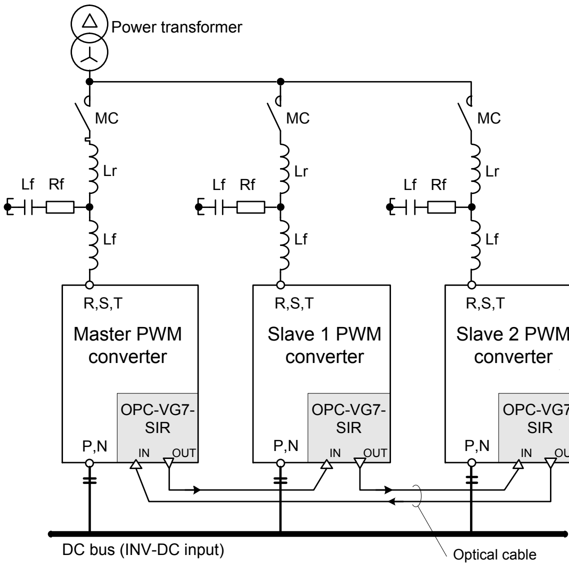


Figure 6.3.13-1: Transformer-less parallel system connection diagram

6.3.13.2 Transformer insulation type parallel system

This system insulates the input to the PWM converter by use of a transformer.

Use the OPC-VG7-SI optical link option card.

Table 6.3.13-2: Transformer insulation type parallel system control specifications

Item	Specifications	
	Unit	Stack
Applicable converter	CT spec, VT spec	MD spec, LD spec
Max. number of converters connected in parallel	6 units (Master: 1 unit, Slave: 5 units)	
Output voltage	640 to 710 VDC	
Carrier frequency	Same as rating specifications.	5 kHz
Input power supply *1	400V series: 3-phase, 380 to 440 V/50Hz, 380 to 460 V/60 Hz	
Input power factor	Approx. 0.99 (100% or more load) *2	

*1 When the input power supply voltage is less than 400 V, the capacity needs to be reduced.

*2 When the power supply voltage is 420 V or more and the operating load is 50% or more, the power factor of the power supply is reduced to approx. 0.95 (only during regenerative operation).

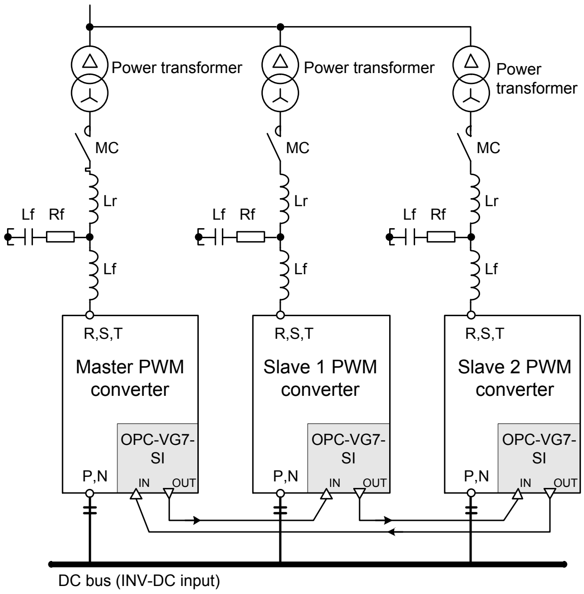


Figure 6.3.13-2: Transformer insulation type parallel system connection diagram

6.3.13.3 Parallel system common specifications

Table 6.3.13-3: Specifications common to both "transformer-less" and "transformer insulation type" parallel systems

Item		Specifications
Parallel control method		AVR constant control with DC ACR minor
Input harmonic current		Conversion coefficient Ki can be set to zero (0) according to the harmonics suppressing guideline by METI.
Restart after momentary power failure		When a momentary power failure occurs, the gate is shut off at the insufficient voltage level, and the converter resumes operation automatically following recovery.
Control function		A part of the slave unit functions is restricted. *1
Communication	Data transmission method	Asynchronous serial communication through plastic optical fiber (loop-back method)
	Transmission rate	1 Mbps
	Error check method	Parity, framing, overrun, BCC, or time-out monitor
	Max. optical cable length (Transmission distance)	20 m (0 to 70°C) - If the wiring length exceeds 20 m, the communication cannot be guaranteed due to transmission loss. * Optical cable supplied with OPC-VG7-SI☐ as standard: 5 m (10 m or 15 m cable should be ordered separately.)
	Erb alarm process (Erb: Link error)	All PWM converters in the parallel system are stopped when an alarm output (30A/B/C) is received. *2
Protective functions	Process if protective function operates	All PWM converters in the parallel system are stopped when an alarm output (30A/B/C) is received. *2 When 30A/B/C is operated, all the PWM converters should be forcibly stopped via an external sequence to ensure the safety.
	Protective function reset process	When a reset command is sent to a desired PWM converter connected through the optical link option card, all the other PWM converter are also reset at the same time (when the cause of the alarm is removed).

*1 The function code setting is restricted as follows.
The master can be set in the same manner as the standard product except for carrier frequency setting (F08). However, the slave functions are restricted.

📖 For details, refer to the instruction manuals listed below.

- RHC-C series Optical link option for parallel system (OPC-VG7-SI): INR-HF52179
- RHC-C series Optical link option for transformer-less parallel system (OPC-VG7-SIR): INR-HF51998
- RHC-D series High-efficiency power regeneration PWM converter (stack type): INR-SI47-1722

*2 For more information on the any alarm protective operation for all the converters in parallel system:

📖 Refer to "(3) If the protective function operates [Parallel system: OPC-VG7-SI/OPC-VG7-SIR is used.]" in "6.3.10.2 Troubleshooting".

(1) Optical fiber cable connection

The optical fiber cable plug colors at both ends are different from each other (gray and blue).

Connect each optical fiber cable to the same-colored connector on the optical link option card. The connection is performed so that the entire connection is looped.

Table 6.3.13-4: Connectors on the optical link option card

Part number	Name	Color	Overview
T-1528	TX	Gray	Transmitter (optical communication send)
R-2528	RX	Blue	Receiver (optical communication receive)

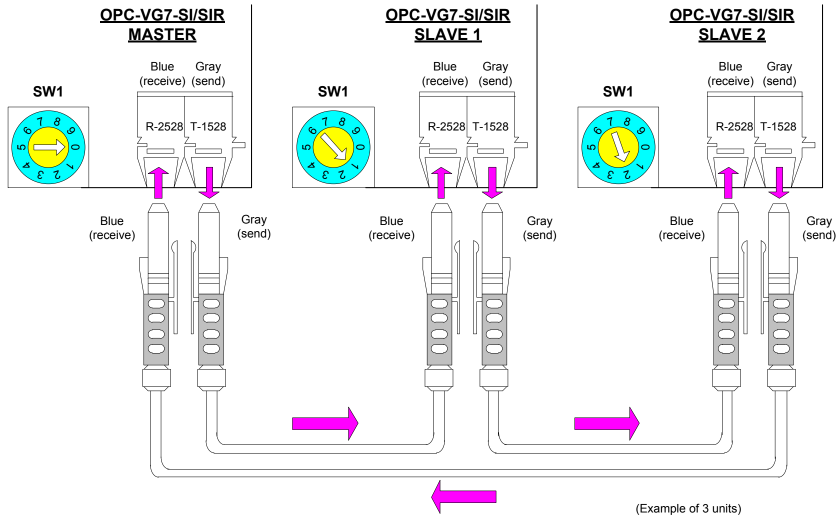


Figure 6.3.13-3: Example of optical fiber cable connections

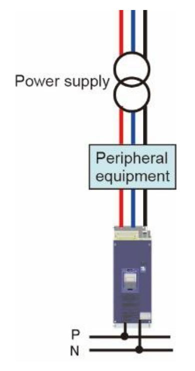
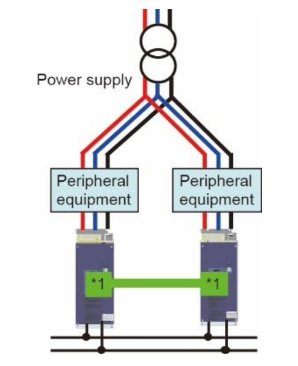
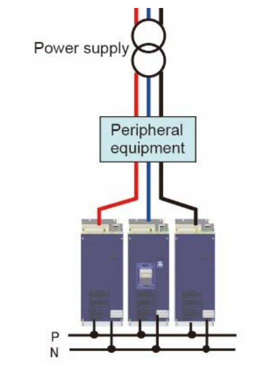
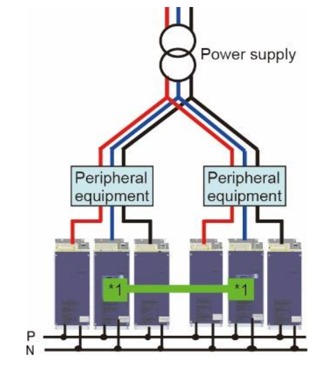
Table 6.3.13-5: Max. absolute rating of plastic fiber cable

Item	Minimum	Maximum	Unit	Remarks
Storage temperature range	-40	+75	°C	
Tension		50	N	30 min. or less
Short-time bending radius	10	—	mm	Operation stops within 1 hr. and "Erb" alarm is given.
Long-time bending radius	35	—	mm	If the cable is bent to a radius of 35 mm or less for a long time, "Erb" alarm may be given. Be sure to keep that the bending radius is 35 mm or more.
Tensile strength (long time)	—	1	N	
Flexibility	—	1000	times	Bent 90° on 10 mm-mandrel (mandrel, spindle).
Impact	—	0.5	kg	Impact test shall conform to MIL-1678, Method2030, Procefurel.

6.3.13.4 Configuration table for transformer-less parallel system

You can implement a redundant system with a greater capacity by connecting two or three converters that have the same capacity in parallel.
Table 6.3.13-6 to Table 6.3.13-8 provides a list of typical combinations but other configurations are also possible.

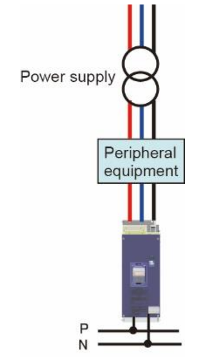
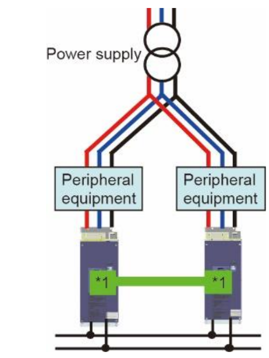
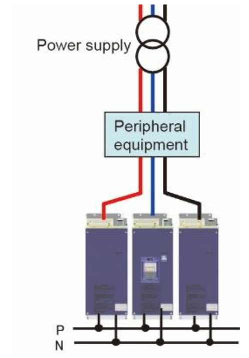
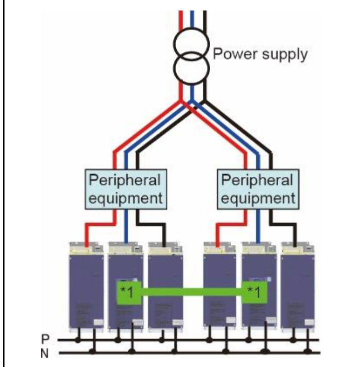
Table 6.3.13-6: Example of combinations in a transformer-less parallel system
(in the case of the 400V series in the MD spec mode)

Connected system	Single unit			Phase-specific		
						
Capacity (kW)	Applicable converter	Applicable converter	Number of units	Applicable converter	Applicable converter	Number of units
132	RHC132S-4D☐					
160	RHC160S-4D☐					
200	RHC200S-4D☐					
220	RHC220S-4D☐					
280	RHC280S-4D☐					
315	RHC315S-4D☐					
355		RHC200S-4D☐	2			
400		RHC200S-4D☐	2			
500		RHC280S-4D☐	2			
630		RHC315S-4D☐	2	RHC630B-4D☐		
710		RHC280S-4D☐	3	RHC710B-4D☐		
800		RHC280S-4D☐	3	RHC800B-4D☐		
1000					RHC630B-4D☐	2
1200					RHC630B-4D☐	2
1500					RHC800B-4D☐	2
1800					RHC630B-4D☐	3
2000					RHC710B-4D☐	3
2400					RHC800B-4D☐	3

*1 Requires the option OPC-VG7-SIR.

*2 To connect PWM converters in parallel (so that all of them have the same output), ensure that they all have the same capacity.

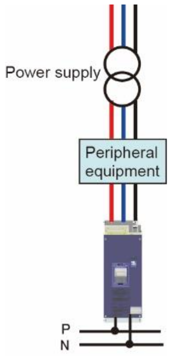
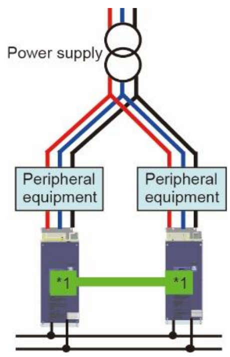
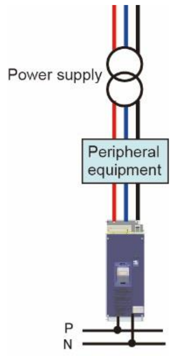
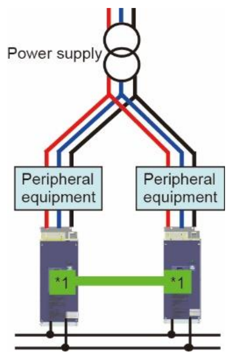
Table 6.3.13-7: Example of combinations in a transformer-less parallel system (in the case of the 400V series in the LD spec mode)

Connected system	Single unit			Phase-specific		
						
Capacity (kW)	Applicable converter	Applicable converter	Number of units	Applicable converter	Applicable converter	Number of units
160	RHC132S-4D☐					
200	RHC160S-4D☐					
220	RHC200S-4D☐					
280						
315	RHC280S-4D☐					
355	RHC315S-4D☐					
400		RHC160S-4D☐	2			
500		RHC280S-4D☐	2			
630		RHC280S-4D☐	2			
710		RHC315S-4D☐	2	RHC630B-4D☐		
800		RHC280S-4D☐	3	RHC710B-4D☐		
1000		RHC315S-4D☐	3	RHC800B-4D☐		
1200					RHC630B-4D☐	2
1500					RHC710B-4D☐	2
1800					RHC800B-4D☐	2
2000					RHC800B-4D☐	2
2400					RHC710B-4D☐	3
3000					RHC800B-4D☐	3

*1 Requires the option OPC-VG7-SIR.

*2 To connect PWM converters in parallel (so that all of them have the same output), ensure that they all have the same capacity.

Table 6.3.13-8 Example of combinations in a transformer-less parallel system (in the case of the 690V series)

Connected system	MD spec			LD spec		
						
Capacity (kW)	Applicable converter	Applicable converter	Number of units	Applicable converter	Applicable converter	Number of units
132	RHC132S-69D☐			-	-	-
160	RHC160S-69D☐			RHC132S-69D☐		
200	RHC200S-69D☐			RHC160S-69D☐		
250	RHC250S-69D☐			RHC200S-69D☐		
280	RHC280S-69D☐			RHC250S-69D☐		
315	RHC315S-69D☐			RHC280S-69D☐		
355	RHC355S-69D☐			RHC315S-69D☐		
400	RHC400S-69D☐			RHC355S-69D☐		
450	RHC450S-69D☐			RHC400S-69D☐		
500		RHC250S-69D☐	2		RHC250S-69D☐	2
630		RHC315S-69D☐	2		RHC280S-69D☐	2
710		RHC355S-69D☐	2		RHC315S-69D☐	2
800		RHC400S-69D☐	2		RHC355S-69D☐	2
1000		RHC355S-69D☐	3		RHC315S-69D☐	3
1200		RHC400S-69D☐	3		RHC355S-69D☐	3
1350		RHC450S-69D☐	3		RHC400S-69D☐	3

*1 Requires the option OPC-VG7-SIR.

*2 To connect PWM converters in parallel (so that all of them have the same output), ensure that they all have the same capacity.

6.3.13.5 Parallel system connection diagram

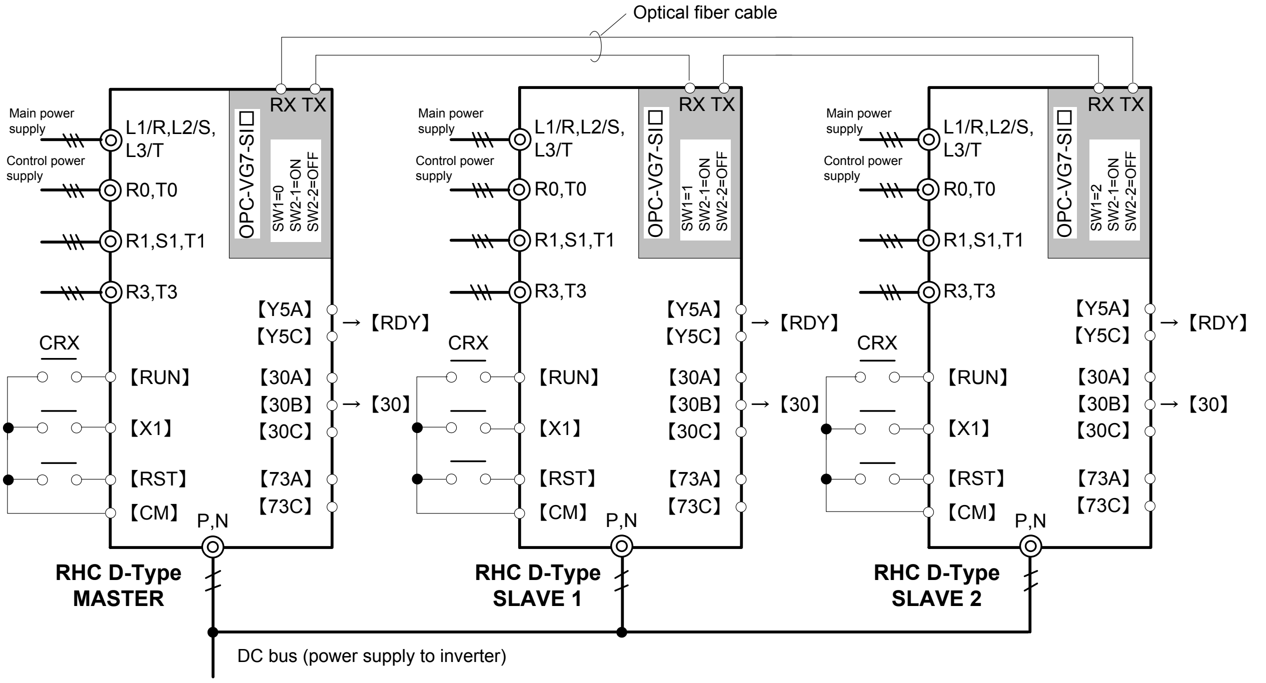


Figure 6.3.13-4: Parallel system connection diagram

Note

(1) Configure a sequence where the units are powered ON at the same time.
The parallel system does not detect any alarm unless the operation starts.

(2) If an alarm occurs (30X operation), all PWM converters are stopped by the alarm. To ensure the safety, open the RUN signals of all the converters.

(3) Configure a sequence where the run command is sent to the inverters after the ready-to-run [RDY] signals of all PWM converters have been confirmed.

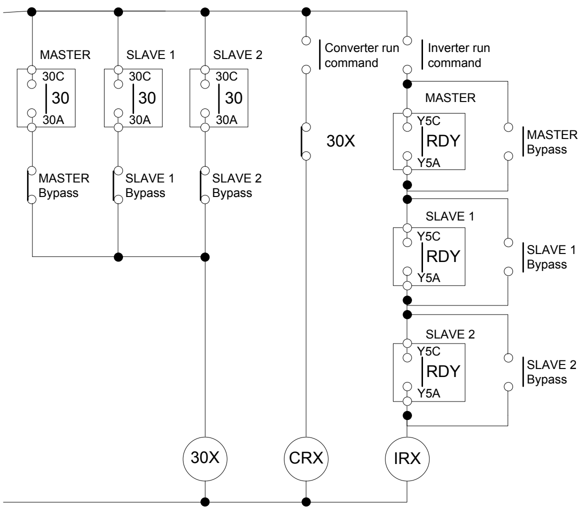


Figure 6.3.13-5: Converter run command sequence (1)

(4) The alarms of all PWM converters (units) can be simultaneously reset by inputting the [RST] signal from any unit. When switched to the single unit system, only the unit that inputs the [RST] signal is to be reset.

(5) When using the parallel/single unit system switching function, assign [OPT-DI] to the contact input of X1. Configure a sequence circuit where the [OPT-DI] signal is input and the run command bypasses the alarm circuits other than those for the single unit operation unit and inputs to only the single unit operation unit when switching to the single unit system.

(6) Input the run and stop commands to both the master and slave units.

(7) The run and stop commands are the same as the standard model.

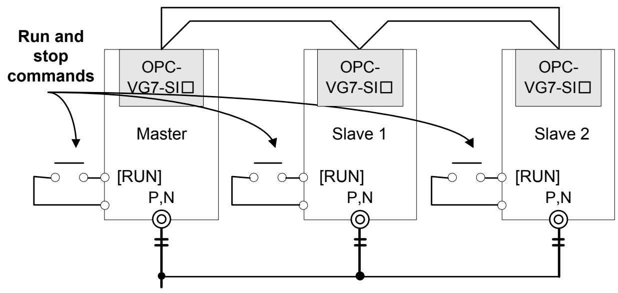


Figure 6.3.13-6: Converter run command sequence (2)

6.3.13.6 Charging circuit in parallel system

When only one charging circuit is used for the parallel system or when the PWM converter has the reduced unit (single unit) operation mode, select an appropriate charging circuit (charging resistor and electromagnetic contactor) based on the capacity calculated using Equation 6.3.13-1.

- Calculate the total capacity of the PWM converters and inverters connected to the DC bus bar (PN).
- After that, the total capacity is multiplied by "1/2". Select the appropriate charging resistor (R0) and electromagnetic contactor (73) from the appropriate PWM converter capacity stated in "6.3.12.2 List of peripherals with no filter stack used" according to the calculated capacity.

$$P_{(CHG)} = \frac{1}{2} \times \sum \left(P_{CNV} + P_{INV} \right) \quad \cdots \text{ Equation 6.3.13-1}$$

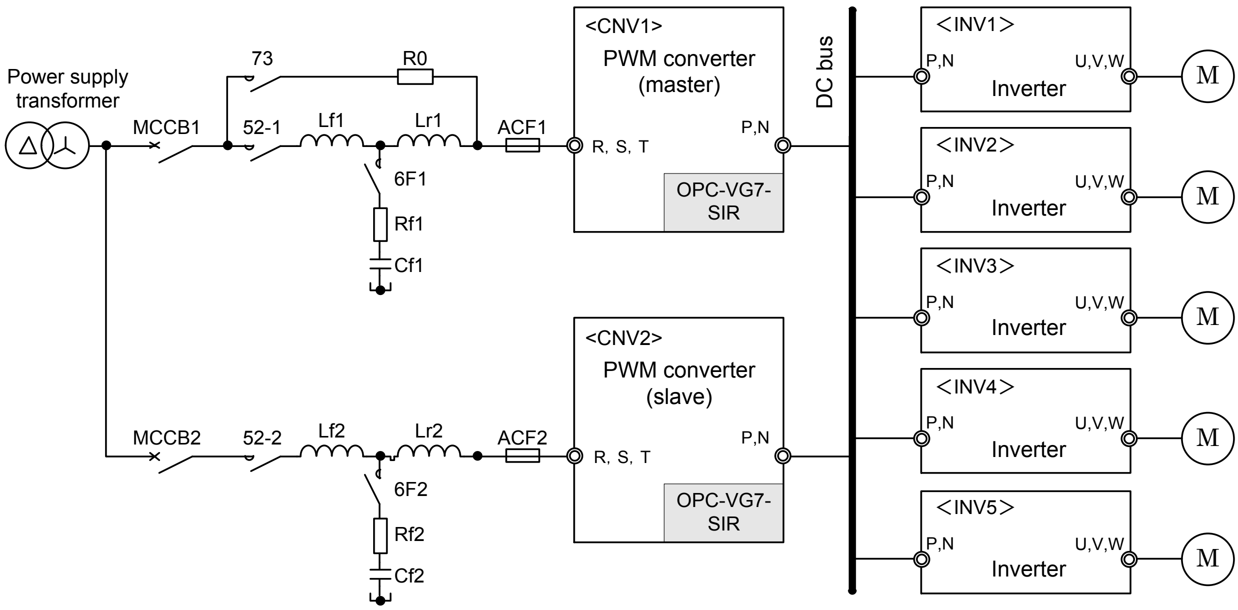
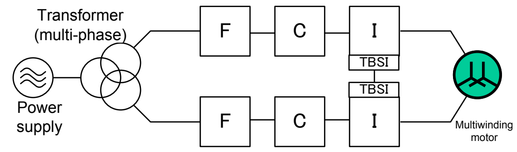
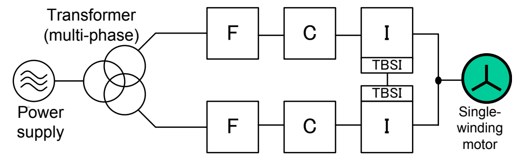
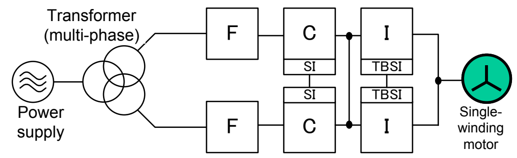
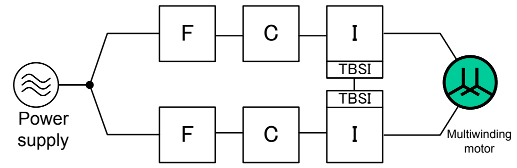
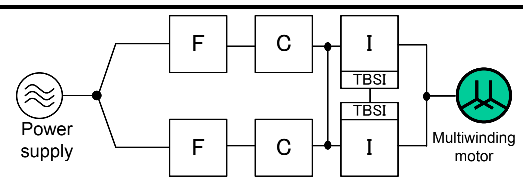
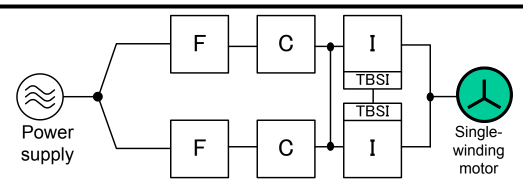


Figure 6.3.13-7: Parallel system configuration (such as configured by one charging circuit)

6.3.14 System configuration examples

No	System configuration diagram (Symbols in diagram) F: Filter circuit or filter stack (RHF-D) C: PWM converter (RHC-C,RHC-D) I: Inverter, TBSI, SI, SIR: Optical communication card (Option)	System configuration	Filter stack (RHF-D) application *1	Filter circuit (peripheral equipment) application
1		⦿ **Applicable** C: Up to 6 units I: Up to 6 parallel sets	⦿ **Applicable**	■ Unit type (RHC-C) ⦿ Applicable ■ Stack type (RHC-D) • RHC132S to 315S-4D ⇒ X Not applicable (*2) • RHC630B to 800B-4D ⇒ ⦿ Applicable
2		**X Not applicable** (For direct parallel connection, use No.3.)	—	—
3		⦿ **Applicable** C: Up to 6 parallel sets I: Up to 3 parallel sets	⦿ **Applicable**	■ Unit type (RHC-C) ⦿ Applicable ■ Stack type (RHC-D) • RHC132S to 315S-4D ⇒ X Not applicable *2 • RHC630B to 800B-4D ⇒ ⦿ Applicable
4		⦿ **Applicable** C: Up to 6 units I: Up to 6 parallel sets	⦿ **Applicable**	
5		**X Not applicable** (To ensure that all the PWM converters have the same output, use No.7.)	—	—
6		**X Not applicable** (To ensure that all the PWM converters have the same output, use No.8.)	—	—

*1 The filter stacks (RHF-D) are dedicated to the use with stack type PWM converters (RHC-D). It cannot be used with unit type PWM converters (RHC-C).

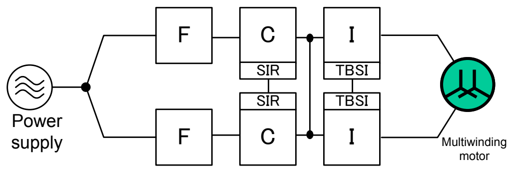
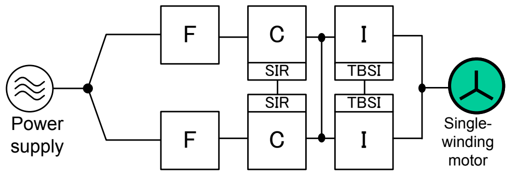
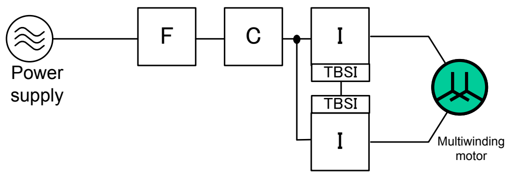
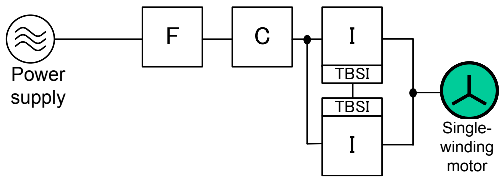
*2 There are restrictions on the use of a filter circuit (peripheral equipment) with stack type PWM converters (RHC-D). Refer to "6.3.12.2 List of peripherals with no filter stack used".

(Note 1) When using any of the above in direct parallel connection and multi-winding driving systems, ensure that all the inverters have the same capacity.

(Note 2) When a single PWM converter is used to drive multiple inverters, ensure that the PWM converter capacity is equal to or greater than the inverter capacity (total).

(Note 3) When a motor is run in a direct parallel connection system, there is a restriction on the wiring length of motor. Refer to "9.4.8 Wiring inductance" in Chapter 9.

(Note 4) Be sure to turn ON the main power to all the PWM converters at once.

No	System configuration diagram (Symbols in diagram) F: Filter circuit or filter stack (RHF-D) C: PWM converter (RHC-C,RHC-D) I: Inverter, TBSI, SI, SIR: Optical communication card (Option)	System configuration	Filter stack (RHF-D) application *1	Filter circuit (peripheral equipment) application
7		⊙ **Applicable** C: Up to 3 parallel sets I: Up to 6 parallel sets	⊙ **Applicable**	■ Unit type (RHC-C) ⊙ Applicable ■ Stack type (RHC-D) • RHC132S to 315S-4D ⇒ X Not applicable (*2) • RHC630B to 800B-4D ⇒ ⊙ Applicable
8		⊙ **Applicable** C: Up to 3 parallel sets I: Up to 3 parallel sets	⊙ **Applicable**	■ Unit type (RHC-C) ⊙ Applicable ■ Stack type (RHC-D) • RHC132S to 315S-4D ⇒ X Not applicable (*2) • RHC630B to 800B-4D ⇒ ⊙ Applicable
9		⊙ **Applicable** I: Up to 6 parallel sets	⊙ **Applicable**	
10		⊙ **Applicable** I: Up to 3 parallel sets	⊙ **Applicable**	

*1 The filter stacks (RHF-D) are dedicated to the use with stack type PWM converters (RHC-D). It cannot be used with unit type PWM converters (RHC-C).

*2 There are restrictions on the use of a filter circuit (peripheral equipment) with stack type PWM converters (RHC-D). Refer to "6.3.12.2 List of peripherals with no filter stack used".

(Note 1) When using any of the above in direct parallel connection and multi-winding driving systems, ensure that all the inverters have the same capacity.

(Note 2) When a single PWM converter is used to drive multiple inverters, ensure that the PWM converter capacity is equal to or greater than the inverter capacity (total).

(Note 3) When a motor is run in a direct parallel connection system, there is a restriction on the wiring length of motor. Refer to "9.4.8 Wiring inductance" in Chapter 9.

(Note 4) Be sure to turn ON the main power to all the PWM converters at once.

Note To connect PWM converters in parallel (so that all of them have the same output), ensure that they all have the same capacity.

6.3.15 Wiring

6.3.15.1 Precautions on wiring

(1) Main circuit (L1/R, L2/S, L3/T)

<u>When installing filter stacks (RHF-D series)</u>

The main circuit's power supply terminals L1/R, L2/S, and L3/T should be connected to the filter stack's terminals U1, V1, and W1.

<u>When not installing filter stacks (RHF-D series)</u>

The main circuit's power supply terminals L1/R, L2/S, and L3/T should be connected to the power supply through the charging circuits (R0, 73), pressurizing reactor (Lr), filter circuits (Lf/Rf/Cf), contactor for power supply (MC), and molded case circuit breaker (MCCB).

Install the charging circuit box, if applicable, between the power supply terminals (L1/R, L2/S, L3/T) and the electromagnetic contactor for the charging circuit. Do not connect any other device (such as a zero-phase reactor) between the charging circuit box and any of L1/R, L2/S, L3/T, R2, and T2.

The wirings of the filter circuit, pressurizing reactor, and charging circuit should be connected as illustrated in Figure 6.3.15-1.

The same circuit configuration is also used for the capacity range that uses the charging box. Additionally, an MCCB or electromagnetic contactor (MC) should be used to ensure that the main circuit can be separated from the power supply system when the protective function of the PWM converter or inverter operates (alarm trip) for some reason.

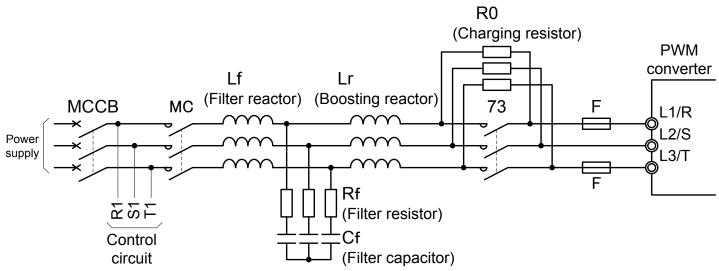


Figure 6.3.15-1: Main input circuit of PWM converter

Note (1) If the wiring is connected incorrectly, the PWM converter does not operate correctly, possibly causing damage to each unit.

(2) The pressurizing slightly generates electromagnetic sound due to high frequency current flowing through it.
If this electromagnetic sound is undesirable, store the boosting reactor into the cabinet.

1) Capacitor for filter

The wiring length between the filter capacitor and filter reactor must be **<u>5 m or less</u>**.

Note The effect of the filter may decrease due to the effect of the wiring inductance.

The filter resistor generates the heat during PWM converter operation. Even when the inverter stops, the PWM converter performs the constant power factor control as the PWM converter operates.
The surface temperature of this resistor may reach approx. 100°C. So, it is recommended to install the filter resistor on the cabinet ceiling (cabinet exterior).
(Refer to "12.5.2 Principles in designing layout in cabinets" in Chapter 12.)

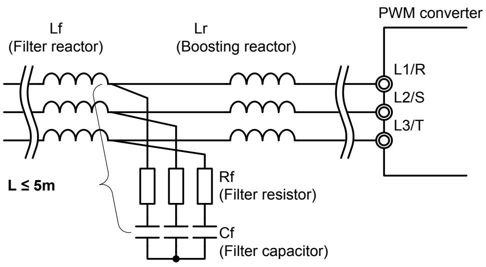


Figure 6.3.15-2: Wiring length of filter circuit

When storing the filter resistor into the cabinet, heat radiation measures must be investigated sufficiently. (Investigate a structure where the heat of the filter resistor does not adversely affect units stored inside the cabinet.)

(2) Main circuit (P(+), N(-))

Connect the converter output terminals (P(+),N(-)) to the inverter DC input terminals (P(+),N(-)). Bus bar connections are assumed. When connecting by wire, ensure that the distance between the stacks (i.e., between the PWM converter and inverter) is **within 2 meters**.

Similarly, when connecting wires to a branch line or terminal of the DC bus bar, ensure that the wiring length is **within 2 meters** and that the wires are in close contact (or twisted).

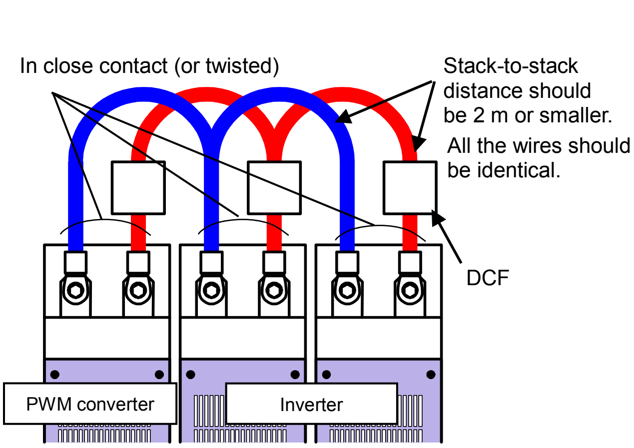


Figure 6.3.15-3: Connecting P and N terminals by wires

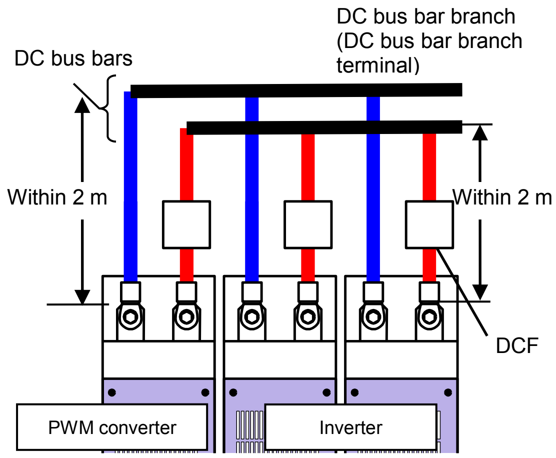


Figure 6.3.15-4: Connecting P and N terminals by bus bars

(3) Grounding

To ensure the safety and take noise prevention measures, be sure to ground the grounding terminals ⏚G of the PWM converter and inverter. In the Electrical Equipment Technical Standards, it is instructed to perform the grounding to the metallic frame of the electrical equipment so as to prevent accidents, such as electric shock or fire.

To connect the terminal, follow the steps below.

1) Connect to grounding electrodes on which class C grounding work (400V series) or class A grounding work (690V series) has been carried out in accordance with the Electrical Equipment Technical Standards.

2) Connect a thick wire to the grounding terminal with a short distance and connect the grounding terminal to the grounding pole dedicated to the inverter system.

For details, refer to "6.3.15.2 Wire size".

(4) Control Circuit

1) R1, S1, and T1 terminals

Since the R1, S1, and T1 terminals are intended to input the reference signal of the converter, connect a filter reactor (Lf) without waveform distortion to the power supply side. The wiring length must be **5 m or less**.

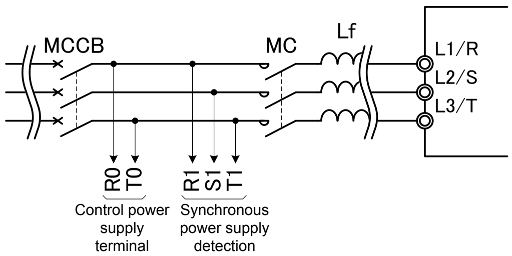


Figure 6.3.15-5: Connection of voltage detection terminal

2) Digital input terminals (RUN, X1, RST, PLC, CM)

① The digital input terminals are turned ON or OFF by the CM terminal.
On the other hand, when the digital input terminals are turned ON or OFF by the open collector output of the programmable controller (PLC) using the external power supply, they may malfunction due to round-about leakage circuit.
In this case, use the PLC terminal to make the connection as illustrated in Figure 6.3.15-6.

② When inputting using the relay contact, use a contact (high contact reliability) that does not cause any contact fault.
Example: Fuji Electric's control relay HH54PW

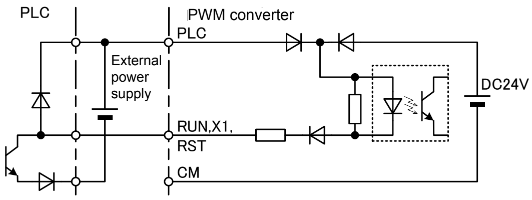


Figure 6.3.15-6: Prevention of round-about leakage by external power supply

3) Transistor output terminals (Y1, Y2, Y3, CME)

① Carefully check the polarities of the external power supply.

② When connecting a control relay, connect a surge absorption diode to both ends of the exciting coil.

4) Contact output terminals (Y5A, Y5C, 30A, 30B, 30C)

The contact specifications are 220 VAC, Max. 50 mA (cosφ= 0.3)/service life 200 thousand cycles, 24 VDC, 1 A (T = 7 ms)/service life 150 thousand cycles. If the terminals exceed these specification values, they should be relayed by the relays with large contact capacity. Additionally, when multiple contact points are needed, the contacts should be amplified using relays having many contact points.

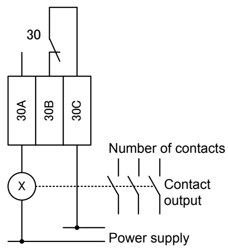


Figure 6.3.15-7: Amplification of the contact capacity and the number of contacts

5) Charging circuit control signals (73A, 73C)

These are control output signals for the charging circuit. Wire these signals, referring to the basic connection diagram.

6) Charging circuit drive input (RHF-D series filter stacks) (73-1, 73-2)

These are control input signals for the charging circuit. Wire these signals, referring to the basic connection diagram.

7) Sequence circuit

The breaker on the power supply side may trip depending on the failure contents of the PWM converter stack. In the standard circuit configuration, the sequence circuit is connected from the secondary side of the MCCB to the auxiliary power supply circuit. So, the auxiliary power supply is also shut down.

In this case, the failure status is not retained. As the breaker is turned ON next, and the contactor is turned ON, the damage inside the converter may expand. To prevent expansion of damage, it is recommended to retain the alarm signal of the PWM converter using the keep relay.

Additionally, a configuration needs to be investigated that stops the operation of the converter by taking the safety into consideration if the protective function on the inverter stack side operates (alarm trip).

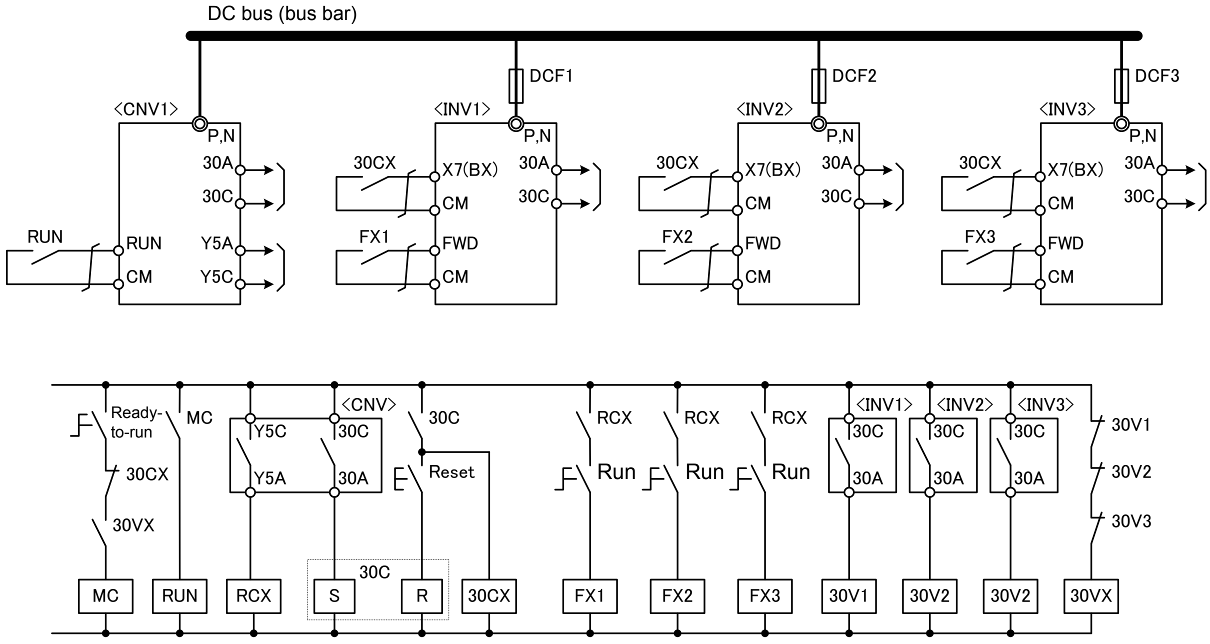


Figure 6.3.15-8: Example of sequence configuration

(5) Auxiliary control power input (R0, T0) and fan power input (CNV: R3, T3 INV: R1, T1)

The wiring to the "R0, T0" "R1, T1" and "R3, T3" terminals may vary depending on the applicable inverter/PWM converter. As described in the group shown in

Table 6.3.15-1, perform the wiring according to the applicable inverter/PWM converter.
Groups D and E apply to the configuration that connects the stack type inverter and PWM converter stack. This section describes group E.

Table 6.3.15-1: Wiring to R0 and T0 terminals

Group	Applicable inverter/converter	Wiring to R0 and T0 Terminals
A	FRN22G11S-☐ or less, FRN22P11S-☐ or less FRN15VG7S-☐ or less FRN500BVG7S-4DC to FRN800BVG7S-4DC FRN30G1S-2 or less, FRN55G1S-4 or less FRN37F1S-2 or less, FRN45F1S-4 or less	Insert the "b" contact of the contactor (52 or 73) to the wiring to R0, T0.
B	FRN30G11S-☐ or more, FRN30P11S-☐ or more FRN18.5VG7S-☐ or more	Switch "CN RXTX" inside the inverter. (For details, refer to the instruction manual for the inverter.)
C	FRN37G1S-2 or more, FRN75G1S-4 or more FRN45F1S-2 or more, FRN55F1S-4 or more	Insert the "b" contact of the isolation transformer or contactor (52 or 73) to the wiring to R0, T0.
D	INV: FRN30SVG1S-4 to FRN75SVG1S-4	Insert the "b" contact of the isolation transformer or contactor (52 or 73) to the wiring to R0, T0.
E	INV: FRN90SVG1S-4 or more FRN90SVG1S-69 or more CNV: RHC132S-4D or more RHC132S-69D or more	

Table 6.3.15-2: Wiring to CNV terminals R3 and T3 and to INV terminals R1 and T1

Group	Applicable inverter	Wiring to the "R1, T1" and "R3, T3" terminals
C	FRN37G1S-2 or more, FRN75G1S-4 or more FRN45F1S-2 or more, FRN55F1S-4 or more	Switch "CN R"/"CN W" inside the inverter. (For details, refer to the instruction manual for the inverter.)
D	INV: FRN30SVG1S-4 to FRN75SVG1S-4	No fan power supply is needed. Since the fan to be used is a DC fan, the power is supplied from the power supply inside each stack.
E	INV: FRN90SVG1S-4 or more FRN90SVG1S-69 or more CNV: RHC132S-4D or more RHC132S-69D or more	The wiring is needed. • Switch the "U1, U2" connector switch in each stack according to the power voltage specifications. 📖 Refer to "4.5.3 Wiring of main circuit and grounding terminals" in Chapter 4.

Even when the power supply is not input to the auxiliary control power input (R0, T0) terminals, the PWM converter or inverter can be operated. However, if the main power is turned off, the control power will also be shut down, and output signals of the PWM converter and inverter and the keypad will be no longer displayed. To retain an alarm output signal to be issued when the protective function operates or keep the keypad displayed even if the main power is shut down, connect the DC power supply to the auxiliary control power input terminals.

[R0 and T0 terminal ratings]

• 400V series: 380 to 480 VAC, 50/60Hz, maximum current: 0.5 A

• 690V series: 575 to 690 VAC, 50/60Hz, maximum current: 0.5 A

When adding an isolation transformer, select the appropriate isolation transformer based on the sum of the required capacities of the inverter and PWM converter, referring to the following tables:

■ **Required transformer capacity for the inverter (FRENIC-VG)**

<table>
<tr><th>Model</th><th>30S</th><th>37S</th><th>45S</th><th>55S</th><th>90S</th><th>110S</th><th>132S</th><th>160S</th><th>200S</th><th>220S</th><th>250S</th><th>280S</th><th>315S</th><th>355S</th><th>400S</th><th>450S</th><th>630B</th><th>710B</th><th>800B</th></tr>
<tr><td>FRN□VG1S-4□</td><td colspan="13">200 VA</td><td colspan="3">—</td><td colspan="3">600 VA</td></tr>
<tr><td>FRN□VG1S-69□</td><td colspan="4">—</td><td colspan="5">200 VA</td><td>—</td><td colspan="6">200 VA</td><td colspan="3">—</td></tr>
</table>

■ **Required transformer capacity for the converter (RHC-D series)**

<table>
<tr><th>Model</th><th>132S</th><th>160S</th><th>200S</th><th>220S</th><th>250S</th><th>280S</th><th>315S</th><th>355S</th><th>400S</th><th>450S</th><th>500S</th><th>630B</th><th>710B</th><th>800B</th></tr>
<tr><td>RHC□-4D□</td><td colspan="4">200VA</td><td>—</td><td colspan="2">200VA</td><td colspan="4">—</td><td colspan="3">600VA</td></tr>
<tr><td>RHC□-69D□</td><td colspan="3">200VA</td><td>—</td><td colspan="6">200VA</td><td colspan="4">—</td></tr>
</table>

[CNV: R3 and T3 terminal ratings, INV: R1 and T1 terminal ratings]

• 400V series: 380 to 440 VAC/50Hz, 380 to 480 VAC/60Hz, Maximum current: 1.0 A
(For phase-specific stacks, the maximum current is 3 times larger than above.)

• 690V series: 660 to 690 VAC, 50/60 Hz, maximum current 1.0 A
575 to 600 VAC, 50/60 Hz, maximum current 1.0 A

■ **Inverter (FRENIC-VG) - Rated capacity of terminals R1 and T1**

<table>
<tr><th>Model</th><th>90S</th><th>110S</th><th>132S</th><th>160S</th><th>200S</th><th>220S</th><th>250S</th><th>280S</th><th>315S</th><th>355S</th><th>400S</th><th>450S</th><th>630B</th><th>710B</th><th>800B</th></tr>
<tr><td>FRN□VG1S-4□</td><td colspan="5">100 VA</td><td colspan="4">200 VA</td><td colspan="3">—</td><td colspan="3">600 VA</td></tr>
<tr><td>FRN□VG1S-69□</td><td colspan="5">100 VA</td><td>—</td><td colspan="6">200 VA</td><td colspan="3">—</td></tr>
</table>

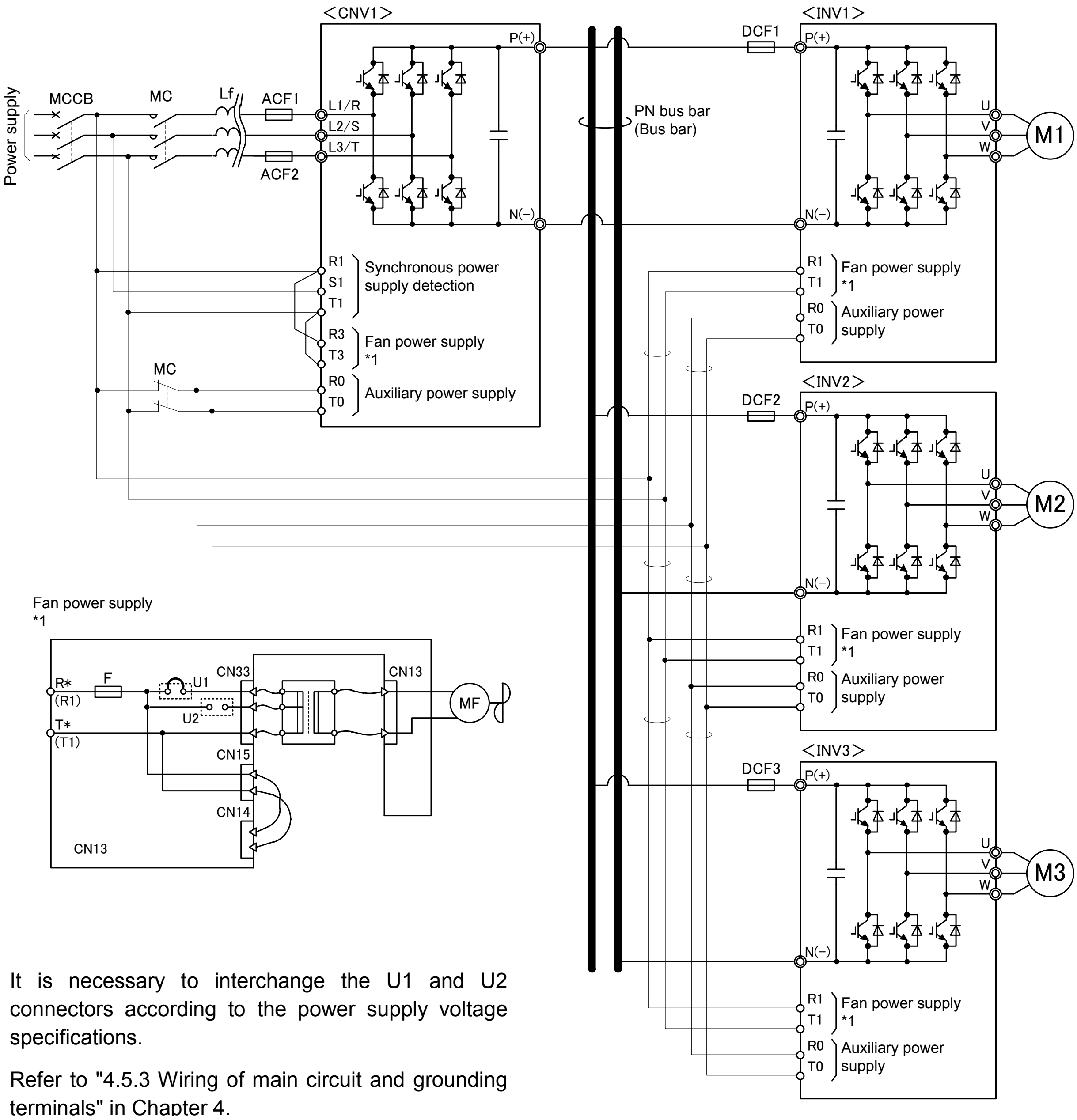
■ **Converter (RHC-D series) - Rated capacity of terminals R3 and T3**

<table>
<tr><th>Model</th><th>132S</th><th>160S</th><th>200S</th><th>220S</th><th>250S</th><th>280S</th><th>315S</th><th>355S</th><th>400S</th><th>450S</th><th>500S</th><th>630B</th><th>710B</th><th>800B</th></tr>
<tr><td>RHC□-4D□</td><td colspan="3">100VA</td><td>200VA</td><td>—</td><td colspan="2">200VA</td><td colspan="4">—</td><td colspan="3">600VA</td></tr>
<tr><td>RHC□-69D□</td><td colspan="3">100VA</td><td>—</td><td colspan="6">200VA</td><td colspan="4">—</td></tr>
</table>

If the fan power input is the same as the main power supply

PWM converters and inverters contain internal parts (such as the AC fan) that operate on the AC power. Therefore, "R3 and T3" terminals of a PWM converter and "R1 and T1" terminals of an inverter must be supplied with AC power.

Note that the PWM converters or inverters belonging to group D do not need this fan power supply.



*1 It is necessary to interchange the U1 and U2 connectors according to the power supply voltage specifications.

📖 Refer to "4.5.3 Wiring of main circuit and grounding terminals" in Chapter 4.

Figure 6.3.15-9: Example of connections when supplying fan power from the same system as main power supply

Figure 6.3.15-9 shows that the fan power supply is supplied at the same time when the PWM converter becomes ready to run.

There is no problem even when the connection is made from the primary side of the same MC as the synchronous power supply detection. In this case, if the fan ON/OFF control function setting of the PWM converter or inverter is set to the factory default ("disabled"), you can operate the fan by just turning ON the MCCB.

From view points of the energy saving and fan service life, it is recommended to change the function or construct the circuit as illustrated in the Figure.

Note: If the fan power supply switching connector is set incorrectly, the cooling fan does not operate at correct RPM and required air volume cannot be obtained. As a result, the overheat (OH1) or overload (OU1) protective function of the converter or inverter may operate (alarm trip).

Cautions on application to non-grounding system power supply

If a ground fault accident occurs on the inverter output side when the **power receiving voltage system of the PWM converter is not grounded**, a round-about leakage circuit may be constructed through the grounding. If this round-about leakage circuit is constructed, this may cause damage to the control power supply circuit of the PWM converter or inverter.

When using such non-grounding system power supply, use an insulation transformer for the input to the auxiliary control power input terminal of the PWM converter or inverter as illustrated in Figure 6.3.15-10 to insulate the power receiving voltage.

When insulating with the insulation transformer, it is not necessary to insert the "b"-contact of the MC.

Additionally, if the power supply system is not clear, it is also recommended to install the transformer in the same manner.

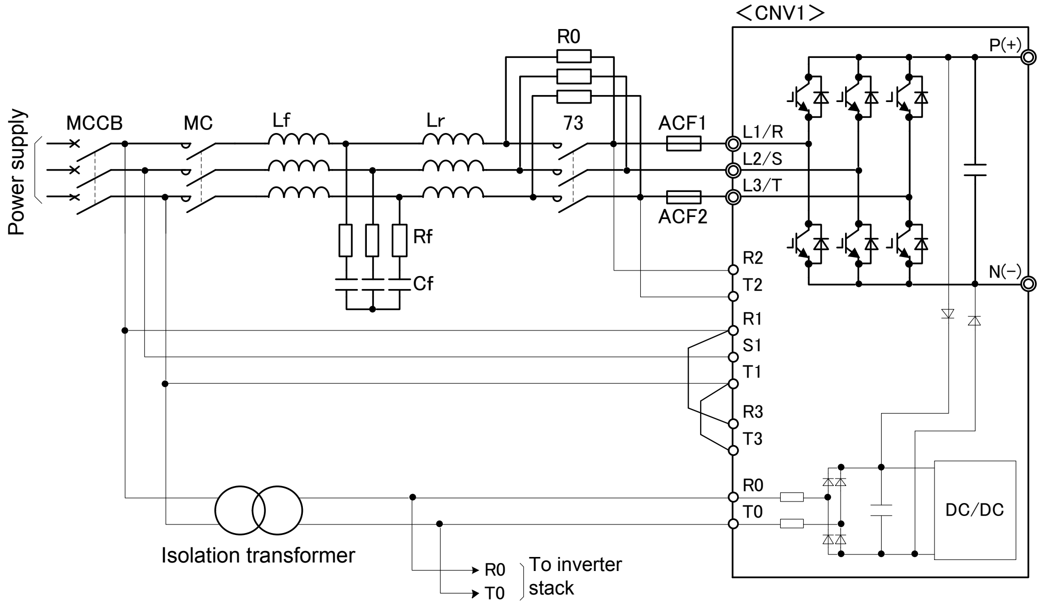


Figure 6.3.15-10: Example of connections with insulation transformer installed

Note: When connecting an earth leakage circuit breaker (ELCB), connect the terminals R0 and T0 to the primary side (power supply side) of the earth leakage circuit breaker.

If connected to the secondary side of the earth leakage circuit breaker, the earth leakage circuit breaker may malfunction since the terminals R0 and T0 of the main power supply inputs of the PWM converter (L1/R to L3/T) are single phase in response to three-phase inputs. When connecting terminals R0 and T0 to the primary side of the earth leakage circuit breaker, be sure to connect the transformer for insulation or the auxiliary "b" contact of the electromagnetic contactor (MC) to the position illustrated in the figure below.

* The following figure describes the PWM converter as an example. For a diode rectifier, perform also the connections in the same manner.

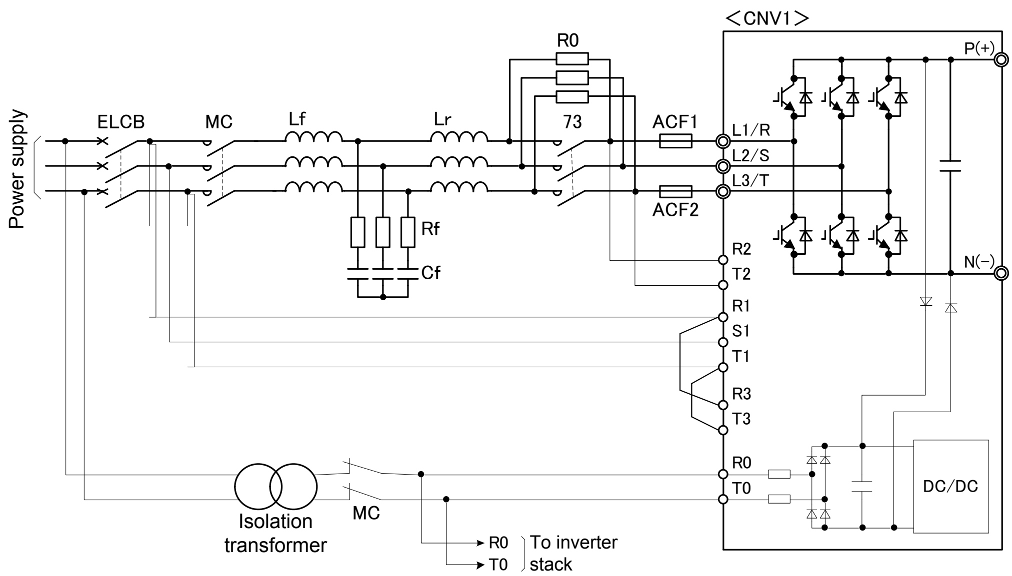


Figure 6.3.15-11: Connection of earth leakage circuit breaker (ELCB)

(6) Other cautions

Be sure to connect to a power supply with required power supply capacity or more stated in "6.3.2 Standard specifications".

If the power supply capacity is smaller than required, the initial charging cannot be performed correctly (power supply is failed) or the protective function of the PWM converter or inverter may operate (alarm trip) due to waveform distortion on the power supply side.

Additionally, if a small capacity transformer is used for the sequence check inside the cabinet, the similar problem may occur. In such case, open (turn OFF) the portion between the "RUN and CM" of the PWM converter, and perform the sequence check of other parts.

6.3.15.2 Wire size

The wire size of the main circuit can be calculated based on the equations shown below.

$$I_{AC} = \frac{kVA}{\sqrt{3} \times Vin \times \cos\theta} \ [A] \ \cdots \quad \text{Equation 6.3.15-1}$$

I_{filt} = Total r.m.s. value of filter capacitor

$$I_{DC} = \frac{P_{CNV}}{Vdc} \ [A] \ \cdots\cdot \quad \text{Equation 6.3.15-2}$$

$$I_{CHG} = \frac{Vin}{\sqrt{3} \times R0} \ [A_{p-p}] \ \cdots\cdot \quad \text{Equation 6.3.15-3}$$

Note: Design a structure where the portion from the output of the PWM converter to the DC bus bar is connected with the Cu bar as much as possible.

Additionally, when using a wire, the wiring length must be **2 m or less**.

- I_{AC} : PWM converter input current [A]
- I_{filt} : Filter circuit current [A]
- *IDC* : PWM converter output current [A]
- I_{CHG} : Charging circuit current [Ap-p]

The reactance components for the capacitor inside the PWM converter or inverter are not taken into consideration. Additionally, as the charging completion time is 1 sec. or less, select an wire with a short-time capacity (I2t). (Charging time: 0.5 sec.)

- kVA : Required power capacity of PWM converter [kVA]
- Vin : Input voltage of PWM converter [V]
- cos θ : Input power factor of PWM converter
- Pcnv : Rated capacity of PWM converter [kW]
- Vdc : Output voltage of PWM converter [V]
- R0 : Charging resistance [Ω]

<Precautions for selecting wire (for all types)>

Note
(1) An "IV wire," a "600 V HIV insulated wire," and a "600 V cross-linked polyethylene insulated wire" were used at permissible temperatures of 60°C, 75°C, and 90°C, respectively, and the values represent aerial wiring.
(2) Wire size is selected at supply voltage of 400 VAC.
(3) The wire size of the charging circuit is calculated based on the short-time allowable current.
(4) The grounding wire is cited from the permissible short circuit current defined in internal wire regulations.
(5) RHC630B to 800B-4D☐ is phase-by-phase stack type (single-phase composition per stack). Therefore, wire connected per stack is given here.

(1) 3-phase 400V series (MD spec)

1) Ambient temperature: 40°C

RHC□-4D□	Main input (including peripheral equipment)					Resistance circuit for filter				Charging circuit			Output: P(+), N(-)					Grounding wire [mm²]	Control wire [mm²]
	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [A]	Permissible temperature (Note 1)			Current [Adc]	Permissible temperature (Note 1)		Current [Ap-p]	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [Adc]		
	60°C	75°C	90°C			60°C	75°C	90°C		60°C	90°C		60°C	75°C	90°C				
132S	100	60	60		233	5.5	3.5	2	33	2	2	133	100	100	60		235	22	1.25
160S	150	100	100	t5×30 (150)	282								150		100	t4×40 (160)	285	38	
200S	200	150			353	8	5.5	3.5	44			266	200	150			355	60	
220S	200				384								250		150		386		
280S	325	200	150	t10×30 (300)	489	14	8	5.5	58	3.5	3.5	532	325	250	200	t8×50 (400)	491		
315S	2×200	250	200		550			8	64				2×200				552		
630B	4×325	2×325	2×250		1099	100	60	38	183	3.5	3.5	532	—	—	—		1102	150	
710B	—	3×325	2×325	t10×125 (1250)	1239				207				—	—	—	t8×50 (400)	1243		
800B	—	4×325			1396			60	233				—	—	—		1400		

* For the RHC630 to 800B-4D□, the wire or bus bar size is one phase (unit) worth.

2) Ambient temperature: 50°C

RHC□-4D□	Main input (including peripheral equipment)					Resistance circuit for filter				Charging circuit			Output: P(+), N(-)					Grounding wire [mm²]	Control wire [mm²]
	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [A]	Permissible temperature (Note 1)			Current [Adc]	Permissible temperature (Note 1)		Current [Ap-p]	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [Adc]		
	60°C	75°C	90°C			60°C	75°C	90°C		60°C	90°C		60°C	75°C	90°C				
132S	200	100	60		233	8	3.5	3.5	33	2	2	133	200	100	60		235	22	1.25
160S	250	150	100	t5×30 (150)	282								250	150	100	t4×40 (160)	285	38	
200S	325		150		353	14	5.5	5.5	44			266	325	200	150		355	60	
220S	2×200	200			384								2×200				386		
280S	2×250	250	200	t10×30 (300)	489	22	14	8	58	3.5	3.5	532	2x250	325	200	t8×50 (400)	491		
315S	2×325	325	250		550				64				2×325	2×325	250		552		
630B	—	3×325	2×325		1099	150	60	38	183	3.5	3.5	532	—	—	—		1102	150	
710B	—	4×325	3×250	t10 ×125 (1250)	1239		100	60	207				—	—	—	t8×50 (400)	1243		
800B	—	—	3×325		1396	200			233				—	—	—		1400		

* For the RHC630 to 800B-4D□, the wire or bus bar size is one phase (unit) worth.

(2) 3-phase 400V series (LD spec)

1) Ambient temperature: 40°C

RHC□-4D□	Main input (including peripheral equipment)					Resistance circuit for filter				Charging circuit			Output: P(+), N(-)					Grounding wire [mm²]	Control wire [mm²]
	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [A]	Permissible temperature (Note 1)			Current [Adc]	Permissible temperature (Note 1)		Current [Ap-p]	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [Adc]		
	60°C	75°C	90°C			60°C	75°C	90°C		60°C	90°C		60°C	75°C	90°C				
132S	150	100	100		282	5.5	3.5	2	33	2	2	133	150	100	100		285	38	1.25
160S	200	150		t5×30 (150)	353	8	5.5	3.5	44				200	150		t4×40 (160)	355	60	
200S					384							266	250		150		386		
280S	2×200	250	200	t10×30 (300)	550	14	8	8	64	3.5	3.5	532	2×200	250	200	t8×50 (400)	552		
315S		325	250		619		14		72				2×250	325	250		625	100	
630B	5×325	3×325	2×325		1239	100	60	38	207	3.5	3.5	532	—	—	—		1243	150	
710B	—	4×325		t10×125 (1250)	1396			60	233				—	—	—	t8×50 (400)	1400		
800B	—	5×325	4×325		1777	150	100	100	300				—	—	—		1750	200	

* For the RHC630 to 800B-4D□, the wire or bus bar size is one phase (unit) worth.

2) Ambient temperature: 50°C

RHC□-4D□	Main input (including peripheral equipment)					Resistance circuit for filter				Charging circuit			Output: P(+), N(-)					Grounding wire [mm²]	Control wire [mm²]
	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [A]	Permissible temperature (Note 1)			Current [Adc]	Permissible temperature (Note 1)		Current [Ap-p]	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [Adc]		
	60°C	75°C	90°C			60°C	75°C	90°C		60°C	90°C		60°C	75°C	90°C				
132S	250	150	100	t5×30 (150)	282	8	3.5	3.5	33	2	2	133	250	150	100	t4×40 (160)	285	38	1.25
160S	325		150		353	14	5.5	5.5	44				325	200	150		355	60	
200S	2×200	200			384							266	2×200				386		
280S	2×325	325	250	t10×30 (300)	550	22	14	8	64	3.5	3.5	532	2×325	325	250	t8×50 (400)	552		
315S		2×200			619	38		14	72				3×325	2×200	325		625	100	
630B	—	4×325	2×325	t10 ×125 (1250)	1239	150	100	60	207	3.5	3.5	532	—	—	—	t8×50 (400)	1243	150	
710B	—	5×325	3×325		1396	200			233				—	—	—		1400		
800B	—	—	5×325		1777	250	150	100	300				—	—	—		1750	200	

* For the RHC630 to 800B-4D□, the wire or bus bar size is one phase (unit) worth.

(3) Three-phase 690V series, IEC standard (MD spec.)

1) Ambient temperature: 40°C

RHC□-69D□	Main input (including peripheral equipment)					Output: P(+), N(-)					Grounding wire [mm²]	Control wire [mm²]
	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [A]	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [Adc]		
		75°C	90°C				75°C	90°C				
132S		38	22	t5×30 (150)	135		38	22	t4×40 (160)	140	22	1.25
160S			38		163			38		170		
200S		95			205		60	60		212		
250S		100	60	t10×30 (300)	253		100		t8×50 (400)	261	38	
280S			100		283			100		293		
315S					319		150			329		
355S		150			359					373		
400S			150		405			150		418	60	
450S		200			455		200			470		

Note 1) PVC was used for permissible temperature of 70 °C, and XLPE for permissible temperature of 90 °C.

Note 2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

(4) Three-phase 690V series, IEC standard (LD spec.)

1) Ambient temperature: 40°C

RHC□-69D□	Main input (including peripheral equipment)					Output: P(+), N(-)					Grounding wire [mm²]	Control wire [mm²]
	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [A]	Permissible temperature (Note 1)			Bus bar size [mm²]	Current [Adc]		
		75°C	90°C				75°C	90°C				
132S		38	38	t5×30 (150)	163		38	38	t4×40 (160)	170	22	1.25
160S		60			205		60	60		212		
200S			60		253					231		
250S		100	100	t10×30 (300)	283		100	100	t8×50 (400)	293	38	
280S					319		150			329		
315S		150			359					373		
355S			150		405			150		418	60	
400S		200			455		200			470		

Note 1) PVC was used for permissible temperature of 70 °C, and XLPE for permissible temperature of 90 °C.

Note 2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

(5) Three-phase 690V series, domestic selection (MD spec.)

1) Ambient temperature: 40°C

RHC□-69D□	Main input (including peripheral equipment): Permissible temperature (Note 1)	Main input: Permissible temperature 75°C	Main input: Permissible temperature 90°C	Main input: Bus bar size [mm²]	Main input: Current [A]	Output: P(+), N(-): Permissible temperature (Note 1)	Output: Permissible temperature 75°C	Output: Permissible temperature 90°C	Output: Bus bar size [mm²]	Output: Current [A]	Grounding wire [mm²]	Control wire [mm²]
132S		38	22	t5×30 (150)	135		38	22	t4×40 (160)	140	22	1.25
160S			38		163			38		170		
200S		60			205		60	60		212		
250S		100	60	t10×30 (300)	253		100		t8×50 (400)	261	38	
280S			100		283			100		293		
315S					319		150			329		
355S		150			359					373		
400S			150		405			150		418	60	
450S		200			455		200			470		

Note 1) PVC was used for permissible temperature of 70 °C, and XLPE for permissible temperature of 90 °C.

Note 2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

(6) Three-phase 690V series, domestic selection (LD spec.)

1) Ambient temperature: 40°C

RHC□-69D□	Main input (including peripheral equipment): Permissible temperature (Note 1)	Main input: Permissible temperature 75°C	Main input: Permissible temperature 90°C	Main input: Bus bar size [mm²]	Main input: Current [A]	Output: P(+), N(-): Permissible temperature (Note 1)	Output: Permissible temperature 75°C	Output: Permissible temperature 90°C	Output: Bus bar size [mm²]	Output: Current [A]	Grounding wire [mm²]	Control wire [mm²]
132S		38	38	t5×30 (150)	163		38	38	t4×40 (160)	170	22	1.25
160S		60			205		60	60		212		
200S			60		253					231		
250S		100	100	t10×30 (300)	283		100	100	t8×50 (400)	293	38	
280S					319		150			329		
315S		150			359					373		
355S			150		405			150		418	60	
400S		200			455		200			470		

Note 1) PVC was used for permissible temperature of 70 °C, and XLPE for permissible temperature of 90 °C.

Note 2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

6.3.16 External dimensions

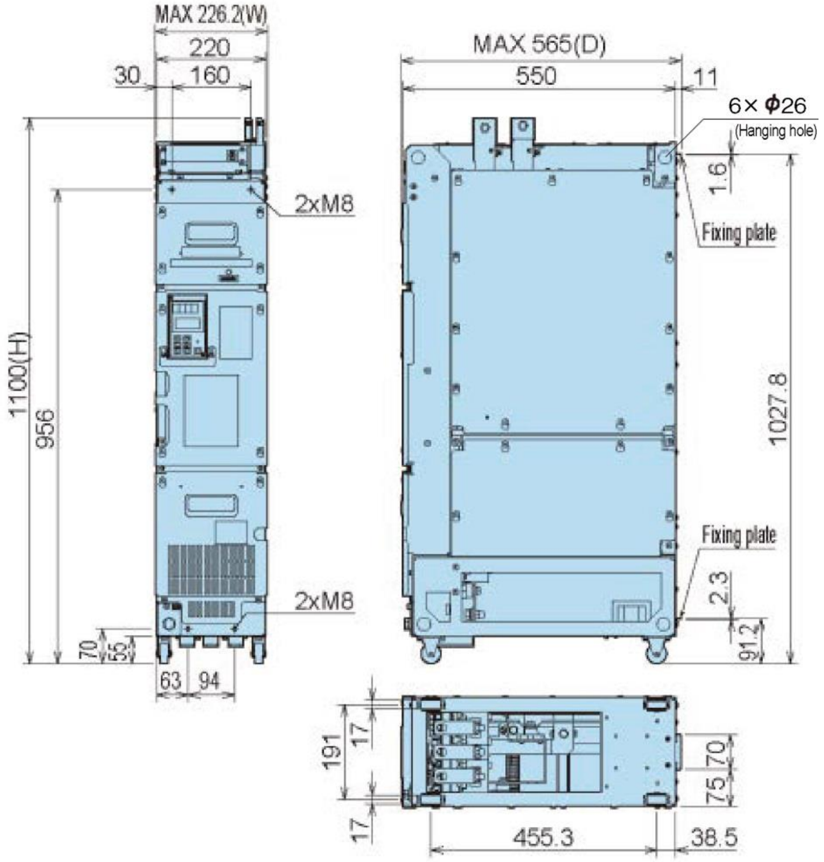
6.3.16.1 List of external dimensions - RHC-D series (stack type)

[Unit: mm]

<table>
<tr><th>Power supply voltage</th><th>Model</th><th>Figure</th><th>W</th><th>H</th><th>D</th><th>Approx. mass [kg]</th><th>Remarks</th></tr>
<tr><td rowspan="9">400V series</td><td>RHC132S-4D□</td><td rowspan="3">A</td><td rowspan="3">226.2</td><td rowspan="3">1100</td><td rowspan="3">565</td><td rowspan="3">95</td><td rowspan="3"></td></tr>
<tr><td>RHC160S-4D□</td></tr>
<tr><td>RHC200S-4D□</td></tr>
<tr><td>RHC220S-4D□</td><td rowspan="3">B</td><td rowspan="3">226.2</td><td rowspan="3">1400</td><td rowspan="3">565</td><td>125</td><td rowspan="3"></td></tr>
<tr><td>RHC280S-4D□</td><td rowspan="2">135</td></tr>
<tr><td>RHC315S-4D□</td></tr>
<tr><td>RHC630B-4D□</td><td rowspan="3">C</td><td rowspan="3">226.2</td><td rowspan="3">1400</td><td rowspan="3">565</td><td rowspan="3">135×3</td><td rowspan="3">A set of three stacks constitutes a single inverter unit.</td></tr>
<tr><td>RHC710B-4D□</td></tr>
<tr><td>RHC800B-4D□</td></tr>
<tr><td rowspan="9">690V series</td><td>RHC132S-69D□</td><td rowspan="3">A</td><td rowspan="3">226.2</td><td rowspan="3">1100</td><td rowspan="3">565</td><td rowspan="3">105</td><td rowspan="3"></td></tr>
<tr><td>RHC160S-69D□</td></tr>
<tr><td>RHC200S-69D□</td></tr>
<tr><td>RHC250S-69D□</td><td rowspan="6">B</td><td rowspan="6">226.2</td><td rowspan="6">1400</td><td rowspan="6">565</td><td rowspan="6">140</td><td rowspan="6"></td></tr>
<tr><td>RHC280S-69D□</td></tr>
<tr><td>RHC315S-69D□</td></tr>
<tr><td>RHC355S-69D□</td></tr>
<tr><td>RHC400S-69D□</td></tr>
<tr><td>RHC450S-69D□</td></tr>
</table>

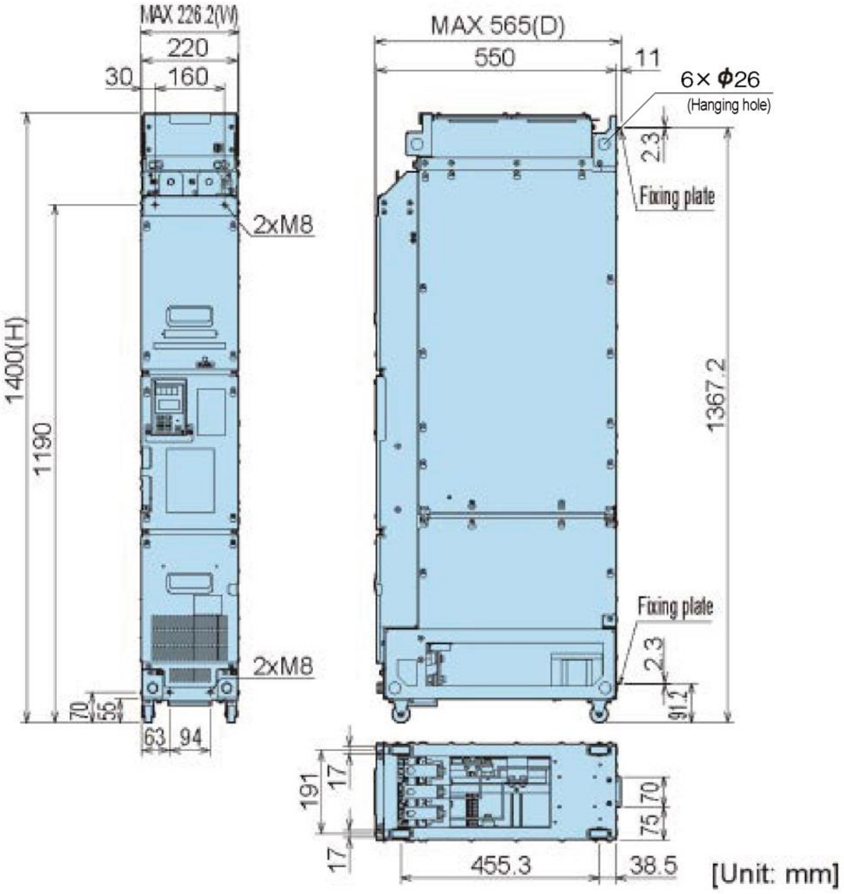
6.3.16.2 External dimensions

(1) Figure A (Frame 3 size: RHC132S-4D☐ to RHC200S-4D☐, RHC132S-69D☐ to RHC200S-69D☐)

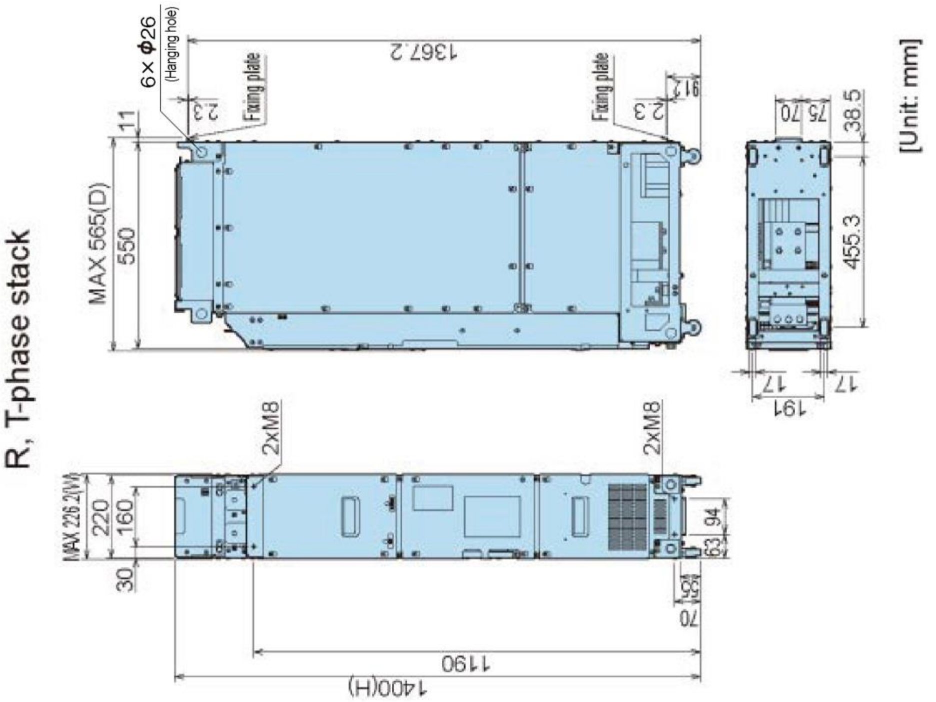


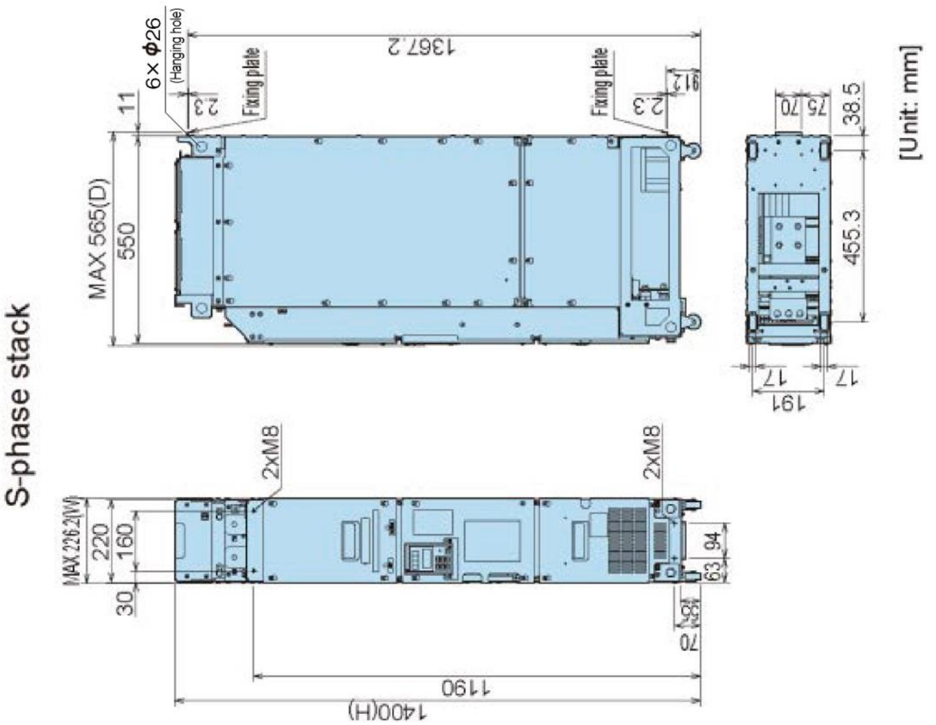
[Unit: mm]

(2) Figure B (Frame 4 size: RHC220S-4D☐ to RHC315S-4D☐, RHC250S-69D☐ to RHC450S-69D☐)



(3) Figure C (Frame 4 size: RHC630B-4D☐ to RHC800B-4D☐)

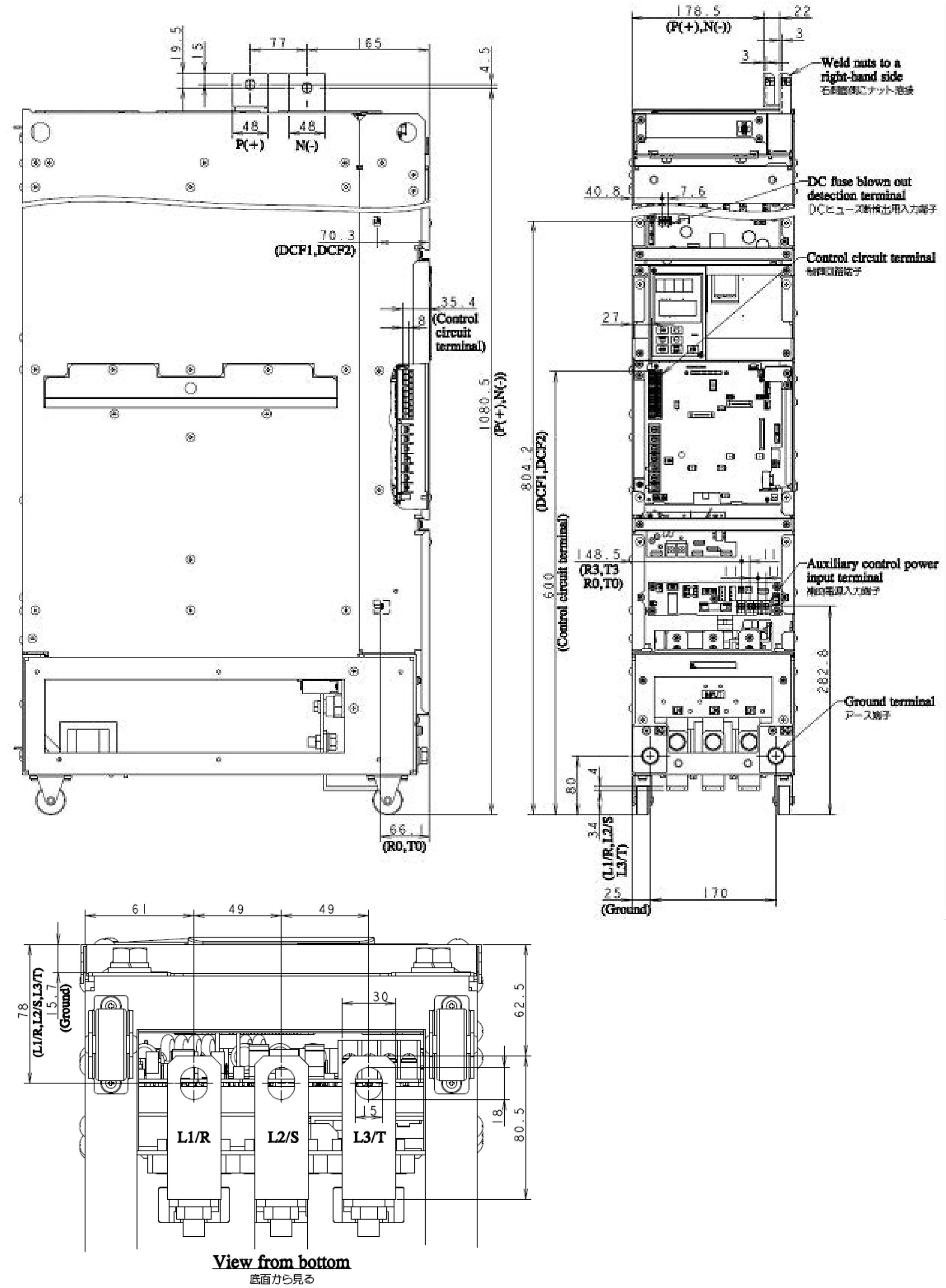




6.3.17 Terminal positions

(1) Main circuit terminals

Unit: [mm]



6.3.17-1: Frame 3 size (RHC132S to 200S-4D☐)

Unit: [mm]

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

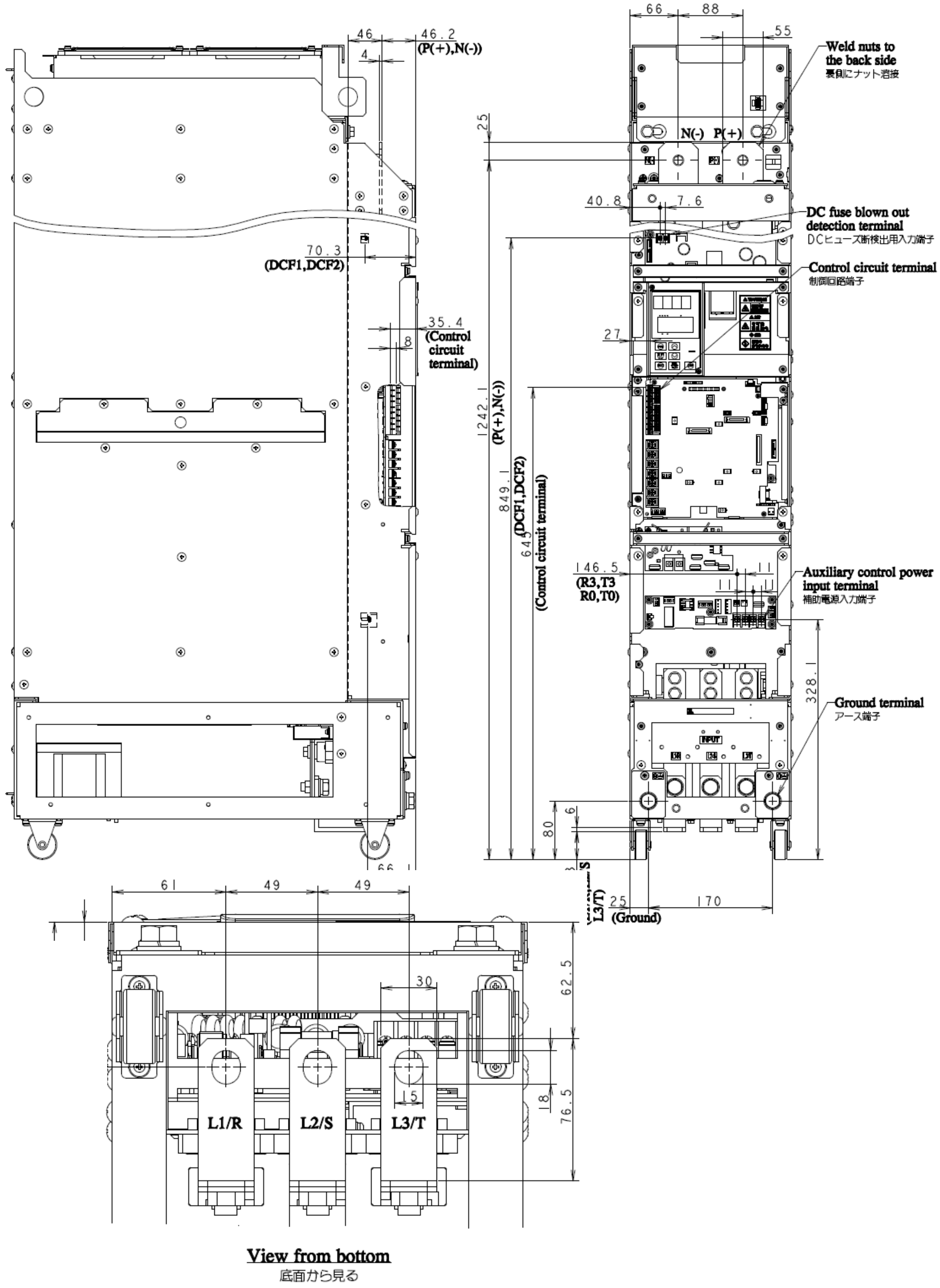


Figure 6.3.17-2: Frame 4 size (RHC220S to 315S-4D☐)

Unit: [mm]

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

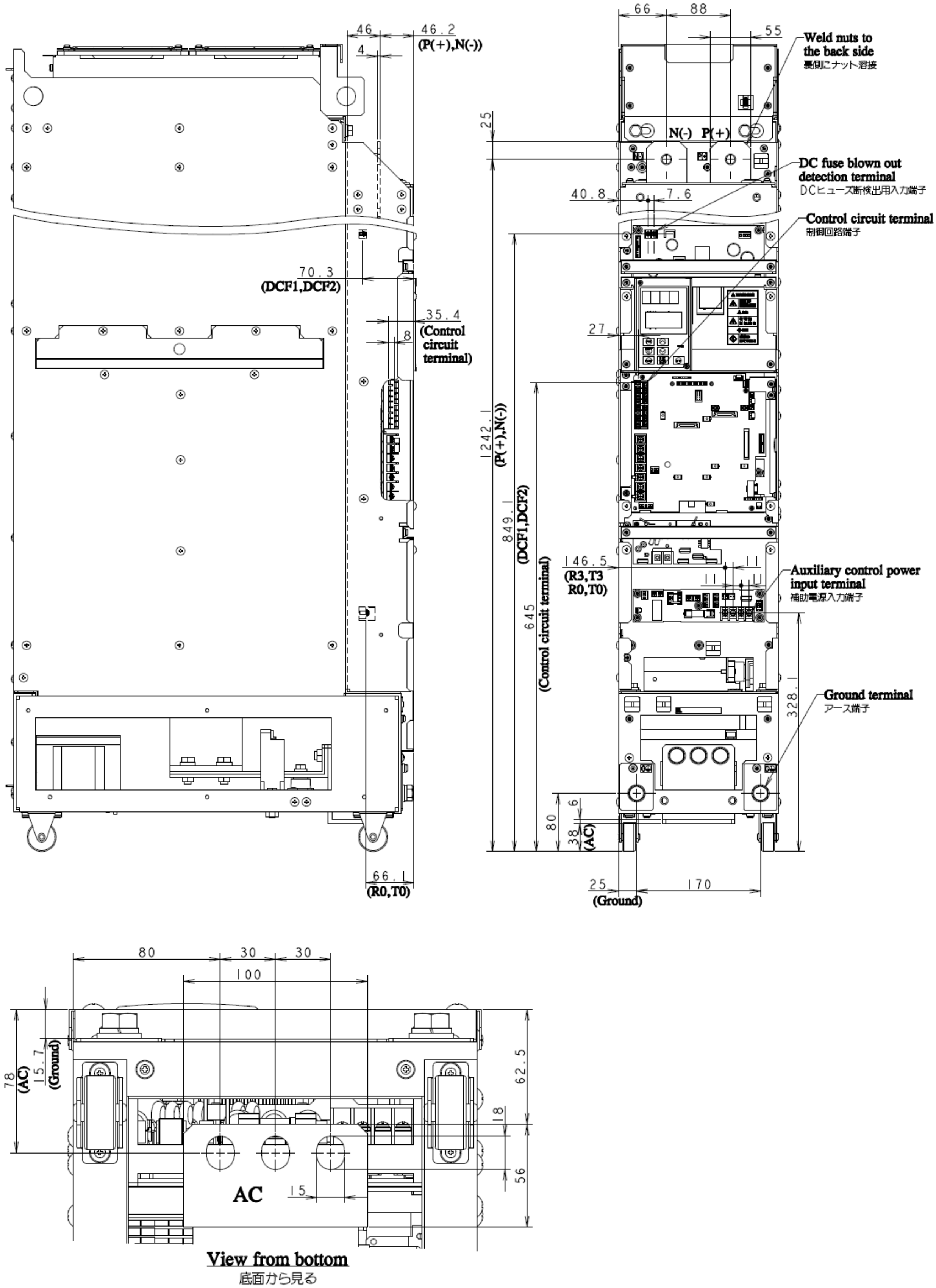


Figure 6.3.17-3: Frame 4 size (RHC630B to 800B-4D☐, S-phase)

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

Unit: [mm]

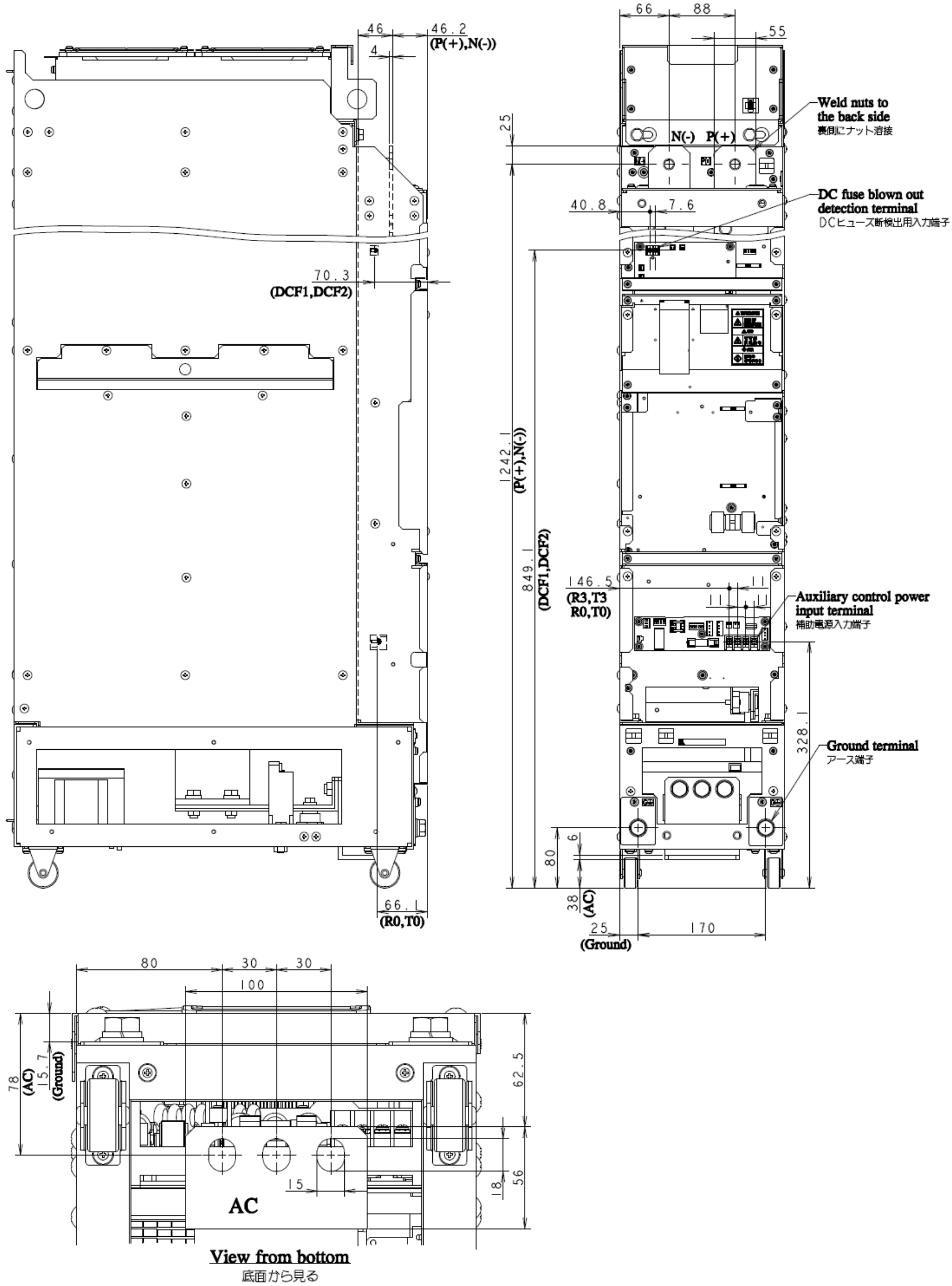


Figure 6.3.17-4: Frame 4 size (RHC630B to 800B-4D□, R-phase, T-phase)

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

Unit: [mm]

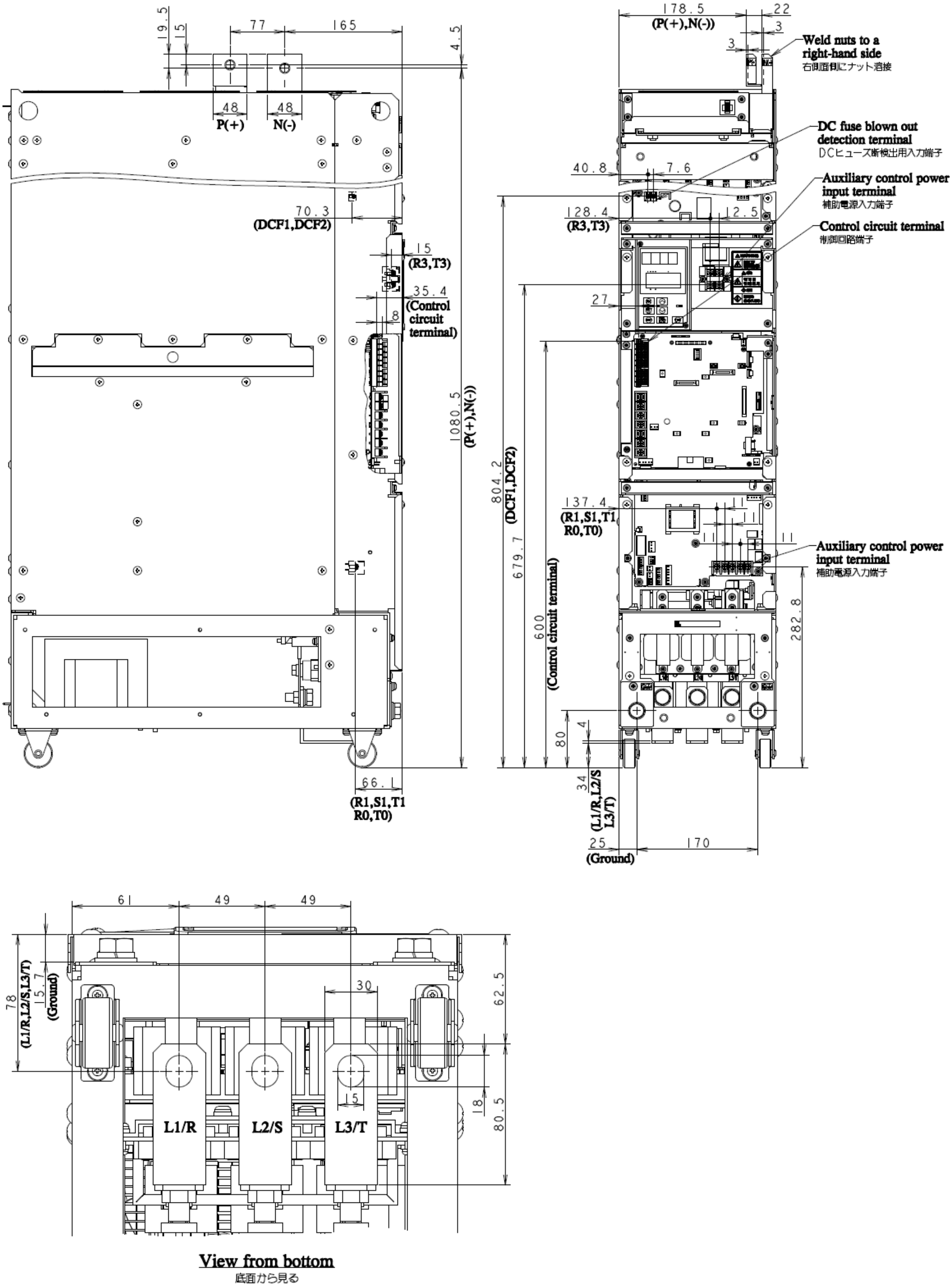


Figure 6.3.17-5: Frame 3 size (RHC132S to 200S-69D☐)

Unit: [mm]

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

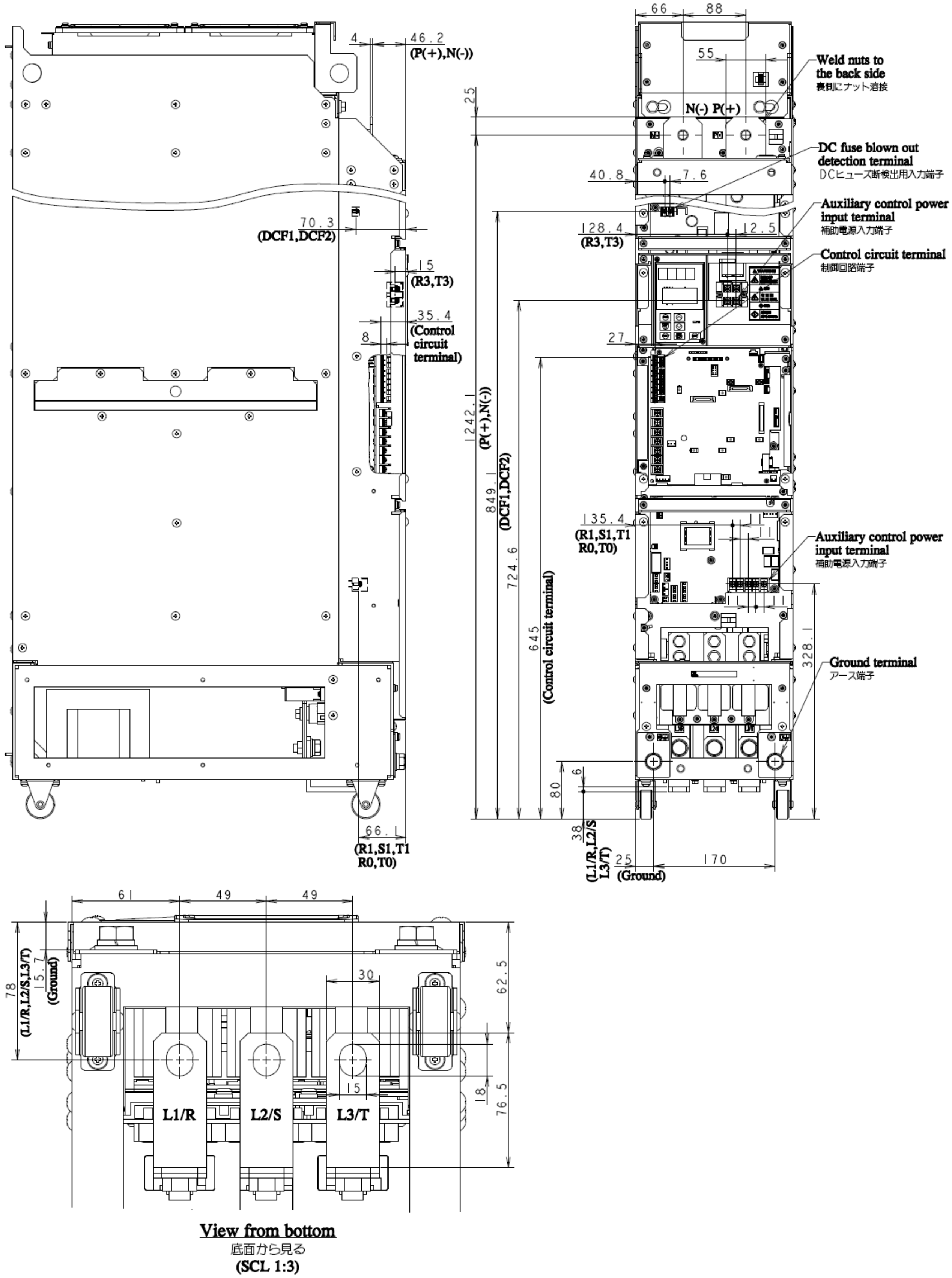
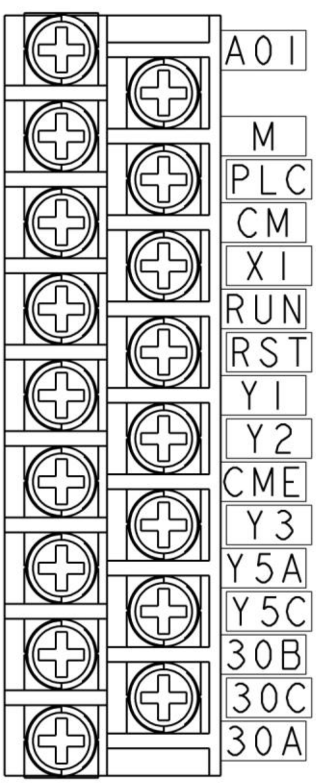


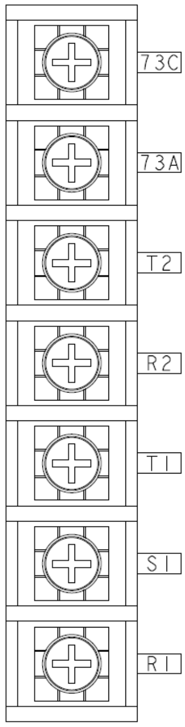
Figure 6.3.17-6: Frame 4 size (RHC250S to 450S-69D☐)

(2) Control Circuit terminals

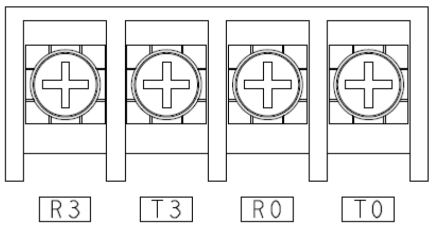
■ **400V series**



Screw size: M3



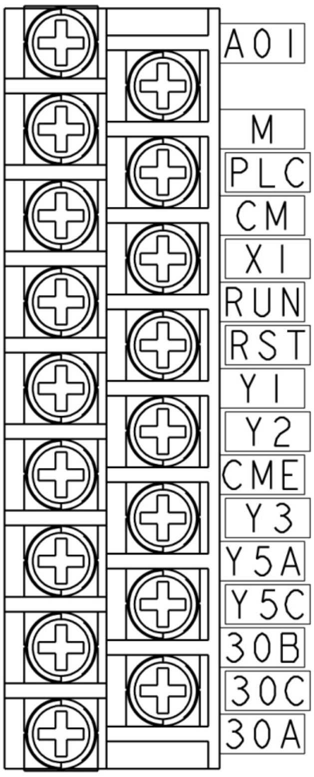
Screw size: M4



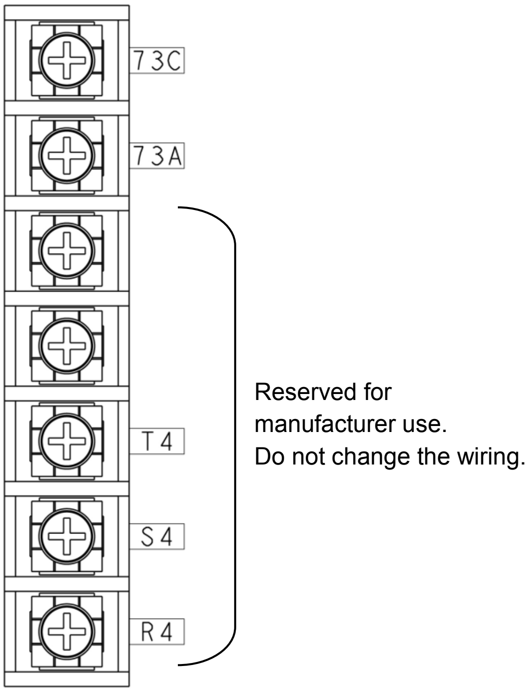
Screw size: M4

Figure 6.3.17-7: Control terminal layout (400V series)

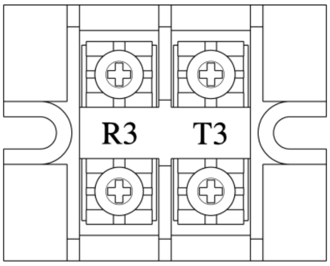
■ **690V series**



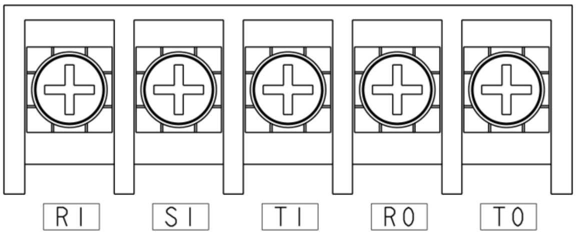
Screw size: M3



Screw size: M4



Screw size: M4



Screw size: M4

Figure 6.3.17-8 Control terminal layout (690V series)

6.3.18 Peripheral equipment external dimensions

(1) Pressurizing reactor (LR4-□□□C)

Figure A

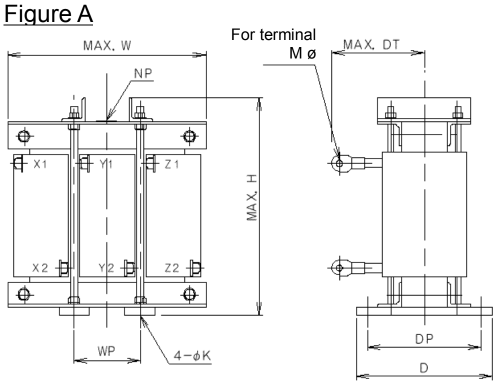
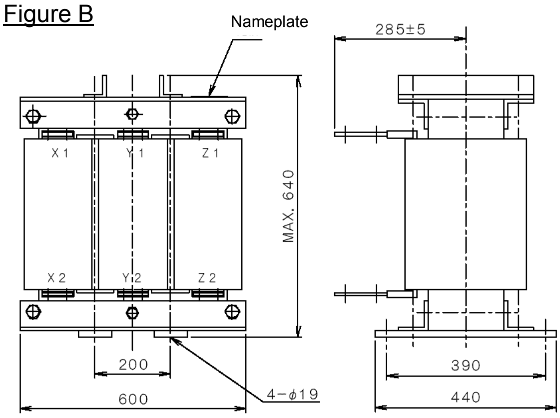


Figure B



Details of terminals

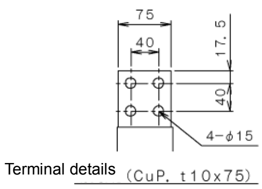
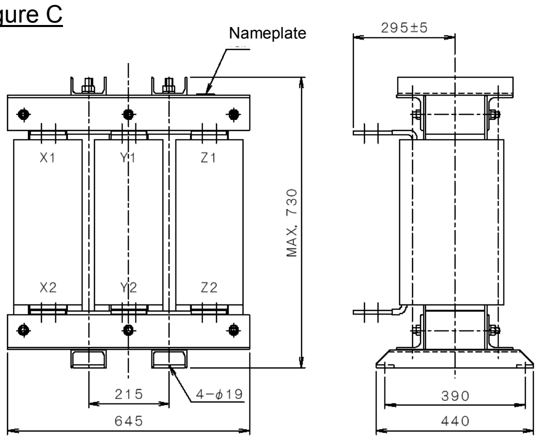
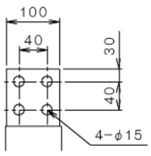


Figure C



Details of terminals



LR4-710C: CuP.t8×100
LR4-800C: CuP.t10×100
LR4-1000C: CuP.t12×100

Voltage	Model	Rated current [A]	Dimensions [mm]								Mass [kg]	Figure	Heat resistant class
			W	WP	D	DP	DT	H	K	Mϕ			
400 V	LR4-160C	304	380	125	300	260	185	550	15	M12	140	A	H
	LR4-220C	418	450	150	330	290	230	620	15	M12	200		
	LR4-280C	532	480	160	330	290	240	740	15	M16	250		
	LR4-315C	599	480	160	340	300	250	760	15	M16	270		
	LR4-355C	674	480	160	355	315	255	830	15	M16	310		
	LR4-400C	760	480	160	380	330	260	890	19	M16	340		
	LR4-500C	950	525	175	410	360	290	960	19	M16	420		
	LR4-630C	1200	600	200	440	390	285	640	19	—	450	B	
	LR4-710C	1350	645	215	440	390	295	730	19	—	510	C	
	LR4-800C	1520	690	230	450	400	290	850	19	—	600		
	LR4-1000C	1750	770	255	550	480	340	940	23	—	950		

(2) Filter reactor (LFC4-□□□C)

Figure A

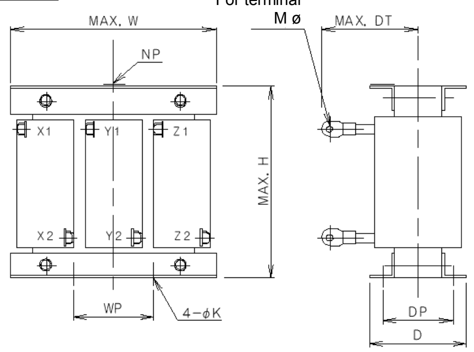


Figure B

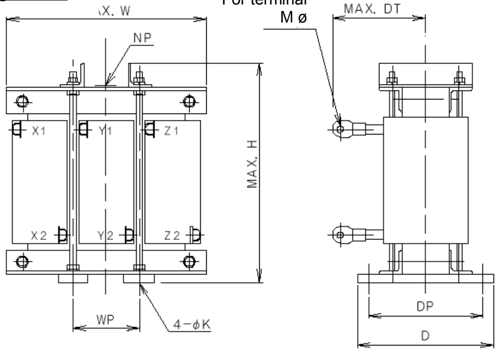
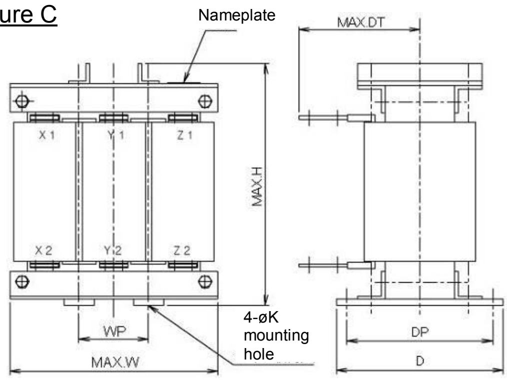
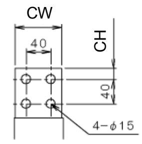


Figure C



Details of terminals
LFC4-630C: CuP. t10×75
LFC4-710C: CuP. t8×100
LF4-800C: CuP. t10×100
LFC4-1000C: CuP. t12×100



Voltage	Model	Rated current [A]	Dimensions [mm]										Mass [kg]	Figure	Heat resistant class
			W	WP	D	DP	DT	H	K	M	CW	CH			
400 V	LFC4-160C	304	255	85	137	110	150	245	10	M12	—	—	22	A	H
	LFC4-220C	418	300	100	210	180	170	320	10	M12	—	—	35	B	
	LFC4-280C	532	330	110	230	195	195	330	12	M16	—	—	43		
	LFC4-315C	599	315	105	230	195	200	365	12	M16	—	—	48		
	LFC4-355C	674	315	105	235	200	210	395	12	M16	—	—	53		
	LFC4-400C	760	345	115	235	200	235	420	12	M16	—	—	60		
	LFC4-500C	950	345	115	240	205	240	480	12	M16	—	—	72		
	LFC4-630C	1200	435	145	295	255	200	550	15	—	75	17.5	175	C	
	LFC4-710C	1350	480	160	295	255	215	570	15	—	100	30	190		
	LFC4-800C	1520	480	160	320	270	220	600	15	—	100	30	220		
	LFC4-1000C	1750	480	160	320	270	240	700	15	—	100	30	240		

(3) Filter capacitor (CF4-□□□C)

Figure A

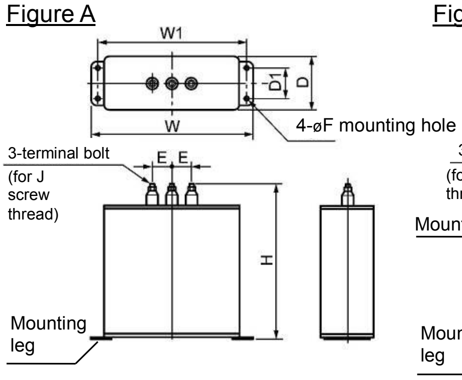
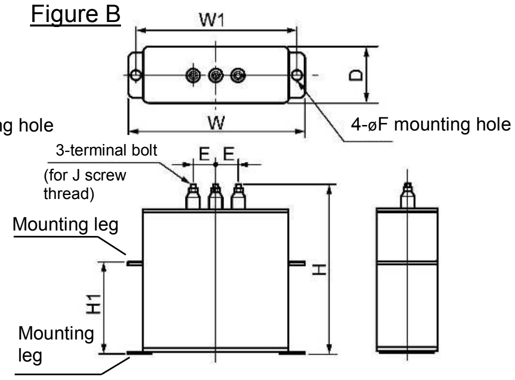


Figure B



Note

- Install vertically. Do not install horizontally.
- Be sure to fasten all the mounting legs to the panel, etc. Figure A: Two (2) mounting legs, Figure B: Four (4) mounting legs

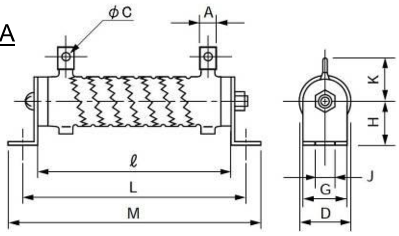
Vibration or impact may cause breakage.

Voltage	Model	Dimensions [mm]									Mass [kg]	Figure	Quantity used
		W	W1	D	D1	E	F	H	H1	J			
400 V	CF4-160C	280	265	90	55	80	7	260	—	M6	6.0	A	1
	CF4-220C	435	400	100	—	80	15 x 20 slotted hole	310	125	M12	13.0	B	
	CF4-280C	435	400	100	—	80	15 x 20 slotted hole	350	165	M12	15.0	B	
	CF4-315C	435	400	100	—	80	15 x 20 slotted hole	460	275	M12	20.0	B	
	CF4-355C	435	400	100	—	80	15 x 20 slotted hole	520	335	M12	23.0	B	
	CF4-400C	435	400	100	—	80	15 x 20 slotted hole	610	425	M12	27.0	B	
	CF4-500C	435	400	100	—	80	15 x 20 slotted hole	310	125	M12	13.0	B	2
	CF4-630C	435	400	100	—	80	15 x 20 slotted hole	460	275	M12	20.0	B	
	CF4-710C	435	400	100	—	80	15 x 20 slotted hole	520	335	M12	23.0	B	
	CF4-800C	435	400	100	—	80	15 x 20 slotted hole	610	425	M12	27.0	B	
	CF4-1000C	435	400	100	—	80	15 x 20 slotted hole	610	425	M12	27.0	B	3

Note 1) The models CF4-500C to CF4-800C use two capacitors while the CF4-1000C use three capacitors. (Parallel connection)
If ordered with quantity = "1", two capacitors will be delivered for the CF4-500C to CF4-800C or three capacitors for the CF4-1000C.

(4) Filter resistor

Figure A



Model	Dimensions [mm]										Mass [kg]	Figure	Quantity used
	M	L	l	D	G	H	K	A	J	φC			
GRZG400 0.38 Ω	411	385	330	47	40	40	46	16	9.5	8.2	0.85	A	3
GRZG400 0.26 Ω													
GRZG400 0.53 Ω													

(Filter resistor - continued)

Figure B

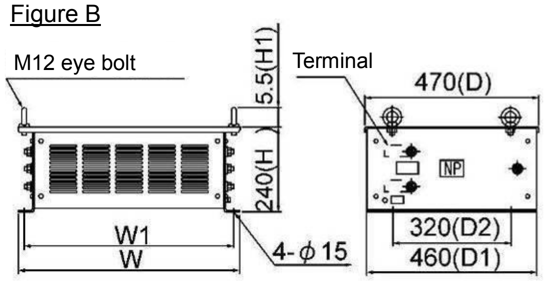
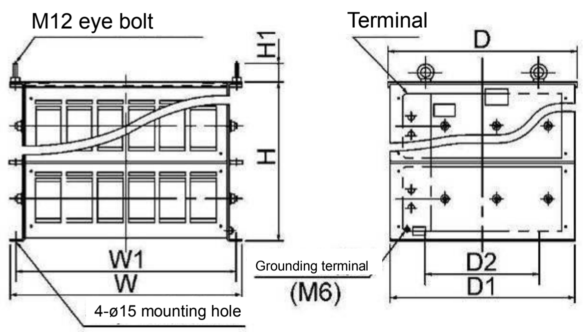


Figure C



Voltage	Model	Dimensions [mm]							Mass [kg]	Figure	Quantity used
		W	W1	D	D1	D2	H	H1			
400 V	RF4-160C	400	370	470	460	320	240	55	22	B	1
	RF4-220C								25		
	RF4-280C	655	625	470	460	320	240	55	31	C	
	RF4-315C								35		
	RF4-355C								36		
	RF4-400C								38		
	RF4-500C								41		
	RF4-630C	655	625	530	520	320	440	55	70		
	RF4-710C										
	RF4-800C								80		
	RF4-1000C	755	725	530	520	320	440	55	—		

(5) Charging resistor

Figure A

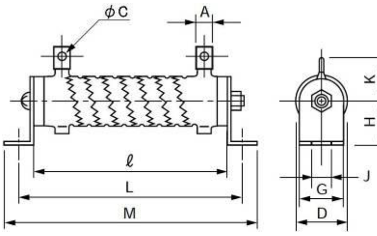


Figure B

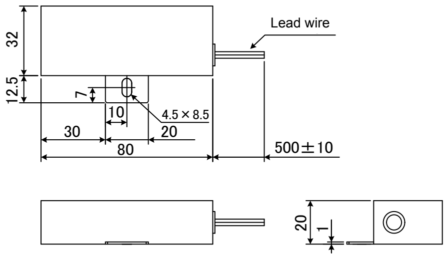
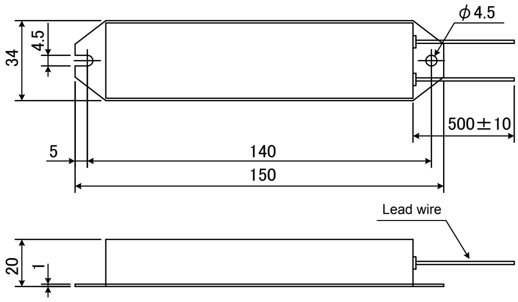


Figure C



Model	Dimensions [mm]										Mass [kg]	Figure	Quantity used
	M	L	*l*	D	G	H	K	A	J	φC			
GRZG120 2 Ω	217	198	165	33	22	22	32	—	6	5.5	0.25	A	3
GRZG400 1 Ω	411	385	330	47	40	40	46	—	9.5	5.5	0.85		
TK50B 30 Ω□ (HF5B0416)	See Figure B										0.15	B	
80W 7.5 Ω (HF5C5504)	See Figure C										0.19	C	

(6) AC fuse

Figure A

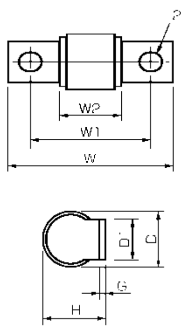


Figure B

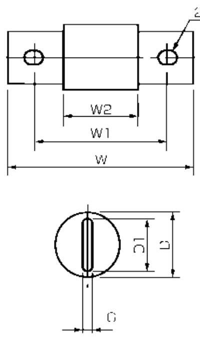
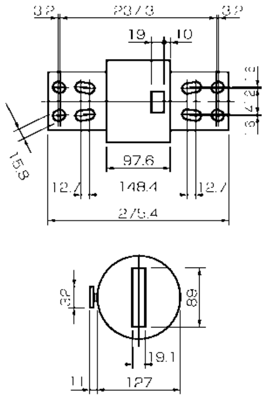
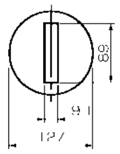


Figure C

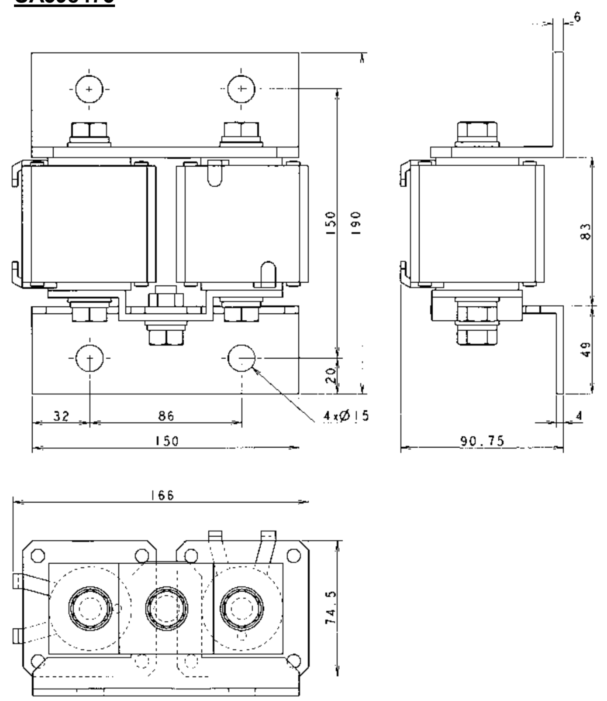


*Side view of A70P1600-4TA

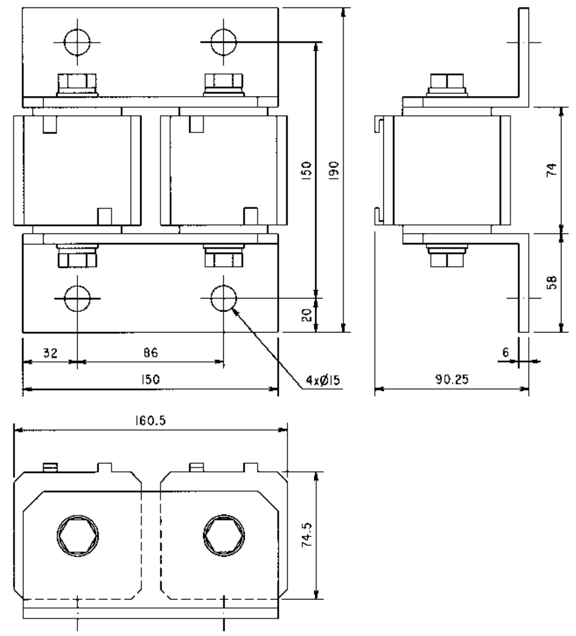


*Side view of A70P2000-4

SA598473



HF5G2655



Voltage	Model	Dimensions [mm]								Mass [kg]	Figure	Quantity used
		W	W1	W2	H	D	D1	G	E			
400 V	CR6L-150/UL	95	70	40	34	30	25	3.2	11×13	0.15	A	2
	CR6L-200/UL	107	82	43	42	37	30	4	11×13	0.25		
	CR6L-300/UL											
	A50P400-4	110	78.6	53.1	—	38.1	25.4	6.4	10.3×18.4	030	B	
	A50P600-4	113.5	81.75	56.4	—	50.8	38.1	6.4	10.3×18.2	0.60		
	A70QS800-4	180.2	129.4	72.2	—	63.5	50.8	9.5	13.5×18.3	1.1		
	A70P1600-4T	See Figure C									C	
	A70P2000-4											
	SA598473	See above								4.5		
	HF5G2655									4.7		

6.3.19 Generated loss

6.3.19.1 Generated loss in MD mode

400V								
Converter		Pressurizing reactor		Filter reactor		Filter resistor		
Model	Generated loss [W]	Model	Generated loss [W]	Model	Generated loss [W]	Model	Quantity	Generated loss [W]
RHC132S-4D□	2450	LR4-160C	1000	LFC4-160C	160	RF4-160C	1	568
RHC160S-4D□	2850							
RHC200S-4D□	3500	LR4-220C	1240	LFC4-220C	200	RF4-220C	1	751
RHC220S-4D□	4000							
RHC280S-4D□	4900	LR4-280C	1430	LFC4-280C	220	RF4-280C	1	1027
RHC315S-4D□	5500	LR4-315C	1660	LFC4-315C	260	RF4-315C	1	1154
RHC630B-4D□	10550	LR4-630C	2300	LFC4-630C	510	RF4-630C	1	4722
RHC710B-4D□	11500	LR4-710C	2600	LFC4-710C	630	RF4-710C	1	5361
RHC800B-4D□	13100	LR4-800C	2900	LFC4-800C	620	RF4-800C	1	6024

690V	
Converter stack	
Model	Generated loss [W]
RHC132S-69D□	2650
RHC160S-69D□	3050
RHC200S-69D□	3900
RHC250S-69D□	5000
RHC280S-69D□	5450
RHC315S-69D□	6000
RHC355S-69D□	4150
RHC400S-69D□	4700
RHC450S-69D□	5300

* The generated loss of the filters shown above is the value for all quantities.

6.3.19.2 Generated loss in LD mode

400V								
Converter		Pressurizing reactor		Filter reactor		Filter resistor		
Model	Generated loss [W]	Model	Generated loss [W]	Model	Generated loss [W]	Model	Quantity	Generated loss [W]
RHC132-4D□	2950	LR4-160C	1000	LFC4-160C	160	RF4-160C	1	568
RHC160-4D□	3450	LR4-220C	1240	LFC4-220C	200	RF4-220C	1	751
RHC200-4D□	3800							
RHC280-4D□	5450	LR4-315C	1660	LFC4-315C	260	RF4-315C	1	1154
RHC315-4D□	6100	LR4-355C	1910	LFC4-355C	300	RF4-355C	1	1286
RHC630B-4D□	11850	LR4-710C	2600	LFC4-710C	630	RF4-710C	1	5361
RHC710B-4D□	12900	LR4-800C	2900	LFC4-800C	620	RF4-800C	1	6024
RHC800B-4D□	16200	LR4-1000C	4500	LFC4-1000C	1080	RF4-1000C	1	7728

690V	
Converter stack	
Model	Generated loss [W]
RHC132S-69D□	3150
RHC160S-69D□	3750
RHC200S-69D□	4250
RHC250S-69D□	5550
RHC280S-69D□	6100
RHC315S-69D□	6700
RHC355S-69D□	4600
RHC400S-69D□	5200

* The generated loss of the filters shown above is the value for all quantities.

6.4 Filter stack (RHF-D series)

6.4.1 Features

■ This filter stack is dedicated to use with the RHC-D series high-efficiency power regeneration PWM converters .

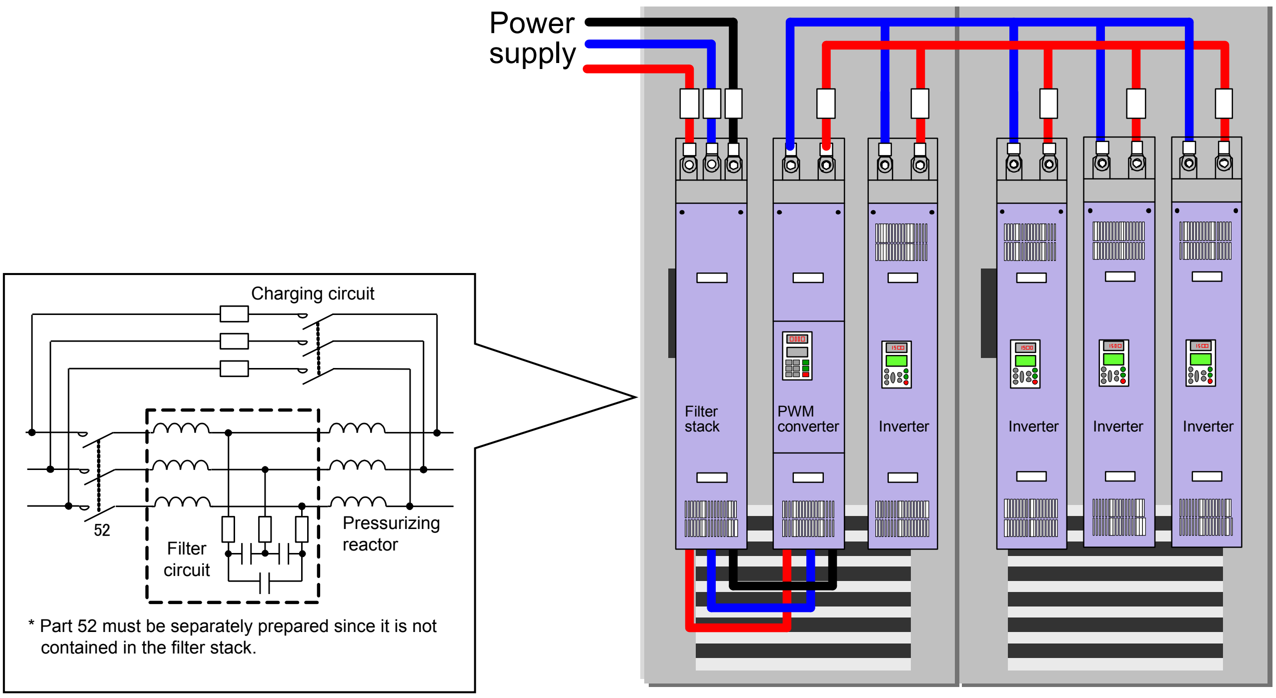
<Lineup>
Applicable to the 400V series PWM converters for 132 kW to 315 kW
Applicable to the 690V series PWM converters for 132 kW to 450 kW
* Cannot be used with unit type PWM converters (RHC-C).

■ All peripherals (filter circuit, pressurizing reactor, charging circuits, etc.) required to run a PWM converter are packaged in a single unit.

This eliminates the need to separately procure peripherals (such as a pressurizing reactor, filter reactor, filter capacitor, charging box, charging resistor).

■ It is possible to save wiring work and installation space for peripherals.

■ Built on the same stack design and shape as inverters and PWM converters. These products effectively help reduce the panel size.



Note The filter stacks (RHF-D) are dedicated to the use with stack type PWM converters (RHC-D series) indicated below. It is not applicable to any other PWM converters.

• 400V series: RHC132S-4D☐ to RHC315S-4D☐

• 690V series: RHC132S-69D☐ to RHC450S-69D☐

For information on the peripheral equipment for the PWM converters (RHC-D), refer to "6.3.12 Configuration of peripherals".

6.4.2 Standard specifications

6.4.2.1 3-phase 400V series

Filter model			RHF160S-4D□	RHF220S-4D□	RHF280S-4D□	RHF355S-4D□
Applicable converter model RHC□□□S-4D	MD mode		132	200	280	315
			160	220	—	—
	LD mode		132	160	—	315
			—	200	—	—
Rated current (A)			282	384	489	619
Input power	Main power supply Number of phases, voltage, and frequency		3-phase, 380 to 440 V/50 Hz, 380 to 460 V/60 Hz			
	Fan power supply Number of phases, voltage, and frequency	400 V input	Single-phase, 380 to 440 V/50Hz, 380 to 460 V/60 Hz *1			
		200 V input	Single-phase, 200 to 220 V/50 Hz, 200 to 230 V/60 Hz *2			
	Allowable fluctuation		Voltage: -15% to +10%, Frequency: -5% to +5%, Voltage unbalance ratio: 2% or less *3			
Permissible carrier frequency			2.5 kHz, 5 kHz			
Approx.mass [kg]			155	195	230	250
Enclosure			IP00 open type			
Noise level			75dB (condition: A-range, distance: 1 m) *4			

*1 For 380 to 398 V/50 Hz or 380 to 430 V/60 Hz power supply, switching of the filter stack internal terminals (U1, U2) is required.

*2 200 V power supply can also be used. For details, refer to "6.2.4 Terminal functions".

*3 $$\text{Interphase unbalance rate}(\%) = \frac{\text{Max. voltage[V]} - \text{Min. voltage[V]}}{\text{3-phase average voltage}} \times 67$$

*4 This is the noise level measured when the filter stack is connected with a PWM converter and inverter of the same capacity and runs at its ratings.

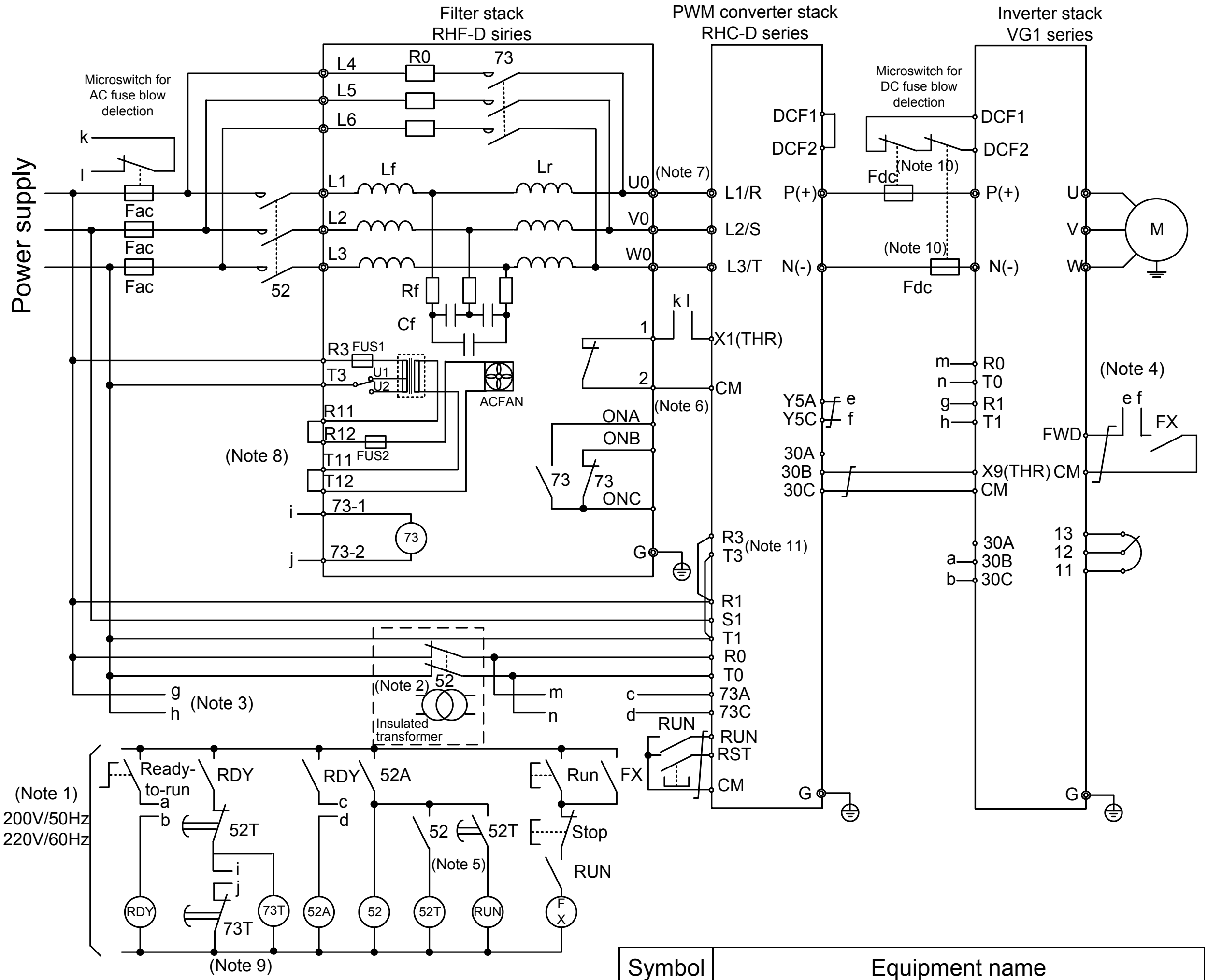
6.4.2.2 3-phase 690V series

<table>
<tr><td colspan="3">Filter model</td><td>RHF160S-69D☐</td><td>RHF220S-69D☐</td><td>RHF280S-69D☐</td><td>RHF355S-69D☐</td><td>RHF450S-69D☐</td></tr>
<tr><td colspan="2" rowspan="4">Applicable converter model RHC☐S-69D☐</td><td rowspan="2">MD mode</td><td>132</td><td>200</td><td>250</td><td>315</td><td>400</td></tr>
<tr><td>160</td><td>-</td><td>280</td><td>355</td><td>450</td></tr>
<tr><td rowspan="2">LD mode</td><td>132</td><td>160</td><td>-</td><td>280</td><td>355</td></tr>
<tr><td>-</td><td>200</td><td>250</td><td>315</td><td>400</td></tr>
<tr><td colspan="3">Rated current (A)</td><td>163</td><td>223</td><td>283</td><td>359</td><td>455</td></tr>
<tr><td rowspan="4">Input power</td><td colspan="2">Main power supply Number of phases, voltage, and frequency</td><td colspan="5">3-phase, 3-wire type, 660 to 690 V, 50/60 Hz
3-phase, 3-wire type, 575 to 600 V, 50/60 Hz
Voltage: -15% to +10%, Frequency: -5% to +5%</td></tr>
<tr><td rowspan="2">Fan power supply Number of phases, voltage, and frequency</td><td>690 V input</td><td colspan="5">Single-phase, 660 to 690 V, 50/60 Hz
Single-phase, 575 to 600 V, 50/60 Hz*1
Voltage: -15% to +10%, Frequency: -5% to +5%</td></tr>
<tr><td>200 V input</td><td colspan="5">Single-phase, 200 to 220 V/50 Hz,200 to 230 V/60 Hz
Voltage: -15% to +10%, Frequency: -5% to +5%</td></tr>
<tr><td colspan="2">Allowable fluctuation</td><td colspan="5">Voltage: -15% to +10%, Frequency: -5% to +5%,
Voltage unbalance ratio: 2% or less</td></tr>
<tr><td colspan="3">Permissible carrier frequency</td><td colspan="5">2.5kHz, 5kHz</td></tr>
<tr><td colspan="3">Approx.mass [kg]</td><td>180</td><td>205</td><td>230</td><td>255</td><td>280</td></tr>
<tr><td colspan="3">Enclosure</td><td colspan="5">IP00 open type</td></tr>
<tr><td colspan="3">Noise level*2</td><td colspan="5">75dB (condition: A-range, distance: 1 m)</td></tr>
</table>

*1 For 575 to 600 V, 50/60 Hz power supply, switching of the filter stack internal terminals (U1, U2) is required.

*2 This is the noise level measured when the filter stack is connected with a PWM converter and inverter of the same capacity and runs at its ratings.

6.4.3 Basic connection diagrams



Symbol	Equipment name
Lr	Pressurizing reactor
Lf	Reactor for filter
Cf	Capacitor for filter
Rf	Resistor for filter
R0	Charging resistor
Rf	Resistor for filter
Fac	AC fuse
Fdc	DC fuse
73	Electromagnetic contactor for charging circuit
52	Electromagnetic contactor for power supply

Figure 6.4.3-1: Basic connection diagram

(Note 1) Connect a step-down transformer to ensure that the sequence circuit voltages are exactly the same as shown in the Figure 6.4.3-1.

(Note 2) Be sure to connect the PWM converter and inverter auxiliary power input terminals (R0, T0) to the main power via contact b of the power supply electromagnetic contactor (52). When using the product with a non-grounded power supply, it is necessary to add an insulated transformer. For more information, refer to "6.3.15-(5)" in Chapter 6.

(Note 3) Be sure to connect the power supply for the inverter's AC fan to the main power directly (not via contact b of #52) so that the power can be fed through terminals R1 and T1.

(Note 4) Create a sequence in which the PWM converter gets ready for operation before the run signal is input to the inverter.

(Note 5) Set the timer for 52T to 1 second.

(Note 6) Be sure to assign the PWM converter digital input terminal (X1) to the external alarm (THR), and to connect the filter stack overheat signal outputs (1, 2). Set contact b input with function code E14 to input with contact b. Furthermore, connect the microswitch for AC fuse blow detection to the digital input terminal (X1) in series with all microswitches and the overheat signal outputs (1, 2).

(Note 7) Ensure correct phase sequence when connecting wires to terminals L1/R, L2/S, L3/T, R2, T2, R1, S1, and T1.

(Note 8) When inputting 200 VAC as the fan power supply, remove jumper wires from between terminals R11 and R12 and from between terminals T11 and T12, and then connect the input to terminals R12 and T12. Note that these terminals are dedicated to the internal fan power supply. Do not use them for any other purposes.

(Note 9) Be sure to set the timer for 73T to 5 seconds.

(Note 10) For the 400V series, connect "Fdc (fuse)" to the P (+) side. No "Fdc (fuse)" is required at the N (-) side. For the 690V series, connect "Fdc (fuse)" to the P (+) side and N(-) side.
Furthermore, use two microswitches and connect them in series.

(Note 11) With the 690V series, there are no R3 or T3 short-circuit wires.

⚠WARNING

- Be sure to assign the PWM converter digital input terminal (X1) to the external alarm (THR), and to connect the filter stack overheat signal outputs (1, 2).
- Be sure to stop the PWM converter and inverter when the overheat signal is output. Furthermore, shut off electromagnetic contactors 52 and 73.

Risk of fire, accident

6.4.4 Terminal functions

Terminal symbol		Name	Specifications
Main circuit	L1, L2, L3	Main power input	Connect to a 3-phase power supply.
	U0, V0, W0	Filter output	Connect to the PWM converter's power input terminals L1/R, L2/S, and L3/T.
	L4, L5, L6	Charging circuit input	Connect to a 3-phase power supply.
	E(G)	For filter grounding	Grounding terminal for the chassis (case) of the filter stack.
	R3, T3	Fan power input	Connection terminals for the AC cooling fan power supply inside the stack. If the fan uses the same voltage as the main power supply, connect this terminal to the power supply.
	R11, R12 T11, T12[*1]	Fan power input (for 200 V input)	Use this terminal when inputting 200 VAC as the power to the AC cooling fan inside the stack. When using a 200 V power supply, remove the jumper wires connected when shipped from the factory and connect terminals R12 and T12 to the power supply. When using the same voltage as the main power supply, ensure that jumper wires are connected between R11 and R12 and between T11 and T12 (factory default).
	U1, U2[*2]	Supply voltage switching terminal	Change the terminal connection depending on the power supply connected to the fan power input terminals. (Refer to Figure 6.4.4-1.)
Input signals	73-1 73-2	Charging circuit contactor Control input	These are control signal input terminals for the charging circuit contactor. <Coil rated capacity> ● 400V series When turned ON ... 200 V/50 Hz: 120 VA, 220 V/60 Hz : 135 VA When retained ... 200 V/50 Hz: 12.7 VA, 220 V/60 Hz : 12.4 VA
Output signals	ONA ONB ONC	Charging circuit operation signal	These are auxiliary contact output terminals for the charging circuit contactor. To be used as signal for operational check of charging circuit. • Contact rating: 24 VDC 3 A * Min. working voltage/current: 5 VDC 3 mA
	1 2	Overheat signal output	Signal is output when internal parts of filter stack are overheated. • Contact rating: 24 VDC (max. 27 V), max. 0.3A/max. 6W * Min. usage voltage, current: 1 VDC, 0.1mA

*1 Terminals R11, R12, T11, and T12 are 200 V power terminals and their withstand voltage is 2000 VAC for 1 minute.

*2 Terminals U1 and U2 can be switched as shown in Figure 6.4.4-1.

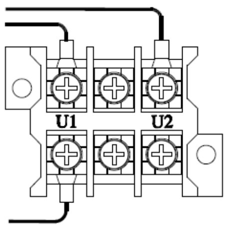
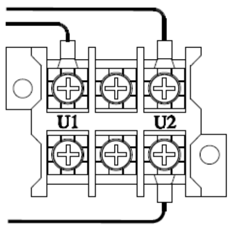
Configuration		
Applied voltage	400V series: 398 to 440 V/50 Hz, 430 to 460 V/60 Hz 690V series: 660 to 690V, 50/60Hz (Factory default)	400V series: 380 to 398 V/50 Hz, 380 to 430 V/60 Hz 690V series: 575 to 600V, 50/60Hz

Figure 6.4.4-1: Supply voltage switching terminal

⚠WARNING

- Be sure to assign the PWM converter digital input terminal (X1) to the external alarm (THR), and to connect the filter stack overheat signal outputs (1, 2).
- Be sure to stop the PWM converter and inverter when the overheat signal is output. Furthermore, shut off electromagnetic contactors 52 and 73.

Risk of fire, accident

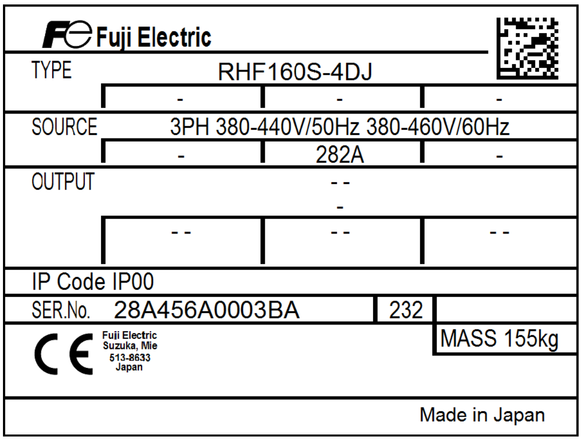
6.4.5 Check before use

Unpack the package and check the following:

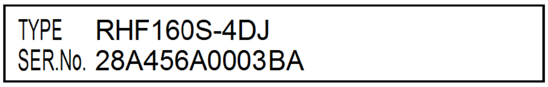
Check that you have properly received the product main unit and the following accessories.

Accessories   Instruction manual

The inverter has not been damaged during transportation—there should be no dents or parts missing. The main nameplates are attached to the main unit. The main nameplate is located on the front face of the main unit (as shown in Figure 6.4.6-2 and Figure 6.4.6-3). Check these main nameplates to see that the inverter is exactly the type you ordered.



(a) Main Nameplate



(b) Sub Nameplate

Figure 6.4.5-1: Main nameplate

TYPE: Filter stack (RHF-D)

RHF 160 S - 4 D□

Indication	Series name
RHF	Filter stack

Indication	Standard applicable converter capacity
160	160kW
220	220kW
280	280kW
355	355kW
450	450kW

Indication	Inverter structure
S	Standard stack type

Indication	Voltage class
4	400 V class series
69	690 V class series

Indication	Development series
D	D series

Indication	Shipping destination/Instruction Manual
J	Japanese
E	English
C	Chinese

Specifications in each mode are printed on the main nameplate.

SOURCE : Power supply rating
OUTPUT : Output rating
IP Code : IP protection grade
MASS : Mass
SER.No. : Production number   2 8 A456A0003BA

- 2: Production year (Last digit of the year)
- 8: Production month   1 to 9: January to September; X, Y, or Z: October, November, or December
- A456A0003BA: Serial number of production lot

If you suspect the product is not working properly or if you have any questions about your product, contact your Fuji Electric representative.

📖 Refer to Chapter 3 "Transportation and Storage" for information on transportation and long-term storage of filter stacks.

📖 Refer to Chapter 4 "Installation and Wiring" for information on installation of filter stacks.
For information on the main circuit wire sizes, refer to "6.4.11 Wire size".

6.4.6 External views

6.4.6.1 Warning label and falling warning label

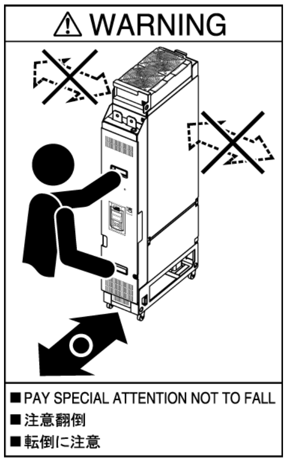


Figure 6.4.6-1: Warning label and falling warning label

6.4.6.2 Appearance

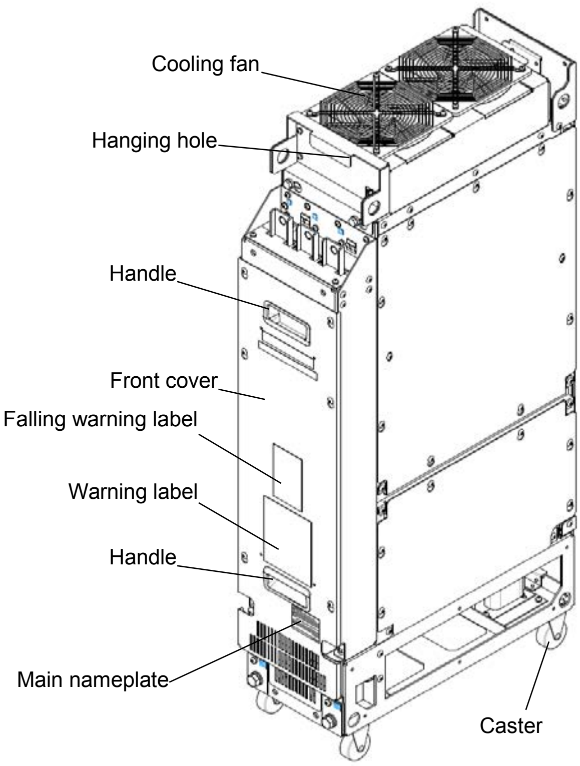


Figure 6.4.6-2: Frame 3 size
(RHF160S to RHF220S-4D☐,RHF160S-69D☐)

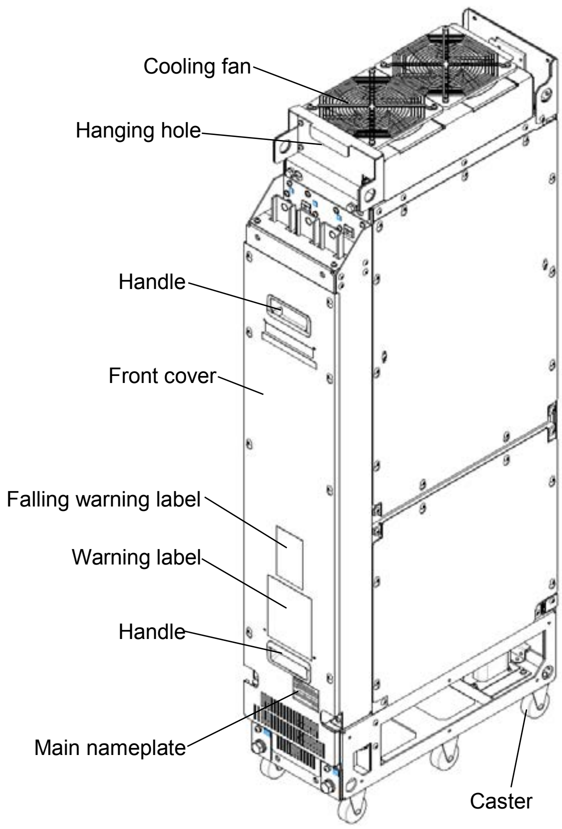


Figure 6.4.6-3: Frame 4 size
(RHF280S to RHF355S-4D☐,RHF220S to RHF355S-69D☐)

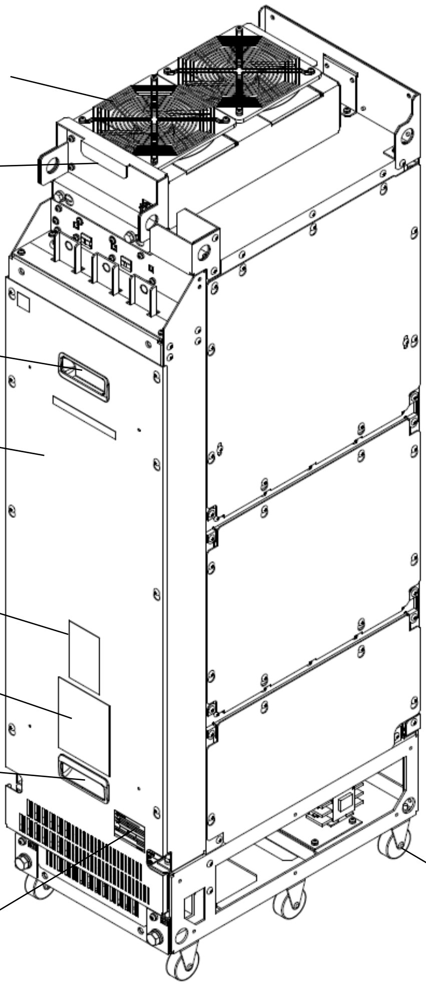


Figure 6.4.6-4: Frame 5 size (RHF450S-69D☐)

6.4.7 External dimensions

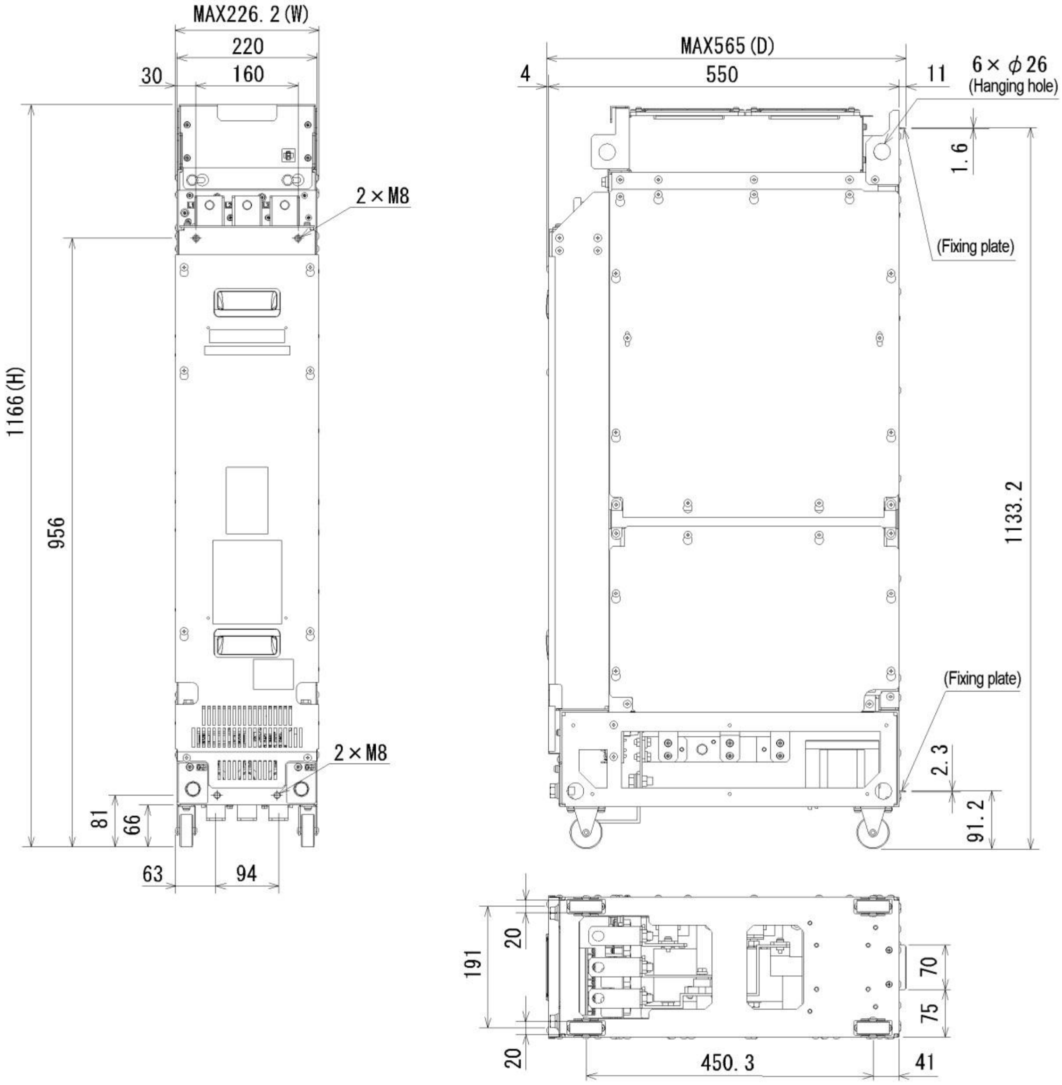
6.4.7.1 List of external dimensions - RHF-D series (stack type)

Unit: [mm]

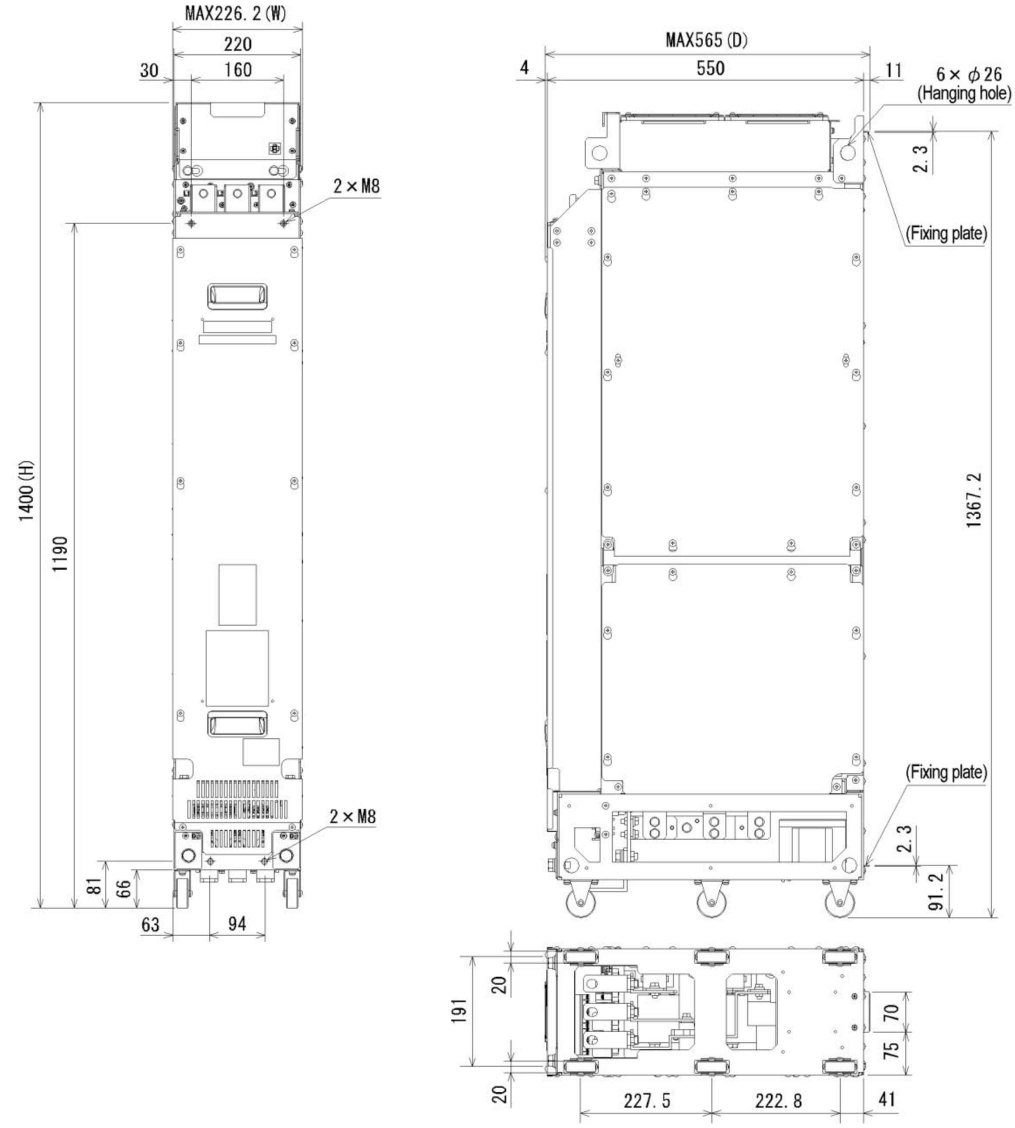
Power supply voltage	Model	Figure	W	H	D	Approx. mass [kg]	Remarks
400V series	RHF160S-4D□	A	226.2	1166	565	155	
	RHF220S-4D□					195	
	RHF280S-4D□	B	226.2	1400	565	230	
	RHF355S-4D□					250	
690V series	RHF160S-69D□	A	226.2	1166	565	180	
	RHF220S-69D□	C	226.2	1400	565	215	
	RHF280S-69D□					230	
	RHF355S-69D□					255	
	RHF450S-69D□	D	336.2	1400	565	280	

6.4.7.2 External dimensions

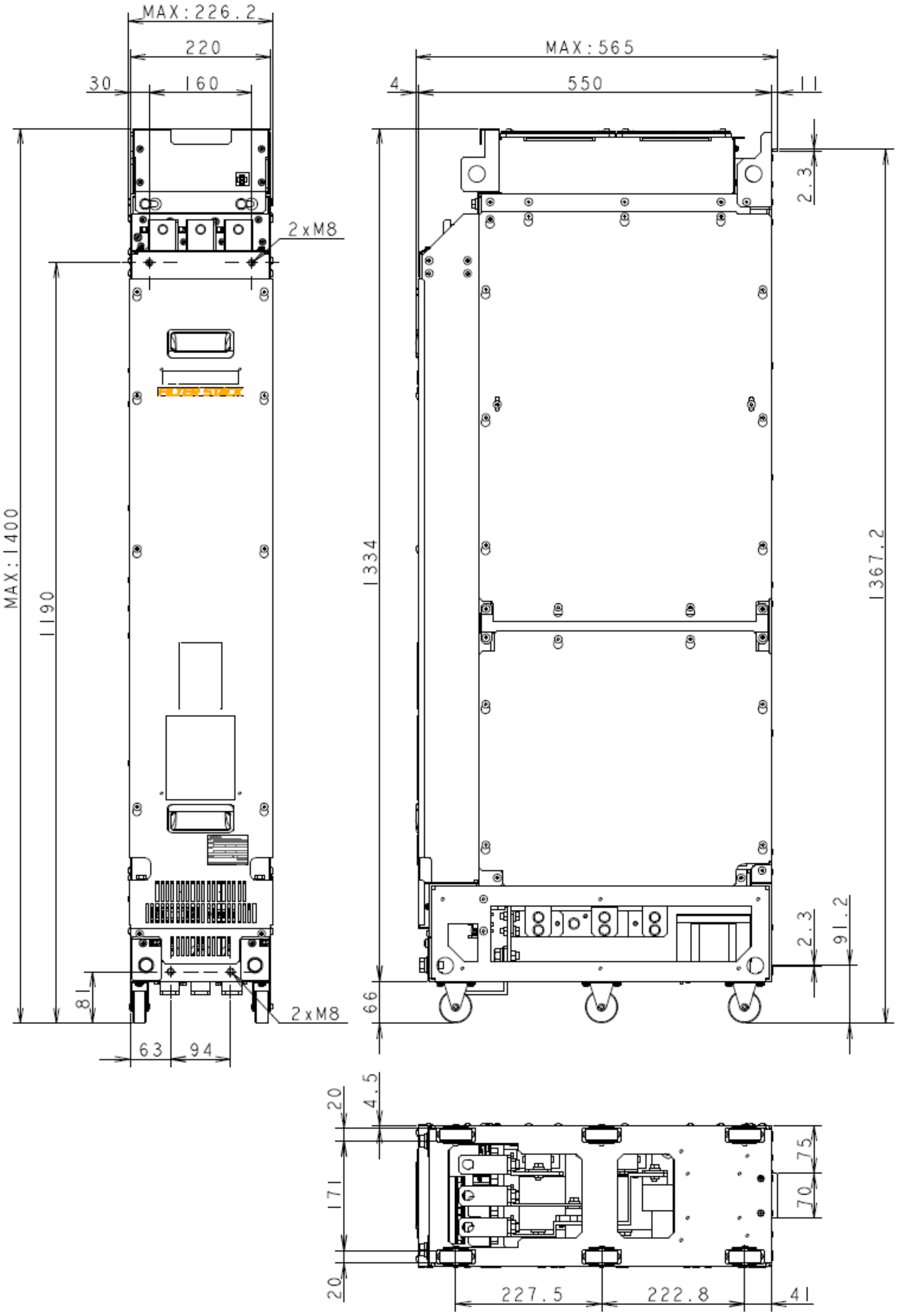
(1) Figure A (Frame 3 size: RHF160S-4D□, RHF220S-4D□,RHF160S-6D□)



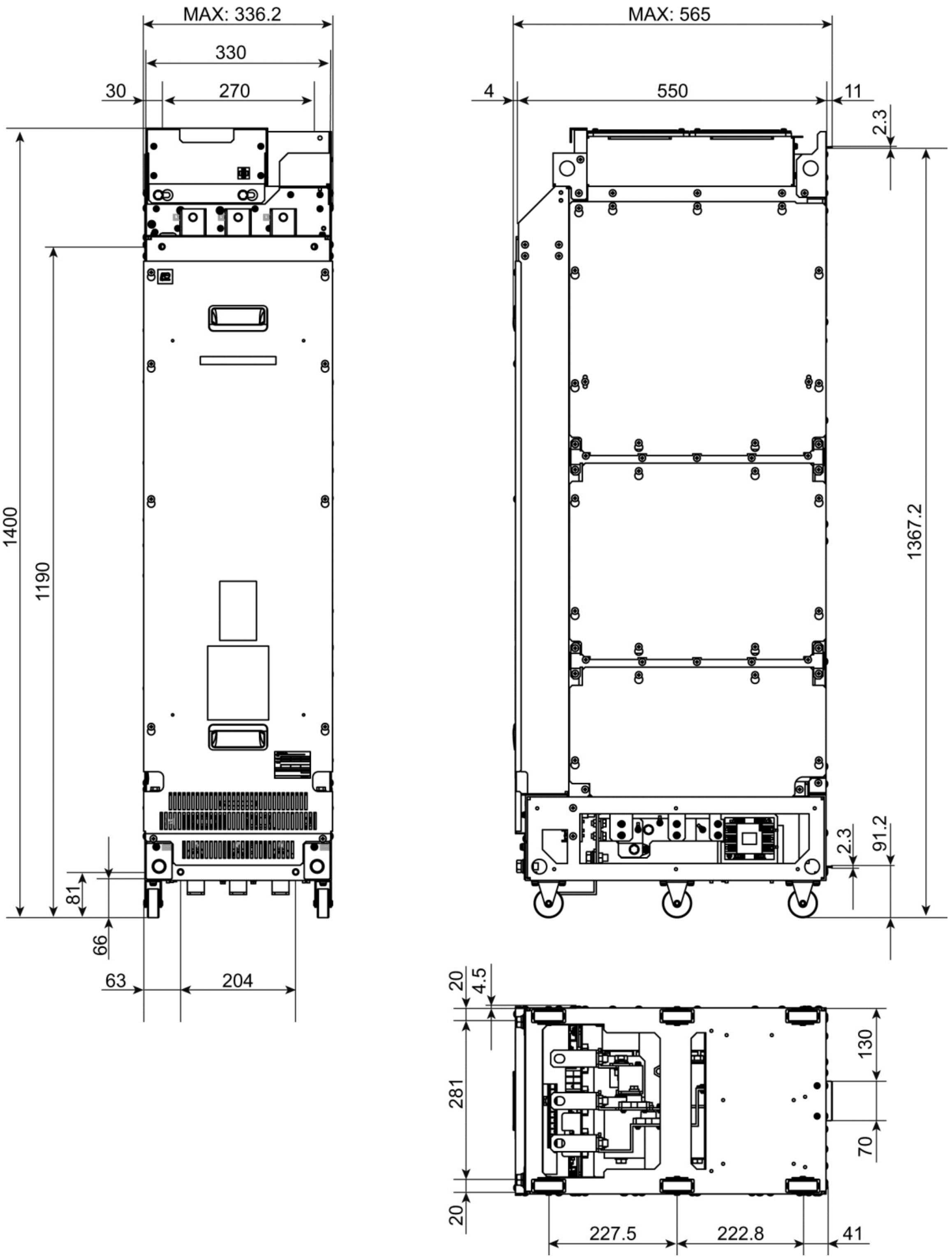
(2) Figure B (Frame 4 size: RHF280S-4D□, RHF355S-4D□)



(3) Figure C (Frame 4 size: RHF220S to 355S-69D□)



(4) Figure D (Frame 5 size: RHF450S-69D□)

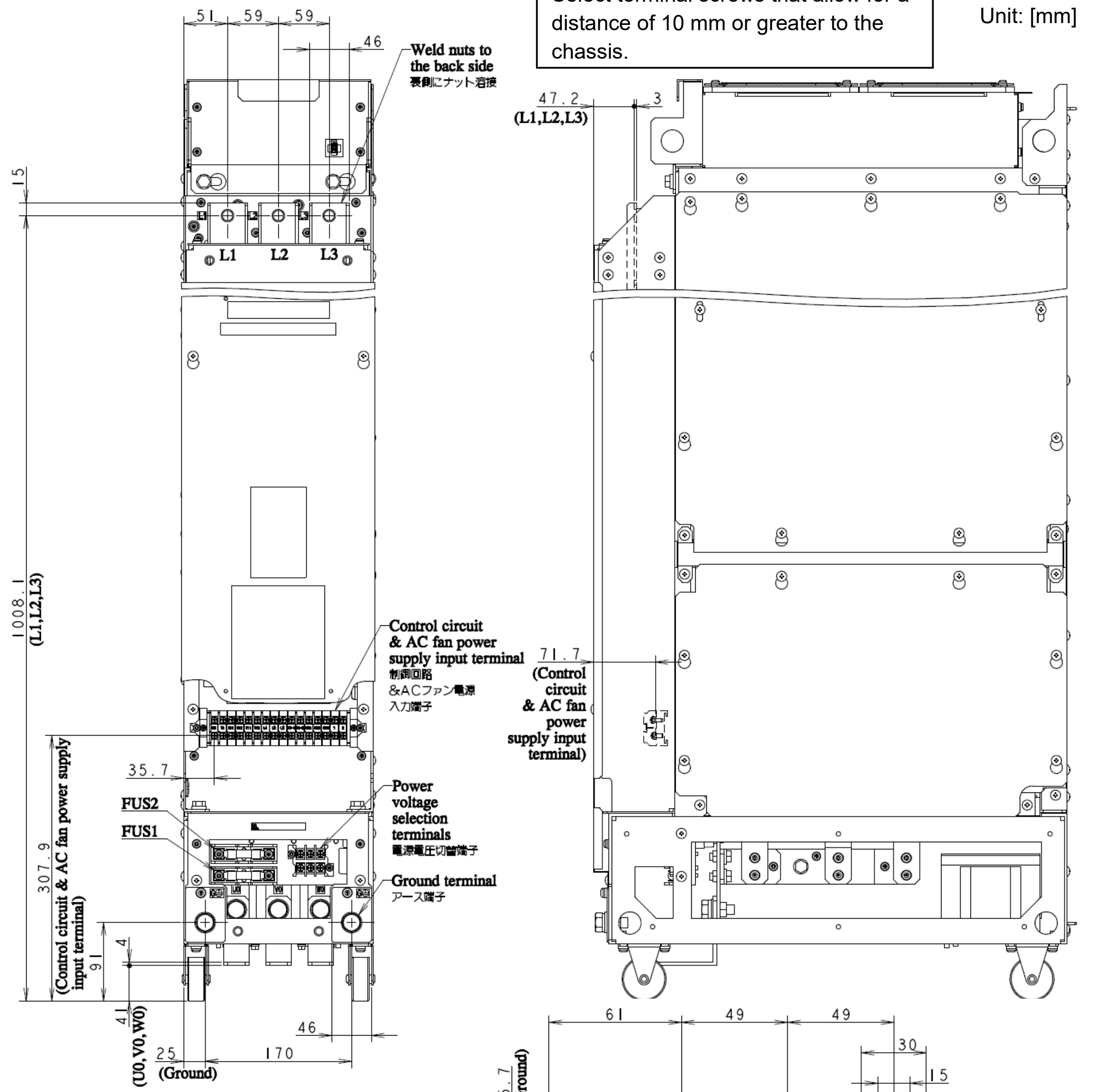


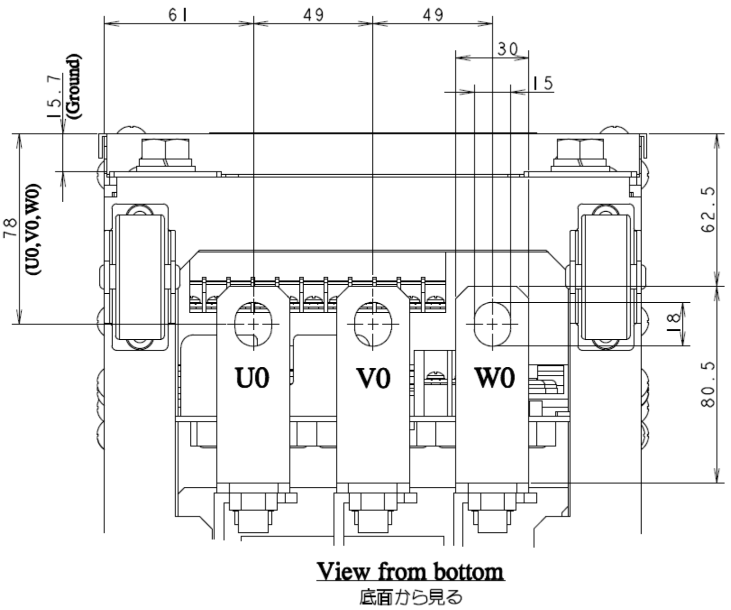
6.4.8 Terminal positions

6.4.8.1 Main circuit terminals

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

Unit: [mm]





Note

Install relay bar terminals at the cabinet side for the main power supply output terminals.

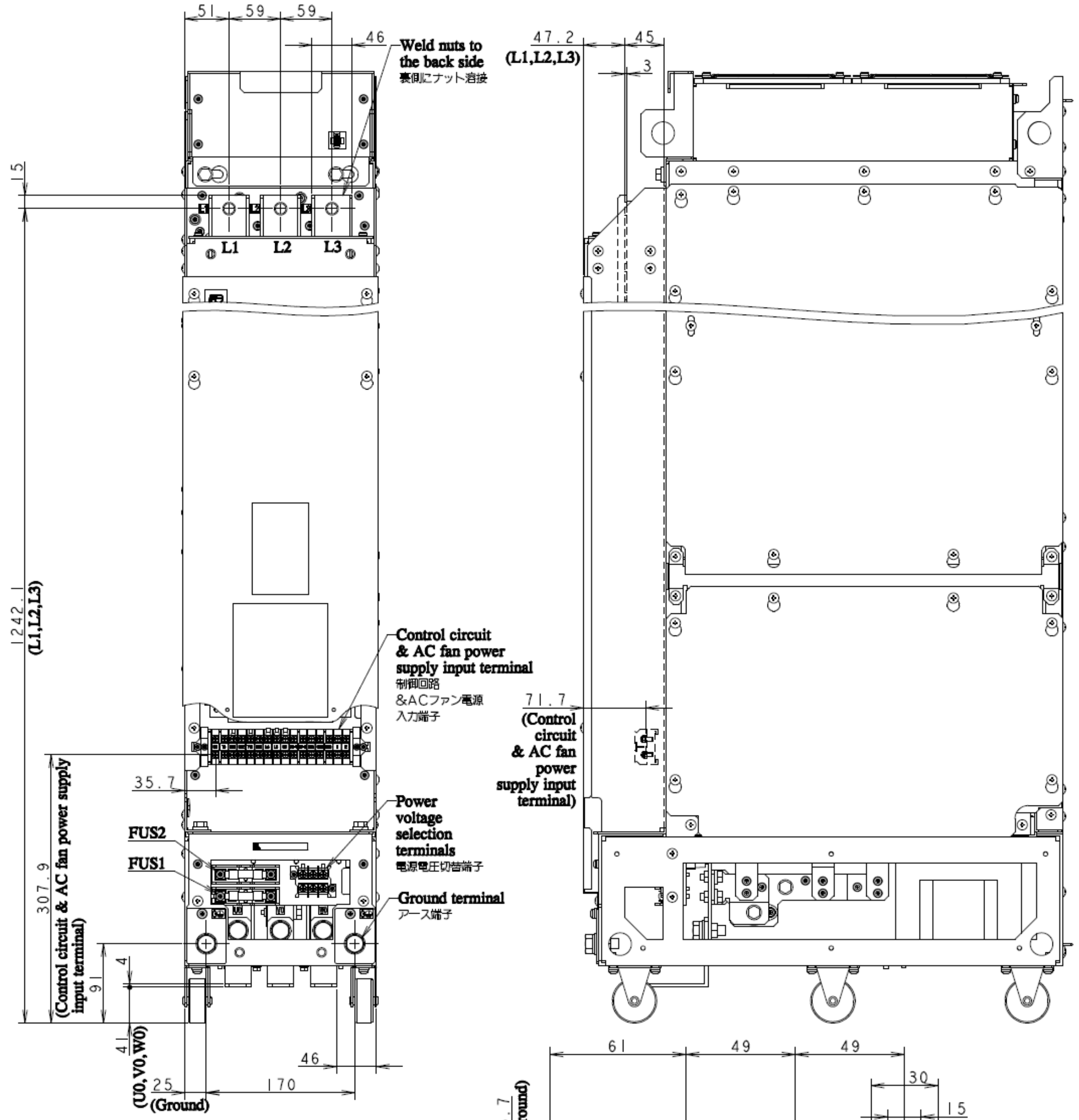
Furthermore, secure firmly with an insulator to prevent terminal shorting.

Terminal name	Terminal symbol	Bolt size
Main power supply input	L1,L2,L3	M12
Main power supply output	U0,V0,W0	
Grounding terminal	⊕G	

Figure 6.4.8-1: Frame 3 size (RHF160S-4D□, RHF220S-4D□, RHF160S-69D□)

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

Unit: [mm]



Note

Install relay bar terminals at the cabinet side for the main power supply output terminals.

Furthermore, secure firmly with an insulator to prevent terminal shorting.

Terminal name	Terminal symbol	Bolt size
Main power supply input	L1,L2,L3	M12
Main power supply output	U0,V0,W0	
Grounding terminal	⊕G	

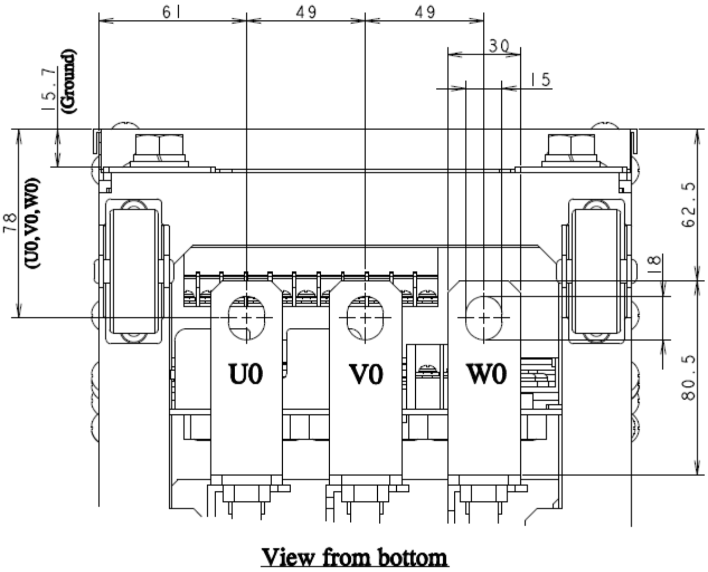
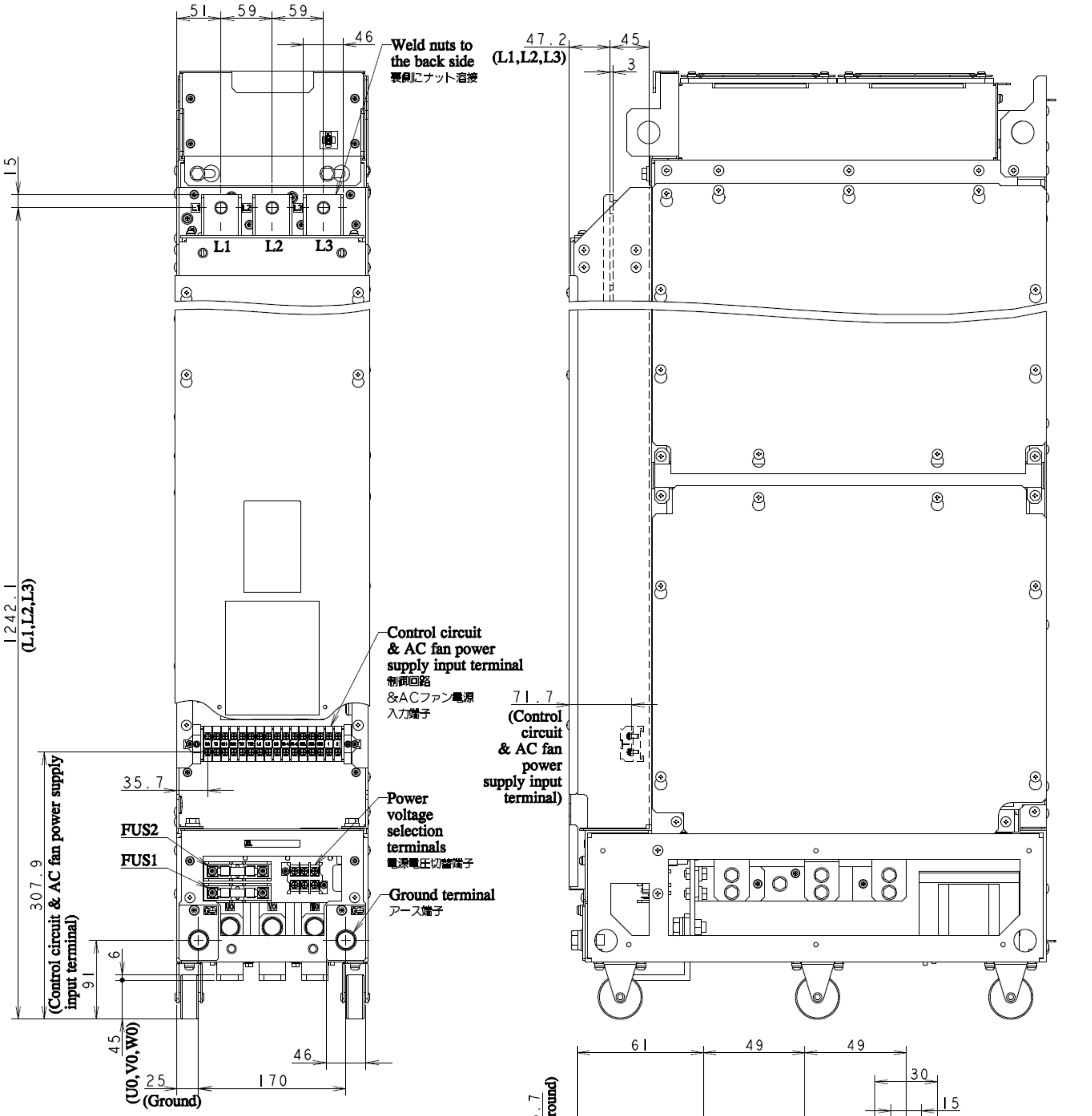
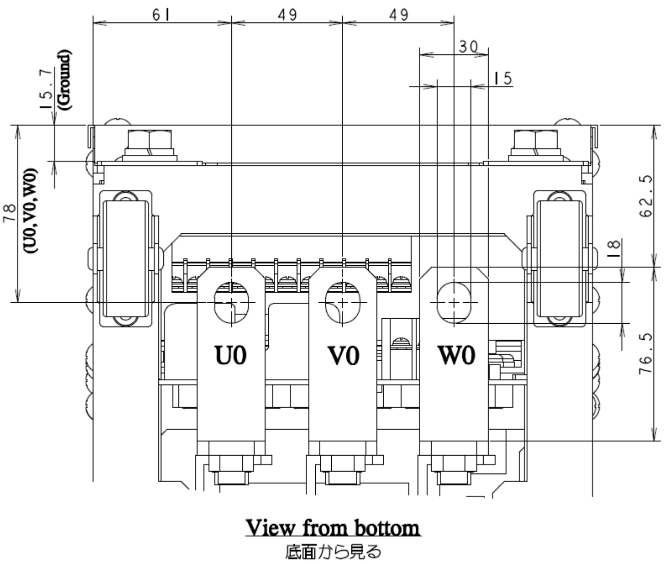


Figure 6.4.8-2: Frame 4 size (RHF280S-4D☐,RHF355S-4D☐)

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

Unit: [mm]





Note

Install relay bar terminals at the cabinet side for the main power supply output terminals.

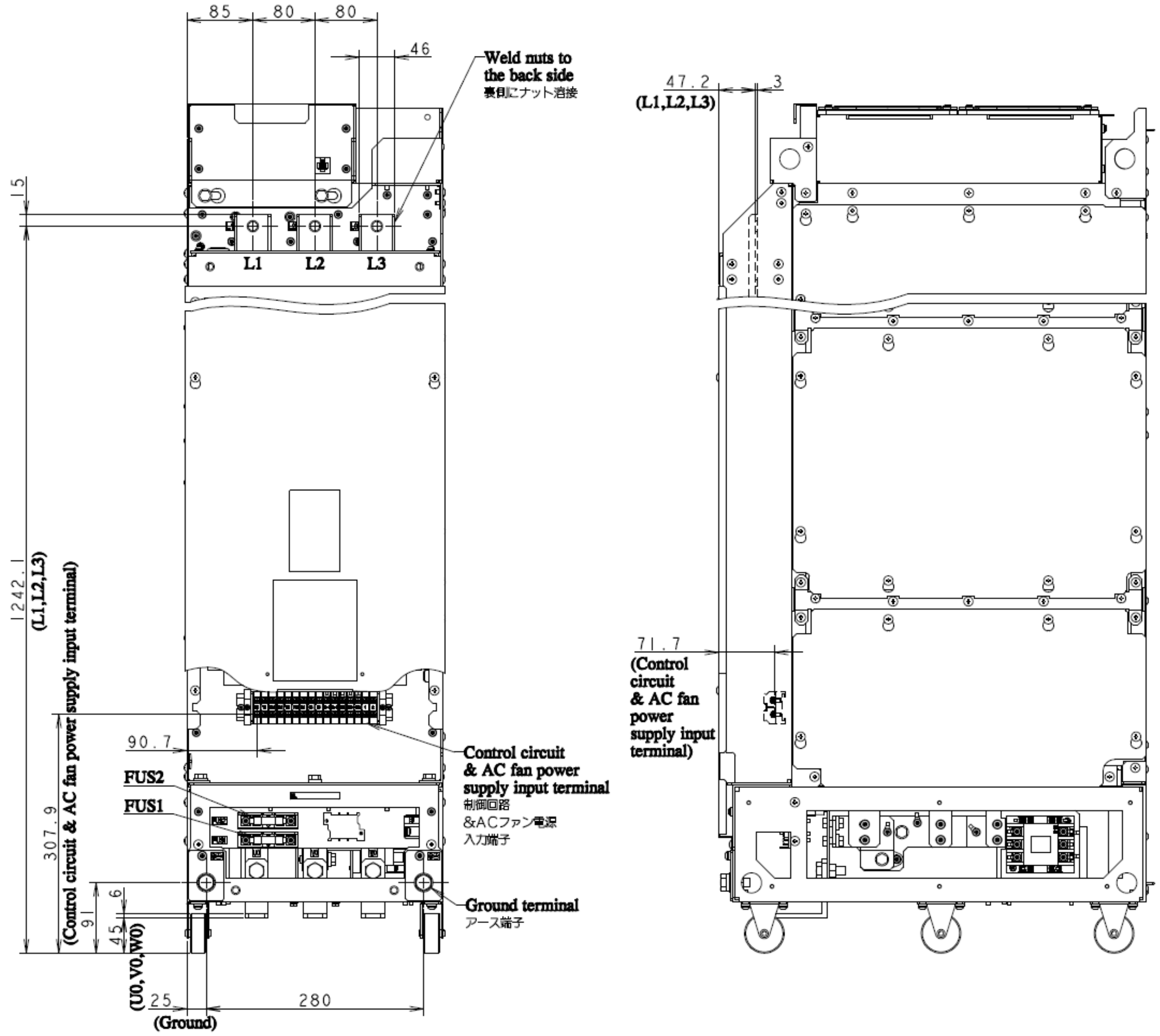
Furthermore, secure firmly with an insulator to prevent terminal shorting.

Terminal name	Terminal symbol	Bolt size
Main power supply input	L1,L2,L3	M12
Main power supply output	U0,V0,W0	
Grounding terminal	⊕G	

Figure 6.4.8-3: Frame 4 size (RHF220S to 355S-69D☐)

Select terminal screws that allow for a distance of 10 mm or greater to the chassis.

Unit: [mm]



Note

Install relay bar terminals at the cabinet side for the main power supply output terminals.

Furthermore, secure firmly with an insulator to prevent terminal shorting.

Terminal name	Terminal symbol	Bolt size
Main power supply input	L1,L2,L3	M12
Main power supply output	U0,V0,W0	
Grounding terminal	⊕G	

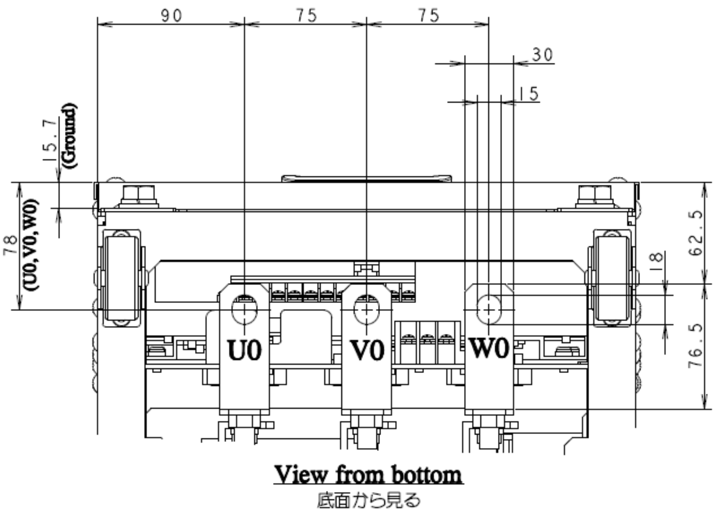


Figure 6.4.8-4: Frame 5 size (RHF450S-69D☐)

6.4.8.2 Control circuit terminal

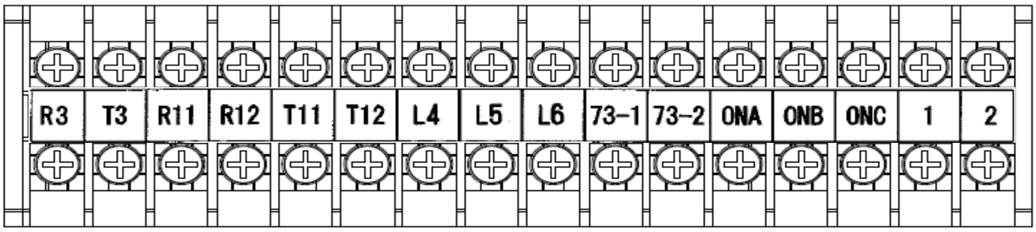


Figure 6.4.8-5: Control terminal layout

6.4.9 Configuration of peripherals

(1) In the case of MD

Power-based series	PWM converter model	Filter stack		MCCB/ELCB rated current [A]	Electromagnetic contactor		AC Fuse		Microswitch	
		Model	Quantity		Model	Quantity	Model	Quantity	Model	Quantity
3-phase 400V	RHC132S-4D□	RHF160S-4D□	1	300	SC-N8	1	170M5446	3	170H3027	3
	RHC160S-4D□	RHF160S-4D□	1	350	SC-N11	1	170M6546	3		
	RHC200S-4D□	RHF220S-4D□	1	500	SC-N12	1	170M6547	3		
	RHC220S-4D□	RHF220S-4D□	1	500	SC-N12	1	170M6547	3		
	RHC280S-4D□	RHF280S-4D□	1	600	SC-N14	1	170M6499	3		
	RHC315S-4D□	RHF355S-4D□	1	700	SC-N14	1	170M6500	3		
3-phase 690V	RHC132S-69D□	RHF160S-69D□	1	175	SC-N6	1	170M5447	3		
	RHC160S-69D□	RHF160S-69D□	1	200	SC-N7	1				
	RHC200S-69D□	RHF220S-69D□	1	250	SC-N8	1	170M5448	3		
	RHC250S-69D□	RHF280S-69D□	1	300	SC-N8	1	170M6548	3		
	RHC280S-69D□	RHF280S-69D□	1	350	SC-N11	1				
	RHC315S-69D□	RHF355S-69D□	1	400	SC-N11	1				
	RHC355S-69D□	RHF355S-69D□	1	500	SC-N12	1	170M6500	3		
	RHC400S-69D□	RHF450S-69D□	1	500	SC-N12	1				
	RHC450S-69D□	RHF450S-69D□	1	600	SC-N14	1				

(2) In the case of LD

Power-based series	PWM converter model	Filter stack		MCCB/ELCB rated current [A]	Electromagnetic contactor		AC Fuse		Microswitch	
		Model	Quantity		Model	Quantity	Model	Quantity	Model	Quantity
3-phase 400V	RHC132S-4D□	RHF160S-4D□	1	350	SC-N11	1	170M5446	3	170H3027	3
	RHC160S-4D□	RHF220S-4D□	1	500	SC-N12	1	170M6546	3		
	RHC200S-4D□	RHF220S-4D□	1	500	SC-N12	1	170M6547	3		
	RHC280S-4D□	RHF355S-4D□	1	700	SC-N14	1	170M6499	3		
	RHC315S-4D□	RHF355S-4D□	1	800	SC-N14	1	170M6500	3		
3-phase 690V	RHC132S-69D□	RHF160S-69D□	1	200	SC-N7	1	170M5447	3		
	RHC160S-69D□	RHF220S-69D□	1	250	SC-N8	1				
	RHC200S-69D□	RHF220S-69D□	1	300	SC-N8	1	170M5448	3		
	RHC250S-69D□	RHF280S-69D□	1	350	SC-N11	1	170M6548	3		
	RHC280S-69D□	RHF355S-69D□	1	400	SC-N11	1				
	RHC315S-69D□	RHF355S-69D□	1	500	SC-N12	1				
	RHC355S-69D□	RHF450S-69D□	1	500	SC-N12	1	170M6500	3		
	RHC400S-69D□	RHF450S-69D□	1	600	SC-N14	1				

Note: The "MCCB/ELCB rated current" column shows the recommended rated current values at panel temperatures 50°C or lower.

* Since the ambient temperature is 40°C, the installation environment standards for MCCBs or ELCBs have been selected taking into account the correction coefficient depending on the temperature conditions (0.90 for 800AF or lower; 0.85 for 1000AF or higher). To select a specific model, consider the short-circuit breaking capacity of the equipment.

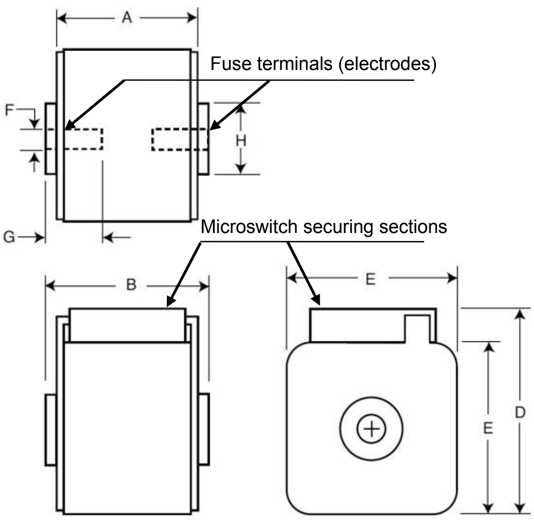
Refer to "6.2.12.3 Use of molded case circuit breakers (MCCBs)" and "6.2.12.4 Use of earth leakage circuit breakers (ELCBs)".

6.4.10 AC fuse external view

Table 6.4.10-1: AC fuse external dimensions table

Drawing No.	Dimensions [mm]							Weight [kg]
	A	B	D	E	F	G	H	
170M5446 170M5447 170M5448	80	81	77	61	M10	10	ø24	0.9
170M6546 170M6547 170M6548	81	83	92	76	M12	10	ø30	1.25
170M6499 170M6500	81	91	92	76	M12	10	ø30	1.25

Note) Column H shows the fuse main circuit terminals.



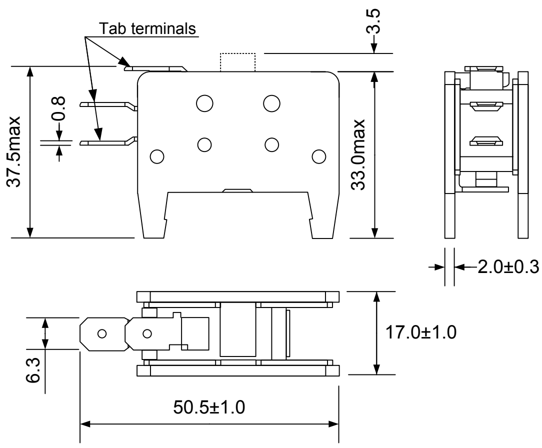


Figure 6.4.10-2: Microswitch external shape

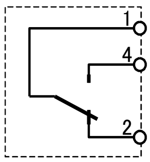


Figure 6.4.10-1: Microswitch contact structure

Note: Attach the microswitch to the fuse so that its tabterminals face down.

Press in the microswitch so that attachment claws hook firmly onto the fuse body.

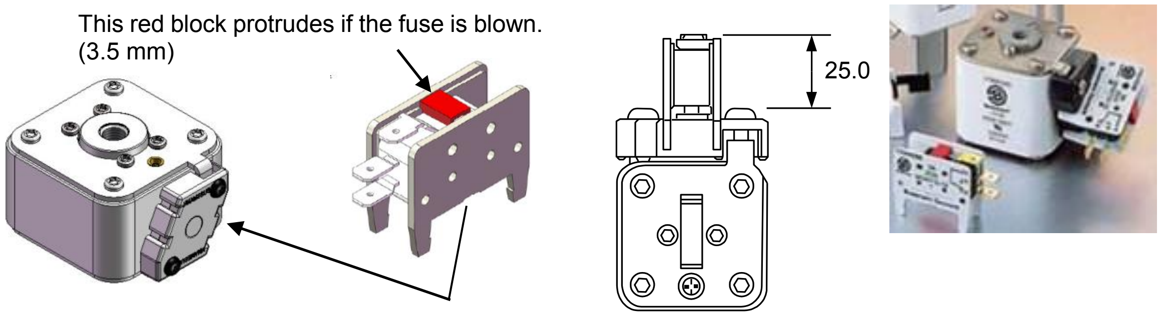


Figure 6.4.10-3: Microswitch attachment method

6.4.11 Wire size

6.4.11.1 3-phase 400V series

(1) Ambient temperature: 40°C

Applicable PWM converters capacity [kW]	RHF□-4D□	Main input (L1, L2, L3) Output (U0, V0, W0)					Grounding wire [mm^2] (Note 2)	Charging circuit (L4) (L5) (L6) [mm^2]	Other (R3, T3) (73-1, 73-2) (R11, R12) (T11, T12) [mm^2]	Control terminal (1, 2) (ONA) (ONB) (ONC) [mm^2]
		Wire size [mm^2] (Permissible temperature) (Note 1)			Bus bar size [mm^2]	Current [A]				
		60°C	75°C	90°C						
132	160S	100	100	60	t5 × 30 (150)	235	22	2	2	1.25
160		150		100		282	38			
200	220S	200	150			355				
220						384	60			
280	280S	2×200	2×150	2×100	t10 × 30 (300)	489		3.5		
315	355S					560				
355						619	100			

(2) Ambient temperature: 50°C

Applicable PWM converters capacity [kW]	RHF□-4D□	Main input (L1, L2, L3) Output (U0, V0, W0)					Grounding wire [mm^2] (Note 2)	Charging circuit (L4) (L5) (L6) [mm^2]	Other (R3, T3) (73-1, 73-2) (R11, R12) (T11, T12) [mm^2]	Control terminal (1, 2) (ONA) (ONB) (ONC) [mm^2]
		Wire size [mm^2] (Permissible temperature) (Note 1)			Bus bar size [mm^2]	Current [A]				
		60°C	75°C	90°C						
132	160S	200	100	60	t5 × 30 (150)	235	22	2	2	1.25
160		250	150	100		282	38			
200	220S	2×150		150		355				
220		2×200	200			384	60			
280	280S	2×325	2×200	2×150	t10 × 30 (300)	489		3.5		
315	355S					560				
355						619	100			

The power supply voltage is 400 VAC.

(Note 1) An "IV wire," a "600 V HIV insulated wire," and a "600 V cross-linked polyethylene insulated wire" were used at permissible temperatures of 60°C, 75°C, and 90°C, respectively, and the values represent aerial wiring.

(Note 2) The grounding wire is cited from the permissible short circuit current defined in internal wire regulations

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6.4.11.2 3-phase 690V series

(1) IEC standard, ambient temperature 40 °C

Applicable PWM converters capacity [kW]	RHF□-69D□	Main input (L1, L2, L3) Output (U0, V0, W0)					Grounding wire [mm²] (Note 2)	Charging circuit (L4) (L5) (L6) [mm²]	Other (R3, T3) (73-1, 73-2) (R11, R12) (T11, T12) [mm²]	Control terminal (1, 2) (ONA) (ONB) (ONC) [mm²]
		Wire size [mm²] (Permissible temperature) (Note 1)			Bus bar size [mm²]	Current [A]				
			75°C	90°C						
132	160S		70	35	t5 x 30 (150)	135	35	2.5	2.5	0.75
160				50		163				
200	220S		95	70		205	50			
250	280S		150	95	t10 x 30 (300)	253	95	4		
280			185	120		283				
315	355S		240	150		319	120			
355						359				
400	450S		300	185		405	150			
450			2x150	2x95		455				

(Note 1) PVC was used for permissible temperature of 70 °C, and XLPE for permissible temperature of 90 °C, and the wire sizes were selected based on the permissible current under the following conditions. If usage conditions differ, select wire sizes based on usage conditions that comply with IEC 60364-5-52:2001 (JIS C 60364-5-52:2006).
Ambient temperature: 40 °C, Multicore cable: 3 cores (conductor: copper), Single cable: aerial wiring, Two or more cables: electric duct wiring

(Note 2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

(2) Domestic selection, ambient temperature 40 °C

Applicable PWM converters capacity [kW]	RHF□-69D□	Main input (L1, L2, L3) Output (U0, V0, W0)					Grounding wire [mm²] (Note 2)	Charging circuit (L4) (L5) (L6) [mm²]	Other (R3, T3) (73-1, 73-2) (R11, R12) (T11, T12) [mm²]	Control terminal (1, 2) (ONA) (ONB) (ONC) [mm²]
		Wire size [mm²] (Permissible temperature) (Note 1)			Bus bar size [mm²]	Current [A]				
			75°C	90°C						
132	160S		38	22	t5 x 30 (150)	135	22	2	2	1.25
160				38		163				
200	220S		60	60		205				
250	280S		100		t10 x 30 (300)	253	38	3.5		
280				100		283				
315	355S		150			319				
355						359				
400	450S			150		405	60			
450			200			455				

(Note 1) PVC was used for permissible temperature of 70 °C, and XLPE for permissible temperature of 90 °C.

(Note 2) Refer to Appendix 9 for information on wire permissible current based on ambient temperature.

6.4.12 Generated loss

Table 6.4.12-1 shows filter stack generated losses.

Table 6.4.12-1: Filter stack generated losses

Power-based series	Model	Generated loss [W]
3-phase 400V	RHF160S-4D☐	2850
	RHF220S-4D☐	3700
	RHF280S-4D☐	4600
	RHF355S-4D☐	5250
3-phase 690V	RHF160S-69D☐	2550
	RHF220S-69D☐	3350
	RHF280S-69D☐	4150
	RHF355S-69D☐	5050
	RHF450S-69D☐	6550

6.5 Braking system (braking unit, braking resistor)

The braking system (braking unit and braking resistor) provides a braking system that consumes regenerative energy from a motor as thermal energy by use of the resistor.

It can be used when using the RHD-D series diode rectifiers to construct a system where regenerative energy is generated.

6.5.1 Overview of braking resistor (DBR)

The FRENIC-VG provides two kinds of braking resistors (DBR):10%ED and 20%ED.

📖 For information on how to select a braking resistor, refer to "9.1.3.3 Selecting the braking resistor with the correct rating" in Chapter 9 of the separate volume "Unit Type Function Code Edition" (24A7-☐-0019).

A braking resistor overheat error function that detects the overheat error of the braking resistor is available.
The overheat error signal should be taken into the FRENIC-VG to prevent burning of the braking resistor.

📖 For information on the specifications, external dimensions, and connection method, refer to "8.5.1.1 overview of braking resistor (DBR)" in Chapter 8 of the separate volume "Unit Type Function Code Edition" (24A7-☐-0019).

6.5.2 Overview of braking unit

This braking unit for braking control is intended to consume the regenerative energy from the motor as thermal energy.
It is used in conjunction with the braking resistor.

The standard duty cycle of the braking unit is the 10%ED rating. When the fan unit (option: BU-F) is installed, however, the braking capacity is increased to the 30%ED.

Additionally, up to 15 braking units can be connected in parallel.

In addition to the standard series, **BUC560-4C** with a continuous regenerative capacity of 560 kW is also available.

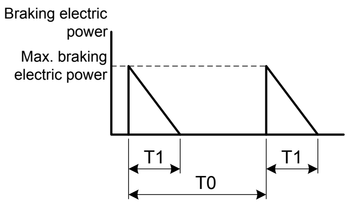
This section describes the braking unit on the assumption of using the standard series braking unit.

📖 For details, refer to the instruction manuals listed below.
Instruction manual for braking unit: INR-HF51196∗
Supplemental description of instruction manual for braking unit: INR-HF51614∗

Table 6.5.2-1: Standard braking unit specifications

Model: BU☐☐☐-4C	37	55	90	132	220
Min. connection resistance [Ω]	12	7.5	4.7	3.0	1.9
Max. braking electric power [kW]	37	56	90	135	240
Generated loss: 10%ED [W]	35	40	50	60	80
Rated input current [Arms]	12	19	31	47	79
Mass [kg]	4	5.5	5.5	9	13
Braking torque:	100%				
%ED: Duty cycle *1	10%ED (30%ED) *2				
Braking time *1	10 sec. (30 sec.) *2 /100 sec.-cycle				
Operating voltage [V]	758				
Protective functions	Fuse blown, Bu overheat, braking operation error, DBR overheat				
Cooling method	Self-cooling (forced cooling)				
Operating environment	Same as inverter				
Max. number of units connected in parallel	15 units (Master, 1 unit, Slave, 14 units) The remaining slave units are controlled at the detection level of the master braking unit operation.				

*1. %ED and braking time are calculated under the conditions shown below.



%ED = (T1/T0) x 100%
• T1: Braking time
• T0: Repetition period
The rated current is the r.m.s. value current in the T0 zone.

*2. The value in ( ) shows the capability when the optional fan unit (BU-F) is installed.

6.5.3 Standard combination

(1) 10%ED spec

Table 6.5.3-1: List of regenerative performance (10%ED spec)

Power supply voltage	MD/LD spec	Regenerative capacity (kW)	Connection diagram	Standard combination					Max. braking torque [%]			Continuous braking (150%-torque conversion value)		Repetition braking (Cycle is 100 sec. or less)	
				Braking unit		Braking resistor				Torque [N·m]					
				Model	Quantity (units)	Model	Quantity (units)	Resistance value [Ω]		50 Hz	60 Hz	Braking time [s]	Dis-charging capability [kWs]	Duty cycle [%ED]	Average loss [kW]
3-phase 400 V	MD spec	3.7	A	BU37-4C	1	DB3.7V-41B	1	96	150	35.3	29.4	10	27.8	10	0.278
		5.5				DB5.5V-41B	1	64		52.5	43.8		41.3		0.413
		7.5				DB7.5V-41B	1	48		71.6	59.7		56.3		0.563
		11				DB11V-41B	1	32		105	87.5		82.5		0.825
		15				DB15V-41B	1	24		143	119		113		1.13
		18.5				DB18.5V-41B	1	18		177	147		139		1.39
		22				DB22V-41B	1	16		210	175		165		1.65
		30		BU55-4C	1	DB30V-41B	1	10		286	239		225		2.25
		37				DB37V-41B	1	9.0		353	294		278		2.78
		45		BU90-4C	1	DB45V-41B	1	8.0		430	358		338		3.38
		55				DB55V-41C	1	6.5		525	438		413		4.13
		75		BU132-4C	1	DB75V-41C	1	4.7		716	597		563		5.63
		90				DB90V-41C	1	3.9		859	716		675		6.75
		110		BU220-4C	1	DB110V-41C	1	3.2		1050	875		825		8.25
		132				DB132V-41C	1	2.6		1261	1050		990		9.90
		160	C			DB160V-41C	1	2.2		1528	1273		1200		12.0
		200	D	BU220-4C	2	DB200V-41C	1	3.5/2		1910	1592		1500		15.0
		220				DB220V-41C	1	3.2/2		2101	1751		1650		16.5
		280	E			DB160V-41C	2	2.2/2		2674	2228		2100		21.0
		315				DB160V-41C	2	2.2/2		3008	2507		2363		23.6
		355	F	BU220-4C	3	DB132V-41C	3	2.6/3		3390	2825		2663		26.6
		400				DB132V-41C	3	2.6/3		3820	3183		3000		30.0
		500	G	BU220-4C	4	DB132V-41C	4	2.6/4		4775	3979		3750		37.5
		630	H			DB160V-41C	4	2.2/4		6016	5013		4725		47.3
	LD spec	37	A	BU55-4C	1	DB30V-41B	1	10	110	259	216	10	204	10	2.25
		45				DB37V-41B	1	9.0		315	263		248		2.78
		55		BU90-4C	1	DB45V-41B	1	8.0		385	321		303		3.38
		75				DB55V-41C	1	6.5		525	438		413		4.13
		90		BU132-4C	1	DB75V-41C	1	4.7		630	525		495		5.63
		110				DB90V-41C	1	3.9		770	642		605		6.75
		132		BU220-4C	1	DB110V-41C	1	3.2		924	770		726		8.25
		160				DB132V-41C	1	2.6		1120	934		880		9.9
		200	C			DB160V-41C	1	2.2		1401	1167		1100		12.0
		220	D	BU220-4C	2	DB200V-41C	1	3.5/2		1541	1284		1210		15.0
		280				DB220V-41C	1	3.2/2		1961	1634		1540		16.5
		355	E			DB160V-41C	2	2.2/2		2486	2072		1953		21.0
		400				DB160V-41C	2	2.2/2		2801	2334		2200		23.6
		450	F	BU220-4C	3	DB132V-41C	3	2.6/3		3151	2626		2475		26.6
		500				DB132V-41C	3	2.6/3		3501	2918		2750		30.0
		630	G	BU220-4C	4	DB132V-41C	4	2.6/4		4412	3677		3465		37.5
		710	H			DB160V-41C	4	2.2/4		4972	4143		3905		47.3

Note: The models DB160V-41C to DB220V-41C use two braking resistors per unit.

Example) Four braking resistors are used for two units of the model DB160V-41C.

(2) 20%ED spec

Table 6.5.3-2: List of regenerative performance (20%ED spec)

Power supply voltage	MD/LD spec	Regenerative capacity (kW)	Connection diagram	Standard combination: Braking unit Model	Braking unit Quantity (units)	Braking resistor Model	Braking resistor Quantity (units)	Resistance value [Ω]	Max. braking torque [%]	Torque [N·m] 50 Hz	Torque [N·m] 60 Hz	Continuous braking (150%-torque conversion value) Braking time [s]	Dis-charging capability [kWs]	Repetition braking (Cycle is 100 sec. or less) Duty cycle [%ED]	Average loss [kW]
3-phase 400 V	MD spec	3.7	A	BU37-4C +BU-F	1	DB3.7V-42B	1	96	150	35.3	29.4	20	55.5	20	0.555
		5.5				DB5.5V-42B	1	64		52.5	43.8		82.5		0.825
		7.5				DB7.5V-42B	1	48		71.6	59.7		113		1.13
		11				DB11V-42B	1	32		105	87.5		165		1.65
		15				DB15V-42B	1	24		143	119		225		2.25
		18.5				DB18.5V-42B	1	18		177	147		278		2.78
		22				DB22V-42B	1	16		210	175		330		3.30
		30		BU55-4C +BU-F	1	DB30V-42C	1	12		286	239		450		4.50
		37				DB37V-42C	1	9.0		353	294		555		5.55
		45		BU90-4C +BU-F	1	DB45V-42C	1	8.0		430	358		675		6.75
		55				DB55V-42C	1	6.5		525	438		825		8.25
		75		BU132-4C +BU-F	1	DB75V-42C	1	4.7		716	597		1125		11.3
		90				DB90V-42C	1	3.9		859	716		1350		13.5
		110		BU220-4C +BU-F	1	DB110V-42C	1	3.2		1050	875		1650		16.5
		132				DB132V-42C	1	2.6		1261	1050		1980		19.8
		160	C			DB160V-42C	1	2.2		1528	1273		2400		24.0
		200	D	BU220-4C +BU-F	2	DB200V-42C	1	3.5/2		1910	1592		3000		30.0
		220				DB220V-42C	1	3.2/2		2101	1751		3300		33.0
		280	E			DB160V-42C	2	2.2/2		2674	2228		4200		42.0
		315				DB160V-42C	2	2.2/2		3008	2507		4725		47.3
		355	F	BU220-4C +BU-F	3	DB132V-42C	3	2.6/3		3390	2825		5325		53.3
		400				DB132V-42C	3	2.6/3		3820	3183		6000		60.0
		500	G	BU220-4C +BU-F	4	DB132V-42C	4	2.6/4		4775	3979		7500		75.0
		630	H			DB160V-42C	4	2.2/4		6016	5013		9450		94.6
	LD spec	37	A	BU55-4C +BU-F	1	DB30V-42C	1	12	110	259	216	20	407	20	4.50
		45				DB37V-42C	1	9.0		315	263		495		5.55
		55		BU90-4C +BU-F	1	DB45V-42C	1	8.0		385	321		605		6.75
		75				DB55V-42C	1	6.5		525	438		825		8.25
		90		BU132-4C +BU-F	1	DB75V-42C	1	4.7		630	525		990		11.3
		110				DB90V-42C	1	3.9		770	642		1210		13.5
		132		BU220-4C +BU-F	1	DB110V-42C	1	3.2		924	770		1452		16.5
		160				DB132V-42C	1	2.6		1120	934		1760		19.8
		200	C			DB160V-42C	1	2.2		1401	1167		2200		24.0
		220	D	BU220-4C +BU-F	2	DB200V-42C	1	3.5/2		1541	1284		2420		30.0
		280				DB220V-42C	1	3.2/2		1961	1634		3080		33.0
		355	E			DB160V-42C	2	2.2/2		2486	2072		3905		47.3
		400				DB132V-42C	3	2.6/3		2801	2334		4400		53.3
		450	F	BU220-4C +BU-F	3	DB132V-42C	3	2.6/3		3151	2626		4950		53.3
		500				DB132V-42C	3	2.6/3		3501	2918		5500		60.0
		630	G	BU220-4C +BU-F	4	DB132V-42C	4	2.6/4		4412	3677		6930		75.0
		710	H			DB160V-42C	4	2.2/4		4972	4143		7810		94.6

Note (1) This option is a custom order production product.

(2) The fan unit (BU-F) is needed for the braking unit.
The models DB200V-42C and DB220V-42C use two braking resistors per unit.
Example) Two braking resistors are used for one unit of the model DB200V-42C.

6.5.4 Installation

Braking resistor (DBR)

(1) In the case of continuous regeneration, the braking resistor heats the average loss of the repetition braking (cycle: 100 sec.) stated in the List of regenerative performance values in Section 6.5.3.
Additionally, when the braking resistor uses metallic grid resistance elements, its surface temperature may reach 100°C or more.
Therefore, it is recommended to install the braking resistor on the top of the cabinet. (🕮Refer to "12.5.2 Principles in designing layout in cabinets" in Chapter 12.)

(2) When storing the braking resistor into the cabinet, heat radiation measures must be investigated sufficiently. (Investigate a structure where the heat of the DBR does not adversely affect units stored inside the cabinet.)

Braking unit

(1) Install vertically. Do not install upside down or horizontally.

(2) Keep a space as illustrated in **Figure 6.5.4-1**. Additionally, since the heat radiates toward the upper portion, do not install units vulnerable to the heat at the upper portion of the braking unit.

(3) Cooling fins are installed on the rear of the braking unit. When the braking unit operates continuously, the fin temperature may increase to approx. 90°C. So, appropriate materials that can endure the temperature increase should be used for the rear.

(4) When using multiple braking units, arrange them horizontally to minimize the mutual heat interference. However, when installing the braking units vertically due to restrictions on space inside the cabinet, partition plates or the like should be mounted to prevent the effects of the heat at the lower portion on the upper portion. (🕮Refer to "12.5.2 Principles in designing layout in cabinets" in Chapter 12.)

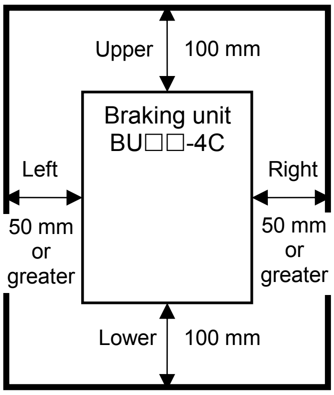


Figure 6.5.4-1: Restrictions on braking unit installation

6.5.5 Protective operation

If an error stated in Table 6.5.5-1 occurs, the braking unit stops the DB drive and outputs the alarm signal (for any alarm) from terminals 1 and 2. (The alarm signal (for any alarm) has no error content classifications.) It is necessary to use this alarm signal so as to put the inverter in the coast-to-a-stop status (i.e., [OH2: external alarm] or [BX: coast-to-a-stop command] is input to the X terminal).

Table 6.5.5-1: Contents of protective operation

Item	Contents (Structure)
Fuse blown	Operates if the fuse in the braking unit main circuit is blown by short-circuit or breakage of the circuit.
Cooling unit overheat	Operates if the temperature of the unit cooling fins increases due to frequent braking operation exceeding the specifications, high ambient temperature, or clogging of cooling fins.
IGBT (switching element) conduction error	Operates if the IGBT (switching element) detects the conduction even when the DB drive signal shows the stop status.
Braking resistor overheat	Operates if the operation frequency of the braking resistor becomes high and the temperature of the braking resistor increases.

6.5.6 Cautions on use of terminal functions

6.5.6.1 Braking resistor (DBR)

Table 6.5.6-1: List of braking resistor (DBR) terminals

Terminal symbol	Terminal name	Description
P, DB	DB unit connection terminal	Connect the P(+)R and DB terminals of the braking unit to these terminals.
1, 2	Braking resistor overheat error	Braking resistor overheat error detection terminal
⏚ G	For braking resistor grounding	Grounding terminal

6.5.6.2 Braking unit

(1) Main circuit and grounding terminal connections

Table 6.5.6-2: Functions of main circuit and grounding terminals

Terminal symbol	Terminal name	Description
P(+), DB(-)	Braking resistor connection terminal	Connect to the P(+)R and DB terminals of the braking resistor.
P(+)R, DB	Braking resistor connection terminals	Connect to the braking resistor.
⏚ G	For braking unit grounding	Grounding terminal

(1) DC interconnecting terminals [(P(+), N(-)]

1) Connect the DC intermediate circuit terminals P(+) and N(-) of the inverter to the terminals P(+) and N(-) of the braking unit.
2) Lay out the units so that the wiring length is 5 m or less. Additionally, perform the twist wiring or close-contact (parallel) wiring for two wires.

(2) Braking resistor connection terminals [(P(+)R and DB)]

1) Connect the terminals P and DB of the braking resistor to the terminals P(+)R and DB of the braking unit.
2) Lay out the units so that the wiring length is 10 m or less. Additionally, perform the twist wiring or close-contact (parallel) wiring for two wires.

(3) Unit grounding terminal [G]

To ensure the safety and take noise prevention measures, be sure to ground the unit grounding terminal ⏚G. In the Electrical Equipment Technical Standards, it is instructed to perform the grounding to the metallic frame of the electrical equipment so as to prevent accidents, such as electric shock or fire.

When making connections, observe the following:

1) According to the Electrical Equipment Technical Standards, connect the grounding terminal to the grounding pole where the class C grounding work has been made.
2) Connect a thick wire to the grounding terminal with a short distance and connect the grounding terminal to the grounding pole dedicated to the inverter system.

For more details, refer to Section 6.5.8.1.

(2) Control terminal connections

Table 6.5.6-3: Functions of control terminals

Terminal symbol	Terminal name	Description
1, 2	Braking unit alarm output (for any alarm)	Outputs a failure signal, such as IGBT overheat or fuse blown inside the braking unit Additionally, this terminal also detects an alarm to stop the DB operation when an error signal is input from the braking unit or braking resistor. Rating: 24 VDC, 3 to 30 mA (max)
i1, i2	DB drive slave input terminal	Use this terminal when connecting braking units in parallel. Remaining slave units are controlled at the DB operation detection level of the master unit. 📖 For details, refer to "6.5.6.2 (3) Examples of connection diagrams".
o1, o2,	DB drive master output terminal	
CN5, CN6	Option fan power supply connection connector	Connect the fan power wires when an optional fan is installed.

2-1) Braking unit alarm output (for any alarm) [1, 2]

Connect the braking unit and braking resistor terminals to the contact inputs assigned to the external alarm input in series like 1⇨2⇨1⇨2. A photo-coupler is used inside the braking unit to detect an error signal from other braking unit or braking resistor as illustrated in Figure 6.5.6-1. This photo-coupler has a **voltage drop of approx. 1 V**. When multiple braking units are connected as a loop, the alarm does not operate by the voltage drop of the photo-coupler.

Therefore, the DB error detection loop connection is restricted as follows.

- Direct input to INV: Up to 3 units
- Detection by relay: Up to 4 units

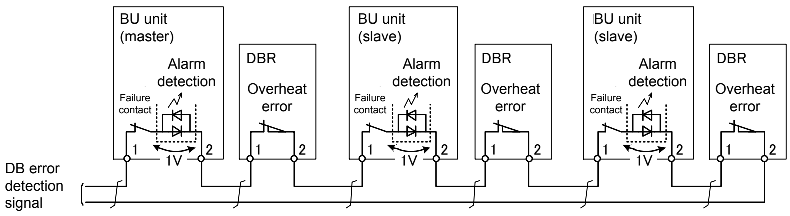


Figure 6.5.6-1: Braking unit and DBR alarm detection circuit (example)

📖 For details on relay connections, refer to Figure 6.5.6-6 "Circuit diagram when detecting DB error by relay".

2-2) DB drive master-slave terminals [input: i1, i2, output: o1, o2]

① These terminals are used when two or more braking units are connected in parallel.
(Master-slave wiring.)
For details about how to connect the terminals, refer to Figure 6.5.6-5.

② When using a single braking unit, set SW1 as illustrated in Figure 6.5.6-2-a. (Factory default)

③ When using braking units in the parallel connection, the SW1 is as follows:
- Master: Short-circuit 2-3 of a). (Factory default)
- Slave: Short-circuit 1-2 of b).

④ To prevent malfunction by noise, use a twisted wiring for the "master-slave wiring" and make the connection with a wiring length of 1.5 m or less (as a rough guideline).

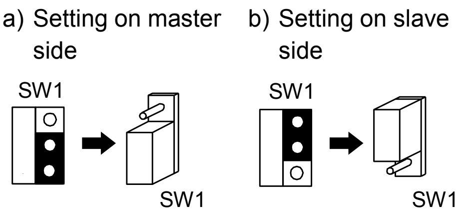


Figure 6.5.6-2: Switching braking unit's SW1

2-3) Option fan power supply connection connectors (CN5 and CN6)

① Connect the DC power supply of the BU-F fan unit (option).

② The connectors CN5 and CN6 have the same function.

③ Do not short-circuit the connectors when they are not used.

Note (1) Separate the control wiring from the main circuit wiring.
(Preventive measures against malfunction by noise.)

(2) Secure the control wiring inside the braking unit so that it is not directly in contact with the electrically live part of the main circuit (terminal block of main circuit).

For details, refer to the braking unit instruction manual (INR-HF51196*).

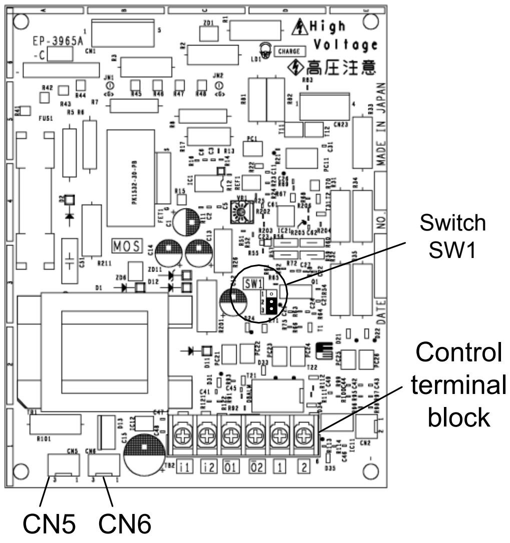


Figure 6.5.6-3: Braking unit control PCB

(3) Examples of connection diagrams

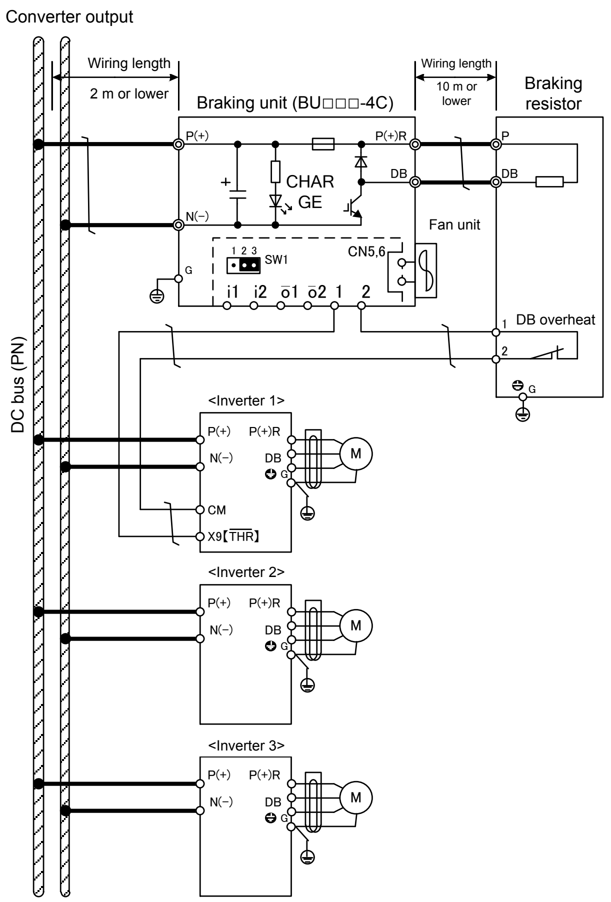


Figure 6.5.6-4: Basic connection diagram

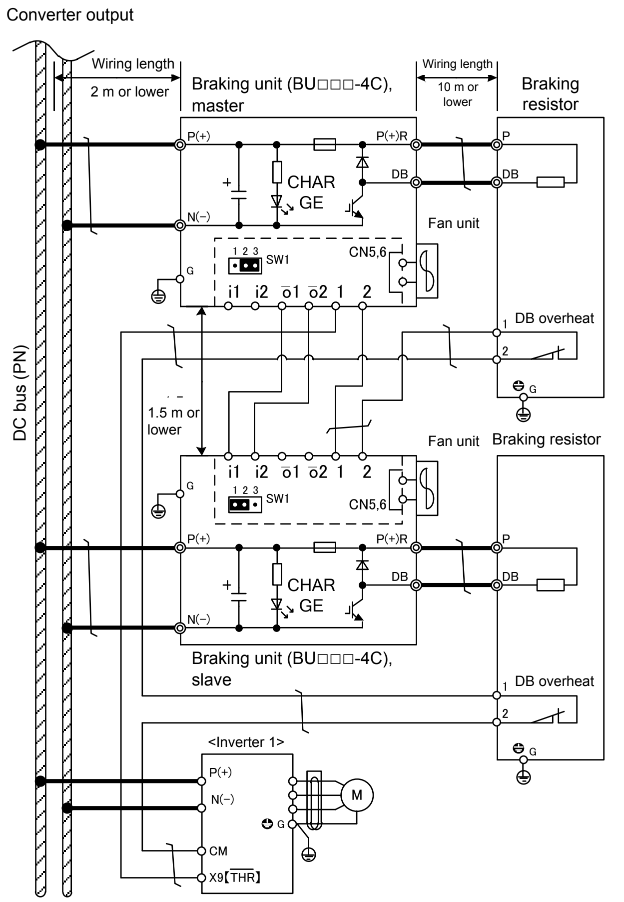


Figure 6.5.6-5: Connection diagram with braking units used in parallel

(4) DB circuit error is detected by relay

When detecting the error signal of the braking unit or braking resistor by the relay or when stopping multiple inverters, use the configuration illustrated in Figure 6.5.6-6.

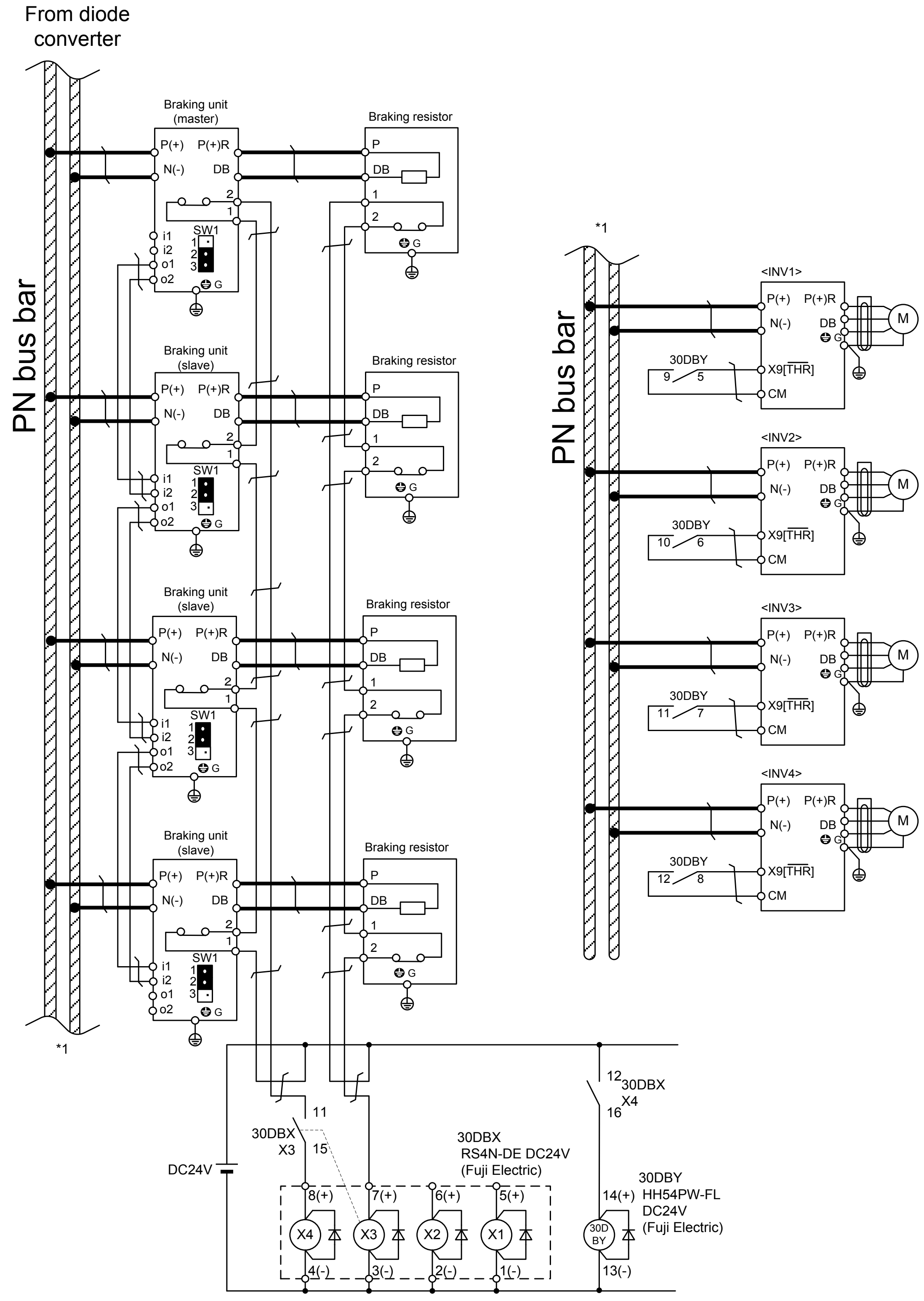


Figure 6.5.6-6: Circuit diagram when detecting DB error by relay

Note

(1) Use a relay that excites the coil using a minute current for the relay, to which the error signal of the braking unit is input. (Recommended: RS4N-DE 24VDC)

(2) In this circuit example, "DB error" to be input to the inverter is normally ON (ON during normal operation). Therefore, the DB error (OH2) is given if the inverter control power starts up earlier than the external 24 V power supply.

(3) When using the DBR for the equipment that restarts after momentary stop, back up the 24 V power supply. If measures for momentary stop are not taken, the DB error (OH2) is given.

6.5.7 Peripheral equipment

The peripherals used in the braking system as shown in Figure 6.5.7-1 have the following circuits.

NSW:	A circuit breaker used to separate the braking unit from the DC bus bar (PN). Since this circuit breaker is used in the common bus bar (DC) shared with the inverter, do not use a molded case circuit breaker (MCCB) with braking characteristics. Be sure to use a non-auto switch.
Charging circuit:	This circuit is intended for initial charging of the braking unit. The circuit is composed of an initial charging resistor, a magnetic contactor, and an option box "MCA-VG7-VSU".

It is not particularly necessary to install the peripheral equipment for normal operation applications.

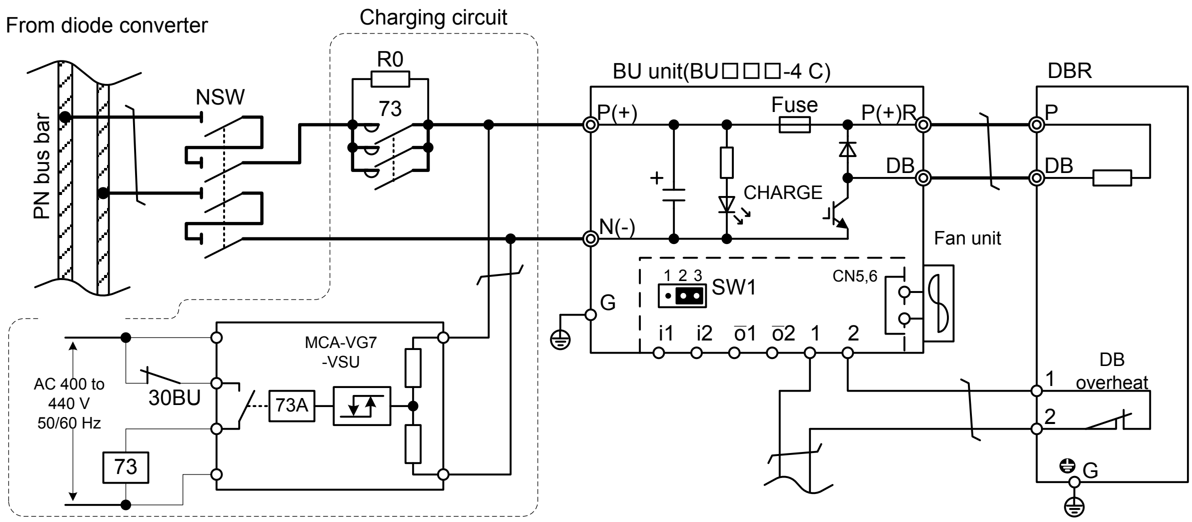


Figure 6.5.7-1: Peripheral equipment configuration for braking system

	Quantity used	Circuit breaker (NSW)	Charging circuit		
			Magnetic contactor (73)	Charging resistor	Voltage detector
BU37-4C	1	BW400RAS-4P	SC-N1+SZ-SP3	GZG100W 20ΩJ (JRM)	MCA-VG7-VSU
BU55-4C	1				
BU90-4C	1				
BU132-4C	1				
BU220-4C	1				
	2		SC-N3+SZ-SP4	80W7.5Ω (HF5C5504)	
	3	BW630RAS-4P	SC-N6+SZ-SP6		
	4		SC-N7+SZ-SP7		

*1. SZ-SP□: 3-phase parallel terminal plate (for short-circuiting of main contact of magnetic contactor)

Note
(1) Open or close the circuit breaker while the DC bus bar is not turned ON.
When operating the circuit breaker while the DC bus bar is turned ON, the external handle that can be operated when the cabinet door is closed should be combined with a non-auto switch.
(2) The circuit breaker should be used in the common DC bus bar shared with the inverter. Therefore, a molded case circuit breaker (MCCB) or an earth leakage circuit breaker (ELCB) with braking characteristics cannot be used.
(3) A 4-pole non-auto switch for DC that can keep the withstand voltage should be used for the circuit breaker.
(4) When using multiple braking units, perform the branch wiring from the secondary side of the unit (73), etc.

6.5.8 Wire size selection

The wire size of the main circuit is calculated from the current value shown below.

$$I_{DB(AVG)} = \sqrt{\frac{P_{AVG}}{R_{DB}}}[A] \quad \cdots \quad \text{Equation 6.5.8-1}$$

$$I_{DB(PEAK)} = \frac{Vdc}{R_{DB}}[A] \quad \cdots \quad \text{Equation 6.5.8-2}$$

- $I_{DB\,(AVG)}$: DB average current [A] when converting it into the average loss
- $I_{DB\,(PEAK)}$: DB peak current [A] in max. braking-regenerative time period
- P_{AVG}: Average loss of DBR [W]
- R_{DB}: Resistance value of DBR [Ω]
- V_{DC}: Braking unit operating voltage (DC intermediate circuit voltage) [V]

Normally, the wire size is calculated from the average loss of the braking resistor. If the maximum electric power is large with low frequency, the wire size should be also calculated from the short-time allowable current in the peak current-regenerative time period.

6.5.8.1 Wire size (obtained from braking unit specifications)

The wire size of a braking unit is selected so that it meets the braking resistor specifications. This section describes applicable wire sizes from the braking unit specifications. For information on how to select the wire size based on the braking resistor specifications, see Section 6.5.8.2.

The DB average current is calculated from "Table 6.5.2-1 Standard braking unit specifications" in "6.5.2 Overview of braking unit" to select appropriate wire sizes, using Equation 6.5.8-1.

Table 6.5.8-1: Recommended wire size based on the braking unit specifications

	Terminal size Main circuit grounding wire	Main circuit: P(+), N(-), P(+)R, DB								Grounding wire ⏚G	Control wire
		10%ED (Standard)				30%ED (BU-F installed)					
		$I_{DB(AVG)}$ [A]	Temperature inside cabinet is 40°C or less.			$I_{DB(AVG)}$ [A]	Temperature inside cabinet is 50°C or less.				
			60°C	75°C	90°C		60°C	75°C	90°C		
BU37-4C	M4	12.0	2	2	2	21.6	5.5	2	2	2	1.25
BU55-4C	M5	19.4				33.6	8	5.5	3.5		
BU90-4C	M6	31.0	5.5	3.5		53.6	22	8	5.5	3.5	
BU132-4C	M8	47.5	8	5.5	5.5	82.2	38	22	14	5.5	
BU220-4C	M10	79.5	22	14	14	137.7	100	38	38	14	

Note: An "IV wire," a "600 V HIV insulated wire," and a "600 V cross-linked polyethylene insulated wire" were used at permissible temperatures of 60°C, 75°C, and 90°C, respectively, and the values represent aerial wiring.

6.5.8.2 Wire size (obtained from braking resistor specifications)

Table 6.5.8-2: Applicable wire size in various combinations of standard baking resistors

Power-based series	Specifications	Regenerative capacity (kW)	Braking resistor		Temperature inside cabinet is 50°C or less.								Temperature inside cabinet is 40°C or less.							
			Model	Quantity	10%ED rating				20%ED rating				10%ED rating				20%ED rating			
					60°C	75°C	90°C	Current [A]	60°C	75°C	90°C	Current [A]	60°C	75°C	90°C	Current [A]	60°C	75°C	90°C	Current [A]
3-phase 400V	MD	3.7	DB3.7V-4☐B	1	2.0	2.0	2.0	1.7	2.0	2.0	2.0	2.4	2.0	2.0	2.0	1.7	2.0	2.0	2.0	2.4
		5.5	DB5.5V-4☐B	1	2.0	2.0	2.0	2.5	2.0	2.0	2.0	3.6	2.0	2.0	2.0	2.5	2.0	2.0	2.0	3.6
		7.5	DB7.5V-4☐B	1	2.0	2.0	2.0	3.4	2.0	2.0	2.0	4.8	2.0	2.0	2.0	3.4	2.0	2.0	2.0	4.8
		11	DB11V-4☐B	1	2.0	2.0	2.0	5.1	2.0	2.0	2.0	7.2	2.0	2.0	2.0	5.1	2.0	2.0	2.0	7.2
		15	DB15V-4☐B	1	2.0	2.0	2.0	6.8	2.0	2.0	2.0	9.7	2.0	2.0	2.0	6.8	2.0	2.0	2.0	9.7
		18.5	DB18.5V-4☐B	1	2.0	2.0	2.0	8.8	2.0	2.0	2.0	12.4	2.0	2.0	2.0	8.8	2.0	2.0	2.0	12.4
		22	DB22V-4☐B	1	2.0	2.0	2.0	10.2	2.0	2.0	2.0	14.4	2.0	2.0	2.0	10.2	2.0	2.0	2.0	14.4
		30	DB30V-4☐C	1	2.0	2.0	2.0	15.0	3.5	2.0	2.0	19.4	2.0	2.0	2.0	15.0	2.0	2.0	2.0	19.4
		37	DB37V-4☐C	1	3.5	2.0	2.0	17.6	5.5	3.5	2.0	24.8	2.0	2.0	2.0	17.6	3.5	2.0	2.0	24.8
		45	DB45V-4☐C	1	3.5	2.0	2.0	20.5	8.0	3.5	2.0	29.0	2.0	2.0	2.0	20.5	3.5	3.5	2.0	29.0
		55	DB55V-4☐C	1	5.5	3.5	2.0	25.2	14	5.5	3.5	35.6	3.5	2.0	2.0	25.2	5.5	3.5	3.5	35.6
		75	DB75V-4☐C	1	8.0	5.5	3.5	34.6	14	8.0	5.5	48.9	5.5	3.5	3.5	34.6	8.0	5.5	5.5	48.9
		90	DB90V-4☐C	1	14	5.5	3.5	41.6	22	14	8.0	58.8	8.0	5.5	3.5	41.6	14	8.0	5.5	58.8
		110	DB110V-4☐C	1	14	8.0	5.5	50.8	38	14	14	71.8	14	5.5	5.5	50.8	14	14	8.0	71.8
		132	DB132V-4☐C	1	22	14	8.0	61.7	38	22	14	87.3	14	8.0	5.5	61.7	22	14	14	87.3
		160	DB160V-4☐C	1	38	14	14	73.9	60	38	22	104	22	14	8.0	73.9	38	22	14	104
		200	DB200V-4☐C	1	38	22	14	92.6	100	38	22	131	22	14	14	92.6	38	38	22	131
		220	DB220V-4☐C	1	60	22	22	102	100	38	38	144	38	22	14	102	60	38	22	144
		280	DB160V-4☐C	2	100	38	38	138	150	60	60	195	60	38	22	138	100	60	38	195
		315	DB160V-4☐C	2	100	38	38	147	150	100	60	207	60	38	22	147	100	60	38	207
		355	DB132V-4☐C	3	150	60	38	175	200	100	60	248	60	60	38	175	150	100	60	248
		400	DB132V-4☐C	3	150	60	60	186	200	100	100	263	100	60	38	186	150	100	60	263
		500	DB132V-4☐C	4	200	100	60	240	325	150	100	340	100	100	60	240	200	150	100	340
		630	DB160V-4☐C	4	250	150	100	293	2x200	200	150	381	150	100	100	293	200	150	100	381
	LD	37	DB30V-4☐C	1	2.0	2.0	2.0	14.9	3.5	2.0	2.0	19.2	2.0	2.0	2.0	14.9	2.0	2.0	2.0	19.2
		45	DB37V-4☐C	1	3.5	2.0	2.0	17.3	5.5	3.5	2.0	24.5	2.0	2.0	2.0	17.3	3.5	2.0	2.0	24.5
		55	DB45V-4☐C	1	3.5	2.0	2.0	20.3	8.0	3.5	2.0	28.7	2.0	2.0	2.0	20.3	3.5	2.0	2.0	28.7
		75	DB55V-4☐C	1	5.5	3.5	2.0	26.3	14	5.5	3.5	37.2	3.5	2.0	2.0	26.3	5.5	3.5	3.5	37.2
		90	DB75V-4☐C	1	8.0	5.5	3.5	33.9	14	8.0	5.5	47.9	5.5	3.5	2.0	33.9	8.0	5.5	5.5	47.9
		110	DB90V-4☐C	1	14	5.5	3.5	41.1	22	14	8.0	58.2	8.0	5.5	3.5	41.1	14	8.0	5.5	58.2
		132	DB110V-4☐C	1	14	8.0	5.5	49.7	38	14	14	70.4	8.0	5.5	5.5	49.7	14	14	8.0	70.4
		160	DB132V-4☐C	1	22	14	8.0	60.8	38	22	14	85.9	14	8.0	5.5	60.8	22	14	14	85.9
		200	DB160V-4☐C	1	38	14	14	73.9	60	38	22	104	22	14	8.0	73.9	38	22	14	104
		220	DB200V-4☐C	1	38	22	14	86.8	60	38	22	123	22	14	14	86.8	38	22	22	123
		280	DB220V-4☐C	1	60	22	22	102	100	38	38	145	38	22	14	102	60	38	22	145
		355	DB160V-4☐C	2	100	38	38	139	150	60	60	197	60	38	22	139	100	60	38	197
		400	DB132V-4☐C	3	100	60	38	148	200	100	60	235	60	38	22	148	100	100	60	235
		450	DB132V-4☐C	3	150	60	38	177	200	100	100	250	60	60	38	177	150	100	60	250
		500	DB132V-4☐C	3	150	60	60	186	200	100	100	263	100	60	38	186	150	100	60	263
		630	DB132V-4☐C	4	200	100	60	241	325	150	100	341	100	100	60	241	200	150	100	341
		710	DB160V-4☐C	4	250	150	100	278	2x200	200	150	394	150	100	60	278	250	150	150	394

Note

(1) An "IV wire," a "600 V HIV insulated wire," and a "600 V cross-linked polyethylene insulated wire" were used at permissible temperatures of 60°C, 75°C, and 90°C, respectively, and the values represent aerial wiring.

(2) Either "1" or "2" appears in ☐ of the braking resistor model shown above. 1: 10%ED, 2: 20%ED

(3) A single DB160V-41C to DB220V-41C, DB200V-42C, or DB220V-42C is comprised of two breaking resistors.

Examples) DB160V-41C x 2 → 4 breaking resistors
DB200V-42C x 1 → 2 breaking resistors

6.5.9 External dimensions

6.5.9.1 Braking resistor (DBR)

Figure A

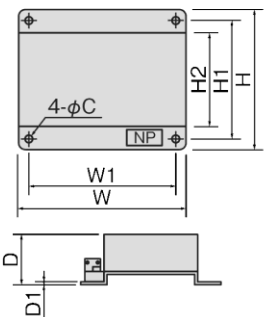
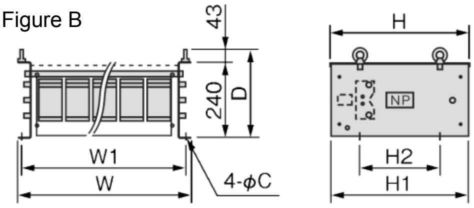


Figure B

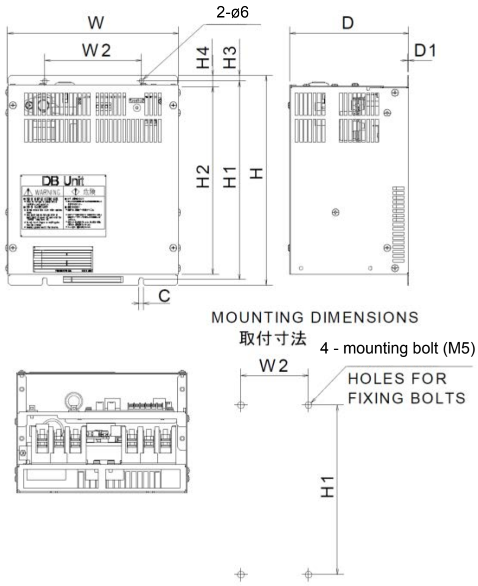


	Model	Dimensions [mm]								Figure	Approx. mass [kg]	Set quantity
		W	W1	H	H1	H2	D	D1	C			
400 V 10%ED	DB3.7V-41B	420	388	280	248	203	140	1.6	8	A	5	
	DB5.5V-41B	420	388	480	448	377	140	1.6	10		7	
	DB7.5V-41B											
	DB11V-41B										8	
	DB15V-41B	420	388	660	628	557	140	1.6	10		11	
	DB18.5V-41B											
	DB22V-41B										14	
	DB30V-41B										19	
	DB37V-41B	425	388	750	718	647	240	1.6	10		21	
	DB45V-41B										26	
	DB55V-41C	550	520	440	430	250	283	—	12	B	26	
	DB75V-41C										30	
	DB90V-41C	650	620	440	430	250	283	—	12		41	
	DB110V-41C	750	720	440	430	250	283	—	12		57	
	DB132V-41C										43	
	DB160V-41C	600	570	440	430	250	283	—	12		74	2 units per set
	DB200V-41C	725	695	440	430	250	283	—	12		50 (x 2)	
	DB220V-41C										51 (×2)	
400 V 20%ED	DB3.7V-42B	420	388	480	448	377	140	1.6	10	A	8	
	DB5.5V-42B										11	
	DB7.5V-42B											
	DB11V-42B										14	
	DB15V-42B	420	388	750	718	647	240	1.6	10		21	
	DB18.5V-42B											
	DB22V-42B										26	
	DB30V-42C	600	570	440	430	250	283	—	12	B	24	
	DB37V-42C	700	670	440	430	250	283	—	12		32	
	DB45V-42C										34	
	DB55V-42C	750	720	440	430	250	283	—	12		45	
	DB75V-42C	550	520	440	430	250	483	—	12		68	
	DB90V-42C	650	620	440	430	250	483	—	12		65	
	DB110V-42C	700	670	440	430	250	483	—	12		82	
	DB132V-42C										86	
	DB160V-42C										100	
	DB200V-42C	700	670	440	430	250	483	—	12		85 (×2)	2 units per set
	DB220V-42C										83 (×2)	

Note For items marked as ▇ in the table above, two resistors of the same shape are used as one set. Carefully check this point when investigating the installation space.

When ordering one unit of this model, one set (two resistors) will be delivered.

6.5.9.2 Braking unit (10%ED)

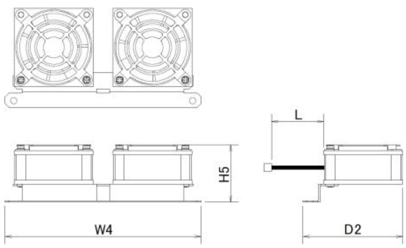


Voltage	Model	Dimensions [mm]									Approx. mass [kg]
		W	W2	H	H1	H2	H3	H4	D	D1	
400 V	BU37-4C	150	100	280	265	250	7.5	15	160	1.2	4
	BU55-4C	230	130								5.5
	BU90-4C										
	BU132-4C	250	150	370	355	340				2.4	9
	BU220-4C			450	435	420					13

6.5.9.3 Braking unit (Applicable to 30%ED)

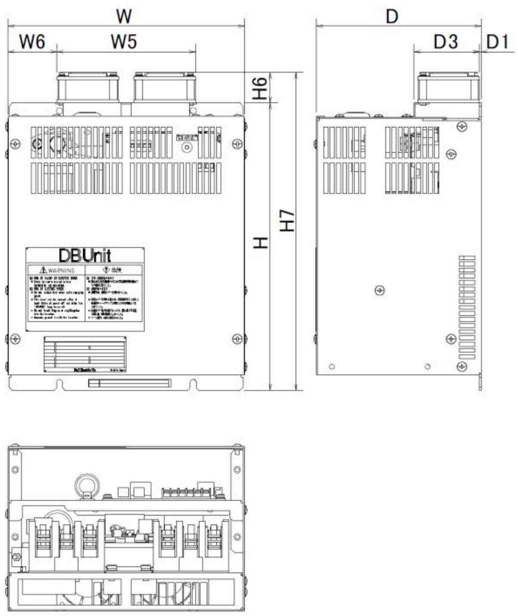
As the fan unit is installed, the braking unit capability is increased.

■ **Fan unit**



Model	Dimensions (mm)			
	W4	H5	D2	L (Fan power supply wire)
BU-F	149	44	76	320

■ **Braking unit and fan unit**

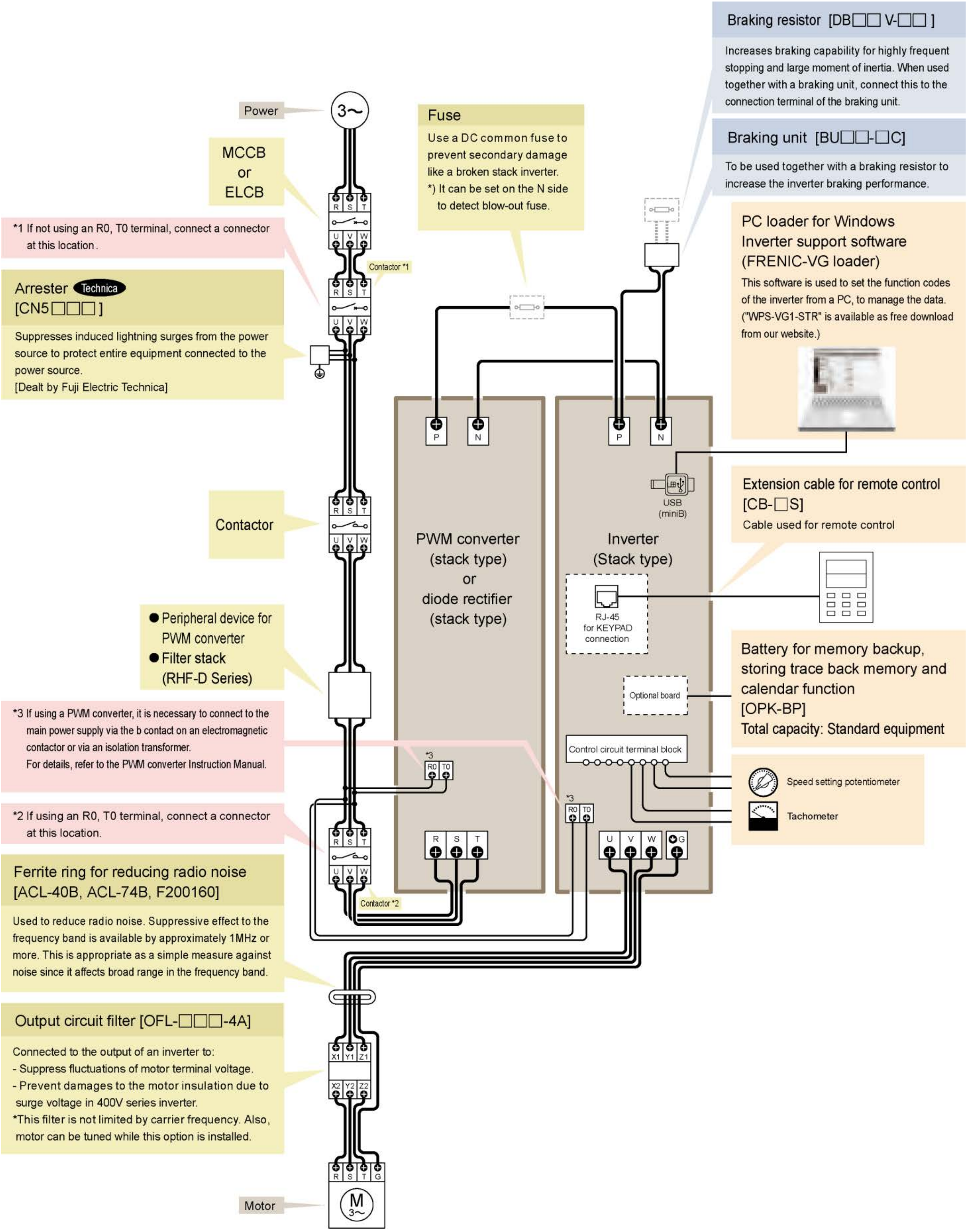


Voltage	Model	Dimensions [mm]								
		W	W5	W6	H	H6	H7	D	D1	D3
400 V	BU37-4C +BU-F	150	135	7.5	280	30	310	160	1.2	64
	BU55-4C +BU-F	230		47.5						
	BU90-4C +BU-F									
	BU132-4C +BU-F	250		57.5	370		400			
	BU220-4C +BU-F				450		480			

Chapter 7 EMC Compatible Peripherals

7.1 Configuring the FRENIC-VG

The following figure shows a typical installation of the PWM converter.



7.2 Anti-noise devices

7.2.1 Output circuit filter (OFL filter)

(1) The OFL filter is an LC filter used at the output side of the inverter for the following purposes:

- Protects the motor from insulation damage caused by micro surge voltage from the inverters.
- Suppresses leakage current (in-line leakage current) in long-distance wiring.
- Suppresses induction noise from the inverter output side wiring. Effective for suppression of surge/in-line leakage current in long wiring length such as in-plant facilities.

(2) Use output circuit filters in your desired combination, since they are available for each of the reactor and the capacitor unit.

(3) Use of output circuit filters is recommended for wiring length in excess of 50 m.

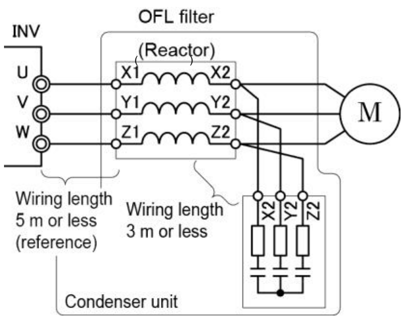


Figure 7.2.1-1: Circuit configuration

For more information, refer to the Output Circuit Filter (OFL-A) Instruction Manual (INR-HF52131∗).

7.2.1.1 Specifications

Power-based series	Applied motor capacity [kW]	Filter model (Procurement type)	Individual type		Rated value specifications			
			Reactor	Capacitor unit	Rated current [A]	Overload capacity [%]	Max. output frequency [Hz]	Rated voltage [V]
400V	30	**OFL-30-4A**	OFL-30-4A-L	OFL-30-4A-R	60	150%/1 min 180%/0.5 s	120 Hz	380 to 480 V
	37	**OFL-37-4A**	OFL-37-4A-L	OFL-37-4A-R	75			
	45	**OFL-45-4A**	OFL-45-4A-L	OFL-45-4A-R	91			
	55	**OFL-55-4A**	OFL-55-4A-L	OFL-55-4A-R	112			
	75	**OFL-75-4A**	OFL-75-4A-L	OFL-75-4A-R	150			
	90	**OFL-90-4A**	OFL-90-4A-L	OFL-90-4A-R	176			
	110	**OFL-110-4A**	OFL-110-4A-L	OFL-110-4A-R	210			
	132	**OFL-132-4A**	OFL-132-4A-L	OFL-132-4A-R	253			
	160	**OFL-160-4A**	OFL-160-4A-L	OFL-160-4A-R	304			
	200	**OFL-200-4A**	OFL-200-4A-L	OFL-200-4A-R	377			
	220	**OFL-220-4A**	OFL-220-4A-L	OFL-220-4A-R	415			
	280	**OFL-280-4A**	OFL-280-4A-L	OFL-280-4A-R	520			
	315	**OFL-315-4A**	OFL-315-4A-L	OFL-400-4A-R	585			
	355	**OFL-355-4A**	OFL-355-4A-L		650			
	630	**OFL-630-4A**	OFL-630-4A-L	OFL-500-4A-R	1170			
	710		Contact your Fuji Electric representative for details.					
	800							
	1000							

Environment	Location of use	• Shall be installed indoor (free from corrosive gases, flammable gases, dusts, oil mist). Pollution degree 2: IEC60664-1 • Shall not be exposed to direct sunlight.		
	Temperature	-10 to 50°C	Storage temperature	-25 to +65°C (max. +30°C for long-term storage)
	Ambient humidity	5 to 95% RH (without condensation)	Storage humidity	5 to 95% RH (without condensation)
	Altitude	1000 m or lower		
Max. output wiring length		400 m or lower		
Withstand voltage/insulation resistance		2500 VAC/min, 1 MΩ or higher (500 VDC megger)		

Note (1) The following range of inverter carrier frequencies can be used:

- OFL-30-4A to OFL-55-4A: 2 to 15 kHz
- OFL-75-4A to OFL-355-4A: 2 to 10 kHz

(2) Reactor and capacitor unit are delivered as a set if ordered in form as specified according to the "Filter model (Procurement type)" in this table. As for device nameplate on reactor and capacitor unit, the above individual type numbers are indicated.

(3) Resistance of capacitor unit will discharge heat when inverter is in operation. Hence, it is recommended to install it on top of the cabinet.

(4) In vector control where output circuit filter is used and wiring length is long, current vibration or torque shortage may occur due to lack of normal motor control, being affected by the inductance of output circuit filter or wiring.
Be sure to select a location for installing inverter and motor by taking into account the wiring length between inverter and motor of 100 m or less, even in the case of using output circuit filter.

7.2.1.2 External dimensions and applicable wire sizes

■ **Reactor**

Figure C

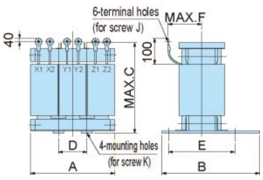


Figure D

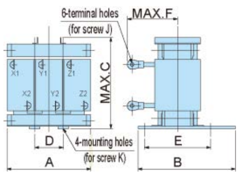
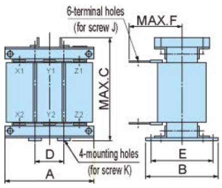
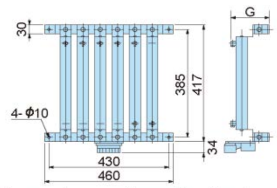


Figure E



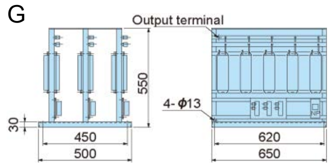
■ **Capacitor unit**

Figure F



The reactor, capacitor and resistor for filter OFL-30-4A or larger have to be installed separately.
(Those items are not included in the mass indicated in the table below. They are shipped as a set by ordering the filter.)

Figure G



Filter model	Figure	Dimensions (mm)										Approx. mass (kg)		Generated loss [W]		Wire size [mm²] *1	
		A	B	C	D	E	F	G		J	K	Reactor	Capacitor	Reactor	Capacitor	Reactor	Capacitor
OFL-30-4A	C/F	210	175	210	70	140	90	160	—	M5	M6	12	3	100	470	Same as wires for inverter	2 (M4)
OFL-37-4A		220	190	220	75	150	95	160	—	M5	M6	15	5.5	110	500		
OFL-45-4A	D/F	220	195	265	70	155	140	160	—	M6	M8	17	5.5	150	660		
OFL-55-4A		260	200	275	85	160	150	160	—	M6	M8	22	5.5	170	740		
OFL-75-4A		260	210	290	85	170	150	233	—	M8	M10	25	10	180	1020		
OFL-90-4A		260	210	290	85	170	155	233	—	M8	M10	28	10	190	1170		
OFL-110-4A		300	230	330	100	190	170	233	—	M8	M10	38	10	240	1170		
OFL-132-4A		300	240	340	100	200	170	233	—	M10	M10	42	10	260	1540		
OFL-160-4A		300	240	340	100	200	180	233	—	M10	M10	48	13	300	1910		
OFL-200-4A		320	270	350	105	220	190	333	—	M10	M12	60	16	330	2190		
OFL-220-4A		340	300	390	115	250	190	333	—	M10	M12	70	16	400	2190		
OFL-280-4A		350	300	430	115	250	200	333	—	M10	M12	78	19	450	3120		
OFL-315-4A	E/G	440	275	450	150	230	170	—	—	M12	M12	90	36	650	2640		
OFL-355-4A		440	290	480	150	245	175	—	—	M12	M12	100	36	680	2640		
OFL-630-4A		480	335	560	160	280	240	—	—	M12	M12	170	36	1300	3400		

*1 Regarding the wires to be connected to the output circuit filter, use those with an appropriate size as explained below:

- For I/O wiring of the filter reactor, use the wires with the same size as those for the inverter to be used.
- For wiring of the filter capacitor, use the "75°C 600 V HIV insulated wires" or "90°C 600 V cross-linked polyethylene-insulated wires". The maximum applicable wire is 5.5 mm² (M4 size).

Note

(1) The wiring length for the filter capacitor must be within 3 m as shown in Figure 7.2.1-1, and the wiring must be separated from the control circuit.

(2) The wire to be connected to the filter capacitor must not touch (closely contact) the resistance elements. If there is a possibility that the wire might contact the resistance elements, be sure to take a measure to protect the wires (for instance, cover the wires with a glass tube).

(3) Install the output circuit filter on the inverter side. Wiring length between inverter and OFL filter should be within 5 m as a rough guideline. However, wiring length longer than this will not pose any particular problem.

7.2.2 Radio noise reducing zero-phase reactor (ACL)

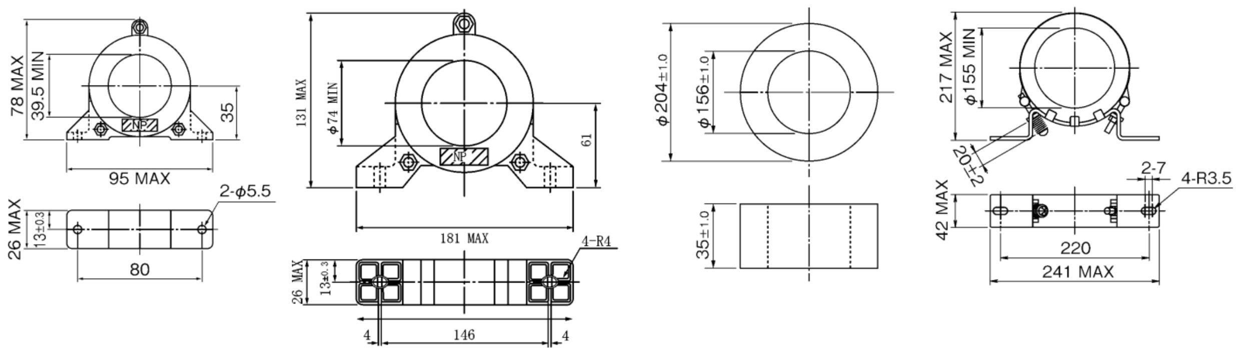
A radio noise reducing zero-phase reactor (ACL) reduces the radio noise generated from the inverter output wiring by leading the inverter output wiring through it 4 times. Three inverter output wires and one grounding wire (4 wires in all) should be led through the reactor 4 times in the same direction. If a shielded wire is used, it should also be led through 4 times. Be sure to use wires rated at 75°C or higher temperatures.

The ACL may generate a large amount of heat because it absorbs high frequency noise components and radiates into the air as heat. If this is the case, take appropriate measures such as lowering the carrier frequency, using wires with higher heat resistance, increasing the number of ACLs to reduce the number of lead-throughs (turns) per ACL, and/or using a larger sized ACL.

The wire sizes that can be used are determined by the dimension (inside diameter) and installation conditions of the radio noise reducing zero-phase reactor (ACL).

Refer to Table 7.2-1: Applicable wire sizes.

7.2.2.1 Specifications



ACL-40B | ACL-74B | F200160 (without installation legs) | F200160PB (with installation legs)

Figure 7.2.2-1: External dimensions of ACL

Table 7.2-1: Applicable wire sizes

Model	Operating conditions: Quantity	Operating conditions: No. of lead-throughs (turns)	Wire size [mm^2]
ACL-40B	1	4	2.0, 3.5, 5.5
	2	2	
	4	1	22, 38, 5.5×2, 8×2, 14×2, 22×2
ACL-74B	1	4	8, 14
	2	2	22, 38, 60, 5.5×2, 8×2, 14×2, 22×2
	4	1	100, 150, 200, 250, 325, 38×2, 60×2, 100×2
F200160 F200160PB	4	1	150×2, 200×2, 250×2, 325×2, 150×3, 200×3, 250×3, 325×3, 250×4, 325×4

Note

(1) The 3 phases (U, V, W) and the dedicated grounding wire for the motor are taken into consideration for the wires in the above table.

(2) The use conditions given in the above table are applied when the wires specified in this manual are used. (IV, HIV, and FLSC wires)

Operating environment

(1) Location of use : Indoor (There must be no corrosive gas, flammable gas, dust, or oil mist.)

: Must not be exposed to direct sunlight.

(2) Temperature : -20 to 50°C (Storage temperature: -30 to +70°C)

(3) Humidity : 5 to 95%Rh (There must be no dew condensation.)

(4) Altitude : 1000 m or less

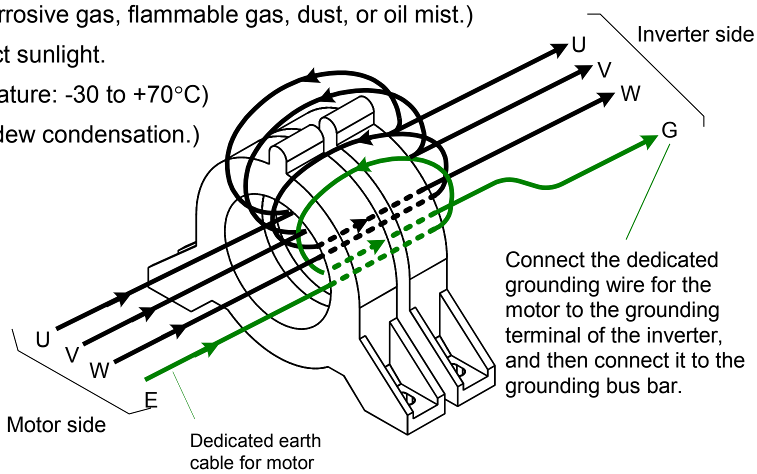


Figure 7.2.2-2: Leading the grounding wire through the ACL

7.2.3 Power filter (power filter for input by Fuji Electric Technica)

Noise current generated from inverter (converter) is suppressed by installing this filter on the input supply side of converter.

Note (1) Do not use a ground capacitor in combination with the power filter.

(2) Since leakage current as given in the specification below will flow constantly, care should be taken for sensitivity current settings of any earth leakage circuit breaker (ELCB) or leakage detector that is used.
(There will be an electrostatic capacity between the power filter and the ground since a ground capacitor is installed in the power filter.)

7.2.3.1 Specifications

Model	Rated current [A]	Leakage current [mA]	Rated voltage [V]	Voltage drop [V]	Withstand voltage [V]	Wire size [mm^2]	
						Main circuit	Grounding
RNFMCH1-40	150	• 2.1 mA or lower (neutral point grounding) • 19.0 mA or lower (S-phase grounding)	480	1.0 V or lower	2500 VAC/minute (between wires and ground)	Same as applicable converters	IV 2 mm^2 or higher
RNFMC2H-40	200						
RNFMC3H-40	300						
RNFMC4H-40	400						
RNFMC5H-40	500	9.9 mA or lower (neutral point grounding)					
RNFMC6H-40	600						
RNFMC9H-40	900						
RNFMC12H-40	1260						

Operating environment	Location of use	• Indoor (There must be no corrosive gas, flammable gas, dust, or oil mist.) • Must not be exposed to direct sunlight.
	Temperature	-10 to 50°C (Storage temperature: -10 to +60°C)
	Humidity	5 to 95%Rh (There must be no dew condensation.)
	Altitude	1000 m or lower

7.2.3.2 Precautions on use

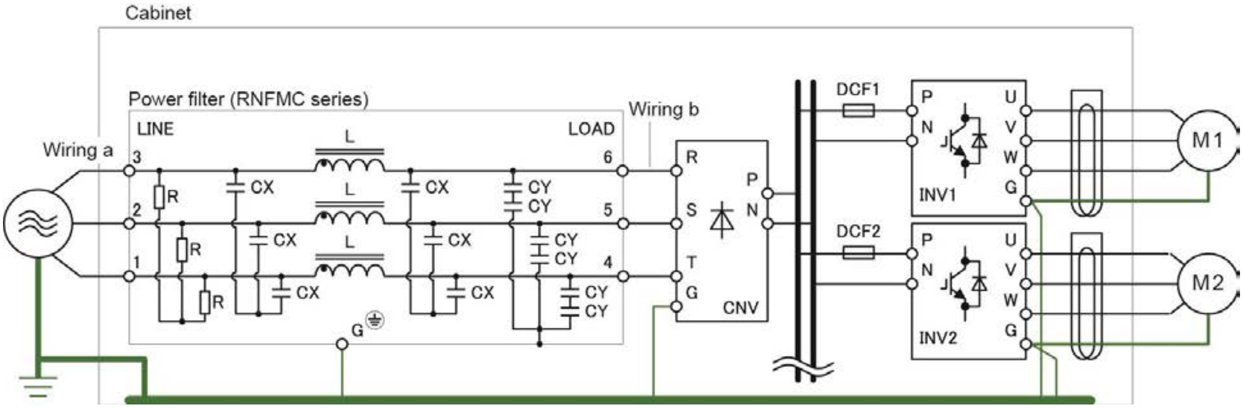


Figure 7.2.3-1: Example configuration where a power filter is used

Note

(1) Connect wires in accordance with the product nameplate.

(2) Be sure to ground power filter. To reduce the ground wire resistance, select the same wire size as the converter and lay the wiring at a minimum distance.

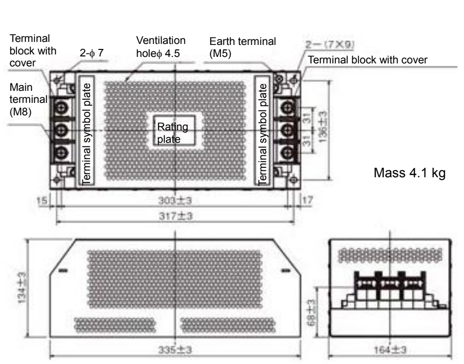
(3) Do not use devices other than those are recommended by Fuji Electric. It may cause risk of burning.

(4) Shorten the wiring length between the power filter and the converter/inverter (wiring c) as much as possible.

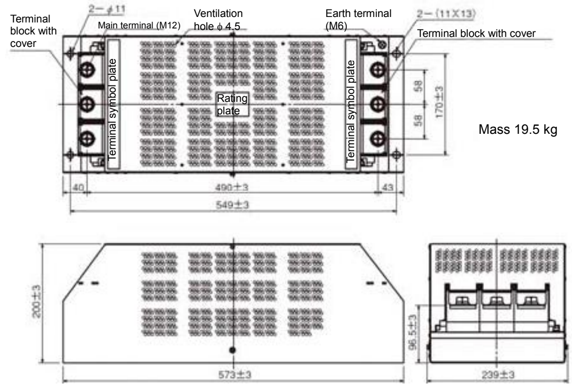
(5) Separate the input line (wiring a) of the power filter from the input/output lines (wiring b) of the converter/inverter as much as possible.

7.2.3.3 External dimensions

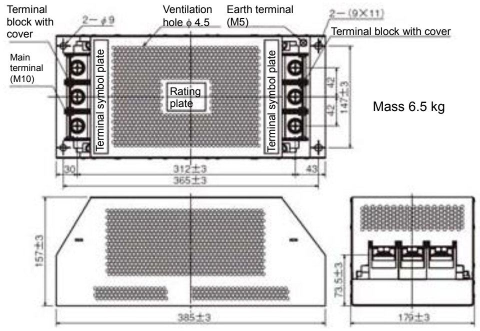
RNFMCH1-40



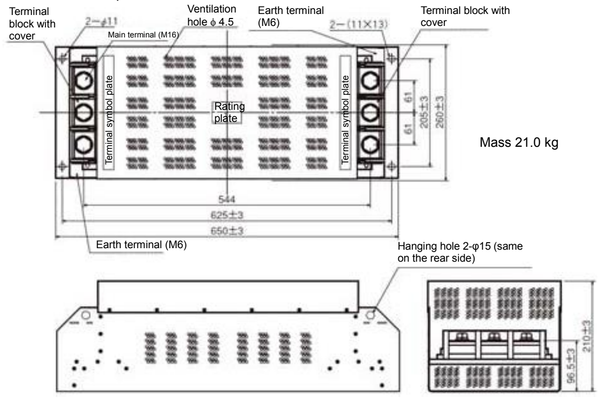
RNFMC4H-40



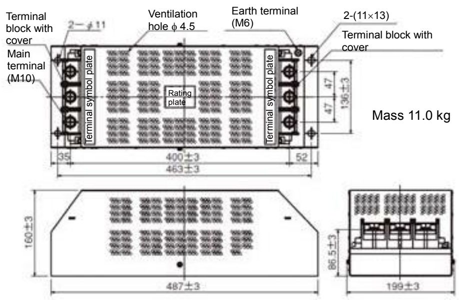
RNFMC2H-40



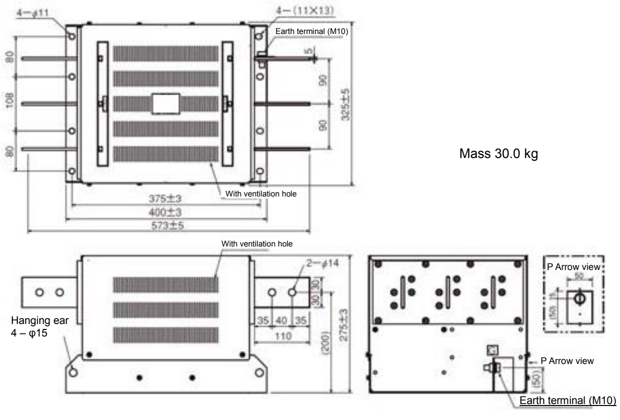
RNFMC5H-40, RNFMC6H-40



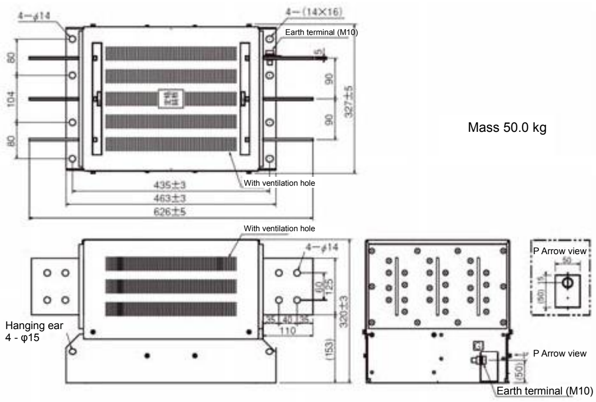
RNFMC3H-40



RNFMC9H-40



RNFMC12H-40

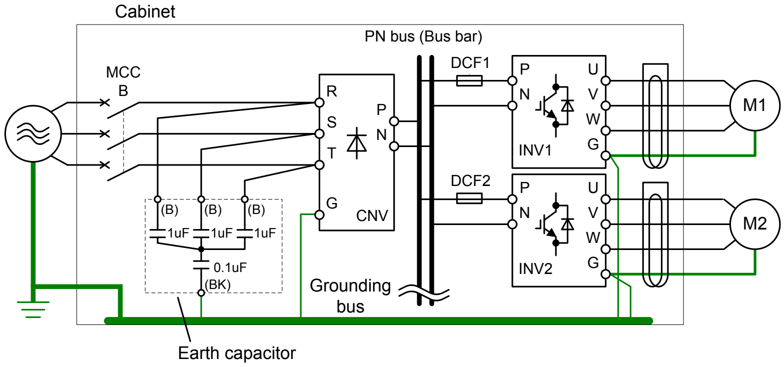


7.2.4 Filter capacitor (ground capacitor) for radio noise reduction

A filter capacitor is effective to reduce AM radio frequency band (1 MHz or lower) noises. Using this filter together with a zero-phase reactor (ACL) enhances the effectiveness.

If you use this ground capacitor, be sure to use one for each input power supply line regardless of the capacity of the converter (inverter).

Model: NFM60M315KPD



* The letter in ( ) of the ground capacitors shows the wire sheath color: (B) for blue or (BK) for black.

Figure 7.2.4-1: Example of circuit

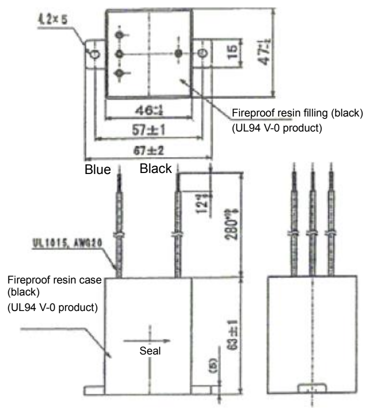


Figure 7.2.4-2: External dimensions

Note

(1) Take care when selecting an earth leakage circuit breaker (ELCB) or leakage detector, because the leakage current is increased when a ground capacitor is installed.

(2) Do not use a ground capacitor together with an EMC filter. (It does not conform to EMC directive.)

(3) Do not use an RNFMC type power filter in conjunction with a ground capacitor.

(4) Do not apply a ground capacitor to the DC bus bar or the output side of the inverter. (Doing so might break the ground capacitor.)

(5) Do not apply a ground capacitor to a PWM converter system. (Doing so might break the ground capacitor.)

(6) About wiring:

- Ground it together with the target device. Make wiring of the ground capacitor as short as possible.
- Do not store this capacitor in the wiring duct for other control wires. (Separate the wiring from other wires.)

(7) When you conduct a pressure test or insulation resistance test, disconnect the ground capacitor so that test voltage will not apply to it. If you conduct a pressure test or the like in the normal state, the ground capacitor will be broken.

(8) Cannot be used for 690V series.

7.2.5 Spark killer

A spark killer is a CR filter that absorbs surge and noise generated from an electromagnetic contactor or a solenoid valve and prevents malfunctions and breakage of the devices.

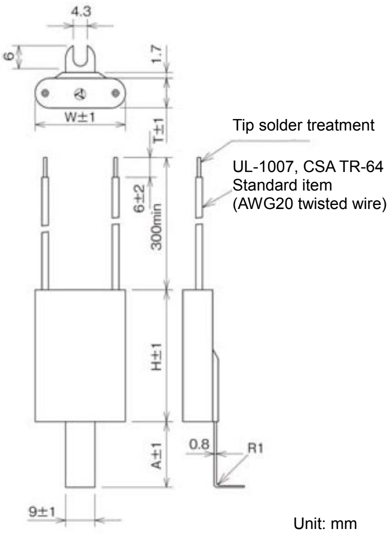


Figure 7.2.5-1: External dimensions

Internal configuration

Specifications

Model	Rated voltage	Capacitance μF ±20%	Resistance Ω ±30%	Outside dimensions (mm)			
				W	H	T	A
S1-B-0	AC250 V	0.1	200 (1/2 W)	17.5	40	7.1	20
S2-A-0		0.2	500 (1/2 W)	27.5		10.4	30

Temperature: -40 to 85°C
Humidity: 5 to 95%Rh

Note The notes 6) and 7) in 7.2.4 also apply.

7.2.6 Noise cut transformer (TRAFY)

In a general insulation transformer, the primary coil and secondary coil electrically insulate the commercial power supply with a commercial frequency, and the voltage of the secondary coil based on the turns ratio is generated. While common mode noise at low frequencies that is close to the commercial frequency can be prevented, if normal mode noise at high frequencies enters, it is transmitted from the primary coil to the secondary coil by electromagnetic induction and static electricity induction.

As a measure for this problem, a shielded transformer, in which a shield (screen) is inserted between the primary coil and secondary coil, is available.

TRAFY is an insulation transformer designed for noise prevention that shields the primary coil, secondary coil, and the whole device (in a three-tier shielding structure) and has a noise attenuation feature across broad frequency bands.

In the case that noise enters from a power supply system, and it causes malfunction of an electronic device, etc., you can prevent the malfunction by connecting TRAFY to the power supply system of that electronic device.

For more information, refer to the catalog "Fuji Noise/Surge Prevention Device TRAFY (HS152)".

Table 7.2-2: Comparison of features of transformers

Type of transformer	Insulation transformer	Shielded transformer	TRAFY Sold by Fuji Electric Technica
Common mode noise	△ (Low frequencies only)	○ (Frequency bands around low frequency and high frequency)	□
Normal mode noise	×	×	□
Structure	Insulates between the primary and secondary coils to prevent transmission of noise from the primary coil to the secondary coil.	In addition to the structure of an insulation transformer, a shield to block electrostatic is installed between the primary and secondary coils to prevent transmission of high frequency noise from the primary coil to the secondary coil.	1) 3-tier shielding structure. Shielding of the primary coil, secondary coil, and between primary and secondary coils. 2) Alternate arrangement of coils. Leakage reactance between the primary and secondary coils is increased.
Effect of noise prevention	Prevents common mode noise at low frequencies.	Prevents common mode noise at low frequency and high frequency. (Common mode noise at the primary coil is transmitted to the ground through the distribution capacitance between the primary coil and shield.)	Prevents both normal mode noise and common mode noise. • Normal mode noise Prevented mainly by the alternate coil arrangement structure. • Common mode noise Prevented mainly by the 3-tier shielding structure.
Problems	1) High frequency noise becomes low impedance due to small floating capacitance between the primary and secondary coils and the noise is transmitted to the secondary coil. 2) Normal mode noise is transmitted to the secondary coil almost as it is.	1) Since the induction coefficient seen from the primary coil, distribution capacitance against the shield and iron core are imbalance, imbalanced common mode noise turns into normal mode noise at the secondary coil. 2) Normal mode noise is transmitted to the secondary coil almost as it is.	

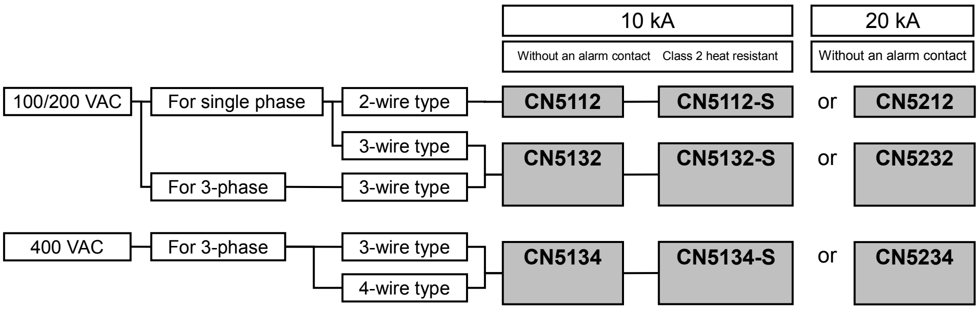
7.2.6.1 Specifications

Series	SA (Standard)	HA (High performance)	DA (with power cord)	CA (with outlet)
Model	**FFT-SA**	**FFT-HA**	**FFT-DA**	**FFT-CA**
Rated capacity [VA]	50,100, 200, 300, 500, 750, 1 K, 1.5 K, 2 K, 3 K, 5 K, 7.5 K, 10 K	100, 200, 300, 500, 750, 1 K, 1.5 K, 2 K, 3 K, 5 K, 7.5 K, 10 K	500, 750, 1 K	
No. of phase (Note 1)	Single phase (3 phases)		Single phase	
Rated voltage [V] (Note 1)	100/100, 200/100, (200/200), (400/200)		100/100	
Rated current	0.5 to 100 A at 100 V, 0.25 to 50 A at 200 V		5, 7.5, 10 A at 100 V	
Rated frequency [Hz]	50/60			
Leakage current [μA]	100 or less			
Insulation type	Type B			
Voltage fluctuation range (Note 2)	±4% (±10% for 50 VA)			
Efficiency [%]	50 VA: 85 or more, 100 to 750 VA: 90 or more, 1 to 10 kVA: 95 or more			
Withstand voltage	2000 VAC – 1 min		1500 VAC – 1 min	
Base standard	JEC-2200 (1995)			

(Note 1) Value within parenthesis is quasi-standard.
(Note 2) Voltage fluctuating range is the value of power factor 0.9.
(Note 3) Please contact us other than the above.

7.2.7 Arrester (arrester for power supply)

An arrester absorbs lightning surge that enters from a power supply system and prevents breakage of electronic devices.



7.2.7.1 Specifications (an excerpt)

		Without an alarm contact			With an alarm contact		
		CN5112	CN5132	CN5134	CN5212	CN5232	CN5234
Applicable circuit/rated voltage (50/60 Hz)		1φ2W, 120 V 1φ2W, 240 V 110 VDC	1φ3W, 100/200 V 3φ3W, 240 V	3φ3W, 440 V 3φ4W, 440 V	1φ2W, 120 V 1φ2W, 240 V 110 VDC	1φ3W,100/200 V 3φ3W,240 V	3φ3W,440 V 3φ4W,440 V
Max. continuous voltage Uc (50/60 Hz)		280 VAC/140 VDC	280 VAC	490 VAC	280 VAC/140 VDC	280 VAC	490 VAC
Test class		JIS C 5381-1 Class II/IEC61643-1 class II					
Nominal discharge current In (8/20 μs)	To ground	5 kA			10 kA		
	Between lines	3 kA		2.5 kA	3 kA		2.5 kA
Max. discharge current Imax (8/20 μs)	To ground	10 kA			20 kA		
	Between lines	6 kA		5 kA	6 kA		5 kA
Total discharge current I total (8/20 μs)		20 kA	30 kA		40 kA	60 kA	
350 μs current Impulse*1	To ground	1 kA			2 kA		1.5 kA
Voltage protection level up	To ground	1500 V or lower		2500 V or lower	1500 V or lower		2500 V or lower
	Between lines	1500 V or lower		2500 V or lower	1500 V or lower		2500 V or lower
	N- to ground	—		1500 V or lower	—		1500 V or lower
Operating conditions		Temperature: -40 to 70°C, relative humidity 95% RH or less; There must be no dew condensation or freezing.					
Connection terminal/wire		Screw terminal connection method: M5 (with protection cover of the charging unit)					
		Connectable wire: 3.5 to 14 mm^2					

*1 Shows the performance that electricity can pass through the positive electrode and negative electrode one time each.

7.2.7.2 Precautions on use

In JIS C5381-12: 2004 "Surge protective devices connected to low-voltage power distribution systems -- Selection and application principles", it is recommended to install a backup breaker (separator) in series with an arrester (SPD). In this connection, we have conducted tests of separators in combination with SPD.

As a result of these tests, it is recommended to use a plug-type fuse as an SPD separator.

In addition, a molded case circuit breaker (MCCB) is also applicable. However, if you use an MCCB as an SPD separator, protective coordination with upper stream must be considered. At least, you need to select the breaking capacity equivalent to that of the breaker for the wiring in the upper stream.

Table 7.2-3: Combination of CN51 (Max. discharge current: 10 kA) series and backup breakers

Breaking capacity	600 VAC 100 KA	230 VAC 25 KA 440 VAC 10 KA	230 VAC 10 KA 440 VAC 7.5 KA	230 VAC 5 KA 440 VAC 2.5 KA	230 VAC 2.5 KA 440 VAC 1.5 KA
Separator type	AFaC-30X (3 units)	BW50RAG-3P 30	BW50SAG-3P 30	BW32SAG-3P 30	BW32AAG-3P 30
Name	Plug-type fuse	**Molded case circuit breaker for wiring (MCCB)**			

🕮 For information about the CN52 Series, refer to Fuji Surge Prevention Device Catalog (HS118☐).

Note When you conduct a pressure test and/or an insulation resistance test of devices and/or wirings, be sure to remove the fuse or turn OFF the auto breaker. If you conduct a pressure test or the like in the normal state, it causes breakage of the arrester and/or incorrect measurement.

7.2.7.3 Examples of circuits

Single phase (120/240 VAC) 3-phase (240/440 VAC)

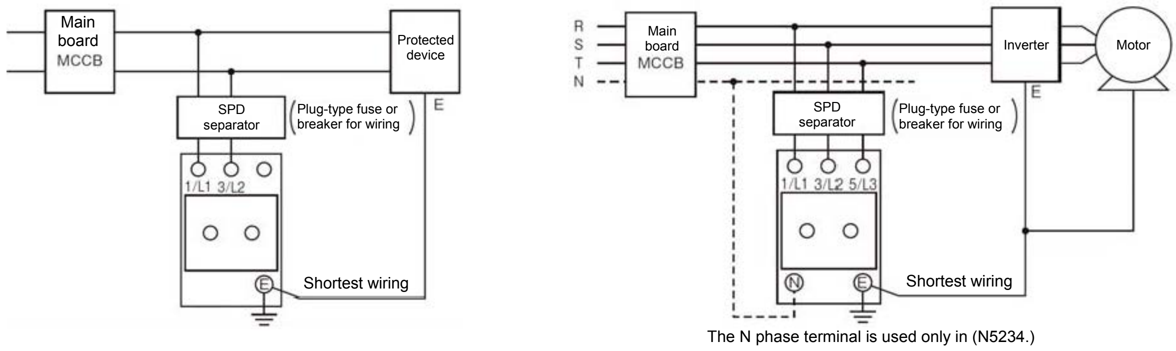


Figure 7.2.7-1: Example of circuit

Note (1) Induction lightning surge enters via wires connected to buildings, facilities, or devices. To prevent induction lightning surge from entering inside, install an arrester near the port.
For facilities far from the port, you need to install another arrester.

(2) About wiring of an arrester:

- Be sure to ground the arrester together with the devices to be protected. The grounding wire between the arrester and the cabinet must be wired as short as possible. (The devices in the cabinet must be connected to the common grounding wire of the cabinet.)
  If they are grounded separately, the devices in the cabinet cannot be protected.
- The grounding wire of the arrester plays a role to immediately discharge the lightning surge entering from devices and facilities to the ground. Be sure to connect the grounding wire to the grounding terminal with a relatively thick (5.5 mm^2) wire in the shortest distance.
  The IEC standard stipulates that an arrester for power must be connected to the grounding terminal of a cabinet or equipment with a 3 mm^2 wire or a larger wire in the shortest distance (0.5 m or less is recommended).
  Similarly, make the wiring of the power supply side using the same size wire in the shortest distance. (The surge amount that the arrester can protect varies according to the wiring impedance connected to the arrester. If wiring is too long, sufficient performance cannot be expected.)
- Perform grounding work in reference to “Restrictions on sharing grounding wires and grounding poles (1350-13)” of Internal Wiring Regulations.
- Do not store the grounding wire in the wiring duct for other control wires.
  (Separate the wiring from other wires.)
- If wiring via the arrester is available at the power supply side, connect wires in V-shape.

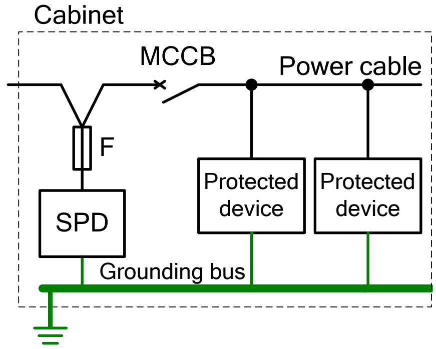
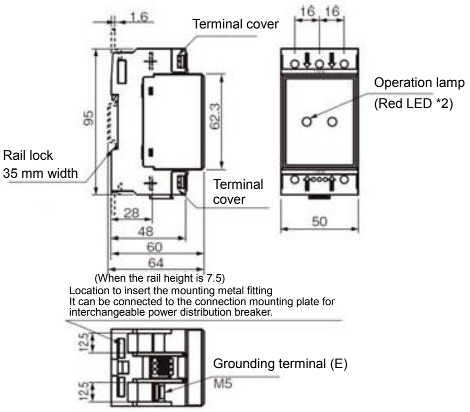
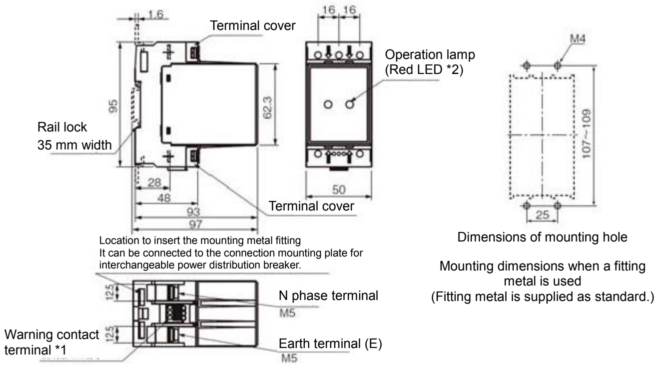


Figure 7.2.7-2: Example of V-shape wire connection

7.2.7.4 External dimensions

CN5112/CN5132/CN5134, CN5212/CN5232	CN5234
	
* The 2-pole products are equipped with the operation lamp on the left only.	

7.3 Noise prevention

The noise prevention devices and wiring methods explained in "7.2 Anti-noise devices" are classified by purpose as shown in Table 7.3-1 and Table 7.3-2. While malfunctions attributable to noise can be alleviated by anti-noise devices, most malfunctions attributable to noise can be also prevented by grounding and wiring.

- Grounding: Noise can be reduced by taking a measure to prevent leakage current that contains a high frequency component of the inverter (converter), which is the source of noise, from entering other grounding path.
- Wiring: Noise can be reduced by wiring that is not affected by conduction noise and radiation noise of wiring.

In addition to the information about the noise prevention explained in this section, refer to the following section as well.

📖 Appendix 5 "Proficient way to use inverters (on preventing electric noise)"

Table 7.3-1: Noise prevention at input circuit side

(◎: Quite effective, ○: Effective, △: Slightly effective)

Means / Purpose	Alternate current reactor (ACL)	Direct current reactor (DCL)	EMC filter Power filter	Zero-phase reactor (ACL)	Ground capacitor	Wiring construction: Wiring*1 means	Wiring construction: Shield wiring Metal pipe wiring	Remarks
Reduction of noise terminal voltage (Leakage noise current on input side)	—	—	◎	△*2	○*3	—	—	
Reduction of radiation noise from input wiring	—	—	○	△*2	—	—	◎*4	
Prevention of induction failure from input wiring	—	—	○	△*2	△	◎	◎*4	
Reduction of input higher harmonic current (Improvement of input power factor)	○	◎	—	—	—	—	—	
Prevention of ELCB trip	—	—	—	—	—	—	—	Use of ELCB by Fuji Electric Co., Ltd. (anti-high frequency products and inverter reinforced products should be used)

Table 7.3-2: Noise prevention at output circuit side

(◎: Quite effective, ○: Effective, △: Slightly effective)

Means / Purpose	OFL filter (OFL-***-4A)	Zero-phase reactor (ACL)	Wiring construction: Wiring*1 means	Wiring construction: Shield wiring Metal pipe wiring	Remarks
Suppression of micro surge voltage	◎	—	—	—	
Reduction of radiation noise from output wiring	—	○	—	◎*4	
Prevention of induction failure from output wiring	○	○*2	◎	◎*4	
Reduction of leakage noise current (Leakage noise current at output side)	—	◎*2	—	◎*4	Use of OFL filter against in-line leakage current is effective "○".
Prevention of ELCB trip					If you use ELCB by Fuji Electric, trip can be prevented. (Use countermeasure products for high frequency or products with enhanced inverters.)

Note

*1 Wiring means refer to wiring between the main input and main output, separate wiring between the main circuit and control circuit, and bundled wiring of inverter output (U, V, and W).

*2 If the turn number of wires connected to the zero-phase reactor (ACL) is increased, noise resistance is enhanced.

*3 Effect of noise prevention is attained by using both ground capacitor and zero phase reactor (ACL).

*4 Poor grounding, even with the use of shielded wire and metal wiring, may reduce noise reduction effect. (Failure or malfunction of other devices may be caused.)

7.3.1 Grounding

Be sure to ground the inverter, anti-noise devices, devices with a grounding terminal, frame and board of the transformer, etc. The purposes of grounding are explained below.

(1) Grounding for safety purpose to prevent disasters such as electric shock caused by electric leakage.

(2) Grounding for noise prevention purpose to prevent transmission of noise generated in the inverter and prevent entry of noise from outside.

According to “Appendix 6 Grounding as noise countermeasure and ground noise”, the following 3 points are important for grounding for noise prevention. Be sure to comply with them when connecting wires and perform wiring.

- Reduce the impedance of the circuit as much as possible.
- Do not share impedance.
- Separate the wires from noise sources so that induction voltage will not be induced.

(1) Wire size

Safety

It is stipulated to ground an external package (metal cabinet) of a low voltage device as shown in Table 7.3.1-1 of "Technical Standards Concerning Electrical Equipment".
In addition, the grounding wire sizes for Class D (Class 3) or Special Class C (Class 3) grounding work are stipulated in “Indoor wiring regulations JEAC8001”. (Table 7.3.1-2)

With these sizes, wires can be protected until the MCCB blocks the ground current when a wiring route contacts the external metal cover connecting to the ground.

Noise prevention

Use electric wires with small impedance, in other words, large size (thick) wires. Even if large size wires cannot be used because of the connecting terminal size, it is desirable to use at least 5.5 mm^2 wires from the aspect of noise prevention.

Table 7.3-3: Grounding of low voltage devices stipulated by “National Electrical Code”

Rated voltage	Type of grounding work	Grounding resistance	Thickness of grounding wire
300 V or lower	Type D	100 Ω or less	Diameter 1.6 mm or more
More than 300 V	Type C	10 Ω or less	

Table 7.3-4: Thickness of grounding wire for Class C (Class 3) grounding work in inner wiring regulations table 1-16

Rated capacity (current) of breaker installed in grounding protection circuit [A]	Min. thickness of grounding wire (thickness of copper wire)			
	General wire		Core or valve of movable wire for multiple cores	
	Single wire [mm^2]	Twisted wire [mm^2]	When single-wire is used [mm^2]	Single core using a valve for 2 cores [mm^2]
20	1.6	2.0	1.25	0.75
30			2	1.25
50	2.0	3.5	3.5	2
100	2.6	5.5	5.5	3.5
200	—	14	14	5.5
400		22	22	14
600		38	38	22
800		60	50	30
1000			60	
1200		100	80	38

(2) Wiring

1) Grounding of motor

Use four wires on the motor (at the output side of the inverter) and connect one of the four wires as a grounding wire to the grounding bus of the cabinet.

If you use shield pipes, metal pipes, or four-core shielded cabtire cables, etc., connect the shield to the grounding bus of the cabinet.

Note

In the case that the wires are grounded near the motor, if leakage current from the inverter flows, the grounding potential becomes different between the grounding section of the cabinet and that of the motor.

In this case, not only induction noise from motor wiring but also from motor grounding will be increased. This, in turn, will affect the control wire laid in the vicinity of the motor.

📖 Refer to “Appendix 6”.

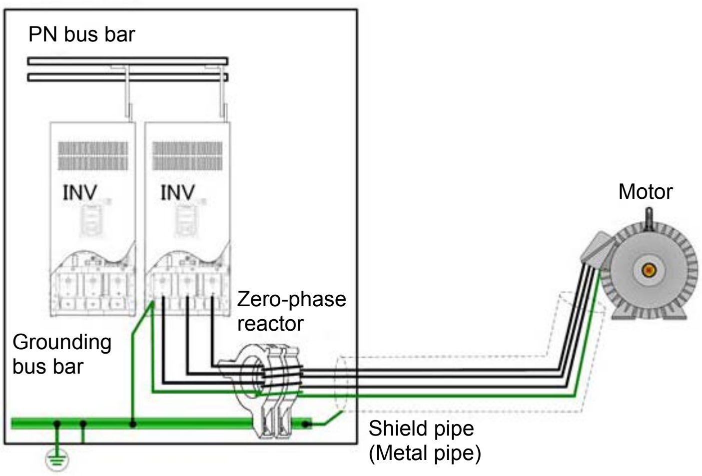


Figure 7.3.1-1: Grounding of inverter and peripherals

2) Grounding in cabinet

General grounding in the cabinet is explained below:

- Install a grounding bus in the cabinet and connect the grounding terminals of the devices in the cabinet to the grounding bus using wires as thick as possible in the shortest distance.
- Use a thick wire as a grounding wire from the cabinet to the ground and connect them in the shortest distance.

With the grounding explained above, both the circuit impedance and common impedance will be lowered.

If you use a board which does not use a grounding bus, install a terminal with which electric wires from the grounding pole can be connected to the board close to the grounding point.

3) Connect the grounding terminals of the inverter and devices and the grounding bus separately (individually).

In the case of serial connection as shown in Figure 7.3.1-2, common impedance exists, and Device A is affected by noise of Device B and Device C, and a failure might occur. Viewing from the ground, the impedance of Device C is increased by the amount equivalent to the impedance of Device A and Device B.

Be sure to connect the grounding wire of each device separately as shown in Figure 7.3.1-3.

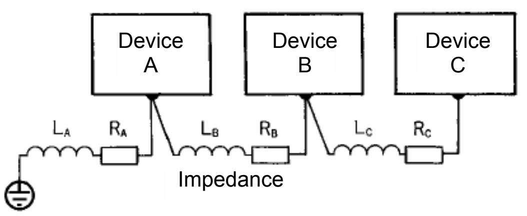


Figure 7.3.1-2: Serial connection of grounding wires

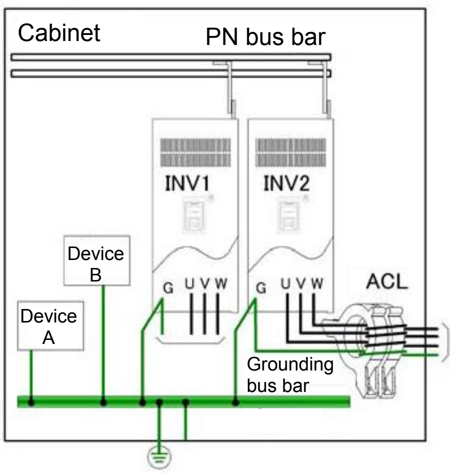


Figure 7.3.1-3: Example of connection of grounding wires

7.3.2 Wiring of main circuit of inverter (PWM converter)

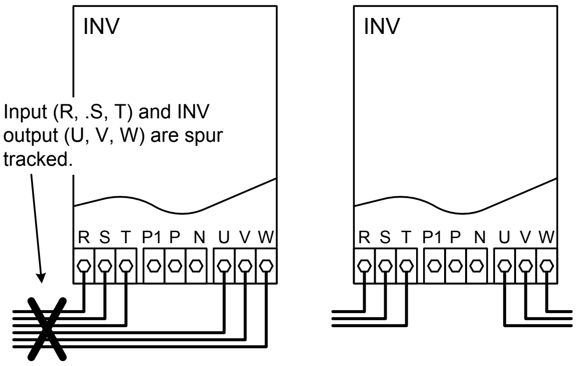
In the wires of the main circuit system of the inverter (PWM converter), large current containing a high frequency component flows. In addition, there is induction noise of leakage current from the inverter (converter). For these reasons, it is essential to take noise prevention measures on the wiring of the main circuit.

Effective measures

(1) Install the zero-phase reactor (ACL) and filters near the main circuit terminal of the inverter (converter) in the shortest distance so that the wiring will not be a noise source.

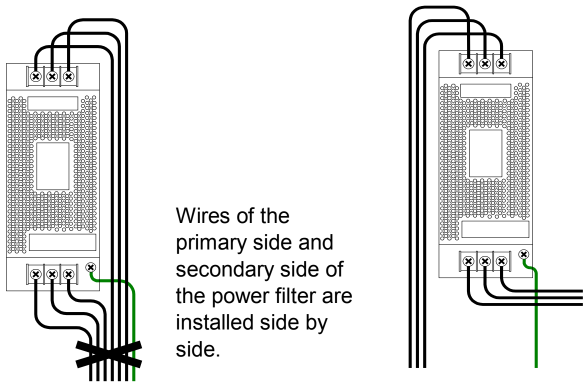
(2) Connect the wires of the main circuit separately from the control wires without installing them side by side as shown in Figure 7.3.3-9: Space and crossing of wires (page 7-22).

(3) Do not attempt to lay the main input section and inverter output wirings side by side because doing so would cause noise to be conducted between lines, impairing the noise prevention effect. (Refer to Figure 7.3.2-1 and Figure 7.3.2-2.)
(If you lay them side by side, be sure to block them from each other using shield pipes, etc.)



(a) Bad example (b) Good example

Figure 7.3.2-1: Example of inverter unit wiring



(a) Bad example (b) Good example

Figure 7.3.2-2: Example of wiring of EMC filter/power filter

(4) Closely connect the main circuit wires in a same route (such as the main input section and inverter output section).
If you use twistable thin wires, twist them.

(5) Avoid a loop-shaped wiring pattern as shown in Figure 7.3.2-4(a). If current flows through such wiring, magnetic flux occurs, becoming a noise source.

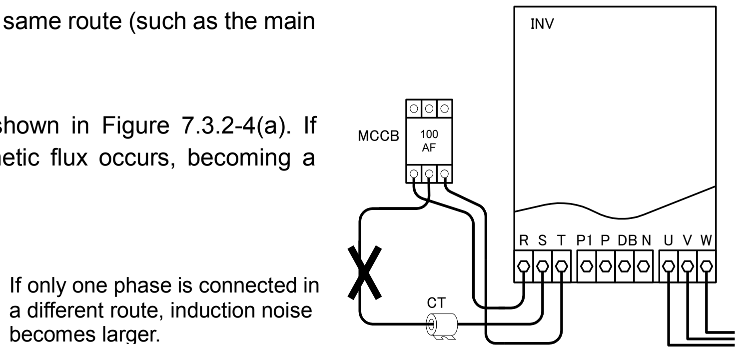


Figure 7.3.2-3: Wiring route

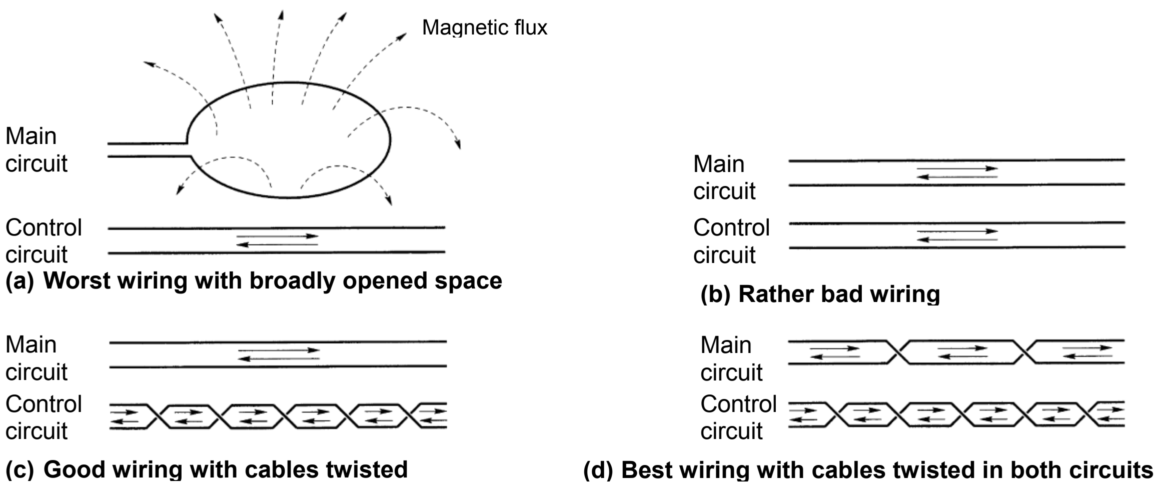


Figure 7.3.2-4: Installation of cables (Reference: Earth and Noise by Kenichi Ito, Nikkan Kogyo Shimbun, Ltd.)

Note

(1) Precautions on in-line high frequency leakage current

When the wiring length from the inverter to motor is long, overheat and over-current trip of the inverter occur due to the effect of leakage current containing a higher frequency component that passes through the floating capacitance between wires of each phase. Moreover, leakage current might increase, and accuracy of current indication might not be secured. Excessive leakage current might flows depending on the condition, resulting in breakage of the inverter.

Therefore, the wiring length between inverter and motor must be 100 m or less.

(50 m or less is a rough guideline for 30 kW or less, taking voltage drop caused by wiring impedance into consideration.)

In-line leakage current can be suppressed by using an **output circuit filter (OFL filter)** for length exceeding 100 m.

- Up to 400 m is acceptable if an OFL filter is used in the case of a V/f control system (single drive system).
- In vector control where output circuit filter is used and wiring length is long, current vibration or torque shortage may occur due to lack of normal motor control, being affected by the inductance of output circuit filter or wiring.

  Be sure to select a location for installing inverter and motor by taking into account the wiring length between inverter and motor of 100 m or less, even in the case of using output circuit filter.

  This naturally increases the length of PG signal line, which may also create a distortion in waveform in PG detected waveform, causing malfunction. It is recommended that you consider using pulse amplifier to amplify PG waveform.

(2) Points to note when multiple-core cable is used

When there are multiple sets of inverters and motors, do not use a multiple-core cable to house the wires of the multiple sets.

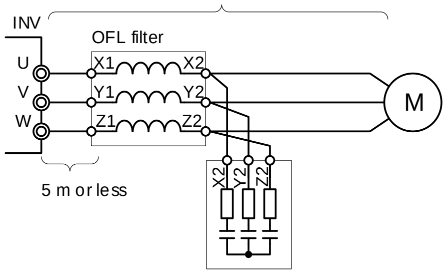


Figure 7.3.2-5: Wiring length when an output circuit filter is used

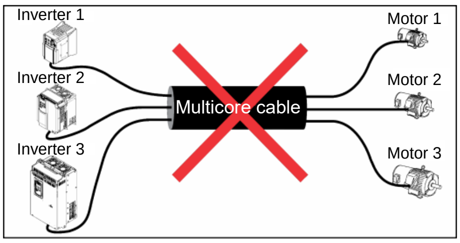


Figure 7.3.2-6: Do not use multiple-core cable

(3) Surge voltage during inverter driving

When a motor is driven by a PWM system inverter, the surge voltage generated by the switching action of the inverter element will be increased by the output voltage and applied to the motor terminal. (Refer to Appendix 8.)

One of the following measures should be taken especially in long motor wiring.

- Use a motor with reinforced insulation. (Our standard motors feature reinforced insulation.)
- Connect an output circuit filter (OFL-□□□-□A) to the output side (secondary side) of the inverter.
- Keep the wiring length from the inverter to the motor as short as possible. (at maximum, 10 to 20 m).

7.3.3 Wiring of control terminals of inverter (PWM converter)

The control terminals (for general contact input and analog I/O signals) of the main unit and option card of the inverter (PWM converter) can operated with small current. Therefore, they are easily affected by noise, and it is essential to take measures for noise prevention.

Noise can be divided into the 4 types as shown in Figure 7.3.3-1. Most of them can be prevented by using an appropriate wiring route (separate wiring, etc.), a twisted cable, and a shielded cable. It is also effective to use a zero phase reactor (wind 5 to 10 times around the zero phase reactor).

As for conduction noise, it is effective to isolate signals from the control terminal side using a control relay or insulation converter (isolator).

📖 For information on noise and how to take measures, refer to Appendix 5 as well.

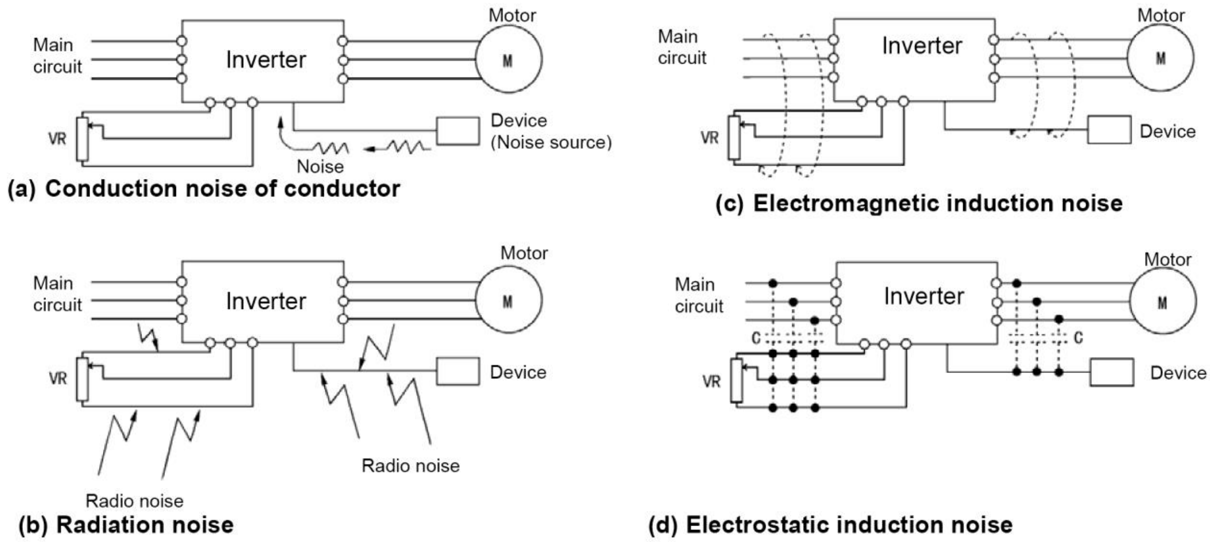


Figure 7.3.3-1: Noise types

(1) How to install twisted cables and shielded cables

1-1) Twisted cables

Regarding the wiring of signal cables, it is recommended to twist and wire the cables as shown in Figure 7.3.3-2.
In addition, it is recommended to use a 0.5 to 1.25 mm^2 KIV wire (JIS C3316), which is a flexible and easy-to-use 60°C and 600 V rated insulated wire.

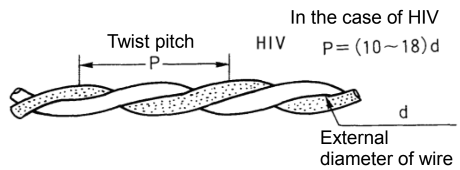


Figure 7.3.3-2: Twisting of vinyl insulated wires

1-2) Shielded cables

There are two types of the shielded wire: One is a **shielded wire** in which a bundle of wires are shielded, and the other is a **twisted-pair shielded wire** in which a wire is twisted and shielded.
(As shielded twisted pair cables, a 1-pair cable, 2-pair cable, and 3-pair cable, etc. are available.)

In addition, there are two types of the shielded twisted pair cable: One has a knitted wire mesh shielding cover, and the other has a shield winding around inner cables. Although the knitted wire mesh shield is more effective in shielding, the working efficiency is lowered (refer to Figure 7.3.3-3).

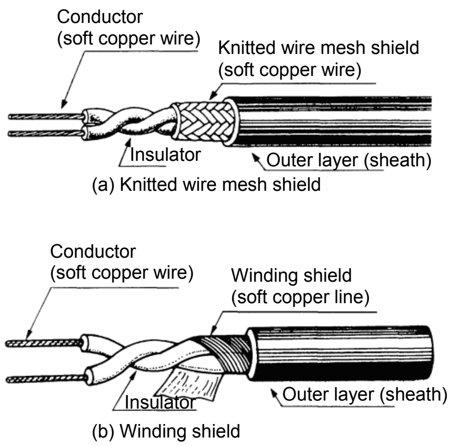


Figure 7.3.3-3: Shielded twisted pair cable

📖 For information on PROFIBUS-DP and DeviceNet and other open buses, and for the serial PG interface for motors (OPC-VG1-SPGT), refer to the installation manual of each bus and the instruction manual of the option card.

Shield processing of a shielded cable should basically be done by shield clamp connection.
See shield processing below for cases where this is not feasible due to connected equipment.

Shield clamp method

A termination method in which the shielded part of a shielded cable is exposed by removing its outer layer, and held firmly together with the grounding bus of the cabinet by conductive clamp material (shield clamp).

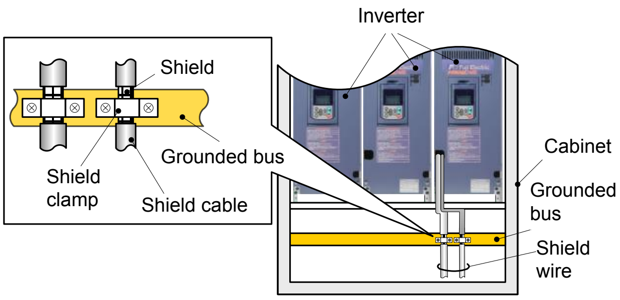


Figure 7.3.3-4: Clamping of shielded wire (example)

<Treatment of the edge of the shielding cover>

(1) Edge to which the shielding cover is not connected

As shown in Figure 7.3.3-5, treat the edge in a way that the shielding cover does not come close to the core cable.

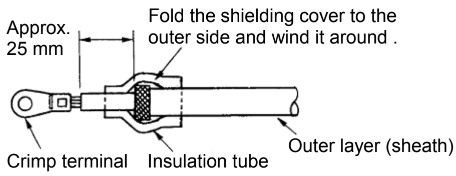


Figure 7.3.3-5: Treatment of the edge to which shielding cover is not connected

(2) Edge to which the shielding cover is connected

Treat the edge as shown in Figure 7.3.3-6 for a shielded wire wound around the wire cover or as shown in Figure 7.3.3-7 for a knitted shielded wire, and then install the insulation tube and crimp terminal as shown in Figure 7.3.3-8.

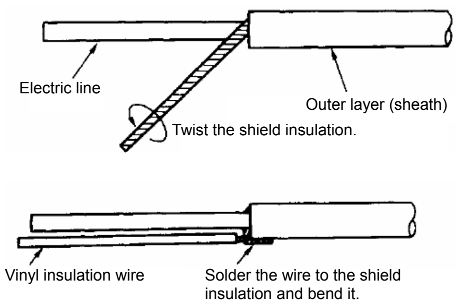


Figure 7.3.3-6: Treatment of winding shield

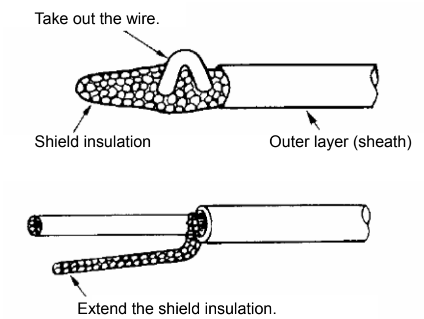
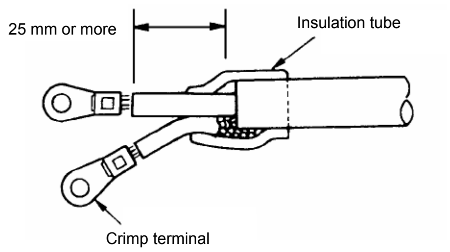
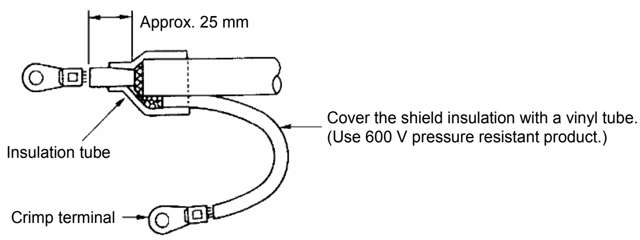


Figure 7.3.3-7: Treatment of knitted shield



(a) Pulling out of shielding cover to the front side



(b) Pulling out of shielding cover to the rear side

Figure 7.3.3-8: Treatment of the edge to which shielding cover is connected

(2) How to install wires

If the wires to the control terminals of the inverter or converter are installed closely to the wires of the main circuit or any other possible noise sources and the wiring length is long, or they are installed side by side, noise has a large impact. For this reason, when you wire the cables to the control terminals of the devices, ensure the shortest possible wiring length while keeping them away from the cables of the main circuit, relay sequence circuit, and transformer circuit for measuring instruments, etc.

1) Main circuit and inverter control circuit

Leave the wire of the control terminal away from that of the main circuit by at least 100 mm. (See Figure 7.3.3-9.) If it is installed near the main circuit out of necessity, put either of the wires into a wire bundling tube with shield, or block the wire with a shielding plate (steel plate), etc., and connect the shielded section to the grounding bus of the cabinet.

If the wire crosses the main circuit, install it at the right angle so that induction of induction noise will be reduced.

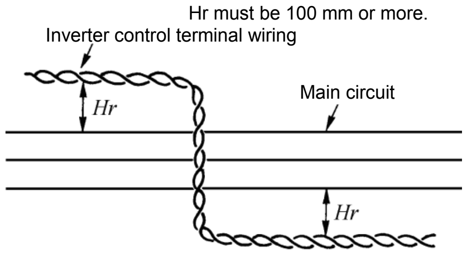


Figure 7.3.3-9: Space and crossing of wires

2) Relay sequence circuit/transformer circuit for measuring instrument and inverter control circuit

Install the wires as keeping them away from the cables of the electromagnetic contactor and other excitation coil circuits because the wires are affected by surge voltage generated when such circuits are opened and closed and by noise entering from outside.

To be more specific, separate the wires of the relay sequence circuit and those of the transformer circuit for measuring instrument in order not to store the cables of the control terminals into one wiring duct.

(If they are separated even if the distance is small, it has a substantial effect.)

If two wiring routes cannot be separated, bundle either of the wires and install them outside the wiring duct. (Refer to Figure 7.3.3-10.)

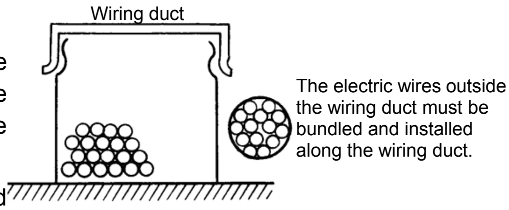


Figure 7.3.3-10: Installation of cables inside and outside of wiring duct

(3) Contact input

Connect the wires of the contact input terminals of the inverter (converter) as short as possible to reduce the effect of noise. If the wiring length exceeds 20 m, insulate the signals using a control relay. Even when you connect the contacts of the control relay to the contact inputs of the inverter (converter), be sure to twist the wires. When you use a shielded wire, connect the shield to the common terminal.

When you connect the contacts to more than one inverter, connect a different contact to each inverter. Do not share the contact as shown in Figure 7.3.3-13 (a).

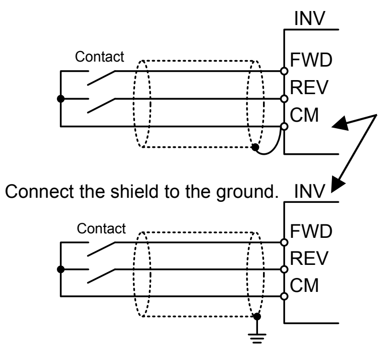


Figure 7.3.3-11: Shield processing

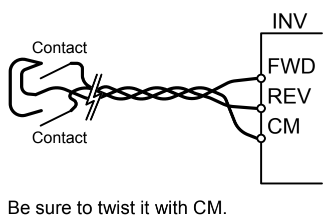


Figure 7.3.3-12: Twist processing

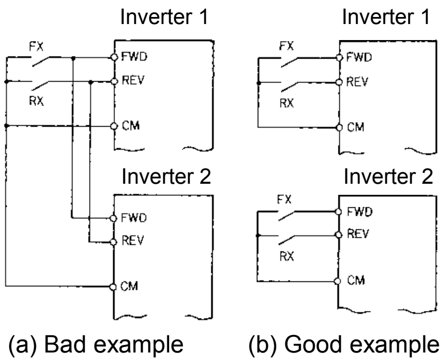


Figure 7.3.3-13: Separation of contacts

Note (1) Analog input/output (11, M) and digital input (CM), and transistor output (CMY) are separated (electrically insulated) on a circuit by circuit basis so as to prevent mutual interference between the circuits. The common terminals of them are separated from the grounding terminal of the inverter or converter. Be sure to follow the instructions given below, otherwise it will lower the noise resistance.

- Especially in the analog circuit and contact input transistor output, do not connect the common terminals to each other. Refrain from connecting the common terminal or the shield of a shielded wire to the ground.
- The shield of a signal line should be connected to the ground when corresponding to the EMC command (CE marking compatible).
  However, malfunction caused by noise may be induced by connecting this shield to the ground.

(2) Do not connect the common terminals (CM) of multiple inverters to each other. If the common terminals of multiple inverters are connected to each other, the noise resistance will be lowered.

Prevention of recovery failure due to floating capacitance of AC operation relay

In an AC operation relay, if the wiring of the control circuit is long (e.g., the location of the relay is far from the location of the switch to operate the relay), the floating capacitance between the wires prevents the relay from recovering even if the switch is turned OFF. The allowable wiring length not affected by the floating capacitance of our control relay is shown below.

📖 For precautions such as those to take when the wiring exceeds the allowable wiring length, refer to the catalog of the relay or other relevant documentation.

Table 7.3-5: Long wiring model

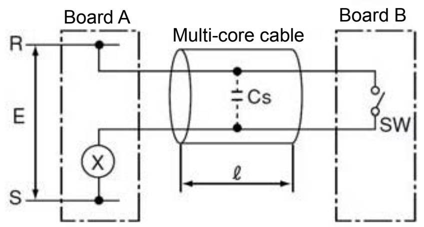
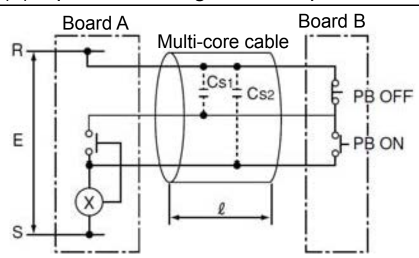
Operation	(1) Operation using continuous input contact	(2) Operation using instant input contact
Equivalent circuit		

Table 7.3-6: Allowable wiring length not affected by floating capacitance

Model \ Operation circuit		100 V			200 V		
		Allowable capacitance (μF)	Allowable cable length (m)		Allowable capacitance (μF)	Allowable cable length (m)	
			Operation method (1)	Operation method (2)		Operation method (1)	Operation method (2)
HH5□ HH62	**50 Hz**	0.051	170	85	0.013	43	21
	60 Hz	0.038	120	60	0.0097	32	16
HH63	**50 Hz**	0.078	260	130	0.018	60	30
	60 Hz	0.063	210	100	0.015	50	25
HH64	**50 Hz**	0.096	320	160	0.024	80	40
	60 Hz	0.078	260	130	0.018	60	30
HH2□	**50 Hz**	0.170	570	280	0.042	140	70
	60 Hz	0.150	500	250	0.036	120	60

(Note) The allowable cable length is calculated on the condition that the floating capacitance between cables is 0.3 (μF/km) (measurement example of CVV 2 mm^2).

If a malfunction occurs although you took into consideration the relationship between the floating capacitance and wiring length, perform the following procedures:

(1) Connect a resistor in parallel with the excitation coil of the relay.

(2) Lower the coil power and change the operation from AC to DC.

If the current flowing (running) through the relay circuit is increased or changed to DC power, the effect of the floating capacitance can be reduced or eliminated. Note that change of the operation power is a large-scale modification, therefore it must be used as an emergency measure.

Table 7.3-7: Example of recommended parallel resistance

Model	Coil rated voltage (V)	Frequency (Hz) \ Cable length (m)	———	100	200	300	400	500	600	700	800	900	1,000
			Recommended resistance/power (k Ω/W)										
HH52	100	50			6.8/3	3.3/6	2.2/9	1.8/11	1.5/13	1.2/17	1.2/17	1.0/20	1.0/20
HH53		60			5.6/4	3.3/6	2.2/9	1.8/11	1.5/13	1.5/13	1.2/17	1.2/17	1.0/20
HH54	200	50		10/8	4.7/17	3.3/24	2.7/30	—	—	—	—	—	—
HH62		60		10/8	5.6/14	3.9/20	3.3/24	—	—	—	—	—	—
HH63	100	50				12/2	3.9/10	2.7/7	1.8/10	1.8/10	1.5/13	1.2/17	1.2/17
		60				5.6/4	3.3/6	2.2/9	1.8/11	1.8/11	1.5/13	1.2/17	1.2/17
	200	50		15/5	5.6/14	3.9/20	2.7/30	—	—	—	—	—	—
		60		12/7	5.6/14	3.9/20	3.3/24	2.7/30	2.2/9	—	—	—	—
HH64	100	50					6.8/3	3.3/6	2.2/9	1.8/11	1.5/13	1.5/13	1.2/17
		60				12/2	3.9/5	2.7/7	—	1.8/11	1.5/13	1.5/13	1.2/17
	200	50		27/3	6.8/12	3.9/20	3.3/24	2.7/30	—	—	—	—	—
		60		18/4	6.8/12	3.9/20	3.3/24	2.7/30	—	—	—	—	—
HH22	100	50							4.7/4	2.7/7	2.2/9	1.8/11	1.5/13
HH23		60							3.3/6	2.2/9	1.8/11	1.5/13	1.5/13
HH24	200	50			8.2/10	4.7/17	3.3/24	2.7/30	—	—	—	—	—
		60			8.2/10	4.7/17	3.3/24	2.7/30	—	—	—	—	—

(Note) Taking into consideration temperature rise, application is partially limited.

(4) Analog input and output

Since the analog signals are weak (0 to 10 VDC, 4 to 20 mADC), they are easily affected by noise. Use a twisted wire or a shielded wire to prevent noise.

If the wiring distance exceeds 20 m, install an insulation converter, etc. For the signals that require response as in the case of torque control, check the response speed of the insulation converter. The analog input has the primary delay soft filter setting as one of the function settings. If you set the filtering time suitable for the system, you can reduce the impact by noise. A zero-phase reactor and LC filter for signals are also effective means.

Note (1) Keep the wiring distance between insulation converter and inverter as short as possible.
(2) Response speed may decline as an effect of filter when using an LC filter.

Wiring method (1)

Use a twisted pair shielded wire up to the input of the converter. (Connect the shield to the common terminal of the converter.)

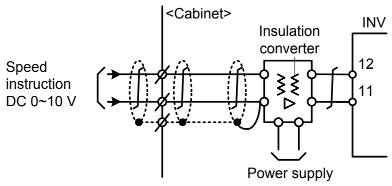


Figure 7.3.3-14: Shield processing (1)

If you ground the shield, process the ends at the insulation converter side and connect it to the grounding terminal.

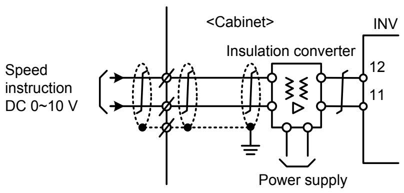


Figure 7.3.3-15: Shield processing (2)

Wiring method (2)

If you connect the analog input and output terminals of multiple inverters, insulate them from analog signals entering from outside.

If not, the analog common terminals are connected between the inverters, and the noise resistance is lowered.

*1 Twist wiring or twisted pair shielded wires (Connect the shield to the common side of the converter.)

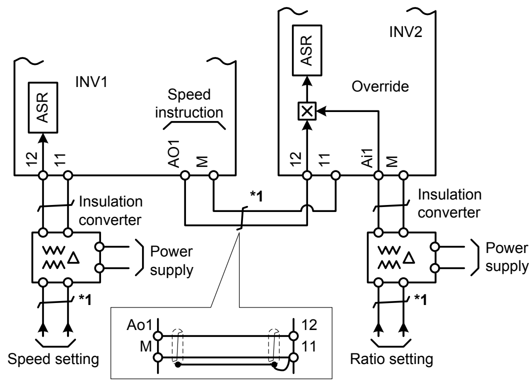
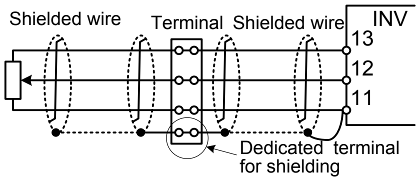
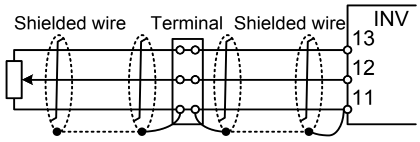


Figure 7.3.3-16: Twist processing

When you relay shielded wires via the terminal block, do not connect them to the relay terminal of the common terminal circuit. Install a dedicated terminal for shielded wires.



a) Good example



b) Bad example

Figure 7.3.3-17: Example of use of a relay terminal block

(5) Common terminal circuit

The common terminal (11) of the analog I/O, common terminal (CM) of the contact input, and common terminal (CMY) of the transistor output separate (electrically insulate) their own signals.

Be sure not to connect the common terminal of the analog I/O to that of other circuits to share the common terminal. If it is connected to other common terminals, a malfunction might occur due to mutual interference between the circuits.

In addition, do not ground the common terminals.

If the common terminals are not sufficient, install a relay terminal block near the inverter control terminal. If you connect the relay terminal block and inverter control terminal with a thick cable, you can reduce the impact of noise.

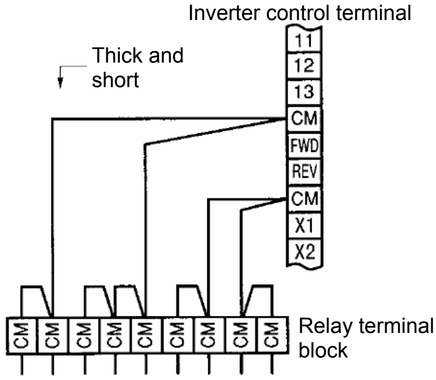


Figure 7.3.3-18: Relay terminal block for common terminals

(6) Speed detection unit (PG detection)

1) It is recommended to use a 2 mm^2 shielded wire for the pulse generator for motor speed detection. Anti-noise measures such as creating signals by using pulse amplifier (insulated type) are effective when wiring length is considerably long.
2) Winding this PG wire on a zero phase reactor (ACL) 5 to 10 turns is an effective anti-noise measure.

Note

- Shield is connected to motor side. However, if inverter should malfunction by the effect of noise, noise may be reduced by connecting the shield to the PGM of the inverter instead of connecting it to the motor side.
- Use of a serial PG and a PG card to drive the synchronous motor, etc. requires a dedicated PG interface option card.

  📖 Refer to the instruction manual of the dedicated PG interface option card.

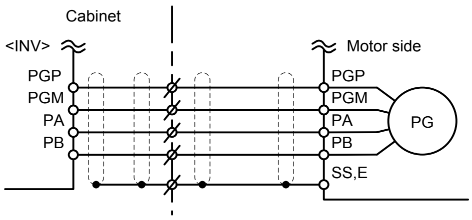


Figure 7.3.3-19: Example of PG wiring

(7) Temperature sensor (NTC thermistor)

It is recommended to use a 2 mm^2 shielded wire for the NTC detection thermistor used for motor temperature correction control and overheat protection function. If the wiring length is considerably long, the overheat protection function of the motor may not operate normally due to malfunction of the detection circuit in the NTC thermistor. Using temperature detection signal of the motor as overheat detection/protection by using PTC thermistor or clixon is also an effective anti-noise measure. (Motor temperature correction calculation in this case, however, will not be performed.)

Note

- Connect shielded wires to the inverter side.

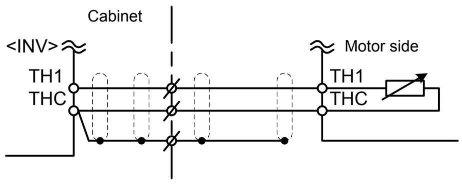
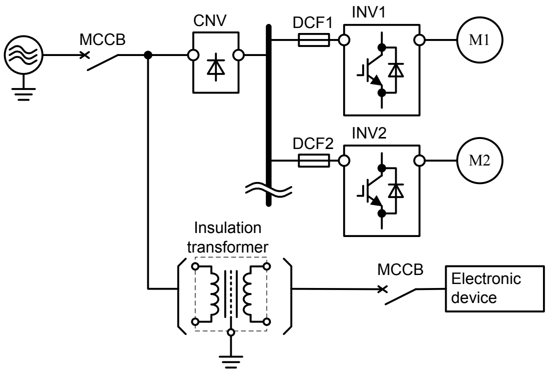


Figure 7.3.3-20: Example of NTC thermistor wiring

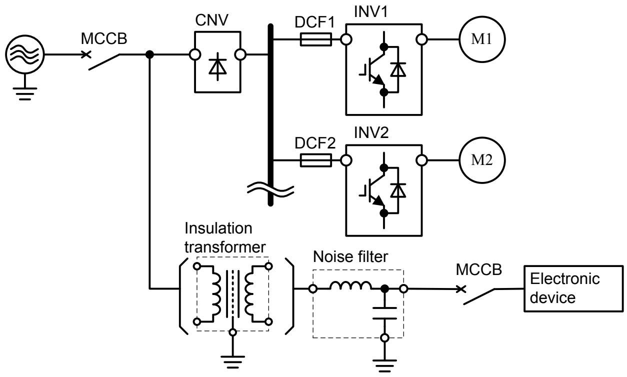
(8) Control power circuit

When control power is supplied from the main circuit power system for the converter (inverter), there might be impact of noise from the converter (inverter). However, most of the impact can be reduced by wiring of the main circuit and arrangement of devices.
The main circuit power system is a 400V system, therefore a general control power prepares power using a step-down transformer with small capacity.
Use an insulation transformer as a step-down transformer. (It is recommended to use a noise-cut transformer or TRAFY.)



Use an insulation transformer as a step-down transformer. (It is recommended to use a noise-cut transformer or TRAFY.)

Figure 7.3.3-21: Example of basic circuit configuration



A noise filter with high attenuation is recommended.

Figure 7.3.3-22: Example of circuit configuration (when a noise filter is used)

FRENIC-VG 8

Chapter 8 Operation

8.1 Function codes

This section lists the function codes.

For more information on the control block diagrams and the function codes, refer to the separate volume "Unit Type Function Code Edition" (24A7-□-0019).

For more details of the control block diagrams (Section 8.1.2), refer to "4.1 Control block diagrams" in Chapter 4 of the separate volume.
For more details of the function codes (Section 8.1.3), refer to "4.3 Function code details" in Chapter 4 of the separate volume.

8.1.1 Function code table

8.1.1.1 Function code groups and identification codes

F***

- F — Function code group
- *** — Identification code unique to the group

Table 8.1-1: Function code classification

Function codes		Function		Remarks
Fundamental function	F00 to F85	Fundamental functions		
Extensional terminal function	E01 to E118	Terminal functions		
			E51, E52	For the option OPC-VG1-AIO
			E55, E56	
			E59, E60	
			E63, E64	
			E67, E68	
			E72, E73	
			E77, E78	
			E82, E83	
			E103, E104	
			E107, E108	
Control function	C01 to C73	Control function		
Motor Parameter function	P01 to P51	Motor parameter function M1		
High performance function	H01 to H228	High performance functions		
Alternative motor parameters	A01 to A171	Motor parameter functions M2 and M3		
option function	o05 to o197	Option function		
			o01 to o04	For the options OPC-VG1-DIA and -DIB
			o05	For the option OPC-VG1-PG (PD)
			o06 to o08	For the option OPC-VG1-PG (LD)
			o09 to o11	For the option OPC-VG1-PMPG
			o12 to o19	For the option OPC-VG1-PG (PR)
			o30 to o32	For communications options (such as OPC-VG1-TL and OPC-VG1-CCL)
			o33, o34, o50	For the terminal block dedicated to the OPC-VG1-TBSI high-speed serial communications
			o38 to o40	For the option OPC-VG1-UPAC
			o101 to o197	For communications options (such as OPC-VG1-TL and OPC-VG1-CCL)
Lift function	L01 to L15	Lift functions		
User function	U01 to U64	User functions (UPAC)		Intended for use with the UPAC option
	U101 to U150	User functions		Reserved for manufacturer use

SaFety function	SF00 to SF31	Safety function	Intended for use when functional safety is implemented For more details, refer to the Functional Safety Option Instruction Manual.
Serial communication function	S01 to S17	Command functions	Operable from the LOC (Keypad), COM (Link: T link, RS-485, SIU, SX, field bus) and UPAC
Monitoring function	M01 to M222	Data monitor functions	

8.1.1.2 Function code table headers

The function code table uses the headers listed below (8.1.1.3).

Table 8.1-2: Function code table header list

Item		Description
Function code		Identification code of function code * The function code of is a parameter varying between unit type and stack type. Although it may be displayed or set for stack type, it will be an invalid function code.
Communications address	485 No.	Address to be used to refer to or change function code data using a communications option. Available for all communications options except OPC-VG1-TL.
	Link No.	Address to be used to refer to or change function code data using a communications option (OPC-VG1-TL, OPC-VG1-SX, etc.). Blank link number fields mean that the corresponding function codes cannot be accessed.
Name		Name assigned to a function code.
Dir		Number of second layer codes in the keypad function code data directory structure. 0: First layer code (no second layer), 1: Second layer code, 2 or more: First layer code (Value will show the number of second layer codes)
Data setting range		Allowable data setting range and definition of each data.
Change when running		Indicates whether or not the function code data can be changed when the inverter is running. O: Change while running allowed, X: Change while running not allowed
Factory default value		Data preset by factory default. When data is changed, * (asterisks) appears on the keypad screen. Initial factory default value can be restored by using the initialization function code.
Data copying		Identifies the function code used when you copy all the data stored in the keypad memory of a source inverter to other destination inverters.
Initialization		Identifies the function code used to perform initialization (revert to the factory default values) by H03 "Data initialization". Most of the function codes will be initialized. O: Data initialized, X: Data not initialized
Format type *1		Indicates the format type used to refer to or change data via the communications link.
Control method: Enable/Disable		Indicates whether or not the function code is available according to the individual control method. Control method PG : Vector control (Induction motor) LES : Sensor-less vector control (Induction motor) VF : V/f control (Induction motor) SM : Vector control (PMSM)

*1 For more information on function code classifications, refer to "4.2.4 Data format list" in Chapter 4 of the separate volume "Unit Type Function Code Edition" (24A7-J-0019).

8.1.1.3 Function code table

■ Fundamental functions (F: Fundamental Functions)

Function codes	Communications address: 485 No.	Communications address: Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable: PG	LES	VF	SM	Remarks
F00	0h	50h	Data protection	0	0 to 1 0: Data change allowed 1: Data protection Write-protects data from the keypad. H29 "Link write protect" defines the write-protect from links (T-link, 485, etc.).	×	0	×	○	40	○	○	○	○	
F01	1h	h	Speed setting N1	0	0 to 9 0: Keypad (∧/∨ keys) 1: Analog 12 input (0 to ±10 V) 2: Analog 12 input (0 to +10 V) 3: UP/DOWN (initial value 0) 4: UP/DOWN (initial value: previous value) 5: UP/DOWN (initial value: creep speed 1, 2) 6: DIA card input 7: DIB card input 8: Ai (N-REFV) input 9: Ai2 (N-REFC) input Defines how to set a speed command.	×	0	○	○	41	○	○	○	○	
F02	2h	h	Operation method	0	0 to 1 0: Key operation (FWD, REV and STOP keys) (LOCAL mode) 1: External signal (FWD and REV terminals) (REMOTE mode) Defines how to input the operation method.	×	0	○	○	42	○	○	○	○	
F03	3h	51h	M1 Maximum speed	3	50 to 30000 r/min	×	1500	○	×	0	○	○	○	○	
F04	4h	52h	M1 Rated speed	1	50 to 30000 r/min	×	Depends on capacity	○	×	0	○	○	○	○	
F05	5h	53h	M1 Rated voltage	1	80 to 999 V	×	Depends on capacity	○	×	0	○	○	○	○	
F07	7h	54h	Acceleration time 1	0	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
F08	8h	55h	Deceleration time 1	0	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
F10	Ah	56h	M1 Electronic thermal (Operation selection)	3	0 to 2 0: No operation (when using exclusive motor for VG) 1: Operation (for general purpose motors: use in the case of self-cooling fan) 2: Operation (for inverter motors: use in the case of externally powered fan)	○	0	○	×	85	○	○	○	○	
F11	Bh	57h	M1 Electronic thermal (Detection level)	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	○	Depends on capacity	○	×	13	○	○	○	○	
F12	Ch	58h	M1 Electronic thermal (Thermal time constant)	1	0.5 to 75.0 min	○	Depends on capacity	○	×	2	○	○	○	○	
F14	Eh	h	Restart after momentary power failure (Operation selection)	0	0 to 5 0: No operation (No restart, immediate alarm LU) 1: No operation (No restart, alarm on power return LU) 2: No operation (No restart, alarm after slow down and stop LU) 3: Operation (Restart, continue operation) 4: Operation (Restart, operate at speed when power was cut off) 5: Operation (Restart, operate at starting speed)	○	0	○	○	0	○	○	○	○	
F17	11h	h	Gain (for speed setting on terminal [12])	0	0.0 to 200.0% Ratio to analog speed setting value on control terminal [12]. Limited at ±110% of maximum speed.	○	100.0	○	○	2	○	○	○	○	
F18	12h	h	Bias (for speed setting on terminal [12])	0	-30000 to 30000 r/min Bias to analog speed setting value on control terminal [12]. Limited at ± maximum speed.	○	0	○	○	5	○	○	○	○	
F20	14h	59h	DC Braking (Braking starting speed)	3	0 to 3600 r/min	○	0	○	○	0	○	○	○	×	
F21	15h	5Ah	DC Braking (Braking level)	1	0 to 100%	○	0	○	○	16	○	○	○	×	
F22	16h	5Bh	DC Braking (Braking time)	1	0.0 to 30.0 s 0.0: No operation 0.1 to 30.0 s: Operation	○	0.0	○	○	2	○	○	○	×	
F23	17h	5Ch	Starting speed	0	0.0 to 150.0 r/min Restrict to over 0.1 Hz (for sensor-less, VF control) Starting speed can be set to secure the torque for starting.	×	0.0	○	○	2	○	○	○	○	
F24	18h	5Dh	Starting speed (Holding time)	0	0.00 to 10.00 s	×	0.00	○	○	3	○	○	○	○	
F26	1Ah	5Eh	Motor sound (Carrier frequency) * Function code invalid for setting change	0	2 to 15 kHz 2: 2 kHz 3: 3 kHz 4: 4 kHz 5: 5 kHz 6: 6 kHz 7: 7 kHz 8, 9: 8 kHz 10, 11: 10 kHz 12, 13, 14: 12 kHz 15: 15 kHz * Internal parameter of stack type is fixed at 2 kHz. (It will operate at 2 kHz even if set.)	×	2	○	○	10	○	○	○	○	

Function codes	Communications address: 485 No.	Communications address: Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable: PG	LES	VF	SM	Remarks
F36	24h	h	30RY Drive mode	0	0 to 1 0: Excitation operation on alarm 1: Normal excitation operation	×	0	○	○	43	○	○	○	○	
F37	25h	60h	Stop speed	3	0.0 to 150.0 r/min Restrict to over 0.1 Hz (for sensor-less, VF control)	×	10.0	○	○	2	○	○	○	○	
F38	26h	61h	Stop speed (Detection mode)	1	0 to 1 0: Detected speed value 1: Speed command value Only speed command value is valid, regardless of the setting value, under sensor-less vector control or V/F control.	×	0	○	○	90	○	×	×	○	
F39	27h	62h	Stop speed (Zero speed control holding time)	1	0.00 to 10.00 s Applies to when timing the application of the mechanical brake.	×	0.50	○	○	3	○	×	×	○	
F40	28h	63h	Torque limiter mode 1	12	0 to 3 0: Limit disable 1: Torque limit 2: Power limit 3: Torque current limit	×	0	○	○	44	○	○	○	○	
F41	29h	64h	Torque limiter mode 2	1	0 to 3 0: Same for 4 quadrants at level 1 1: Drive (Level 1) and brake (Level 2) 2: Upper limit (Level 1), lower limit (Level 2) 3: Switch between levels 1 and 2 for all the 4 quadrants Levels 1 and 2 are specified by the sources defined by F42 and F43, respectively.	×	0	○	○	45	○	○	○	○	
F42	2Ah	65h	Torque limiter value (Level 1) selection	1	0 to 5 0: Function code (F44) 1: Ai [TL-REF1] 2: DIA card 3: DIB card 4: Link enable 5: PID output	×	0	○	○	46	○	○	○	○	
F43	2Bh	66h	Torque limiter value (Level 2) selection	1	0 to 5 0: Function code (F45) 1: Ai [TL-REF2] 2: DIA card 3: DIB card 4: Link enable 5: PID output	×	0	○	○	47	○	○	○	○	
F44	2Ch	67h	Torque limiter value (Level 1)	1	-300 to 300%	○	150	○	○	5	○	○	○	○	
F45	2Dh	68h	Torque limiter value (Level 2)	1	-300 to 300%	○	10	○	○	5	○	○	○	○	
F46	2Eh	69h	Mechanical loss compensation value	1	-300.00 to 300.00%	○	0.00	○	○	7	○	○	×	○	
F47	2Fh	6Ah	Torque bias T1	1	-300.00 to 300.00% Torque biases T1 to T3 are switchable with DI.	○	0.00	○	○	7	○	○	×	○	
F48	30h	h	Torque bias T2	1	-300.00 to 300.00%	○	0.00	○	○	7	○	○	×	○	
F49	31h	h	Torque bias T3	1	-300.00 to 300.00%	○	0.00	○	○	7	○	○	×	○	
F50	32h	h	Torque bias startup timer	1	0.00 to 1.00 s Specifies the time required for generating 300% torque.	○	0.00	○	○	3	○	○	×	○	
F51	33h	FBh	Torque command monitor (Polarity selection)	1	0 to 1 0: Torque polarity 1: + on drive, - on brake Specifies the polarity of torque related data output (e.g., AO monitor, keypad LED monitor, and keypad LCD monitor).	○	0	○	○	48	○	○	○	○	
F52	34h	h	LED Monitor (Display coefficient A)	8	-999.00 to 999.00 Specifies the conversion coefficient for displaying the load shaft speed and line speed on the keypad LED monitor. Display value = Motor speed x (0.01 to 200.00) Data is valid only between 0.01 and 200.00, out of range data will be restricted.	○	1.00	○	○	12	○	○	○	○	
F53	35h	h	LED Monitor (Display coefficient B)	1	-999.00 to 999.00 Display coefficient A: Maximum value Display coefficient B: Minimum value Display coefficients A and B are used to set the conversion coefficients for determining the display values for the PID command value, PID feedback amount, and PID output (Process amount). Display value = (Command or feedback value) x (Display coefficient A - B) + B	○	1.00	○	○	12	○	○	○	○	
F54	36h	h	LED Monitor (Display filter)	1	0.0 to 5.0 s	○	0.2	○	○	2	○	○	○	○	
F55	37h	H	LED Monitor (Display selection)	1	00 to 32	○	0	○	○	49					
					00: Speed detection 1/Speed command (r/min) (F56 switches the display while motor is stopped)						○	○	×	○	
					01: Speed setup 4 (ASR input) (r/min)						○	○	○	○	
					02: Output frequency command value (slide in) (Hz)						○	○	○	○	
					03: Torque current command value (%)						○	○	×	○	
					04: Torque command value (%)						○	○	×	○	
					05: Torque calculated value (%)						○	○	○	○	
					06: Power consumption (Motor output) (switched by F60) (kW, HP)						○	○	○	○	
					07: Output current detected value (A)						○	○	○	○	
					08: Output voltage detected value (V)						○	○	○	○	
					09: DC link bus voltage detected value (V)						○	○	○	○	
					10: Magnetic flux command value (%)						○	○	×	×	
					11: Magnetic flux calculated value (%)						○	○	×	×	
					12: Motor temperature (°C) (when NTC thermistor is not used, "---" is displayed)						○	○	○	○	
					13: Load axis rotational speed detected value, command value (r/min) (Display with the motor stopped is switchable with F56.)						○	○	×	○	
					14: Line speed detected value, command value (m/min) (Display with the motor stopped is switchable with F56.)						○	○	○	○	
					15: Ai adjusted value (12) (%)						○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
F55	37h	H	LED Monitor (Display selection)	1	16: Ai adjusted value (Ai1) (%)	○	0	○	○	49	○	○	○	○	
					17: Ai adjusted value (Ai2) (%)						○	○	○	○	
					18: Ai adjusted value (Ai3) (%)						○	○	○	○	
					19: Ai adjusted value (Ai4) (%)						○	○	○	○	
					The following data will be hidden depending upon the mode or options. 20: PID command value (%)						○	○	○	○	
					21: PID feedback value (%)						○	○	○	○	
					22: PID output value (%)						○	○	○	○	
					23: Option monitor 1 (HEX)						○	○	○	○	
					24: Option monitor 2 (HEX)						○	○	○	○	
					25: Option monitor 3 (DEC)						○	○	○	○	
					26: Option monitor 4 (DEC)						○	○	○	○	
					27: Option monitor 5 (DEC)						○	○	○	○	
					28: Option monitor 6 (DEC)						○	○	○	○	
					29: -						-	-	-	-	
					30: Load factor (%)						○	○	○	○	
					31: Input power (F60 switches units.) (kW/HP)						○	○	○	○	
					32: Input watt-hour (x 100 kWh)						○	○	○	○	
F56	38h	H	LED Monitor (Display when stopped)	1	0 to 1 0: Display command value 1: Display actual value The display with the motor stopped is switchable with F55. Relevant data are speed (0), load axis rotational speed (13), and line speed (14).	○	0	○	○	50	○	○	○	○	
F57	39h	h	LCD Monitor (Display selection)	1	0 to 1 0: Display operation guidance screen (Operating condition, Rotation direction) 1 Display bar graph of operation data (Speed detect 1, Current, Torque command value) Switches the running mode screen on the keypad.	○	0	○	○	51	○	○	○	○	
F58	3Ah	h	LCD Monitor (Language selection)	1	0 to 7 0: Japanese 1: English 2-5: - 6: Chinese 7: Korean	○	0	○	×	52	○	○	○	○	
F59	3Bh		LCD Monitor (Contrast adjustment)	1	0 (Low) to 10 (High)	○	5	○	○	0	○	○	○	○	
F60	3Ch		Output unit (HP/kW) setting	0	0 to 1 0: kW 1: HP Switches the display unit for the inverter output (power consumption) of the keypad LED and LCD monitors and the selection list (kW-HP) for P02 "Motor selection (M1)".	○	0	○	○	53	○	○	○	○	
F61	3Dh	6Bh	ASR1-P (Gain)	10	0.1 to 500.0 times	○	10.0	○	○	2	○	○	×	○	
F62	3Eh	6Ch	ASR1-I (Integral constant)	1	0.000 to 10.000 s P control when set to 0.000	○	0.200	○	○	4	○	○	×	○	
F63	3Fh	6Dh	ASR1-FF (Gain)	1	0.000 to 9.999 s	○	0.000	○	○	4	○	○	×	○	
F64	40h	6Eh	ASR1 Input filter	1	0.000 to 5.000 s	○	0.040	○	○	4	○	○	○	○	
F65	41h	6Fh	ASR1 Detection filter	1	0.000 to 0.100 s Specifies the first order delay filter time constant for the detected speed value.	○	0.005	○	○	4	○	○	×	○	
F66	42h	70h	ASR1 Output filter	1	0.000 to 0.100 s Specifies the first order delay filter time constant for the torque command.	×	0.002	○	○	4	○	○	×	○	
F67	43h	71h	S-curve acceleration 1 (Start)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
F68	44h	72h	S-curve acceleration 1 (End)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
F69	45h	73h	S-curve deceleration 1 (Start)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
F70	46h	74h	S-curve deceleration 1 (End)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
F72	48h	h	Pre-excitation operation selection	4	0 to 1 0: Operates when starting operation. Pre-excitation continues for the duration specified by F74. 1: Operates when starting and stopping operation. Pre-excitation continues for the duration specified by F74 or until the magnetic flux command reaches the level specified by E48, whichever is earlier.	×	0	○	○	230	○	○	×	×	
F73	49h	h	Magnetic flux level at light load	1	10 to 100%	○	100	○	○	16	○	×	×	×	
F74	4Ah	75h	Pre-excitation (Duration)	1	0.0 to 10.0 s When the operation command is turned ON (FWD, REV), the unit automatically enters the pre-excitation state for the time specified in this function code.	×	0.0	○	○	2	○	○	×	×	
F75	4Bh	76h	Pre-excitation (Initial level)	1	100 to 400%	×	100	○	○	0	○	○	×	×	
F76	4Ch	h	Speed limiter (Mode selection)	3	0 to 3 0: Limits to Normal: Level 1, Reverse: level 2. 1: Limits to Normal: Level 1, Reverse: level 1. 2: Limits to upper limit at level 1, lower limit at level 2. 3: Limits to Normal: Level 1, Reverse: level 2. Terminal [12] input added as a bias	×	0	○	○	91	○	○	○	○	
F77	4Dh	4Fh	Speed limiter (Level 1)	1	-110.0 to 110.0%	○	100.0	○	○	6	○	○	○	○	
F78	4Eh	FEh	Speed limiter (Level 2)	1	-110.0 to 110.0%	○	100.0	○	○	6	○	○	○	○	
F79	4Fh	77h	Motor selection (M1, M2, M3)	0	0 to 2 0: M1 selected Note that switching of contacts by X functions has priority over this function code setting. 1: M2 selected (X function disable) 2: M3 selected (X function disable) Select a motor to be used from M1, M2 and M3.	×	0	○	×	54	○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
F80	50h	h	Current rating switching	0	0 to 3 **Stack type** 0,2,3 : MD (high duty overload current 150%-1min) 1 : LD (low duty overload current 110%-1min) * It switches the dual ratings (MD, LD) of inverter. As for keypad display, HD display is operated in accordance with MD spec. **Unit type** 0,2 : HD (high duty overload current 150%-1min/200%-3sec) 1 : LD (low duty overload current 120%-1min) 3 : MD (medium duty overload current 150%-1min) * It switches the triple ratings (HD, LD, MD) of inverter.	×	0	○	×	56	○	○	○	○	
F81	51h	h	Offset for speed setting on terminal [12]	3	-30000 to 30000 r/min Specifies the offset for analog speed setting value on control terminal [12].	○	0	○	○	5	○	○	○	○	
F82 (*1)	52h	h	Dead zone for speed setting on terminal [12]	1	0.0 to 150.0 r/min Limits the speed command value below specified value ± to 0 r/min for analog speed setting value on control terminal [12].	○	0.0	○	○	2	○	○	○	○	
F83	53h	h	Filter for speed setting on terminal [12]	1	0.000 to 5.000 s	○	0.005	○	○	4	○	○	○	○	
F84	54h	h	Display coefficient for input watt-hour data * Invalid for use in stack type	0	0.000 to 9999 Specifies a display coefficient for displaying the input watt-hour data (M116). M116 = F84 x M115 "Input watt-hour" (kWh) Specification of 0.000 clears the input watt-hour data.	○	0.010	○	○	101	○	○	○	○	
F85	55h	h	Display filter for calculated torque	0	0.000 to 1.000 s Specifies a display filter for calculated torque output for monitoring (keypad LED monitor and keypad LCD monitor).	○	0.100	○	○	4	○	○	○	○	

(*1) Supported by ROM version H1/2 0019 or later.

■ Terminal functions (E: Extensional terminal Functions)

Function codes	Communications address: 485 No.	Communications address: Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable: PG	LES	VF	SM	Remarks
E01	101h	78h	X1 Function selection	13	00 to 79	×	0	○	○	57					
					00, 01, 02, 03: Multistep speed selection (1 to 15 speeds) [00: SS1, 01: SS2, 02: SS4, 03: SS8]						○	○	○	○	
					04, 05: ASR, acceleration and deceleration selection (4 speeds) [4: RT1, 5: RT2]						○	○	○	○	
					06: Self-holding selection [HLD]						○	○	○	○	
					07: Coast to a stop [BX]						○	○	○	○	
					08: Failure reset [RST]						○	○	○	○	
					09: External alarm [THR]						○	○	○	○	
					10: Jogging operation [JOG]						○	○	○	○	
					11: Speed setting N2/Speed setting N1 [N2/N1]						○	○	○	○	
					12: Motor M2 selection [M-CH2]						○	○	○	○	
					13: Motor M3 selection [M-CH3]						○	○	○	○	
					14: Direct current brake command [DCBRK]						○	○	○	×	
					15: ACC/DEC zero clear command [CLR]						○	○	○	○	
					16: UP/DOWN specification creep speed switching [CRP-N2/N1]						○	○	○	○	
					17: UP/DOWN specification UP command [UP]						○	○	○	○	
					18: UP/DOWN specification DOWN command [DOWN]						○	○	○	○	
					19: Keypad edit permission command (data change allowed) [WE-KP]						○	○	○	○	
					20: PID control cancel [KP/PID]						○	○	○	○	
					21: Normal and reverse operation switching [IVS]						○	○	○	○	
					22: Interlock (52-2) IL]						○	○	○	○	
					23: Link edit permission command [WE-LK]						○	○	○	○	
					24: Linked operation selection [LE]						○	○	○	○	
					25: Universal DI [U-DI]						○	○	○	○	
					26: Starting characteristic selection [STM]						○	○	○	○	
					27: Synchronous operation command (PG (PR) option function) [SYC]						○	×	×	○	
					28: Zero speed lock command [LOCK]						○	×	×	○	
					29: Pre-excitation command [EXITE]						○	○	×	×	
					30: Limitation of speed command value cancel [N-LIM] (Related codes: F76, F77, F78)						○	○	○	○	
					31: H41 [Torque command] cancel [H41-CCL]						○	○	×	○	
					32: H42 [Torque current command] cancel [H42-CCL]						○	○	×	○	
					33: H43 [Magnetic flux command] cancel [H43-CCL]						○	×	×	×	
					34: F40 [Torque limited mode 1] cancel [F40-CCL]						○	○	×	○	
					35: Torque limit (Level 1, Level 2 selection) [TL2/TL1]						○	○	○	○	
					36: Bypass [BPS]						○	○	○	○	
					37, 38: Torque bypass command 1/2 [37: TB1, 38: TB2]						○	○	×	○	
					39: Droop selection [DROOP]						○	○	×	○	
					40: Ai1 zero hold [ZH-AI1]						○	○	○	○	
					41: Ai2 zero hold [ZH-AI2]						○	○	○	○	
					42: Ai3 zero hold (AIO option function) [ZH-AI3]						○	○	○	○	
					43: Ai4 zero hold (AIO option function) [ZH-AI4]						○	○	○	○	
					44: Ai1 polarity reversal [REV-AI1]						○	○	○	○	
					45: Ai2 polarity reversal [REV-AI2]						○	○	○	○	
					46: Ai3 polarity reversal (AIO option function) [REV-AI3]						○	○	○	○	
					47: Ai4 polarity reversal (AIO option function) [REV-AI4]						○	○	○	○	
					48: PID command value reverse operation selection [PID-INV]						○	○	○	○	
					49: PG alarm cancel [PG-CCL]						○	×	×	○	
					50: Insufficient voltage cancel [LU-CCL]						○	○	○	○	
					51: Ai torque bias hold [H-TB]						○	○	×	○	
					52: STOP1 (decelerate to stop in normal deceleration time) [STOP1]						○	○	○	○	
					53: STOP2 (decelerate to stop in “deceleration time 4”) [STOP2]						○	○	○	○	
					54: STOP3 (Ignore deceleration time specification, and decelerate to stop using maximum output torque)						○	○	○	○	
					55: DIA data latch (DIA option function) [DIA]						○	○	○	○	
					56: DIB data latch (DIB option function) [DIB]						○	○	○	○	
					57: Multiple system cancel [MT-CCL]						○	×	○	×	
					58-67: Custom Di1-Di10 [C-DI1 to C-DI10]						○	○	○	○	
					68: Load weighting parameter selection (To be supported soon) [AN-P2/1]						○	×	×	○	
					69: PID clear [PID-CCL]						○	○	○	○	
					70: PID FF item enable [PID-FF]						○	○	○	○	
					71: Speed limit calculation complete reset signal (To be supported soon) [NL-RST]						○	×	×	○	
					72: Toggle signal 1 [TGL1]						○	○	○	○	
					73: Toggle signal 2 [TGL2]						○	○	○	○	
					74: External mock alarm [FTB]						○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
E01	101h	78h	X1 Function selection	13	75: NTC thermistor alarm cancel [NTC-CCL]	×	0	○	○	57	○	○	○	○	
					76: Life early warning cancel [LF-CCL]						○	○	○	○	
					77: - [SPG-AP]						-	-	-	-	
					78: PID feedback switching signal [PID-1/2]						○	○	○	○	
					79: PID torque bias selection [TB-PID]						○	○	×	○	
E02	102h	79h	X2 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	1	○	○	57	○	○	○	○	
E03	103h	7Ah	X3 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	2	○	○	57	○	○	○	○	
E04	104h	7Bh	X4 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	3	○	○	57	○	○	○	○	
E05	105h	7Ch	X5 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	4	○	○	57	○	○	○	○	
E06	106h	7Dh	X6 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	5	○	○	57	○	○	○	○	
E07	107h	7Eh	X7 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	7	○	○	57	○	○	○	○	
E08	108h	7Fh	X8 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	8	○	○	57	○	○	○	○	
E09	109h	80h	X9 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	9	○	○	57	○	○	○	○	
E10	10Ah	81h	X11 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	25	○	○	57	○	○	○	○	
E11	10Bh	82h	X12 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	25	○	○	57	○	○	○	○	
E12	10Ch	83h	X13 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	25	○	○	57	○	○	○	○	
E13	10Dh	84h	X14 Function selection	1	0 to 79 (Refer to Terminal [X1] Function.)	×	25	○	○	57	○	○	○	○	
E14	10Eh	h	X Function Normal open/close	0	0000 to 01FF 0: Normal open 1: Normal close Specifies whether to open or close the contact for terminals [X1] to [X9].	×	0000	○	○	35	○	○	○	○	
E15	10Fh	85h	Y1 Function selection	13	0 to 84	×	1	○	○	58					
					00: In operation [RUN]						○	○	○	○	
					01: Speed available [N-EX]						○	○	○	○	
					02: Speed agreement [N-AG1]						○	○	×	○	
					03: Speed achieved [N-AR]						○	○	○	○	
					04: Speed detection 1 [N-DT1]						○	○	○	○	
					05: Speed detection 2 [N-DT2]						○	○	○	○	
					06: Speed detection 3 [N-DT3]						○	○	○	○	
					07: Stopped due to insufficient voltage [LU]						○	○	○	○	
					08: Torque polarity detected (brake/drive) [B/D]						○	○	×	○	
					09: Torque limited TL]						○	○	○	○	
					10: Torque detect 1 [T-DT1]						○	○	○	○	
					11: Torque detect 2 [T-DT2]						○	○	○	○	
					12: Keypad operation [KP]						○	○	○	○	
					13: Stopped [STOP]						○	○	○	○	
					14: Preparation for operation complete [RDY]						○	○	○	○	
					15: Magnetic flux detect signal [MF-DT]						○	○	×	×	
					16: Motor M2 selected [SW-M2]						○	○	○	○	
					17: Motor M3 selected [SW-M3]						○	○	○	○	
					18: Brake release signal [BRK]						○	○	×	○	
					19: Alarm contents [AL1]						○	○	○	○	
					20: Alarm contents [AL2]						○	○	○	○	
					21: Alarm contents [AL4]						○	○	○	○	
					22: Alarm contents [AL8]						○	○	○	○	
					23: Cooling fan in operation [FAN]						○	○	○	○	
					24: Retry function in operation [TRY]						○	○	○	○	
					25: Universal DO [U-DO]						○	○	○	○	
					26: Cooling fin overheat early warning [INV-OH]						○	○	○	○	
					27: Synchronization control complete [SY-C]						○	×	×	○	
					28: Life early warning [LIFE]						○	○	○	○	
					29: Accelerating [U-ACC]						○	○	○	○	
					30: Decelerating [U-DEC]						○	○	○	○	
					31: Inverter overload early warning [INV-OL]						○	○	○	○	
					32: Motor temperature overheat early warning [M-OH]						○	○	○	○	
					33: Motor overload early warning [M-OL]						○	○	○	○	
			* Invalid for use in stack type ⇒		34: DB overload early warning [DB-OL]						○	○	×	○	
					35: Transmission failure [LK-ERR]						○	○	○	○	
					36: Load weighting control limited [ANL]						○	×	×	○	
					37: Load weighting control in calculation [ANC]						○	×	×	○	
					38: Analog torque bias on hold [TBH]						○	○	×	○	
					39 to 48: Custom Do1-Do10 [C-DO1 to C-DO10]						○	○	○	○	
					49: -						-	-	-	-	
					50: -						○	×	×	○	
					51: Establishing multiple system communication [MTS]						○	×	×	○	
					52: Multiple system cancel response [MEC-AB]						○	×	×	○	
					53: Multiple system master selection [MSS]						○	×	×	○	
					54: Multiple system self error [AL-SF]						○	×	×	○	
					55: Stopped due to communication failure [LES]						○	○	○	○	
					56: Alarm output (for any alarm) [ALM]						○	○	○	○	
					57: Light alarm [L-ALM]						○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
					58: Maintenance early warning [MNT]						○	○	○	○	
			* Invalid for use in stack type ⇒								○	○	○	○	
					60: DC fan lock signal [DCFL]						○	○	○	○	
					61: Speed agreement 2 [N-AG2]						○	○	×	○	
					62: Speed agreement 3 [N-AG3]						○	○	×	○	
					63: Axial fan stop signal [MFAN]						○	○	○	○	
					64: Free assignment RDY (*1) [AS-RDY]						-	-	-	-	
					65: -						-	-	-	-	
					66: Droop selection response [DSAB]						○	○	×	○	
					67: Torque command/Torque current command cancel response [TCL-C]						○	○	×	○	
					68: Torque limited mode 1 cancel response [F40-AB]						○	○	×	○	
					71: 73 input command [PRT-73]						○	○	○	○	
					72: Y terminal test output ON [Y-ON]						○	○	○	○	
					73: Y terminal test output OFF [Y-OFF]						○	○	○	○	
					74: -						-	-	-	-	
					75: Life of battery for clock [BATT]						○	○	○	○	
					76: -						×	×	×	○	
					77: SPGT battery warning (To be supported soon) [SPGT-B]						○	○	○	○	
					78: -						-	-	-	-	
					79: -						-	-	-	-	
			(*2)		80: EN terminal detection circuit failure [DECF]						○	○	○	○	
			(*2)		81: EN terminal OFF [ENOFF]						○	○	○	○	
			(*2)		82: Safety function in operation [SF-RUN]						○	○	○	○	
			(*2)		83: -						-	-	-	-	
			(*2)		84: STO diagnosis in progress [SF-TST]						○	○	○	○	
E16	110h	86h	Y2 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	2	○	○	58	○	○	○	○	
E17	111h	87h	Y3 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	3	○	○	58	○	○	○	○	
E18	112h	88h	Y4 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	4	○	○	58	○	○	○	○	
E19	113h	89h	Y5 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	14	○	○	58	○	○	○	○	
E20	114h	8Ah	Y11 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	26	○	○	58	○	○	○	○	
E21	115h	8Bh	Y12 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	26	○	○	58	○	○	○	○	
E22	116h	8Ch	Y13 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	26	○	○	58	○	○	○	○	
E23	117h	8Dh	Y14 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	26	○	○	58	○	○	○	○	
E24	118h	8Eh	Y15 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	26	○	○	58	○	○	○	○	
E25	119h	8Fh	Y16 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	26	○	○	58	○	○	○	○	
E26	11Ah	90h	Y17 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	26	○	○	58	○	○	○	○	
E27	11Bh	91h	Y18 Function selection	1	0 to 84 (Refer to Terminal [Y1] Function.)	×	26	○	○	58	○	○	○	○	
E28	11Ch	h	Y Function Normal open/close	0	0000 to 001F 0: Normal open 1: Normal close Specifies the normal condition of Y1 to Y5.	×	0000	○	○	36	○	○	○	○	
E29	11Dh	92h	PG Pulse output selection	0	0 to 10 0: No division 1: 1/2 2: 1/4 3: 1/8 4: 1/16 5: 1/32 6: 1/64 0 to 6: Internal PG input is divided and output. 7: Internal speed command: Pulse oscillation mode 8: PG (PD): Pulse detection input oscillation mode 9: PG (PR): Pulse command input oscillation mode 10: Internal PG/PG (SD): Speed detection pulse input oscillation mode 7 to 10: Input pulse is divided arbitrarily and output. (AB 90° phase difference signal)	×	0	○	○	92	○	×	×	○	
E30	11Eh	h	Motor overheat protection (Temperature)	8	50 to 200°C	○	150	○	○	0	○	○	○	○	
E31	11Fh	h	Motor overheat early warning (Temperature)	1	50 to 200°C	○	75	○	○	0	○	○	○	○	
E32	120h	CDh	M1-M3 PTC activation level	1	0.00 to 5.00 V The PTC is activated if the input voltage of the PTC terminal exceeds this activation level when the PTC thermistor is selected.	×	1.60	○	○	3	○	○	○	○	
E33	121h	h	Inverter overload early warning	1	25 to 100%	○	90	○	○	0	○	○	○	○	
E34	122h	h	Motor overload early warning	1	25 to 100%	○	90	○	○	0	○	○	○	○	

*1 Availble in the ROM version H1/2 02□□, which supports PROFINET-IRT.
*2 Available when the ROM version is H1/2 0020 or later.

Function codes	Communications address: 485 No.	Communications address: Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable: PG	Control method: Enable/Disable: LES	Control method: Enable/Disable: VF	Control method: Enable/Disable: SM	Remarks
E35	123h	h	DB Overload protection * E35 to E37 Invalid for use in stack type	1	0 to 100% Specifies %ED of the braking resistor relative to the inverter capacity. When E35 = 0, the overheat protection function (dbH) is disabled.	○	0	○	○	0	○	○	×	○	
E36	124h	h	DB Overload early warning	1	0 to 100%	○	80	○	○	0	○	○	×	○	
E37	125h	h	DB Thermal time constant	1	0 to 1000 s	○	300	○	○	0	○	○	×	○	
E38	126h	93h	Speed detection mode	8	000 to 111 Detection mode of 0 x E39/E40/E41 0: Speed detection 1: Speed setting Under V/f control, only the specified reference speed is valid.	○	000	○	○	9	○	○	×	○	
E39	127h	94h	Speed detection level 1	1	0 to 30000 r/min If N-FB1± (Detected speed 1) or N-REF4 (Speed setting 4) exceeds this speed detection level 1, the inverter issues the detection signal.	○	1500	○	○	0	○	○	○	○	
E40	128h	95h	Speed detection level 2	1	-30000 to 30000 r/min	○	1500	○	○	5	○	○	○	○	
E41	129h	96h	Speed detection level 3	1	-30000 to 30000 r/min	○	1500	○	○	5	○	○	○	○	
E42	12Ah	97h	Speed arrival (Detection width)	1	1.0 to 20.0% If the detected speed comes within the range of N-REF2 (Speed setting 2) ± detection width, the inverter issues the detection signal.	○	3.0	○	○	2	○	○	×	○	
E43	12Bh	98h	Speed agreement (Detection width)	1	1.0 to 20.0% If N-FB2± (Detected speed 2) is within the range of N-REF4 (Speed setting 4) ± detection width, the inverter issues the detection signal.	○	3.0	○	○	2	○	○	×	○	
E44	12Ch	99h	Speed agreement (Off-delay timer)	1	0.000 to 5.000 s	○	0.100	○	○	4	○	○	×	○	
E45	12Dh	9Ah	Speed disagreement Alarm use and disuse	1	00 to 21 Digit of 1: Speed disagreement alarm (Er-S) 0: Disuse 1: Use Digit of 10: Lin open phase detection (L in) 0: Standard level 1: For manufacturer use 2: Cancel	×	00	○	○	9	○	○	×	○	
E46	12Eh	9Bh	Torque detection level 1	3	0 to 300% Calculated value under V/f control. If the torque command value exceeds this setting value, the inverter issues the detection signal.	○	30	○	○	16	○	○	○	○	
E47	12Fh	9Ch	Torque detection level 2	1	0 to 300%	○	30	○	○	16	○	○	○	○	
E48	130h	9Dh	Magnetic flux detection level	1	10 to 100% Detection signal is output when the magnetic flux calculation value exceeds the specified value.	×	100	○	○	16	○	○	×	×	
E49	131h	h	Terminal [Ai1] Function	4	0 to 27	×	0	○	○	59					
					00: Input signal cut off [OFF] -						○	○	○	○	
					01: Speed auxiliary setting 1 [AUX-N1] ±10 V/± Nmax						○	○	○	○	
					02: Speed auxiliary setting 2 [AUX-N2] ±10 V/± Nmax						○	○	○	○	
					03: Torque limit (Level 1) [TL-REF1] ±10 V/±150%						○	○	○	○	
					04: Torque limit (Level 2) [TL-REF2] ±10 V/±150%						○	○	○	○	
					05: Torque bias [TB-REF] ±10 V/±150%						○	○	×	○	
					06: Torque command [T-REF] ±10 V/±150%						○	○	×	○	
					07: Torque current command [IT-REF] ±10 V/±150%						○	○	×	○	
					08: When UP/DOWN is set, creep speed 1 [CRP-N1] ±10 V/± Nmax						○	○	○	○	
					09: When UP/DOWN is set, creep speed 2 [CRP-N2] ±10 V/± Nmax						○	○	○	○	
					10: Magnetic-flux command [MF-REF] +10 V/+100%						○	×	×	×	
					11: Line speed detection [LINE-N] ±10 V/± Nmax						○	○	○	○	
					12: Motor temperature [M-TMP] +10 V/200°C						○	○	○	○	
					13: Speed override [N-OR] ±10 V/±50%						○	○	○	○	
					14: Universal Ai [U-AI] ±10 V/±4000 (h)						○	○	○	○	
					15: Amount of PID feedback 1 [PID-FB1] ±10 V/±20000 (d)						○	○	○	○	
					16: Amount of PID command [PID-REF] ±10 V/±20000 (d)						○	○	○	○	
					17: PID correction gain [PID-G] ±10 V/±4000 (h)						○	○	○	○	
					18 to 24: Custom Ai 1 to 7 [C-AI1 to C-AI7]						○	○	○	○	
					25: Speed main setting [N-REFV] ±10 V/± Nmax						○	○	○	○	
					26: Current input speed setting (4-20 mADC) [N-REFC] 4-20 mADC/Nmax (26: Current input speed setting can be used only on Ai2.)						○	○	○	○	
					27: Amount of PID feedback 2 [PID-FB2] ±10 V/±20000 (d)						○	○	○	○	
E50	132h	h	Terminal [Ai2] Function	1	0 to 27 (Refer to Terminal [Ai1] Function.)	×	0	○	○	59	○	○	○	○	
E51	133h	h	Terminal [Ai3] Function	1	0 to 27 (Refer to Terminal [Ai1] Function.) (26: Current input speed setting can be used only on Ai2.)	×	0	○	○	59	○	○	○	○	
E52	134h	h	Terminal [Ai4] Function	1	0 to 27 (Refer to Terminal [Ai1] Function.) (26: Current input speed setting can be used only on Ai2.)	×	0	○	○	59	○	○	○	○	
E53	135h	h	Ai1 Gain	4	-10.000 to 10.000 times	○	1.000	○	○	8	○	○	○	○	
E54	136h	h	Ai2 Gain	1	-10.000 to 10.000 times	○	1.000	○	○	8	○	○	○	○	
E55	137h	h	Ai3 Gain	1	-10.000 to 10.000 times (displayed when AIO option is installed)	○	1.000	○	○	8	○	○	○	○	
E56	138h	h	Ai4 Gain	1	-10.000 to 10.000 times (displayed when AIO option is installed)	○	1.000	○	○	8	○	○	○	○	
E57	139h	h	Ai1 Bias	4	-100.0 to 100.0%	○	0.0	○	○	6	○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
E58	13Ah	h	Ai2 Bias	1	-100.0 to 100.0%	○	0.0	○	○	6	○	○	○	○	
E59	13Bh	h	Ai3 Bias	1	-100.0 to 100.0% (displayed when AIO option is installed)	○	0.0	○	○	6	○	○	○	○	
E60	13Ch	h	Ai4 Bias	1	-100.0 to 100.0% (displayed when AIO option is installed)	○	0.0	○	○	6	○	○	○	○	
E61	13Dh	h	Ai1 Filter	4	0.000 to 0.500 s	○	0.010	○	○	4	○	○	○	○	
E62	13Eh	h	Ai2 Filter	1	0.000 to 0.500 s	○	0.010	○	○	4	○	○	○	○	
E63	13Fh	h	Ai3 Filter	1	0.000 to 0.500 s	○	0.010	○	○	4	○	○	○	○	
E64	140h	h	Ai4 Filter	1	0.000 to 0.500 s	○	0.010	○	○	4	○	○	○	○	
E65	141h	h	Up/Down limiter (Ai1)	4	0.00 to 60.00 s Specifies the duration required when the inverter internal data changes from 0 V to 10 V if the voltage on analog input terminal changes from 0 V to 10 V.	○	0.00	○	○	3	○	○	○	○	
E66	142h	h	Up/Down limiter (Ai2)	1	0.00 to 60.00 s	○	0.00	○	○	3	○	○	○	○	
E67	143h	h	Up/Down limiter (Ai3)	1	0.00 to 60.00 s	○	0.00	○	○	3	○	○	○	○	
E68	144h	h	Up/Down limiter (Ai4)	1	0.00 to 60.00 s	○	0.00	○	○	3	○	○	○	○	
E69	145h	h	AO1 Function selection	5	0 to 40	○	1	○	○	60					
					00: Speed detection 1 (Speed meter, one way swing) [N-FB1+] ± Nmax/10 V						○	○	×	○	
					01: Speed detection 1 (Speed meter, two way swing) [N-FB1±] ± Nmax/±10 V						○	○	×	○	
					02: Speed setting 2 (before calculation of acceleration/deceleration) [N-REF2] ± Nmax/±10 V						○	○	○	○	
					03: Speed setting 4 (ASR input) [N-REF4] ± Nmax/±10 V						○	○	○	○	
					04: Speed detection 2 (ASR input) [N-FB2±] ± Nmax/±10 V						○	○	×	○	
					05: Line speed detection [LINE-N±] ± Nmax/±10 V						○	○	○	○	
					06: Torque current command (Torque ampere meter, two way swing) [IT-REF±] ±150%/±10 V						○	○	×	○	
					07: Torque current command (Torque ampere meter, one side swing) [IT-REF+] ±150%/10 V						○	○	×	○	
					08: Torque command (Torque meter, two way swing) [T-REF±] ±150%/±10 V						○	○	×	○	
					09: Torque command (Torque meter, one way swing) [T-REF+] ±150%/10 V						○	○	×	○	
					10: Motor current [I-AC] 200%/10 V						○	○	○	○	
					11: Motor voltage [V-AC] 200%/10 V						○	○	○	○	
					12: Power consumption (Motor output) [PWR] 200%/10 V						○	○	○	○	
					13: DC link bus voltage [V-DC] 800 V/10 V						○	○	○	○	
					14: +10 V output test [P10] Output equivalent to +10 V						○	○	○	○	
					15: -10 V output test [N10] Output equivalent to -10 V						○	○	○	○	
					16: Motor temperature [TMP-M] ±200°C/±10 V						○	○	○	○	
					30: Universal AO [U-AO] -						○	○	○	○	
					31-37: Custom Ao1-Ao7 [C-AO1 to C-AO7]						○	○	○	○	
					38: Input power [PWR-IN] 200%/10 V						○	○	○	○	
					39: Magnetic pole position signal [SMP] TOP/5 V						×	×	×	○	
					40: PID output value [PID-OUT] ±200%/±10 V						○	○	○	○	
E70	146h	h	AO2 Function selection	1	0 to 40 (Refer to Terminal [Ao1] function.)	○	6	○	○	60	○	○	○	○	
E71	147h	h	AO3 Function selection	1	0 to 40 (Refer to Terminal [Ao1] function.)	○	3	○	○	60	○	○	○	○	
E72	148h	h	AO4 Function selection	1	0 to 40 (Refer to Terminal [Ao1] function.)	○	0	○	○	60	○	○	○	○	
E73	149h	h	AO5 Function selection	1	0 to 40 (Refer to Terminal [Ao1] function.)	○	0	○	○	60	○	○	○	○	
E74	14Ah	h	AO1 Gain	5	-100.00 to 100.00 times	○	1.00	○	○	7	○	○	○	○	
E75	14Bh	h	AO2 Gain	1	-100.00 to 100.00 times	○	1.00	○	○	7	○	○	○	○	
E76	14Ch	h	AO3 Gain	1	-100.00 to 100.00 times	○	1.00	○	○	7	○	○	○	○	
E77	14Dh	h	AO4 Gain	1	-100.00 to 100.00 times (displayed when AIO option is installed)	○	1.00	○	○	7	○	○	○	○	
E78	14Eh	h	AO5 Gain	1	-100.00 to 100.00 times (displayed when AIO option is installed)	○	1.00	○	○	7	○	○	○	○	
E79	14Fh	h	AO1 Bias	5	-100.0 to 100.0%	○	0.0	○	○	6	○	○	○	○	
E80	150h	h	AO2 Bias	1	-100.0 to 100.0%	○	0.0	○	○	6	○	○	○	○	
E81	151h	h	AO3 Bias	1	-100.0 to 100.0%	○	0.0	○	○	6	○	○	○	○	
E82	152h	h	AO4 Bias	1	-100.0 to 100.0% (displayed when AIO option is installed)	○	0.0	○	○	6	○	○	○	○	
E83	153h	h	AO5 Bias	1	-100.0 to 100.0% (displayed when AIO option is installed)	○	0.0	○	○	6	○	○	○	○	
E84	154h	h	AO1-5 Filter	0	0.000 to 0.500 s	○	0.010	○	○	4	○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
E90	15Ah	h	Link command function selection 1 (To be supported soon)	2	00 to 13	○	0	○	○	231					
					00: Input signal cut off [OFF]						○	○	○	○	
					01: Speed auxiliary setting 1 [AUX-N1]						○	○	○	○	
					02: Speed auxiliary setting 2 [AUX-N2]						○	○	○	○	
					03: Torque bias [TB-REF]						○	○	×	○	
					04: When UP/DOWN is set, creep speed 1 [CRP-N1]						○	○	○	○	
					05: When UP/DOWN is set, creep speed 2 [CRP-N2]						○	○	○	○	
					06: Line speed detection [LINE-N]						○	○	○	○	
					07: Motor temperature [M-TMP]						○	○	○	○	
					08: Speed override [N-OR]						○	○	○	○	
					09: Amount of PID feedback 1 [PID-FB1]						○	○	○	○	
					10: Amount of PID commands [PID-REF]						○	○	○	○	
					11: PID correction gain [PID-G]						○	○	○	○	
					12: Amount of PID feedback 2 [PID-FB2]						○	○	○	○	
					13: Observer torque FB [OBS-TFB]						○	○	×	○	
E91	15Bh	h	Link command function selection 2 (To be supported soon)	1	00 to 12 When E91 is except 0 [OFF], analog setting via the communications link (S17) has priority over Ai input specified by Ai function selection. (Refer to the Link command function selection 1.)	○	0	○	○	231	○	○	○	○	
E101	1E01h	h	Ai1 Offset	4	-100.00 to 100.00%	○	0.00	○	○	7	○	○	○	○	
E102	1E02h	h	Ai2 Offset	1	-100.00 to 100.00%	○	0.00	○	○	7	○	○	○	○	
E103	1E03h	h	Ai3 Offset	1	-100.00 to 100.00% (displayed when AIO option is installed)	○	0.00	○	○	7	○	○	○	○	
E104	1E04h	h	Ai4 Offset	1	-100.00 to 100.00% (displayed when AIO option is installed)	○	0.00	○	○	7	○	○	○	○	
E105	1E05h	h	Ai1 Dead zone	4	0.00 to 10.00% Limits all command values below input values to 0 V.	○	0.00	○	○	3	○	○	○	○	
E106	1E06h	h	Ai2 Dead zone	1	0.00 to 10.00%	○	0.00	○	○	3	○	○	○	○	
E107	1E07h	h	Ai3 Dead one	1	0.00 to 10.00% (displayed when AIO option is installed)	○	0.00	○	○	3	○	○	○	○	
E108	1E08h	h	Ai4 Dead zone	1	0.00 to 10.00% (displayed when AIO option is installed)	○	0.00	○	○	3	○	○	○	○	
E109	1E09h	h	Dividing ratio for FA, FB pulse output (Numerator)	2	1 to 65535 Specifies numerator of the dividing ratio for FA, FB, and pulse output.	×	1000	○	○	0	○	×	×	○	
E110	1E0Ah	h	Dividing ratio for FA, FB pulse output (Denominator)	1	1 to 65535 Specifies the denominator of the dividing ratio for FA and FB pulse output.	×	1000	○	○	0	○	×	×	○	
E114	1E0Eh	h	Speed agreement 2 (Detection width)	4	1.0 to 20.0% If N-FB2± (Detected speed 2) is within the range of N-REF4 (Speed setting 4) ± detection width, the inverter issues the speed agreement signal N-AG2.	○	3.0	○	○	2	○	○	×	○	
E115	1E0Fh	h	Speed agreement 2 (Off delay timer)	1	0.000 to 5.000 s Specifies the off-delay timer of the speed agreement signal N-AG2.	○	0.100	○	○	4	○	○	×	○	
E116	1E10h	h	Speed agreement 3 (Detection width)	1	1.0 to 20.0% If N-FB2± (Detected speed 2) is within the range of N-REF4 (Speed setting 4) ± detection width, the inverter issues the speed agreement signal N-AG3.	○	3.0	○	○	2	○	○	×	○	
E117	1E11h	h	Speed agreement 3 (Off delay timer)	1	0.000 to 5.000 s Specifies the off-delay timer of the speed agreement signal N-AG3.	○	0.100	○	○	4	○	○	×	○	
E118	1E12h	h	Temperature for axial fan stop signal	0	0 to 200°C If the NTC detection temperature of the motor having an NTC thermistor drops below this setting value, the inverter turns ON the axial fan (Motor cooling fan) stop signal MFAN.	○	0	○	○	0	○	○	○	○	

■ Control functions (C: Control Functions)

Function codes	Communications address: 485 No.	Communications address: Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable: PG	LES	VF	SM	Remarks
C01	201h	h	Jump speed 1	4	0 to 30000 r/min Enables the inverter to jump over a point on the reference speed in order to skip a resonance point of the driven machinery (load) and the motor speed. Up to three different jump points can be specified.	○	0	○	○	0	○	○	○	○	
C02	202h	h	Jump speed 2	1	0 to 30000 r/min	○	0	○	○	0	○	○	○	○	
C03	203h	h	Jump speed 3	1	0 to 30000 r/min	○	0	○	○	0	○	○	○	○	
C04	204h	h	Jump width	1	0 to 1000 r/min	○	0	○	○	0	○	○	○	○	
C05	205h	9Eh	Multistep speed 1	17	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21) Multistep speeds 1 to 15 can be switched by turning terminal commands SS1, SS2, SS4 and SS8 ON/OFF.	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C06	206h	9Fh	Multistep speed 2	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C07	207h	A0h	Multistep speed 3	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C08	208h	A1h	Multistep speed 4	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C09	209h	A2h	Multistep speed 5	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C10	20Ah	A3h	Multistep speed 6	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C11	20Bh	A4h	Multistep speed 7	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C12	20Ch	h	Multistep speed 8	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C13	20Dh	h	Multistep speed 9	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C14	20Eh	h	Multistep speed 10	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C15	20Fh	h	Multistep speed 11	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C16	210h	h	Multistep speed 12	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C17	211h	h	Multistep speed 13	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C18	212h	h	Multistep speed 14/Creeping speed 1	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21) C18 and C19 apply also to the creep speed under UP/DOWN control.	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C19	213h	h	Multistep speed 15/Creeping speed 2	1	0 to 30000 r/min / 0.00 to 100.00% / 0.0 to 999.9 m/min (switch with C21)	○	0/0.00/ 0.0	○	○	0	○	○	○	○	
C20	214h	h	Multistep speed agreement timer	1	0.000 to 0.100 s When SS1, SS2, SS4 and SS8 are kept at the same status for the duration specified by this function code, the inverter switches the speed setting value.	○	0.000	○	○	4	○	○	○	○	
C21	215h	h	Multistep speed setting definition	1	0 to 2 0: 0 to 30000 r/min 1: 0.00 to 100.00% 2: 0.0 to 999.9 m/min Defines the unit of multistep speed specified by C05 to C19. When C21 = 1, the percentage of the maximum speed (F03/A06/A106) of the selected motor applies.	×	0	○	○	93	○	○	○	○	
C25	219h	h	Speed setting N2	0	0 to 9 0: Keypad (∧/∨ keys) 1: Analog 12 input (0 to ±10 V) 2: Analog 12 input (0 to +10 V) 3: UP/DOWN (initial value 0) 4: UP/DOWN (initial value: previous value) 5: UP/DOWN (initial value: creep velocity 1, 2) 6: DIA card input 7: DIB card input 8: Ai (N-REFV) input 9: Ai2 (N-REFC) input The speed command specified by this function code takes effect when X terminal function N2/N1 is turned ON.	×	0	○	○	41	○	○	○	○	
C29	21Dh	h	Jogging speed	0	0 to 30000 r/min Specifies the speed to be applied when the motor jogs.	○	50	○	○	0	○	○	○	○	
C30	21Eh	h	ASR-P (Gain) JOG	9	0.1 to 500.0 times	○	10.0	○	○	2	○	○	×	○	
C31	21Fh	h	ASR-I (Integral constant) JOG	1	0.000 to 10.000 s P control when set to 0.000	○	0.200	○	○	4	○	○	×	○	
C32	220h	h	ASR-JOG (Input filter)	1	0.000 to 5.000 s	○	0.040	○	○	4	○	○	○	○	
C33	221h	h	ASR-JOG (Detection filter)	1	0.000 to 0.100 s	○	0.005	○	○	4	○	○	×	○	
C34	222h	h	ASR-JOG (Output filter)	1	0.000 to 0.100 s	×	0.002	○	○	4	○	○	×	○	
C35	223h	h	Acceleration time JOG	1	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
C36	224h	h	Deceleration time JOG	1	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
C37	225h	h	S-curve JOG (Start side)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
C38	226h	h	S-curve JOG (End side)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
C40	228h	h	ASR2-P (Gain)	10	0.1 to 500.0 times	○	10.0	○	○	2	○	○	×	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
C41	229h	h	ASR2-I (Integral constant)	1	0.000 to 10.000 s P control when set to 0.000	○	0.200	○	○	4	○	○	×	○	
C42	22Ah	h	ASR2-FF (Gain)	1	0.000 to 9.999 s	○	0.000	○	○	4	○	○	×	○	
C43	22Bh	h	ASR2 Input filter	1	0.000 to 5.000 s	○	0.040	○	○	4	○	○	○	○	
C44	22Ch	h	ASR2 Detection filter	1	0.000 to 0.100 s	○	0.005	○	○	4	○	○	×	○	
C45	22Dh	h	ASR2 Output filter	1	0.000 to 0.100 s	×	0.002	○	○	4	○	○	×	○	
C46	22Eh	h	Acceleration time 2	1	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
C47	22Fh	h	Deceleration time 2	1	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
C48	230h	h	S-curve 2 (Start side)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
C49	231h	h	S-curve 2 (End side)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
C50	232h	h	ASR3-P (Gain)	10	0.1 to 500.0 times	○	10.0	○	○	2	○	○	×	○	
C51	233h	h	ASR3-I (Integral constant)	1	0.000 to 10.000 s P control when set to 0.000	○	0.200	○	○	4	○	○	×	○	
C52	234h	h	ASR3-FF (Gain)	1	0.000 to 9.999 s	○	0.000	○	○	4	○	○	×	○	
C53	235h	h	ASR3 Input filter	1	0.000 to 5.000 s	○	0.040	○	○	4	○	○	○	○	
C54	236h	h	ASR3 Detection filter	1	0.000 to 0.100 s	○	0.005	○	○	4	○	○	×	○	
C55	237h	h	ASR3 Output filter	1	0.000 to 0.100 s	×	0.002	○	○	4	○	○	×	○	
C56	238h	h	Acceleration time 3	1	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
C57	239h	h	Deceleration time 3	1	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
C58	23Ah	h	S-curve 3 (Start side)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
C59	23Bh	h	S-curve 3 (End side)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
C60	23Ch	h	ASR4-P (Gain)	10	0.1 to 500.0 times	○	10.0	○	○	2	○	○	×	○	
C61	23Dh	h	ASR4-I (Integral constant)	1	0.000 to 10.000 s P control when set to 0.000	○	0.200	○	○	4	○	○	×	○	
C62	23Eh	h	ASR4-FF (Gain)	1	0.000 to 9.999 s	○	0.000	○	○	4	○	○	×	○	
C63	23Fh	h	ASR4 Input filter	1	0.000 to 5.000 s	○	0.040	○	○	4	○	○	○	○	
C64	240h	h	ASR4 Detection filter	1	0.000 to 0.100 s	○	0.005	○	○	4	○	○	×	○	
C65	241h	h	ASR4 Output filter	1	0.000 to 0.100 s	×	0.002	○	○	4	○	○	×	○	
C66	242h	h	Acceleration time 4	1	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
C67	243h	h	Deceleration time 4	1	0.01 to 99.99 s 100.0 to 999.9 s 1000 to 3600 s	○	5.00	○	○	13	○	○	○	○	
C68	244h	h	S-curve 4 (Start side)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
C69	245h	h	S-curve 4 (End side)	1	0 to 50%	○	0	○	○	0	○	○	○	○	
C70	246h	h	ASR Switching time	0	0.00 to 2.55 s	○	1.00	○	○	3	○	○	×	○	
C71	247h	A5h	Acceleration/deceleration time switching speed	0	0.00 to 100.00%	○	0.00	○	○	3	○	○	○	○	
C72	248h	A6h	ASR Switching speed	0	0.00 to 100.00%	○	0.00	○	○	3	○	○	×	○	
C73	249h	h	Creep speed switching (under UP/DOWN control)	0	00 to 11 (Creep speed 1) (Creep speed 2) 0: Code (C18, C19) 1: Ai (CRP1, CRP2)	×	00	○	○	9	○	○	○	○	

■ Motor parameter functions M1 (P: Motor Parameter Functions)

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
P01	301h	h	M1 Drive control	0	0 to 5 0: Vector control (Induction motor) 1: Sensor-less vector control (Induction motor) 2: Simulated operation mode 3: Vector control (PMSM) 4: - 5: V/f control (Induction motor)	×	0	○	×	55	○	○	○	○	
P02	302h	h	M1 Motor selection	26	0 to 50 Display (kW, HP) changes by setting F60 = 0, 1. 00 to 35: FRENIC-VG dedicated motor setup Data at F04, F05, and P03 to P27 are automatically set. Data at F04, F05, and P03 to P27 are automatically set and write-protected. 36: P-OTHER (keypad display is P-OTR) Data at F04, F05, and P03 to P27 are write-protected and cannot be overwritten. Data at F04, F05, and P03 to P27 are automatically set and write-protected. 37: OTHER Data at F04, F05, and P03 to P27 are write-protected and cannot be overwritten. Write protection of F04, F05, and P03 to P27 is not performed. 38 to 50: FRENIC-VG dedicated setup (type 8) Data at F04, F05, and P03 to P27 are automatically set. Data at F04, F05, and P03 to P27 are automatically set and write-protected. For the relationship between the setting data and the motor type, refer to "List of applicable motors" in Section 4.3.3.2, [82] codes.	×	Depends on capacity	○	×	82	○	○	○	○	
P03	303h	A7h	M1 Rated capacity	1	For inverters of 400 kW or less 0.00 to 500.00 kW when F60 = 0 0.00 to 600.00 HP when F60 = 1 For inverters of 500 kW or more 0.00 to 1200 kW when F60 = 0 0.00 to 1600 HP when F60 = 1 For multiwinding motors, set the motor capacity per wiring.	×	Depends on capacity	○	×	3 13	○	○	○	○	
P04	304h	A8h	M1 Rated current	1	0.01 to 99.99A 100.0 to 999.9A 1000 to 2000A	×	Depends on capacity	○	×	13	○	○	○	○	
P05	305h	A9h	M1 Number of poles	1	2 to 100 poles	×	4	○	×	1	○	○	○	○	
P06	306h	AAh	M1 %R1	1	0.00 to 30.00%	○	Depends on capacity	○	×	3	○	○	○	○	
P07	307h	ABh	M1 %X	1	0.00 to 200.00%	○	Depends on capacity	○	×	3	○	○	○	○	
P08	308h	ACh	M1 Exciting current/Magnetic flux weakening current (-Id)	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	○	Depends on capacity	○	×	13	○	○	○	○	
P09	309h	ADh	M1 Torque current	1	0.01 to 99.99A 100.0 to 999.9A 1000 to 2000A	○	Depends on capacity	○	×	13	○	○	×	○	
P10	30Ah	AEh	M1 Slip frequency (For driving)	1	0.001 to 10.000 Hz	○	Depends on capacity	○	×	4	○	○	×	×	
P11	30Bh	AFh	M1 Slip frequency (For braking)	1	0.001 to 10.000 Hz	○	Depends on capacity	○	×	4	○	○	×	×	
P12	30Ch	B0h	M1 Iron loss factor 1	1	0.00 to 10.00%	○	Depends on capacity	○	×	3	○	○	×	○	
P13	30Dh	B1h	M1 Iron loss factor 2	1	0.00 to 10.00%	○	Depends on capacity	○	×	3	○	○	×	○	
P14	30Eh	B2h	M1 Iron loss factor 3	1	0.00 to 10.00%	○	Depends on capacity	○	×	3	○	○	×	○	
P15	30Fh	B3h	M1 Magnetic saturation factor 1	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 93.75%.	○	Depends on capacity	○	×	2	○	○	×	×	
P16	310h	B4h	M1 Magnetic saturation factor 2	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 87.5%.	○	Depends on capacity	○	×	2	○	○	×	×	
P17	311h	B5h	M1 Magnetic saturation factor 3	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 75%.	○	Depends on capacity	○	×	2	○	○	×	×	
P18	312h	B6h	M1 Magnetic saturation factor 4	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 62.5%.	○	Depends on capacity	○	×	2	○	○	×	×	
P19	313h	B7h	M1 Magnetic saturation factor 5	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 50%.	○	Depends on capacity	○	×	2	○	○	×	×	
P20	314h	B8h	M1 Secondary time constant	1	0.001 to 9.999 s	○	Depends on capacity	○	×	4	○	○	×	×	
P21	315h	B9h	M1 Induced voltage factor	1	0 to 999 V	○	Depends on capacity	○	×	0	○	○	×	○	
P22	316h	BAh	M1 R2 Correction factor 1	1	0.500 to 5.000	○	Depends on capacity	○	×	4	○	○	×	○	
P23	317h	BBh	M1 R2 Correction factor 2	1	0.500 to 5.000	○	Depends on capacity	○	×	4	○	○	×	×	
P24	318h	BCh	M1 R2 Correction factor 3	1	0.010 to 5.000	○	Depends on capacity	○	×	4	○	○	×	×	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
P25	319h	BDh	M1 Exciting current correction factor	1	0.000 to 5.000	○	Depends on capacity	○	×	4	○	○	×	×	
P26	31Ah	BEh	M1 ACR-P (Gain)	1	0.1 to 20.0	○	1.0	○	×	2	○	○	×	○	
P27	31Bh	BFh	M1 ACR-I (I-time)	1	0.1 to 100.0 ms	○	1.0	○	×	2	○	○	×	○	
P28	31Ch	C0h	M1 PG Pulse resolution	0	100 to 60000 * Set P28 to 32768 when using the option card OPC-VG1-SPGT.	×	1024	○	×	0	○	×	×	○	
P29	31Dh	D6h	M1 External PG correction factor	0	0000 to 4FFF	×	4000	○	×	9	○	×	×	○	
P30	31Eh	C1h	M1 Thermistor selection	0	0 to 3 0: No thermistor 1: NTC thermistor selected 2: PTC thermistor selected 3: Ai [M-TMP] The protection level of the motor protective functions should be specified by E30 to E32.	×	1	○	×	84	○	○	○	○	
P32	320h	h	M1 Online Auto tuning	0	0 to 1 0: Disable 1: Enable Selects the compensation function for the resistance change caused by the temperature rise of the motor running.	○	0	○	×	0	○	○	×	×	
P33	321h	h	M1 Maximum output voltage/Maximum voltage limit value	0	80 to 999 V	×	220/ 440	○	×	0	×	×	○	○	
P34	322h	h	M1 Slip compensation	3	-20.000 to 5.000 Hz	○	0.000	○	×	8	×	×	○	×	
P35	323h	h	M1 Torque boost	1	0.0 to 20.0 Function specific to V/f control. The following selections are possible. 0.0: Automatic torque boost (for fixed torque characteristic load) 0.1 to 0.9: For squared torque characteristic load 1.0 to 1.9: For proportional torque characteristic load 2.0 to 20.0: For fixed torque characteristic load	○	0.0	○	×	2	×	×	○	×	
P36	324h	h	M1 Current fluctuation damping gain	1	0.00 to 1.00	○	0.20	○	×	3	×	×	○	×	
P42	32Ah	h	M1 q axis inductance magnetic saturation coefficient	10	0.0 to 100.0%	○	100.0	○	×	2	×	×	×	○	
P43	32Bh	h	M1 Magnetic flux limiting value	1	50.0 to 150.0%	○	Depends on capacity	○	×	2	×	×	×	○	
P44	32Ch	h	M1 Overcurrent protection level	1	0.00: No operation 0.01 to 99.99A 100.0 to 999.9A 1000 to 2000A Specifies the allowable current value to prevent the permanent magnet of a PMSM from getting demagnetized. If the current exceeding this setting value flows, an overcurrent alarm (OC) occurs.	×	0.00	○	×	13	×	×	×	○	
P45	32Dh	h	M1 Torque correction gain 1	1	0.00 to 10.00	○	Depends on capacity	○	×	3	×	×	×	○	
P46	32Eh	h	M1 Torque correction gain 2	1	0.00 to 10.00	○	Depends on capacity	○	×	3	×	×	×	○	
P47	32Fh	h	M1 Torque correction gain 3	1	-1.000 to 1.000	○	Depends on capacity	○	×	8	×	×	×	○	
P48	330h	h	M1 Torque correction gain 4	1	-1.000 to 1.000	○	Depends on capacity	○	×	8	×	×	×	○	
P49	331h	h	M1 Torque correction gain 5	1	-50.00 to 50.00	○	Depends on capacity	○	×	7	×	×	×	○	
P50	332h	h	M1 Torque correction gain 6	1	-50.00 to 50.00	○	Depends on capacity	○	×	7	×	×	×	○	
P51	333h	h	M1 Torque correction gain 7	1	-1.000 to 1.000	○	Depends on capacity	○	×	8	×	×	×	○	

■ High performance functions (H: High Performance Functions)

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
H01	401h	h	Tuning operation selection	0	0 to 4 0: No operation	×	0	×	×	61	○	○	○	○	
					1: ASR auto tuning (To be supported soon)						○	○	×	○	
					2: Motor constant auto tuning: R1, Lσ						○	○	○	×	
					3: Motor stop auto tuning						○	○	○	×	
					4: Motor rotation auto tuning After writing the data, this function's data code automatically returns to 0. To save the tuned data, perform the Full save function (H02).						○	○	○	×	
H02	402h	Eh	Full save function	0	0 to 1 When auto tuning is executed at H01, or when the data is written by way of the link system (T-Link, field bus, and RS-485, etc.), the data goes out when the power supply of the inverter is turned off. This function must operate when preservation is necessary. After writing the data, this function's data code automatically returns to 0.	○	0	×	×	11	○	○	○	○	
H03	403h	h	Data initialization	0	0 to 1 Setting H03 to "1" reverts the function code data modified by the customer to the factory defaults. Initialization targets include all fields of F, E, C, H, o, L and U codes except motor parameter fields (P, A) and F04, F05, F10 to F12, and F58. Upon completion of the initialization, the H03 data automatically reverts to "0."	×	0	×	×	11	○	○	○	○	
H04	404h	h	Auto-reset (Times)	0	0 to 10 0: No operation 1 to 10 times The auto-resetting signal can be output to the output terminal.	×	0	○	○	0	○	○	○	○	
H05	405h	h	Auto-reset (Reset interval)	0	0.01 to 20.00 s	×	5.00	○	○	3	○	○	○	○	
H06	406h	h	Cooling fan ON/OFF control	0	0 to 1 0: No operation 1: Operation It is possible to output the FAN (cooling fan in operation) signal in conjunction with this function. This control detects the temperature of the heat sink in the inverter unit and turns the cooling fan ON/OFF automatically.	×	0	○	○	68	○	○	○	○	
H08	408h	h	Rev. phase sequence lock	0	0 to 1 0: Disable 1: Enable	○	0	○	○	68	○	○	×	○	
H09	409h	C2h	Starting mode (Auto search)	0	0 to 2 0: No operation 1: Operation (only when restarting from momentary power failure) 2: Operation Auto search detects the idling motor speed at starting and drives the motor at the same speed.	○	2	○	○	0	×	○	○	×	
H10	40Ah	C3h	Energy-saving operation	0	0 to 1 0: Disable 1: Enable	×	0	○	○	68	○	×	×	×	
H11	40Bh	h	Automatic operation OFF function	0	0 to 4 0: Decelerate to stop when OFF between FWD-CM and REV-CM 1: Operation OFF when below stop speed in F37 even if ON between FWD-CM and REV-CM 2: Coast to a stop when OFF between FWD-CM and REV-CM 3: ASR deceleration to stop when OFF between FWD-CM and REV-CM (under torque control) 4: Coast to a stop when OFF between FWD-CM and REV-CM (under torque control)	○	0	○	○	0	○	○	○	○	
H13	40Dh	C4h	Restart mode after momentary power failure setting (Wait time)	5	0.1 to 5.0 s	×	0.5	○	○	2	○	○	○	○	
H14	40Eh	h	Momentary power failure restart setting (Speed reduction rate)	1	1 to 3600 r/min/s	○	500	○	○	0	×	×	○	×	
H15	40Fh	h	Momentary power failure restart setting (Operation continuation level)	1	3-phase 200 V: 200 to 300 V 3-phase 400 V: 400 to 600 V This setting applies when F14 (Operation selection) = 2 (Trip after recovery from power failure) or F14 = 3 (Continue to run).	○	235/ 470	○	○	0	○	○	○	○	
H16	410h	h	Momentary power failure restart setting (Self-holding specification of operation command)	1	0 to 1 0: Specified in H17 1: Max. time (operating commands are retained by the inverter while the control power supply is established inside the inverter, or while the DC intermediate circuit voltage is approximately zero)	×	1	○	○	94	○	○	○	○	
H17	411h	h	Momentary power failure restart setting (Self-holding time in operation command)	1	0.0 to 30.0 s	×	30.0	○	○	2	○	○	○	○	
H19	413h	C5h	Active drive	0	0 to 1 0: Disable 1: Enable Under vector control, this function automatically limits the output torque to avoid an overload trip, etc.	×	0	○	○	68	○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
H20	414h	C6h	PID Control (Operation selection)	8	0 to 3 0: No operation 1: Operation 2: Reverse operation 1 3: Reverse operation 2	×	0	○	○	69	○	○	○	○	
H21	415h	C7h	PID Control (Command selection)	1	0 to 1 0: Keypad or 12 input 1: Analog input [PID-REF]	○	0	○	○	70	○	○	○	○	
H22	416h	C9h	PID Control (P-action)	1	0.000 to 10.000 times	○	1.000	○	○	4	○	○	○	○	
H23	417h	CAh	PID Control (I-action)	1	0.00 to 100.00 s	○	1.00	○	○	3	○	○	○	○	
H24	418h	CBh	PID Control (D-action)	1	0.000 to 10.000 s	○	0.000	○	○	4	○	○	○	○	
H25	419h	C8h	PID Control (Upper limit value)	1	-300 to 300%	×	100	○	○	5	○	○	○	○	
H26	41Ah	CCh	PID Control (Lower limit value)	1	-300 to 300%	×	-100	○	○	5	○	○	○	○	
H27	41Bh	CEh	PID Control (Speed command selection)	1	0 to 2 0: Disable 1: PID selection 2: Speed adjustment selection	×	0	○	○	95	○	○	○	○	
H28	41Ch	CFh	Droop control	0	0.0 to 25.0%	○	0.0	○	○	2	○	○	×	○	
H29	41Dh	h	Link function (Code protection)	2	0 to 1 0: Writing code from link allowed 1: Write-protects code from link Setting H29 to "1" protects function code data from getting changed mistakenly via the link (T-Link, RS-485, etc.). Via the link, data can be written to the "normal code fields" (given above) or "command data fields" (S fields). The S fields are defined by H30.	○	0	○	○	40	○	○	○	○	
H30	41Eh	D0h	Link function (Linked operation)	1	0 to 3 Monitor / Command data / Operation (FWD, REV) 0: ○ × × 1: ○ ○ × 2: ○ × ○ 3: ○ ○ ○	○	0	○	○	72	○	○	○	○	
H31	41Fh	h	RS-485 Setup (Station address)	10	0 to 255 Broadcast: 0: RTU), (99: Fuji) address: 1 to 255 Specifies the station address of RS-485.	×	1	○	×	0	○	○	○	○	
H32	420h	h	RS-485 Setup (Selection of operation when error occurs)	1	0 to 3 0: Forced stop (Er5) 1: Stop after continuing operation for timer operating time (H33) (Er5) 2: Stop if transmission failure continues longer than timer operating time (H33) (Er5) 3: Continue operation	○	3	○	○	73	○	○	○	○	
H33	421h	h	RS-485 Setup (Timer operating time)	1	0.01 to 20.00 s	○	2.00	○	○	3	○	○	○	○	
H34	422h	h	RS-485 Setup (Transmission speed)	1	0 to 4 0: 38400bps 1: 19200bps 2: 9600bps 3: 4800bps 4: 2400bps	○	0	○	×	74	○	○	○	○	
H35	423h	h	RS-485 Setup (Data length)	1	0 to 1 0: 8bit 1: 7bit	○	0	○	×	75	○	○	○	○	
H36	424h	h	RS-485 Setup (Selection of parity bit)	1	0 to 2 0: None 1: Even parity 2: Odd parity	○	1	○	×	76	○	○	○	○	
H37	425h	h	RS-485 Setup (Selection of stop bit)	1	0 to 1 0: 2bit 1: 1bit	○	1	○	×	77	○	○	○	○	
H38	426h	h	RS-485 Setup (Communication interrupt time)	1	0.0 to 60.0 s 0.0: Interrupt detection disable 0.1 to 60.0: Interrupt detection enable	○	60.0	○	○	2	○	○	○	○	
H39	427h	h	RS-485 Setup (Response interval time)	1	0.00 to 1.00 s	○	0.01	○	○	3	○	○	○	○	
H40	428h	h	RS-485 Setup (Protocol selection)	1	0 to 2 0: Fuji general purpose inverter protocol 1: SX protocol (Loader protocol) 2: Modbus RTU protocol When using FRENIC-VG loader, specify “1: SX protocol”.	×	1	○	×	78	○	○	○	○	
H41	429h	D1h	Torque command selection	4	0 to 5 0: Internal ASR enable 1: Ai (T-REF) enable 2: DIA card enable 3: DIB card enable 4: Link enable 5: PID enable	×	0	○	○	64	○	○	×	○	
H42	42Ah	D2h	Torque current command selection	1	0 to 4 0: Internal ASR enable 1: Ai (IT-REF) enable 2: DIA card enable 3: DIB card enable 4: Link enable	×	0	○	○	65	○	○	×	○	
H43	42Bh	D3h	Magnetic flux command selection	1	0 to 3 0: Internal calculation enable 1: Ai (MF-REF) enable 2: Function code H44 enable 3: Link enable	×	0	○	○	66	○	×	×	×	
H44	42Ch	D4h	Magnetic-flux command value	1	10 to 100%	×	100	○	○	16	○	×	×	×	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
H46	42Eh	D7h	Observer (Mode selection)	7	0 to 2 0: Observer not operational 1: Load disturbance observer 2: Oscillation suppression observer	×	0	○	○	79	○	○	×	○	
H47	42Fh	D8h	Observer (M1 Compensation gain)	1	0.00 to 1.00 times	○	0.00	○	○	3	○	○	×	○	
H48	430h	h	Observer (M2 Compensation gain)	1	0.00 to 1.00 times	○	0.00	○	○	3	○	○	×	○	
H49	431h	D9h	Observer (M1 I-time)	1	0.005 to 1.000 s	○	0.100	○	○	4	○	○	×	○	
H50	432h	h	Observer (M2 I-time)	1	0.005 to 1.000 s	○	0.100	○	○	4	○	○	×	○	
H51	433h	DAh	Observer (M1 load inertia)	1	0.001 to 50.000 kg･m^2 The magnification is switchable by H228.	○	Depends on capacity	○	×	4	○	○	×	○	
H52	434h	h	Observer (M2 load inertia)	1	0.001 to 50.000 kg･m^2 The magnification is switchable by H228.	○	0.001	○	×	4	○	○	×	○	
H53	435h	D5h	Line speed feedback selection	0	0 to 3 0: Line speed disable (internal PG enable) However, higher value is selected between Ai input and PG (LD) on UPAC. 1: Analog line speed detect (AI-LINE) 2: Digital line speed detect (PG (LD)) 3: High selector (selects the higher level between motor speed and line speed)	○	0	○	○	67	○	○	○	○	
H55	437h	h	Zero speed control (Gain)	2	0 to 100 times For details, refer to terminal X function LOCK assigned by any of E01 to E13.	○	5	○	○	0	○	×	×	○	
H56	438h	h	Zero speed control (Completion range)	1	0 to 100 pulses	○	100	○	○	0	○	×	×	○	
H57	439h	h	Overvoltage suppression	2	0 to 1 0: No operation 1: Operation	×	0	○	○	68	○	○	○	○	
H58	43Ah	h	Overcurrent suppression	1	0 to 1 0: No operation 1: Operation	×	0	○	○	68	○	○	○	○	
H60	43Ch	h	Load weighting control (Definition 1 of load weighting control function)	7	0 to 3 0: Disable 1: Method 1 2: Method 2 3: Method 3	×	0	○	○	80	○	×	×	○	
H61	43Dh	h	Load weighting control (Definition 2 of load weighting control function)	1	0 to 1 0: Hoisting with motor rotating normally 1: Lowering with motor rotating normally	×	0	○	○	81	○	×	×	○	
H62	43Eh	h	Load weighting control (Hoisting speed)	1	0.0 to 999.9 m/min	×	0.0	○	○	2	○	×	×	○	
H63	43Fh	h	Load weighting control (Counter weight mass)	1	0.00 to 600.00 t	×	0.00	○	○	3	○	×	×	○	
H64	440h	h	Load weighting control (Safety factor)	1	0.50 to 1.20	×	1.00	○	○	3	○	×	×	○	
H65	441h	h	Load weighting control (Machine efficiency)	1	0.500 to 1.000	×	0.500	○	○	4	○	×	×	○	
H66	442h	h	Load weighting control (Rated load)	1	0.00 to 600.00 t	×	0.00	○	○	3	○	×	×	○	
H68	444h	h	Alarm data deletion	0	0 to 1 After writing the data, this function's data code automatically returns to 0. Setting H68 to "1" deletes all of the alarm history, alarm causes and alarm information held in the inverter memory.	○	0	×	×	11	○	○	○	○	
H70	446h	h	For manufacturer 1	2	0 to 9999 Reserved. (Do not access this function code.)	×	0	○	×	0	○	○	×	○	
H71	447h	h	For manufacturer 2	1	0 to 10 Reserved. (Do not access this function code.)	×	0	×	×	62	○	○	○	○	
H74	44Ah	h	PG detection circuit self-diagnosis selection	0	0 to 1 0: Disable 1: Enable This function activates the inverter's function for self-diagnosis of the speed detection circuit by PG (Pulse generator) signal input (PA, PB).	×	0	○	○	225	○	×	×	×	
H75	44Bh	h	Phase sequence configuration of main circuit output wires	0	0 to 1 0: Normal phase U-V-W 1: Reverse phase U-W-V Switches the phase sequence of the inverter main circuit.	×	0	○	○	197	○	○	○	×	
H76	44Ch	h	Main power down detection * Invalid for use in stack type	0	0 to 1 0: No operation 1: Operation Set this function to "Operation" to enable the AC power monitoring function. Set this function to "No operation" when DC power is supplied, e.g., connecting with a power regenerative converter but the inverter AC input power is not supplied.	○	0	○	○	0	○	○	○	○	
H77	44Dh	h	Cooling fan ON-OFF control continuation timer	0	0 to 600 s Specifies the condition of the cooling fan ON/OFF control by H06.	○	600	○	○	0	○	○	○	○	
H78	44Eh	h	Initialization of startup counter/total run time	6	0 to 6 0: No operation 1: M1 Number of startups 2: M2 Number of startups 3: M3 Number of startups 4: M1 Cumulative run time 5: M2 Cumulative run time 6: M3 Cumulative run time Initializes the number of startups and cumulative run time for each of M1 to M3.	×	0	×	×	0	○	○	○	○	

Function codes	Communications address 485 No.	Communications address Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable PG	LES	VF	SM	Remarks
H79	44Fh	h	Cooling fan operation cumulative time initialization setting	1	0 to 65535 (in units of 10 hours) Initializes the cumulative run time when the cooling fan is replaced. Usually, write "0" after replacement.	×	0	×	×	0	○	○	○	○	
H80	450h	h	Capacity of main circuit capacitor initial value measurement * Invalid for use in stack type	1	0 to 32767 When the capacitance measurement is user mode (H104), setting this function code to "0" and shutting down the inverter power starts measuring the initial value of the capacitance and writes the measurement result to this function code.	×	0	×	○	0	○	○	○	○	
H81	451h	h	Initialization of cumulative life of main circuit capacitor	1	0 to 65535 (in units of 10 hours) Initializes the elapsed time of the main circuit capacitor.	×	0	×	○	0	○	○	○	○	
H82	452h	h	Number of startups for maintenance	1	0 to 65535 Specifies the number of startups for performing maintenance of the machinery.	○	0	×	○	0	○	○	○	○	
H83	453h	h	Maintenance Interval	1	0 to 65535 (in units of 10 hours) Specifies the maintenance interval for performing maintenance of the machinery.	○	8760	×	○	0	○	○	○	○	
H84 *1	454h	h	Speed calculation period when extremely low speed (for maker)	0	0.0 to 200.0ms The sampling period setting of the encoder pulse in extremely low speed region. This is a function code for maker. Do not access this function code.	N	0.0	Y	Y	2	Y	N	N	Y	
H85	455h	h	Calendar clock (Year/month)	4	0000 to FFFF Upper 2 digits: Year, Lower 2 digits: Month	○	0001	×	○	143	○	○	○	○	
H86	456h	h	Calendar clock (Day/hour)	1	0000 to FFFF Upper 2 digits: Day, Lower 2 digits: Hour	○	0100	×	○	144	○	○	○	○	
H87	457h	h	Calendar clock (Minute/second)	1	0000 to FFFF Upper 2 digits: Minute, Lower 2 digits: Second	○	0000	×	○	145	○	○	○	○	
H88	458h	h	Calendar clock (Setting up clock)	1	0 to 1 0: No operation 1: Setting up clock Setting H88 to "1" sets up the calendar clock in accordance with the settings of H85 to H87. After that, the H88 data automatically reverts to "0."	○	0	×	×	11	○	○	○	○	
H90	45Ah	h	Overspeed alarm detection level	0	100 to 160%	○	120	○	○	0	○	○	×	○	
H96 *1	460h	h	ASR operation selecting	0	o to 3 0: P priority (VG1) 1: I priority (compatible with VM5) 2: P priority (compatible with VM5) 3: For maker (Do not select this)	N	0	Y	Y	201	Y	Y	N	Y	
H101	1F01h	h	PID command filter time constant	0	0 to 5000ms Specifies the time constant of the PID command filter (after switched by H21).	○	0	○	○	0	○	○	○	○	
H103	1F03h	h	Protective/Maintenance function selection 1 * Invalid for use in stack type ⇒	9	0000 to 1111 Selects the protective functions individually. [0: Disable, 1: Enable] Thousands digit: Start delay alarm (LOC) Hundreds digit: Ground fault alarm (EF) Tenths digit: Output phase loss alarm (OPL) Units digit: Braking transistor broken (dbA)	○	0101	○	○	9	○	○	○	○	
H104	1F04h	h	Protective/Maintenance function selection 2 * Invalid for use in stack type ⇒	1	0000 to 1111 Selects the protective/other functions individually. [0: Disable, 1: Enable] Thousands digit: PG wire break alarm (PG) Hundreds digit: Lower the carrier frequency Tenths digit: Judge the life of main circuit capacitor Units digit: Select capacitance measurement of main circuit (0: Referenced on factory default value, 1: Referenced on user measurement)	○	1110	○	○	9	○	○	○	○	
H105	1F05h	h	Protective/Maintenance Function Selection 3	1	0000 to 1111 Selects the protective/maintenance functions individually. (0: Disable, 1: Enable) Thousands digit: -- Hundreds digit: Speed disaccord alarm Er9 operation 1 *1 Tenths digit: Speed disaccord alarm Er9 operation 2 *1 Units digit: Save the integrated value of motor electronic thermal	○	0000	○	○	9	○	○	○	○	
H106	1F06h	h	Light alarm object definition 1	1	0000 to 1111 [0: Heavy alarm (Err), 1: Light alarm (L-AL)] Digit of 1000: OH4 "motor overheat" Digit of 100: OL1-OL3 "motor overload" (common for M1-M3) Digit of 10: nrb "NTC thermistor disconnected" Digit of 1: OH2 "external failure"	○	0000	○	○	9	○	○	○	○	
H107	1F07h	h	Light alarm object definition 2	1	0000 to 1111 [0: Heavy alarm (Err), 1: Light alarm (L-AL)] Digit of 1000: Er5 "RS-485 failure" Digit of 100: Er4 "network failure" Digit of 10: Reserved Digit of 1: ArF "toggle failure error"	○	0000	○	○	9	○	○	○	○	
H108	1F08h	h	Light alarm object definition 3	1	0000 to 1111 [0: Heavy alarm (Err), 1: Light alarm (L-AL)] Digit of 1000: Err "mock alarm" Digit of 100: dFA "DC fan lock" Digit of 10: Er9 "speed disagreement" LOC "Start delay" Digit of 1: ArE "E-SX bus tact synchronization error"	○	0000	○	○	9	○	○	○	○	

(*1) Available when ROM version is newer than H1/2 0067.

Function codes	Communications address: 485 No.	Communications address: Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable: PG	LES	VF	SM	Remarks
H109	1F09h	h	Light alarm object definition 4	1	0000 to 1111 [0: Heavy alarm (Er-r), 1: Light alarm (L-AL)] Digit of 1000: Reserved Digit of 100: Reserved Digit of 10: Reserved Digit of 1: Reserved	○	0000	○	○	9	○	○	○	○	
H110	1F0Ah	h	Light alarm object definition 5	1	0000 to 1111 [0: Light alarm cancel, 1: Light alarm (L-AL)] Digit of 1000: MOH "Motor overheat early warning" MOL "Motor overload early warning" Digit of 100: BaT "Battery life" Digit of 10: LiF "Life early warning" Digit of 1: OH/OL "Fin overheat early warning/Overload early warning"	○	0000	○	○	9	○	○	○	○	
H111	1F0Bh	h	Light alarm object definition 6	1	0 to 1 0: Disable (L-AL no indication) 1: Enable (L-AL indicated) Specifies whether or not to display L-AL on the LED monitor when a light alarm occurs.	○	1	○	○	68	○	○	○	○	
H112	1F0Ch	h	M1 Magnetic saturation extension coefficient 6	7	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 43.75%.	○	43.8	○	×	2	○	×	×	×	
H113	1F0Dh	h	M1 Magnetic saturation extension coefficient 7	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 37.5%.	○	37.5	○	×	2	○	×	×	×	
H114	1F0Eh	h	M1 Magnetic saturation extension coefficient 8	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 31.25%.	○	31.3	○	×	2	○	×	×	×	
H115	1F0Fh	h	M1 Magnetic saturation extension coefficient 9	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 25%.	○	25.0	○	×	2	○	×	×	×	
H116	1F10h	h	M1 Magnetic saturation extension coefficient 10	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 18.75%.	○	18.8	○	×	2	○	×	×	×	
H117	1F11h	h	M1 Magnetic saturation extension coefficient 11	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 12.5%.	○	12.5	○	×	2	○	×	×	×	
H118	1F12h	h	M1 Magnetic saturation extension coefficient 12	1	0.0 to 100.0% Compensation factor for exciting current when the magnetic flux command is 6.25%.	○	6.3	○	×	2	○	×	×	×	
H125	1F19h	h	Observer (M3 compensation gain)	3	0.00 to 1.00 times	○	0.00	○	○	3	○	○	×	○	
H126	1F1Ah	h	Observer (M3 I-time)	1	0.005 to 1.000 s	○	0.100	○	○	4	○	○	×	○	
H127	1F1Bh	h	Observer (M3 load inertia)	1	0.001 to 50.000 kg·m^2 The magnification is switchable by H228.	○	0.001	○	○	4	○	○	×	○	
H134	1F22h	h	Speed drop detection delay timer	5	0.000: No operation 0.001 to 10.000 s	×	0.000	○	○	4	○	○	×	○	
H135	1F23h	h	Speed command detection level (FWD)	1	0.0: No operation 0.1 to 150.0 r/min	×	0.0	○	○	2	○	○	×	○	
H136	1F24h	h	Speed command detection level (REV)	1	0.0: No operation 0.1 to 150.0 r/min	×	0.0	○	○	2	○	○	×	○	
H137	1F25h	h	Speed drop detection level	1	0.0: No operation 0.1 to 150.0 r/min	×	0.0	○	○	2	○	○	×	○	
H138	1F26h	h	Speed drop detection delay timer	1	0.000 to 10.000 s	×	0.000	○	○	4	○	○	×	○	
H140	1F28h	h	Start delay detection (Detection level)	2	0.0 to 300.0 %	○	150.0	○	○	2	○	○	×	○	
H141	1F29h	h	Start delay detection (Detection timer)	1	0.000 to 10.000 s	○	1.000	○	○	4	○	○	×	○	
H142	1F2Ah	h	Mock alarm	0	0 to 1 0: No operation 1: A mock alarm occurs When H108 does not define a mock alarm as a light alarm, a heavy alarm (Er-r) occurs; when it defines a mock alarm as a light alarm, a light alarm (L-AL) occurs. Depressing the STOP + FUNC/DATA keys on the keypad for 3 seconds will also cause the alarm.	○	0	×	×	11	○	○	○	○	
H144	1F2Ch	h	Toggle data error timer	0	0.01 to 20.00 s Specifies the toggle signal error detection time.	○	0.10	○	○	3	○	○	○	○	
H145	1F2Dh	h	Reverse rotation prevention for sensor-less control (Selection of lower limit frequency operation)	3	0 to 3 0: Disable 1: Enable for FWD polarity operation 2: Enable for REV polarity operation 3: Enable for both FWD/REV polarities	×	0	○	○	202	×	○	×	×	
H146	1F2Eh	h	Reverse rotation prevention for sensor-less control (Lower limit frequency (FWD))	1	0.000 to 10.000 Hz	×	0.000	○	○	4	×	○	×	×	
H147	1F2Fh	h	Reverse rotation prevention for sensor-less control (Lower limit frequency (REV))	1	0.000 to 10.000 Hz	×	0.000	○	○	4	×	○	×	×	
H148	1F30h	h	First order frequency filter	0	0 to 100 ms Increase this setting if the speed fluctuation is large under sensor-less vector control.	×	0	○	○	0	×	○	×	×	
H149	1F31h	h	Machine runaway detection speed setting	0	0.0 to 20.0% 0.0: Disable 0.1 to 20.0% Assuming the maximum speed as 100%.	×	0.0	○	○	2	○	○	×	○	
H160	1F3Ch	h	M1 Initial magnetic polarity position detection method	3	0 to 3 0: Pull-in by current for IPMSM (Interior Permanent Magnet Synchronous Motor) 1-3: -	×	0	○	×	0	×	×	×	○	
H161	1F3Dh	h	M1 Draw current command	1	10 to 200 % 100%/Motor rated current	×	80	○	×	0	×	×	×	○	
H162	1F3Eh	h	M1 Pull-in frequency	1	0.1 to 10.0 Hz	×	1.0	○	×	2	×	×	×	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
H170	1F46h	h	M2 Initial magnetic polarity position detection method	3	0 to 3 0: Pull-in by current for IPMSM (Interior Permanent Magnet Synchronous Motor) 1-3: -	×	0	○	×	0	×	×	×	○	
H171	1F47h	h	M2 Draw current command	1	10 to 200 % 100%/Motor rated current	×	80	○	×	0	×	×	×	○	
H172	1F48h	h	M2 Pull-in frequency	1	0.1 to 10.0 Hz	×	1.0	○	×	2	×	×	×	○	
H180	1F50h	h	M3 Initial magnetic polarity position detection method	3	0 to 3 0: Pull-in by current for IPMSM (Interior Permanent Magnet Synchronous Motor) 1-3: -	×	0	○	×	0	×	×	×	○	
H181	1F51h	h	M3 Draw current command	1	10 to 200% 100%/Motor rated current	×	80	○	×	0	×	×	×	○	
H182	1F52h	h	M3 Pull-in frequency	1	0.1 to 10.0 Hz	×	1.0	○	×	2	×	×	×	○	
H201	2001h	h	Load weighting control (Switching of load weighting control parameters) (To be supported soon)	13	0 to 1 0: H51, H64, H65 enable, H202-H213 disable 1: H51, H64, H65 disable, H202-H213 enable	×	0	○	○	0	○	×	×	○	
H202	2002h	h	Load weighting control (Load inertia (hoisting 1)) (To be supported soon)	1	0.001 to 50.000 kg·m^2 Applies to winding-up operation when AN-P2/1 is OFF. The magnification is switchable by H228.	×	0.001	○	○	4	○	×	×	○	
H203	2003h	h	Load weighting control (Safety factor (hoisting 1)) (To be supported soon)	1	0.50 to 1.20 Applies to winding-up operation when AN-P2/1 is OFF.	×	1.00	○	○	3	○	×	×	○	
H204	2004h	h	Load weighting control (Mechanical efficiency (hoisting 1)) (To be supported soon)	1	0.500 to 1.000 Applies to winding-up operation when AN-P2/1 is OFF.	×	0.500	○	○	4	○	×	×	○	
H205	2005h	h	Load weighting control (Load inertia (hoisting 2)) (To be supported soon)	1	0.001 to 50.000 kg·m^2 Applies to winding-up operation when AN-P2/1 is ON. The magnification is switchable by H228.	×	0.001	○	○	4	○	×	×	○	
H206	2006h	h	Load weighting control (Safety factor (hoisting 2)) (To be supported soon)	1	0.50 to 1.20 Applies to winding-up operation when AN-P2/1 is ON.	×	1.00	○	○	3	○	×	×	○	
H207	2007h	h	Load weighting control (Mechanical efficiency (hoisting 2)) (To be supported soon)	1	0.500 to 1.000 Applies to winding-up operation when AN-P2/1 is ON.	×	0.500	○	○	4	○	×	×	○	
H208	2008h	h	Load weighting control (Load inertia (lowering 1)) (To be supported soon)	1	0.001 to 50.000 kg·m^2 Applies to winding-down operation when AN-P2/1 is OFF. The magnification is switchable by H228.	×	0.001	○	○	4	○	×	×	○	
H209	2009h	h	Load weighting control (Safety factor (lowering 1)) (To be supported soon)	1	0.50 to 1.20 Applies to winding-down operation when AN-P2/1 is OFF.	×	1.00	○	○	3	○	×	×	○	
H210	200Ah	h	Load weighting control (Mechanical efficiency (lowering 1)) (To be supported soon)	1	0.500 to 1.000 Applies to winding-down operation when AN-P2/1 is OFF.	×	0.500	○	○	4	○	×	×	○	
H211	200Bh	h	Load weighting control (Load inertia (lowering 2)) (To be supported soon)	1	0.001 to 50.000 kg·m^2 Applies to winding-down operation when AN-P2/1 is ON. The magnification is switchable by H228.	×	0.001	○	○	4	○	×	×	○	
H212	200Ch	h	Load weighting control (Safety factor (lowering 2)) (To be supported soon)	1	0.50 to 1.20 Applies to winding-down operation when AN-P2/1 is ON.	×	1.00	○	○	3	○	×	×	○	
H213	200Dh	h	Load weighting control (Mechanical efficiency (lowering 2)) (To be supported soon)	1	0.500 to 1.000 Applies to winding-down operation when AN-P2/1 is ON.	×	0.500	○	○	4	○	×	×	○	
H214	200Eh	h	Load weighting control (Multi limit speed pattern function selection) (To be supported soon)	14	0 to 1 0: H60 definition enable, H215-H224 disable 1: H60 definition disable, H215-H224 enable	×	0	○	○	0	○	×	×	○	
H215	200Fh	h	Load weighting control (Multi limit speed pattern (maximum speed)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the maximum speed.	×	50.0	○	○	2	○	×	×	○	
H216	2010h	h	Load weighting control (Multi limit speed pattern (rated speed)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed.	×	100.0	○	○	2	○	×	×	○	
H217	2011h	h	Load weighting control (Multi limit speed pattern (rated speed x 1.1)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed*1.1.	×	90.9	○	○	2	○	×	×	○	
H218	2012h	h	Load weighting control (Multi limit speed pattern (rated speed x 1.2)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed*1.2.	×	83.3	○	○	2	○	×	×	○	
H219	2013h	h	Load weighting control (Multi limit speed pattern (rated speed x 1.4)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed*1.4.	×	71.4	○	○	2	○	×	×	○	
H220	2014h	h	Load weighting control (Multi limit speed pattern (rated speed x 1.6)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed*1.6.	×	62.5	○	○	2	○	×	×	○	
H221	2015h	h	Load weighting control (Multi limit speed pattern (rated speed x 1.8)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed*1.8.	×	55.5	○	○	2	○	×	×	○	
H222	2016h	h	Load weighting control (Multi limit speed pattern (rated speed x 2.0)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed*2.0.	×	50.0	○	○	2	○	×	×	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
H223	2017h	h	Load weighting control (Multi limit speed pattern (rated speed x 2.5)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed*2.5.	×	40.0	○	○	2	○	×	×	○	
H224	2018h	h	Load weighting control (Multi limit speed pattern (rated speed x 3.0)) (To be supported soon)	1	0.1 to 100.0% Specifies the torque level at the rated speed*3.0.	×	33.3	○	○	2	○	×	×	○	
H225	2019h	h	Load weighting control (Speed limit determination section (start speed)) (To be supported soon)	1	0.1 to 100.0% Specifies the starting speed of the determination section. The rated speed is assumed as 100%.	×	75.0	○	○	2	○	×	×	○	
H226	201Ah	h	Load weighting control (Speed limit determination section (ending speed)) (To be supported soon)	1	0.1 to 100.0% Specifies the end speed of the determination section. The rated speed is assumed as 100%.	×	93.7	○	○	2	○	×	×	○	
H227	201Bh	h	Load weighting control (Functional definition 3) (To be supported soon)	1	0 to 2 0: Calculation of hoisting and lowering speed limit individually 1: Drive lowering using speed limit of previous hoisting Enable the winding-down speed limit calculation under specific conditions 2: Drive lowering using speed limit of previous hoisting Limit the winding-down speed with the rated speed under specific conditions	×	0	○	○	0	○	×	×	○	
H228	201Ch	h	Load inertia magnification setting	0	0 to 2 0: Multiplied by 1 (0.001 to 50.000 kg·m²) 1: Multiplied by 10 (0.01 to 500.00 kg·m²) 2: Multiplied by 100 (0.1 to 5000.0 kg·m²) H51, H52, H202, H205, H208, H211 Switch the specified scaling factor for the “load inertia”.	×	630 kW or less 0 710 kW, 800 kW 1 1000 kW 2	○	○	193	○	×	×	○	
H322	2116h	h	Notch filter 1 (Resonance frequency)	6	10 to 2000 Hz	○	1000	○	○	0	○	○	×	○	
H323	2117h	h	Notch filter 1 (Attenuation level)	1	0 to 40 dB	○	0	○	○	0	○	○	×	○	
H324	2118h	h	Notch filter 1 (Frequency range)	1	0 to 3	○	2	○	○	0	○	○	×	○	
H325	2119h	h	Notch filter 2 (Resonance frequency)	1	10 to 2000 Hz	○	1000	○	○	0	○	○	×	○	
H326	211Ah	h	Notch filter 2 (Attenuation level)	1	0 to 40 dB	○	0	○	○	0	○	○	×	○	
H327	211Bh	h	Notch filter 2 (Frequency range)	1	0 to 3	○	2	○	○	0	○	○	×	○	

■ Motor parameter functions M2, M3 (A: Alternative Functions)

Function Codes	Communications address: 485 No.	Communications address: Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable: PG	LES	VF	SM	Remarks
A01	501h	h	M2 Drive control	29	0 to 5 0: Vector control (Induction motor) 1: Sensor-less vector control (Induction motor) 2: - 3: Vector control (PMSM) 4: - 5: V/f control (Induction motor)	×	0	○	×	228	○	○	○	○	
A02	502h	h	M2 Rated capacity	1	For inverters of 400 kW or less 0.00 to 500.00 kW when F60 = 0 0.00 to 600.00 HP when F60 = 1 For inverters of 500 kW or more 0.00 to 1200 kW when F60 = 0 0.00 to 1600 HP when F60 = 1 For multiwinding motors, set the motor capacity per wiring.	×	0.00	○	×	3 13	○	○	○	○	
A03	503h	h	M2 Rated current	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	×	0.01	○	×	13	○	○	○	○	
A04	504h	h	M2 Rated voltage	1	80 to 999 V	×	80	○	×	0	○	○	○	○	
A05	505h	h	M2 Rated speed	1	50 to 30000 r/min	×	1500	○	×	0	○	○	○	○	
A06	506h	h	M2 Max. speed	1	50 to 30000 r/min	×	1500	○	×	0	○	○	○	○	
A07	507h	h	M2 Number of poles	1	2 to 100 poles	×	4	○	×	1	○	○	○	○	
A08	508h	h	M2 %R1	1	0.00 to 30.00%	○	0.00	○	×	3	○	○	○	○	
A09	509h	h	M2 %X	1	0.00 to 200.00%	○	0.00	○	×	3	○	○	○	○	
A10	50Ah	h	M2 Exciting current/Magnetic flux weakening current (-Id)	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	○	0.01	○	×	13	○	○	○	○	
A11	50Bh	h	M2 Torque current	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	○	0.01	○	×	13	○	○	×	○	
A12	50Ch	h	M2 Slip frequency (For driving)	1	0.001 to 10.000 Hz	○	0.001	○	×	4	○	○	×	×	
A13	50Dh	h	M2 Slip frequency (For braking)	1	0.001 to 10.000 Hz	○	0.001	○	×	4	○	○	×	×	
A14	50Eh	h	M2 Iron loss factor 1	1	0.00 to 10.00%	○	0.00	○	×	3	○	○	×	○	
A15	50Fh	h	M2 Iron loss factor 2	1	0.00 to 10.00%	○	0.00	○	×	3	○	○	×	○	
A16	510h	h	M2 Iron loss factor 3	1	0.00 to 10.00%	○	0.00	○	×	3	○	○	×	○	
A17	511h	h	M2 Magnetic saturation factor 1	1	0.0 to 100.0%	○	93.8	○	×	2	○	○	×	×	
A18	512h	h	M2 Magnetic saturation factor 2	1	0.0 to 100.0%	○	87.5	○	×	2	○	○	×	×	
A19	513h	h	M2 Magnetic saturation factor 3	1	0.0 to 100.0%	○	75.0	○	×	2	○	○	×	×	
A20	514h	h	M2 Magnetic saturation factor 4	1	0.0 to 100.0%	○	62.5	○	×	2	○	○	×	×	
A21	515h	h	M2 Magnetic saturation factor 5	1	0.0 to 100.0%	○	50.0	○	×	2	○	○	×	×	
A22	516h	h	M2 Secondary time constant	1	0.001 to 9.999 s	○	0.001	○	×	4	○	○	×	×	
A23	517h	h	M2 Induced voltage factor	1	0 to 999 V	○	0	○	×	0	○	○	×	○	
A24	518h	h	M2 R2 Correction factor 1	1	0.000 to 5.000	○	1.000	○	×	4	○	○	×	○	
A25	519h	h	M2 R2 Correction factor 2	1	0.000 to 5.000	○	1.000	○	×	4	○	○	×	×	
A26	51Ah	h	M2 R2 Correction factor 3	1	0.010 to 5.000	○	1.000	○	×	4	○	○	×	×	
A27	51Bh	h	M2 Exciting current correction factor	1	0.000 to 5.000	○	0.000	○	×	4	○	○	×	×	
A28	51Ch	h	M2 ACR-P (Gain)	1	0.1 to 20.0	○	1.0	○	×	2	○	○	×	○	
A29	51Dh	h	M2 ACR-I (I-time)	1	0.1 to 100.0 ms	○	1.0	○	×	2	○	○	×	○	
A30	51Eh	h	M2 PG Pulse resolution	0	100 to 60000	×	1024	○	×	0	○	×	×	○	
A31	51Fh	h	M2 Thermistor selection	0	0 to 3 0: No thermistor 1: NTC thermistor selected 2: PTC thermistor selected 3: Ai [M-TMP] The protection level of the motor protective functions should be specified by E30 to E32.	×	1	○	×	84	○	○	○	○	
A32	520h	h	M2 Electronic thermal (Operation selection)	3	0 to 2 0: No operation (when using exclusive motor for VG) 1: Operation (for general purpose motors: use in the case of self-cooling fan) 2: Operation (for inverter motors: use in the case of externally powered fan)	○	0	○	×	85	○	○	○	○	
A33	521h	h	M2 Electronic thermal (Detection level)	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	○	0.01	○	×	13	○	○	○	○	
A34	522h	h	M2 Electronic thermal (Thermal time constant)	1	0.5 to 75.0 min	○	0.5	○	×	2	○	○	○	○	
A51	533h	h	M2 External PG correction factor	0	0000 to 4FFF	×	4000	○	×	9	○	×	×	○	
A52	534h	h	M2 Online auto tuning	0	0 to 1 0: Disable 1: Enable	○	0	○	×	0	○	○	×	×	
A53	535h	h	M2 Maximum output voltage/Maximum voltage limit value	0	80 to 999 V	×	80	○	×	0	×	×	○	○	
A54	536h	h	M2 Slip compensation	3	-20.000 to 5.000 Hz	○	0.000	○	×	8	×	×	○	×	
A55	537h	h	M2 Torque boost	1	0.0 to 20.0 Function specific to V/f control. The following selections are possible. 0.0: Automatic torque boost (for fixed torque characteristic load) 0.1 to 0.9: For squared torque characteristic load 1.0 to 1.9: For proportional torque characteristic load 2.0 to 20.0: For fixed torque characteristic load	○	0.0	○	×	2	×	×	○	×	
A56	538h	h	M2 Current fluctuation damping gain	1	0.00 to 1.00	○	0.20	○	×	3	×	×	○	×	

Function Codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
A59	53Bh	h	M2 ABS signal input definition	13	0 to 16 Specifies according to the encoder specifications. Defines the interface to detect magnetic polarity position. 0: 1bit (Terminal; F0) Z phase interface 1: 3bit (Terminal; F0, F1, F2) U, V, W phase interface 2: 4bit (Terminal; F0, F1, F2, F3) grey code interface 3 to 5: Reserved 6: SPGT 17 bit serial interface 7 to 16: Reserved	×	0	○	×	0	×	×	×	○	
A60	53Ch	h	M2 Magnetic pole position offset	1	0.0 to 359.9 (0° to 359.9° CCW direction) Specifies the offset value for the encoder reference position and the actual motor magnetic pole position.	○	0.0	○	×	2	×	×	×	○	
A61	53Dh	h	M2 Salient pole ratio (%Xq/%Xd)	1	1.000 to 5.000 Specifies the saliency ratio of PMSM. Setting value = Lq/Ld To drive a SPM motor, set 1.000.	×	1.000	○	×	4	×	×	×	○	
A62	53Eh	h	M2 q axis inductance magnetic saturation coefficient	1	0.0 to 100.0%	○	100.0	○	×	2	×	×	×	○	
A63	53Fh	h	M2 Magnetic flux limiting value	1	50.0 to 150.0%	○	100.0	○	×	2	×	×	×	○	
A64	540h	h	M2 Overcurrent protection levels	1	0.00: No operation 0.01 to 99.99 A 100.0 to 999.9 A 1000 to 5000 A Specifies the allowable current value to prevent the permanent magnet of a PMSM from getting demagnetized. If the current exceeding this setting flows, an overcurrent alarm (OC) occurs.	×	0.00	○	×	13	×	×	×	○	
A65	541h	h	M2 Torque correction gain 1	1	0.00 to 10.00	○	1.00	○	×	3	×	×	×	○	
A66	542h	h	M2 Torque correction gain 2	1	0.00 to 10.00	○	1.00	○	×	3	×	×	×	○	
A67	543h	h	M2 Torque correction gain 3	1	-1.000 to 1.000	○	0.000	○	×	8	×	×	×	○	
A68	544h	h	M2 Torque correction gain 4	1	-1.000 to 1.000	○	0.000	○	×	8	×	×	×	○	
A69	545h	h	M2 Torque correction gain 5	1	-50.00 to 50.00	○	0.00	○	×	7	×	×	×	○	
A70	546h	h	M2 Torque correction gain 6	1	-50.00 to 50.00	○	0.00	○	×	7	×	×	×	○	
A71	547h	h	M2 Torque correction gain 7	1	-1.000 to 1.000	○	0.000	○	×	8	×	×	×	○	
A101	2401h	h	M3 Drive control	29	0 to 5 0: Vector control (Induction motor) 1: Sensor-less vector control (Induction motor) 2: - 3: Vector control (PMSM) 4: - 5: V/f control (Induction motor)	×	5	○	×	228	○	○	○	○	
A102	2402h	E5h	M3 Rated capacity	1	For inverters of 400 kW or less 0.00 to 500.00 kW when F60 = 0 0.00 to 600.00 HP when F60 = 1 For inverters of 500 kW or more 0.00 to 1200 kW when F60 = 0 0.00 to 1600 HP when F60 = 1 For multiwinding motors, set the motor capacity per wiring.	×	0.00	○	×	3 13	○	○	○	○	
A103	2403h	E6h	M3 Rated current	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	×	0.01	○	×	13	○	○	○	○	
A104	2404h	E7h	M3 Rated voltage	1	80 to 999 V	×	80	○	×	0	○	○	○	○	
A105	2405h	E9h	M3 Rated speed	1	50 to 30000 r/min	×	1500	○	×	0	○	○	○	○	
A106	2406h	EAh	M3 Max. Speed	1	50 to 30000 r/min	×	1500	○	×	0	○	○	○	○	
A107	2407h	EBh	M3 Number of poles	1	2 to 100 poles	×	4	○	×	1	○	○	○	○	
A108	2408h	ECh	M3 %R1	1	0.00 to 30.00%	○	0.00	○	×	3	○	○	○	○	
A109	2409h	EDh	M3 %X	1	0.00 to 200.00%	○	0.00	○	×	3	○	○	○	○	
A110	240Ah	EEh	M3 Exciting current/Magnetic flux weakening current (-Id)	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	○	0.01	○	×	13	○	○	○	○	
A111	240Bh	h	M3 Torque current	1	0.01 to 99.99 A 100.0 to 999.9 A 1000 to 2000 A	○	0.01	○	×	13	○	○	×	○	
A112	240Ch	h	M3 Slip frequency (For driving)	1	0.001 to 10.000 Hz	○	0.001	○	×	4	○	○	×	×	
A113	240Dh	h	M3 Slip frequency (For braking)	1	0.001 to 10.000 Hz	○	0.001	○	×	4	○	○	×	×	
A114	240Eh	h	M3 Iron loss factor 1	1	0.00 to 10.00%	○	0.00	○	×	3	○	○	×	○	
A115	240Fh	h	M3 Iron loss factor 2	1	0.00 to 10.00%	○	0.00	○	×	3	○	○	×	○	
A116	2410h	h	M3 Iron loss factor 3	1	0.00 to 10.00%	○	0.00	○	×	3	○	○	×	○	
A117	2411h	h	M3 Magnetic saturation factor 1	1	0.0 to 100.0%	○	93.8	○	×	2	○	○	×	×	
A118	2412h	h	M3 Magnetic saturation factor 2	1	0.0 to 100.0%	○	87.5	○	×	2	○	○	×	×	
A119	2413h	h	M3 Magnetic saturation factor 3	1	0.0 to 100.0%	○	75.0	○	×	2	○	○	×	×	
A120	2414h	h	M3 Magnetic saturation factor 4	1	0.0 to 100.0%	○	62.5	○	×	2	○	○	×	×	
A121	2415h	h	M3 Magnetic saturation factor 5	1	0.0 to 100.0%	○	50.0	○	×	2	○	○	×	×	
A122	2416h	h	M3 Secondary time constant	1	0.001 to 9.999 s	○	0.001	○	×	4	○	○	×	×	
A123	2417h	h	M3 Induced voltage factor	1	0 to 999 V	○	0	○	×	0	○	○	×	○	
A124	2418h	h	M3 R2 Correction factor 1	1	0.500 to 5.000	○	1.000	○	×	4	○	○	×	○	
A125	2419h	h	M3 R2 Correction factor 2	1	0.500 to 5.000	○	1.000	○	×	4	○	○	×	×	
A126	241Ah	h	M3 R2 Correction factor 3	1	0.010 to 5.000	○	1.000	○	×	4	○	○	×	×	
A127	241Bh	h	M3 Exciting current correction factor	1	0.000 to 5.000	○	0.000	○	×	4	○	○	×	×	
A128	241Ch	h	M3 ACR-P (Gain)	1	0.1 to 20.0	○	1.0	○	×	2	○	○	×	○	
A129	241Dh	h	M3 ACR-I time	1	0.1 to 100.0 ms	○	1.0	○	×	2	○	○	×	○	
A130	241Eh	h	M3 PG pulse resolution	0	100 to 60000	×	1024	○	×	0	○	×	×	○	

Function Codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
A131	241Fh	F1h	M3 Thermistor selection	0	0 to 3 0: No thermistor 1: NTC thermistor selected 2: PTC thermistor selected 3: Ai [M-TMP] The protection level of the motor protective functions should be specified by E30 to E32.	×	1	○	×	84	○	○	○	○	
A132	2420h	F2h	M3 Electronic thermal (Operation selection)	3	0 to 2 0: No operation (when using exclusive motor for VG) 1: Operation (for general purpose motors: use in case of self-cooling fan) 2: Operation (for inverter motors: use in case of externally powered fans) Using an NTC thermistor of a FRENIC-VG-dedicated motor activates the motor overheat protection. If it happens, disable the electronic thermal overload protection.	○	0	○	×	85	○	○	○	○	
A133	2421h	F3h	M3 Electronic thermal (Detection level)	1	0.01 to 99.99A 100.0 to 999.9A 1000 to 2000A	○	0.01	○	×	13	○	○	○	○	
A134	2422h	F4h	M3 Electronic thermal (Thermal time constant)	1	0.5 to 75.0 min	○	0.5	○	×	2	○	○	○	○	
A151	2433h	h	M3 External PG correction factor	0	0000 to 4FFF	×	4000	○	×	9	○	×	×	○	
A152	2434h	h	M3 Online Auto tuning	0	0 to 1 0: Disable 1: Enable	○	0	○	×	0	○	○	×	×	
A153	2435h	E8h	M3 Maximum output voltage/Maximum voltage limit value	0	80 to 999 V	×	80	○	×	0	×	×	○	○	
A154	2436h	EFh	M3 Slip compensation	3	-20.000 to 5.000 Hz	○	0.000	○	×	8	×	×	○	×	
A155	2437h	F0h	M3 Torque boost	1	0.0 to 20.0 Function specific to V/f control. The following selections are possible. 0.0: Automatic torque boost (for fixed torque characteristic load) 0.1 to 0.9: For squared torque characteristic load 1.0 to 1.9: For proportional torque characteristic load 2.0 to 20.0: For fixed torque characteristic load	○	0.0	○	×	2	×	×	○	×	
A156	2438h	h	M3 Current fluctuation damping gain	1	0.00 to 1.00	○	0.20	○	×	3	×	×	○	×	
A159	243Bh	h	M3 ABS signal input definition	13	0 to 16 Specifies according to the encoder specifications. Defines the interface to detect magnetic polarity position. 0: 1bit (Terminal; F0) Z phase interface 1: 3bit (Terminal; F0, F1, F2) U, V, W phase interface 2: 4bit (Terminal; F0, F1, F2, F3) grey code interface 3 to 5: Reserved 6: SPGT 17 bit serial interface 7 to 16: Reserved	×	0	○	×	0	×	×	×	○	
A160	243Ch	h	M3 Magnetic pole position offset	1	0.0 to 359.9 (0° to 359.9° CCW direction) Specifies the offset value for the encoder reference position and the actual motor magnetic pole position.	○	0.0	○	×	2	×	×	×	○	
A161	243Dh	h	M3 Salient pole ratio (%Xq/%Xd)	1	1.000 to 5.000 Specifies the saliency ratio of PMSM. Setting value = Lq/Ld To drive a SPM motor, set 1.000.	×	1.000	○	×	4	×	×	×	○	
A162	243Eh	h	M3 q axis inductance magnetic saturation coefficient	1	0.0 to 100.0 %	○	100.0	○	×	2	×	×	×	○	
A163	243Fh	h	M3 Magnetic flux limiting value	1	50.0 to 150.0 %	○	100.0	○	×	2	×	×	×	○	
A164	2440h	h	M3 Overcurrent protection level	1	0.00: No operation 0.01 to 99.99 A 100.0 to 999.9A 1000 to 5000A Specifies the allowable current value to prevent the permanent magnet of a PMSM from getting demagnetized. If the current exceeding this setting flows, an overcurrent alarm (OC) occurs.	×	0.00	○	×	13	×	×	×	○	
A165	2441h	h	M3 Torque correction gain 1	1	0.00 to 10.00	○	1.00	○	×	3	×	×	×	○	
A166	2442h	h	M3 Torque correction gain 2	1	0.00 to 10.00	○	1.00	○	×	3	×	×	×	○	
A167	2443h	h	M3 Torque correction gain 3	1	-1.000 to 1.000	○	0.000	○	×	8	×	×	×	○	
A168	2444h	h	M3 Torque correction gain 4	1	-1.000 to 1.000	○	0.000	○	×	8	×	×	×	○	
A169	2445h	h	M3 Torque correction gain 5	1	-50.00 to 50.00	○	0.00	○	×	7	×	×	×	○	
A170	2446h	h	M3 Torque correction gain 6	1	-50.00 to 50.00	○	0.00	○	×	7	×	×	×	○	
A171	2447h	h	M3 Torque correction gain 7	1	-1.000 to 1.000	○	0.000	○	×	8	×	×	×	○	

■ Option functions (O: Option Functions)

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
o01	601h	F5h	DIA function selection	4	0 to 1 0: Binary 1: BCD	×	0	○	○	86	○	○	○	○	
o02	602h	F6h	DIB function selection	1	0 to 1 0: Binary 1: BCD	×	0	○	○	86	○	○	○	○	
o03	603h	h	DIA BCD input setting	1	99 to 7999	×	1000	○	○	0	○	○	○	○	
o04	604h	h	DIB BCD input setting	1	99 to 7999	×	1000	○	○	0	○	○	○	○	
o05	605h	h	PG (PD) option setting (Return pulse selection)	0	0 to 1 0: Main unit PG 1: PG (PD) option	×	0	○	○	96	○	×	×	○	
o06	606h	h	PG (LD) option setting (Digital line speed detect definition/ (Encoder pulse resolution))	3	100 to 60000 P/R	○	1024	○	○	0	○	○	○	○	
o07	607h	h	PG (LD) option setting (Digital line speed detect definition/ (Detected pulse correction 1))	1	1 to 9999	○	1000	○	○	0	○	○	○	○	
o08	608h	h	PG (LD) option setting (Digital line speed detect definition/ (Detected pulse correction 2))	1	1 to 9999	○	1000	○	○	0	○	○	○	○	
o09	609h	h	M1 ABS signal input definition	3	0 to 16 Specifies according to the encoder specifications. Defines the interface to detect magnetic polarity position. 0: 1bit (Terminal; F0) Z phase interface 1: 3bit (Terminal; F0, F1, F2) U, V, W phase interface 2: 4bit (Terminal; F0, F1, F2, F3) grey code interface 3 to 5: Reserved 6: SPGT 17 bit serial interface 7 to 16: Reserved	×	0	○	×	0	×	×	×	○	
o10	60Ah	h	M1 Magnetic pole position offset	1	0.0 to 359.9 (0° to 359.9° CCW direction) Specifies the offset value for the encoder reference position and the actual motor magnetic pole position.	○	0.0	○	×	2	×	×	×	○	
o11	60Bh	h	M1 Salient pole rate (%Xq/%Xd)	1	1.000 to 5.000 Specifies the saliency ratio of PMSM. Setting value = Lq/Ld To drive a SPM motor, set 1.000.	×	1.000	○	×	4	×	×	×	○	
o12	60Ch	h	PG (PR) pulse-train option setting (Command pulse selection)	8	0 to 1 0: PG (PR) option 1: Internal speed command	×	0	○	○	97	○	×	×	○	
o13	60Dh	h	PG (PR) pulse-train option setting (Pulse-train input style selection)	1	0 to 2 0: A, B phase 90 degrees phase difference 1: A phase: command pulse, B phase: command code 2: A phase: normal pulse, B phase: reverse pulse	×	0	○	○	98	○	×	×	○	
o14	60Eh	F7h	PG (PR) pulse-train option setting (Command pulse correction 1)	1	1 to 9999	○	1000	○	○	0	○	×	×	○	
o15	60Fh	F8h	PG (PR) pulse-train option setting (Command pulse correction 2)	1	1 to 9999	○	1000	○	○	0	○	×	×	○	
o16	610h	F9h	PG (PR) pulse-train option setting (APR gain 1)	1	0.1 to 999.9 times	○	1.0	○	○	2	○	×	×	○	
o17	611h	FAh	PG (PR) pulse-train option setting (F/F gain 1)	1	0.0 to 1.5 times	○	0.0	○	○	2	○	×	×	○	
o18	612h	h	PG (PR) pulse-train option setting (Width exceeding deviation)	1	0 to 65535 pulses	○	65535	○	○	0	○	×	×	○	
o19	613h	h	PG (PR) pulse-train option setting (Zero width deviation)	1	0 to 1000 pulses	○	20	○	○	0	○	×	×	○	
o20	614h	h	APR gain 2 (To be supported soon)	1	0.1 to 999.9 times	○	1.0	○	○	2	○	×	×	○	
o21	615h	h	F/F gain 2 (To be supported soon)	1	0.0 to 1.5 times	○	0.0	○	○	2	○	×	×	○	
o22	616h	h	Position control gain switching selection (To be supported soon)	3	0 to 3 0: No operation 1: Position deviation (x 10) 2: Speed detection (10000/max speed) 3: Speed command (10000/max speed) Select a trigger to switch between the 1st and 2nd gains of the position control system. Switching gains can reduce noise or vibration when the inverter is stopped.	○	0	○	○	229	○	×	×	○	
o23	617h	h	Position control switching level (To be supported soon)	1	0 to 10000	○	0	○	○	0	○	×	×	○	
o24	618h	h	Position control gain switch timing (To be supported soon)	1	0 to 1000 ms	○	0	○	○	0	○	×	×	○	
o30	61Eh	h	Link option setting (Activity at transmission failure)		0 to 3 0: Immediate trip (Er-4) 1: Trip after continuing operation for time specified as operation continuance (Er-4) 2: Trip when transmission failure continues after operation time (Er-4) 3: Operation continuance Specifies the error processing to be performed if a communications link error occurs. For CC-Link, when o30 = 0 to 3, the inverter produces different operation from above.	×	0	○	○	73	○	○	○	○	
o31	61Fh	h	Link option setting (Operation time at transmission failure)	1	0.01 to 20.00 s Specifies the duration from an occurrence of communications problem on the link until the inverter causes a communications error.	×	0.10	○	○	3	○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
o32	620h	h	Link option setting (Transmission format)	1	0 to 4 0: Transmission format 1 1: Transmission format 2 2: Transmission format 3 3: Transmission format 4 4: Transmission format 5	×	0	○	×	87	○	○	○	○	
o33 (*1)	621h	FDh	Multiplex system (Control mode)	2	0 to 5 0: Disable 1: Multi-winding system 2: Multiplex system 1 (Direct parallel system) 3: Multiplex system 2 4: Reserved 1 5: Reserved 2 Selects whether to use terminal block supporting high speed serial communication as a multi-winding system or as a multiplex system. Single operation is possible when disabled. Refer to MT-CCL (Multiplex system cancel) in the description of E01 to E13 (Terminal X function).	×	0	○	○	232	○	×	×	×	
o34	622h	h	Multiplex System (No. of slave stations)	1	1 to 5 Specifies the numbers of slave units except a master unit when the multiplex system is enabled.	×	1	○	○	0	○	×	×	×	
o38 (*1)	626h	h	UPAC Start/Stop	3	0 to 2 0: Stop UPAC 1: Start UPAC 2: Start UPAC (Initial startup) Specifies whether to start or stop UPAC option.	×	0	○	○	68	○	○	○	○	
o39 (*1)	627h	h	UPAC memory mode	1	00 to 1F When UPAC is stopped, this function can be used to specify the affected area. Setting 0; hold/1; zero clear 1bit: IQ area 2bit: M area 3bit: RM area 4bit: FM area 5bit: SFM area When UPAC is stopped from running or in the stopped state, this function defines whether to zero-clear or hold the specified memory area.	×	00	○	○	9	○	○	○	○	
O40 (*1)	628h	h	UPAC address	1	100 to 255 Sets up the UPAC station number used to access from PC to UPAC via RS-485 communication.	×	100	○	×	0	○	○	○	○	
o50	632h	h	Multiplex system (Station number assignment)	0	0 to 5 0: Master 1-5: Slave 1 to 5	×	0	×	○	0	○	×	×	×	
o101 (*2)	2501h	h	Free assignment reflection	0	0 to 1 Automatically reset to 0 after data writing.	×	0	×	×	11	○	○	○	○	
o122	2516h	h	Write function code assignment 1	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o123	2517h	h	Write function code assignment 2	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o124	2518h	h	Write function code assignment 3	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o125	2519h	h	Write function code assignment 4	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o126	251Ah	h	Write function code assignment 5	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o127	251Bh	h	Write function code assignment 6	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o128	251Ch	h	Write function code assignment 7	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o129	251Dh	h	Write function code assignment 8	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o130	251Eh	h	Write function code assignment 9	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o131	251Fh	h	Write function code assignment 10	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o132	2520h	h	Write function code assignment 11	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o133	2521h	h	Write function code assignment 12	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o160	253Ch	h	Read function code assignment 1	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o161	253Dh	h	Read function code assignment 2	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o162 (*2)	253Eh	h	Read function code assignment 3	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o163 (*2)	253Fh	h	Read function code assignment 4	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o164 (*2)	2540h	h	Read function code assignment 5	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o165 (*2)	2541H	h	Read function code assignment 6	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o166 (*2)	2542h	h	Read function code assignment 7	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o167 (*2)	2543h	h	Read function code assignment 8	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o168 (*2)	2544h	h	Read function code assignment 9	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o169 (*2)	2545h	h	Read function code assignment 10	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o170 (*2)	2546h	h	Read function code assignment 11	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	
o171 (*2)	2547h	h	Read function code assignment 12	0	0000 to FFFF	○	0000	○	○	9	○	○	○	○	

(*1) Available when the ROM version is H1/2 0020 or later.
(*2) Availble in the ROM version H1/2 02□□, which supports PROFINET-IRT.

■ Lift functions (L: Lift Functions)

Function codes	Communications address 485 No.	Communications address Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable PG	LES	VF	SM	Remarks
L01	901h	h	Password data 1	0	0 to 9999 A maximum of 8-digit password can be specified with L01 and L02 to restrict access to change or check function code data. Setting either one of L01 and L02 at any numeral except "0" enables password protection.	○	0	×	×	0	○	○	×	○	
L02	902h	h	Password data 2	0	0 to 9999	○	0	×	×	0	○	○	×	○	
L03	903h	h	Lift rated speed	0	0.0 to 999.9 m/min	○	100.0	○	○	2	○	○	×	○	
L04	904h	h	Preset S-curve pattern	11	0 to 2 0: Not used Normal accel/decel, S-curve (15 steps, S-curve 5) 1: Method 1 VG3, VG5 method. SS1, SS2, and SS4 are all OFF with 12 input enable. 2: Method 2 VG7, FRENIC-VG method. SS1, SS2, and SS4 are all OFF with zero speed. Select S-curve pattern and application of multistep speed setting.	○	0	○	○	80	○	○	×	○	
L05	905h	h	Select S-curve pattern 1	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L06	906h	h	Select S-curve pattern 2	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L07	907h	h	Select S-curve pattern 3	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L08	908h	h	Select S-curve pattern 4	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L09	909h	h	Select S-curve pattern 5	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L10	90Ah	h	Select S-curve pattern 6	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L11	90Bh	h	Select S-curve pattern 7	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L12	90Ch	h	Select S-curve pattern 8	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L13	90Dh	h	Select S-curve pattern 9	1	0 to 50%	○	0	○	○	0	○	○	×	○	
L14	90Eh	h	Select S-curve pattern 10	1	0 to 50%	○	0	○	○	0	○	○	×	○	

■ User functions (UPAC) (U: User Functions)

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
U01	B01h	DBh	USER P1	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U02	B02h	DCh	USER P2	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U03	B03h	DDh	USER P3	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U04	B04h	DEh	USER P4	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U05	B05h	DFh	USER P5	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U06	B06h	E0h	USER P6	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U07	B07h	E1h	USER P7	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U08	B08h	E2h	USER P8	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U09	B09h	E3h	USER P9	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U10	B0Ah	E4h	USER P10	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U11	B0Bh	h	USER P11 SX, E-SX bus Communication format selection	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U12	B0Ch	h	USER P12	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U13	B0Dh	h	USER P13 SX bus Station number monitor	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U14	B0Eh	h	USER P14	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U15	B0Fh	h	USER P15	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U16	B10h	h	USER P16	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U17	B11h	h	USER P17	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U18	B12h	h	USER P18	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U19	B13h	h	USER P19	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U20	B14h	h	USER P20	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U21	B15h	h	USER P21	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U22	B16h	h	USER P22	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U23	B17h	h	USER P23	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U24	B18h	h	USER P24	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U25	B19h	h	USER P25	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U26	B1Ah	h	USER P26	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U27	B1Bh	h	USER P27	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U28	B1Ch	h	USER P28	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U29	B1Dh	h	USER P29	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U30	B1Eh	h	USER P30	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U31	B1Fh	h	USER P31	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U32	B20h	h	USER P32	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U33	B21h	h	USER P33	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U34	B22h	h	USER P34	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U35	B23h	h	USER P35	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U36	B24h	h	USER P36	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U37	B25h	h	USER P37	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U38	B26h	h	USER P38	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U39	B27h	h	USER P39	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U40	B28h	h	USER P40	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U41	B29h	h	USER P41	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U42	B2Ah	h	USER P42	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U43	B2Bh	h	USER P43	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U44	B2Ch	h	USER P44	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U45	B2Dh	h	USER P45	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U46	B2Eh	h	USER P46	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U47	B2Fh	h	USER P47	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U48	B30h	h	USER P48	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U49	B31h	h	USER P49	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U50	B32h	h	USER P50	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U51	B33h	h	USER P51	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U52	B34h	h	USER P52	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U53	B35h	h	USER P53	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U54	B36h	h	USER P54	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U55	B37h	h	USER P55	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U56	B38h	h	USER P56	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U57	B39h	h	USER P57	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U58	B3Ah	h	USER P58	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U59	B3Bh	h	USER P59	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U60	B3Ch	h	USER P60	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U61	B3Dh	4Bh	USER P61/U-Ai1	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U62	B3Eh	4Ch	USER P62/U-Ai2	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U63	B3Fh	4Dh	USER P63/U-Ai3	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U64	B40h	4Eh	USER P64/U-Ai4	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U101	2701h	h	USER P101	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U102	2702h	h	USER P102	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U103	2703h	h	USER P103	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U104	2704h	h	USER P104	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U105	2705h	h	USER P105	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U106	2706h	h	USER P106	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U107	2707h	h	USER P107	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
U108	2708h	h	USER P108	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U109	2709h	h	USER P109	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U110	270Ah	h	USER P110	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U111	270Bh	h	USER P111	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U112	270Ch	h	USER P112	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U113	270Dh	h	USER P113	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U114	270Eh	h	USER P114	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U115	270Fh	h	USER P115	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U116	2710h	h	USER P116	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U117	2711h	h	USER P117	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U118	2712h	h	USER P118	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U119	2713h	h	USER P119	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U120	2714h	h	USER P120	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U121	2715h	h	USER P121	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U122	2716h	h	USER P122	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U123	2717h	h	USER P123	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U124	2718h	h	USER P124	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U125	2719h	h	USER P125	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U126	271Ah	h	USER P126	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U127	271Bh	h	USER P127	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U128	271Ch	h	USER P128	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U129	271Dh	h	USER P129	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U130	271Eh	h	USER P130	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U131	271Fh	h	USER P131	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U132	2720h	h	USER P132	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U133	2721h	h	USER P133	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U134	2722h	h	USER P134	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U135	2723h	h	USER P135	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U136	2724h	h	USER P136	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U137	2725h	h	USER P137	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U138	2726h	h	USER P138	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U139	2727h	h	USER P139	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U140	2728h	h	USER P140	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U141	2729h	h	USER P141	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U142	272Ah	h	USER P142	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U143	272Bh	h	USER P143	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U144	272Ch	h	USER P144	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U145	272Dh	h	USER P145	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U146	272Eh	h	USER P146	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U147	272Fh	h	USER P147	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U148	2730h	h	USER P148	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U149	2731h	h	USER P149	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	
U150	2732h	h	USER P150	0	-32768 to 32767	○	0	○	○	5	○	○	○	○	

■ Safety functions (SF: Safety Functions)

Function codes	Communications address 485 No.	Communications address Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable PG	LES	VF	SM	Remarks
SF00	2800h	h	Password state monitor	0	0 or 1 0: Locked 1: Unlocked	×	0	×	×	0	○	○	○	○	
SF01	2801h	h	SS1 Level	0	30 to 30000 r/min	×	150	×	×	0	○	○	○	○	
SF02	2802h	h	SS1 Timer	0	0.01 to 99.9 s 100.0 to 999.9 s 1000 to 3600 s	×	10.00	×	×	13	○	○	○	○	
SF03	2803h	h	SS1/SLS Deceleration time	0	0.01 to 99.9 s 100.0 to 999.9 s 1000 to 3600 s	×	5.00	×	×	13	○	○	○	○	
SF04	2804h	h	SLS Level	0	30 to 30000 r/min	×	300	×	×	0	○	○	○	○	
SF05	2805h	h	SLS Timer	0	0.01 to 99.9 s 100.0 to 999.9s 1000 to 3600 s	×	10.00	×	×	13	○	○	○	○	
SF06	2806h	h	SS1/SLS Upper limit value	0	0 to 30000 r/min	×	300	×	×	0	○	○	○	○	
SF07	2807h	h	Motor maximum speed	0	50 to 30000 r/min	×	1500	×	×	0	○	○	○	○	
SF08	2808h	h	Upper limit monitor wait time	0	0.01 to 99.9 s 100.0 to 999.9 s 1000 to 3600 s	×	0.00	×	×	13	○	○	○	○	
SF09	2809h	h	PG Breakdown detection	0	0 to 1 0: Disable 1: Enable	×	1	×	×	68	○	○	○	○	
SF10	280Ah	h	PG Pulse resolution	0	100 to 60000	×	1024	×	×	0	○	○	○	○	
SF11	280Bh	h	Speed detection filter	0	0.000 to 0.100 s	×	0.010	×	×	4	○	○	○	○	
SF12	280Ch	h	STO Diagnosis early warning time	0	0.0 to 1.0 s	×	0.0	×	×	2	○	○	○	○	
SF20	2814h	h	Terminal [SL1]/[SL2] function selection	0	0 to 2 0: No function 1: SS1 function 2: SLS function	×	0	×	×	219	○	○	○	○	
SF21	2815h	h	SS1 Stop mode	0	0 to 1 0: Speed monitoring 1: Time monitoring	×	1	×	×	220	○	○	○	○	
SF22	2816h	h	Encoder selection	0	0 to 2 0: Recommended PG or PG-less 1: Recommended 15 V encoder 2: Non-recommended 12 V encoder	×	0	×	×	221	○	○	○	○	
SF23	2817h	h	Fault reaction selection	0	0 to 1 0: STO (SBC operation when SBC is enabled) 1: SS1	×	0	×	×	222	○	○	○	○	
SF24	2818h	h	SBC Function selection	0	0 to 2 0: Disable 1: Enable – via safety relay 2: Enable – brake direct connection	×	0	×	×	224	○	○	○	○	
SF25	2819h	h	SS1 Error processing selection	0	0 to 1 0: Fault reaction selection 1: Light alarm selection	×	0	×	×	227	○	○	○	○	
SF26	281Ah	h	SLS Deceleration error processing selection	0	0 to 1 0: Fault reaction selection 1: Light alarm selection	×	0	×	×	223	○	○	○	○	
SF27	281Bh	h	SLS Upper limit error processing selection	0	0 to 1 0: Fault reaction selection 1: Light alarm selection	×	0	×	×	223	○	○	○	○	
SF28	281Ch	h	Full save of safety parameters	0	0 to 1 0: Do not save 1: Save all (auto-reset to 0)	×	0	×	×	0	○	○	○	○	
SF30	281Eh	h	Safety related password authentication 1	0	0000 to FFFF	×	0	×	×	9	○	○	○	○	
SF31	281Fh	H	Safety related password authentication 2	0	0000 to FFFF	×	0	×	×	9	○	○	○	○	

(1*) Functions SF01 to SF31 are available when the ROM version is H1/2 0020 or later.

■ Command functions (S: Serial Communication Functions)

Function codes	Communications address: 485 No.	Communications address: Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable PG	LES	VF	SM	Remarks
S01	701h	1h	Frequency/Speed command (Setting 1)	7	-20000 to 20000 : (data)*Nmax/20000 r/min	○	-	×	×	5	○	○	○	○	
S02	702h	2h	Torque command	1	-327.68 to 327.67% : 0.01%/1d	○	-	×	×	7	○	○	×	○	
S03	703h	3h	Torque current command	1	-327.68 to 327.67% : 0.01%/1d	○	-	×	×	7	○	○	×	○	
S04	704h	4h	Magnetic-flux command	1	-327.68 to 327.67% : 0.01%/1d	○	-	×	×	7	○	×	×	×	
S05	705h	5h	Orientation position command	1	0000 to FFFF	○	-	×	×	9	○	×	×	○	
S06	706h	6h	Run command 1	1	0000 to FFFF	○	-	×	×	32	○	○	○	○	
S07	707h	7h	Universal Do	1	0000 to FFFF	○	-	×	×	33	○	○	○	○	
S08	708h	8h	Acceleration time	2	0.0 to 3600.0 s	○	-	×	×	2	○	○	○	○	
S09	709h	9h	Deceleration time	1	0.0 to 3600.0 s	○	-	×	×	2	○	○	○	○	
S10	70Ah	Ah	Torque limiter level 1	2	-327.68 to 327.67% : 0.01%/1d	○	-	×	×	7	○	○	×	○	
S11	70Bh	Bh	Torque limiter level 2	1	-327.68 to 327.67% : 0.01%/1d	○	-	×	×	7	○	○	×	○	
S12	70Ch	Ch	Run command 2	0	0000 to FFFF	○	-	×	×	9	○	○	○	○	
S13	70Dh	h	Universal Ao	0	-16384 to 16384 (-10 V to +10 V)	○	-	×	×	5	○	○	○	○	
S16	710h	h	General purpose setting 1 (To be supported soon)	2	-32768 to 32767 Assign functions using E90.	○	-	×	×	5	○	○	○	○	
S17	711h	h	General purpose setting 2 (To be supported soon)	1	-32768 to 32767 Assign functions using E91.	○	-	×	×	5	○	○	○	○	

■ Monitor data functions (M: Monitor Functions)

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
M01	801h	Fh	Speed setting 4 (ASR input)	15	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	○	○	○	○	
M02	802h	10h	Torque command value	1	0.01%/1d	×	-	×	×	7	○	○	×	○	
M03	803h	11h	Torque current command value	1	0.01%/1d	×	-	×	×	7	○	○	×	○	
M04	804h	12h	Magnetic-flux command value	1	0.01%/1d	×	-	×	×	7	○	○	×	×	
M05	805h	13h	Output frequency command value	1	0.1Hz/1d	×	-	×	×	2	○	○	○	○	
M06	806h	14h	Detected speed value	1	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	○	○	×	○	
M07	807h	15h	Calculated torque value	1	0.01%/1d	×	-	×	×	7	○	○	○	○	
M08	808h	16h	Calculated torque current value	1	0.01%/1d	×	-	×	×	7	○	○	○	○	
M09	809h	17h	Output frequency	1	0.1 Hz/1d	×	-	×	×	2	○	○	○	○	
M10	80Ah	18h	Motor output	1	0.1 kW/1d	×	-	×	×	2	○	○	○	○	
M11	80Bh	19h	Effective output current value	1	0.1 A/1d	×	-	×	×	2	○	○	○	○	
M12	80Ch	1Ah	Effective output voltage value	1	0.1 V/1d	×	-	×	×	2	○	○	○	○	
M13	80Dh	1Bh	Run command (Final run command)	1	0000 to FFFF	×	-	×	×	32	○	○	○	○	
M14	80Eh	1Ch	Running Status	1	0000 to FFFF	×	-	×	×	21	○	○	○	○	
M15	80Fh	1Dh	Output terminals Y1 to Y18	1	0000 to FFFF	×	-	×	×	33	○	○	○	○	
M16	810h	1Eh	Latest alarm data (Multiple alarm, trip cause)	4	0000 to 5540	×	-	×	×	14	○	○	○	○	
M17	811h	1Fh	Latest alarm history	1	0000 to FF40	×	-	×	×	15	○	○	○	○	
M18	812h	20h	1st last alarm history	1	0000 to FF40	×	-	×	×	15	○	○	○	○	
M19	813h	21h	2nd last alarm history	1	0000 to FF40	×	-	×	×	15	○	○	○	○	
M20	814h	22h	Cumulative run time	7	0 to 65535 h	×	-	×	×	0	○	○	○	○	
M21	815h	23h	DC link bus voltage	1	1 V/1d	×	-	×	×	0	○	○	○	○	
M22	816h	24h	Motor temperature	1	1°C/1d	×	-	×	×	5	○	○	○	○	
M23	817h	25h	Model code	1	0000 to FFFF 200V series: 1313h 400V series: 1314h	×	-	×	×	29	○	○	○	○	
M24	818h	26h	Capacity code	1	0 to 34	×	-	×	×	28	○	○	○	○	
M25	819h	27h	Inverter ROM (Main control) version	1	0000 to FFFF	×	-	×	×	9	○	○	○	○	
M26	81Ah	28h	Communications error code	1	0000 to FFFF	×	-	×	×	34	○	○	○	○	
M27	81Bh	29h	Alarm (Latest) Speed command value	19	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	○	○	○	○	
M28	81Ch	2Ah	Alarm (Latest) Torque command value	1	0.01%/1d	×	-	×	×	7	○	○	×	○	
M29	81Dh	2Bh	Alarm (Latest) Torque current command value	1	0.01%/1d	×	-	×	×	7	○	○	×	○	
M30	81Eh	2Ch	Alarm (Latest) Magnetic-flux command value	1	0.01%/1d	×	-	×	×	7	○	○	×	×	
M31	81Fh	2Dh	Alarm (Latest) Output frequency command value	1	0.1 Hz/1d	×	-	×	×	2	○	○	○	○	
M32	820h	2Eh	Alarm (Latest) Detected speed value	1	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	○	○	×	○	
M33	821h	2Fh	Alarm (Latest) Calculated torque value	1	0.01%/1d	×	-	×	×	7	○	○	○	○	
M34	822h	30h	Alarm (Latest) Calculated torque current value	1	0.01%/1d	×	-	×	×	7	○	○	○	○	
M35	823h	31h	Alarm (Latest) Output frequency	1	0.1 Hz/1d	×	-	×	×	2	○	○	○	○	
M36	824h	32h	Alarm (Latest) Motor output	1	0.1 kW/1d	×	-	×	×	2	○	○	○	○	
M 37	825h	33h	Alarm (Latest) Effective output current value	1	0.1 A/1d	×	-	×	×	2	○	○	○	○	
M38	826h	34h	Alarm (Latest) Effective output voltage value	1	0.1 V/1d	×	-	×	×	2	○	○	○	○	
M39	827h	35h	Alarm (Latest) Run command	1	0000 to FFFF	×	-	×	×	32	○	○	○	○	
M40	828h	36h	Alarm (Latest) Running status	1	0000 to FFFF	×	-	×	×	21	○	○	○	○	
M41	829h	37h	Alarm (Latest) Output signals	1	0000 to FFFF	×	-	×	×	33	○	○	○	○	
M42	82Ah	38h	Alarm (Latest) Cumulative run time	1	0 to 65535 h	×	-	×	×	0	○	○	○	○	
M43	82Bh	39h	Alarm (Latest) DC link bus voltage	1	1 V/1d	×	-	×	×	0	○	○	○	○	
M44	82Ch	3Ah	Alarm (Latest) Inverter internal temperature	1	1°C/1d	×	-	×	×	5	○	○	○	○	
M45	82Dh	3Bh	Alarm (Latest) Cooling fin temperature	1	1°C/1d	×	-	×	×	5	○	○	○	○	
M46	82Eh	3Ch	Capacity of main circuit capacitor	3	0 to 100%	×	-	×	×	0	○	○	○	○	
M47	82Fh	3Dh	Service life of capacitor on PCB	1	0 to 65535 [10h]	×	-	×	×	0	○	○	○	○	
M48	830h	3Eh	Cooling fan service life	1	0 to 65535 [10h]	×	-	×	×	0	○	○	○	○	
M49	831h	3Fh	Speed setting 1 (before multistep speed command)	3	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	○	○	○	○	
M50	832h	40h	Speed setting 2 (before calculation of acceleration/deceleration)	1	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	○	○	○	○	
M51	833h	41h	Speed setting 3 (after speed limiting)	1	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	○	○	○	○	
M52	834h	42h	Control output 1	3	0000 to FFFF	×	-	×	×	125	○	○	○	○	
M53	835h	43h	Control output 2	1	0000 to FFFF	×	-	×	×	126	○	○	○	○	
M54	836h	44h	Control output 3	1	0000 to FFFF	×	-	×	×	127	○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
M55	837h	45h	Option monitor 1	6	0000 to FFFF	×	-	×	×	9	O	O	O	O	
M56	838h	46h	Option monitor 2	1	0000 to FFFF	×	-	×	×	9	O	O	O	O	
M57	839h	47h	Option monitor 3	1	0 to 65535	×	-	×	×	0	O	O	O	O	
M58	83Ah	48h	Option monitor 4	1	0 to 65535	×	-	×	×	0	O	O	O	O	
M59	83Bh	49h	Option monitor 5	1	-32768 to 32767	×	-	×	×	5	O	O	O	O	
M60	83Ch	4Ah	Option monitor 6	1	-32768 to 32767	×	-	×	×	5	O	O	O	O	
M61	83Dh	h	Current date, Year/Month	3	0000 to FFFF Upper 2 digits: Year, Lower 2 digits: Month	×	-	×	×	143	O	O	O	O	
M62	83Eh	h	Current date, Day/Hour	1	0000 to FFFF Upper 2 digits: Day, Lower 2 digits: Hour	×	-	×	×	144	O	O	O	O	
M63	83Fh	h	Current date, Minute/Second	1	0000 to FFFF Upper 2 digits: Minute, Lower 2 digits: Second	×	-	×	×	145	O	O	O	O	
M64	840h	h	Date of occurrence of (Latest) alarm, Year/Month	3	0000 to FFFF Upper 2 digits: Year, Lower 2 digits: Month	×	-	×	×	143	O	O	O	O	
M65	841h	h	Date of occurrence of (Latest) alarm, Day/Hour	1	0000 to FFFF Upper 2 digits: Day, Lower 2 digits: Hour	×	-	×	×	144	O	O	O	O	
M66	842h	h	Date of occurrence of (Latest) alarm, Minute/Second	1	0000 to FFFF Upper 2 digits: Minute, Lower 2 digits: Second	×	-	×	×	145	O	O	O	O	
M67	843h	h	Date of removal of (Latest) alarm, Year/Month	3	0000 to FFFF Upper 2 digits: Year, Lower 2 digits: Month	×	-	×	×	143	O	O	O	O	
M68	844h	h	Date of removal of (Latest) alarm, Day/Hour	1	0000 to FFFF Upper 2 digits: Day, Lower 2 digits: Hour	×	-	×	×	144	O	O	O	O	
M69	845h	h	Date of removal of (Latest) alarm, Minute/Second	1	0000 to FFFF Upper 2 digits: Minute, Lower 2 digits: Second	×	-	×	×	145	O	O	O	O	
M70	846h	h	(Latest) Alarm extension ID	18	0 to 1 0 Occurred in local unit 1: Occurred in other unit	×	-	×	×	212	O	O	O	O	
M71	847h	h	(Latest) Multiple alarm, 2nd	1	0000 to FFFF	×	-	×	×	14	O	O	O	O	
M72	848h	h	(Latest) Multiple alarm, 3rd	1	0000 to FFFF	×	-	×	×	14	O	O	O	O	
M73	849h	h	(Latest) Multiple alarm, 4th	1	0000 to FFFF	×	-	×	×	14	O	O	O	O	
M74	84Ah	h	(Latest) Multiple alarm, 5th	1	0000 to FFFF	×	-	×	×	14	O	O	O	O	
M75	84Bh	h	(Latest) Alarm, subcode	1	0000 to FFFF	×	-	×	×	9	O	O	O	O	
M76	84Ch	h	(Latest) Alarm, maximum speed	1	0 to 65535 r/min	×	-	×	×	0	O	O	O	O	
M77	84Dh	h	(Latest) Alarm, input power	1	0.0 to 6553.5 kW	×	-	×	×	2	O	O	O	O	
M78	84Eh	h	(Latest) Alarm, motor temperature	1	1°C/1d	×	-	×	×	5	O	O	O	O	
M79	84Fh	h	(Latest) Alarm, running status 2 (a)	1	0000 to FFFF	×	-	×	×	141	O	O	O	O	
M80	850h	h	(Latest) Alarm, running status 2 (b)	1	0000 to FFFF	×	-	×	×	142	O	O	O	O	
M81	851h	h	Alarm (Latest) Run command (Communications link)	1	0000 to FFFF	×	-	×	×	32	O	O	O	O	
M82	852h	h	Alarm (Latest) Run command 2 (Communications link)	1	0000 to FFFF	×	-	×	×	9	O	O	O	O	
M83	853h	h	Alarm (Latest) For manufacturer	1	0000 to FFFF	×	-	×	×	9	O	O	O	O	
M84	854h	h	Alarm (Latest) M1 Number of startups	1	0 to 65535 times	×	-	×	×	0	O	O	O	O	
M85	855h	h	Alarm (Latest) M2 Number of startups	1	0 to 65535 times	×	-	×	×	0	O	O	O	O	
M86	856h	h	Alarm (Latest) M3 Number of startups	1	0 to 65535 times	×	-	×	×	0	O	O	O	O	
M87	857h	h	Alarm (Latest) EN terminal input	1	0000 to FFFF	×	-	×	×	100	O	O	O	O	
M93	85Dh	h	Light alarm (Latest)	4	0 to 255	×	-	×	×	102	O	O	O	O	
M94	85Eh	h	Light alarm (1st last)	1	0 to 255	×	-	×	×	102	O	O	O	O	
M95	85Fh	h	Light alarm (2nd last)	1	0 to 255	×	-	×	×	102	O	O	O	O	
M96	860h	h	Light alarm (3rd last)	1	0 to 255	×	-	×	×	102	O	O	O	O	
M98	862h	h	EN terminal input	0	0000 to FFFF	×	-	×	×	100	O	O	O	O	
M100	2900h	h	Effective parameter set condition	0	0000 to FFFF	×	-	×	×	9	O	O	O	O	
M101	2901h	h	Run command 2 (Communications link)	0	0000 to FFFF Monitors X terminal functions to be used exclusively via the communications link.	×	-	×	×	32	O	O	O	O	
M102	2902h	h	Load factor	0	-327.68 to 327.67% Motor load factor, Motor rated load/100%	×	-	×	×	7	O	O	O	O	
M103	2903h	h	Input power	0	0.0 to 6553.5kW Input power to inverter	×	-	×	×	2	O	O	O	O	
M104	2904h	h	Running status 2(a)	0	0000 to FFFF	×	-	×	×	141	O	O	O	O	
M105	2905h	h	Running status 2(b)	0	0000 to FFFF	×	-	×	×	142	O	O	O	O	
M106	2906h	h	Detected load shaft speed value	0	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	O	O	O	O	
M107	2907h	h	Detected line speed value	0	-32000 to 32000 : (data)*Nmax/20000 r/min	×	-	×	×	5	O	O	O	O	
M108	2908h	h	PID command value	0	-327.68 to 327.67%	×	-	×	×	7	O	O	O	O	
M109	2909h	h	PID feedback amount	0	-327.68 to 327.67%	×	-	×	×	7	O	O	O	O	
M110	290Ah	h	PID output value	0	-327.68 to 327.67%	×	-	×	×	7	O	O	O	O	
M112	290Ch	h	Remaining allowance for M1 motor overload	3	0 to 65535% When M112 = 0 (%), the inverter issues OL1 alarm.	×	-	×	×	0	O	O	O	O	
M113	290Dh	h	Remaining allowance for M2 motor overload	1	0 to 65535% When M113 = 0 (%), the inverter issues OL2 alarm.	×	-	×	×	0	O	O	O	O	

Function codes	Communications address 485 No.	Communications address Link No.	Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/Disable PG	LES	VF	SM	Remarks
M114	290Eh	h	Remaining allowance for M3 motor overload	1	0 to 65535% When M114 = 0 (%), the inverter issues OL3 alarm.	×	-	×	×	0	○	○	○	○	
M115	290Fh	h	Input watt-hour * Invalid for use in stack type	4	0.000 to 9999 100 kWh/1.000d Limited at 999900 kWh.	×	-	×	×	101	○	○	○	○	
M116	2910h	h	Input watt-hour data * Invalid for use in stack type	1	0000 to 9999 100 kWh/1.000d *Display coefficient M115 "input watt-hour" x F84 "Display coefficient for input watt-hour data" Specifying the electric rate per 100 kWh with F84 shows the input watt-hour data.	×	-	×	×	101	○	○	○	○	
M117	2911h	h	Input watt-hour (Lower 16 bits) *Invalid for use in stack type	1	(81920d/unit 100% rating) [kW] x Cumulative time [s] x 2^(-16)	×	-	×	×	9	○	○	○	○	
M118	2912h	h	Input watt-hour (Upper 16 bits) *Invalid for use in stack type	1	(81920d/unit 100% rating) [kW] x Cumulative time [s] x 2^(-32)	×	-	×	×	9	○	○	○	○	
M119	2913h	h	Inverter internal temperature (Real-time value)	2	-32768 to 32767°C	×	-	×	×	5	○	○	○	○	
M120	2914h	h	Cooling fin temperature (Real-time value)	1	-32768 to 32767°C	×	-	×	×	5	○	○	○	○	
M121	2915h	h	Main circuit capacitor life (Elapsed time)	0	0 to 65535 [10h]	×	-	×	×	0	○	○	○	○	
M123	2917h	h	M1 Number of startups	3	0 to 65535 times	×	-	×	×	0	○	○	○	○	
M124	2918h	h	M2 Number of startups	1	0 to 65535 times	×	-	×	×	0	○	○	○	○	
M125	2919h	h	M3 Number of startups	1	0 to 65535 times	×	-	×	×	0	○	○	○	○	
M126	291Ah	h	M1 Cumulative motor run time	3	0 to 65535 [10h]	×	-	×	×	0	○	○	○	○	
M127	291Bh	h	M2 Cumulative motor run time	1	0 to 65535 [10h]	×	-	×	×	0	○	○	○	○	
M128	291Ch	h	M3 Cumulative motor run time	1	0 to 65535 [10h]	×	-	×	×	0	○	○	○	○	
M129	291Dh	h	Run command (Communications link)	0	0000 to FFFF	×	-	×	×	32	○	○	○	○	
M130	291Eh	h	Torque bias	0	-327.68 to 327.67%	×	-	×	×	7	○	○	×	○	
M131	291Fh	h	Magnetic pole position signal	0	-32768 to 32767	×	-	×	×	5	×	×	×	○	
M132	2920h	h	Universal AO1	0	0000 to FFFF	×	-	×	×	9	○	○	○	○	
M133	2921h	h	Option AO1	0	0000 to FFFF	×	-	×	×	9	○	○	○	○	
M134	2922h	h	Control input 1	0	0000 to FFFF	×	-	×	×	133	○	○	○	○	
M135	2923h	h	Control input 2	0	0000 to FFFF	×	-	×	×	134	○	○	○	○	
M136	2924h	h	Control input 3	0	0000 to FFFF	×	-	×	×	135	○	○	○	○	
M137	2925h	h	Control input 4	0	0000 to FFFF	×	-	×	×	136	○	○	○	○	
M138	2926h	h	Control input 5	0	0000 to FFFF	×	-	×	×	137	○	○	○	○	
M139	2927h	h	Control input 6	0	0000 to FFFF	×	-	×	×	138	○	○	○	○	
M140	2928h	h	Control input 7	0	0000 to FFFF	×	-	×	×	139	○	○	○	○	
M141	2929h	h	Control input 8	0	0000 to FFFF	×	-	×	×	140	○	○	○	○	
M142	292Ah	h	Control output 4	0	0000 to FFFF (bit 0: E-SX bus tact synchronizing signal)	×	-	×	×	128	○	○	○	○	
M143	292Bh	h	Control output 5	0	0000 to FFFF	×	-	×	×	129	○	○	○	○	
M144	292Ch	h	Control output 6	0	0000 to FFFF	×	-	×	×	130	○	○	○	○	
M146	292Eh	h	Detected speed value 2	0	-32000 to 32000 r/min	×	-	×	×	5	○	○	×	○	
M147	292Fh	h	Exciting current command	0	-327.68 to 327.67%	×	-	×	×	7	○	○	×	×	
M148	2930h	h	Detected exciting current	0	-327.68 to 327.67%	×	-	×	×	7	○	○	×	×	
M149	2931h	h	Magnetic-flux calculation	0	0.00 to 655.35%	×	-	×	×	3	○	○	×	×	
M161	293Dh	h	Ai adjustment value (12)	5	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M162	293Eh	h	Ai adjustment value (Ai1)	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M163	293Fh	h	Ai adjustment value (Ai2)	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M164	2940h	h	Ai adjustment value (Ai3)	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M165	2941h	h	Ai adjustment value (Ai4)	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M166	2942h	h	Input signal (Terminal)	0	0000 to FFFF	×	-	×	×	32	○	○	○	○	
M167	2943h	h	Analog input signal (12)	3	-32768 to 32767 (-16384 to 16384: -10 V to +10 V)	×	-	×	×	5	○	○	○	○	
M168	2944h	h	Analog input signal (Ai1)	1	-32768 to 32767 (-16384 to 16384: -10 V to +10 V)	×	-	×	×	5	○	○	○	○	
M169	2945h	h	Analog input signal (Ai2)	1	-32768 to 32767 (-16384 to 16384: -10 V to +10 V)	×	-	×	×	5	○	○	○	○	
M170	2946h	h	Analog output signal (Ao1)	3	-32768 to 32767 (-16384 to 16384: -10 V to +10 V)	×	-	×	×	5	○	○	○	○	
M171	2947h	h	Analog output signal (Ao2)	1	-32768 to 32767 (-16384 to 16384: -10 V to +10 V)	×	-	×	×	5	○	○	○	○	
M172	2948h	h	Analog output signal (Ao3)	1	-32768 to 32767 (-16384 to 16384: -10 V to +10 V)	×	-	×	×	5	○	○	○	○	
M173	2949h	h	AIO Input/Output status 1 (Ai3)	4	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M174	294Ah	h	AIO Input/Output status 1 (Ai4)	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M175	294Bh	h	AIO Input/Output status 2 (Ao4)	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M176	294Ch	h	AIO Input/Output status 2 (Ao5)	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M177	294Dh	h	PG (SD) input pulse	4	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M178	294Eh	h	PG (LD) input pulse	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M179	294Fh	h	PG (PR) input pulse	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M180	2950h	h	PG (PD) input pulse	1	-32768 to 32767	×	-	×	×	5	○	○	○	○	
M181	2951h	h	DIOA input status (Terminal)	0	0000 to FFFF	×	-	×	×	146	○	○	○	○	
M182	2952h	h	DIOA input status (Via communications link)	0	0000 to FFFF	×	-	×	×	146	○	○	○	○	
M183	2953h	h	DIOB optional input status	0	0000 to FFFF	×	-	×	×	26	○	○	○	○	
M184	2954h	h	DIOB optional output status	0	0000 to FFFF	×	-	×	×	27	○	○	○	○	
M193	295Dh	h	General-purpose setting 1 monitor (To be supported soon)	0	-32768 to 32767 Monitors the S16 setting value.	×	-	×	×	5	○	○	○	○	

Function codes	Communications address		Name	Dir	Data setting range	Change when running	Factory default value	Data copying	Initialization	Classification	Control method: Enable/ Disable				Remarks
	485 No.	Link No.									PG	LES	VF	SM	
M194	295Eh	h	General-purpose setting 1 monitor (To be supported soon)	0	-32768 to 32767 Monitors the S17 setting value.	×	-	×	×	5	○	○	○	○	
M200	2A00h	h	Pulse-train position command monitor	5	0000 to FFFF	×	-	×	×	9	○	×	×	○	
M201	2A01h	h	Detected position monitor	1	0000 to FFFF	×	-	×	×	9	○	×	×	○	
M202	2A02h	h	Detected position (Z-phase input) monitor	1	0000 to FFFF	×	-	×	×	9	○	×	×	○	
M220	2A14h	h	Load weighting speed limit	3	-32000 to 32000: (data)*Nmax/20000 r/min	×	-	×	×	5	○	○	×	○	
M221	2A15h	h	Hoisting load calculation result monitor	1	0 to 65535 kg	×	-	×	×	0	○	○	×	○	
M222	2A16h	h	Travel torque calculation monitor	1	-327.68 to 327.67%	×	-	×	×	7	○	○	×	○	

8.1.2 Control block diagrams

Refer to "4.1 Control block diagrams" in Chapter 4 of the separate volume "Unit Type Function Code Edition" (24A7-☐-0019).

8.1.3 Function code details

Refer to "4.3 Function code details" in Chapter 4 of separate volume "Unit Type Function Code Edition" (24A7-☐-0019).

8.2 Keypad and test run

8.2.1 Operating from the keypad

Refer to "3.4 Operating from the keypad" in Chapter 3 of separate volume "Unit Type Function Code Edition" (24A7-☐-0019).

8.2.2 Trial operation procedures

Refer to "3.5 Trial operation procedures" in Chapter 3 separate volume "Unit Type Function Code Edition" (24A7-☐-0019).

8.3 Using standard RS-485

8.3.1 Standard RS-485 communication port

Refer to "5.1 Standard RS-485 communication port" in Chapter 5 of the separate volume "Option Edition" (24A7-☐-0045).

8.3.2 Fuji general purpose communication

Refer to "5.2 Fuji general purpose communication" in Chapter 5 of the separate volume "Option Edition" (24A7-☐-0045).

8.3.3 Modbus RTU

Refer to "5.3 Modbus RTU" in Chapter 5 of the separate volume "Option Edition" (24A7-☐-0045).

8.4 FRENIC-VG Loader (Free version)

Refer to the separate volume "FRENIC-VG Loader (Free version) Instruction Manual (INR-SI47-1588∗)".

8.5 Control options

Refer to Chapter 6 "Control Options" of the separate volume "Option Edition" (24A7-☐-0045).

FRENIC-VG

9

Chapter 9 Selecting Model

9.1 Guidance for capacity selection

9.1.1 Selection of capacity for motor and inverter

9.1.1.1 Output torque characteristics

Figure 9.1-1 shows the output torque characteristics for the motor dedicated to FRENIC-VG. The characteristics are shown in the following quadrants according to speed and torque polarity.

	(Speed)	(Torque)	
• Quadrant 1:	+	+	•••Normal rotation drive
• Quadrant 2:	-	+	•••Reverse braking
• Quadrant 3:	-	-	•••Reverse rotation drive
• Quadrant 4:	+	-	•••Normal rotation braking

Speed: 100% at motor base speed
Torque: 100% at continuous rated torque

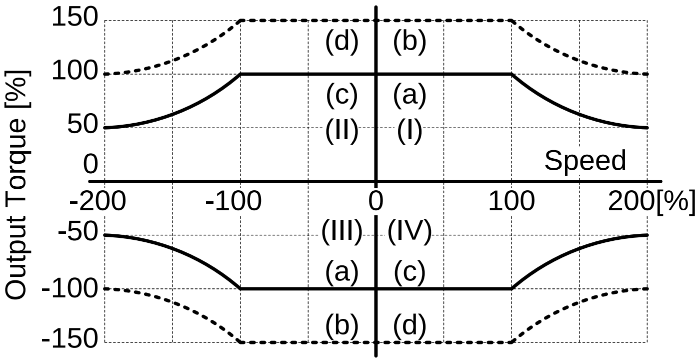


Figure 9.1-1: Output torque characteristics (MD specification)

(1) Consecutively allowable torque **Curve [a] of quadrants 1 and 3**

Curve (a) shows the torque which can be consecutively output in drive mode. When the speed is under base speed (100%) in the speed control range (0 to 200%), rated output torque (100%) can be output. When speed is over base speed (100%), the constant output characteristic curve applies and the torque becomes inversely proportional, decreasing in magnitude.

Especially in "very low speed under speed control range," the allowable torque decreases due to restrictions imposed by the temperature rise inside the inverter. The value is 80% using inverter output frequency conversion at under 0.1 Hz. When operating the induction motor at under 0.1 Hz, consecutive operation is possible at under 0.1 Hz if the slipping is taken into account. When operating the synchronous motor at under 0.1 Hz, the operation must consider the decrease in torque because the speed is synchronized.

(2) Short duration maximum braking torque **Curve [b] of quadrants 1 and 3**

Curve (b) shows the allowable output torque for short durations (60s) in drive mode and is generally used in acceleration and deceleration. The magnitude can be 150% of the consecutive rated torque.

Especially in "very low speed under speed control range," the allowable torque decreases due to the restrictions imposed by the temperature rise inside the inverter. The value is 100% when using inverter output frequency conversion at under 0.1 Hz.

(3) Starting torque **near zero speed of quadrants 1 and 3**

The torque near zero speed in quadrants 1 and 3 is the starting torque. The consecutive output torque is 80%, but the starting activity passes through the very slow speed range in a short duration under 30s, so the starting torque is 150%.

(4) Braking torque **quadrants 2 and 4**

Quadrants 2 and 4 show the range of "braking mode." Curve (c) shows the braking torque which can be output in the consecutive rated current range of the inverter, and curve (d) shows the braking torque which can be output by the 60s rated current. The decrease of the output torque (80%) in the very slow speed range is the same as in the case of drive mode.

The time rating of the braking torque is determined by the other dominating condition. As the mechanical energy is regenerated in braking mode, the time rating of the "braking resistor" or the "braking resistance unit" becomes critical.

The time rating of the braking resistor is described in this manual or the catalog as allowance (kW) from the perspective of typical electrical discharge loss and the allowance (kWs) from the perspective of discharge withstand current rating.

🕮 Refer to Chapter 6 "6.5 Braking system (braking unit, braking resistor)" for braking-related values when the combination of the braking units and braking resistors is standard.

9.1.1.2 Procedures for capacity selection

Figure 9.1-2 Procedures for capacity selection (flowchart) shows a typical procedure for selecting capacity. The steps numbered from **(1)** to **(5)** in the flowchart are described in detail on the following pages.

Capacity can be selected easily when restrictions to acceleration and deceleration time are not applied in the selection. The procedure becomes slightly complicated when "a constant restriction is applied to acceleration and deceleration time" or when "acceleration and deceleration are performed frequently."

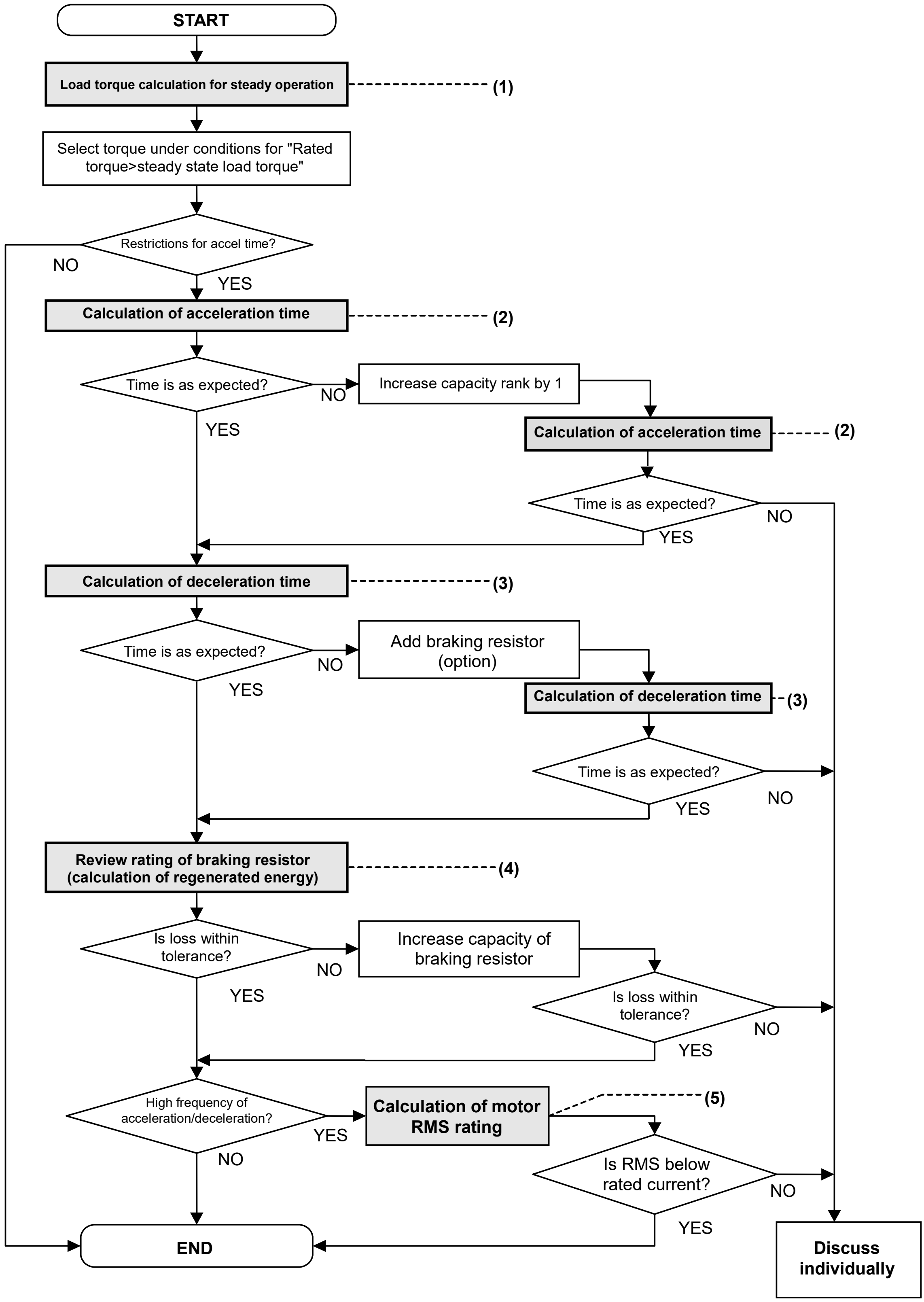


Figure 9.1-2: Procedures for capacity selection

(1) Load torque calculation for rated operation (Refer to Section 9.1.2.1 for calculation details)

"Load torque for steady operation" is the converted motor axis torque required to rotate the load at a constant rotation speed. This is calculated considering the reduction gear efficiency (η_G).

$$\text{"Load torque at constant speed operation" in drive mode} = \frac{\text{Actual load torque } \tau_L}{\text{Reduction gear efficiency } \eta_G}$$

$$\text{"Load torque at constant speed operation" in braking mode} = \text{Actual load torque } \tau_L \times \text{Reduction gear efficiency } \eta_G$$

This calculation must be performed when selecting the capacity for any load.

The load torque at constant speed operation is calculated, and the capacity is temporarily selected such that the motor's consecutive rated torque exceeds this value. Capacity without excess can be selected when the motor's rated rotation speed (especially the base speed) is matched to the load's rated rotation speed (base speed). To match this rated rotation speed, appropriate "transmission gear ratio" and "number of motor poles" must be selected.

When restrictions are not applied to acceleration and deceleration times and the load is not for elevators, the previously mentioned temporary capacity should be used.

(2) Calculation of the acceleration time (Refer to Section 9.1.2.2 for calculation details)

When a constant requirement is imposed on acceleration time, this calculation is performed. The calculation is performed according to the following procedure.

1) Calculate the load and the motor "Moment of inertia."

If the moment of inertia is large, acceleration becomes difficult, requiring longer acceleration time. Calculate the "load moment of Inertia" referring to "9.1.2.2 Calculation of acceleration and deceleration time." Refer to the motor catalog for the "motor moment of inertia."

2) Calculate the "Minimum acceleration torque." (See Figure 9.1-3)

The difference between the one minute rated value for "9.1.1.1 (2) Short Duration Maximum Drive Torque" and the "Load torque for constant speed operation" calculated above in (1) is the "acceleration torque." Seek the value which minimizes this "acceleration torque" throughout the entire operation pattern with varying speed.

Exercise caution as the torque decreases inversely proportional to speed at speed exceeding the motor rated rotation speed.

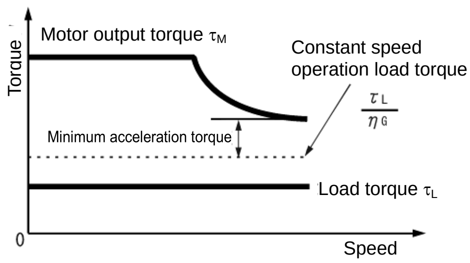


Figure 9.1-3: Example of minimizing acceleration torque

3) Calculate the "Acceleration time."

Substitute the above value into equation (9.1.2-15) in "9.1.2.2 Calculation of acceleration and deceleration time" to compute the acceleration time.

When the acceleration time does not satisfy the requirement, increase the capacity of the inverter and the motor by one rank and perform the calculation again.

(3) Calculation of the deceleration time (Refer to Section 9.1.2.2 for calculation details)

Calculate the deceleration time as in the case of acceleration time by researching the deceleration torque characteristics of the motor throughout the entire range of varying speed.

1) Calculate the "Moment of inertia" of the load and the motor.

This is the same as in the case of acceleration time. When the moment of inertia is large, the deceleration time increases.

2) Calculate the "Minimum deceleration torque." (Refer to Figure 9.1-4 and Figure 9.1-5)

When the load torque is positive, see Figure 9.1-4.

When the load torque is negative in cases such as the braking load in elevators, see Figure 9.1-5. Exercise caution in this case as the minimum deceleration torque is decreased due to the regeneration activity.

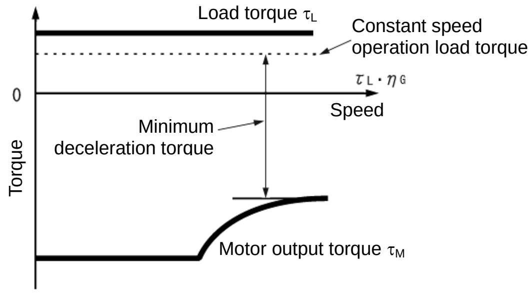


Figure 9.1-4: Example of minimizing deceleration torque (1)

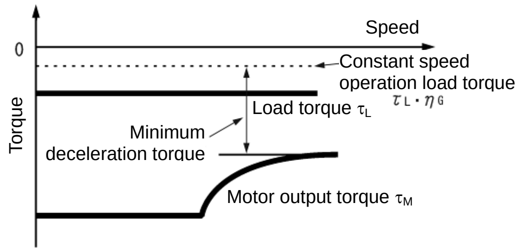


Figure 9.1-5: Example of minimizing deceleration torque (2)

3) Calculate the "Deceleration time."

As in the case of acceleration time, substitute the above value into equation (9.1.2-16) to calculate the deceleration time. When the deceleration time does not satisfy the requirement, increase the capacity of the inverter and motor by one rank and perform the calculation again.

(4) Review of the braking resistor rating (Refer to Section 9.3.3.1 for calculation details)

Review of the braking resistor rating can be divided into two types depending on the repeat period of the braking.

1) Repeat period is under 100s	Calculate the average loss and review the value.
2) Repeat period is over 100s	The allowable braking energy is determined by the maximum regenerated capacity at braking. Chapter 6 "6.5 Braking system (braking unit, braking resistor)" shows the list of allowances.

(5) Calculation of the motor RMS rating (refer to Section 9.1.2.3 for calculation details)

In metalworking machineries or conveying equipment which require positioning control, operation is repeated at high frequency in short duration rating conditions.
In these cases, calculate the maximum equivalent RMS current (actual current) and confirm that this value is within the tolerance (rated current value) of the motor.

Precautions in reviewing capacity

When driving the FRENIC-VG exclusive motor, select the capacity such that the mean-square value of the torque is below 100% of the rated torque.
When driving general-purpose motors, select the capacity such that the mean-square value of the current, which takes into account the motor cooling efficiency, is less than the motor rated current. Select the inverter such that the mean-square value of the current is less than the inverter rated current value.

9.1.2 Equation for capacity selection

9.1.2.1 Calculation of load torque for rated operation

(1) General equation

The details of the torque calculation method will be explained for cases where the motor drives a load which moves linearly.
When the force required to move a linear motion object at constant velocity V [m/s] is F [N] and the motor speed driving this is N_M [r/min], the required motor output torque τ_M [N·m] is defined by the following equation (9.1.2-1).

$$\tau_M = \frac{60}{2\pi \cdot N_M} \cdot \frac{F}{\eta_G} \quad [N \cdot m] \qquad \cdots \quad (9.1.2\text{-}1)$$

η_G: transmission efficiency

When the motor is in braking mode, the efficiency operates in the reverse direction. In this case, the required motor torque τ_M [N·m] changes as described in equation (9.1.2-2).

$$\tau_M = \frac{60 \cdot v}{2\pi \cdot N_M} \cdot F \cdot \eta_G \quad [N \cdot m] \qquad \cdots \quad (9.1.2\text{-}2)$$

The expression $(60 \cdot V)/(2\pi \cdot N_M)$ is the equivalent rotation radius corresponding to the motor axis rotation speed V [m/s].
Additionally, the F [N] in this general equation changes as follows depending on the type of load.

(2) Approach for handling the required force F

■ **Case of horizontal transport load**

For simplicity, assume the physical configuration for horizontal transport as shown in Figure 9.1-6. If the table mass is WO [kg], payload is W [kg], and the coefficient of friction is μ, then the frictional force F [N] can be expressed by the equation (9.1.2-3).
This frictional force is the force required to drive the horizontal transport load.

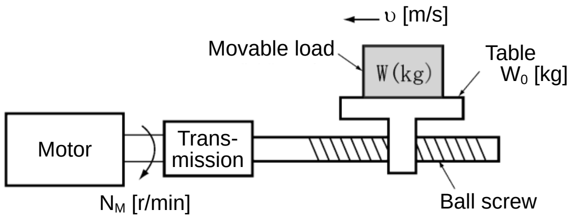


Figure 9.1-6: General diagram of horizontal transport load

$$F = (Wo + W) \cdot g \cdot \mu \quad [N] \qquad \cdots \quad (9.1.2\text{-}3)$$

g: gravitational acceleration (≈ 9.8 (m/s²))

Therefore, the driving torque τ_M [N·m] at the motor axis can be expressed as in equation (9.1.2-4).

$$\tau_M = \frac{60 \cdot v}{2\pi \cdot N_M} \cdot \frac{(Wo + W) \cdot g \cdot \mu}{\eta_G} \quad [N \cdot m] \qquad \cdots \quad (9.1.2\text{-}4)$$

■ **Case of vertical elevator load**

For simplicity, assume that the physical configuration for the vertical elevator is shown in Figure 9.1-7.
If the masses of the cage, payload, and the balance weight are WO, W, and W_B [kg] respectively, the force required for the vertical elevator load F [N] can be expressed by equation (9.1.2-5) and equation (9.1.2-6).

[Ascent]

$$F = (Wo + W - W_B) \cdot g \ [N] \ \cdots \quad (9.1.2\text{-}5)$$

[Descent]

$$F = (Wo - W - W_B) \cdot g \ [N] \ \cdots \quad (9.1.2\text{-}6)$$

When the maximum loading capacity is Wmax, the balance weight mass is generally W_B = Wo + W_{max}/2.
Depending on the mass of the movable load, braking modes can exist in both ascending and descending movements where F [N] can become negative, so exercise caution.

The calculation of the required torque τ at the motor axis should be performed using the appropriate formula from equation (9.1.2-1) and equation (9.1.2-2) according to the drive mode or the braking mode. In other words, when F [N] is positive, use equation (9.1.2-1) and use equation (9.1.2-2) when the value is negative, to perform the calculation.

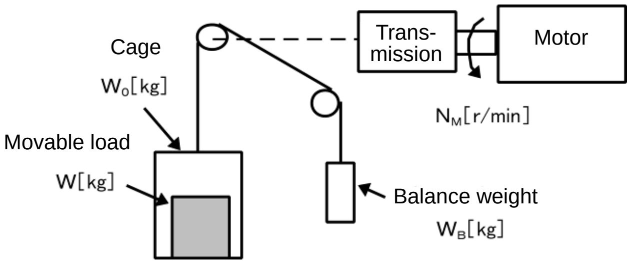


Figure 9.1-7: General diagram for vertical elevator load

■ **Case of inclined elevator load**

The case of inclined elevators is similar to the case of vertical elevators. However, the frictional force cannot be ignored, so the equation form changes between ascending and descending movements. When the inclination angle is θ as in Figure 9.1-8 and the coefficient of friction is μ, the force F [N] required to drive is shown by the following equations.

[Ascent]

$$F = [(Wo + W - W_B)(\sin\theta + \mu \cdot \cos\theta) - W_B] \cdot g \ [N] \ \cdots \quad (9.1.2\text{-}7)$$

[Descent]

$$F = [W_B - (Wo + W)(\sin\theta + \mu \cdot \cos\theta)] \cdot g \ [N] \ \cdots \quad (9.1.2\text{-}8)$$

As in the case of vertical elevators, braking mode exists in both ascending and descending movements depending on the mass of the movable load. The calculation for the required motor axis torque is also identical.

In other words, use equation (9.1.2-1) when F [N] is positive and use equation (9.1.2-2) when the value is negative, to perform the calculation.

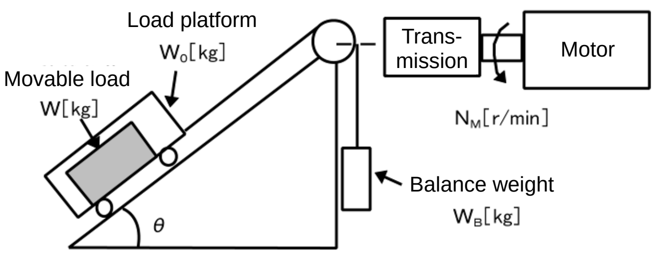


Figure 9.1-8: General diagram for inclined elevator load

9.1.2.2 Calculation of acceleration and deceleration time

When an object with moment of inertia J [kg·m^2] is rotating at speed N [r/min], the rotating object has kinetic energy defined by equation (9.1.2-9).

$$E = \frac{J}{2} \cdot \left(\frac{2\pi \cdot N}{60} \right)^2 \ [J] \quad \cdots \quad (9.1.2\text{-}9)$$

In trying to accelerate this rotating object, the kinetic energy is enlarged. Conversely, in trying to decelerate this object, the kinetic energy must be released. The torque required to accelerate and decelerate is given in equation (9.1.2-10).

$$\tau = J \cdot \frac{2\pi}{60} \cdot \left(\frac{d_N}{dt} \right) \ [N \cdot m] \quad \cdots \quad (9.1.2\text{-}10)$$

In accelerating and decelerating movements, the mechanical moment of inertia is an important factor. The calculation method for the inertia is clarified first, and the description of calculation for acceleration and deceleration will follow.

(1) Calculation of the moment of inertia

For objects rotating around a rotating axis, the moment of inertia for that object can be computed by first decomposing it to micro parts. Then, multiply the square of the distance from the rotating axis to the micro part with the mass and sum up all of the products. The moment of inertia of the object is the summation value. Moment of inertia J can be calculated by the following equation.

$$J = \sum (Wi \cdot ri2) \ [kg \cdot m^2] \quad \cdots \quad (9.1.2\text{-}11)$$

Next, the calculation equation for the moment of inertia of the load or load systems with various shapes is described.

1) Cylinders and cylindrical columns

Cylinder is the most typical shape of rotating objects. Figure 9.1-9 shows an object with external and internal diameters at D1 and D2 [m] respectively and the total mass weighing W [kg]. The moment of inertia J [kg·m^2] around the center axis of the cylinder can be calculated by the equation (9.1.2-12).

$$J = \frac{\mathrm{W} \cdot (\mathrm{D1}^2 + \mathrm{D2}^2)}{8} \ [kg \cdot m^2] \quad \cdots \quad (9.1.2\text{-}12)$$

Similarly, cylindrical columns are calculated with internal diameter D2 = 0.

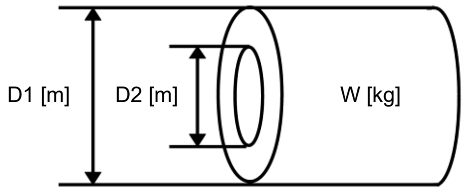


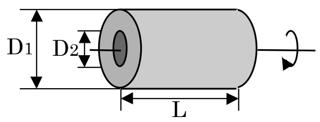
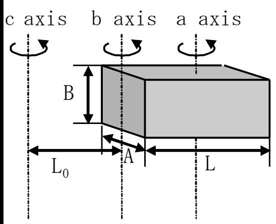
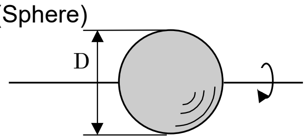
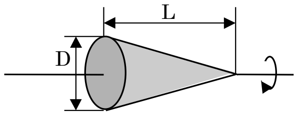
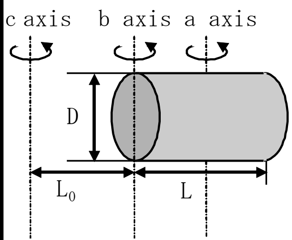
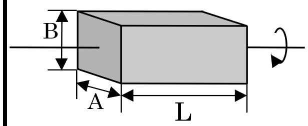
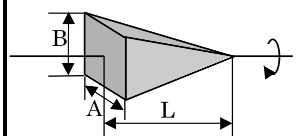
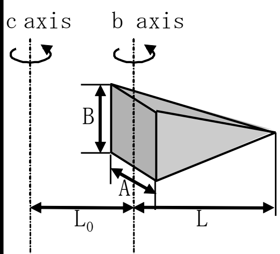
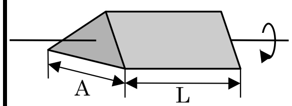
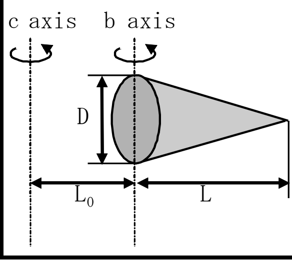
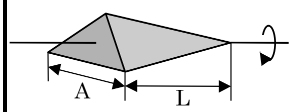
Figure 9.1-9: Cylinder

Chapter 9 Selecting Model

2) Case of general rotating objects

Table 9.1-1 shows equations for "calculating moment of inertia J [kg・m^2] of various rotating objects" including the rotating cylindrical object described above.

Table 9.1-1: Moment of inertia of various rotating objects

Form	Mass W [kg] / Moment of Inertia J [kg•m^2]	Form	Mass W [kg] / Moment of Inertia J [kg•m^2]
(Cylinder) 	$W=\frac{\pi}{4}\cdot(D_1^{\,2}-D_2^{\,2})\cdot L\cdot\rho$ $J=\frac{1}{8}\cdot W\cdot(D_1^{\,2}+D_2^{\,2})$		$W=A\cdot B\cdot L\cdot\rho$ $J_a=\frac{1}{12}\cdot W\cdot(L^2+A^2)$ $J_b=\frac{1}{12}\cdot W\cdot(L^2+\frac{1}{4}\cdot A^2)$ $J_c\approx W\cdot(L_0^{\,2}+L_0\cdot L+\frac{1}{3}\cdot L^2)$
(Sphere) 	$W=\frac{\pi}{6}\cdot D^3\cdot\rho$ $J=\frac{1}{10}\cdot W\cdot D^2$		
(Circular cone) 	$W=\frac{\pi}{12}\cdot D^2\cdot L\cdot\rho$ $J=\frac{3}{40}\cdot W\cdot D^2$		$W=\frac{\pi}{4}\cdot D^2\cdot L\cdot\rho$ $J_a=\frac{1}{12}\cdot W\cdot(L^2+\frac{3}{4}\cdot D^2)$ $J_b=\frac{1}{3}\cdot W\cdot(L^2+\frac{3}{16}\cdot D^2)$ $J_c\approx W\cdot(L_0^{\,2}+L_0\cdot L+\frac{1}{3}\cdot L^2)$
(Quadrangular prism) 	$W=A\cdot B\cdot L\cdot\rho$ $J=\frac{1}{12}\cdot W\cdot(A^2+B^2)$		
(Quadrangular pyramid) 	$W=\frac{1}{3}\cdot A\cdot B\cdot L\cdot\rho$ $J=\frac{1}{20}\cdot W\cdot(A^2+B^2)$		$W=\frac{1}{3}\cdot A\cdot B\cdot L\cdot\rho$ $J_b=\frac{1}{10}\cdot W\cdot(L^2+\frac{1}{4}\cdot A^2)$ $J_c\approx W\cdot(L_0^{\,2}+\frac{3}{2}\cdot L_0\cdot L+\frac{3}{5}\cdot L^2)$
(Equilateral triangular prism) 	$W=\frac{\sqrt{3}}{4}\cdot A^2\cdot L\cdot\rho$ $J=\frac{1}{3}\cdot W\cdot A^2$		$W=\frac{\pi}{12}\cdot D^2\cdot L\cdot\rho$ $J_b=\frac{1}{10}\cdot W\cdot(L^2+\frac{3}{8}\cdot D^2)$ $J_c\approx W\cdot(L_0^{\,2}+\frac{3}{2}\cdot L_0\cdot L+\frac{3}{5}\cdot L^2)$
(Equilateral trigonal pyramid) 	$W=\frac{\sqrt{3}}{12}\cdot A^2\cdot L\cdot\rho$ $J=\frac{1}{5}\cdot W\cdot A^2$		

* Density of major metals (at 20°C) ρ[kg/m^3] Steel: 7860, Copper: 8940, Aluminum: 2700

3) Case of traveling load

Suppose that a moving table driven by a motor exists as shown in Figure 9.1-6. If the motor rotates at speed N_M [r/min] when the table speed is V [m/s] and the equivalent distance from the rotating axis is $60 \cdot V/(2\pi \cdot N_M)$ [m], the moment of inertia of the table from the rotating axis can be calculated by equation (9.1.2-13).

$$J = \left(\frac{60 \cdot v}{2\pi \cdot N_M} \right)^2 \cdot (Wo + W) \ [kg \cdot m^2] \quad \cdots \quad (9.1.2\text{-}13)$$

4) Case of elevator load

For loads attached by rope as in Figure 9.1-7 and Figure 9.1-8, the moment of inertia is calculated by taking the summation of object mass in motion by equation (9.1.2-14), although the direction of motion differs.

$$J = \left(\frac{60 \cdot v}{2\pi \cdot N_M} \right)^2 \cdot (Wo + W + W_B) \ [kg \cdot m^2] \quad \cdots \quad (9.1.2\text{-}14)$$

(2) Calculation of the acceleration time

Figure 9.1-10: Load model including transmission uses models of typical loads. These assume that the loads are attached via a transmission with efficiency η_G.

The time required to accelerate to NM [r/min] from stopped state with this load is given by equation (9.1.2-15).

$$t_{ACC} = \frac{J1 + J2/\eta_G}{\tau_M - \tau L/\eta_G} \cdot \frac{2\pi (N_M - 0)}{60} \ [S] \quad \cdots \quad (9.1.2\text{-}15)$$

J1 : Moment of inertia of the motor axis [kg·m²]
J2 : Moment of inertia of the load axis converted to the motor axis [kg·m²]
τ_M : Minimum value of motor output torque in drive mode [N·m]
τ_L : Maximum value of load torque converted to the motor axis [N·m]
η_G : Efficiency of the transmission

As can be seen by these equations, the apparent moment of inertia is affected by transmission efficiency, becoming (J1 + J2/η_G).

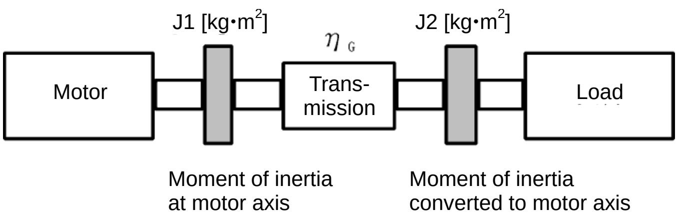


Figure 9.1-10: Load model including transmission

(3) Calculation of the deceleration time

In the load system of Figure 9.1-10, the time required to stop the motor rotating at speed NM [r/min] can be typically calculated by equation (9.1.2-16).

$$t_{DEC} = \frac{J1 + J2 \cdot \eta_G}{\tau_M - \tau_L \cdot \eta_G} \cdot \frac{2\pi (0 - N_M)}{60} \ [S] \quad \cdots \quad (9.1.2\text{-}16)$$

In this equation, typically the output torque τ_M is negative and the load torque τ_L is positive, which reduces the deceleration time.

However, in the case of elevator loads, τ_L may become negative in braking mode, extending the deceleration time.

Tip For elevator loads, calculate the deceleration time using the maximum negative value possible for the load torque τ_L converted to the motor axis when selecting the capacity.

(4) Calculation of non-linear acceleration and deceleration time

For loads which are frequently accelerated and decelerated, all of the surplus motor torque may be used to accelerate and decelerate in the shortest time. Vector control allows this type of operation easily.

The acceleration and deceleration in these cases are non-linear, and the time required to complete acceleration and deceleration cannot be computed by one equation.

Therefore, speed N is subdivided into ΔN parts and the acceleration and deceleration time of the parts are computed. Then the times of the parts are integrated until the end of acceleration and deceleration in order to compute the total time. The calculation of the parts increase in accuracy as the subdivision increases. Therefore, computers are used for calculating the actual acceleration and deceleration time.

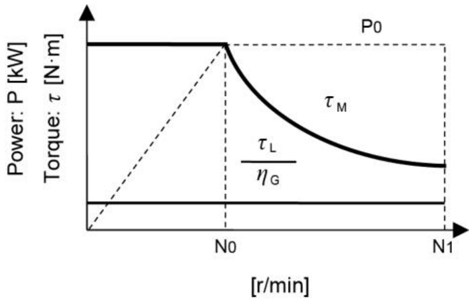


Figure 9.1-11: Example of functional characteristics for driving equipment with constant output

The following shows the method to calculate.

Figure 9.1-11 shows an example of the driving equipment with constant output characteristics. The region below N0 shows constant torque while the region from N0 to N1 shows constant output. The acceleration time can be calculated using equation (9.1.2-17).

$$t_{ACC} = \frac{J1 + {J2}/{\eta_G}}{\tau_M - {\tau L}/{\eta_G}} \cdot \frac{2\pi \cdot \Delta N}{60} \quad [S] \quad \cdots \quad (9.1.2\text{-}17)$$

First, calculate the moment of inertia J1 for the motor axis, the moment of inertia J2 of the load axis converted to the motor axis, load torque τ_L converted to the motor axis, and the efficiency η_G of the transmission. Then, calculate the maximum motor torque τ_M using the suitable equation below according to the speed range.

[τ_M for N ≤ N0]: Constant torque

$$\tau_M = \frac{60 \cdot P0}{2\pi \cdot N0} \quad [N \cdot m] \quad \cdots \quad (9.1.2\text{-}18)$$

[τM for N0 ≤ N ≤ N1]: Constant output (torque inversely proportional to speed)

$$\tau_M = \frac{60 \cdot P0}{2\pi \cdot N} \quad [N \cdot m] \quad \cdots \quad (9.1.2\text{-}19)$$

When the calculation results above do not meet the target values, the capacity of the driving equipment should be increased by one rank.

(5) Calculation of non-linear deceleration time

The calculation of the deceleration time can be performed using the same equations as for the acceleration time.

$$t_{DEC} = \frac{J1 + J2 \cdot \eta_G}{\tau_M - \tau L \cdot \eta_G} \cdot \frac{2\pi \cdot \Delta N}{60} \quad [S] \quad \cdots \quad (9.1.2\text{-}20)$$

In this equation, both τ_M and ΔN are negative values, so in general, load torque τ_L assists deceleration.
However, in the case of elevator loads, modes exist where τ_L becomes negative. In these cases, the polarities of τ_M and τ_L differ, impeding deceleration.

9.1.2.3 Calculation of the motor RMS rating

For loads which are frequently and repeatedly accelerated and decelerated, the load current varies widely and enters the region for the motor's short duration rating. In these cases, consideration and measures for heat tolerance are necessary. The heat generated by the motor is thought to be approximately proportional to the square of the load current, resulting in temperature rise proportional to the heat generated for FRENIC-VG exclusive motors with forced cooling fans.

For cases when the motor is repeatedly run in adequately short periods compared to the motor's thermal time constant, the following procedure can be followed to calculate the "equivalent current." Then, select the motor such that this "equivalent current" does not exceed the rated current.

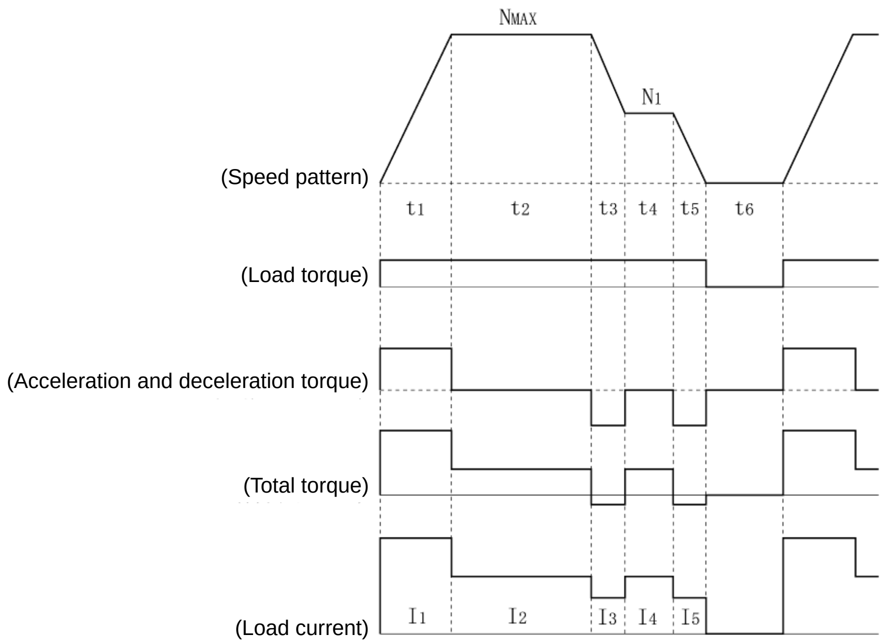


Figure 9.1-12: Example of repeating operation

For these calculations, first find the required torque for each segment of the speed pattern. Next, use the motor torque current curve to convert to the load current pattern.

Then the motor's equivalent current Ieq can be computed using equation (9.1.2-21).

$$Ieq = \sqrt{\frac{I1^2 \cdot t1 + I2^2 \cdot t2 + I3^2 \cdot t3 + I4^2 \cdot t4 + I5^2 \cdot t5}{t1 + t2 + t3 + t4 + t5}} \quad [A] \quad \cdots \quad (9.1.2\text{-}21)$$

For the actual calculation, the motor torque current curve does not exist. Use the following equation (9.1.2-22) which calculates the load current I from load torque $\tau 1$, and then compute equivalent current Ieq.

$$I = \sqrt{\left(\frac{\tau 1}{100} \cdot \mathrm{It100}\right)^2 + \mathrm{Im100}^2} \quad [A] \quad \cdots \quad (9.1.2\text{-}22)$$

$\tau 1$: Load torque [%], It100 = torque current (P09: M1 torque current), Im100 = excitation current (P08: M1 excitation current)

- Refer to Chapter 12 "Replacement Material" in separate volume, FRENIC-VG User's Manual Unit/Function Codes Edition (24A7-□-0019) for P08 and P09 function code data.
- Refer to the torque current and excitation current relevant to A code instead of the P code when using a second motor.

9.2 Inverter capacity selection

9.2.1 Overview of the control method

FRENIC-VG provides vector control with speed sensor (induction motor, synchronous motor), sensor-less vector control (induction motor), and V/f control (induction motor).

The following provides a general description of these control modes.

9.2.1.1 Vector control with speed sensor (induction motor, synchronous motor)

In this control mode, the primary current of the AC motor is controlled by decomposing the primary current into the magnetic flux current and the torque current components to achieve control performance equivalent to that of DC motors.

Vector control with sensor is more suitable for quicker response and higher precision applications than V/f control mode.

(1) Good acceleration and deceleration characteristics

(2) Wide range of speed control

(3) Provision of torque control

(4) Quick control response

9.2.1.2 Sensor-less vector control (induction motor)

Vector control with speed sensor possesses superior performance such as quick response and high precision but requires speed sensors, necessitating attachment of and wiring to the speed sensor.

In comparison, this control mode is slightly inferior in performance than vector control with speed sensor. However, speed sensor-less vector control estimates the motor rotation speed from the motor terminal voltage or the primary current without using speed sensors, and uses the estimation as the speed feedback signal for vector control.

9.2.1.3 V/f control (induction motor)

This control mode operates the motor by varying the frequency and voltage according to the V/f pattern, without using speed sensors. The scheme is not suitable for systems requiring torque control, high precision speed control, and quick response. However, the adjustment is simple and provides only a few restrictions to the driving motor, making it suitable for numerous fan and pump applications as well as inverters.

9.2.2 Selection of MD/LD specification

9.2.2.1 Precautions for selection

FRENIC-VG is built to dual rating specifications. The applicable specification can be switched by altering the parameter settings between the MD (Medium Duty) specification and LD (Low Duty) specification. The MD specification can drive motors with capacities identical to the inverter, and the LD specification allows the inverter to drive motors with capacities which are one or two ranks higher.

Select the inverter capacity by reviewing the MD specification/LD specification in "9.2.2.2 Guidance for selection," the overloading characteristics, and the capacity of the motor to be used.

MD spec: Apply to equipment where the inverter’s load current in normal operations is less than the inverter rated current (MD specification), and the load current in overload operation is less than 150% of the rated current (MD specification) for 1 minute.

LD spec: Apply to variable load equipment such as fans, pumps, and centrifugal machines where the inverter’s load current in normal operations is less than the inverter rated current (LD specification), and the load current in overload operation is less than 110% of the inverter rated current (LD specification) for 1 minute.
The inverter rated current (LD specification) is based on a motor capacity which is one or two ranks higher than that of the inverter.

Note Replacement of FRENIC5000VG7S (HT specification) by FRENIC-VG:
FRENIC-VG does not provide a specification equivalent to the HT specification of VG7. When replacing VG7 HT specification by FRENIC-VG, use an inverter with one rank higher capacity.

9.2.2.2 Guidance for selection

Table 9.2-1 shows the functional differences between the MD specification and the LD specification. If the LD specification satisfies the requirements in your applications in view of overload capacity and functionality, you can select inverters with capacities (LD specification) which are one or two ranks lower than the motor capacity.

Table 9.2-1: MD specification/LD specification functional differences

Function	MD spec	LD spec	Remarks
Use	General purpose load	Low overload applications	
Motor capacity range	[400V class series] 30 to 315 kW 630 to 800 kW* [690V class series] 90 to 450 kW	[400V class series] 37 to 355 kW 710 to 1000 kW* [690V class series] 110 to 450 kW	* mark represents stack by phases
Function code setting (MD/LD spec switch)	F80=0, 2, 3	F80=1	Setting at factory shipping: F80=0 0 and 2 are displayed as HD on keypad.
Inverter rated current level	Inverter and motor should have same capacity Rated current is based on motor	Rated current is based on motor capacity which is one or two ranks higher than that of inverter	In LD spec, the consecutive rated current rises by one or two ranks, but the % of the consecutive rated current for overload capacity lowers. For details, refer to Chapter 2 "Specifications."
Overload capacity	150% of rated current for 1 minute	110% of rated current for 1 minute	Rated currents differ between MD and LD specifications.

Note
(1) No output frequency range differs between MD and LD specifications.
(2) When constructing a system comprising converters and inverters, MD and LD specifications may co-exist. In this case, select rated capacities and overload capacities for the converters, which meet the required inverter capacities (rated and overload).

9.3 Converter selection

9.3.1 Converter model selection

Converter is available in diode rectifier and PWM converter. Please select the type of converter depending on load status of machinery system used, and harmonic currents regulation on the supply side.

Table 9.3-1: Advantages of various converters

Item	Diode rectifier	PWM converter
Points for selection	• System with small capacity for regenerative energy • System using generators for power supply (no regeneration) • System with restrictions in installation space	• System with large capacity for regenerative energy • System with regulations on power supply side harmonic current (supply power factor)
Price	Low	High
Installation space	Small	Large
Regenerative electric power processing	Regeneration not possible only with the diode rectifier (Resistive regeneration can be applied with braking resistor + braking unit)	Possible

Note: Price and installation space show comparison between diode rectifier and PWM converter.

9.3.2 Converter capacity selection

The converter capacity is selected based on the total capacity of inverters connected to the converter output or the total load capacity calculated from the motor operating conditions.

The following provides descriptions of converter capacity selection, taking in the event of one inverter and parallel connection of multiple units as an example.

Note: Even if the capacity of the operated inverter is small, select a converter capacity which is more than 50% of the total capacity of all inverters connected to the converter.

Applied converter capacity ≥ (Capacity of all connected inverters x 50%)

9.3.2.1 Single unit operation

When driving one inverter, select a converter capacity (consecutive rating, basic rating, overload rating) which is identical to the inverter.
(Refer to No. 1 and No. 5 in Table 9.3-2)

9.3.2.2 Operation with multiple units connected

See below the example case of four inverters, 315 kW, 280 kW, 110 kW, and 90 kW, connected. Calculate the converter capacity using "Equation (9.3.2-1)" and "Equation (9.3.2-2)."

Use the same equation for consecutive rating and overload rating (150% or 110%).

$$\sum INV = INV1 + INV2 + INV3 + INV4$$ …(9.3.2-1) : When all inverters operate in drive mode

$$\sum INV = INV1 + INV2 + INV3 + (INV4 \times -0.95)$$ …(9.3.2-2) : Only INV4 is in regenerative mode

Note: For regenerative mode, multiply by the coefficient -0.95.

Table 9.3-2: Consecutive rating

(Unit: kW)

No.	INV1	INV2	INV3	INV4	Total	Applied PWM converter type (example)	Remarks
1	315	—	—	—	315	RHC315S-4D☐	Single unit drive operation
2	315	280	110	90	795	RHC800B-4D☐	All units drive operation
3	315	280	110	0	705	RHC710B-4D☐	Limited operation: 3 driven, 1 stopped
4	315	280	110	-86	620	RHC630B-4D☐	Limited operation: 3 driven, 1 regenerating

Table 9.3-3: Overload rating

(Unit: kW)

No.	INV1	INV2	INV3	INV4	Total	Applied PWM converter type (example)	Remarks
5	473	—	—	—	473	RHC315S-4D☐	Single unit drive operation
6	473	420	165	135	1193	RHC800B-4D☐	All units drive operation
7	315	420	165	0	900	RHC710B-4D☐	Limited operation: 3 driven, 1 stopped
8	315	420	165	-128	772	RHC630B-4D☐	Limited operation: 3 driven, 1 regenerating

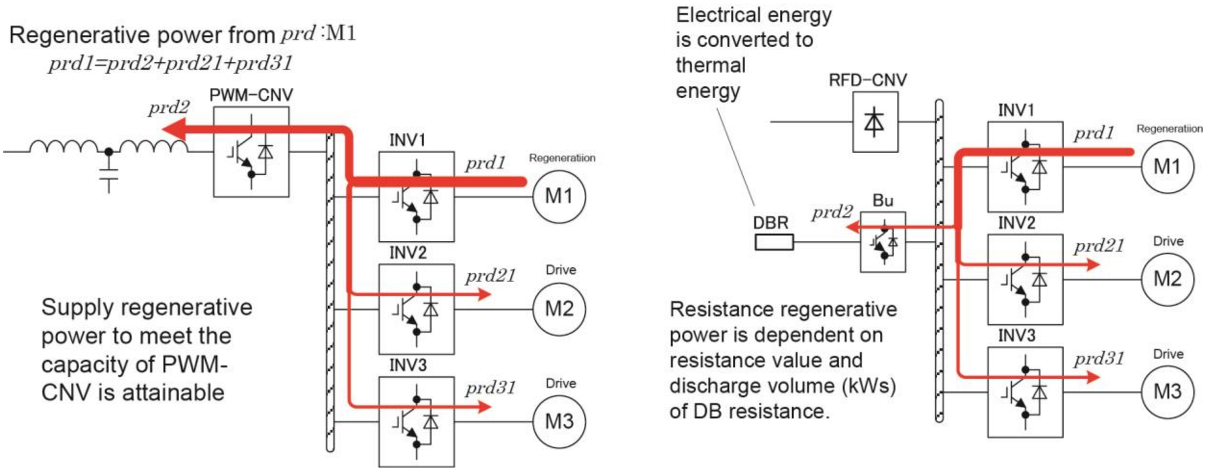
9.3.3 Capacity of resistive braking

9.3.3.1 Review of braking resistor rating

By using a PWM converter in combination with plural inverters, the regenerative energy generated during motor braking may be recycled to the power supply, or utilized as driving energy of other motors in driving operation.

On the other hand, the energy generated from the combination of diode rectifier and plural inverters may also be utilized as driving energy in other motors. However, as it is not revivable in power supply in principle, the unconsumed regenerative energy will cause the DC link bus voltage to increase, resulting in an alarm trip condition (overvoltage). For this reason a braking system (braking resistor + braking unit) will be required to convert the regenerative energy into thermal energy and dissipate the converted energy.

The method of capacity calculation of braking resistor is given in this chapter.



(a) PWN converter (b) Diode rectifier

Figure 9.3-1: Flow of regenerative energy in combination with converter

The energies which can be regenerated in inverter operations are kinetic energy due to inertia or the potential energy of elevators.

1) Kinetic energy due to inertia

When an object with moment of inertia J [kg·m^2] is rotating at rotational speed N2 [r/min], the kinetic energy of this rotating object is shown in equation (9.3.3-1).

$$E = \frac{J}{2} \cdot \left(\frac{2\pi \cdot N2}{60} \right)^2 \quad [J = Ws] \qquad \cdots \quad (9.3.3\text{-}1)$$

$$\approx \frac{1}{182.4} \cdot J \cdot N2^2 \quad [J] \qquad \cdots \quad (9.3.3\text{-}1)'$$

When decelerating this object to rotational speed N1 [r/min], the released energy is shown in equation (9.3.3-2).

$$E = \frac{J}{2} \cdot \left[\left(\frac{2\pi \cdot N2}{60} \right)^2 - \left(\frac{2\pi \cdot N1}{60} \right)^2 \right] \qquad \cdots \quad (9.3.3\text{-}2)$$

$$\approx \frac{1}{182.4} \cdot J \cdot \left(N2^2 - N1^2 \right) \quad [J] \qquad \cdots \quad (9.3.3\text{-}2)'$$

In the case of a typical load model as shown in Figure 9.1-10, the energy regenerated to the inverter is calculated from the transmission efficiency η_G and the motor efficiency η_M by equation (9.3.3-3).

$$E \approx \frac{1}{182.4} \cdot \left(J1 + J2 \cdot \eta_G \right) \cdot \eta_M \cdot \left(N2^2 - N1^2 \right) \quad [J] \qquad \cdots \quad (9.3.3\text{-}3)$$

2) Potential energy of elevators

When descending an object of weight W [kg] from height h2 [m] to h1 [m], the released potential energy can be expressed as equation (9.3.3-4).

$$E = W \cdot g \cdot \left(h1 - h2 \right) \quad [J = Ws] \qquad \cdots \quad (9.3.3\text{-}4)$$

g ≈ 9.8065 [m/s^2]

The energy regenerated to the inverter circuit is calculated from the transmission efficiency η_G and motor efficiency η_M by equation (9.3.3-5).

$$E = W \cdot g \cdot \left(h1 - h2 \right) \cdot \eta_G \cdot \eta_M \quad [J = Ws] \qquad \cdots \quad (9.3.3\text{-}5)$$

9.3.3.2 Procedures for selection

The following selection conditions must be satisfied according to the repeating period.

(1) Period is less than 100 s: [Condition 1] and [Condition 3]

(2) Period is over 100 s: [Condition 1] and [Condition 2]

[Cond 1]: "Maximum braking torque" must be smaller than the value specified in the table of Chapter 6 "6.5.3 Standard combination." If the "Maximum braking torque" exceeds the value in the table, select a capacity which is one rank larger.

[Cond 2]: The discharged capacity per braking must be smaller than the "Discharge withstand current rating kWs" in the table. For details of the calculation, refer to previous section "9.3.3.1 Review of braking resistor rating."

[Cond 3]: The average loss, which is the discharged capacity divided by the repeating period, must be smaller than the "Average loss kW" shown in Chapter 6 "6.5.3 Standard combination."

9.3.3.3 Precautions for selection

Braking time T1, repeat period T0, and utilization rate %ED are converted under the conditions of deceleration braking by rated torque as shown in Figure 9.3-2. However, these values do not need to be used in the calculations for capacity selection.

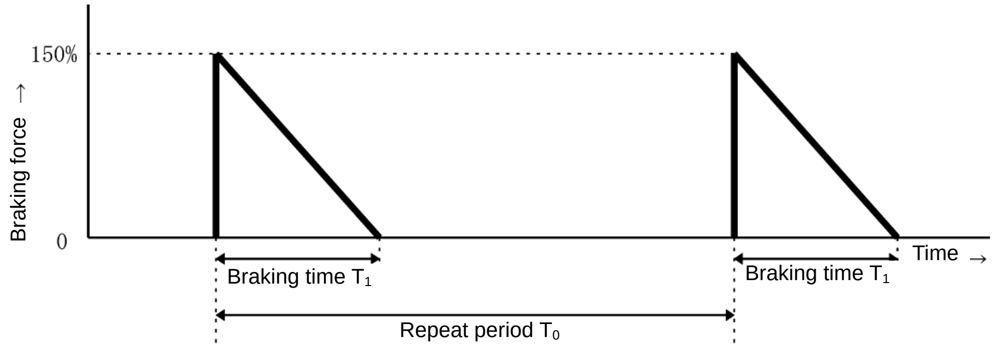


Figure 9.3-2: Approach to utilization rate

$$\text{Utilization Rate } \%ED = \frac{T1}{T0} \times 100 \ [\%] \quad \cdots \quad (9.3.3\text{-}6)$$

9.4 Direct parallel connection system

Direct parallel connection is a method for controlling one motor by connecting 2 to 3 inverters that are identical in capacity.

<Features>

(1) A combination of plural inverters of smaller capacity allows easier restoration or replacement in breakdown as compared to a single unit of inverter of large capacity.

(2) Quick operation recovery is possible without any alterations to the wiring using inverters which have not failed.

- When failures occur during direct parallel operation, operation can be resumed using the remaining, normal inverters (operation with reduced number of units).
- Number of inverter units operated can be varied according to load conditions (operation with reduced number of units).

9.4.1 Restrictions of direct parallel connection system

There are some restrictions as follows.

(1)	Number of direct parallel units for connection	:	2 to 3 inverters with equal capacities
(2)	Motor control mode	:	The direct parallel connection system is available under vector control with speed sensor and sensor-less vector control, and can be used for induction motors. When controlling a motor using the direct parallel connection system, the optional high speed serial communication terminal block (OPC-VG1-TBSI) is necessary.
(3)	Inverter output wiring	:	Refer to "Chapter 9.4.8 Wiring inductance" (pages 9-29).
(4)	Speed response, current response	:	50 Hz speed control response This scheme may not be able to support some conditions requiring very high speed responsiveness or torque control accuracy.
(5)	Functional safety	:	The option card (OPC-VG1-SAFE) for supporting functional safety is not applicable.
(6)	Operation with reduced number of units	:	When operating with reduced number of units, contactors must be attached to the inverter output side because the wiring for the motor and inverter will be detached.
(7)	Auto-tuning function	:	This function enables the system to automatically determine the motor constant according to the direct parallel connection condition and store motor parameters depending on the motor constant.

9.4.2 Basic configuration of direct parallel connection

Configuration

Inverter		When using this control scheme, one OPC-VG1-TBSI (optional built-in terminal block supporting high speed serial communication) is required for every inverter.
System option Note 2)	Contactor Note1)	When running with reduced number of units, contactors are used to detach inverters which will not be operated.
	Output circuit filter Note 2)	Refer to "9.4.8 Wiring inductance" (pages 9-29).
	PG/NTC switcher	To be used for engine cutoff when PG vector control (vector control with speed sensor) or NTC thermistor (motor temperature detection) are used. MCA-VG7-CPG may be used for direct parallel connection of 2 units.
	PLC	A section of the function code must be modified in changing to operate with reduced number of units, from 3 units to 2 units. Using PLC will automatically rewrite this function code. Using PLC is recommended in systems for advanced operation with reduced number of units, which requires rewriting of parameter settings.

Note 1) Select contactors and OFL filters whose capacity and type are appropriate for the inverters being used.

Note 2) Use of these options is not necessarily required for direct parallel connection system.
(It is however required in cases such as when using optional function of engine cutoff.)

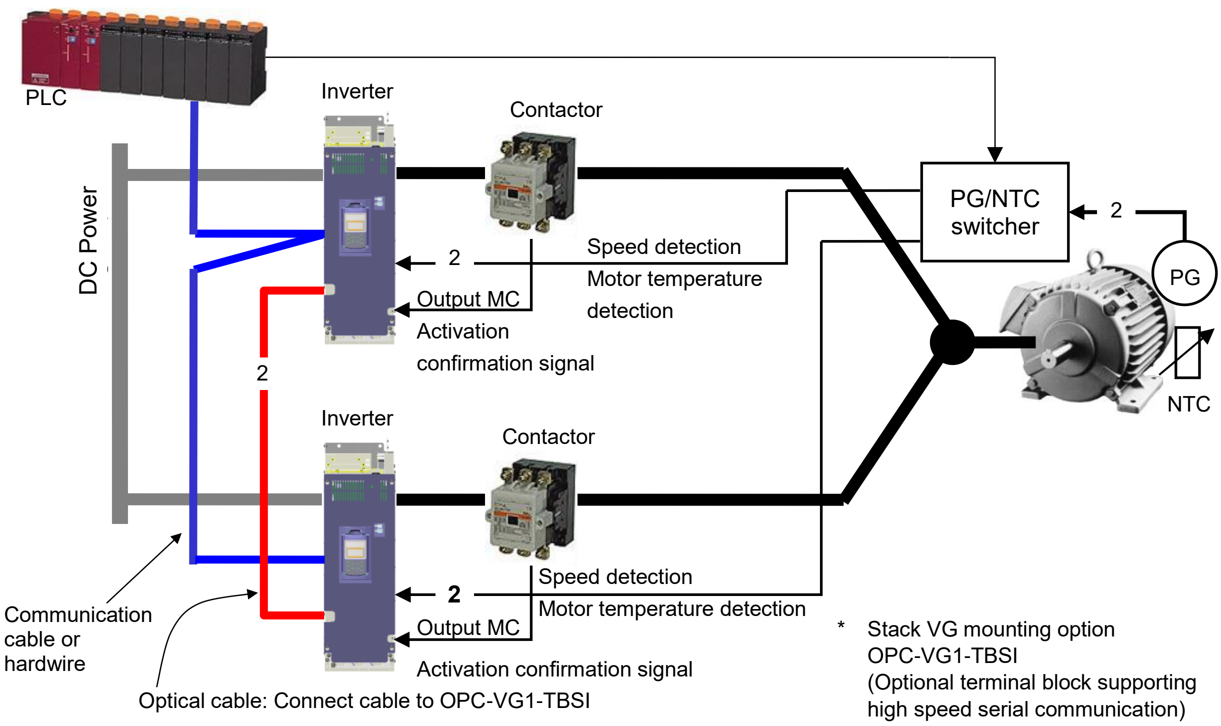


Figure 9.4-1: Example of system configuration with two units in direct parallel connection

Note

- To determine some of the motor parameters, multiply by the inverse of the number of units connected in direct parallel connection.
  Refer to "9.4.6 Motor constants" (pages 9-25).
- The master inverter exercises integrated control of operation and speed commands over the slaves.
- In the case of three units in the direct parallel connection system, up to three motor constants can be set in advance even when conducting operation with reduced number of units such as two or one. Switching among the motor constants is done by the X terminal input of the inverters.

9.4.3 Function code setup

When conducting direct parallel connection, the following function codes must be set up.

Table 9.4-1: Multiple system setup code

F.No.	Function code name	Description
o33	Multiple system control system	Setup of the multiple system control mode (direct parallel connection system, etc.)
o34	Multiple system slave exchange number	Setup of the number of slave inverter exchanges (number of units) for the multiple system
o50	Multiple system exchange number setup	Setup of exchange numbers for high speed serial communication (OPC-VG1-TBSI)

o33 **Multiple System Control System**

Set the value according to the multiple system configuration below.
Also review the page on multiple system cancellations in E01 to E13 "X Function Selection."

Note) Available in inverters having a ROM version H1/2 0020 or later.

Specified value
0 : Invalid (single unit operation)
1 : Multi-winding system
2 : Multiple system 1 (direct parallel system)
3 : Multiple system 2 (unassigned)
4 : Reserve 1
5 : Reserve 2

o34 **Multiple system slave exchange number**

When the multiple system is enabled, set the number of slave exchanges (number of units) excluding the master.

Setup value range 1 to 5
For configuring direct parallel connection systems
1: Two units configured in direct parallel connection (one slave unit)
2: Three units configured in direct parallel connection (two slave units)
3 to 5: Invalid (Not utilize for direct parallel connection)

o50 **Multiple system exchange number setup**

Set exchange numbers for the terminal blocks supporting high speed serial communication (OPC-VG1-TBSI) in the multiple system.

Specified value
0 : Master
1 to 5 : Slave

<Setup example>

(1) System with two units
Specify o34=1 for both the master INV and slave INV.

(2) System with three units
Specify o34=2 for both the master INV and slave INV.

Note: For the multiple system exchange number setup (o50), set up in the order to connect to the master.

<Invalid setup example>

Master INV (o50 = 0), slave 1 (o50 = 2)

Slave INV2 (o50 = 1), slave 3 (o50 = 3)

*: *** show invalid setups.

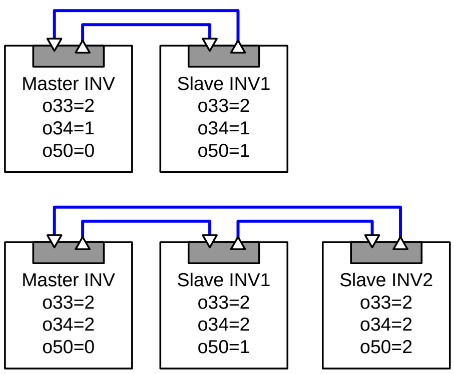


Figure 9.4-2: Function code setup example

Note: When the setup for o34 (Multiple System Slave Exchange Number) is wrong, the system may not operate and the alarm may not be activated. Reconfirm that the setup is correct.

9.4.4 Basic connection diagram

9.4.4.1 Configuration of 2 units in direct parallel connection

The following shows an example of two inverters used in direct parallel connection.

This connection diagram shows a configuration which has considered operation with reduced number of units. When operation with reduced number of units will not be conducted, elimination of inverter output contactors and simplification of operation sequence are possible.

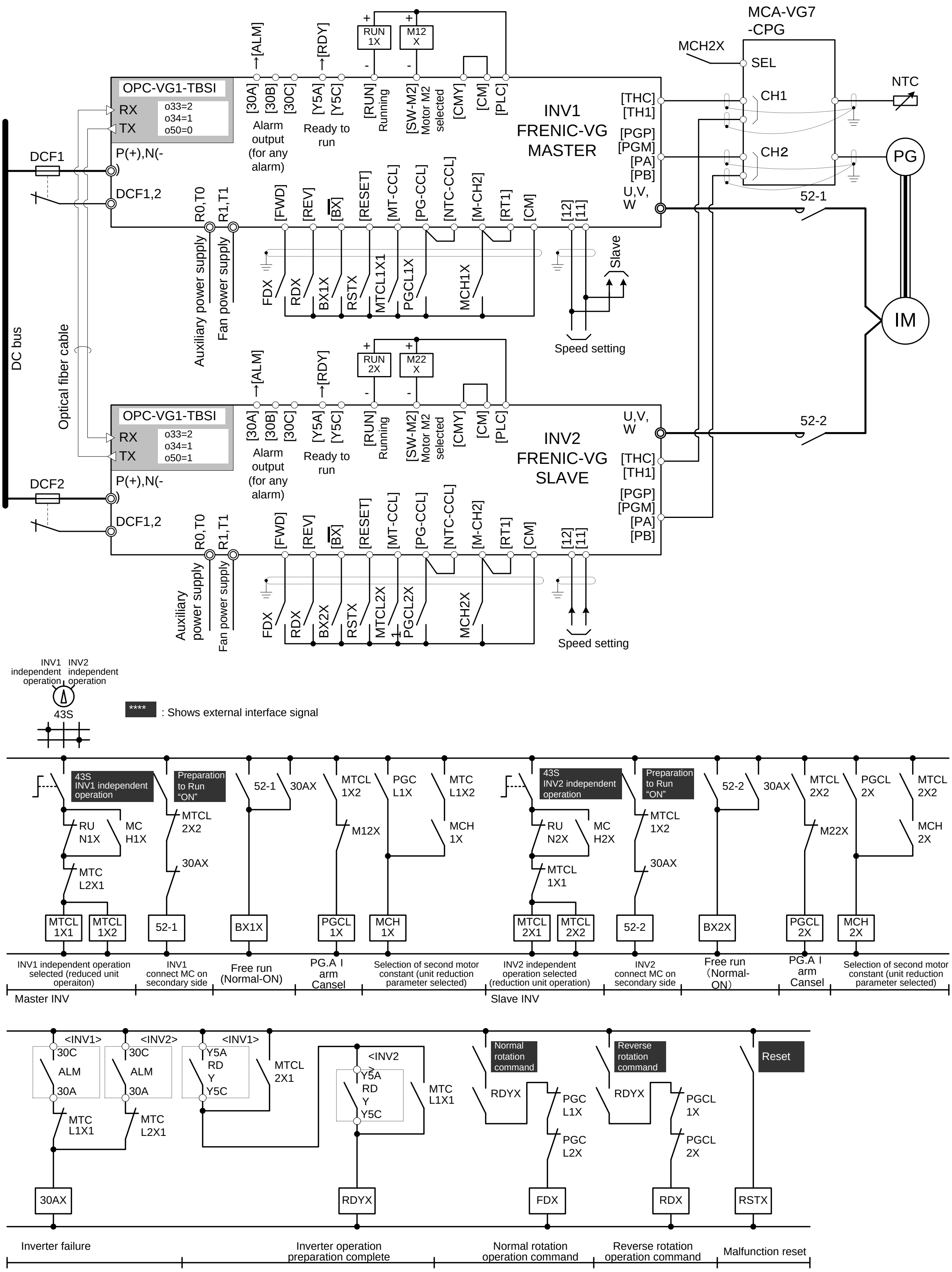


Figure 9.4-3: Basic configuration for direct parallel connection system using two inverters

<Supplementary explanation for the connection diagram>

(1) Basic items

1) For safety, when alarm is activated (30X actuated), input coast to a stop command [BX] to the two inverter units. In the connection diagram shown, the coast to a stop command is configured to **normally on** (ordinarily closed, open signifies coast to a stop command). This input should be constructed by hardware circuit for safety.
2) Configure the two inverters such that after operation preparation is complete [RDY], FWD and REV can be turned ON. The diagram shows the case where the operation preparation complete function is allocated to relay output.
3) The alarm of slave inverters can be released by the reset command [RST] of the master inverter.
4) For installations into facilities which restart after instantaneous power failures, use the running restart function which searches the direction and speed of free running rotation and picks up smoothly to reengage drive.

(2) Case of operation with reduced number of units

When running with reduced number of units, realize the following setup.

1) Realize the setup in "Table 9.4-2" below for X terminal input (Di) and Y terminal output (Do).

Table 9.4-2: Required X terminal functions for operation with reduced number of units

	Specified value / Setup name	Explanation of use in Operation with Reduced Number of Units
Di	57 [MT-CCL] Multiple system cancellation	Release direct parallel connection when turned ON. The system will be able to run on one independent inverter. When running independently on either of the two units, assign this function to both of the units.
	12 [M-CH2] Motor M2 selection	When running on a single unit, the system is enabled to select the second motor constant and run the motor without changing the setting of the first motor constant.
	49 [PG-CCL] PG alarm cancellation	Alarm is temporarily canceled for PG routing and NTC thermistor routing disconnection detecting function while preparing for operation with reduced number of units. If record of these two alarms does not cause a problem, this function does not have to be used. In this case, reset the alarm when running again.
	75 [NTC-CCL] NTC thermistor alarm cancellation	
	4 [RT1] Second ASR selection	If the system is running on a single unit using ASR constants (acceleration and deceleration times and P gain and integral action time for the ASR) set for direct parallel operation, the load inertia may be too large. This can cause overload protection to be activated. Avoid the overload trip by selecting the second ASR. Using the torque restriction (torque current restriction) is also effective.
Do	0 [RUN] Inverter operating	This signal signifies that the inverter is running. During direct parallel connection operation, the system outputs a signal to signify that the master inverter is running. During single unit operation, the system outputs signals to signify that respective inverters are running.
	16 [SW-M2] Second motor selection complete	When the system receives a second motor selection signal and completes a transition to the second motor constant inside the inverters, the system outputs an ON signal.

To switch to operation with reduced number of units, follow the steps below.

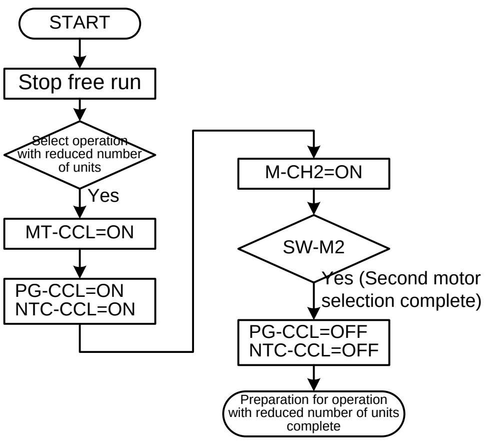


Figure 9.4-4: Flowchart for switching to operation with reduced number of units

2) For installations into facilities which restart after instantaneous power failures, use the running restart function which searches the direction and speed of free running rotation and picks up smoothly to reengage drive or use [IL] of the X terminal.
   Use of the running restart function is recommended especially for PG vector control method.
3) For simple systems, hardware can be constructed as Figure 9.4-3. However, when a more complex process sequence is desired, construction of a system structure which operates on communication with PLC is recommended.

9.4.5 Configuration of 3 units in direct parallel connection

The circuit diagram of a direct parallel connection system using three inverters, where operation with reduced number of units is not conducted, is shown below.

In the case of two inverters in direct parallel connection system, the relay circuit is the same as in the diagram below if operation with reduced number of units is not conducted.

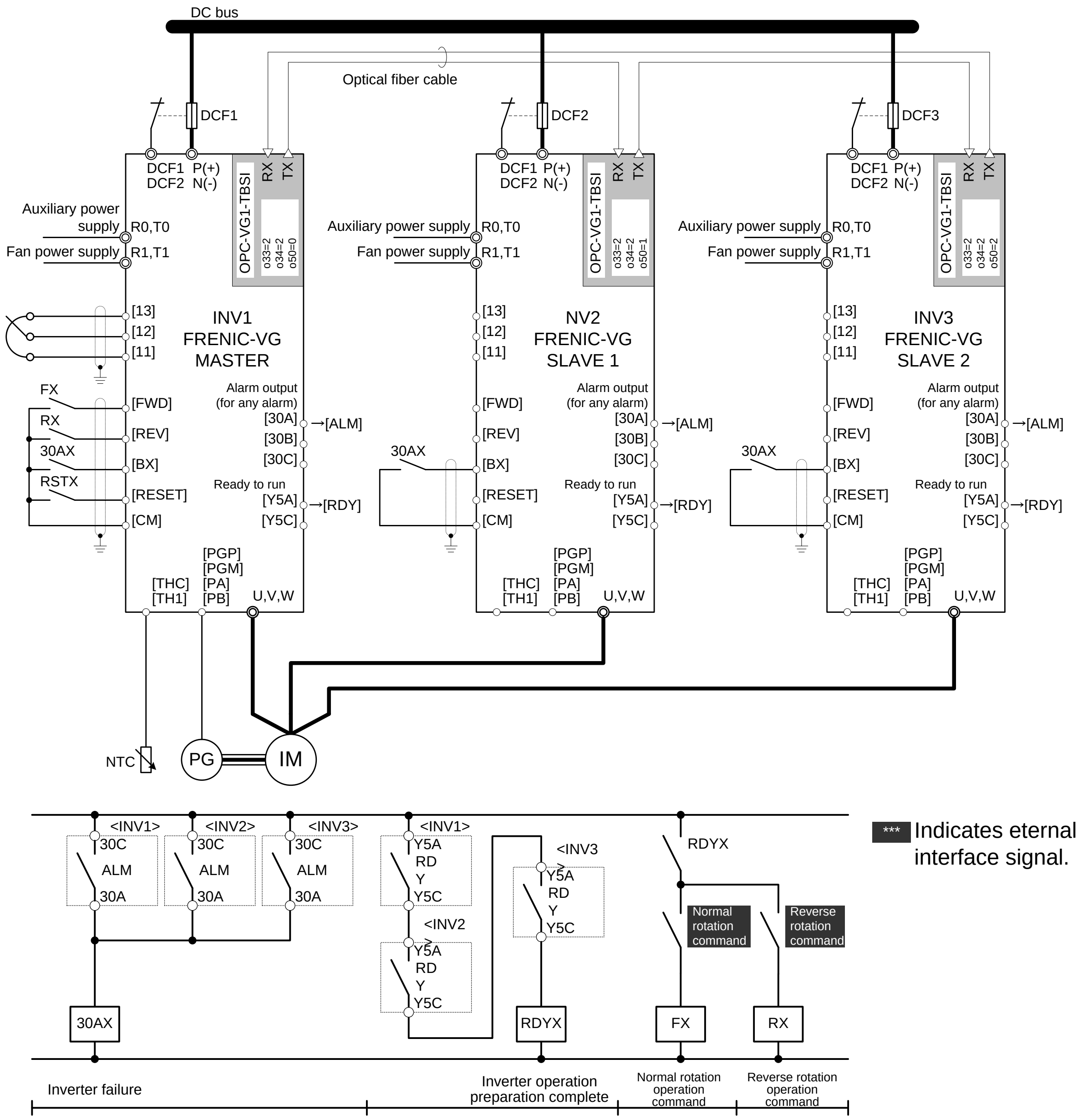


Figure 9.4-5: Basic configuration (without operation in reduced number of units) for direct parallel connection system using three inverters

<Supplementary explanation for the connection diagram>

(1) For safety, when alarm is activated (30X actuated), input coast to a stop command [BX] to the three inverter units. This input should be constructed by hardware circuit for safety.

(2) Configure the three inverters such that after operation preparation is complete [RDY], FWD and REV can be turned ON.

(3) The alarm of slave inverters can be released by the reset command [RST] of the master inverter.

(4) When installing into facilities which restart after instantaneous power failures, use the running restart function which searches the direction and speed of free running rotation and picks up smoothly to reengage drive.

9.4.6 Motor constants

Direct parallel connection system is a control method where a single winding motor is operated in parallel by plural inverters. Therefore, the motor constant required for inverter to control the motor is "1/number of connected inverter units."

When an operation with reduced number of inverters, a characteristic of the direct parallel connection system, is performed, the motor constants need to be changed. FRENIC-VG allows the selection of up to three motor constants. Selection among the motor constants can be made by the motor constant switching function of X terminal.

Table 9.4-3 shows a setting method of motor parameters including the time of the operation with reduced number of inverters.

When performing operation with reduced number of inverters in the direct parallel connection system, set motor parameters after determining the definitions of motor constant codes.

<Definitions>

- M1: Maximum number of connected units = 1 unit — M1 code consists of motor parameters for single unit operation.
- M2: Maximum number of connected units = 2 units — M2 code consists of motor parameters for direct parallel connection system of 2 units.
- M3: Maximum number of connected units = 3 units — M3 code consists of motor parameters for direct parallel connection system of 3 units.

Table 9.4-3: Explanation of change of motor parameters in the operation with reduced number of inverters

Parameter name		Parameter code			Coefficient of setting value in operation with reduced number of inverters
		M1 code	M2 code	M3 code	
Control system		P01	A01	A101	
Motor selection		P02	—	—	
Maximum speed		F03	A06	A106	
Rated speed		F04	A05	A105	
Rated voltage		F05	A04	A104	
Rated capacity		**P03**	**A02**	**A102**	**× (1/No. of units in direct parallel connection)**
Rated current		**P04**	**A03**	**A103**	**× (1/No. of units in direct parallel connection)**
No. of poles		P05	A07	A107	
%R1		P06	A08	A108	
%X		P07	A09	A109	
Exciting current		**P08**	**A10**	**A110**	**× (1/No. of units in direct parallel connection)**
Torque current		**P09**	**A11**	**A111**	**× (1/No. of units in direct parallel connection)**
Slip on driving, braking		P10, P11	A12, A13	A112, A113	
Iron loss coefficient 1 to 3		P12 to P14	A14 to A16	A114 to A116	
Magnetic saturation coefficient 1 to 5		P15 to P19	A17 to A21	A117 to A121	
Secondary time constant		P20	A22	A122	
Inductive voltage coefficient		P21	A23	A123	
R2 correction coefficient 1 to 3		P22 to P24	A24 to P26	A124 to A126	
Exciting current correction coefficient		P25	A27	A127	
ACR Constant	**P gain**	P26	A28	A128	
	Integral action time	P27	A29	A129	
No. of PG pulses		P28	A30	A130	
Thermistor selection		P30	A31	A131	
Electronic thermal (activation selection)		F10	A32	A132	

Note (1) Shaded parts [ ] in Table show parameters which are set to different values between the M1 and M2 (M3) codes for the operation with reduced number of inverters.
Set the other parameters to same values among the M1, M2 and (M3) codes.

(2) **ACR constants** should be less than the standard set values when operating at direct parallel connection. (Adjust the constants while operating the motor.)
Use the standard set values in the operation reduced to one unit of the inverter.

(3) Use motor constants by assigning them to motor M2 selection and motor M3 selection [MCH2, MCH3] of the X terminal function.

Table 9.4-4 shows setting values assigned to motor parameters in the cases of the direct parallel connection system of two or three inverters and a single inverter, taking the motor parameters of a 280 kW motor as an example.

Table 9.4-4: Setting example of motor parameters

			Setting value of function code			Remark
Condition: No. of INVs			1 unit	2 units	3 units	No. of inverters connected to one unit of motor
Control system		P01	0	0	0	
Motor selection		P02	37	37	37	
Maximum speed		F03	1500	1500	1500	
Rated speed		F04	750	750	750	
Rated voltage		F05	380	380	380	
Rated capacity		**P03**	**280.00**	**140.00**	**93.33**	**× (1/No. of units in direct parallel connection)**
Rated current		**P04**	**565.0**	**282.5**	**188.3**	**× (1/No. of units in direct parallel connection)**
No. of poles		P05	6	6	6	
%R1		**P06**	1.12	1.12	1.12	
%X		**P07**	15.41	15.41	15.41	
Exciting current		**P08**	**240.3**	**120.2**	**80.10**	**× (1/No. of units in direct parallel connection)**
Torque current		**P09**	**508.1**	**254.1**	**169.4**	**× (1/No. of units in direct parallel connection)**
During driving		P10	0.274	0.274	0.274	
Slip on braking		P11	0.274	0.274	0.274	
Iron loss coefficient	1	P12	3.00	3.00	3.00	
	2	P13	0.00	0.00	0.00	
	3	P14	0.00	0.00	0.00	
Magnetic saturation coefficient	1	P15	89.3	89.3	89.3	
	2	P16	83.3	83.3	83.3	
	3	P17	71.4	71.4	71.4	
	4	P18	59.5	59.5	59.5	
	5	P19	47.6	47.6	47.6	
Secondary time constant		P20	1.122	1.122	1.122	
Inductive voltage coefficient		P21	350	350	350	
R2 correction coefficient	1	P22	1.000	1.000	1.000	
	2	P23	1.000	1.000	1.000	
	3	P24	1.000	1.000	1.000	
Exciting current correction coefficient		P25	0.000	0.000	0.000	
ACR Constant	**P gain**	**P26**	**1.0**	**0.5**	**0.5**	Use these setting values as default settings, and adjust them later while checking operation in test runs.
	Integral action time	**P27**	**1.0**	**5**	**5**	
No. of PG pulses		P28	1024	1024	1024	
Thermistor selection		P30	1	1	1	

Note

(1) As a typical example, setting values assigned for the M1 code are shown. The same setting values will be shown when the M2 or M3 code is set/selected.

(2) Values set to P03, P04, P08, and P09 are floating-point numbers. Set the values by calculating them to settable decimal point.
Set the values by rounding them when they cannot be divided.

(3) Set ACR constants to the setting values specified in this Table. Then, adjust the values while checking the operation status in test runs.

9.4.7 Protective functions in direct parallel connection system

This section describes protective functions (batch alarm, reset, disconnection detection) for direct parallel connection. For other protective functions, see Chapter 11 "Troubleshooting."

(1) Batch alarm process

An alarm is indicated on all stations by optical link communication, 30X operation is executed and the inverter outputs are shut down. Alarm codes indicated on the keypad LED display enable the discrimination of a station which has caused the alarm. A function of the Y terminal provides the monitoring of the multi-system self station failure [AL-SF].

Example 1: When the master inverter goes into an alarm state (on occurrence of fin overheat (0H1))

Y terminal function: For the master inverter, the multi-system self station failure [AL-SF] is turned on.

LED display: "o" (other station) is prefixed to the alarm codes for the slave inverters 1 and 2.

Inverter	Alarm code	Remark
Master	0H1	Station which has caused alarm
Slave 1	o0H1	Other station
Slave 2	o0H1	Other station

Example 2: When the slave inverter 2 goes into an alarm state (on occurrence of fin overheat (0H1))

Y terminal function: For the slave inverter 2, the multi-system self station failure [AL-SF] is turned on.

LED display: "o" (other station) is prefixed to the alarm codes for the master inverter and slave inverter 1.

Inverter	Alarm code	Remark
Master	o0H1	Other station
Slave 1	o0H1	Other station
Slave 2	0H1	Station which has caused alarm

* Alarm sub codes (for manufacturers) are updated only on the station which has caused the alarm.

(2) Reset process

In the direct parallel connection system, all stations are batch reset provided that the alarm cause is cleared.

However, in the case of single unit operation, only a self station inverter is reset provided that the alarm cause is cleared.

If the system is running on a single inverter, perform the reset process by inputting a reset command from an external device (X terminal or communication by SX bus etc.) or by pressing the reset button on the keypad of the inverter.

Table 9.4-5: Reset target

	Direct parallel connection		Single unit operation (Cancellation of direct parallel connection)	Reset target
	Master INV	Slave INV		
Master inverter reset process	Alarm trip	—	—	All inverters
	—	Alarm trip	—	All inverters
	—	—	Alarm trip	Master INV only
Slave inverter reset process	Alarm trip	—	—	All inverters
	—	Alarm trip	—	All inverters
	—	—	Alarm trip	Only slave INV

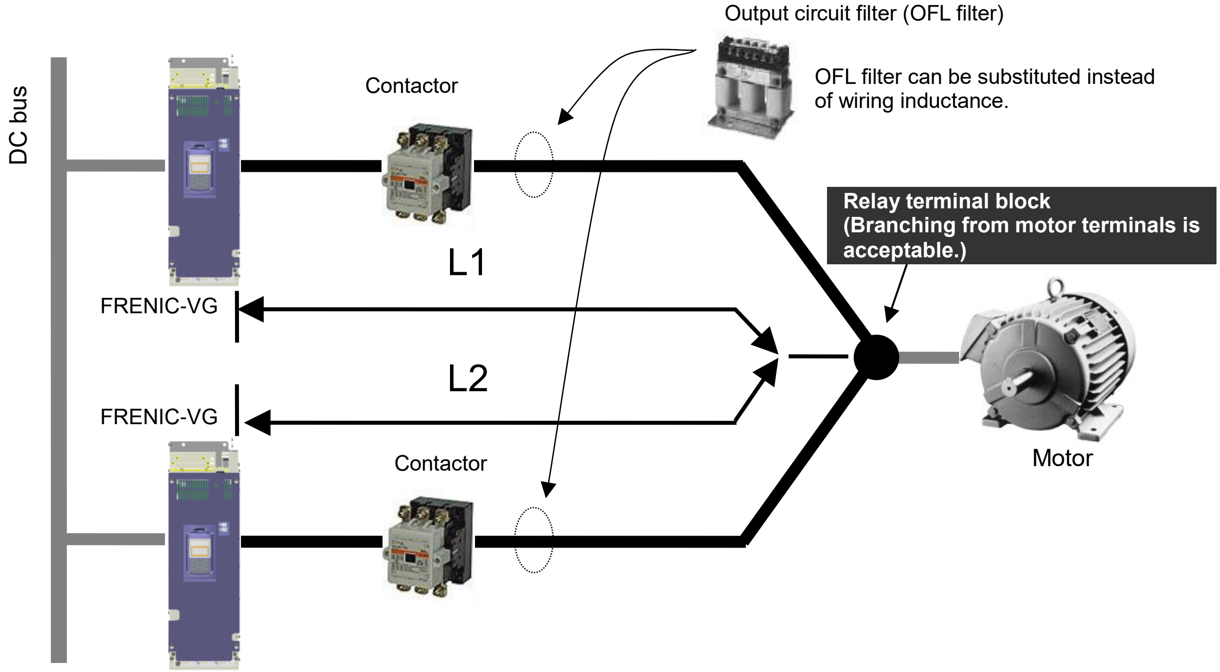
(3) Invalidation of disconnection detection

In the direct parallel connection system, the master inverter performs arithmetic operation of motor control integrally. Therefore, the slave inverters do not require motor detection signals through devices such as PG and NTC thermistor. Accordingly, PG disconnection detection and NTC disconnection detection are disabled under the conditions of "Multi-system" and "Slave."

Note When "PG vector control" and "NTC thermistor: Valid" are selected in the motor control system at the time of conducting single unit operation, disconnection detection function works and an alarm trip results.

9.4.8 Wiring inductance

In some cases, control over the direct parallel connection cannot be normally performed owing to the influence of a surge voltage caused by the switching of the inverters. Therefore, it is recommended to install output circuit filters (OFL filters) that suppress the occurrence of the surge voltage.
If a space for storing OFL filters cannot be secured in your cabinet, however, motor operation by the direct parallel connection system becomes possible when suppressing the surge voltage to a level that causes no trouble to the direct parallel control by **wiring inductance between the inverters and motor (regulated by wiring length)**.
This section explains the wiring inductance (wiring length) in the direct parallel connection system.



Restrictions on wiring length in direct parallel connection system

- **L1 = L2 (equal in wiring length)**
- **Refer to "9.4.8.1 Direct parallel connection combinations and wiring lengths" for wiring length by inverter capacity.**

Figure 9.4-6 Explanatory drawing of restrictions on direct parallel connection

Note
(1) In the figure above, two inverters in the direct parallel connection are shown. The same applies to the case of three inverters.
(2) If L1 and L2 are cabtire cables or shielded wires, the wiring length of them should be at least three times the length specified in the section 9.4.8.1.
(3) Make sure that L1 and L2 are equal in length.
(4) OFL filters can be installed on either primary or secondary side of contactors.
Make sure that the wiring length between the output circuit filters OFL-L1 and OFL-L2 is from 2 to 20 m if they are installed on the secondary side of the contactors.
(In the case of direct parallel connection of 3 units, the total wiring length among respective OFL filters should be within the range.)

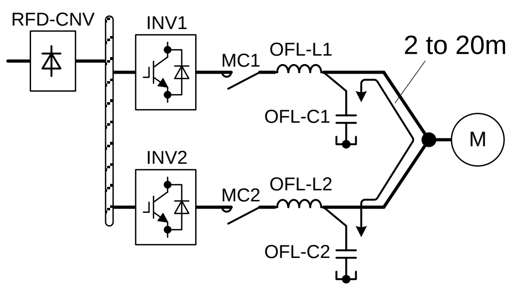
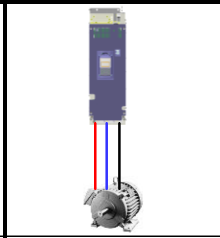
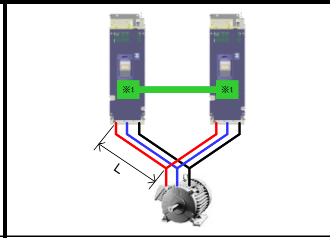
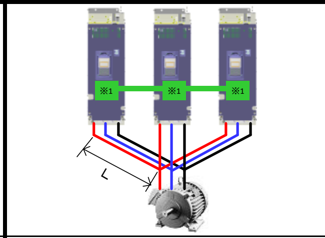
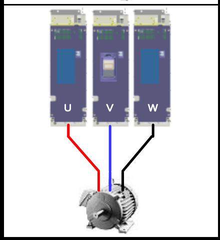
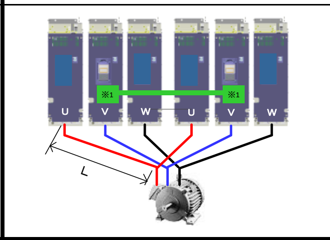
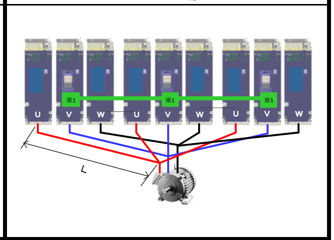


Figure 9.4-7: Restrictions on use of OFL filters

9.4.8.1 Direct parallel connection combinations and wiring lengths

Table 9.4-6 shows specifications (rated currents, minimum wiring lengths) for direct parallel connection system combinations (2 units, 3 units). The rated current and minimum wiring length vary with the combination.

Table 9.4-6: Wiring lengths and combinations for direct parallel connection

Configuration	Single unit operation	Direct parallel connection system	
	1 unit	2 units	3 units
Standard			
Phase-specific			

Power supply voltage	Inverter type	Configuration	Single unit: Rated current [A] MD spec	Single unit: Rated current [A] LD spec	2 units: Rated current [A] MD spec	2 units: Rated current [A] LD spec	2 units: Minimum wiring length (L) [m]	3 units: Rated current [A] MD spec	3 units: Rated current [A] LD spec	3 units: Minimum wiring length (L) [m]
400V class series	FRN30SVG1S-4□	Standard	60	75	114	143	92	171	214	122
	FRN37SVG1S-4□		75	91	143	173	74	214	259	98
	FRN45SVG1S-4□		91	112	173	213	61	259	319	81
	FRN55SVG1S-4□		112	150	213	285	49	319	428	66
	FRN75SVG1S-4□		150	176	285	334	37	428	502	49
	FRN90SVG1S-4□		176	210	334	399	32	502	599	42
	FRN110SVG1S-4□		210	253	399	481	27	599	721	35
	FRN132SVG1S-4□		253	304	481	578	22	721	866	29
	FRN160SVG1S-4□		304	377	578	716	18	866	1074	25
	FRN200SVG1S-4□		377	415	716	789	15	1074	1183	20
	FRN220SVG1S-4□		415	468	789	889	14	1183	1334	18
	FRN250SVG1S-4□		468	520	889	988	12	1334	1482	16
	FRN280SVG1S-4□		520	585	988	1112	11	1482	1667	15
	FRN315SVG1S-4□		585	650	1112	1235	18	1667	1853	24
	FRN630BVG1S-4□	Phase-specific	1170	1370	2223	2603	4.7	3335	3905	6.3
	FRN710BVG1S-4□		1370	1480	2603	2812	4.0	3905	4218	5.3
	FRN800BVG1S-4□		1480	1850	2812	3515	3.7	4218	5273	4.9
690V class series	FRN90SVG1S-69□	Standard	100	130	190	247	85	285	371	114
	FRN110SVG1S-69□		130	140	247	266	66	371	399	88
	FRN132SVG1S-69□		140	161	266	306	61	399	459	81
	FRN160SVG1S-69□		161	216	306	410	53	459	616	71
	FRN200SVG1S-69□		216	265	410	504	40	616	755	53
	FRN250SVG1S-69□		265	295	504	561	33	755	841	43
	FRN280SVG1S-69□		295	330	561	627	29	841	941	39
	FRN315SVG1S-69□		330	365	627	694	26	941	1040	35
	FRN355SVG1S-69□		365	410	694	779	24	1040	1169	31
	FRN400SVG1S-69□		410	460	779	874	21	1169	1311	28
	FRN450SVG1S-69□		460	—	874	—	19	1311	—	25

*1 The OPC-VG1-TBSI (sold separately as option) is necessary.

Note The minimum wiring lengths are specified on condition that the electric wires are in recommended wire sizes (FLSC electric wires). When substantially different electric wires or cabtire shielded wires are used, the wiring inductance changes. Thus, the wiring length should be reviewed.

In the case of a cabtire shield wire, **the wiring length should be approximately three times the minimum wiring length specified in this table**.

9.4.9 Precautions for use

This section explains precautions in setting function codes and during operation. In the direct parallel connection system, restrictions are placed on some functions, such as control interface functions, function codes and monitor codes. See the following details.

9.4.9.1 Powering ON

There is no restriction on the order in which the main power (direct current) is supplied to each inverter. However, when some of the inverters in direct parallel connection are not ready to operate, entering an operation command (FWD, REV) causes an alarm trip condition.

9.4.9.2 Setting before operation

The function codes listed in Table 9.4-7 should each be set to same setting values among the master inverter and the slave inverters.

Note The motor will not operate normally if the codes each are set to different values.

Table 9.4-7: Function codes requiring same settings

Function code	Function	Remarks
F03 to F05, P, A all codes	Motor parameters	Ensure the same setting.
F36	30Ry mode	Required to design a failure sequence externally.
F80	Current rating switching	Ensure the same setting.
H04, H05	Retry operation	Same setting is required when retry operation is made valid.
o33, o34	Multiple system setting code	Ensure the same setting.

9.4.9.3 Command input

Input an operation command, a speed command or a torque limit, etc. to only the master inverter in the direct parallel connection system. The specification (scale etc. of speed command etc.) of command input is the same with the standard specification.

Note When the multiple system is canceled by means of a setting made to the X terminal function, operation and speed commands need to be input to the inverters to be driven.

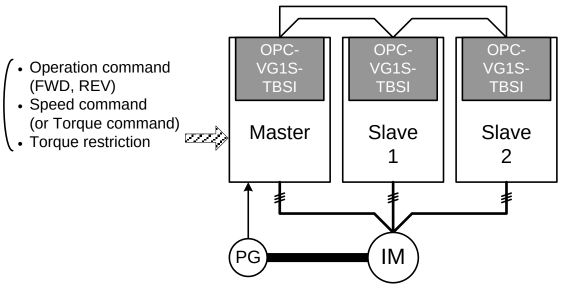


Figure 9.4-8: Command input

9.4.9.4 Input/output interface (I/O functions)

When the direct parallel connection system is selected, the input/output interface functions of the slave inverters are restricted. (No restriction is placed on the functions of the master inverter.)

Table 9.4-8 indicates the input/output interface functions available on the slave inverters.

Note When the multiple system is canceled by a setting made to the X terminal, restrictions on the functions are removed.

Table 9.4-8: Restrictions on I/O functions (direct parallel connection system is selected)

Category	Available functions even on slave **(Functions not listed are invalid)**	Terminal symbol	Remark
Di	Coast to a stop command	[7: BX]	Causes all units of the system to coast to a stop.
	Error reset	[8: RST]	Resets all units of the system.
	External alarm	[9: THR]	
	Motor M2 selection	[12: M-CH2]	
	Motor M3 selection	[13: M-CH3]	
	Keypad edit permission command	[19: WE-KP]	
	Universal DI	[25: U-DI]	
	Short voltage cancel	[50: LU-CCL]	
	Multi-system cancel	[57: MT-CCL]	
	External simulated failure	[74: FTB]	
	Life prediction cancel	[76: LF-CCL]	
	Safety function input terminal	[EN1] [EN2]	Terminal used exclusively for controlling safety function input. Causes all units of system to coast to a stop. However, output is shut down by hardware for only the units into which the signal is inputted.
Do	Operating	[0: RUN]	Operated by operation information from master inverter.
	Stopping under short voltage	[7: LU]	
	Stopping	[13: STOP]	
	Operation preparation completion	[14: RDY]	Operation preparation completion signal of self inverter is outputted.
	Motor M2 selection state	[16: SW-M2]	
	Motor M3 selection state	[17: SW-M3]	
	Alarm contents	[19: AL1] [20: AL2] [21: AL4] [22: AL8]	Alarm information about master inverter and self inverter are added on 4 bits and outputted.
	Cooling fan operating	[23: FAN]	
	Universal DO	[25: U-DO]	
	Cooling fin overheat prediction	[26: INV-OH]	
	Life prediction	[28: LIFE]	
	Inverter overload prediction	[31: INV-OL]	
	DB overload prediction	[34: DB-OL]	
	Transmission error	[35: LK-ERR]	
	Multi-system communication established	[51: MTS]	
	Multi-system cancel response	[52: MEC-AB]	
	Multi-system self station failure	[54: AL-SF]	
	Batch alarm	[56: ALM]	
	Light failure	[57: L-ALM]	
	Maintenance prediction	[58: MNT]	
	DC fan lock signal	[60: DCFL]	
	73 input command	[71: PRT-73F]	
	Y terminal test output ON	[72: Y-ON]	
	Y terminal test output OFF	[73: Y-OFF]	
	Clock battery life	[75: BATT]	
	EN terminal detection circuit error	[80: DECF]	
	EN terminal OFF	[81: ENOFF]	
	Safety function operating	[82: SF-RUN]	
	Motor stopping by safety function	[83: SF-STP]	
	During STO test by safety function	[84: SF-TST]	
Ai	Universal Ai	[14: U-Ai]	
	Others, invalid		
Ao	Motor current	[I-AC]	
	Motor voltage	[V-AC]	
	DC intermediate voltage	[VDC]	
	+10, -10 V test	[P10, N10]	

Note: Even when functions not described are selected in AO, output (monitor) is '0' (displays '0').

9.4.9.5 Keypad functions

When the direct parallel connection system is selected, the keypad functions of the slave inverters are restricted. (No restriction is placed on the functions of the master inverter.)

Table 9.4-9 indicates keypad functions available on the slave inverters.

Note
- When the multiple system is canceled by a setting made to the X terminal function, restrictions on the functions are removed.
- All other functions work effectively such as I/O check, maintenance information, load rate measurement, I/O status upon alarm, alarm history and copy function.

Table 9.4-9: Restrictions on keypad monitor display (direct parallel connection system is selected)

Category	Name	Remarks
LED monitor	Output current detection value	Displays current detection value of self inverter
	Output voltage detection value	Displays voltage detection value of self inverter
	DC intermediate voltage detection value	Displays intermediate voltage detection value of self inverter
Operation state monitor	Output current detection value	Displays current detection of self inverter
	Output voltage detection value	Displays voltage detection of self inverter
Alarm information	Output current detection value upon alarm occurrence	Displays current detection value of self inverter upon alarm trip
	Output voltage detection value upon alarm occurrence	Displays current detection value of self inverter upon alarm trip
	Accumulated operation time upon alarm occurrence	Displays voltage detection value of self inverter upon alarm trip
	Motor output command value upon alarm occurrence	Outputs motor output command value multiplied by the number of inverters upon alarm trip
	Inverter inside air upon alarm occurrence	Displays inside air temperature of self inverter upon alarm trip
	Cooling fin temperature upon alarm occurrence	Displays cooling fin temperature of self inverter upon alarm trip
	Communication status upon alarm occurrence (4 points)	

9.4.9.6 Function codes (F to U)

When the direct parallel connection system is selected, the function codes (F to U) of the slave inverters are restricted. (No restriction is placed on the functions of the master inverter.)

Table 9.4-10 to Table 9.4-14 below summarize restrictions on the slave inverters. Beware of the details.

0: Setting becomes invalid
1: Setting becomes valid (Code that has to be set to same value as master inverter)
2: Setting becomes valid (Code that does not have to be set to same value as master inverter)
3: Setting becomes valid (Code for which setting specific to multi-winding is required)

Note that certain function codes must be set to the same value for both the master and slave inverters.

Table 9.4-10: Slave inverters: Categories for F00 to F85

Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category
F00	2	F11	0	F24	0	F42	0	F51	2	F60	2	F69	0	F80	1
F01	0	F12	0	F26	0	F43	0	F52	2	F61	0	F70	0	F81	0
F02	2	F14	0	F27	0	F44	0	F53	2	F62	0	F73	0	F82	0
F03	1	F17	0	F36	1	F45	0	F54	2	F63	0	F74	0	F83	0
F04	1	F18	0	F37	0	F46	0	F55	2	F64	0	F75	0	F84	2
F05	1	F20	0	F38	0	F47	0	F56	2	F65	0	F76	0	F85	0
F07	0	F21	0	F39	0	F48	0	F57	2	F66	0	F77	0		
F08	0	F22	0	F40	0	F49	0	F58	2	F67	0	F78	0		
F10	0	F23	0	F41	0	F50	0	F59	2	F68	0	F79	2		

Table 9.4-11: Slave inverters: Categories for E01 to E118

Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category
E01	2	E14	2	E27	2	E40	0	E53	0	E66	0	E79	2	E106	0
E02	2	E15	2	E28	2	E41	0	E54	0	E67	0	E80	2	E107	0
E03	2	E16	2	E29	0	E42	0	E55	0	E68	0	E81	2	E108	0
E04	2	E17	2	E30	0	E43	0	E56	0	E69	2	E82	2	E109	0
E05	2	E18	2	E31	0	E44	0	E57	0	E70	2	E83	2	E110	0
E06	2	E19	2	E32	0	E45	0	E58	0	E71	2	E84	2	E114	0
E07	2	E20	2	E33	0	E46	0	E59	0	E72	2	E90	0	E115	0
E08	2	E21	2	E34	0	E47	0	E60	0	E73	2	E91	0	E116	0
E09	2	E22	2	E35	2	E48	0	E61	0	E74	2	E101	0	E117	0
E10	2	E23	2	E36	2	E49	0	E62	0	E75	2	E102	0	E118	0
E11	2	E24	2	E37	2	E50	0	E63	0	E76	2	E103	0		
E12	2	E25	2	E38	0	E51	0	E64	0	E77	2	E104	0		
E13	2	E26	2	E39	0	E52	0	E65	0	E78	2	E105	0		

Note

- Only the functions listed in "Section 9.4.9.4" (Pages 9-31) are effective for E01 to E13, E15 to E27 and E69 to E73.
- C01 to C73: All 0
- P01 to P27: 1, P28 to P58: 0

Table 9.4-12: Slave inverters: Categories for H01 to H227

Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category
H01	0	H20	0	H36	2	H53	0	H74	0	H90	0	H118	1		
H02	2	H21	0	H37	2	H55	0	H75	0			H142	2		
H03	2	H22	0	H38	2	H56	0	H76	2			H149	0		
H04	1	H23	0	H39	2	H57	0	H77	2	H105	2				
H05	1	H24	0	H40	2	H58	0	H78	2	H106	2				
H06	2	H25	0	H41	0	H60	0	H79	2	H107	2				
H08	0	H26	0	H42	0	H61	0	H80	2	H108	2				
H09	0	H27	0	H43	0	H62	0	H81	2	H109	2				
H10	0	H28	0	H44	0	H63	0	H82	2	H110	2				
H11	0	H29	2	H46	0	H64	0	H83	2	H111	2				
H13	0	H30	1	H47	0	H65	0	H84	2	H112	1				
H14	0	H31	2	H48	0	H66	0	H85	2	H113	1				
H15	0	H32	2	H49	0	H67	0	H86	2	H114	1				
H16	0	H33	2	H50	0	H68	2	H87	2	H115	1				
H17	0	H34	2	H51	0	H70	0	H88	2	H116	1				
H19	0	H35	2	H52	0	H71	0			H117	1				

Note

- H201 to H227: All 0
- A01 to A29, A32 to A34: 1
- A30, A31, A51, A71 to A74, A101 to A129, A132 to A134: 1, A130, A131, A151, A171 to A174: 0

Table 9.4-13: Slave inverters: Categories for o01 to o50

Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category
o01	0	o04	0	o07	0	o13	0	o16	0	o19	0	o32	2	o50	3
o02	0	o05	0	o08	0	o14	0	o17	0	o30	2	o33	3		
o03	0	o06	0	o12	0	o15	0	o18	0	o31	2	o34	3		

Note

- L01 to L15: All 0
- U code: All 2

9.4.9.7 Function codes (S: command data)

When the direct parallel connection system is selected, the function codes (S: command data) of the slave inverters are restricted. (No restriction is placed on the functions of the master inverter.)

Only S06 "Operation command 1" and S07 "Universal DO" of the slave inverters work effectively.

Note, however, that only the functions listed in "Section 9.4.9.4" (Pages 9-31) are valid.

9.4.9.8 Function codes (M: monitor codes)

When the direct parallel connection system is selected, the function codes (M: monitor codes) of the slave inverters are restricted. (No restriction is placed on the functions of the master inverter.)

Table 9.4-14 below summarizes restrictions on the slave inverters. Beware of the details.

Table 9.4-14: Slave inverters: Categories for M01 to M222

Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category	Code	Category
M01	0	M22	0	M43	1	M65	1	M86	1	M114	0	M139	1	M162	0
M02	0	M23	1	M44	1	M66	1	M91	1	M115	1	M140	1	M163	0
M03	1	M24	1	M45	1	M67	1	M92	1	M116	1	M141	1	M164	0
M04	0	M25	1	M46	1	M68	1	M93	1	M119	1	M142	1	M165	0
M05	1	M26	1	M47	1	M69	1	M94	1	M120	1	M143	1	M166	1
M06	1	M27	0	M48	1	M70	1	M95	1	M121	1	M144	1	M167	1
M07	1	M28	0	M49	0	M71	1	M96	1	M123	1	M147	0	M168	1
M08	1	M29	1	M50	0	M72	1	M100	1	M124	1	M148	1	M169	1
M09	1	M30	0	M51	0	M73	1	M101	1	M125	1	M149	1	M170	1
M10	2	M31	1	M52	1	M74	1	M102	0	M126	1	M150	1	M171	1
M11	1	M32	1	M53	1	M75	1	M103	1	M127	1	M151	1	M172	1
M12	1	M33	1	M54	1	M76	0	M104	1	M128	1	M152	1	M177	0
M13	1	M34	1	M55	1	M77	1	M105	1	M129	1	M153	1	M178	0
M14	1	M35	1	M56	1	M78	0	M106	0	M130	0	M154	1	M179	0
M15	1	M36	2	M57	1	M79	1	M107	0	M132	1	M155	1	M180	0
M16	1	M37	1	M58	1	M80	1	M108	0	M133	1	M156	1	M185	0
M17	1	M38	1	M59	1	M81	1	M109	0	M134	1	M157	1	M186	1
M18	1	M39	1	M60	1	M82	1	M110	0	M135	1	M158	1	M221	0
M19	1	M40	1	M62	1	M83	1	M111	1	M136	1	M159	1	M222	0
M20	1	M41	1	M63	1	M84	1	M112	0	M137	1	M160	1		
M21	1	M42	1	M64	1	M85	1	M113	0	M138	1	M161	0		

9.5 Motors

9.5.1 Vibration, noise and vibration proof

Vibration level, noise level and vibration proof of the vector dedicated motors are as specified in Table 9.5-1.

Table 9.5-1: Vibration level, noise level and vibration proof of vector dedicated motors

Dedicated applicable motor Note 1) [kW]	No. of poles	Type	Vibration level [μm]		Noise level [dB (A)] Note 2)		Vibration proof [m/s²]
		MVK__	Base speed 1500 [r/min]	Maximum speed Note 3) 3600 [r/min]	Base speed 1500 [r/min]	Maximum speed 3600 [r/min]	
22	4	8185A	5 or less	7 or less	71	73	7 or less Note 4)
30		8187A		7 or less		73	
37		8207A					
45		8208A	5 or less	7 or less Note 5)	71	73	
55		9224A	Note 5)	15 or less	Note 5)	Note 5)	
75		9254A					
90		9256A					
110		9284A					
132		9286A					
160		528KA					
200		528LA					
220		531FA					
250		531GA					
280		531HA					
300		535GA					
315		535GA					
355		535HA					
400		535JA					

Note 1) See the section "2.3.1 Dedicated motor specifications" in Chapter 2 for the specifications and external shape drawings of the dedicated motors.

Note 2) Values are the levels measured at the position 1 [m] away from the motor in the direction of terminal box.

Note 3) Maximum speed is 3000 [r/min] for 30 to 45 [kW], 2400 [r/min] for 55 to 75 [kW] and 2000 [r/min] for 90 to 220 [kW].

Note 4) If actual vibration exceeds the values above, a separate anti-vibration measure is required.

Note 5) Contact us individually.

9.5.2 Allowable radial load on shaft end

[Load applied point]

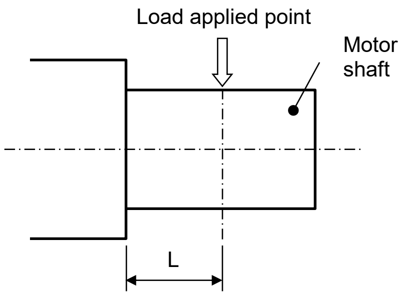


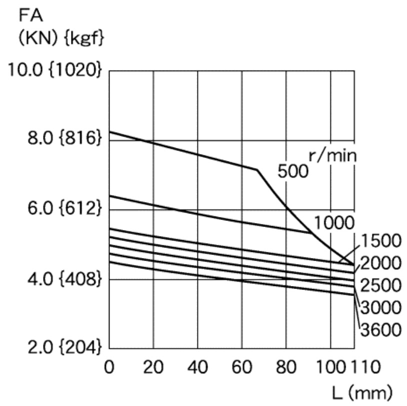
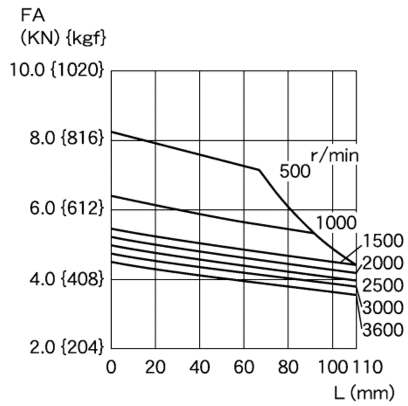
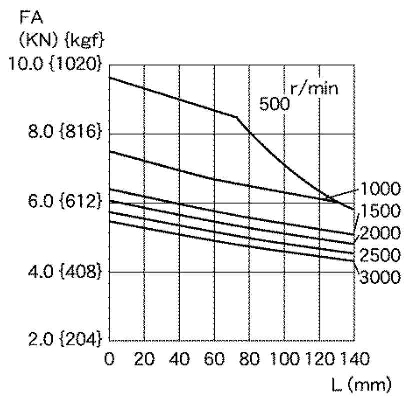
Figure 9.5-1: Explanation of load applied point

Maximum allowable values of radial load applied by the belt are shown in the Figure below for each frame number and rotation speed.

The allowable values in the Figure indicate that, when the point determined by the radial load FA [kN] acting on the motor shaft and the length L [mm] from the stepped part of the shaft end to the center of the pulley (the distance between FA loaded points) is within the curve, the motor can be driven by that pulley.

Refer to the technical leaflet of induction motors for the details.

Contact us individually when using a motor (55 kW or larger) exceeding the Frame No. 200L.

Frame No. 180M MVK8185A [22 kW]	Frame No. 180 MVK8187A [30 kW]	Frame No. 200L MVK8207A [37 kW] MVK8208A [45 kW]
		

9.5.3 Allowable thrust load

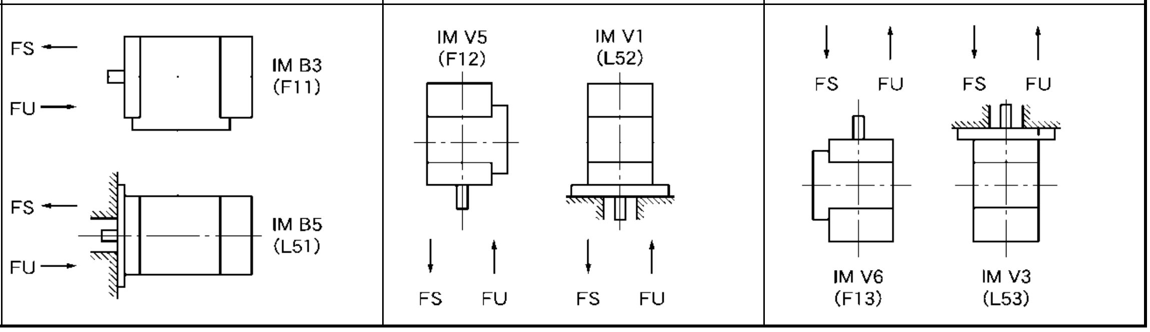
Allowable thrust loads on the vector dedicated motors are as specified in Table 9.5-2.

Table 9.5-2: Allowable thrust loads on vector dedicated motors Unit: kN (kgf)

Unit: kN (kgf)

Frame No.	Type MVK__	Horizontal use IM B3 (F11), IM B5 (L51)						Vertical use IM V5 (F12), IM V1 (L52)						Vertical use IM V6 (F13), IM V3 (L53)					
		Thrust direction: FS			Thrust direction: FU			Thrust direction: FS			Thrust direction: FU			Thrust direction: FS			Thrust direction: FU		
		2 poles	4 poles	6 poles	2 poles	4 poles	6 poles	2 poles	4 poles	6 poles	2 poles	4 poles	6 poles	2 poles	4 poles	6 poles	2 poles	4 poles	6 poles
180M	8184A 8185A	2 (200)	2.7 (280)	3.3 (340)	1.9 (190)	2.3 (230)	2.8 (290)	1.8 (180)	2.3 (230)	2.9 (300)	2.2 (220)	2.7 (280)	3.4 (350)	1.6 (160)	2 (200)	2.6 (270)	2.4 (240)	3.2 (330)	3.9 (400)
180L	8187A																		
200L	8207A	1.9 (190)	3.8 (390)	4.5 (460)	2 (200)	3.2 (330)	3.7 (380)	1.5 (150)	3.2 (330)	3.8 (390)	2.6 (270)	4 (410)	4.8 (490)		2.7 (280)	3 (310)	2.5 (250)	4.6 (470)	5.6 (570)
	8208A	1.2 (120)	5.4 (550)	6.5 (-)	1.2 (120)	5.4 (550)	6.5 (-)	0.4 (40)	4.4 (445)	5.3 (-)	2.3 (230)	6.9 (700)	8.2 (-)	0.4 (40)	4.4 (445)	5.3 (-)	2.3 (230)	6.9 (700)	8.2 (-)
225S	9224A	1.1 (110)	5.2 (535)	6.2 (630)	1.1 (110)	5.2 (535)	6.2 (630)	0.3 (30)	4.1 (415)	4.8 (490)				0.3 (30)	4.1 (415)	4.8 (490)			
250S	9254A	1 (100)	6.4 (650)	7.6 (770)	1 (100)	6.4 (650)	7.6 (770)	—	4.9 (500)	5.6 (570)	—	8.4 (860)	10.3 (1050)	—	4.9 (500)	5.6 (570)	—	8.4 (860)	10.3 (1050)
250M	9256A	0.9 (90)	6.2 (630)	7.3 (740)	0.9 (90)	6.2 (630)	7.3 (740)	—	4.5 (460)	5.1 (520)	—	8.5 (870)	10.4 (1060)	—	4.5 (460)	5.1 (520)	—	8.5 (870)	10.4 (1060)
280S	9284A	0.8 (80)	5.9 (600)	6.9 (700)	0.8 (80)	5.9 (600)	6.9 (700)	—	3.7 (380)	4.2 (430)	—	9.2 (940)	10.8 (1100)	—	3.7 (380)	4.2 (430)	—	9.2 (940)	10.8 (1100)
280M	9286A	0.7 (70)	5.7 (580)	6.7 (680)	0.7 (70)	5.7 (580)	6.7 (680)	—	3.1 (320)	3.8 (390)	—	9.3 (950)	10.9 (1110)	—	3.1 (320)	3.8 (390)	—	9.3 (950)	10.9 (1110)
—	528KA 528LA 531FA 531GA 531HA 535GA 535HA 535JA	*Contact us individually.						*Contact us individually.						*Contact us individually.					

Mounting method and thrust direction



Note (1) In Frame No. 250S and larger, allowable thrust loads on the motors for direct connection are specified.

(2) The allowable thrust loads in this table are calculated based on the assumption that the radial load is borne by the normal sized half coupling.

9.5.4 List of special combinations

9.5.4.1 Combination list of 380V series

When building a system comprising our vector dedicated motor, FRENIC-VG inverters and RHD-D series diode rectifier converters, and if the system receives an incoming voltage of 380 VAC, select inverters with capacities which are one rank higher than the capacity of the motor as specified in Table 9.5-3.

Table 9.5-3: Reference table in the case of incoming voltage of 380 V (only in the case of FRENIC-VG + RHD-D series)

Type		4-pole non-standard special motor			4-pole standard motor		
Base speed [r/min]		1500			Base speed: 1,500 [r/min], Max. speed: 1,500 [r/min]		
Max. load torque [%]		150			150		
Model/Item		Model		Max. speed Nmax [r/min]	Model		Potential max. speed Nmax [r/min] Note 2)
		Motor MVK___	Inverter FRN___		Motor MVK___	Inverter FRN___	
Output [kW]	22	8185A	30SVG1S-4□	3600	8185A	—	2000
	30	8187A	37SVG1S-4□		8187A	30SVG1S-4□	2200
	37	8207A	45SVG1S-4□		8207A	37SVG1S-4□	1600
	45	8208A	55SVG1S-4□		8208A	45SVG1S-4□	2100
	55	9224A	75SVG1S-4□	2400	9224A	55SVG1S-4□	1600
	75	9254A	90SVG1S-4□		9254A	75SVG1S-4□	2000
	90	9256A	110SVG1S-4□	2000	9256A	90SVG1S-4□	2000
	110	9284A	132SVG1S-4□		9284A	110SVG1S-4□	2000
	132	9286A Note1)	160SVG1S-4□		9286A	132SVG1S-4□	1500
	160	528KA Note1)	200SVG1S-4□		528KA	160SVG1S-4□	1500
	200	528LA Note1)	220SVG1S-4□		528LA	200SVG1S-4□	1500
	220	531FA Note1)	280SVG1S-4□		531FA	220SVG1S-4□	1500

Note 1) The electrical characteristics of the motor are the same with those of the standard motor. The motor is combined with inverter with higher capacity.

Note 2) The maximum rotation speed is specified at which the 150% overload rated torque can be obtained with 380 V input. When a 150% overload constant is required at the speed or faster, select one rank higher inverter to increase the capacity.

This table is not applicable when PWM converters (RHC-D series) are used. (Inverters are applicable in the combination of standard specifications.)

9.5.4.2 Combination list of low base speed series

When driving a low base speed motor of which base rotation speed is slower than that of the standard vector dedicated motor, see Table 9.5-4 to select an applicable inverter.

Table 9.5-4: Combinations of inverters and low base speed motors

No. of poles, standard/ non-standard		6-pole non-standard special motor						4-pole standard motor	
Base speed		500 [r/min]	650 [r/min]	750 [r/min]	850 [r/min]	1,000 [r/min]		1,000 [r/min]	
Max. speed		2,000 [r/min]	2,000 [r/min]	1,800 [r/min]	1,700 [r/min]	2,000 [r/min]	2,400 [r/min]	3,000 [r/min]	3,600 [r/min]
Output [kW]	22	MVK9284A FRN37SVG1S -4□	MVK9250A FRN30SVG1S -4□	MVK8207A FRN30SVG1S -4□		MVK8187A FRN30SVG1S -4□		MVK8207A FRN37SVG1S -4□	
	30	MVK9284A FRN45SVG1S -4□	MVK9256A FRN37SVG1S -4□		MVK9221A FRN37SVG1S -4□	MVK8207A FRN37SVG1S -4□		MVK8208A FRN45SVG1S -4□	
	37	MVK9286A FRN55SVG1S -4□	MVK9284A FRN45SVG1S -4□		MVK9224A FRN45SVG1S -4□	MVK9221A FRN45SVG1S -4□			
	45	MVK528KA FRN75SVG1S -4□	MVK9284A FRN55SVG1S -4□		MVK9250A FRN55SVG1S -4□	MVK9224A FRN55SVG1S -4□			
	55	MVK528LA FRN75SVG1S -4□	MVK9286A FRN75SVG1S- 4□		MVK9256A FRN75SVG1S -4□	MVK9250A FRN75SVG1S -4□			
	75	MVK531GA FRN110SVG1S -4□	MVK528LA FRN90SVG1S- 4□		MVK9284A FRN90SVG1S -4□	MVK9256A FRN90SVG1S -4□			
	90	MVK531HA FR132SVG1S -4□	MVK531GA FRN110SVG1S -4□		MVK9286A FRN110SVG1S -4□	MVK9284A FRN110SVG1S -4□			
	110		MVK531HA FRN132SVG1S -4□		MVK528KA FRN132SVG1S -4□	MVK9286A FRN132SVG1S -4□			
	132		MVK531HA FRN200SVG1S -4□		MVK528LA FRN160SVG1S -4□	MVK528KA FRN160SVG1S -4□			
	160					MVK528LA FRN200SVG1S -4□			
	200					Note 1)			

Note 1) Contact us separately.

9.6 Conversion from SI units

The SI units are used for all calculation formulae given in this chapter "Model Selection." This section explains conversion formulae and calculation formulae to other units.

9.6.1 Conversion of units

(1) Force

- $1\ [kgf] \approx 9.8\ [N]$
- $1\ [N] \approx 0.102\ [kgf]$

(2) Torque

- $1\ [kgf \cdot m] \approx 9.8\ [N \cdot m]$
- $1\ [N \cdot m] \approx 0.102\ [kgf \cdot m]$

(3) Work and energy

- $1\ [kgf \cdot m] \approx 9.8\ [N \cdot m] = 9.8\ [J] = 9.8\ [W \cdot s]$

(4) Power

- $1\ [kgf \cdot m/s] \approx 9.8\ [N \cdot m/s] = 9.8\ [J/s] = 9.8\ [W]$
- $1\ [N \cdot m/s] \approx 1\ [J/s] = 1\ [W] \approx 0.102\ [kgf \cdot m/s]$

(5) Rotation speed

- $1\ [r/\min] = \dfrac{2\pi}{60}\ [rad/s] = 0.1047\ [rad/s]$
- $1\ [rad/s] = \dfrac{60}{2\pi}\ [r/\min] = 9.549\ [r/\min]$

(6) Inertia constant

- $J\ [kg \cdot m^2]$: Moment of inertia
- $GD^2\ [kg \cdot m^2]$: Flywheel effect
- $GD^2 = 4J$
- $J = \dfrac{GD^2}{4}$

(7) Pressure and stress

- $1\ [mmAq] \approx 9.8\ [Pa] \approx 9.8\ [N/m^2]$
- $1\ [Pa] \approx 1\ [N/m^2] \approx 0.102\ [mmAq]$
- $1\ [bar] \approx 100000\ [Pa] \approx 0.102\ [kg \cdot cm^2]$
- $1\ [kg \cdot cm^2] \approx 98000\ [Pa] \approx 980\ [mbar]$
- $1\ \text{atmosphere} = 1013\ [mbar] = 760\ [mmHg]$
  $= 101300\ [Pa] \approx 1.033\ [kg/cm^2]$

9.6.2 Calculation formulae

(1) Torque, power, and rotation speed

- $P\ [W] \approx \dfrac{2\pi}{60} \cdot N\ [r/\min] \cdot \tau\ [N \cdot m]$
- $P\ [W] = 1.026 \cdot N\ [r/\min] \cdot T\ [kgf \cdot m]$
- $\tau\ [N \cdot m] \approx 9.55 \cdot \dfrac{P\ [W]}{N\ [r/\min]}$
- $T\ [kgf \cdot m] \approx 0.974 \cdot \dfrac{P\ [W]}{N\ [r/\min]}$

(2) Kinetic energy

- $E\ [W] \approx \dfrac{1}{182.4} \cdot J\ [kg \cdot m^2] \cdot N^2\ [(r/\min)^2]$
- $E\ [W] \approx \dfrac{1}{730} \cdot GD^2\ [kg \cdot m^2] \cdot N^2\ [(r/\min)^2]$

(3) Torque of linear moving load

[Driving mode]

- $\tau\ [N \cdot m] \approx 0.159 \cdot \dfrac{V\ [m/\min]}{N_M\ [r/\min] \cdot \eta_G} \cdot F\ [N]$
- $T\ [kgf \cdot m] \approx 0.159 \cdot \dfrac{V\ [m/\min]}{N_M\ [r/\min] \cdot \eta_G} \cdot F\ [kgf]$

[Braking mode]

- $\tau\ [N \cdot m] \approx 0.159 \cdot \dfrac{V\ [m/\min]}{N_M\ [r/\min] / \eta_G} \cdot F\ [N]$
- $T\ [kgf \cdot m] \approx 0.159 \cdot \dfrac{V\ [m/\min]}{N_M\ [r/\min] / \eta_G} \cdot F\ [kgf]$

(4) Acceleration torque

[Driving mode]

- $\tau\ [N \cdot m] \approx \dfrac{J\ [kg \cdot m^2]}{9.55} \cdot \dfrac{\Delta N\ [r/\min]}{\Delta ts\ [s] \cdot \eta_G}$
- $T\ [kgf \cdot m] \approx \dfrac{GD^2\ [kg \cdot m^2]}{375} \cdot \dfrac{\Delta N\ [r/\min]}{\Delta ts\ [s] \cdot \eta_G}$

[Braking mode]

- $\tau\ [N \cdot m] \approx \dfrac{J\ [kg \cdot m^2]}{9.55} \cdot \dfrac{\Delta N\ [r/\min] \cdot \eta_G}{\Delta ts\ [s]}$
- $T\ [kgf \cdot m] \approx \dfrac{GD^2\ [kg \cdot m^2]}{375} \cdot \dfrac{\Delta N\ [r/\min] \cdot \eta_G}{\Delta ts\ [s]}$

(5) Acceleration time

- $t_{ACC}\ [s] \approx \dfrac{J1 + J2/\eta_G\ [kg \cdot m^2]}{\tau M - \tau L/\eta_G\ [N \cdot m]} \cdot \dfrac{\Delta N\ [r/\min]}{9.55}$
- $t_{ACC}\ [s] \approx \dfrac{GD1^2 + GD2^2/\eta_G\ [kg \cdot m^2]}{T_M - T_L/\eta_G\ [kgf \cdot m]} \cdot \dfrac{\Delta N\ [r/\min]}{375}$

(6) Deceleration time

- $t_{DEC}\ [s] \approx \dfrac{J1 + J2 \cdot \eta_G\ [kg \cdot m^2]}{\tau M - \tau L/\eta_G\ [N \cdot m]} \cdot \dfrac{\Delta N\ [r/\min]}{9.55}$
- $t_{DEC}\ [s] \approx \dfrac{GD1^2 + GD2^2 \cdot \eta_G\ [kg \cdot m^2]}{T_M - T_L \cdot \eta_G\ [kgf \cdot m]} \cdot \dfrac{\Delta N\ [r/\min]}{375}$

Chapter 10 Maintenance and Inspection

10.1 Inspection cycle

Perform inspections based on the details and cycle shown in Table 10.1-1.

Table 10.1-1 List of periodic inspections

Name of inspection	Cycle	Details of inspection
Daily inspection	Every day	See Daily inspection
Periodic inspection	Once every year	See Periodic inspection
10-year inspection *1	Once every 10 years	Replacement of the cooling fans of the inverter and some converters *2 Replacement and detailed check of the capacitors of the main circuit

*1 The 10-year inspection must be performed by a person who has received training by Fuji Electric. Contact your Fuji Electric representative. (Except for replacement of the cooling fans.)

*2 For the standard replacement frequency of the cooling fans, see "10.4 Periodic replacement parts."

Note For stack-type models, the service life of each component is estimated when the model is used under an ambient temperature of 30ºC and a load rate of 100% for the MD spec and 80% for the LD spec.

The replacement cycle may be shortened in an environment where the ambient temperature is higher than the environment spec of 30ºC or where exposed to heavy dust.

The standard replacement frequency is for reference only, and not meant to guarantee service life.

10.2 Daily inspection

Visually inspect the inverter from outside whether there is any failure while it is in operation and powered on and the covers remain installed.

Perform the following inspections:

Table 10.2-1 List of daily inspections

Location	Item	Method	Criteria
Ambient environment	(1) Check the ambient temperature, humidity, vibration, atmosphere (dust, gas, oil mist, drop of water, etc.). (2) Check if there is any tool and/or hazardous material around the inverter.	(1) Check them visually and make measurement using gauges. (2) Check them visually.	(1) The specifications stipulated in "2.2.1 Installation environment" of Chapter 2 must be satisfied. (2) No tools and hazardous materials must be left.
External appearance, etc.	(1) Check if the fixing screws of the main circuit and control wiring are loosened. (*Check them before the inverter is powered on.) (2) Check if there is any trace of overheat and/or discoloration, etc. (3) Check if there is any abnormal noise, abnormal vibration, and/or offensive smell, etc.	(1) Tighten the screws firmly. (2) Check them visually. (3) Check them by listening, viewing, and smelling.	(1) The screws must not be loosened. If they are loosened, tighten them firmly. 2) & 3) There must be no such faults.
Cooling fan	Check if any abnormal noise and/or abnormal vibration is generated while they are in operation.	Check them by listening and viewing.	There must be no such faults.
Display on keypad	Check if any alarm appears on the keypad.	Check it visually.	For the alarms, see Chapter 11 "Troubleshooting".
Performance	Check if the expected performance (which meets the standard specifications) is obtained.	Check the monitor of the keypad.	There must be no fault in the operation data including the operation frequency, current, and voltage, etc.
Door (cabinet)	Check if the door is opened and closed smoothly. Check if the handle moves without any problems. Check if the bolts of the hinges and hooks are not loosened. Check if there is no hole in the air filter.	Check them visually and actually operate them.	(1) The door must be opened and closed smoothly. (2) The screws must not be loosened, and the filter must not get dirty outstandingly and have holes.

10.3 Periodic inspection

In the periodic inspection, the inspection items and methods vary according to the power condition, etc. This section explains the inspection items for each power condition.

10.3.1 Periodic inspection 1 (Before power is on or after operation is stopped)

Among the periodic inspection items, those that must be checked before the power is on and immediately after the operation is stopped are explained in Table 10.3-1. Regarding the inspection items for immediately after the operation is stopped, be sure to shut down the power and detach the front cover before performing the inspection.

It takes time until the capacitors of the main circuit discharge after the power is turned OFF.

For safety, after the charge lamp (CHARGE) of the inverter is turned OFF, check that the DC voltage is lowered to the safe level (DC +25 V or less) using a tester, etc., and then start the inspection.

Table 10.3-1 List of periodic inspections 1

Location		Item	Method	Criteria
Structural parts including cases and covers of cabinet and inverter		1) Check if the bolts (tightening sections) are not loosened. 2) Check if there is any deformation and breakage. (Check if the cabinet is not deformed.) 3) Check if there is any discoloration caused by overheat. 4) Check if any dirt and/or dust is affixed.	1) Tighten the bolts firmly. 2), 3), 4) Check them visually.	1), 2), 3), 4) There must be no such faults. If any dirt is affixed, wipe it with a soft cloth.
Air suction filter (cabinet)		Check if there is any hole on the filter. Check if significant dust is affixed. Check if the air filer is hardened.	1), 2) Check them visually. 3) Touch the filter by hand.	1), 2) There must be no such faults. 3) The fabric must not be damaged.
Main circuit	Common	1) Check if the bolts, etc. are not loosened or dropped. 2) Check if there is any arc mark, deformation, crack, breakage, and/or discoloration caused by overheat and/or deterioration on the devices and insulation materials (insulation sheets, insulation tubes, and other insulators). 3) Check if any dirt and/or dust is affixed.	1) Tighten them firmly. 2), 3) Check them visually.	1), 2), 3) There must be no such faults. If any dirt is affixed, wipe it with a soft cloth. It might be difficult to find arc marks on the devices because they have a protection cover, etc.
	Conductor/ Electric wire	1) Check if there is any discoloration and/or warp caused by overheat on the conductors. 2) Check if there is any tear, crack, or discoloration on the covers of the electric wires.	1), 2) Check them visually.	1), 2) There must be no such faults.
	Terminal block	Check if it is damaged.	Check it visually.	There must be no such fault.
	Capacitors in main circuit	1) Check if there is any liquid leakage, discoloration, crack, and extension of the cases. 2) Check if the safety valve sticks out and if any valve extends too much. 3) Measure the electrostatic capacity, if necessary.	1), 2) Check them visually.	1), 2) There must be no such faults.
	Braking resistor	1) Check if there is any offensive smell and/or crack of insulators caused by overheat. 2) Check if the wires are disconnected.	1) Check them visually and by smelling. 2) Check it visually or detach the connection at one side and make measurement using a tester.	1) There must be no such faults. 2) The value displayed on the resistor must be within ±10%.

Control circuit	PCB	1) Check if any screw or connector is loosened. 2) Check if there is any offensive smell and/or discoloration. 3) Check if there is any crack, breakage, deformation, and outstanding rust. 4) Check if there is any liquid leakage from and/or deformation of the capacitors. * Detection of the service life based on the maintenance information.	1) Tighten them firmly. 2) Check them visually and by smelling. 3) Check them visually. 4) Check them visually.	1), 2), 3), 4) There must be no such faults.
Cooling system	Cooling fan	1) Check if there is any fault. 2) Check if the bolts, etc. are not loosened. 3) Check if there is any discoloration caused by overheat. * Detection of the service life based on the maintenance information.	1) Rotate the fan by hand. (Be sure to turn the power OFF beforehand.) 2) Tighten them firmly. 3) Check it visually.	1) The fan must rotate smoothly. 2), 3) There must be no such faults.
	Ventilation opening	Check if the cooling fin, air suction opening, and/or exhaust opening is clogged, and if any foreign material is affixed to them.	Check it visually.	No dust and foreign material are affixed. If they are, remove them by a brush or air, etc.

10.3.2 Periodic inspection 2 (After power is on, inverter is energized)

Visually inspect the inverter from the outside to check if there is any failure in the operation while it is powered on and the covers remain attached.

Perform the periodic inspection 2 in accordance with the items listed in Table 10.3-2 List of periodic inspections 2.

Table 10.3-2 List of periodic inspections 2

Location	Item	Method	Criteria
Voltage	Check if the main circuit voltage and control circuit voltage are correct.	Measure the voltage using a tester, etc.	The voltage must meet the standard specifications.
Structural parts including cases and covers	Check if there is any abnormal noise and/or abnormal vibration during operation.	Check them visually and by listening.	There must be no such faults.
Transformer and reactor	Check if there is any abnormal roaring noise and/or offensive smell during operation.	Check them visually and by listening and smelling.	There must be no such faults.
Electromagnetic contactor and relay	Check if there is any chattering noise during operation.	Check it by listening.	There must be no such faults.

[Additional Information]

(1) The frequency of the periodic inspection (once a year) shown in Table 10.3-1 and Table 10.3-2 is reference information. You can determine the frequency according to the environment where the inverter is used.

(2) Save the results of the periodic inspection and keep the logs, and use them to determine the operation and maintenance, and estimate the service life of the equipment.

(3) Check the accumulated operation time on the keypad upon inspection and use it to determine the replacing timing of parts.
(See Inverter Instruction Manual.)

(4) Even if the inverter is stored in a cabinet, dust may enter the inverter. Be sure to check if dust settles on the cooling fans or cooling fins of the inverter upon periodic inspection.
(If the cooling fans and/or cooling fins are covered with a lot of dust, the cooling performance is lowered, and the temperature protection function of the inverter might work. In addition, the temperature around the electronic parts rises, and it affects some consumable parts, lowering their service life.)

10.4 Periodic replacement parts

Some parts used in the inverter are consumable owing to their characteristics. While their service life varies according to the surrounding environment and use conditions, it is recommended to replace them based on the standard replacement frequency shown in Table 10.4-1. Some of them need knowledge for replacement.

Table 10.4-1 Replacement parts

Replacement part		Standard replacement frequency	Remarks
Parts in inverter/ converter	Capacitors of main circuit	Every 10 yrs	
	Electrolytic capacitors on PCB	Every 10 yrs	
	Cooling fan	Every 10 yrs	
	Fuse	Every 10 yrs	
	Battery for memory backup	Every 5 yrs	
Cooling fan (for cabinet)		Every 3 to 5 yrs (reference)	Contact the manufacturer of the cooling fan and determine the replacement frequency. It is 3 years for a cooling fan of general specifications.
Air filter		-	The replacement frequency varies according to the use conditions. Clean the air filter or replace it with a brand-new one. (For details, see the next page.)
Fuse		Every 10 yrs	

(Note) The estimated service life is calculated using the following conditions for MD and LD specifications respectively. In an environment where the ambient temperature is higher than 30°C or there is a lot of dust, the standard replacement frequency might become shorter.

- MD specification: Inverter ambient temperature: 30°C; Load rate: 100%
- LD specification: Inverter ambient temperature: 30°C; Load rate: 80%

Note the following matters for operation:

(1) The standard replacement frequencies listed in the table above are the reference values. If you replace the parts with new ones at these frequencies, failures can be prevented at high probabilities. They do not guarantee the complete operation during the specified number of years.

(2) The above table is not applied to the unused spare parts in stock.
It can be applied only if the unused spare parts are stored in a ventilated cool and dark place and they are powered on approx. every one year.

(3) You can replace the cooling fans and batteries. On the other hand, other parts must be replaced by those who have received training by Fuji Electric. Contact your Fuji Electric representative for purchase of replacement parts of the cooling fans and batteries or request for replacement of other parts.

Replacement of air filter

An air filter to be mounted on the air suction opening (our standard filter is mounted on the door) collects dust inhaled together with air from outside. If the air filter is clogged, the ventilation performance is lowered (the cooling air volume is lowered), and the temperature in the panel rises, causing overheat and/or failures.

For this reason, you need to perform periodical inspection, and clean or replace the air filter when it gets dirty substantially.

<Reference>

Recommended air filter: Viledon air filter (PS/400) by Japan Vilene Co., Ltd.

(1) Mounting example

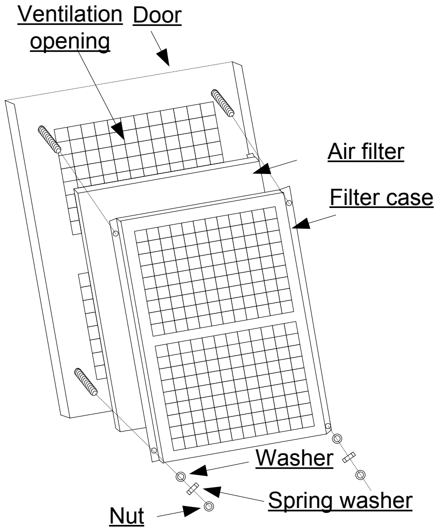


Figure 10.4-1 Example of air filter mounting structure

Mount the air filter so that the left side of the air filter faces the outer side of the panel as shown in the figure below. Failure to do so impairs the performance of the air filter.

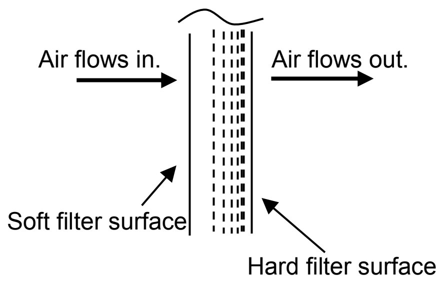


Figure 10.4-2 Air filter mounting direction

(2) Example of reuse

The air filter recommended by Fuji Electric is reusable.

- Wash the air filter in a water tank by gently pressing it.
- Clean the filter by spray.
- Blow the dirt on the filter with compressed air or suck it using a vacuum cleaner.

If you use neutral detergent, oily dust, etc. can be also removed.

To prevent deterioration of the air filter during cleaning, do not rub and squeeze when you wash it. Be sure to dry the air filter naturally after cleaning.

While the number of times that the filter can be reused varies according to the use condition and cleaning method, the performance of the filter is lowered after it is reused.

Therefore, it is recommended to replace the air filter with a new one after cleaning and reusing it three times.

Chapter 11 Troubleshooting

11.1 Protective functions

The FRENIC-VG series of inverters has various protective functions as listed below to prevent the system from going down and reduce system downtime.

(1) The protective functions marked with an asterisk "*" in the table below are disabled by default. Enable them according to your needs.

(2) The FRENIC-VG has roughly three protective functions and lightning surge protection function. The inverter performs any of these functions according to the status of its operation, input interface setting, input signal, and communication interface:

1) The "**heavy alarm**" detection function which, upon detection of an abnormal state, displays the alarm code and causes the inverter to trip
2) The "**light alarm**" detection function which displays the alarm code but lets the inverter continue the current operation
3) Other "**warning signal**" output functions
4) Lightning surge protection function

If any problem arises, understand the protective functions listed below and follow the procedures given in the following sections for troubleshooting.

Table: 11.1-1 Description of protective functions

Protective functions		Description
Heavy alarm (detection)		This function detects an abnormal state, causes the inverter to trip, and displays an alarm code corresponding to each factor on the keypad. See Table: 11.3-1 " Abnormal states detectable (heavy alarm and light alarm objects)" for alarm codes. For details, see description corresponding to each alarm code in the troubleshooting. The inverter retains and displays the latest and the last 10 alarm codes and the latest and the last three pieces of detail information. For more information, see Sections 3.4.4.8 and 3.4.4.9 in Chapter 3 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".
Light alarm *		This function detects an abnormal state and displays “L -AL” for a "light alarm," and lets the inverter continue the current operation without tripping. It is possible to define which abnormal states should be categorized as a "light alarm". (See Table: 11.3-1.) For instructions on how to check and release light alarms, see Section 3.4.3.5 in Chapter 3 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".
Warning	Stall prevention	When the torque command value exceeds the torque limiter level (F44, F45) during acceleration/deceleration or constant speed running, this function limits the torque generated by the motor in order to avoid an overcurrent trip.
	Motor overload early warning*	When the inverter output current has exceeded the specified level, this function issues the motor overload early warning signal [M-OL] before the motor electronic thermal function causes the inverter to trip for motor protection.
	Retry*	When the inverter has stopped because of an alarm trip, this function allows the inverter to automatically reset and restart itself. (The number of retries and the latency between stop and reset can be specified.)
Surge protection		This function protects the inverter from a surge voltage invaded between main circuit power lines and the ground.

Note) If the DC link bus voltage drops below the undervoltage level, alarm information is not saved.

11.2 Before proceeding with troubleshooting

⚠WARNING

- If any of the protective functions has been activated, first remove the cause. Then, after checking that all the run commands are set to OFF, release the alarm. If the alarm is released while any run commands are set to ON, the inverter may supply the power to the motor, running the motor, which could be dangerous.

Injury may occur.

- Even if the inverter has interrupted power to the motor, voltage may be output to inverter output terminals U, V, and W if any voltage is applied to the main power supply input terminals.
- Before inspection, perform the following: Turn OFF the power supply and wait at least ten minutes. Make sure that the LED monitor and charging lamp are turned OFF. Further, make sure, using a tester or a similar instrument, that the DC link bus voltage between the main circuit terminals P (+) and N (-) has dropped to the safe level (+25 VDC or below).

Electric shock may occur.

Follow the procedure below to solve problems.

(1) First, check that the inverter is correctly wired. — Refer to Chapter 2, "Section 2.4.1 Connection diagrams."

(2) Check whether an alarm code or the "light alarm" indication (L-AL) is displayed on the LED monitor.

- If an alarm code appears on the LED monitor — Go to Section 11.3.
- If the "light alarm" indication (L-AL) appears on the LED monitor — Go to Section 11.4.
- If neither an alarm code nor "light alarm" indication (L-AL) appears on the LED monitor

<u>Abnormal</u> motor operation — Go to Section 11.5.1. (Page 11-27)

[1] The motor does not rotate
[2] The motor rotates, but the speed does not change
[3] The motor runs in the opposite direction to the command
[4] Speed fluctuation or current oscillation (e.g. hunting) occurs during running at constant speed
[5] Grating sound is heard from the motor or the motor sound fluctuates
[6] The motor does not accelerate or decelerate within the specified time
[7] The motor does not restart even after the power recovers from a momentary power failure
[8] The motor abnormally heats up
[9] The motor does not run as expected
[10] When the motor accelerates or decelerates, the speed is not stable
[11] The motor stalls during acceleration
[12] When the T-Link communications option is in use, neither a run command nor a speed command takes effect
[13] When the SX-bus communications option is in use, neither a run command nor a speed command takes effect
[14] When the CC-Link communications option is in use, neither a run command nor a speed command takes effect
[15] Under bar (_) appears

<u>Problems with inverter settings</u> — Go to Section 11.5.2. (Page 11-38)

[1] Nothing appears on the keypad
[2] The desired function code
[3] Data of function codes cannot be changed from the keypad
[4] Data of function codes cannot be changed via the communications link

If any problems persist after the above recovery procedure, contact your Fuji Electric representative.

11.3 If an alarm code appears on the LED monitor

If an alarm is detected, check the alarm cord displayed on the 7-segment LED of the keypad. Some alarm codes are followed by alarm sub codes that denote the detailed error causes.

For the alarm sub code checking procedure, refer to "Section 3.4.4.8 Reading alarm information" in Chapter 3 of separate volume "Unit Type/Function Codes Edition (24A7-□-0019)".

(1) For alarm codes followed by alarm sub codes, the alarm sub code is indicated with a 4-digit numeric value (0001 to □□□□) in the bracket [ ].

(2) For alarm codes not followed by alarm sub codes, the alarm sub code is set at "0000", and "--" is written in the table below.

11.3.1 List of alarm codes

Table: 11.3-1 Abnormal states detectable (heavy alarm and light alarm objects)

Alarm code	Error cause	Heavy alarm objects	Light alarm objects	Retry objects	Alarm sub code	Remarks	Ref. page
dCF	DC fuse disconnection	○	–	–	–	If DCF1 and DCF2 are not connected, an error cannot be detected	11-5
d0	Excessive positioning deviation	○	–	–	–		11-5
EC	Encoder communication error	○	–	–	0001 to 2000	When OPC-VG1-SPGT is installed	11-6
ECF	ENABLE circuit (safety stop circuit) failure	○	–	–	0001	Input timing mismatch between EN1 and EN2 terminals	11-6
					0002	PCB failure	
					0005 to 0008	CPU error	
EF	Ground fault	○	–	–	–		11-7
Er1	Memory error	○	–	–	0001 to 0008	For manufacturers	11-7
Er2	Keypad communications error	○	–	–	0001	Detection of wire break	11-8
					0002	Detection of wire break (during operation by way of TP)	
Er3	CPU error	○	–	–	0001 to 0008	For manufacturers	11-8
Er4	Network error	○	○	–	0001 to 0004		11-9
Er5	RS-485 communications error	○	○	–	0001	Communications error (timeout)	11-10
					0002	Communications error (transmission error)	
Er6	Operation error	○	–	–	0001	Error in mounting of option(s)	11-11
					0002	Auto-tuning malfunction	
					0008 to 8000	For manufacturers	
Er7	Output wiring fault	○	–	–	0001	Output wiring fault during tuning	11-12
					0002	Speed not attained during rotation-tuning	
					0004 to 0040	For manufacturers	
Er8	A/D converter error	○	–	–	0001 to 0004	For manufacturers	11-12
Er9	Speed not agreed	○	○	–	0001	Motor 1 speed deviation	11-13
					0002	Motor 2 speed deviation	
					0004	Motor 3 speed deviation	
					0008	Machine runaway detected by H149	
ErA	UPAC error	○	–	–	0001 to 0004		–
Erb	Inter-inverter communications link error	○	–	–	0002 to 0400	For manufacturers	11-14
ErH	Hardware error	○	–	–	0001 to 1000	For manufacturers	11-14
Err	Mock alarm	○	○	–	–		11-14
Et1	Encoder error 1	○	–	–	–	When OPC-VG1-SPGT is installed	11-14

(To be continued)

Table: 11.3-1 Abnormal states detectable (Heavy alarm and light alarm objects) (Continued)

Alarm code	Error cause	Heavy alarm objects	Light alarm objects	Retry objects	Alarm sub code	Remarks	Ref. page
LOC	Start delay	○	○	–	–		11-15
LU	Undervoltage	○	–	–	–		11-16
nrb	NTC thermistor wire break	○	○	–	–		11-16
OC	Overcurrent	○	–	○	0001 to 0004	For manufacturers	11-17
					0100	Overcurrent to demagnetizing limiting current for PMSM	
OH1	Heat sink overheat	○	–	○	0001 to 0008	Protection by thermistor	11-18
					0010 to 0200	For manufacturers	
OH2	External alarm	○	○	–	0001	Protection by THR signal	11-19
OH3	Inverter internal overheat	○	–	○	0001 to 0008	Protection by thermistor	11-19
					0010	For manufacturers	
OH4	Motor overheat	○	○	○	–		11-20
OL1	Motor 1 overload	○	○	○	–		11-21
OL2	Motor 2 overload	○	○	○	–		–
OL3	Motor 3 overload	○	○	○	–		–
OLU	Inverter overload	○	–	○	0001 to 0010	For manufacturers	11-22
OPL	Output phase loss detection	○	–	–	0001	Loss of one or more phases	11-23
					0002	Loss of two or more phases	
OS	Overspeed	○	–	–	–		11-23
OU	Overvoltage	○	–	–	0001	For manufacturers	11-24
PG	PG wire break	○	–	–	0001	Detection of wire break (inverter PA, PB)	11-25
					0002	Detection of wire break (option)	
					0004	Detection of power supply disconnection (inverter)	
					0010 to 0400	Failure in PG wiring for PMSM	
Ar-E	E-SX bus tact synchronization error	○	○	–	–		11-26
Ar-F	(PLC) Toggle abnormality error	○	○	–	–		11-26
SrF	Functional safety card error	○	–	–	0001 to 000d (8001 to 800d)	When OPC-VG1-SAFE is installed ∗ For details, refer to the OPC-VG1-SAFE instruction manual (INR-SI47-1541-JE).	–
SiF		○	–	–	000e to 0015 (800e to 8015)		
SnF		–	○	–	0016 to 0018 (8016 to 8018)		

11.3.2 Possible causes of alarms, checks and measures

[1] dCF DC fuse disconnection

Problem The DC fuse connected to the input terminals P (+) and N (-) of the FRENIC-VG blew.

Note
(1) Connect microswitch (b-contact) provided for DC fuse to input terminals (DCF1, DCF2) for detecting DC fuse disconnection.
(2) If the fuse has been disconnected, the internal elements may be broken. NEVER turn the power ON to prevent secondary damage. Contact your Fuji Electric representative.

Possible Causes	What to Check and Suggested Measures
(1) The fuse blew	Check whether there has been any excess surge or noise coming from outside. ➔ Take measures against surges and noise. ➔ Request for repair work on inverter. (Please contact our service department.)
	Disconnect the wiring from the output terminals [U], [V] and [W] and perform a Megger test on the inverter and the motor. ➔ Find and remove the ground fault parts. (Check the wiring, etc. as well.) If the DC fuse was disconnected due to ground faults that have occurred at the inverter and/or motor, repair and inspection might be required. (Ask your Fuji Electric representative.)
(2) Are the input terminals P (+) and N (-) short circuited?	Modify the structure of the cabinet. ➔ Request for repair work on inverter. (Please contact our service department.)
(3) Is wiring of microswitch disconnected?	➔ Check for disconnection of cable by using tester, etc. ➔ Check for any loose wiring. (Also check for any loose terminal screw.)

[2] dO Excessive positioning deviation

Problem An excessive positioning deviation has occurred.

Possible Causes	What to Check and Suggested Measures
(1) Wrong wiring to the motor	Check the wiring to the motor. ➔ Connect the inverter output wiring U, V, and W to the motor wiring U, V, and W, respectively. (It is also possible to use H75: phase sequence configuration of main circuit output wiring).
(2) The motor cannot rotate mechanically.	➔ Check whether the brake is applied.
(3) Output torque is too small.	➔ Increase the torque limiter level (F44, F45).
(4) Deviation override width is too small	➔ Review the deviation override width. (o18)
(5) Insufficient gain in positioning control system.	➔ Readjust the positioning loop gain. (o16)
(6) The acceleration/deceleration by pulse train command is too rapid.	➔ Increase the acceleration/deceleration time.

[3] EC Encoder communication error

Problem Communication error. (When OPC-VG1-SPGT is installed)

Possible Causes	What to Check and Suggested Measures
(1) Communications with the ABS encoder are interrupted.	➔ Check for disconnection of cable using a tester, etc. ➔ Check for any loose wiring. (Also check for any loose terminal screw.) ➔ Check if the encoder is a model specified for OPC-VG1-SPGT. ➔ Communication error might have occurred due to ringing in communication data. Install a terminating resistor (220 Ω, 1/4 W). ➔ Malfunction might have occurred due to noise. Insert a ferrite core.
(2) Disconnection (poor connection) of ABS encoder cable	
(3) OPC-VG1-SPGT is not installed properly.	Check that the option card is properly engaged with the connector of the inverter. ➔ Reinstall the option card properly.

For more information, see "Section 6.8 OPC-VG1-SPGT" in Chapter 6 of separate volume "Option Edition (24A7-□-0045)".

[4] ECF ENABLE circuit (safety stop circuit) failure

(1) Alarm sub-code 0001

Problem A failure occurred in the enable input circuit.

Possible Causes	What to Check and Suggested Measures
(1) Poor contact of control circuit terminal block	Check that the control circuit terminal block is securely fitted on the inverter.
(2) Enable input circuit faulty logic	Check the ON/OFF state of EN1 and EN2 using I/O check. ➔ Check that wiring is properly installed between the EN1 and PS terminals as well as between the EN2 and PS terminals. ➔ Operate the relay so as to synchronize ON/OFF between EN1 and EN2. ➔ Check the relay for fusion of the contacts and any problem. If a problem exists, replace the relay. ➔ Check the ON/OFF timing between EN1 and EN2 for a time lag. Make sure that the time lag is less than 50 ms.
(3) Failure in enable input circuit	A failure occurs even after measures in (2) are taken. ➔ Request for repair work on inverter. (Please contact our service department.) * Inform the representative of the alarm sub code displayed.

(2) Alarm sub-code 0002, 0005 to 0008

Problem A failure or any other error occurred in PCB or CPU.

Possible Causes	What to Check and Suggested Measures
(1) Inverter affected by strong electrical noise	Check if appropriate noise control measures have been implemented (e.g. correct grounding and routing of signal wires, communication cables and main circuit wires). ➔ Improve the noise control measures.
(2) Short circuit on the printed circuit board(s)	Check the printed circuit board(s) for short circuits, dust and any adherents. ➔ Request for repair work on inverter. (Please contact our service department.) * Inform the representative of the alarm sub code displayed.

Note To remove the ECF error, turn the power to the inverter OFF and then ON.
The error cannot be removed by pressing the RESET key.

[5] *EF* Ground fault

Problem A ground fault current flew from the output terminal of the inverter.

Possible Causes	What to Check and Suggested Measures
(1) Ground faults have occurred at the inverter output terminal(s).	Disconnect the wiring from the inverter output terminals [U], [V] and [W] and perform a Megger test on the inverter and the motor. ➔ Remove the ground fault parts (including replacement of the wires, relay terminals and motor).
(2) The setting of the motor rated current (P04, A03, A103) is small relative to the inverter rated current.	The motor rated current is set at a value that is too small to the inverter rated current. ➔ Check the setting of the motor rated current (P04, A03, A103). ➔ Disable the ground fault detection by setting "0" to the hundreds digit of H103 (Protection/maintenance function 1).

[6] *Er1* Memory error

Problem Error occurred in writing data to the memory in the inverter.

Possible Causes	What to Check and Suggested Measures
(1) When writing function code data (especially initializing or copying data), the inverter was shut down so that the voltage to the control PCB has dropped.	Initialize the function code data by setting H03 to "1." After initialization, check if pressing the RESET key can release the alarm. ➔ Revert the initialized function code data to their previous customized settings (Note), then restart the operation.
(2) Inverter affected by strong electrical noise when writing function code data (especially initializing data)	• Check if appropriate noise control measures have been implemented (e.g. correct grounding and routing of control and main circuit wires). • Perform the same check as described in (1) above. ➔ Implement noise control measures. Revert the initialized function code data to their previous customized settings, then restart the operation.
(3) Control circuit failure [Sub code: 0001 to 0008]	Initialize the function code data by setting H03 to "1," then reset the alarm by pressing the RESET key and check that the alarm goes on. ➔ Request for repair work on inverter. (Please contact our service department.) The PCB (CPU) failed and needs to be replaced. * Inform the representative of the alarm sub code displayed.
(4) High-frequency rewriting to the non-volatile memory has reached the limit of the electronic device (approx. 1,000,000 times). [Sub code: 0001 to 0008]	Function code data setting has been frequently changed. ➔ Request for repair work on inverter. (Please contact our service department.) The PCB (non-volatile memory) failed and needs to be replaced. *Inform the representative of the alarm sub code displayed. ➔ Decrease the frequency of rewriting. Decrease the frequency of full save operations. Note When you access H02 (full save) using PLC, etc., do not perform the full save operation every task cycle of PLC.

(Note) Function code data can be easily reverted to the previously customized settings by using the backup data copied in the keypad memory with "Menu #10 Copying data" in Programming mode. (Refer to "Section 3.4.4.10 Copying data" in Chapter 3 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".)

[7] Er-2 Keypad communications error

Problem A communications error occurred between the keypad and the inverter.

Possible Causes	What to Check and Suggested Measures
(1) Disconnection or poor contact of communications cable [Sub code: 0001]	Check continuity of the cable, contacts and connections. ➔ Re-insert the connector firmly. ➔ Replace the communication cable.
(2) The keypad is not properly installed. [Sub code: 0001]	Many control wires are connected, and consequently the front cover is lifted. The keypad is not inserted properly into the front cover. ➔ Use wires of the recommended size (0.75 mm^2) for wiring. ➔ Change the wiring layout inside the unit so that the front cover can be mounted firmly.
(3) Inverter affected by strong electrical noise [Sub code: 0002]	Check if appropriate noise control measures have been implemented (e.g. correct grounding and routing of communication cables and main circuit wires). ➔ Implement noise control measures.
(4) A keypad failure occurred.	Replace the keypad with another one and check whether a keypad communications error (Er-2) occurs. ➔ Replace the keypad.
(5) A keypad designed for any other series of inverters is connected.	Check whether the connected keypad is a multi-function keypad designed for other series (MEGA, …., etc.). ➔ Replace the keypad with the one designed for the FRENIC-VG.

[8] Er-3 CPU error

Problem A CPU error occurred.

Possible Causes	What to Check and Suggested Measures
(1) Inverter affected by strong electrical noise	Check if appropriate noise control measures have been implemented (e.g. correct grounding and routing of signal wires, communications cables, and main circuit wires). ➔ Implement noise control measures.
(2) Short circuit on the printed circuit board(s) [Sub code: 0001 to 0008]	Check the printed circuit board(s) for short circuits, accumulation of dust or dirt. ➔ Request for repair work on inverter. (Please contact our service department.) * Inform the representative of the alarm sub code displayed.

Note To remove the Er-3 (CPU error), turn the power to the inverter OFF and then ON.
The error cannot be removed by pressing the RESET key.

[9] Er-4 Network error

Problem The connected option card detected an error.

	Possible Causes	What to Check and Suggested Measures
Common	(1) Wrong wiring	➔ Check if the wiring is correct. If not, correct the wiring. • The specified cable is used. • There is no wire break. • The wiring length is within the range of the specification. • The shielded wires are properly treated. • The signal lines are not wired in parallel with the power lines. • The maximum extension cable length, inter-station cable length, and the number of devices connected are as specified.
	(2) Wrong address (station number) setting	➔ Set a new link address. (After a new link address is set, reset the power.)
T-link option	(1) The power to the MICREX IO terminal is OFF.	Check the power to the MICREX IO terminal. ➔ Turn ON the power to the MICREX IO terminal and reset the inverter alarm state.
	(2) Wrong wiring	Check if the wiring is correct. • The T-Link network has terminating resistors. (1 resistor at each end: 100 Ω) • The SD terminal of the T-Link is not connected to a frame ground (FG). • A crimp terminal is used for connection.
SX bus/E-SX bus option	(1) The SX-bus power is shut down or the PLC's CPU module is down.	Check the power to the SX (E-SX) bus and the status of the PLC's CPU module. ➔ Turn ON the power to the SX-bus or E-SX bus, recover the PLC's CPU module, and reset the inverter alarm state. Check if the power capacity is sufficient. ➔ If not, add an electric repeater on the SX bus (E-SX bus).
	(2) An error has occurred at any other station.	Check the detailed RAS information on the PLC's CPU module to find a faulty station. ➔ Recover the faulty station and reset the inverter alarm state.
	(3) SX bus terminating connector is not inserted.	➔ Insert an SX bus terminating connector at each end of the bus. Note E-SX bus does not use a terminating connector. (If it is used, the devices connected to the E-SX bus might get broken.)
CC-Link option	(1) The power to the PLC is shut down or the PLC's CPU module is down.	Check the power to the PLC and the status of the PLC's CPU module. ➔ Turn ON the power to the PLC, recover the PLC's CPU module, and reset the inverter alarm state.
	(2) An error has occurred at any other station.	Check the detailed RAS information on the PLC's CPU module to find a faulty station. ➔ Recover the faulty station and reset the inverter alarm state.
	(3) Wrong wiring	Check if the following wiring is correct. • The CC-Link network has terminating resistors (1 resistor at each end: 110 Ω). • The minimum cable length between CC-Link stations is as specified. • Connection to the terminal block is proper.

* For more information on the option cards, see Chapter 6 of separate volume "Option Edition (24A7-☐-0045)".

[10] Er-5 RS-485 communications error

Problem A communications error occurred during RS-485 communication.

Possible Causes	What to Check and Suggested Measures
(1) Communication conditions of the inverter do not match that of the host equipment. [Sub code: 0002]	Compare the settings of function codes H32 to H40 (for communications) with those of the host equipment. ➔ Correct any settings that differ.
(2) Even though no-response error detection time (H38) has been set, communication is not performed within the specified cycle. [Sub code: 0001]	Check the host equipment side. ➔ Change the settings of host equipment software or disable the no-response error detection time (H38 = 0).
(3) The host equipment did not operate due to defective software, settings, or defective hardware. [Sub code: 0002]	Check the host equipment (e.g. PLCs and computers). ➔ Remove the cause of the host equipment error.
(4) The RS-485 converter did not operate due to incorrect connections and settings, or defective hardware.	Check the RS-485 converter (e.g. check for poor contact or incorrect wiring). ➔ Change the various RS-485 converter settings, reconnect the wires, or replace hardware with recommended devices as appropriate.
(5) Disconnection or poor contact of communications cable	Check the continuity of the cables, contacts and connections. ➔ Replace the cable.
(6) Inverter affected by strong electrical noise	• Check if appropriate noise control measures have been implemented (e.g. correct grounding and routing of communications cables and main circuit wires). • Check if decreasing the communication speed (H34) down to 2400 bps causes no alarm. ➔ Implement noise control measures. ➔ Implement noise reduction measures on the host equipment. ➔ Replace the RS-485 converter with a recommended insulated one. ➔ Keep the inverter running, using the selection of operation when error occurs (H32).
(7) Terminating resistor not properly configured	Check that the inverter serves as a terminating device in the RS485 network. ➔ Configure the terminating resistor switch (SW4) for RS-485 communication correctly. (To use the inverter as a terminating device, turn the switch (SW4) to the ON position.) For more information, see "Section 3.3.3.9 Setting up the slide switches" in Chapter 3 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".
(8) Response interval does not match the send/receive switching time of the RS-232C–RS-485 converter.	Check whether the specified response interval (H39) matches the specification of the actual converter. ➔ Match the response interval (H39) with the specification of the converter.

[11] Er-6 Operation error

Problem An incorrect operation was attempted, resulting in an error.

Possible Causes	What to Check and Suggested Measures
(1) Restrictions on mounting of option(s) not observed [Sub code: 0001]	Check the model of option(s) mounted. ➔ Check the restrictions on mounting of the option(s). This error cannot be shown as mounting status of control options in "Menu #4 I/O check" on the keypad. Check whether the configurations of the customizing switches (SW) on the two option boards are the same. ➔ Change the SW configuration.
(2) Auto-tuning not performed in accordance with correct procedure [Sub code: 0002]	Check whether tuning started with digital input BX, STOP1, STOP2 or STOP3 being ON. ➔ With all of digital input BX, STOP1, STOP2 and STOP3 being OFF, start tuning. Check whether tuning started with digital input EN1 or EN2 being opened. ➔ With each of digital input EN1 and EN2 connected with PS, start tuning. Check whether 20 seconds or more have elapsed immediately after writing to H01 until the FWD key is pressed. ➔ Press the FWD key on the keypad within 20 seconds immediately after writing to H01. ➔ Before writing to H01, make sure that F02 = 0 and H30 = 0 or 1.
(3) The PG detection circuit self-diagnosis function (H74) has been performed with the PG (SD)/PGo (SD) card being mounted. [Sub code: 0080]	Check whether the PG (SD)/PGo (SD) card is mounted. ➔ Remove the PG (SD)/PGo (SD) card, then perform the self-diagnosis function of the PG detection circuit.
(4) When the multiplex system is selected (o33 ≠ 0), the multiplex system station number (o50) is greater than the number of multiplex system slave stations (o34). [Sub code: 0100]	➔ Review the settings of o50 and o34.
(5) When the multiplex system is selected (o33 ≠ 0), the motor control mode setting is not proper. [Sub code: 0200]	Some motor control modes are not available under the multiplex system. ➔ Review the selected control mode (P01, A01, A101). For available control mode, refer to "Section 6.6 OPC-VG1-TBSI" in Chapter 6 of separate volume "Option Edition (24A7-☐-0045)".
(6) The multiplex system control mode setting (o33) has been changed either from the setting 1 to the setting 2 or vice versa. [Sub code: 0800]	The alarm cannot be released until the inverter is turned off and on. ➔ Review the setting of o33 and turn the inverter off and on.
(7) Mismatch between the multiplex system control mode setting (o33) and the number of multiplex system slave stations setting (o34) [Sub code: 4000]	Multiplex systems have restrictions on the number of slave stations. ➔ Review the settings of o33 and o34. For available control mode, refer to "Section 6.6 OPC-VG1-TBSI" in Chapter 6 of separate volume "Option Edition (24A7-☐-0045)".

[12] Er-7 Output wiring fault

Problem Auto-tuning failed.

Possible Causes	What to Check and Suggested Measures
(1) A phase was missing (There was a phase loss) in the connection between the inverter and the motor. [Sub code: 0001] [Sub code: 0020, 0040]	➔ Properly connect the motor to the inverter. ➔ Check the state of the contactor connected at the inverter output side.
(2) A tuning operation involving motor rotation (H01 = 4) was attempted while the brake was applied to the motor. [Sub code: 0002]	Check that the brake can be released. ➔ Specify the tuning that does not involve the motor rotation (H01 = 2 or 3). ➔ Release the brake before tuning that involves the motor rotation (H01 = 4).
(3) Tuning of magnetic pole position offset value has failed. [Sub code: 0010]	➔ Correct the wiring of the PG. ➔ Adjust the settings of the pull-in current (H161) and pull-in frequency (H162). For more information, refer to the following sections in separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)". • "Section 3.5.4.2 [3] Setting the magnetic pole position offset value" in Chapter 3 • "Section 3.5.4.2 [3] (2) Automatic adjustment of the magnetic pole position offset value" in Chapter 3

[13] Er-8 A/D converter error

Problem An error occurred in the A/D converter circuit.

Possible Causes	What to Check and Suggested Measures
(1) Inverter affected by strong electrical noise	Check if appropriate noise control measures have been implemented (e.g. correct grounding and routing of signal wires, communications cables, and main circuit wires). ➔ Implement noise control measures.
(2) Short circuit on the printed circuit board(s) [Sub code: 0001 to 0004]	Check the printed circuit board(s) for short circuits, accumulation of dust or dirt. Check for dew condensation in the inverter unit. Check whether foreign materials have gotten into the inverter unit. ➔ Fix the printed circuit board(s). ➔ Ask your Fuji Electric representative to repair the inverter. * Inform the representative of the alarm sub code displayed.

[14] Er-9 Speed mismatch

Problem An excessive deviation has occurred between the speed command and the detected speed.

Possible Causes	What to Check and Suggested Measures
(1) Incorrect setting of function code data [Sub code: 0001 to 0004]	Check the settings of the following function codes: P05, A07 and A107 (Motor, No. of poles), P28, A30 and A130 (Return (Feedback input) encoder pulse count), P29, A51 and A151 (Return (Feedback input) pulse correction factor 1), and H149 (Machine runaway detection speed setting). ➔ Specify motor parameters in accordance with the motor and PG. ➔ Review the data of the following function codes. • E43 (Speed agreement, Detection width) • E44 (Speed agreement, Off-delay timer) • E45 (Speed disagreement, Alarm use/disuse)
(2) Overload [Sub code: 0001 to 0004]	Measure the inverter output current. ➔ Reduce the load. ➔ Increase the inverter capacity. Check whether any mechanical brake is working. ➔ Release the mechanical brake.
(3) Mismatch between function code data settings and the motor characteristics [Sub code: 0001 to 0004]	Check the motor parameters. ➔ Perform auto-tuning, using H01.
(4) Wrong wiring of the PG [Sub code: 0001 to 0004]	Check the wiring between the PG and the inverter. ➔ Correct the wiring.
	Check that the relationships between the PG feedback signal and the run command are as follows: • For the FWD command: the B phase pulse is in the High level at rising edge of the A phase pulse • For the REV command: the B phase pulse is in the Low level at rising edge of the A phase pulse ➔ If the relationship is wrong, interchange the A and B phase wires. ➔ Note that if the digital input signal ***IVS*** ("normal/inverse operation") is active, the above operation is reversed.
(5) Wrong wiring to the motor [Sub code: 0001 to 0004]	Check the wiring to the motor. ➔ Connect the inverter output wiring U, V, and W to the motor wiring U, V, and W, respectively. (It is also possible to use H75: Phase sequence configuration of main circuit wiring.)
[Under vector control with/without speed sensor] (6) The motor speed does not rise due to the torque limiter operation. [Sub code: 0001 to 0004]	Check the setting of the torque limiter (operation level) (F44, F45). ➔ Change the F44 or F45 data to an appropriate value. If no torque limiter operation is required, disable the torque limiter (F40 = 0).
(7) During running of the motor (after the mechanical brake is released), the deviation between the speed command value (Reference speed 4, ASR input) and the actual speed exceeds the setting of E43. [Sub code: 0008]	Check the wiring to the motor. ➔ Connect the inverter output wiring U, V, and W to the motor wiring U, V, and W, respectively.

[15] Er-b Inter-inverter communications link error

Problem A communications link error occurred between high-speed serial communication terminal options.

Possible Causes	What to Check and Suggested Measures
(1) The optical cable is disconnected or inserted poorly into the connector. [Sub code: 0001 to 0020]	➔ Connect the optical cable fully.
(2) The optical cable is bundled or bent with the bend radius of 35 mm or less. [Sub code: 0001 to 0020]	➔ Increase the bend radius of the optical cable to more than 35 mm.
(3) The optical cable or connectors on the inverter were exposed to intense light (e.g. direct sunlight or strobe light). [Sub code: 0001 to 0020]	➔ Do not expose the optical cable or the connectors on the inverter to intense light.
(4) Discrepancy in capacity between master and slave inverters [Sub code: 0200]	The multiplex system cannot be configured with inverters of different capacities.
(5) Discrepancy in current rating (F80) between master and slave inverters [Sub code: 0400]	The multiplex system cannot be configured with inverters of different current rating settings (F80). ➔ Review the current rating settings (F80).

[16] Er-H Hardware error

Problem The LSI on the power supply printed circuit board (PCB) malfunctions.

Possible Causes	What to Check and Suggested Measures
The control PCB or power supply PCB is defective.	The control PCB or power supply PCB (including the gate PCB) needs to be replaced. ➔ Request for repair work on inverter. (Please contact our service department.) * Inform the representative of the alarm sub code displayed.

[17] Err Mock alarm

Problem The LED displays Err.

Possible Causes	What to Check and Suggested Measures
The STOP + FUNC/DATA keys were held down for more than 5 seconds.	➔ To escape from this alarm state, press the RESET key.

[18] Et1 Encoder error 1

Problem ABS encoder position detection data error. (When OPC-VG1-SPGT is installed)

Possible Causes	What to Check and Suggested Measures
(1) Data received from the ABS encoder is wrong.	➔ Use shielded wire to prevent being affected by noise. Recommended shielded wire: WSC-P06P□□-□ (twisted 6-pair shielded wire)
(2) The ABS encoder has been broken.	➔ Replace the ABS encoder.

* For more information, see "Section 6.8 OPC-VG1-SPGT" in Chapter 6 of separate volume "Option Edition (24A7-□-0045)".

[19] LoC Start delay

Problem At the startup, an excessive deviation has occurred between the speed command and the detected speed.

Possible Causes	What to Check and Suggested Measures
(1) Incorrect setting of function code data	Check the settings of the following function codes: P05, A07 and A107 (Motor, No. of poles), P28, A30 and A130 (Return (Feedback input) encoder pulse count), and P29, A51 and A151 (Return (Feedback input) pulse correction factor 1). ➔ Specify motor parameters in accordance with the motor and PG. ➔ Review the data of the following function codes. Related function code: • H140 Start delay detection (Start delay detection level) • H141 Start delay detection (Start delay detection timer)
(2) Overload	Measure the inverter output current. ➔ Reduce the load. ➔ Increase the inverter capacity. Check whether any mechanical brake is working. ➔ Release the mechanical brake.
(3) Mismatch between function code data settings and the motor characteristics	Check the motor parameters. ➔ Perform auto-tuning, using H01.
(4) Wrong wiring of the PG	Check the wiring between the PG and the inverter. ➔ Correct the wiring. Refer to Chapter 3, "Section 3.5.2 Powering ON and checking" of separate volume "Unit Type/Function Codes Edition (24A7-□-0019)".
	Check that the relationships between the PG feedback signal and the run command are as follows: • For the FWD command: the B phase pulse is in the High level at rising edge of the A phase pulse • For the REV command: the B phase pulse is in the Low level at rising edge of the A phase pulse ➔ If the relationship is wrong, interchange the A and B phase wiring. ➔ Note that if the digital input signal IVS ("normal/inverse operation") is active, the above operation is reversed.
(5) Wrong wiring to the motor	Check the wiring to the motor. ➔ Connect the inverter output wiring U, V, and W to the motor wiring U, V, and W, respectively. (It is also possible to use H75: Phase sequence configuration of main circuit wiring.)
(6) The motor speed does not rise due to the torque limiter operation.	Check the setting of the torque limiter (operation level) (F44, F45). ➔ Change the F44 or F45 data to an appropriate value. If no torque limiter operation is required, disable the torque limiter (F40 = 0).
(7) During running of the motor (after the mechanical brake is released), the torque current command value exceeds the specified level (function code H140) and the actual speed drops below the specified "stop speed" (function code F37), and then the state is kept for the specified duration (function code H141).	Check the wiring to the motor. ➔ Connect the inverter output wiring U, V, and W to the motor wiring U, V, and W, respectively.

[20] LU Undervoltage

Problem DC link bus voltage has dropped below the undervoltage level.

Possible Causes	What to Check and Suggested Measures
(1) A momentary power failure occurred.	➔ Release the alarm. ➔ To restart running the motor without treating this condition as an alarm, set the data of F14 (Restart mode after momentary power failure (mode selection)) to "3," "4," or "5," depending on the load type.
(2) The power to the inverter was switched back to ON too soon (when F14 = 1).	Check if the power to the inverter was switched back to ON after the inverter was shut down while the control power was still alive. (Check whether the LEDs on the keypad light.) ➔ Turn the power ON again after all LEDs on the keypad go off.
(3) The power supply voltage does not reach the inverter's specification range.	Measure the input voltage. ➔ Increase the power supply voltage to within the specified range.
(4) Peripheral equipment for the power circuit malfunctioned, or the wiring is incorrect.	Measure the input voltage to find which peripheral equipment malfunctioned or which wiring is incorrect. ➔ If any, replace the faulty peripheral equipment and/or correct the incorrect wiring.
(5) Any other load(s) connected to the same power supply system has required a large starting current, causing a temporary power supply voltage drop.	Measure the input voltage and check the voltage fluctuation. ➔ If any, reconsider the power supply system configuration.
(6) Insufficient capacity of the power supply transformer increases load, causing a power supply voltage drop.	Measure the output current. ➔ Reduce the load. ➔ Reconsider the capacity of the power supply transformer.
(7) No power is supplied to the auxiliary power supply (R0-T0).	Measure the input voltage of the auxiliary power supply. ➔ Insert various circuit breakers or magnetic contactor (MC). ➔ Check for voltage drop, connection failure, poor contact and other problems, and then take measures against them.

[21] nrb NTC thermistor wire break

Problem A wire break is found in the NTC thermistor detection circuit.

Possible Causes	What to Check and Suggested Measures
(1) The NTC thermistor cable is broken.	Check whether the motor cable is broken. ➔ Replace the motor cable.
(2) The temperature around the motor is extremely low (lower than -30°C).	Measure the temperature around the motor. ➔ Reconsider the use environment of the motor.
(3) The NTC thermistor is broken.	Measure the resistance of the NTC thermistor (including a spare thermistor). ➔ Connect a spare thermistor to the motor. ➔ If the spare thermistor is also broken, replace the motor.

* A negative temperature coefficient (NTC) thermistor is used to protect the motor from overheat, and under vector control, to compensate for the temperature in the motor parameters.

A dedicated motor (VG motor) for Fuji vector control has a built-in NTC thermistor.

[22] OC Overcurrent

Problem The inverter momentary output current exceeded the overcurrent level.

Possible Causes	What to Check and Suggested Measures
(1) The inverter output lines were short-circuited.	Disconnect the wiring from the inverter output terminals (U, V and W) and measure the interphase resistance of the motor wiring. Check if the resistance is too low. ➔ Remove the short-circuited part (including replacement of the wiring, relay terminals and motor).
(2) Ground faults have occurred at the inverter output lines.	Disconnect the wiring from the inverter output terminals (U, V and W) and perform a Megger test for the inverter and the motor. ➔ Remove the ground fault parts (including replacement of the wires, relay terminals and motor).
(3) Overload	Measure the motor current with a measuring device to trace the current trend. Then, use this data to judge if the trend is over the calculated load value for your system design. ➔ If the load is too heavy, reduce it or increase the inverter capacity. Trace the current trend and check if there are any sudden changes in the current. ➔ If there are any sudden changes, make the load fluctuation smaller or increase the inverter capacity. ➔ Enable overcurrent suppression function (H58 = 1). [Under V/F control]
[Under V/f control] (4) Excessive torque boost specified (in the case of manual torque boost)	Check whether decreasing the torque boost (P35, A55, A155) does not stall the motor. ➔ If no stall occurs, decrease the torque boost (P35, A55, A155).
[Under V/f control] (5) The acceleration/deceleration time was too short.	Check that the motor generates enough torque required during acceleration/deceleration. That torque is calculated from the moment of inertia for the load and the acceleration/deceleration time. ➔ Increase the acceleration/deceleration time (F07, F08, C46, C47, C56, C57, C66, C67). ➔ Increase the inverter capacity. ➔ Review the braking method.
(6) Malfunction caused by noise	Check if noise control measures are appropriate (e.g. correct grounding and routing of control and main circuit wires). ➔ Implement noise control measures. (For details, refer to "Appendix 5.") ➔ Enable the retry function (H04). ➔ Connect a surge absorber to magnetic contactor's coils or other solenoids (if any) causing noise.
[Under vector control with/without speed sensor] (7) Exciting current was too small during auto-tuning.	Check whether it happens during auto-tuning. ➔ Increase the exciting current (P08, A10, A110) and then perform auto-tuning.
[Under vector control with speed sensor] (8) Mismatch between the PG's pulse resolution specification and the function code setting	Check the function code setting. ➔ Match the function code settings with the PG specifications. (P28, A30, A130)
[Under vector control with speed sensor] (9) Wrong wiring of the PG	Check the wiring between the PG and the inverter for the phase sequence, wire breaks, shielding and twisting. ➔ Correct the wiring.

Possible Causes	What to Check and Suggested Measures
[Under vector control with speed sensor] (10) PG defective	Check whether the inverter internal control circuit (PG input circuit) is faulty, using the self-diagnosis function of the PG detection circuit (H74). ➔ If the result is "Normal," replace the PG. ➔ If it is "Abnormal," contact your Fuji Electric representative. ➔ Check the PG waveform using an oscilloscope. ➔ Replace the PG.

[23] OH1 Heat sink overheat

Problem Temperature around heat sink has risen abnormally.

Possible Causes	What to Check and Suggested Measures
(1) The surrounding temperature exceeded the range of the inverter specification. [Sub code: 0001 to 0008]	Measure the temperature around the inverter. ➔ Lower the temperature around the inverter (e.g. ventilate the panel where the inverter is mounted).
(2) Ventilation path is blocked. [Sub code: 0001 to 0008]	Check if there is sufficient clearance around the inverter. ➔ Change the mounting place to ensure the clearance.
	Check if the heat sink is not clogged. ➔ Clean the heat sink. (For the cleaning procedure, contact your Fuji Electric representative.)
(3) Cooling fan's airflow volume decreased due to the service life expired or failure. [Sub code: 0001 to 0008] [Sub code: 0010 to 0200]	Check the cumulative run time of the cooling fan.* ➔ Replace the cooling fan. (Contact your Fuji Electric representative.)
	Visually check whether the cooling fan rotates normally. ➔ Replace the cooling fan. (Contact your Fuji Electric representative.)
(4) Overload [Sub code: 0001 to 0008]	Measure the output current. ➔ Reduce the load (Use the heat sink overheat early warning [INV-OH] (E15 to E27) or the inverter overload early warning [INV-OL] (E15 to E27) to reduce the load before the overload protection is activated.).

* Refer to "Section 3.4.4.6 Reading maintenance information" in Chapter 3 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".

[24] OH2 External alarm

Problem External alarm ("THR") was inputted. (When the external alarm signal "THR" has been assigned to any of digital input terminals.)

Possible Causes	What to Check and Suggested Measures
(1) An alarm function of external equipment was activated.	Check the operation of external equipment. ➔ Remove the cause of the alarm that occurred in external equipment.
(2) Wrong connection or poor contact in external alarm wiring	Check if the "external alarm" signal wiring is correctly connected to the terminal to which the "External alarm" (function code data = 9) has been assigned. (Any of E01 through E09 should be set to "9.") ➔ Connect the external alarm wiring correctly.
(3) Incorrect setting of function code data	Check whether the normal/negative logic of the external signal matches that of the "THR" command specified by E14. ➔ Ensure the matching of the normal/negative logic.
(4) The surrounding temperature exceeded the range of the braking resistor temperature specification.	Measure the temperature around the braking resistor. ➔ Lower the surrounding temperature (e.g. ventilate the inverter).
(5) The capacity of the braking resistor is insufficient.	Reconsider the capacity and %ED of the braking resistor. ➔ Review the braking resistor.
(6) Diode rectifier RHD-D is overheated	When a diode rectifier RHD-D is being used, please check all possible reasons and countermeasures discribed in [23]OH1 heat sink overheat.
(7) PWM converter RHC-D is tripped	When a PWM converter RHC-D is being used, please remove the possible alarm reasons according to chapter 6.3.10.2 trouble shooting.
(8) AC fuse has blown	Confirm if the AC fuse has blown or not. ➔ Request the repair of inverter. (Contact the service department of our company) ➔ Confirm the ground fault part and remove it.(The wiring should also be checked.) If the AC fuse blown is caused by ground fault, it may be necessary to have inverter repaired and inspected. (Contact the service department of our company) Confirm if the wire of microswitch is disconnected or not. ➔ Confirm the wire with tester. ➔ Confirm if any bolt is loosened. (Confirm bolts of terminals.)

[25] OH3 Inverter internal overheat

Problem Temperature inside the inverter has exceeded the allowable limit.

Possible Causes	What to Check and Suggested Measures
(1) The surrounding temperature exceeded the inverter's specification limit. [Sub code: 0001 to 0008]	Measure the surrounding temperature. ➔ Lower the temperature around the inverter (e.g. ventilate the panel where the inverter is mounted).
(2) Temperature detection circuit failure (Thermistor wire break) [Sub code: 0010]	➔ Request for repair work on inverter. (Please contact our service department.) * Inform the representative of the alarm sub code displayed.

[26] *OH4* Motor overheat (PTC/NTC thermistor)

Problem   Temperature of the motor has risen abnormally.

Possible Causes	What to Check and Suggested Measures
(1) The temperature around the motor exceeded the range of the motor specification.	Measure the temperature around the motor. ➔ Lower the surrounding temperature.
(2) Cooling system for the motor failed.	Check if the cooling system of the motor is operating normally. ➔ Repair or replace the cooling system of the motor.
(3) Overload	Measure the output current. ➔ Reduce the load (e.g. Use the motor overload early warning (E34) to reduce the load before the overload protection is activated.). ➔ Lower the temperature around the motor.
(4) The activation level (E32) of the PTC thermistor for motor overheat protection was set inadequately.	Check the PTC thermistor specifications and recalculate the detection voltage. ➔ Modify the data of function code.
(5) The activation level (E30) of the NTC thermistor for motor overheat protection was set inadequately.	Check the data of function code E30 (motor overheat protection level). ➔ When a motor exclusive to vector control is used, set E30 to 150°C (Factory default). ➔ When the motor temperature is entered via any of analog input terminals [Ai1] to [Ai4], set E30 to the protection level matching the motor specification.
(6) Settings for the PTC/NTC thermistor are improper.	Check the setting of the thermistor mode selection (function code P30, A31, A131). ➔ Change the data of P30, A31 or A131 in accordance with the thermistor used.
(7) NTC thermistor model (characteristics) is not correct.	Check the NTC thermistor model (characteristics). ➔ Use the NTC thermistor incorporated in a motor exclusive to vector control.
[Under V/f control] (8) Excessive torque boost specified (P35, A55, A155)	Check whether decreasing the torque boost (function code P35, A55, A155) does not stall the motor. ➔ If no stall occurs, decrease the data of P35, A55 or A155.
[Under V/f control] (9) The V/f pattern did not match the motor.	Check whether the motor rated speed (F04, A05, A105) and the motor rated voltage (F05, A04, A104) match the values on the motor's main nameplate. ➔ Match the function code data with the values on the motor's main nameplate.
(10) Incorrect setting of function code data	Although no PTC thermistor is used, the thermistor mode selection is enabled (function code P30, A31, A131). ➔ Change the data of the thermistor mode selection (P30, A31 or A131) to "0" (Disable).
(11) The input voltage of the motor cooling fan is out of the range of the specification.	Check the input voltage of the motor cooling fan. ➔ Review the power supply system.
(12) The air passage of the motor cooling fan is clogged.	Check the air passage of the motor cooling fan. ➔ Perform cleaning. (For the cleaning procedure, contact your Fuji Electric representative.)
(13) Mismatch of motor parameters	For exclusive motors for the FRENIC-VG: Check whether the data of function code P02 matches the connected motor. ➔ Correct the data of P02. ➔ For other motors: Perform auto-tuning.

[27] OLn Overload of motor 1 through 3

Problem Electronic thermal protection for motor 1, 2, or 3 activated.

OL1 : Motor 1 overload
OL2 : Motor 2 overload
OL3 : Motor 3 overload

Possible Causes	What to Check and Suggested Measures
(1) The electronic thermal characteristics do not match the motor overload characteristics.	Check the motor characteristics. ➔ Reconsider the data of function codes F10, F12, A32, A34, A132 and A134. ➔ Use an external thermal relay.
(2) The activation level for the electronic thermal protection is not appropriate.	Recheck the continuous allowable current of the motor. ➔ Reconsider and change the data of function code F11, A33 or A133.
(3) The specified acceleration/ deceleration time is too short.	Recalculate the acceleration/deceleration torque and time needed for the load, based on the moment of inertia for the load and the acceleration/deceleration time. ➔ Increase the acceleration/deceleration time (F07, F08, C46, C47, C56, C57, C66, C67).
(4) Overload	Measure the output current. ➔ Reduce the load (e.g. Use the motor overload early warning (E34) to reduce the load before the overload protection is activated.).
[Under V/f control] (5) Excessive torque boost specified	Check whether decreasing the torque boost (function code P35, A55, A155) does not stall the motor. ➔ If no stall occurs, decrease the data of P35, A55 or A155.
[Under vector control with/without speed sensor] (6) The control constants of the automatic speed regulator (ASR) are inadequate.	Check whether the actual motor speed overshoots or undershoots the speed command value. ➔ Readjust the ASR (ASR gain, constant of integration, etc.).

[28] OLU Inverter overload

Problem Electronic thermal overload protection for inverter activated.

Possible Causes	What to Check and Suggested Measures
(1) The surrounding temperature exceeded the range of the inverter specification.	Measure the temperature around the inverter. ➔ Lower the surrounding temperature (e.g. ventilate the panel where the inverter is mounted.).
[Under V/f control] (2) Excessive torque boost specified	Check whether decreasing the torque boost (P35, A55, A155) does not stall the motor. ➔ If no stall occurs, decrease the torque boost (P35, A55, A155).
(3) The specified acceleration/deceleration time was too short.	Recalculate the acceleration/deceleration torque and time needed for the load, based on the moment of inertia for the load and the acceleration/deceleration time. ➔ Increase the acceleration/deceleration time (F07, C35, C46, C56, C66).
(4) Overload	Measure the load factor to see that it does not exceed 100%. (Refer to "Section 3.4.4.7 Measuring load factor" in Chapter 3 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".) ➔ Reduce the load (e.g. Use the overload early warning (E33) and reduce the load before the overload protection is activated.).
(5) Ventilation paths are blocked.	Check if there is sufficient clearance around the inverter. ➔ Change the mounting place to ensure the clearance. Refer to Chapter 4 "Installation and Wiring"
	Check if the heat sink is not clogged. ➔ Perform cleaning. (For the cleaning procedure, contact your Fuji Electric representative.)
(6) Cooling fan's airflow volume decreased due to the service life expired or failure.	Check the cumulative run time of the cooling fan. ➔ Replace the cooling fan. (Contact your Fuji Electric representative.)
	Visually check that the cooling fan rotates normally. ➔ Replace the cooling fan. (Contact your Fuji Electric representative.)
(7) The output wiring to the motor are too long, causing a large leakage current from them.	Measure the leakage current. ➔ Insert an output circuit filter (OFL).
[Under vector control with/without speed sensor] (8) Reference speed fluctuating	Check whether the reference speed is fluctuating. ➔ Increase the ASR input filter setting (F64, C43, C53, C63).
[Under vector control with/without speed sensor] (9) The control constants of the automatic speed regulator (ASR) are inadequate.	Check whether the actual motor speed overshoots or undershoots the speed command value. ➔ Readjust the ASR (ASR gain, constant of integration, etc.).
(10) Wrong wiring of the PG	Check the wiring of the PG. ➔ Correct the wiring. (Refer to Chapter 3, "Section 3.5.2 Powering ON and checking" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".)
(11) Wrong (inverse) wiring to the motor	Check the wiring to the motor. ➔ Correct the wiring. (It is also possible to use H75 phase sequence configuration of main circuit wiring.)
(12) The magnetic pole position of the synchronous motor (PMSM) is out of place.	Check the magnetic pole position. ➔ Adjust the magnetic pole position. (o10, A60, A160) (Refer to Chapter 3, "Section 3.5.3.3 Vector control for PMSM with speed sensor ■ Adjusting the magnetic pole position" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".)

[29] OPL Output phase loss

Problem Output phase loss occurred.

Possible Causes	What to Check and Suggested Measures
(1) Inverter output wiring is broken.	Measure the output current. ➔ Replace the output wiring.
(2) The motor winding is broken.	Measure the output current. ➔ Replace the motor.
(3) The inverter output terminals or motor input terminals are weakly tightened.	Check if any screws on those terminals have become loose. ➔ Tighten the terminal screws to the recommended torque.
(4) A single-phase motor has been connected.	➔ Single-phase motors cannot be used. (The FRENIC-VG is a drive for three-phase motors.)

[30] OS Overspeed

Problem The motor rotates in an excessive speed. (When Motor speed ≥ Maximum reference speed × H90 ÷ 100)

Possible Causes	What to Check and Suggested Measures
[Under vector control with/without speed sensor] (1) Incorrect setting of function code data	Check the maximum speed setting (function code F03, A06, A106). ➔ Modify the data of F03, A06 or A106 in accordance with the machinery.
	Check the setting of the speed limiter (F76 to F78). ➔ Enable the speed limiter (F76 to F78).
[Under vector control with/without speed sensor] (2) Insufficient gain of the automatic speed regulator (ASR)	Check whether the actual speed overshoots the commanded one in higher speed operation. ➔ Increase the ASR gain (F61). (Depending on the situations, reconsider the setting of the filter constants or the integral time.)
[Under vector control with/without speed sensor] (3) The overspeed alarm detection level is not appropriate.	Check the setting of the overspeed alarm detection level (H90/Factory default 120%). ➔ Set the data of H90, taking into account the maximum allowable speed for the machinery.
[Under vector control with speed sensor] (4) Noises superimposed on the PG signal.	Check the PG signal input monitor and check whether appropriate noise control measures have been implemented (e.g. correct grounding and routing of signal wires and main circuit wires). ➔ Implement noise control measures. (For details, refer to "Appendix 5.")
[Under vector control with/without speed sensor] (5) Droop gain too large	Check whether the droop gain is appropriate. ➔ Decrease the droop gain (H28).
[Under vector control with/without speed sensor] (6) The motor parameters do not match the connected motor.	For motors exclusive to the FRENIC-VG: Check whether the setting of function code P02 matches the connected motor. ➔ Correct the data of P02. For other motors: ➔ Perform auto-tuning.
[Under vector control without speed sensor] (7) Breaks in the inverter output circuit	Check the inverter output circuit. ➔ Correct the wiring.
[Under vector control with speed sensor] (8) PG waveform abnormal	Measure the PG waveform. ➔ Replace the PG.

Possible Causes	What to Check and Suggested Measures
[Under vector control with speed sensor] (9) Mismatch between the PG's pulse resolution specification and the function code setting	Check the function code setting. ➔ Match the function code settings (P28, A30, A130) with the PG specifications.
(10) The magnetic pole position of the synchronous motor (PMSM) is out of place.	Check the magnetic pole position. ➔ Adjust the magnetic pole position. (o10, A60, A160) (Refer to Chapter 3, "Section 3.5.3.3 Vector control for PMSM with speed sensor ■ Adjusting the magnetic pole position" of separate volume "Unit Type/Function Codes Edition (24A7-□-0019)".)

[31] OU Overvoltage

Problem The DC link bus voltage exceeded the overvoltage detection level.

Possible Causes	What to Check and Suggested Measures
(1) The power supply voltage exceeded the range of the inverter specification.	Measure the input voltage. ➔ Decrease the power supply voltage to within the specified range.
(2) A surge current entered the input power supply.	In the same power supply system, if a phase-advancing capacitor is turned ON/OFF or a thyristor converter is activated, a surge (momentary large increase in the input voltage) may be caused in the input power. ➔ Install a DC reactor.
(3) The deceleration time was too short for the moment of inertia of the load.	Recalculate the deceleration torque based on the moment of inertia of the load and the deceleration time. ➔ Increase the deceleration time (F08, C36, C47, C57, C67). ➔ Consider the use of a braking resistor or PWM converter. ➔ Decrease the moment of inertia of the load. ➔ Enable the overvoltage suppression function (H57). ➔ Select the power limit function (F40 = 2). [Under vector control with speed sensor] ➔ Enable the torque limiter (F40 to F45).
(4) The acceleration time was too short.	Check if an overvoltage alarm occurs after acceleration. ➔ Increase the acceleration time (F07, C35, C46, C56, C66). ➔ Select the S-curve acceleration/deceleration (F67 to F70). ➔ Consider the use of a braking resistor or PWM converter. ➔ Decrease the moment of inertia of the load.
(5) Braking load was too heavy.	Compare the braking torque of the load with that of the inverter. ➔ Consider the use or enhancement of a braking resistor (DBR) or the use of PWM converter.
(6) Malfunction caused by noise	Check if the DC link bus voltage was below the protective level when the overvoltage occurred. ➔ Implement noise control measures. (For details, refer to "Appendix 5.") ➔ Enable the auto-reset (H04). ➔ Connect a surge absorber to magnetic contactor's coils or other solenoids (if any) causing noise.
(7) The inverter output lines were short-circuited.	Disconnect the wiring from the inverter output terminals (U, V and W) and measure the interphase resistance of the motor wiring. Check if the resistance is too low. ➔ Remove the short-circuited part (including replacement of the wiring, relay terminals and motor).
(8) Wrong connection of the braking resistor	Check the connection. ➔ Correct the connection.
(9) Large, rapid decrease of the load	Check whether the inverter runs at the time of rapid decrease of the load. ➔ Consider the use or enhancement of a braking resistor (DBR) or the use of PWM converter.

[32] *PG* PG wire break

Problem The pulse generator (PG) wiring has been broken somewhere in the circuit.

Possible Causes	What to Check and Suggested Measures
(1) Break in the PG wiring Inverter PA, PB: [Sub code: 0001] Inverter power supply: [Sub code: 0004] Option: [Sub code: 0002] (OPC-VG1-PG, OPC-VG1-PMPG)	Check whether the PG is correctly connected to the option or any wire is broken. ➔ Check whether the PG is connected correctly. Or, tighten up the related terminal screws. ➔ Check whether any joint or connecting part bites the wire sheath. ➔ Replace the wire.
[PMSM] When the option card (OPC-VG1-PMPG) is used: (2) Connection failure of speed/magnetic pole position sensor (3) Mismatch between the motor rotation direction and sensor output [Sub code: 0010 to 0400]	Check the output wiring of the speed/magnetic pole position sensor for poor contact or the phase sequence of the AB phases and UVW phases. ➔ Correct the connection between the option card and the speed/magnetic pole position sensor. Check the motor wiring for poor contact or the phase sequence. ➔ Correct the connection between the inverter and the motor.
(4) Connection failure of option card (OPC-VG1-PG, OPC-VG1-PMPG)	Check whether the connector of the option card engages with that of the inverter unit. ➔ Mount the option card on the inverter unit correctly.
(5) PG related circuit affected by strong electrical noise	Check if appropriate noise control measures have been implemented (e.g. correct grounding and routing of signal wires, communication cables, and main circuit wires.). ➔ Implement noise control measures. ➔ Separate the control circuit wiring from the main circuit wiring as far as possible.
(6) Motor drive control mode wrongly selected	Check the motor drive control mode currently selected. ➔ If no speed sensor is mounted, select the vector control without speed sensor.
(7) Mismatch between the PG power voltage (specification) and the voltage setting of PGP terminal	Check the PG power supply voltage (specification) and the voltage setting of PGP terminal (switchable with SW6). ➔ Set SW6 properly. For details, refer to Chapter 3, "Section 3.3.3.9 Setting up the slide switches" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".
(8) PG wires small in size	Check whether the PG wires satisfy the recommended wire size. ➔ Replace the wires with the recommended one.
(9) PG waveform abnormal	Check whether the inverter internal control circuit (PG input circuit) is faulty, using the self-diagnosis function of the PG detection circuit (H74). ➔ If the result is "Normal," replace the PG. ➔ If it is "Abnormal," contact your Fuji Electric representative. Check the PG waveform using an oscilloscope. ➔ Replace the PG.

[33] Ar-E E-SX bus tact synchronization error

Problem E-SX bus tact synchronization error occurred during operation.

Possible Causes	What to Check and Suggested Measures
Alarm occurred due to noise.	Check if noise entered the E-SX bus. ➔ Check if the E-SX bus is mounted in parallel with the main circuit cable. If so, modify the wiring route. ➔ Insert the ferrite core. ➔ Lower the tact frequency if possible.

* For more information, see Section 6.14, Chapter 6 in separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)" of separate volume "Option Edition (24A7-☐-0045)".

[34] Ar-F Toggle abnormality error

Problem A toggle abnormality monitoring error occurred. (Available when T-Link, SX bus, or E-SX bus is used.)

Possible Causes	What to Check and Suggested Measures
Toggle abnormality monitoring error occurred.	➔ Check if the CPU of the host PLC is stopped.

11.4 If the "light alarm" indication (L-AL) appears on the LED monitor

If the inverter detects a minor abnormal state "light alarm," it can continue the current operation without tripping. (Light alarm function)

When a light alarm occurs, the "light alarm" indication L-AL is displayed on the LED monitor, the LED under the FWD key blinks, and the "light alarm" signal "L-ALM" is output to a general-purpose output terminal. (To use the L-ALM, it is necessary to assign the signal to any of the digital output terminals by setting any of function codes E15 through E19 to "57.")

Function codes H106 through H110 specify which alarms should be categorized as "light alarm." The available "light alarm" codes are check-marked in the "Light alarm" object column in Table: 11.3-1 (page 11-3).

For the "light alarm" factors and the alarm removal procedure, refer to Chapter 3, "Section 3.4.3.5 Monitoring light alarms" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".

11.5 If neither an alarm code nor "light alarm" indication (L-AL) appears on the LED monitor

11.5.1 Abnormal motor operation

[1] The motor does not rotate

Possible Causes	What to Check and Suggested Measures
(1) No power supplied to the inverter	Check the input voltage and interphase voltage unbalance. ➔ Check if the input devices work properly and if the wiring is correct, etc. ➔ Check for voltage drop, phase loss, poor connections, or poor contacts, and fix them if necessary. ➔ If only the auxiliary control power input is supplied, also supply the main power to the inverter. ➔ Check the converter for any faults.
(2) No run forward/reverse command was inputted, or both the commands were inputted simultaneously (terminal block operation).	Check the input status of the forward/reverse command with Menu "I/O check" on the keypad. ➔ Input a run command. ➔ Set either the forward or reverse operation command to off. ➔ Correct the run command source. (Set the data of F02 to "1.") ➔ Connect the external circuit wiring to control circuit terminals [FWD] and [REV] correctly. ➔ Make sure that the sink/source slide switch (SW1) on the printed circuit board (PCB) is properly configured. For details, refer to Chapter 3, "Section 3.3.3.9 Setting up the slide switches" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".
(3) A run command with higher priority than the one attempted was active, and the run command was stopped.	Referring to the run command block diagram*, check the higher priority run command using Menu "DATA CHECK" and Menu "I/O check" with the keypad. ➔ Correct the wrong setting of function code data of Communications link function (Mode selection) (H30) or cancel the higher priority run command.
(4) No analog speed command input.	Check whether the analog speed command has been entered correctly, using Menu "I/O check" on the keypad. ➔ Connect the external circuit wiring to terminals [13], [12], [11], [Ai1] and [Ai2] correctly. ➔ Inspect the speed command potentiometers, signal converters, switches and relay contacts. Replace defective one(s), if any.
[Under V/f control] (5) The reference speed was below the starting or stop speed.	Check whether the speed command has been entered correctly, using Menu "I/O check" on the keypad. ➔ Set the reference speed at the same or higher than the starting speed (F23). ➔ Reconsider the starting speed (F23), and if necessary, change it to the lower value. ➔ Inspect the speed command potentiometers, signal converters, switches and relay contacts. Replace defective one(s), if any. ➔ Connect the external circuit wiring to terminals [13], [12], [11], [Ai1] and [Ai2] correctly.
(6) A reference speed with higher priority than the one attempted was active.	Referring to the run command block diagram*, check the higher priority run command using Menu "DATA CHECK" and Menu "I/O check" with the keypad. ➔ Correct the wrong setting of function code data (e.g. cancel the higher priority run command). ➔ Correct the wrong setting of function code data of Communications link function (Mode selection) (H30) or cancel the higher priority run command.

* Refer to "Section 4.1 Block diagrams for control logic" in Chapter 4 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".

Possible Causes	What to Check and Suggested Measures
(7) The speed limiter settings were made incorrectly.	Check the data of function codes F76 (Speed limiter mode selection), F77 and F78 (Speed limiter levels 1 and 2). ➔ Correct the data of F76 through F78.
(8) The coast-to-stop command was effective.	Check the data of function codes E01 through E09 and the input status of X terminals, using Menu "I/O check" on the keypad. ➔ Release the coast-to-stop command setting.
(9) No enable input on [EN1] or [EN2]	Check the input status of the EN terminal, using Menu "I/O check" on the keypad. ➔ Connect terminals [EN1] and [EN2]. • To make inverters not compliant with the Functional Safety Standard (STO), short-circuit each of terminals [EN1] and [EN2] with [PS]. (Refer to "Section 3.3.3.8 Wiring of control circuit terminals, [EN1] [EN2]" in Chapter 3 of separate volume "Unit Type/Function Codes Edition (24A7-□-0019)".) • To make inverters compliant with the Functional Safety Standard (STO), refer to the instruction manual. 📖 Refer to FRENIC-VG Instruction Manual.
(10) Broken wires, incorrect connection or poor contact with the motor. Or the motor defective.	Check the wiring and the motor. (Measure the output current.) ➔ Repair the wiring to the motor, or replace them. ➔ Repair the motor or replace it. When the motor needs to be repaired, contact your Fuji Electric representative.
(11) Overload	Measure the output current. ➔ Reduce the load (In winter, the load tends to increase.) ➔ Increase the inverter and motor capacities. Check whether any mechanical brake is activated. ➔ Release the mechanical brake, if any.
(12) Torque generated by the motor is insufficient.	Check that the motor switching signal (selecting motor 1, 2 or 3) is correct with Menu "I/O check" using the keypad and that the data of function codes matches each motor. ➔ Correct the motor switching signal. ➔ Modify the function code data to match the connected motor.
[Under V/f control] (13) Torque generated by the motor is insufficient.	Check whether the reference speed is below the slip-compensated speed of the motor. (Function codes P10 and P11 for M1, A12 and A13 for M2, and A112 and A113 for M3). ➔ Change the reference speed so that it becomes higher than the slip-compensated speed of the motor. Check whether increasing the toque boost (Function code P35, A55, A155) starts rotating the motor. ➔ Increase the data of P35, A55 or A155. Check the data of function code F04, A05 or A105. ➔ Change the V/f pattern setting to match each motor.
(14) No reference speed setting (keypad operation)	Check the reference speed on the keypad. ➔ Modify the reference speed by pressing [↑] key.
[Under vector control with speed sensor] (15) Incorrect setting of the number of poles of the motor	Check whether the setting of function code P05, A07 or A107 (No. of poles) matches the number of poles of the actual motor. ➔ Set the data of P05, A07 or A107 to the correct number of poles.
[Under vector control with speed sensor] (16) Wrong wiring between the motor and pulse generator (PG)	Check the motor wiring (phase sequence) and the polarity of the PG. ➔ Correct the wiring.

Possible Causes	What to Check and Suggested Measures
[Under vector control with/without speed sensor] (17) Incorrect setting of the torque limiter level	Check whether the torque limiter level is set to zero (0). ➔ Modify the torque limiter level to the appropriate value.
[Under vector control with/without speed sensor] (18) Incorrect setting of the torque command value	Check whether the torque command value is zero (0) under torque control mode. ➔ Modify the torque command value to the appropriate value.
[Under vector control with speed sensor] (19) Mismatch between the PG's specification and the function code setting	Check whether the setting of function code P28, A30 or A130 matches the pulse resolution specification of the actual PG. ➔ Modify the data of P28, A30 or A130 to the appropriate value. Check whether the voltage setting of terminal PGP (SW6) matches the power supply voltage specification of the actual PG. ➔ Set SW6 to the appropriate position. For details, refer to Chapter 3, "Section 3.3.3.9 Setting up the slide switches" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".
(20) The magnetic pole position of the synchronous motor (PMSM) is out of place.	Check the magnetic pole position. ➔ Adjust the magnetic pole position (o10, A60, A160). *

* Refer to Chapter 3, "Section 3.5.3.3 Adjusting the magnetic pole position" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".

[2] The motor rotates, but the speed does not change

Possible Causes	What to Check and Suggested Measures
(1) The setting of the maximum speed was too low.	Check the data of function code F03, A06 or A106 (Maximum speed). ➔ Modify the data of F03, A06 or A106 to the appropriate value.
(2) The setting of the speed limiter was too low.	Check the setting of the speed limiter (F76 to F78). ➔ Modify the data of F76 to F78 to the appropriate value.
(3) The reference speed did not change.(Analog setting)	Check whether the reference speed has been entered correctly, using Menu "I/O check" on the keypad. ➔ Increase the reference speed. ➔ Inspect the speed command potentiometers, signal converters, switches, and relay contacts. Replace any ones that are faulty. ➔ Connect the external circuit wiring to terminals [13], [12], [11], [Ai1] and [Ai2] correctly.
(4) The external circuit wiring to terminals [X1] to [X9] or signal assignment to those terminals is wrong.	Check whether the reference speed has been entered correctly, using Menu "I/O check" on the keypad. ➔ Connect the external circuit wiring to terminals [X1] to [X9] correctly. ➔ Correct the data of E01 to E14. ➔ Correct the data of C05 to C21. (Multistep speed settings)
(5) A reference speed (e.g. multistep speed or via communications link) with higher priority than the one attempted was active and the reference speed was too low.	Referring to the speed command block diagram*, check the function code data check and Menu "I/O check" with the keypad. ➔ Correct any incorrect data of function code data (e.g. cancel the higher priority reference speed).
(6) The acceleration or deceleration time was too long or too short.	Check the settings of the acceleration/deceleration time (function codes F07, F08, C35, C36, C46, C47, C56, C57, C66 and C67). ➔ Change the acceleration/deceleration time to match the load.

Possible Causes	What to Check and Suggested Measures
(7) Overload	Measure the output current. ➔ Reduce the load. Check whether any mechanical brake is activated. ➔ Release the mechanical brake.
[Under V/f control] (8) Function code settings do not agree with the motor characteristics.	If auto-torque boost (Function code P35, A55, A155) is enabled, check whether the data of P03, P04, P06, P07 and P08 for M1, A02, A03, A08, A09 and A10 for M2, A102, A103, A108, A109 and A110 for M3 matches the parameters of the motor. ➔ Perform auto-tuning of the inverter for the motor to be used.
[Under V/f control] (9) The output frequency does not increase due to the current limiting operation.	Decrease the value of the torque boost (Function code P35, A55, A155), then run the motor again and check if the speed increases. ➔ Adjust the value of the torque boost (P35, A55, A155). Check the data of function codes F04, A05 and A105 to ensure that the V/f pattern setting is right. ➔ Match the V/f pattern setting with the motor ratings.
(10) The motor speed does not increase due to the torque limiter operation.	Check whether the data of torque limiter level related function codes F40 through F45 is correctly configured. Check the "TL2/TL1" terminal command ("Select torque limiter level 2/1") is correct. ➔ Correct the data of F44 or F45 or enter the "F40-CCL" terminal command (Cancel F40 (Torque limiter mode 1)).
(11) Incorrect settings of bias and gain for analog input.	Check the data of function codes F17, F18 and E53 to E60. ➔ Correct the bias and gain settings.
(12) The reference speed did not change. (Keypad operation)	Check whether modifying the reference speed setting on the keypad changes the reference speed. ➔ Modify the reference speed setting by pressing the [↑] and [↓] keys.
[Under vector control with speed sensor] (13) Wrong wiring of the PG	Check the wiring between the PG and the inverter for the phase sequence, wire breaks, shielding and twisting. ➔ Correct the wiring.
[Under vector control with speed sensor] (14) Wrong wiring between the inverter and the motor	Check the phase sequence (U, V, and W) of the motor wiring. ➔ Connect the inverter output terminals U, V, and W to the motor input terminals U, V, and W, respectively.
[Under vector control with/without speed sensor] (15) Function code settings do not agree with the motor characteristics.	For motors exclusive to the FRENIC-VG: Check whether the data of function code P02 matches the specification of the connected motor. ➔ Correct the data of P02. For other motors: ➔ Perform auto-tuning.

* Refer to "Section 4.1 Block diagrams for control logic" in Chapter 4 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".

[3] The motor runs in the opposite direction to the command

Possible Causes	What to Check and Suggested Measures
[Under V/f control] [Under vector control without speed sensor] (1) Wrong wiring to the motor	Check the wiring to the motor. ➔ Connect the inverter output terminals U, V, and W to the motor input terminals U, V, and W, respectively.
(2) The rotation direction specification of the motor is opposite to that of the inverter.	The rotation direction of IEC-compliant motors is opposite to that of the FRNIC-VG1 dedicated motors. ➔ Switch the "FWD"/"REV" signal setting.
(3) Incorrect setting of speed command related function code data	Check the data of the speed command related function codes, referring to the speed command selection block diagram*1. ➔ Correct the data of the related function codes.
[Under vector control with speed sensor] (4) Wrong wiring of the PG	Check the wiring to the motor. ➔ Correct the wiring. * 2

*1 For details, refer to Chapter 4 of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".

*2 Refer to Chapter 3, "Section 3.5.2 Mounting direction of a pulse encoder (PG) and PG signals" separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)".

[4] Speed fluctuation or current oscillation (e.g. hunting) occurs during running at constant speed

Possible Causes	What to Check and Suggested Measures
(1) The analog speed command fluctuates.	Check the signal status for the speed command with Menu "I/O check" using the keypad. ➔ Increase the filter constants (F83, E61 to E64) for the speed command. ➔ Take measures to keep the speed command value constant.
(2) An external speed command potentiometer is used.	Check that there is no noise on the signal wires connecting to external sources. ➔ Separate the control circuit wiring from the main circuit wiring as far as possible. (Do not install the main circuit wires and control circuit wires side by side.) ➔ Use shielded or twisted wires for control circuit wiring. ➔ Set a ferrite core on the signal wire. (In the case of 1 MHz or higher: ACL-40B) ➔ Use an insulation converter. Check whether the speed command potentiometer is malfunctioning due to noise from the inverter. ➔ Connect a capacitor (0.22 uF or less) to the output terminal of the speed command potentiometer or set a ferrite core on the signal wire.
(3) Speed switching or multistep speed command was enabled.	Check whether the relay signal for switching the speed command is chattering. ➔ If the relay contact is defective, replace the relay.
[Under V/f control] (4) The wiring length between the inverter and the motor is too long.	Check whether auto-torque boost is enabled (P35, A55, A155). ➔ Perform auto-tuning. Disable the auto-torque boost (select manual torque boost), then check that the motor vibration stops. ➔ Make the output wiring as short as possible.
(5) The machinery is hunting due to vibration caused by low rigidity of the load side. Or the current is irregularly oscillating due to special motor parameters.	Once disable all the automatic control systems (speed control, auto-torque boost, current limiting, torque limiter and droop control), then check that the motor vibration comes to a stop. ➔ Under vector control with/without speed sensor, readjust the speed control system. (F61 to F66, C40 to C45, C50 to C55) ➔ Disable the automatic control system(s) causing the vibration.
(6) Function code settings do not agree with the motor characteristics.	For motors exclusive to the FRENIC-VG: Check whether the setting of function code P02 matches the specification of the connected motor. ➔ Correct the data of P02. For other motors: ➔ Perform auto-tuning.
[Under vector control with/without speed sensor] (7) Load is fluctuating.	Check whether the automatic speed regulator (ASR) is properly configured. (F61 to F66, C40 to C45, C50 to C55) ➔ Readjust the speed control system. (F61 to F66, C40 to C45, C50 to C55)
(8) Output voltage of PWM converter is not stable.	➔ Refer to Instruction Manuals for PWM converter. You may be required to change the setting of function code U04 (AVR control response), for example.

[5] Grating sound is heard from the motor or the motor sound fluctuates

Possible Causes	What to Check and Suggested Measures
(1) Resonance with the load	Check the machinery mounting accuracy of the load side or check whether there is resonance with the mounting base. ➔ Disconnect the motor from the machinery and run it alone to find where the resonance comes from. Upon locating the cause, improve the characteristics of the source of the resonance. ➔ Adjust the jump speed (C01 to C04) to avoid continuous running in the frequency range causing resonance. ➔ Specify the observer (H47 to H52, H125 to H127) to suppress vibration. (Depending on the characteristics of the load, this may take no effect.) ➔ Decrease the P gain of the auto speed regulator (ASR). (F61, C40, C50, C60)

[6] The motor does not accelerate or decelerate within the specified time

Possible Causes	What to Check and Suggested Measures
(1) The inverter runs the motor with S-curve acceleration/deceleration.	Check the data of function codes F67 to F70 (S-curve acceleration/deceleration pattern). ➔ Select the linear pattern. (F67 to F70=0) ➔ Decrease the acceleration/deceleration time (F07, F08, C46, C47, C56, C57, C66, C67).
[Under V/f control] (2) The current limiting operation prevented the frequency from increasing (during acceleration).	Check whether the acceleration time and torque boost are properly specified. ➔ Increase the data of F07, C35, C46, C56 or C66 (acceleration time). ➔ Decrease the torque boost (P35, A55, A155) and restart the inverter to check that the speed increases.
(3) Overload	Measure the output current. ➔ Reduce the load.
[Under V/f control] (4) Torque generated by the motor was insufficient.	Check that increasing the torque boost (P35, A55, A155) starts the motor. ➔ Increase the value of the torque boost (P35, A55, A155).
(6) Torque generated by the motor is limited by the torque limiter operation.	Check whether data of torque limiter level related function codes (F40 to F45) is correctly configured and the "TL2/TL1" terminal command ("Select torque limiter level 1/2") is correct. ➔ Correct the data of F40 to F45 or reset them to the factory defaults. Check whether the speed command potentiometer is malfunctioning due to noise from the inverter. ➔ Set the torque limiter (TL2 or TL1) switching signal correctly. ➔ Increase the acceleration/deceleration time (F07, F08, C35, C36, C46, C47, C56, C57, C66, C67).
(7) The specified acceleration or deceleration time was incorrect.	Check the terminal commands "RT1" and "RT2" for acceleration/deceleration times using the X terminal (digital input terminal). ➔ Correct the signal settings.
(8) Current limiting settings on PWM converter were changed.	➔ Refer to Instruction Manuals for the PWM converter. Check that no change is made on the settings of H15 to H18. (If limit value is set lower than it should be.)

[7] The motor does not restart even after the power recovers from a momentary power failure

Possible Causes	What to Check and Suggested Measures
(1) The data of function code F14 is either "0," "1," or "2."	Check if an undervoltage trip (LU) occurs. ➔ Change the data of F14 (Restart mode after momentary power failure, Mode selection) to "3," "4," or "5."
(2) The run command remains OFF even after the power has been restored.	Check the input signal with Menu "I/O check" using the keypad. ➔ Check the power recovery sequence with an external circuit. If necessary, consider the use of a relay that can keep the run command ON.
	In 3-wire operation, the power to the inverter control circuit has been shut down once because of a long momentary power failure time, or the self-holding selection signal "HOLD" has been turned OFF once. ➔ Change the design or the setting so that a run command can be issued again within 2 seconds after the power has been restored.

[8] The motor abnormally heats up

Possible Causes	What to Check and Suggested Measures
(1) Airflow volume of the motor's cooling fan decreased due to the service life expired or failure.	Visually check whether the cooling fan rotates normally. ➔ Repair or replace the cooling fan. (Contact your Fuji Electric representative.)
[Under V/f control] (2) Excessive torque boost specified	Check whether decreasing the torque boost (P35, A55, A155) decreases the output current but does not stall the motor. ➔ If no stall occurs, decrease the torque boost (P35, A55, A155).
(3) Continuous running in extremely slow speed	Check the running speed of the inverter. ➔ Change the running speed setting or replace the motor with an exclusive motor for inverters (motor with separately powered cooling fan).
(4) Overload	Measure the inverter output current. ➔ Reduce the load. ➔ Increase the inverter capacity and motor capacity.
[Under vector control with/without speed sensor] (5) Function code settings do not agree with the motor characteristics.	For exclusive motors for the FRENIC-VG: Check whether the setting of function code P02 matches the specification of the connected motor. ➔ Correct the data of P02. For other motors: ➔ Perform auto-tuning.
(6) Motor defective	Check whether the inverter output voltages (U, V and W) are well-balanced. ➔ Repair or replace the motor. (Contact your Fuji Electric representative.)

[9] The motor does not run as expected

Possible Causes	What to Check and Suggested Measures
(1) Incorrect setting of function code data	Check that function codes are correctly configured and no unnecessary configuration has been done. ➔ Configure all the function codes correctly.
	Make a note of function code data currently configured and then initialize all function code data using H03. ➔ After the above process, reconfigure function codes one by one, checking the running status of the motor.
(2) Under torque control, the inverter keeps output although the run command is OFF.	Check the setting of the automatic operation OFF function (H11). ➔ Set the data of H11 to "2" (Coast to a stop when a run command is turned OFF) or "4" (Coast to a stop when a run command is turned OFF under torque control).

[10] When the motor accelerates or decelerates, the speed is not stable

Possible Causes	What to Check and Suggested Measures
[Under vector control with/without speed sensor] The ASR constants are inadequate.	Check whether the automatic speed regulator (ASR) is properly adjusted under speed control. ➔ Readjust the function codes (F61 to F66, C40 to C45, C50 to C55).

[11] The motor stalls during acceleration

Possible Causes	What to Check and Suggested Measures
[Under vector control with/without speed sensor] (1) Function code settings do not agree with the motor characteristics.	For exclusive motors for the FRENIC-VG: Check whether the setting of function code P02 matches the connected motor. ➔ Correct the data of P02. For other motors: ➔ Perform auto-tuning.
(2) The specified acceleration time is too short.	Check the data of F07, C35, C46, C56 or C66 (acceleration time). ➔ Increase the acceleration time.
(3) The moment of inertia of the load is large.	Measure the inverter output current. ➔ Decrease the moment of inertia of the load. ➔ Increase the inverter capacity.
(4) Large voltage drop on wires	Check the terminal voltage of the motor. ➔ Use larger size wires between the inverter and motor or make the wiring distance shorter.
(5) The torque of the load is large.	Measure the output current. ➔ Decrease the torque of the load. ➔ Increase the inverter capacity.
[Under V/f control] (6) Torque generated by the motor was insufficient.	Check that increasing the torque boost (P35, A55, A155) starts the motor. ➔ Increase the value of the torque boost (P35, A55, A155).

[12] When the T-Link communications option is in use, neither a run command nor a speed command takes effect

Possible Causes	What to Check and Suggested Measures
(1) Incorrect setting of the communications link operation (H30)	Check whether the setting of the communications link operation is correct (H30). ➔ Correct the data of H30. ➔ Check the status of the X terminal to which the communications link operation selection [LE] is assigned.
(2) Incorrect setting of the transmission format (o32)	Check whether the setting of the transmission format is correct (o32). ➔ Correct the data of o32 (4W + 4W or 8W + 8W).
(3) Incorrect setting of the link number	Check the current setting of the link number (that should be configured in hexadecimal). ➔ Review the function code list.
(4) Data not written to the I/O relay area as assigned	Check the data held in the I/O relay area, using the MICREX loader. ➔ Investigate writing into the I/O relay area.

[13] When the SX-bus communications option is in use, neither a run command nor a speed command takes effect

Possible Causes	What to Check and Suggested Measures
(1) Incorrect setting of the communications link operation (H30)	Check whether the setting of the communications link operation is correct (H30). ➔ Correct the data of H30.
(2) Terminal command [LE] is assigned to an X terminal, but the terminal is OFF.	Check the status of the X terminal (digital input terminal) to which the [LE] command is assigned. ➔ Turn the corresponding X terminal input ON.
(3) Incorrect setting of the transmission format selection (U11)	Check whether the transmission format selected by U11 is identical with the one selected in the system configuration definition. ➔ Correct the setting of the transmission format.
(4) Incorrect setting of the link number	Check the current setting of the link number (that should be configured in hexadecimal). ➔ Review the function code list.
(5) Data not written to the I/O memory area as assigned to the address	Check the data in application programs, using the SX loader. ➔ Investigate writing into the I/O memory area.

[14] When the CC-Link communications option is in use, neither a run command nor a speed command takes effect

Possible Causes	What to Check and Suggested Measures
(1) Incorrect setting of the communications link operation (H30)	Check whether the setting of the communications link operation is correct (H30). ➔ Correct the data of H30.
(2) Terminal command [LE] is assigned to an X terminal, but the terminal is OFF.	Check the status of the X terminal (digital input terminal) to which the LE command is assigned. ➔ Turn the corresponding X terminal ON.
(3) Incorrect setting of the transmission format selection (o32)	Check whether the transmission format selected by o32 is identical with the one selected in the system configuration definition. ➔ Correct the setting of the transmission format.
(4) Incorrect setting of the link number	Check the current setting of the link number (that should be configured in hexadecimal). ➔ Review the function code list.
(5) Data not written to the I/O memory area as assigned to the address	Check the data in application programs, using the PLC loader. ➔ Investigate writing into the I/O memory area.

[15] Under bar (_) appears

Problem Although you pressed the (FWD) key or (REV) key or entered a run forward command "FWD" or a run reverse command "REV", the motor did not start and an under bar (_) appeared on the LED monitor.

Possible Causes	What to Check and Suggested Measures
(1) The DC link bus voltage was low.	Select Menu "MAINTENANCE" in Programming mode on the keypad and check the DC link bus voltage which should be 400 VDC or less for three-phase 400V class series, and 580 VDC or less for three-phase 690V class series. ➔ Connect the inverter to a power supply that meets its input power supply voltage specifications. ➔ Check if converter is operating normally.
(2) The main power is not ON, while the auxiliary control power input to the control circuit is supplied.	Check whether the main power is turned ON and peripheral equipment does not run. ➔ Turn the main power ON. Check if any loosened screw causes poor contact. ➔ Tighten the screws at the specified torque.
(3) Breaks in wiring to the main power supply input terminals	Measure the input voltage. ➔ Repair or replace the main power input wiring or input devices (MCCB, MC, etc.).

11.5.2 Problems with inverter settings

[1] Nothing appears on the keypad

Possible Causes	What to Check and Suggested Measures
(1) No power (neither main power nor auxiliary control power) supplied to the inverter	Measure the input voltage and check the voltage and interphase unbalance. ➔ Turn ON a molded case circuit breaker (MCCB), an earth leakage circuit breaker (ELCB) (with overcurrent protection) or a magnetic contactor (MC). ➔ Check for voltage drop, phase loss, poor connections, or poor contacts and fix them if necessary.
(2) The keypad was not properly connected to the inverter.	Check whether the keypad is properly connected to the inverter. ➔ Remove the keypad, put it back, and see whether the problem recurs. ➔ Replace the keypad with another one and check whether the problem recurs.
	When running the inverter remotely, ensure that the extension cable is securely connected both to the keypad and to the inverter. ➔ Disconnect the cable, reconnect it, and see whether the problem recurs. ➔ Replace the keypad with another one and check whether the problem recurs.

[2] The desired function code does not appear

Possible Causes	What to Check and Suggested Measures
(1) The function code does not appear.	Check whether the function code is located in a different directory. ➔ Display the function codes in the directory, referring to Chapter 3, "Section 3.4.4 Programming mode" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)." Check whether an option board is mounted. ➔ Display the function codes in the directory, referring to Chapter 3, "Section 3.4.4 Programming mode" of separate volume "Unit Type/Function Codes Edition (24A7-☐-0019)". * No "o" codes appear unless an option board is mounted.

[3] Data of function codes cannot be changed from the keypad

Possible Causes	What to Check and Suggested Measures
(1) An attempt was made to change function code data that cannot be changed when the inverter is running.	Check if the inverter is running with Menu "OPR MNTR" using the keypad and then confirm whether the data of the function codes can be changed when the motor is running, referring to the list of function codes. ➔ Stop the motor and then change the data of the function codes.
(2) The data of the function codes is protected.	Check the data of function code F00 (Data protection). ➔ Change the data of F00 from "Enable data protection" (F00 = 1) to "Disable data protection" (F00 = 0).
(3) The "WE-KP" terminal command ("Enable data change with keypad") is not entered, though it has been assigned to a digital input terminal.	Check the data of function codes E01 to E09 and the input signal status with Menu "I/O check" using the keypad. ➔ Input a "WE-KP" command through a digital input terminal.
(4) The FUNC/DATA key was not pressed.	Check whether you have pressed the FUNC/DATA key after changing the function code data. ➔ Press the FUNC/DATA key after changing the function code data. Check that "STORING…" is displayed on the LCD monitor.
(5) The data of function code F02 cannot be changed.	Check if either one of the "FWD" and "REV" terminal signals is turned ON. ➔ Turn OFF both "FWD" and "REV" terminal signals.

[4] Data of function codes cannot be changed via the communications link

Possible Causes	What to Check and Suggested Measures
(1) An attempt was made to change function code data that cannot be changed when the inverter is running.	Check if the inverter is running with Menu "OPR MNTR" using the keypad and then confirm whether the data of the function codes can be changed when the motor is running, referring to the list of function codes. ➔ Stop the motor and then change the data of the function codes.
(2) The data of the function codes is protected.	Check the data of function code H29 (Data protection). ➔ Change the data of H29 from "Enable data protection" (H29 = 1) to "Disable data protection" (H29 = 0).
(3) The "WE-LK" terminal command ("Enable data change via communications link") is not entered, though it has been assigned to a digital input terminal.	Check the data of function codes E01 to E09 and the input status with Menu "I/O check" using the keypad. ➔ Input a "WE-LK" command through a digital input terminal.
(4) The "Full save function" (H02) was not executed.	Check that the "Full save function" was executed (H02 = 1). ➔ If data of function codes is changed, execute the "Full save function" (H02 = 1).
(5) The data of function code F02 cannot be changed.	Check if either one of the "FWD" and "REV" terminal signals is turned ON. ➔ Turn OFF both "FWD" and "REV" terminal signals.

Chapter 12 Cabinet Construction

12.1 Installation environment

The inverter is housed in a cabinet (board made of steel sheets) to protect against the surrounding environment and as countermeasures for EMI, human protection, and other concerns. The environments where the cabinets are installed vary, and the installation environment can affect the life and performance of the inverter. In Japan, the “Switchboard and Control Panel Ratings and Tests (JEM1460:2008)” standard of Japan Electrical Manufacturers’ Association defines the use conditions. (Refer to Appendix 2.)

JEM1460 specifies normal use conditions and special use conditions. Unless special provisions are specified, normal use conditions are assumed.

The inverter is designed for indoor use under normal use conditions. Therefore, countermeasures are implemented on the cabinet for use in special environment or outdoors. However, quantitative understanding of the conditions and phenomena for special use conditions is difficult and the criteria for judgment is unclear in many cases, as can be seen from JEM1460. Therefore, countermeasures are not always adequate.

In these situations, the most effective, economic and maintenance-friendly countermeasure is to install the inverter where normal use conditions apply. Therefore in cabinet design, care must be taken to make sure that the use conditions adequately meet the actual inverter installation environment.

This chapter describes the countermeasures for the cabinet installed under typical, special conditions.

Item		Concerns for installation location
Temperature		Vicinity of heat generating objects such as blast furnaces, thermostatic ovens, and boilers; sealed rooms and boxes (such as containers); tropical regions, freezers, and cold districts
Humidity		Food processing factories, inside drying facilities such as for wood, transportation facilities such as for frozen materials, inside tunnels, locations with snow and ice, locations using water and vapor
Vibration/Impact		Installation on vehicles, ships, and machines such as press machines and cranes
Atmosphere	Dust	Vicinity of casting factories, cement factories, spinning mills, fertilizer plants, flour mills, steel mills, sawmills, construction sites, garbage incinerators, and grinder facilities
	Oil mist	Locations where oil mist exists such as in casting factories, at press machines, and at machine tools
	Salt	Locations affected by sea-salt particles such as seashores and ships
	Flammable gas, Corrosive gas (sulfuration gas)	Chemical factories, petroleum refineries, fuel gas facilities, gasoline stations, water purification plants, hot springs, geothermal power plants, and coal mines
Outdoor		Outdoor installation location

12.1.1 Ambient temperatures

The ambient temperature of the control board (hereafter called cabinet) is in the range of -10 to +40°C in accordance with the inverter specifications.
Additionally, “No condensation and freezing due to sudden temperature changes” is a condition.

The cabinet houses instruments which use electronic devices such as CPUs and memories, and the ambient temperature is determined from the operating temperature range of these parts. (Aluminum electrolytic capacitor life is calculated based on the operating temperature.)

For this reason, malfunction and decrease of product life occur when the ambient temperature of the inverter exceeds the allowable range. If the temperature does not fall within the allowable range, perform the following measures.

High temp. countermeasure	(1) Suppress temperature increase inside the cabinet by increasing ventilation volume (cooling air flow). (2) When the heat generated by the instruments inside the cabinet affects the temperature, increase the spacing surrounding the heat generating instruments and increase the airflow on the outside of the cabinet. (3) For radiated heat and warm air from direct sunlight and heaters, install partitions to eliminate the effect of the heat. (4) Use industrial panel coolers or install in a location with air conditioning (close to air conditioning ducts).
Low temp. countermeasure	(1) Install a space heater inside the cabinet. Caution: Beware of local overheating when installing space heaters. (2) For enclosed cabinets, request the user to keep the power on constantly (even when switched off). (3) Move to a location with normal temperature surroundings or a location with air conditioning.

12.1.2 Humidity (condensation)

High humidity can cause decrease of insulation and erosion, resulting in spatial dielectric breakdown in worst cases when the humidity becomes extremely low. Also, relative humidity can increase rapidly and cause condensation when the temperature changes quickly and the water vapor pressure in the air cannot follow the change.

The inverter has an electronic circuit that has a very little insulation distance between the circuits, causing short circuit when condensations occur. Countermeasures for condensation are necessary for this reason.

High humidity condensation countermeasure	(1) Install a space heater inside the cabinet. Caution: Beware of local overheating when installing space heaters. (2) Request the user to keep the power on constantly (even when switched off). (3) Move to a location with normal temperature surroundings or a location with air conditioning. (4) Apply anti-dust measures to the cabinet and use panel coolers.
Low humidity countermeasure	Under typical environment, the humidity will not drop below 5% in most cases. Static electricity occurs easily when humidity is below 5%, and it can affect various instruments. Move the equipment to a location where the humidity is within the operating range (i.e., the humidity is 5% or higher).

[Selection of the space heater]

As a simple condensation countermeasure, the relative humidity inside the cabinet can be lowered by increasing the temperature inside the cabinet (⊿T) with respect to the external temperature.

The temperature increase (⊿T) setting can be used to mitigate the humidity.
The following are rough guidelines.

- When ⊿T = 5K, relative humidity decreases by 20%
- When ⊿T = 10K, relative humidity decreases by 40%

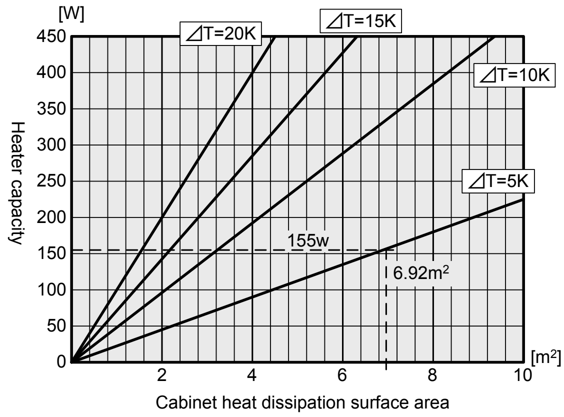
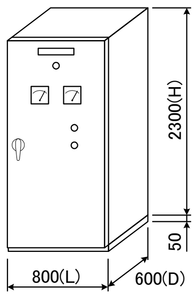


Figure 12.1-1: Selection of space heater (1)

Selection of space heater capacity (for cabinets without a ventilation outlet)

Specify ⊿T and determine heater capacity from the natural heat dissipation capacity of the cabinet and Figure 12.1-1.

◆Example of heater capacity selection (calculation example) (Note 1)



(1) Cabinet external dimensions

Width (L) = 800 mm
Depth (D) = 600 mm
Height (H) = 2300 mm

Note 1 The channel base is not included.

(2) Calculation of cabinet heat dissipation surface area

The heat dissipation area (bottom side area is subtracted from the total external area) of the cabinet is calculated below.

$$S = [(L \times H) \times 2] + [(D \times H) \times 2] + [(L \times D) \times 1]$$
$$= [(0.8 \times 2.3) \times 2] + [(0.6 \times 2.3) \times 2] + [(0.8 \times 0.6) \times 1] = 6.92[m^2]$$

(3) Selection of the space heater capacity

Space heater capacity can be selected based on the cabinet heat dissipation area (S) and the specified temperature increase value.

- S = 6.92 [m^2]
- Specified temperature increase value ⊿T = 5K

Reading from the graph in Figure 12.1-2, the space heater capacity should be 155 [W].

Given the above, a space heater with a similar capacity of 150 W or higher, is selected.

If instruments that are continuously powered exist (for example, power supply transformers), subtract the heat loss by the continuously powered instrument from the space heater capacity selected above to derive the final space heater capacity.

Selection of space heater capacity for cabinets with a ventilation outlet

When the cabinet has a ventilation outlet, Figure 12.1-1: Selection of space heater (1) and Figure 12.1-2: Selection of space heater (2) can be used to calculate the heater capacity.

When the ventilation outlet area is 0.8% of the heat dissipation area, T (temperature increase with ventilation outlet/temperature increase without ventilation outlet) becomes 50% reading from Figure 12.1-2. Therefore, to increase the temperature inside the cabinet by ⊿T = 5K,

$$T = \frac{\Delta T_{\mathrm{H}}}{\Delta T_{\mathrm{L}}} \times 100[\%] \quad \cdots \quad \text{Equation 12.1-1}$$

From Equation 12.1-1, the following equation is derived:

$$\Delta T_L = \frac{\Delta T_{\mathrm{H}}}{\Delta T_{\mathrm{L}}} \times 100[\%] = \frac{5K}{50[\%]} 100[\%] = 10K$$

When converted to the value for cabinets without a ventilation outlet, a space heater capable of increasing the temperature by ⊿T = 10K should be selected.

Then, calculate the space heater capacity by following the steps for "**Selection of space heater capacity (for cabinets without a ventilation outlet)**".

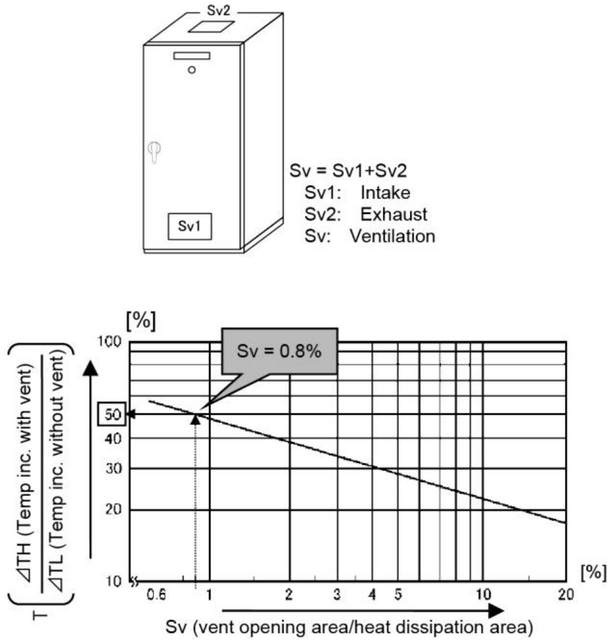


Figure 12.1-2: Selection of space heater (2)

<Electrochemical migration behavior (ion migration behavior)>

When humidity is high, electrochemical migration behavior (also called ion migration behavior) can progress, causing short circuit between electronic instruments. Care should be taken to keep humidity within the inverter specifications to avoid condensation.

What is electrochemical migration behavior?

Electrochemical migration behavior begins when water molecules attach to the metal sections of electronic circuits such as semiconductors. The metal sections rise in temperature when current flows and metal ions start to dissolve into the water molecules. The dissolved metal ions become metal films while being attracted to adjacent metals, extending towards nearby conductors. In the end, metal (conductor) short circuit is created.

<Relationship between humidity and corrosion>

The relationship between humidity and corrosion of steel materials is shown in Figure 12.1-3. When humidity increases as shown, the amount of corrosion increases.

Copper is commonly used for conductors, but copper erodes as well. Corrosion of the section contacting the conductor decreases the conductive area.

Plate the conductor protection to protect against corrosion.

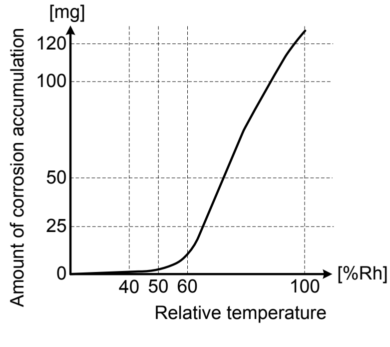


Figure 12.1-3: Relationship between humidity and corrosion

<Condensation>

The graph of Figure 12.1-4: Relationship between humidity and temperature difference summarizes the conditions causing condensation (humidity and temperature difference). As can be seen, large temperature difference can cause condensation at relatively low humidity level. Caution is necessary on the temperature difference between the inside of the cabinet and the surroundings.

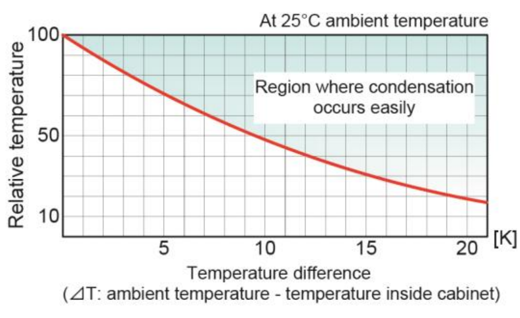


Figure 12.1-4: Relationship between humidity and temperature difference

12.1.3 Altitude

Insulation and cooling depend on air. Lower air pressure increases the possibility for insulation breakdown, reducing insulation durability. Thin air also reduces cooling effect, making the operating inverter rise in temperature more easily. For these reasons, reduce the voltage tolerance test value (not the rated voltage) and the rated current value (applicable motor capacity) by applying the factors shown in Table 12.1-1 when using at altitudes above 1000 meters.

Table 12.1-1: Reduction factor for the altitudes

Altitude	Output current (motor capacity) reduction factor	Voltage tolerance test reduction factor
1000 m or lower	1.00	1.00
1001 to 1500 m	0.97	0.95
1501 to 2000 m	0.95	0.90
2001 to 2500 m	0.91	0.85
2501 to 3000 m	0.88	0.80

12.1.4 Vibration

Vibration durability is expressed in terms of externally applied vibration amplitude and acceleration rate by operating frequency. When vibrations exceeding allowable limits are applied, instruments are exposed to mechanical stress, causing “loosening of the mechanical sections” or “breakage due to mechanical fatigue”. For installations in high vibration locations, implement the following anti-vibration measures.

(1) Anti-vibration measure

1) Attach anti-vibration rubber.
   When protecting only the inverter from vibration, attach to the inverter fastening section. When protecting the entire cabinet, attach as shown in Figure 12.1-5.
2) Use a cabinet structure which does not transmit vibration.
   Use flexible structure and absorb the transmitted vibration.
3) Install at a location distant from the vibration source.

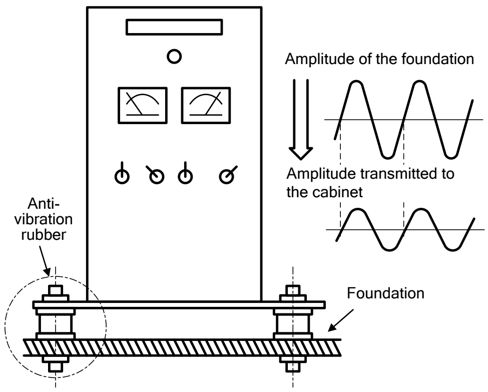


Figure 12.1-5: Example of anti-vibration rubber application

(2) Overview of vibrational acceleration

Vibrational acceleration is not known commonly, and quantitative understanding is difficult. The following explains vibrational acceleration using the example of a simple harmonic oscillation (sine wave vibration).

Displacement changes over time for simple harmonic oscillation, as depicted in Figure 12.1-6. Equation 12.1-2 describes this displacement.

$$x = a \bullet \sin \omega t \cdots$$ Equation 12.1-2

χ : Displacement at arbitrary time [m]

a : Amplitude on one side [m]

ω : Angular velocity [m/s]

t : Time [s]

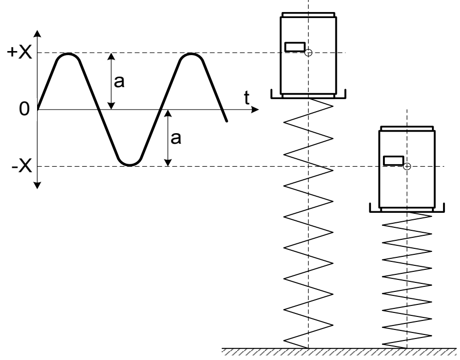


Figure 12.1-6: Waveform of simple harmonic oscillation

Vibrational acceleration can be derived by differentiating Equation 12.1-2 twice.

$$dx^2 / dt^2 = -\omega^2 a \bullet \sin \omega t \cdots \quad \text{Equation 12.1-3}$$

Substitute ω = 2πf into Equation 12.1-3.
(f: vibration frequency [Hz])

$$\begin{aligned} dx^2 / dt^2 &= -(2\pi f)^2 a \bullet \sin 2\pi f t \\ &= \alpha [m/s^2] \end{aligned} \cdots \text{Equation 12.1-4}$$

Maximum value of vibrational acceleration α is derived when sin2πft = -1, so it can be calculated by the following equation (Equation 12.1-5):

$$\alpha = (2\pi f)^2 \bullet a \cdots \quad \text{Equation 12.1-5}$$

Example: When a vibration of 10 [Hz] vibrational frequency and 1.5 [mm] amplitude on one side is applied to the inverter (a = 0.0015 m, f = 10 Hz),

$$\alpha = (2 \times \pi \times 10_{\text{Hz}})^2 \times 0.0015_m = 5.9[m/s^2]$$

<Reference>

To express the value relative to gravitational acceleration, divide by gravitational acceleration G = 9.8 m/s^2

α = 5.9/9.8 = 0.6 G

In other words, when a sine wave of 10 Hz vibrational frequency and 1.5 mm amplitude on one side is applied, the vibrational acceleration is 5.9 m/s^2 {0.6 G}.

12.1.5 Surrounding environment

The cabinet housing the inverter should be installed in places which suit the specified inverter specification environment, such as electric rooms.
However, there are occasions when it is unavoidable to install the inverter at locations not fitting the inverter specifications. The following explains typical measures to implement in such cases.

Dust and oil mist

In environments with high level of dust and oil mist, these may stick to and accumulate inside the cabinet, causing contact failures, deterioration of insulation, and corrosion in electrical instruments. If the dust contains humidity, the cooling fins of the inverter may become clogged and cause degradation of cooling capacity and inverter overheat alarm.

Additionally, conductive and humid dust can cause failures in electrical instruments quickly, and oil mist considerably reduces the life of electronic components.

Salt [seashore]

Sea-salt particles are scattered in the air on ships, coastal cranes, and factories on seashores. When these sea-salt particles accumulate, moisture absorption phenomenon of the sea-salt particles (occurrence increases when relative humidity exceeds 75%) causes reduction in the surface resistance of insulators, increasing the occurrence of flashovers even at rated voltages. The particles also cause corrosion from the contacted areas when attached to metals. Fuji Electric inverters are designed assuming 0.01 [mg/cm^2] per year of permeating salt volume. Measures must be implemented to contain salt volume within this limit when installing close to seashores.

Fuji Electric offers inverters and electric instruments (MCCB and contactors) with enhanced resistance to the effects of salt damage and humidity, in the product lineup. For details, contact your Fuji Electric representative.

Corrosive gas (sulfuration gas)

Corrosive gas such as hydrogen sulfide gas and chlorine exist in the air in petroleum chemical factories, sewage plants, and hot spring areas.

Corrosive gas invokes erosion of metal, rust, and deterioration of insulation, causing failures in and markedly reducing the life of electric and electronic instruments.

As hydrogen sulfide gas is heavier than air and is gaseous, preventing cabinet entry is difficult with typical cabinet construction.

Fuji Electric offers inverters and electric instruments (MCCB and magnetic contactors) with enhanced resistance to the effects of sulfuration gas, in the product lineup. For details, contact your Fuji Electric representative.

Flammable (combustive) gas, vapor, and powder dust

In flour mills where flammable gas and powder dust are produced, electrical instruments which use mechanical structures such as contactors and relays may cause sparks when contact points are opened and closed. Danger of explosion exists in these cases. All instruments for installation in locations with danger of explosion must be examined according to explosion-proof construction examination regulations for electric machinery and appliance. A certification organization specified by the government performs the tests for explosion-proof performance on the product submitted for examination and determines acceptability. For a product passing the examination, an acceptance number is issued.

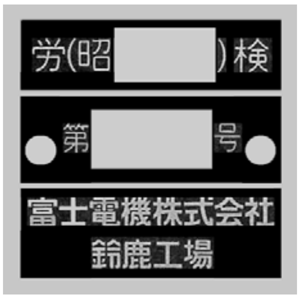
When installing in locations with danger of explosion, electrical instruments which use mechanical structures such as inverters and relays must be tested for explosion-proof performance as a stand-alone unit. When instruments not certified on explosion-proof performance are used, the cabinet housing the electrical instruments must be examined for explosion-proof performance.

Creating cabinets with explosion-proof construction is difficult, and cabinets with typical construction cannot be used in dangerous locations. Therefore, install them in safe locations.

Additionally, when installing only the motor in dangerous locations, the inverter and the motor as a set must be examined for explosion-proof performance of the motor.

(Regardless of whether a new or existing motor is used, the motor must be combined with the inverter for the explosion-proof performance examination.)

Fuji Electric manufactures explosion-proof motors and submits them for examinations on requested orders. For details, contact your Fuji Electric representative.



N89-4451-2

Figure 12.1-7: Certification label

12.2 Construction

In the design and manufacturing of cabinets, protection levels, heat dissipation of the housed instruments, and the layout of the housed instruments affect the safety, dimensions, and construction of the cabinet. This section describes the protective construction of the cabinet, the cooling system of the instruments, and the layout of the instruments.

12.2.1 Protective construction

12.2.1.1 Protective construction by IP class

The cabinet protection level is compliant to “JEM1267 (2008) Protection Levels for Switchboards and Control Panels (2008)” of Japan Electrical Manufacturers’ Association. Protective construction matching the installation location should be determined.

This standard includes the following two categories.

(1) Protection of instruments inside the cabinet against penetration by solid, external objects and protection of humans against nearing dangerous sections inside the cabinet

(2) Protection of instruments inside the cabinet against harmful effects by water penetration

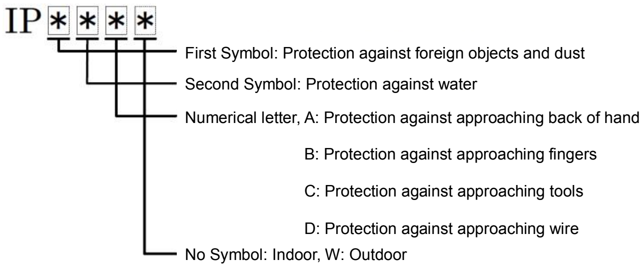
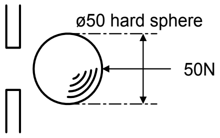
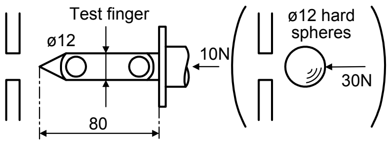
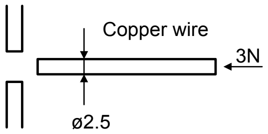
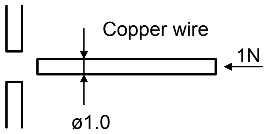


Table 12.2-1: Protection levels for “Nearing dangerous sections” and “Solid, external objects” expressed by the first numerical parameter

First symbol IP☐x (protection against foreign objects and dust)			
Symbol	Protection from	Test method	Criteria
0	Unprotected	—	—
1	Solid, foreign objects larger than 50 mm		Does not pass through openings, and maintains appropriate clearance against live sections and moving sections
2	Solid, foreign objects larger than 12.5 mm		Maintains appropriate clearance against live sections and moving sections (withstanding voltage warranty)
3	Solid, foreign objects larger than 2.5 mm		Does not enter housing
4	Solid, foreign objects larger than 1.0 mm		Same as above
5	Dust-protected	Visual inspection Visual inspection defined in terms of installation requirements (Note 1)	Lack of dust accumulation which impedes normal operation
6	Dust-tight	Visual inspection Visual inspection defined in terms of installation requirements (Note 2)	Dust does not penetrate into the housing

Remarks: X should be used when the degree of protection is not specified (ex. IP2X, IPX3)

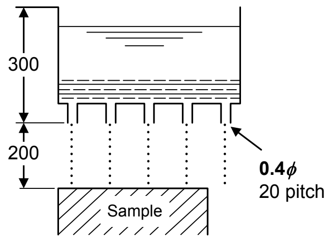
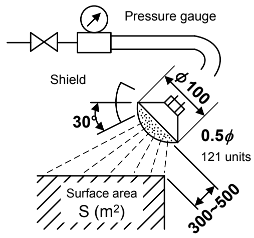
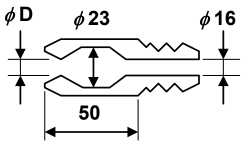
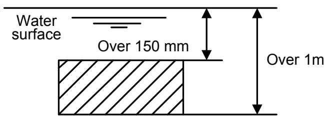
Note 1) IP5X installation requirements

Construction has shielded external surfaces all around and is carefully designed for dust protection at small crevices on doors and ventilation openings. The construction may allow dust accumulation but not on insulators.

Note 2) IP6X installation requirements

Construction has shielded external surfaces all around and has packings attached on doors and bonding sections of the cabinet. Ventilation openings should be normally not created, but they can be constructed if adequate measures to prevent dust penetration, such as filters, are implemented.

Table 12.2-2: Protection level against water expressed by the second numerical parameter

Second symbol IPx□ (protection against water)				
Symbol	Protection from	Test method		Criteria
0	Unprotected	—		—
1	Dripping water		• Precipitation: 3 to 5 mm/min • Time: 10 min	• Water should be discharged properly from the drain if available • Water should not be present around cables and cable terminals • Live parts and insulators should not become wet • Operation of instruments should not be obstructed
2	Water dripping with 15° inclination		• Precipitation: 3 to 5 mm/min • Tilt sample by 15°, in 4 directions • Time: 10 min	
3	Water spray from vertical to 60°		• Jet water: 10 L/min • Water pressure: 80 to 100 kPa • Time: 5 min or longer • With 30° shield	
4	Spray from all directions		Same as above (without shield)	
5	Jet water from all directions	 3m from nozzle to housing	• D = 6.3 • Jet water: 12.5 L/min • Water pressure: 30 kPa (Water spray 2.5 m ascent) • Time: 3 min at minimum	
6	Jet water from all directions		• D = 12.5 • Jet water: 100 L/min • Water pressure: 100 kPa (Water spray 8 m ascent) • Time: 3 min at minimum	
7	Immersion in water		• Time: 30 min	
8	Submerged	As agreed on between manufacturer and user		

12.2.1.2 Protective construction by NEMA standard class

In some cases, protection levels are expressed in terms of NEMA standards along with IP class. This section describes the protection level by NEMA standards and approximate IP classes.

NEMA standards was defined by NEMA (National Electrical Manufacturers Association: USA), and the relevant container type is defined by NEMA250 (Enclosure for Electrical Equipment (1000 V Maximum).
The container type is commonly expressed as NEMA 4 or NEMA Type 4.

Major types of NEMA standards include explosion-proof and non-explosion-proof types as well as indoor and outdoor types which are classified by type numbers.

	Indoor	Indoor and outdoor
Non-explosion-proof	Type 1, 2, 5, 12, 12K, 13K	Type 3, 3R, 3S, 4, 4X, 6, 6P
Explosion-proof	Type 7, 8, 9, 10	

Type	Overview	Approximate IP code
1	Indoor use primarily to provide a degree of protection against contact with the enclosed equipment and against a limited amount of falling dirt.	IP30
2	Indoor use to provide a degree of protection against limited amounts of falling water and dirt. (IP31)	IP31
3	Outdoor use to provide a degree of protection against windblown dust, rain, and sleet; undamaged by the formation of ice on the enclosure	IP64
3R	Outdoor use to provide a degree of protection against falling rain and sleet: undamaged by the formation of ice o the enclosure.	IP32
3S	Outdoor use to provide a degree of protection against windblown dust, rain and sleet; external mechanisms remain operable while ice laden.	
4	Indoor or outdoor use to provide a degree of protection against splashing water, windblown dust and rain, hose directed water; undamaged by the formation of ice on the enclosure.	IP66
4X	Indoor or outdoor use to provide a degree of protection against splashing water, windblown dust and rain, hose directed water; undamaged by the formation of ice on the enclosure, resists corrosion.	IP66
5		
6	Indoor or outdoor use to provide a degree of protection against the entry of water during temporary submersion at a limited depth; undamaged by the formation of ice on the enclosure.	
6P	Indoor and outdoor use to provide a degree of protection against the entry of water during prolonged submersion at a limited depth.	
11	Indoor use to provide by oil immersion a degree of protection of the enclosed equipment against the corrosive effects of corrosive liquids and gases.	
12,12K	Indoor use to provide a degree of protection against dust, falling dirt and dripping noncorrosive liquids. (IP65)	IP65
13	Indoor use to provide a degree of protection against dust and spraying of water, oil and noncorrosive coolants. (IP65)	IP65

Table 12.2-3: Target of protection for non-explosion-proof containers

Target of protection	1	2	3	3R	3S	4	4X	5	6	6P	12, 12K	13
Prevention of accidental contact with internal parts	O	O	O	O	O	O	O	O	O	O	O	O
Protection from falling dust	O	O	O	O	O	O	O	O	O	O	O	O
Protection from accumulation of floating dust in the circulating air flow								O				
Protection from floating dust in the circulating air flow											O	O
Protection from blown dust			O		O	O	O					
Protection from dripping and light spraying		O						O			O	
Protection from spraying						O	O					
Protection from spraying of water and non-corrosive lubricants												O
Protection from jet streams						O	O		O	O		
Protection from rain, sleet, and snow			O	O	O	O	O					
Protection from temporary immersion in water									O			
Protection from intermittent immersion in water										O		
Maintenance of function after exterior is frozen			O	O		O	O		O	O		
Maintenance of function after exterior is frozen					O							
Protection from corrosion							O					
Reference IP codes **(refer to text)**	10	11	54	14	54	56	56	52	67	67	52	54

12.3 Cabinet

The cabinet construction can be modified to adapt to individual installation environments. This section describes the modifications to the cabinet construction to adapt to installation environments.

12.3.1 Indoor cabinet

Generally, control cabinets which house electrical instruments such as inverters use cabinet constructions made of steel sheets. The steel sheets shield the components from penetration by foreign objects and for human safety. Since the electrical instruments each generate heat, ventilation openings should be created to cool the inside of the cabinets. On the ventilation openings, air filters should be attached to prevent dust penetration, other than in specially cleaned environments such as clean rooms.

Typical indoor cabinets must implement IP protective construction which does not allow penetration of a cylindrical rod with 12.5 mm diameter from ventilation openings or crevices in the casing. The IP code for this level of protection will be IP2X.

For water, the unprotected IPXO is common. However, construction that does not allow direct penetration to the interior by small amounts of sprayed water drops, or that does not allow wetting of the conductive parts and the insulators around the conductive parts in the case of indirect penetration, is required.

12.3.2 Outdoor cabinet

Cabinets installed outdoors are affected by direct sunlight, rain, wind, and snow, so the construction must be able to withstand all weather conditions, in principle.

Typically, protective construction is added to cabinet construction for indoors.

<Example of countermeasure: IP33W equivalent without direct sunlight>

(1) Attach the roof and create a construction which does not allow rain to seep in from the door, bonding surfaces, or the ventilation openings.
Attach gallery structure and air filter to the intake opening to prevent rain from wetting the air filter.
(When the air flow speed at the intake section is fast, rain and dust can easily be drawn in. The intake area should be made larger compared to installations in indoor electric rooms.)

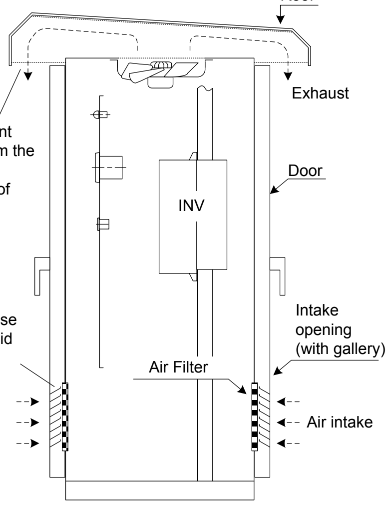


Figure 12.3-1: Outdoor cabinet example

(2) Attach wire screens to openings such as the ventilation opening to prevent intrusion by small animals.

(3) For the tools to attach to the door, use outdoor types. Otherwise, attach a window to the door and make the tools operable with direct view from the window.
(The desirable construction for the operating tools will shield the board even when the window is open.)

(4) On the bonding surfaces for the roof, door, and the cabinet, "attach packing and water drain", or use a "labyrinthine structure".

Direct sunlight

From the heat of the direct sunlight, the cabinet surface temperature rises and may reach up to 70°C on the roof section at noon in the summer time. When the surface temperature rises, internal temperature also rises, and the tolerable upper level temperature of the housed instruments may be exceeded.

<Example of countermeasure>

(1) For the roof section where direct sunlight affects the most, use “Double layer roof construction” or “Construction with heat insulating material”.

(2) Use light color for the cabinet surfaces to reduce heat absorption or use heat insulating paint.

(3) Increase the cabinet volume as much as possible. Use large ventilation (cooling) fans.

(4) Install at shaded locations where the effect of direct sunlight is small.

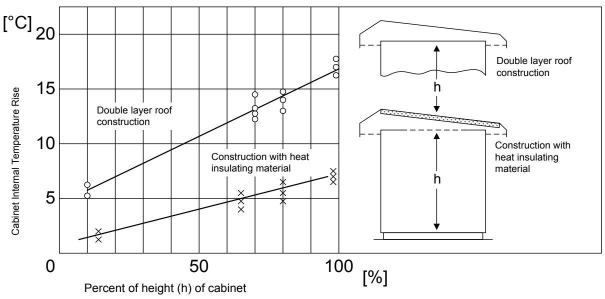


Figure 12.3-2: Example of cabinet internal temperature rise due to direct sunlight

Countermeasures for condensation

When the inside of the cabinet is subjected to sudden temperature changes as in the case of direct sunlight after rain or vice versa, condensation can result.

Condensations on the inside roof portion of the cabinet can cause water drops which cause damage on electrical instruments.

The following construction is recommended for installation in such environments.

<Example of countermeasure>

(1) Implement high humidity and condensation countermeasures 1) and 2) described in “12.1.2 Humidity (condensation)”.

(2) Change the roof section to double layer roof construction or construction with heat insulating material.

(3) Tilt the roof to avoid buildup of rain.

Snow

For outdoor installations in snowfall areas, construction enhancements are necessary in order to prevent penetration of powder snow in addition to rain and to withstand the load of accumulated snow. Since powder snow can penetrate from small crevices, snow countermeasures for the cabinet with openings require a considerable amount of cost and labor.

Additionally, the condensation may result in the inside of the cabinet during early spring when the temperature changes suddenly.

Therefore, avoid outdoor cabinet installations in snowfall areas. Indoor installation is recommended.

Wind pressure

The cabinet door can open and close due to effects of wind pressure when the cabinet is installed in strong wind areas and in high locations such as on seacoast cranes.

(The worker may suffer injury if the door closes due to wind pressure while conducting maintenance checkup.)

When installing the cabinet in strong wind pressure areas, attaching devices such as door stoppers and latches is recommended.

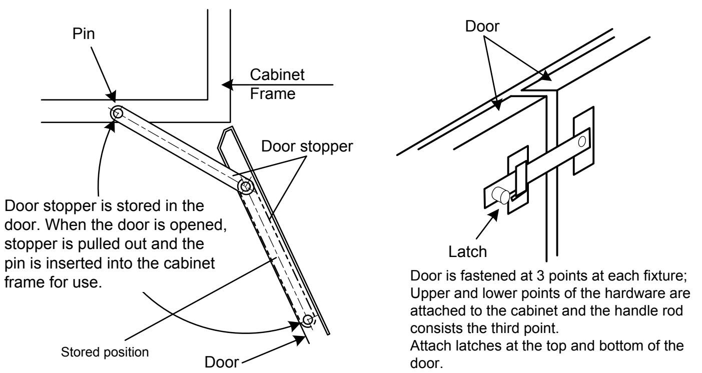


Figure 12.3-3: Example of countermeasure to prevent door opening and closing due to wind pressure

12.3.3 Cabinet installation in indoor special environment

Water drop proof cabinet

When installing the cabinet at indoor locations close to water and oil ducts, protection levels such as IP21 and IP22 are required.

In this case, water protection of the construction must prevent internal penetration by small volume of water drops at angles within 15° from vertical.

(1) Add a simple lean-to on the top of a cabinet with protection level equivalent to indoor installation.

(2) Attach gallery to the intake opening.

(3) Create a construction that allows quick water discharge when cables and cable terminal surroundings become wet.

Dust-protected, dust-tight, and water-proof cabinet

When installing the cabinet where mist is dispersed such as mineral stopes, tunnel digging sites, and cement factories, protection levels (dust-protected and water-proof levels) equivalent to IP51 and IP54 are required.

(1) Fabricate the contacting surface between the cabinet frame and the door in a water draining structure, and attach airtight packing with cushion on the contacting surface between the cabinet frame and the door.

(2) Fill in the gaps on the outside screws using caulking compound.

(3) Cool the inside of the cabinet using panel coolers and heat exchangers for cabinets which support IP51 and IP54.

(4) Apply plating to wires and conductors and use SUS type screws.

(5) Use polyurethane or epoxy type resin paint to paint the cabinet. (This reduces corrosion of the cabinet.)

(6) For moving parts of the cabinet, make adjustments such that the hook on the handle will not scratch off the paint. (Use SUS cover plate or resin caps.)

Dust-tight IP6X level can be implemented depending on the amount of dust. To comply with IP6X equivalent level, cabinet must be air purged, and the pressure inside the cabinet must be raised. When the amount of heat generated by the housed instruments is large, the modifications become extensive. For this reason, installation of the cabinet in environments requiring IP6X protection level is not recommended.

Corrosion protection and corrosion resistant cabinets

Specialized cabinet construction is necessary to prevent corrosion of electrical instruments housed in the cabinet from corrosive gas such as sulfuration gas. (To increase the pressure inside the cabinet, treatments such as air purge are necessary.)

When installing, use electrical instruments treated for anti-corrosive gas and implement the measures for dust-protected, dust-tight, and waterproof cabinet in the previous section.

Salt tolerant cabinets

When installing close to seashores, the following measures are effective. However, maintenance checkups and frequent cleaning may be necessary.

(1) Use salt tolerant filters for ventilated cabinets.

- Salt tolerant filters have very fine openings, resulting in very mild air flow velocity. Therefore, the intake area must be made large.
- Also, the salt tolerant filters cannot be recycled.

(2) Fabricate the contacting surface between the cabinet frame and the door in a water draining structure, and attach airtight packing with cushion on the contacting surface between the cabinet frame and the door.

(3) Cool the inside of the cabinet using panel coolers and heat exchangers for cabinets which support IP51 and IP54.

(4) Apply plating to wires and conductors and use SUS type screws.

(5) Use polyurethane or epoxy type resin paint to paint the cabinet. (This reduces corrosion of the cabinet.)

(6) For moving parts of the cabinet, make adjustments such that the hook on the handle will not scratch off the paint. (Use SUS cover plate or resin caps.)

12.4 Cooling

The inverter generates heat in the switching operation in the IGBT main circuit when driving the motor. Even when housed in cabinets, the inside temperature will not rise if all of the amount of heat generated can be dissipated. However, when the cabinets use constructions close to full enclosure, the internal temperature rises.

The inverters and the peripheral instruments housed in the cabinets have individual tolerances for ambient temperature. Cabinet heat dissipation and cooling are important because the performance and the life of the housed instruments degrade when these tolerances are exceeded.

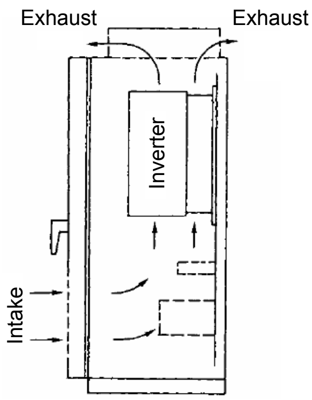
12.4.1 Cooling method

Commonly used cooling methods are categorized and their characteristics are shown (in Tables 12.4-1 to 12.4-3).

(1) Natural cooling

Cooling method using heat dissipation by natural convection current and cooling fans of housed instruments.

Table 12.4-1: Types and characteristics of cooling methods (1)

Type	Natural ventilation
Overview	• Forced ventilation by the inverter cooling fan • Construction which circulates natural air
Characteristics	◆ Economical. ◆ Dust can penetrate easily from intake openings if air filters are not installed. (Dust can penetrate easily from cabinet top surface if exhaust air does not flow.) ◆ Air filters should be installed. If only natural air circulation is used, the ventilation volume drops considerably. (The calculation of the intake opening area is difficult.) ◆ In cases where the cooling fan attached to the inverter is used for forced exhaust. Exhaust ducts and hoods may need to be attached by occasion. 
Application	Cabinets housing extended capacity inverters

(2) Forced cooling

The cabinet is force-cooled using fans, panel coolers, and heat exchangers.
The cabinet will not grow larger even when the amount of heat generated inside is large. The methods are applicable from small to large capacity inverter boards.

Table 12.4-2: Types and characteristics of cooling methods (2)

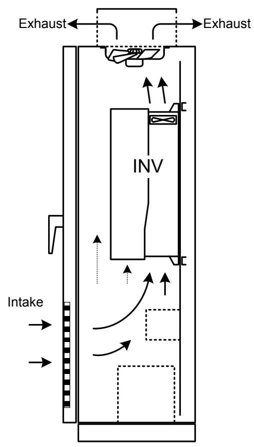
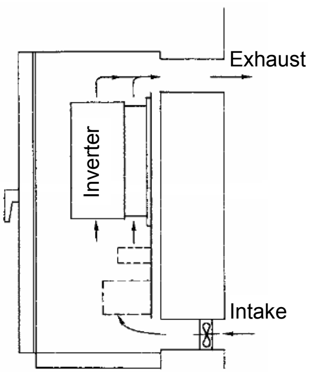
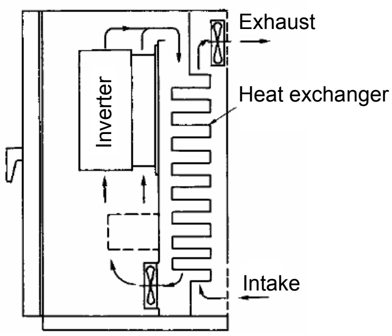
Type	Forced cooling by ventilation fan (exhaust method)
Overview	Cooling method using an exhaust fan attached to the roof of the cabinet
Characteristics	◆ An air filter that collects dust is necessary for the intake opening. ◆ The number of parts for maintenance increases: • Fan • Air filter ◆ Periodic maintenance is necessary. 
Application	Installation to typical indoor environment Measures for outdoor installation are necessary for outdoor applications

Table 12.4-3: Types and characteristics of cooling methods (3)

Type	Forced cooling by ventilation fan (pressurized air method)	Cooling by panel cooler/heat exchanger
Overview	Air purge cooling using fresh air (pressurized fan)	Cooling method using panel coolers and heat exchangers
Characteristics	◆ Ventilating duct must be furnished. ◆ The pressure inside the cabinet can be raised by increasing the air flow volume of the pressurizing fan. (Air purge) Suction of dust and mist into the cabinet can be prevented. 	◆ Dust-protected construction (IP51 and IP54 equivalent) is necessary. ◆ The number of parts of maintenance increases (panel cooler, heat exchanger) ◆ Periodic maintenance is necessary. 
Application	Installation to indoor location with poor surroundings	Installation to typical indoor environment Measures for outdoor installation are necessary for outdoor applications

12.4.2 Installation condition specification and selection of cooling system

The cabinet cooling method is selected considering the installation environment, operation load conditions (amount of heat generated), and others.

Condition 1)	Ambient temperature:	40°C (Typical indoor condition) JEM1460 specifies ambient temperature to be 40°C for both indoor and outdoor. If ambient temperature can be lowered depending on the installation environment, this should be reflected in the selection conditions.
Condition 2)	Allowable internal temperature:	50°C (Typical allowable temperature upper limit for instruments housed in cabinets) Out of the housed instruments, the temperature of the instrument with the lowest allowable temperature upper limit should be used as a reference.
Condition 3)	Total amount of heat generated by housed instruments:	The amount of heat generated by the inverter varies with loading capacity, operation cycle pattern (calculation of average load), and carrier frequency.

Amount of heat generated (heat loss) by internally housed instruments

Calculate the heat loss (amount of heat) incurred by the entire cabinet. Follow the steps below in calculating the amount of heat generated.

(1) Calculate the heat loss of the inverter and the other heat generating instruments individually and add.
The amount of heat generated by the inverter becomes larger with increasing capacity. If the loading capacity and the operation cycle pattern can be specified, these should be considered. The amount of heat generated also differs depending on the carrier frequency.

(2) The heat loss of wires and small parts (frequency setting device and fuses) is difficult to digitize. Based on historical data with safety factor, estimate 10 to 15% of the value calculated in (1).

(3) If the cabinet is heated by radiant heat from the surroundings and direct sunlight, convert the amount of heat received to loss [W].

Add the values found in (1), (2), and (3) to obtain the total heat loss of the cabinet.

The actual cooling is difficult to estimate using only theory because heat dissipation varies slightly depending on the cabinet construction and the placement of the instruments. Accumulated data and experience should be factored into specific designs.

12.4.3 Examples of cooling calculations by cooling system

12.4.3.1 Forced cooling by ventilation fan

A typical forced cooling by ventilation fan (exhaust method) will be used as an example for the illustration. In this cooling method, heat dissipation from ventilation fan is much larger than the heat dissipation from cabinet surfaces, so the heat dissipation from the cabinet surface using natural convection will be ignored. JEM-TR148 defines the equation for ventilation fan cooling. This equation will be used.

$$q = \rho \times C \times Q(To - Ta)$$ ・・ Equation 12.4-1

$$Q = \frac{q}{\rho \times C(To - Ta)}$$ ・・ Equation 12.4-2

q : Total amount of heat generated by the entire cabinet [kW]
ρ : Air density 1.057 (to 1.251) [kg/m^3] (at 50 to 0°C)
C : Specific heat of air 1.0 [kJ/kg・°C]
Q : Ventilation air volume [m^3/s]
To : Air temperature at exhaust opening (cabinet internal temperature) [°C]
Ta : Air temperature at intake opening (ambient temperature) [°C]

Calculation example

Substituting into Equation 12.4-2,

$$Q = \frac{q}{\rho \times C(To - Ta)} = \frac{1080 \times 0.001}{1.057 \times 1.0(50 - 40)}$$

$$\fallingdotseq 0.103[m^3 / s]$$

$$Q = 6.2[m^3 / \min]$$

(Conditions) ρ = 1.057 [kg/m^3]
C = 1.0 [kJ/kg・°C]
Ts = 50 [°C]
Ta = 40 [°C]

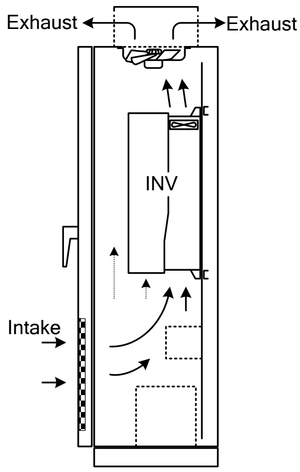


Figure 12.4-1: Forced cooling by ventilation fan (exhaust method)

Hence, regardless of cabinet dimensions, using a fan with 6.2 [m^3/min] air flow will make cooling possible.
The results show that the cooling can be done if cooling fan and the intake area can cool the heat generated inside the cabinet.

The cooling construction using the inverter cooling fan, which is one method of natural cooling, can be calculated similarly using Equation 12.4-2 in this section.

With this method, however, exhaust from the inverter flows back into the cabinet if there is quite a distance between the exhaust opening and inverter cooling fan, and therefore an exhaust duct should be fitted to prevent back-flow.

And as heat dissipation results from natural convection, very little heat is dissipated. Consequently, application is only possible for inverter boards for which little heat is generated.

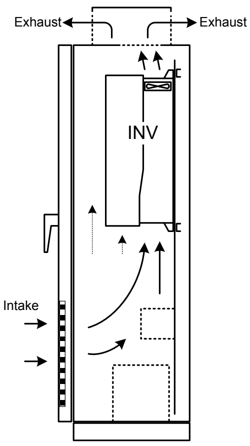


Figure 12.4-2: Natural ventilation (forced cooling with inverter cooling fan)

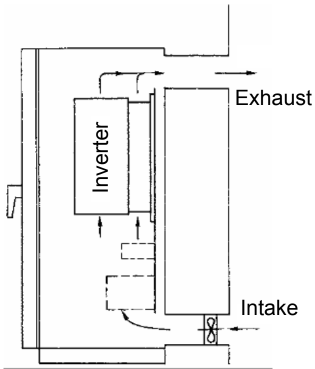


Figure 12.4-3: Forced cooling by ventilation fan (pressurized air method)

The case of pressurized air method can be calculated similarly using the equation in this section (Equation 12.4-2).

When air is pressurized by a cabinet mounted fan, air filters are typically attached before and after the fan. If the distance between the fan and the filters is short, the fan will not be able to produce the rated air flow.

Also, if the air filter comparable in size to the fan is used, the air flow speed through the filter increases, shortening the cleaning and replacement cycle of the filter.

12.4.3.2 Cooling by heat exchanger

The cooling performance when heat exchangers are used can be calculated using technical information from heat exchanger manufacturers and “Board Heat Exchanger Technical Council Documents No. 003 Selection Method for Board Heat Exchanger Model”.

The heat exchangers which can be attached to cabinets have size limitations, and the rated capacities are relatively small in most cases. (Heat dissipation capacity is low compared to forced cooling fans.) For this reason, the heat dissipation from cabinet surfaces is also included in the heat calculations.

Also, the cabinet internal temperature cannot be lowered to below the ambient temperature.

$$R = \frac{q}{Ts - Ta} - h \times A \quad \cdots \quad \text{Equation 12.4-3}$$

q : Total amount of heat generated by the entire cabinet [W]

R : Rated cooling capacity of heat exchanger [W/°C]

h : Thermal conductivity (heat loss coefficient) 5 to 6 [W/m^2･°C]

A : Effective heat dissipation area of cabinet [m^2]

Ts : Cabinet internal temperature [°C]

Ta : Ambient temperature [°C]

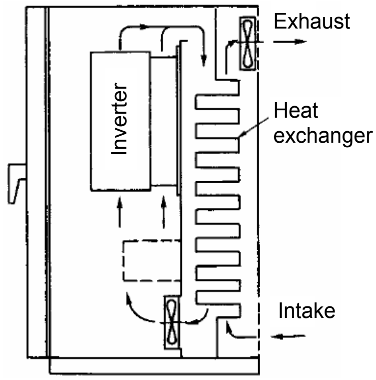


Figure 12.4-4: Cooling by heat exchanger

Calculation example

Substituting the values into Equation 12.4-3,

$$R = \frac{q}{Ts - Ta} - h \times A$$
$$= \frac{1080}{50 - 40} - 5.4 \times 6 = 75.6[W/℃]$$

Hence, select a board heat exchanger with rated cooling capacity of 75.6 [W/°C] or higher from heat exchanger catalogues.

12.4.4 Cooling by panel cooler

The cooling capacity when panel coolers are used can be calculated using technical documents from panel cooler manufacturers.

The cooling capacity differs depending on ambient temperature and the configured temperature of the panel cooler.

$$P = q + h \times A(Ta - Ts) \quad \cdots \quad \text{Equation 12.4-4}$$

q : Total amount of heat generated by the entire cabinet [W]

P : Required cooling capacity of panel cooler [W/°C]

h : Thermal conductivity (heat loss coefficient) 5 to 6 [W/m^2･°C]

A : Effective heat dissipation area of cabinet [m^2]

Ts : Configured temperature of the panel cooler [°C]

Ta : Ambient temperature [°C]

Equation 12.4-4 shows that the cabinet surface area exposed to the ambient temperature affects the required cooling capacity of the cooler.

When the configured temperature of the panel cooler is set below ambient temperature, the cabinet surface is affected by radiant heat of the ambient temperature, adding radiant heat to the total amount of heat generated by housed instruments.

When ambient temperature is higher than the configured panel cooler temperature, cabinet surface radiates heat and this amount is subtracted (dissipated).

Calculation example

Substituting the values into Equation 12.4-4,

$$P = q + h \times A(Ta - Ts)$$
$$= 1080 + 5.4 \times 6(40 - 50) = 756[W]$$

Hence, select a panel cooler with cooling capacity of 756 [W] or higher when ambient temperature = 40°C and the configured panel cooler temperature = 50°C, from panel cooler catalogues.

12.5 Selection of cooling fan

This section describes the selection and verification of cooling fans to be used on cabinets with forced cooling by ventilation fans.

For more details, refer Appendix 3.

<Procedures>

(1) Calculate the total heat loss of the instruments housed in the cabinet.

(2) Determine the temperature rise value within the cabinet and calculate ventilation volume (air flow) Q [m^3/s] according to “12.4.3 Forced cooling by ventilation fan”.

(3) Estimate the pressure loss due to the air flow through the cabinet (air flow speed) using analogical reasoning on the air flow characteristics inside the cabinet and accumulated operation data. Deriving pressure loss from the equation is difficult, so actual data measurements will be necessary.

(4) Calculate the required ventilation volume (air flow) Q [m^3/s] using the fan characteristic curves (Q-Ps curve) listed in fan catalogues and technical documents and the estimated pressure loss from (3). Determine the fan to use.
The resistance curve is a diagram based on pressure loss. The fan is operated at the intersection of the fan characteristic curve and the resistance curve shown in Figure 12.5-1. The air flow of this intersection (operating point) becomes the ventilation volume of the cabinet.

(5) Attach the selected fan, and verify the temperature rise inside the cabinet at full load operation. Typically, internal temperature of the cabinet is 50°C when ambient temperature is 40°C. In this case, the allowable temperature rise in the cabinet will be up to 10K.

(6) If the temperature rise inside the cabinet exceeds 10K, perform the following countermeasures.
   1) Improve the air flow inside the cabinet and reduce pressure loss.
   2) Replace with a larger fan.
   3) If the temperature surrounding the inverter is high despite the low temperature at the exhaust opening, attach partitioning boards to increase the air flow around the inverter.

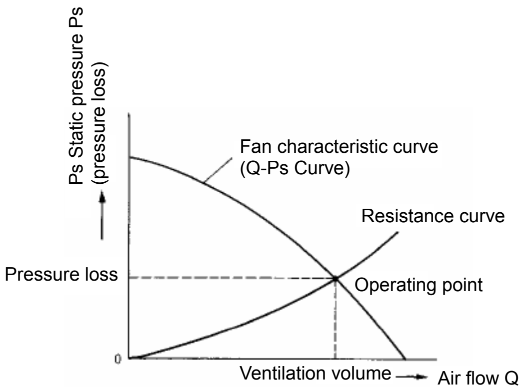


Figure 12.5-1: Fan operating characteristics

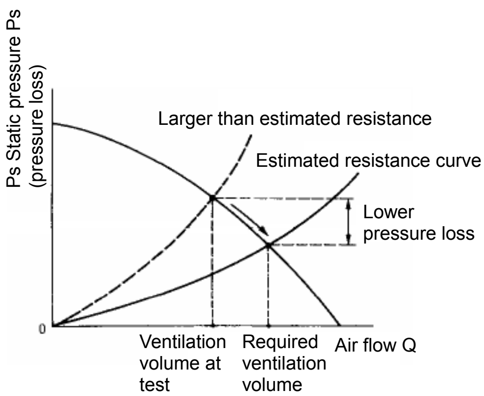


Figure 12.5-2: Case when ventilation volume is insufficient

12.5.1 Air filter size calculation

When drawing in external air using a fan, use a dust air filter on the intake opening, because dust may be suctioned from the intake opening. The recommended air filters are shown below.

<Recommended air filter information>

Manufacturer: Japan Vilene http://www.vilene.co.jp

Product name: Viledon® air filter regenerative type for general use

Specifications:

Item \ Part No.	PS/150N	PS/300N	PS/400N	PS/600N
Material	Polyester/modern acrylic			
Std size W x L [m]	1.6×30		1.6×20	
Thickness [mm]	8±3	10±2	14±2	20±3
Typical air speed [m/s]	2.5			
Init pressure loss [Pa]	30	54	64	90
Avg collection efficiency [%]	63	73	76	82
Operating temperature [mm]	80°C or lower			

The recommended part number is PS/400N.

Select part types, according to installation environment.

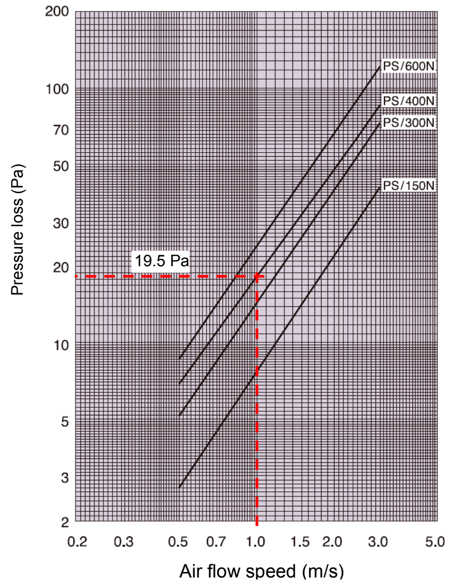


Table 12.5-1: Relationship between air flow speed and pressure loss

Calculate the air filter effective area and ventilation opening area using the following equation.

$$Af = \frac{Q}{Vf} \quad \cdots \qquad \text{Equation 12.5-1}$$

Af : Air filter effective area [m²]

Q : Required ventilation volume (air flow) [m³/s]

Vf : Air flow speed through air filter [m/s]

In the specification of the air filter, the air flow speed through the air filter is 2.5 m/s. As time passes, dust begins to clog the path through the filter. Maintaining the same air flow volume increases air flow speed along with increase in pressure loss. When the maximum dust retention volume is exceeded, pressure loss exceeds the limit and the ventilation volume decreases.

Therefore, at Fuji Electric, air flow speed of 1±0.5 [m/s] is used to calculate the effective area of filters.

(Depending on the installation location, large exhaust volume from the exhaust opening may have the exhaust heat suctioned from the intake opening.)

Air filters should be replaced or cleaned and reused before the ventilation volume (air flow) lower limit is reached. Also, the cooling fan requires static pressure commensurate with the pressure loss of the air filter, so select the air filter considering this pressure loss.

Calculation example

Substituting Q = 0.103 [m³/s] and Vf = 0.75 [m/s] from Equation 12.5-1,

$$Af = \frac{Q}{Vf} = \frac{0.103}{0.75} = 0.137[m^2]$$

Q = 0.103 m³/s

Vf = 0.75 m/s

Hence, create an intake opening which will allow an effective air filter area of over 0.137 [m²].

Additionally, a construction which positions the intake opening at the bottom of the cabinet and the exhaust opening on the roof as shown in Figure 12.5-3 is recommended.

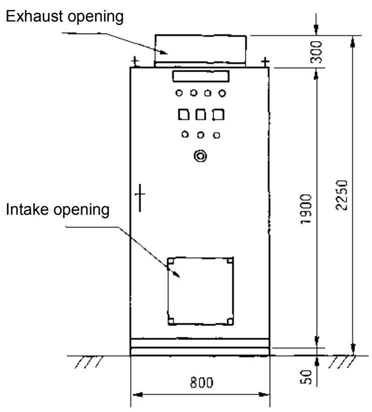


Figure 12.5-3: Control cabinet with intake and exhaust openings

12.5.2 Principles in designing layout in cabinets

(1) Ascertain that instruments, parts, and materials which are vulnerable to heat are cooled.
The exhaust heat from the inverter cooling fan can reach up to 60°C. The reactor also reaches high temperature. Therefore, the electrical instruments should not be placed at locations where the exhaust heat from the inverter hits, at locations close to the reactor, and at locations on route of air flow carrying emitted heat from the reactor.

(2) Avoid local temperature increase.
The air flow inside the cabinet moves towards the direction where the area of the air flow path is larger. (Air flows in the route of least flow resistance.)
Positioning high heat generating instruments together will cause local build-up of heat.
For this reason, place the instruments in the cabinet such that the fresh air drawn in from the intake opening will flow towards the high heat generating instruments. Be creative to implement improvements such as attaching air stirring fans inside the cabinet and furnishing ventilation openings and ducts where hot air builds up.

(3) Avoid heat interaction between instruments.
Place instruments with high heat generation towards the top, and place instruments apart.
Inverters may intake and exhaust from the sides. For details, refer to the inverter technical documents or the users' manual and secure distance between instruments.

(4) Exercise caution against the surrounding environment.
In space confined installations, the exhaust heat from the cabinet (radiant heat from the cabinet surface) will increase room temperature. If heat generating objects (furnaces and machines which heat up) are close, the cabinet will be affected by the heat dissipated from the objects.
Reconsider room ventilation, cooling methods, and installation location.
Be careful that the cabinet will not draw in its own exhaust heat.

(5) Exercise caution to prevent dust from entering through crevices. (use of packing and sealing) Seal crevices using packings for doors and construction wiring clay for cable lead-in sections, even for cases of forced cooling using ventilation fans.

Forced cooling by ventilation fan (exhaust method)

(1) Construct such that the parts requiring cooling are in the path of air flow. Air passes through sections with lower resistance. If the ventilation fan and the inverter are positioned as in Figure 12.5-4, most of the fresh air drawn in from the intake opening will pass directly to the exhaust opening without passing through the inverter. In these cases, install dampers or partitioning boards to guide air flow to the heated sections.

(2) For inverters with cooling fans, be careful of the air flow direction between the ventilation fans and the cabinet cooling fans. When the air flow directions oppose, air flow cancel each other out, reducing cooling air volume.

(3) When attaching multiple inverters or instruments with high heat generation, position side-by-side as in Figure 12.5-5.
If dimensional restrictions make vertical positioning of the instruments unavoidable, create a construction with partitioning boards to prevent heat effect. Without the partitioning boards, the exhaust heat from the lower inverter will be drawn into the upper inverter.

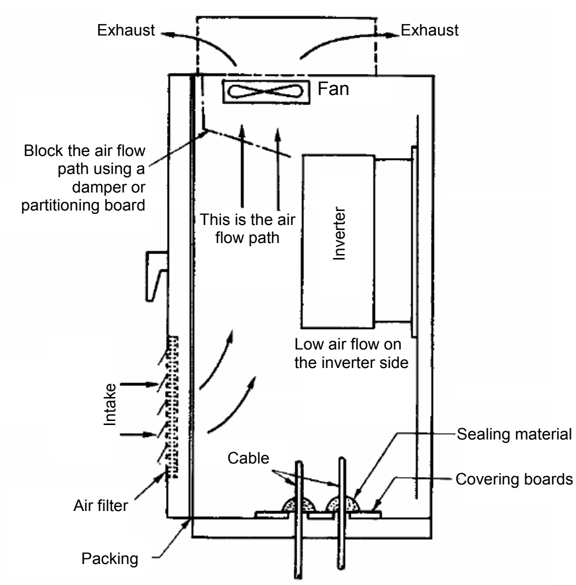
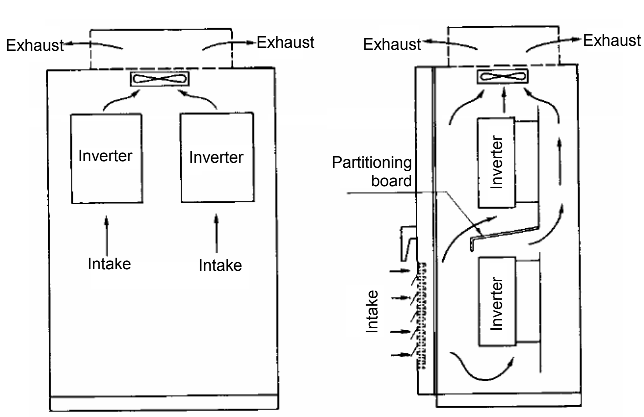


Figure 12.5-4: Example of damper attachment



(a) Side-by-side placement (b) Vertical placement

Figure 12.5-5: Multiple inverters

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Appendix

Appendix 1 Guideline concerning safety of switchboards

Appendix -1.1 Introduction

Product liability law (PL law enforced on July, 1995) is a short law consisting of six articles which contain the following two main points.

(1) When human life, body, or property is infringed due to “defects” of the manufactured product, then the damage must be compensated.

(2) “Defect” refers to the state where normally available safety is lacking for normally presumable usage, and product liability is an enactment of the new rule concerning responsibility for product defects.

The following three points are the most important responsibilities of manufacturers defined by PL law.

(1) Establishment of internal company structure

(2) Specific implementation items for product safety
Eliminating danger in design to fundamentally secure safety is the most important in securing product safety. Secondly, protective covers, safety devices, and safety mechanisms are implemented when safety cannot be secured in design or for technical reasons, or when the cost is not economically reasonable. Thirdly, warning labels are attached, but this should be done only as the last resort. Preferably, the warning labels should not be attached, and frequent use should be avoided.

(3) Education on product safety

This guideline describes the fundamental items to be respected (establishment of internal company structure, specific items to be implemented for product safety, and market support) by JSIA member companies in securing product safety.

Appendix -1.2 Establishment of company internal structure

Every company must clarify their corporate philosophy concerning product safety. Company internal structure concerning product safety should be established, work should be allotted, and safety standards should be defined. "Product safety policy" must be defined stating that "product safety is the highest priority in corporate management." Effort must be made to inform all employees on safety while requiring conformance. Structure for product safety must be established in the company as a whole.

Appendix -1.3 Specific implementation items for product safety

Appendix -1.3.1 Considerations for safety when signing contracts

(1) Confirmation of contract conditions

(2) Related parties will discuss thoroughly on contract conditions such as product specification. Agreements should be made on product safety items, especially for instruments requiring periodic maintenance and instruments for which service life may cause issues.

(3) Confirmation of responsibility allotment
Agreements should be made on the method of solution and cost allotment, when a third party other than the contracting parties incurs damages arising from product defects.

Appendix -1.3.2 Securing safety in planning, development, and design phases

Perform the following product safety measures during the planning, development, and design phases when much of the functions and performance related to product safety are determined.

(1) Forecasting dangers of the product
During product design, effort should be made for research, development and improvement for enhancement of safety along with conformance to various safety standards. Also, perform the following to forecast dangers of the relevant product.

1) Forecast dangers of the product for various phases from distribution, use, to disposal. Also forecast dangers due to product deterioration, and consider effects to the environment.

2) During the initial design phase, consider the actual method of use by the customer and forecast dangers in use conditions (including unintended use of product and alterations).

(2) Comparison of product usefulness and danger
Compare the usefulness to society and the dangers which can arise from the relevant product, and determine the validity of productization.

(3) Specifying the technical level concerning safety

1) List related laws and standards, and conduct technical study to adapt to laws and public standards.

2) For the technical level for product safety, consider the safety level of similar products in similar price range or the possibility of alternate designs at reasonable price (for example, the dewatering bin in washing machines have possibility of injury if hands touch the dewatering bin while still turning; terminating the rotation upon opening of the washing machine lid is an alternate design which can be implemented within reasonable cost increase range) and avoid falling short of industry standards. Rather, attempt to secure levels surpassing the industry standards. Collect and research information concerning safety technologies for this purpose.

(4) Securing safety

Prioritize measures to secure safety through design and keep in mind that warning indications are last resorts. Depending on the level of possible damage, eliminate and reduce the danger, and provide warnings according to the following procedures.

1) When occurrence of danger in the relevant product can be predicted, secure fundamental safety by attempting to eliminate the cause through design.

2) When fundamental safety cannot be secured, implement protective covers, safety devices, and safety mechanisms to reduce danger, as necessary.

3) When occurrence of danger still remains, implement appropriate measures by attaching warning labels and providing warnings in user manuals.

4) Avoid using materials containing hazardous substances and dangerous substances. When these are used inevitably, research related laws and public standards, and implement appropriate measures to prevent danger and to protect the environment.

Appendix -1.3.3 Securing safety in manufacturing and inspection phases

(1) Procurement

When purchasing raw materials or parts and when outsourcing all or part of the product, request the supplier to take necessary measures to secure product safety.

(2) Manufacturing

Provide and maintain control standards, work orders, manufacturing facilities, jigs, and tools for securing the required safety level in manufacturing phase. In addition, implement necessary measures such as clarifying the process management method, to ensure that safety is not lost as a result of causes in manufacturing phase.

(3) Inspection

Specify inspection standards, determine inspection methods, and maintain inspection technology and inspection instruments considering the actual use of the product.

Appendix -1.3.4 Securing safety in storage, wrapping and packaging, transport, assembly, installation, and adjustment phases

(1) Storage, wrapping and packaging, and transport

Implement necessary prevention measures in storage, wrapping and packaging as well as transport phases to avoid loss of safety functions of the product and occurrence of damage to the operator and surroundings due to damaged product.

(2) Assembly, installation, and adjustment

Implement necessary prevention measures at assembly, installation, and adjustment phases to avoid loss of safety functions of the product and occurrence of damage to the operator and surroundings while considering the use conditions and the environment conditions surrounding the relevant product.

Appendix -1.3.5 Securing safety in maintenance, checkup, and repair phases

Provide necessary work standards or work manuals to prevent damage to the operator and surroundings and loss of product safety functions while maintenance, checkups, and repairs are conducted. Items for periodic checkup should be clearly stated in the work manual on the frequency and range.

Appendix -1.3.6 Securing safety in used products and in the disposal phase

When selling used products, implement product safety measures according to the product liability law for new products.

Implement necessary and appropriate measures to secure safety related to product disposal such as disposal method, disposal procedures, and avoidance of generation of hazardous substances at product disposal phase.

Appendix -1.4 Market support

When a deficiency is found in the product after shipping or delivery, inform the customer on methods to circumvent danger. At the same time, implement appropriate measures such as repair, adjustment, and collection of the relevant product including the stock.

Appendix -1.5 Accident cause analysis and measures to prevent recurrence

In the event that an accident is caused by the product, implement necessary measures to identify the cause, to prevent expansion of damage, and to prevent recurrence of similar accidents.

Appendix -1.6 Information management

Accumulate information and technologies related to product safety, and implement appropriate measures to check and store necessary information and discard it when no longer necessary. For the storage period, create storage standards according to the importance of the information and the ten year responsibility period specified in the product liability law, and store accordingly.

Appendix -1.7 Education on product safety

In order to fully inform and to require conformance by various sections on product safety concept, conduct company internal education on the importance of product safety measures and the implementation methods. Also conduct awareness campaigns as necessary.

Appendix -1.8 Closing remarks

The product liability law is expected to be effective in changing mindsets of product manufacturers and consumers on product safety and in relieving the burden of proof for the aggrieved party, among others. However, electrical facilities such as switchboards are manufactured based on laws and technical standards. As care has been exercised historically for safety, there is no universal way to identify what are "defects" and where they lie. Therefore, the only way to improve safety is for individual companies to enhance the safety of products on their own. As precedents are accumulated, the relationship between product liability law and switchboards should become clearer.

Japan Electrical Manufacturers' Association will establish a new product liability committee to propose a fundamental policy concerning product liability measures, to implement and to disseminate specific measures, to collect information, and to research on product liability insurances.

(End of appendix)

Reference document: “Guidelines concerning product safety of heavy electrical machinery” issued by Japan Electrical Manufacturers’ Association

Appendix 2 Excerpt from switchboard and control board standards by Japan Electrical Manufacturers' Association

This appendix describes Japan Electrical Manufacturers' Association standard (JEM standard) related to cabinets housing inverters.

Appendix -2.1 Rating and testing for switchboards and control boards (excerpt) 1460: 2008

Japan Electrical Manufacturers' Association standard JEM

Rating and testing for switchboards and control boards (excerpt) 1460: 2008
Rating and testing for low voltage switchgear and control gear assemblies (boards)

4. Use conditions

Unless otherwise specified, the cabinet will be used in the standard use condition defined in 4.1 along with the major circuit and control circuit constituting the cabinet.
When the actual use condition differs from the standard use condition, the main circuit instruments and the control circuit instruments used for cabinet must be designed for the special use condition required by the user or appropriate measures must be implemented.

4.1 Standard use condition

The standard use condition for the cabinet is specified by either one of the following.

4.1.1 Indoor

a) Ambient temperature range is between -5°C to +40°C and the average temperature measured for 24 hours is below 35°C.
b) Altitude is below 1000 meters.
c) Relative humidity range is between 45 to 85%. No dew condensation is allowed.

4.1.2 Outdoor

a) Ambient temperature range is between -25°C to +40°C and the average temperature measured for 24 hours is below 35°C.
b) Altitude is below 1000 meters.
c) Relative humidity outside the cabinet is not defined. However, the condensation inside the cabinet must be at a level which does not affect the internal instruments.
d) Wind pressure is below 1000 Pa (equivalent to wind speed 40 m/s).

4.2 Special use condition

Special use condition is specified by any of the following. When using in this condition, the user will specify the conditions to the manufacturer and the countermeasures will be determined through discussion between the user and the manufacturer. Additionally, if the temperature and humidity differ from 4.1 during transportation, storage, and installation, countermeasures will be determined through discussion between the user and the manufacturer.

a) Ambient temperature, humidity, and altitude exceed the definitions in 4.1.
b) Temperature or air pressure changes rapidly.
c) Excessive vapor, oil mist, smoke, dust, salt, and corrosive substance is in the air.
d) Explosive, flammable, and other hazardous gas is in the air.
e) Cabinet is exposed to excessive snow fall, fog, or wind pressure.
f) Cabinet is exposed to strong electrical or magnetic fields.
g) Cabinet is exposed to abnormal vibration or impact.
h) Cabinet is mounted on vehicles for transportation during operation.

Appendix -2.2 Construction and dimensions of switchboards and control boards (excerpt) 1459: 2005

Japan Electrical Manufacturers' Association standard JEM

Construction and dimensions of switchboards and control boards (excerpt) 1459: 1998
General requirements for construction and external
dimensions of switchgear and control gear assemblies (Control)

4. Cabinet construction

4.1 Typical construction For the typical construction, the following requirements apply:

a) The casing shall be made of robust metal with construction capable of withstanding the weight of the housed instruments and the impact in operation.

b) The casing shall be treated to prevent rust and be painted with durable paint.

c) If the temperature of the housed instruments exceeds allowable temperature due to temperature increase in the cabinet, appropriate ventilation opening or ventilation device shall be installed.

d) For cabinets installed outdoors or in comparable locations, heaters or other condensation prevention devices shall be installed if possibility of failure exists due to internal condensation.

e) Construction other than a) to d) shall adequately meet the protection levels defined in 4.3.

4.2 Construction of individual parts

4.2.1 Door For the door construction, the following requirements apply:

a) **Construction**	Use a construction which resists deformation and non-alignment, supported by hinges and with doors machined to "L" or "[" shape. For outdoor cabinets, door handles and hinges shall use material resisting or treated for corrosion.
b) **Hinge**	Door hinge shall be made of metal.
c) **Stopper**	Install stopper to hold the open position on doors for self-standing, outdoor cabinets.
d) **Monitoring window**	Use glass or durable, transparent material when installing monitoring windows.

4.2.2 Detachable cover

The detachable cover shall have construction and weight for easy detachment. The cover shall be such that it can be attached to avoid falling due to vibrations. Addition of handles for attachment and detachment is desirable, if necessary.

4.2.3 Ceiling board

When installing ceiling boards, consider the need of a ventilation and/or cable outlet opening, and the protection level.

4.2.4 Roof

The roof shall be inclined or otherwise designed to resist buildup of rain and snow on the top. Also, add a lean-to or the like to resist penetration of rain and snow into the casing.

4.2.5 Floor board

When installing a floor board, consider the safety of the access to the inside of the cabinet, dropping of objects into the cable outlet opening, and prevention of intrusion by small animals into the cabinet.

4.2.6 Base

When installing a base, consider the floor thickness of the installation location, cabinet construction, and the relationship to adjacent cabinets. Use base construction and material which eases installation of the casing.

4.2.7 Posts

Posts shall possess enough rigidity to support the casing. Also, consider making the inside of the posts available for wires and cables.

4.2.8 Ventilation opening cover

When installing ventilation opening covers, consider the classification of the protection level and ventilation efficiency.

4.3 Protection level

Follow JEM1267 for names and inspection methods for the protection levels.

Appendix -2.3 Grounding of switchboards and control boards (excerpt) 1323: 2005

Japan Electrical Manufacturers' Association standard JEM

Grounding of switchboards and control boards (excerpt) 1323: 2005
Earthing for low-voltage switchgear and control gear assemblies (boards)

1. Scope of application

This standard defines the grounding for switchboards using electrical circuit with alternating current below 600 V or direct current below 750 V and control boards (hereafter called boards) electrical circuit with alternating current below 1000 V or direct current below 1200 V. However, the definition does not apply to the grounding of the main circuit.

4. Types of cabinet grounding

4.1 Grounding of the main board

a) Inside the board, grounding terminals or grounding buses which are connected to the main board electrically by welding or tightening metal screws in order to ground the board. The grounding terminals or the grounding buses are grounded through the grounding wire.
b) For door casings with attaching instruments, connection by wire to the cabinet main body is desirable. However, electrically equivalent connections (use of metal hinges treated to prevent corrosion, use of toothed washers, or use of metal screws to tighten metal supporting surfaces) can also be used for grounding.
c) For door casings without attaching instruments, secure conduction using metal screws and metal hinges.

4.2 Grounding of the casing of instruments attached to cabinets and instrument mounting brackets

When grounding is necessary for safety and performance guarantee reasons, connect the casing of attached instruments to the grounding terminal or grounding bus using the cabinet internal grounding wire. For casings of general instruments attached to the cabinet and instrument mounting brackets, metal screw tightening method may be used to connect to the cabinet body electrically. However, for attaching brackets to moving instruments, connection with the cabinet body through electrical wire is desirable, but electrically equivalent connections (use of metal hinges with corrosion protection) may also be used.

4.3 Grounding of circuit

For measurement and control circuits requiring grounding, connect to the grounding terminal or grounding bus using cabinet internal grounding wire.

5. Construction of the ground terminal

The grounding terminal shall use crimped terminal tightening type construction or electrical wire tightening type construction which can be connected by cabinet internal grounding wire and grounding wire.

6. Construction of the ground bus

The grounding bus shall be 25 mm x 3 mm or greater if made of copper and shall use crimped terminal tightening type construction or electrical wire tightening type construction which can be connected by cabinet internal grounding wire and grounding wire.

Remark: If the grounding bus is not made of copper, equivalent heat and mechanical requirements shall be met.

7. Thickness of cabinet internal ground

The thickness of cabinet internal grounding wire shall meet the requirements shown in Table 2.3-1.

Table 2.3-1: Thickness of cabinet internal grounding wire

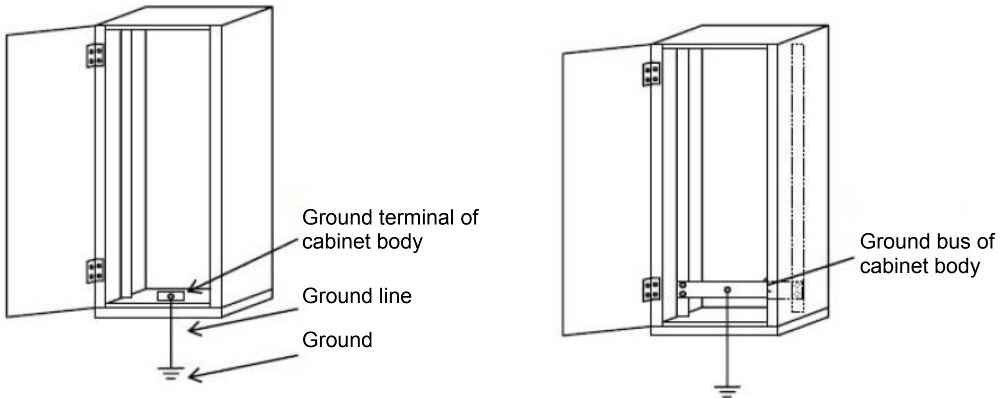
<table>
<tr><th colspan="2">Applicable circuit</th><th>Thickness of cabinet internal grounding wire [(1)] [mm^2]</th><th>Remarks (Types of grounding construction)</th></tr>
<tr><td rowspan="3">Casing of attached instruments</td><td>300 VAC or less, 300 VDC or less</td><td>2 or greater</td><td>Class D grounding work</td></tr>
<tr><td>More than 300 VAC and 600 VAC or less
More than 300 VDC and 750 VDC or less</td><td>2 or greater</td><td>Class C grounding work</td></tr>
<tr><td>More than 600 VAC, more than 750 VDC</td><td>5.5 or greater</td><td>Class A grounding work</td></tr>
<tr><td colspan="2">Secondary and tertiary circuits of transformers for special high voltage instruments</td><td>5.5 or greater</td><td>Class A grounding work</td></tr>
<tr><td colspan="2">Secondary and tertiary circuits of transformers for high voltage instruments</td><td>2 or greater</td><td>Class D grounding work</td></tr>
</table>

Note (1) The thicknesses for cabinet internal grounding wire in this table show the minimum values for copper lines.

2. Contents of individual constituting elements

2.3 Grounding of cabinet body (4.1 of main body)

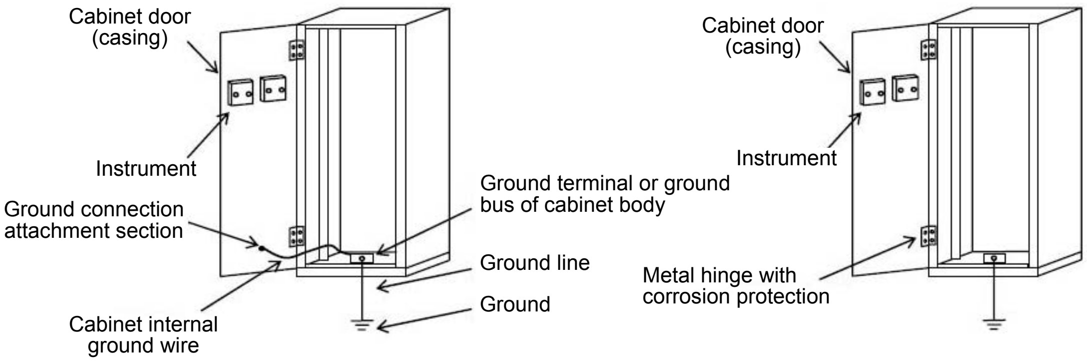
a) To ground the cabinet body, it is desirable to create grounding terminals in cabinets with few cabinet internal grounding wires and create grounding bus in cabinets with many cabinet internal grounding wires or cabinets placed side by side. However, if grounding terminals are created on each board and the grounding wire connects the grounding terminals, grounding buses are not required. Figure 2 shows examples of cabinet body grounding.



a) Example of ground terminal   b) Example of ground bus

Figure 2: Example of cabinet body grounding

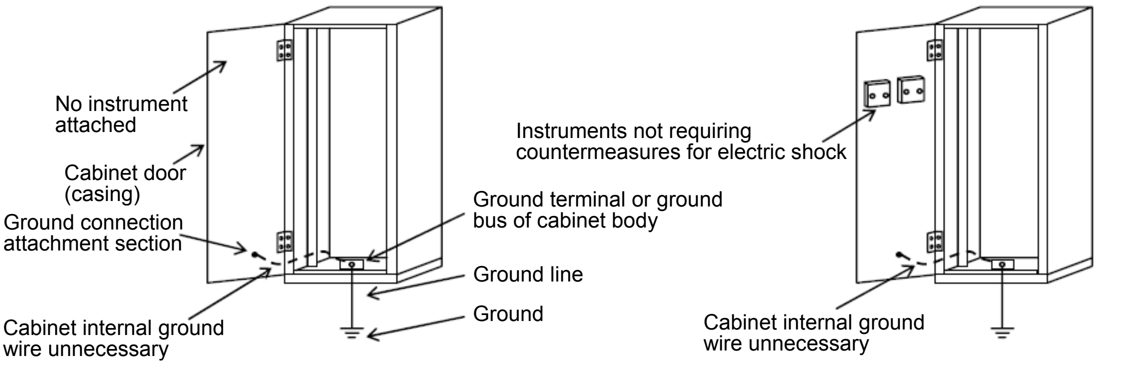
b) For metal casings such as cabinet doors allowing instrument attachment, connecting the cabinet body (or the grounding terminal and grounding bus installed on the cabinet body) and the door casing by electrical wire is desirable. It is deemed that grounding between the cabinet body and the brackets can be secured through electrically equivalent connections which allow conduction (for example, metal hinges with corrosion protection, toothed washers, use of sliding contacts, tightening by metal screw on metal support surface) [refer to JIS C 8480 7.4.3.1.5 b) and c)]. When using insulating hinges, however, the cabinet body and the casing must be connected by electrical wire. Figure 3 shows examples of door casing grounding of the cabinet with attached instrument.



a) Example to connect using cabinet internal ground wire   b) Example to connect using metal hinge

Figure 3: Example of casing grounding for cabinet with attached instruments

c) For casings such as cabinet doors, side panels, and roof panels not requiring instrument attachment, metal screw and metal hinge connections are considered adequate for securing conduction [refer to JIS C 8480 7.4.3.1.5 c)]. Electrical wire connections are also unnecessary when attaching instruments built with circuits not requiring countermeasures for electric shock and using voltages within the limit of very low voltage [refer to JIS C 8480 7.4.3.1.5 C) and IEC60439-1]. Figure 4 shows examples for casings of cabinets with instruments not requiring countermeasures for electric shock and casings of boards without attaching instruments.



a) Example of no instrument attached to door casing

b) Example of attaching only instruments not requiring countermeasures for electric shock to door casing

Figure 4: Example of case grounding for door casing without attached instruments and for door casing attaching only instruments not requiring countermeasures for electric shock

d) Cabinet bodies made of insulator are rare these days, but grounding through grounding terminals or grounding buses will be adequate also for these cases.

2.4 Grounding of the casing of instruments attached to cabinets and instrument mounting brackets (main body 4.2)

When the casings of instruments attached to cabinets and the mounting brackets have metal surfaces, and when the pressure exerted on the surface is adequately high, the surface is deemed to adequately secure conduction for the protective circuit. Therefore, metal casings of typical cabinet attached instruments can be considered to be electrically connected to the cabinet body by metal screw connections, making grounding by dedicated wires unnecessary. To guarantee good conductivity, however, caution should be exercised on the following points.

a) When ground connection attachment sections (such as frame grounding terminals) are available on the casings of cabinet attached instruments requiring grounding for safety and for performance guarantee, connect the ground connection sections on instrument casings to the grounding terminal or the grounding bus of the cabinet using cabinet internal grounding wire. Figure 5 a) shows an example.

b) When ground connection attachment sections (such as frame grounding terminals) are not available on the casings of cabinet attached instruments, and when the casings of cabinet attached instruments are equipped with metal support surfaces, the connection made by the metal screws can be considered to provide adequate electrical connection to the cabinet, making grounding by dedicated wires unnecessary. Figure 5 b) shows an example.

c) When the casings of cabinet attached instruments are not connected with the cabinet grounding terminals or grounding buses using cabinet internal grounding wire but instead are connected to the instrument mounting brackets, and when the mounting brackets are not equipped with metal support surfaces, connect the mounting brackets and the cabinet grounding terminals or the grounding buses by cabinet internal grounding wire. Figure 5 c) shows an example.

d) When the casings of cabinet attached instruments are not connected to the cabinet grounding terminals or grounding buses using cabinet internal grounding wire but instead are connected to the instrument mounting brackets, and when the mounting brackets are equipped with metal support surfaces, the connection made by the metal screws can be considered to provide adequate electrical connection to the cabinet body, making grounding by dedicated wires unnecessary. Figure 5 d) shows an example.

e) When the casings of cabinet attached instruments are not connected to the cabinet grounding terminals or grounding buses using cabinet internal grounding wire but instead are connected to the moving instrument mounting brackets, and when conduction cannot be secured due to hinges using isolation, connect the moving mounting brackets and the cabinet grounding terminals or the grounding buses by cabinet internal grounding wire. Figure 5 e) shows an example.

f) When the casings of cabinet attached instruments are not connected to the cabinet grounding terminals or grounding buses using cabinet internal ground wire but instead are connected to the moving instrument mounting brackets, and when conduction can be secured through metal hinges, grounding by dedicated wires is unnecessary. Figure 5 f) shows an example.

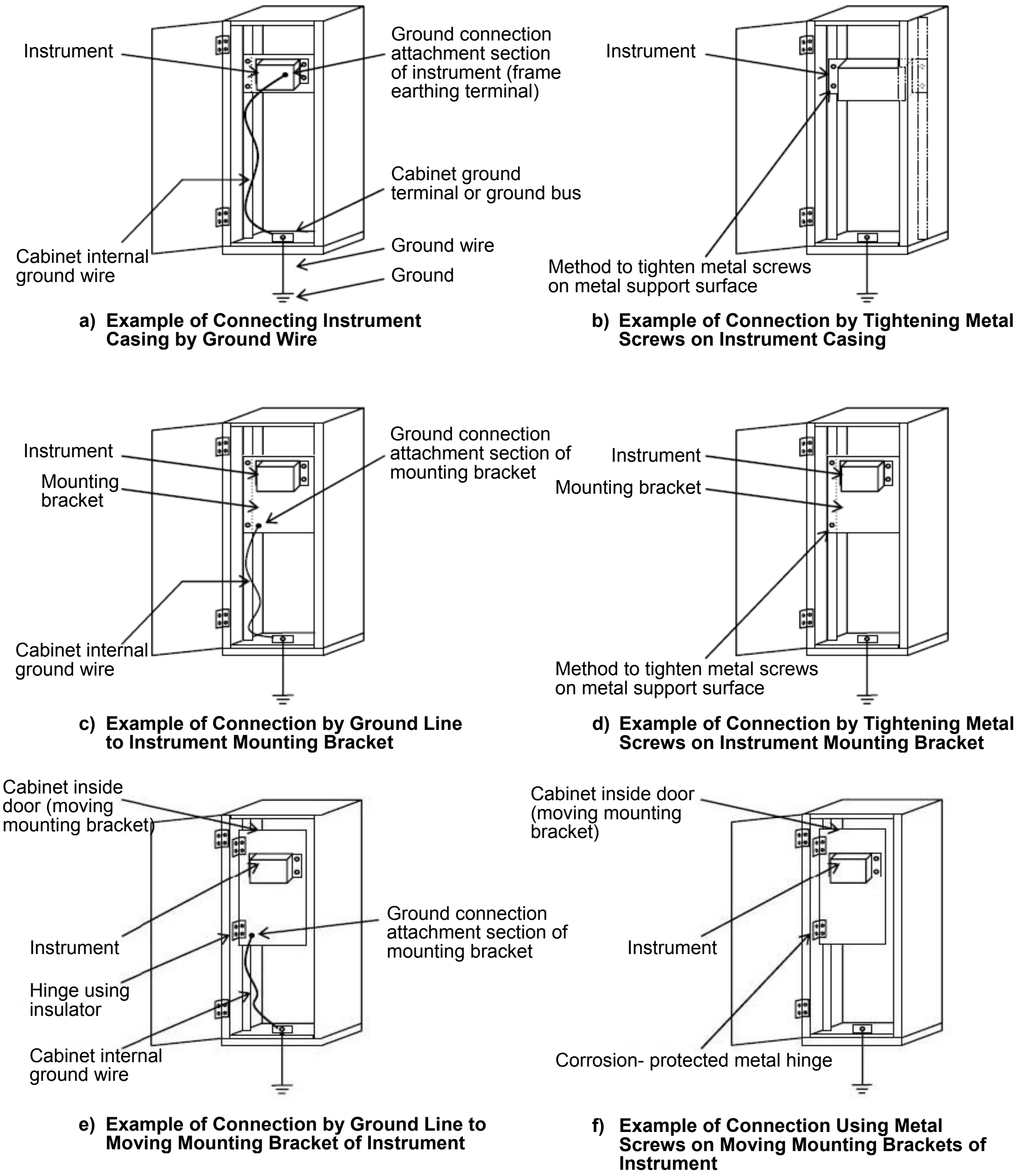
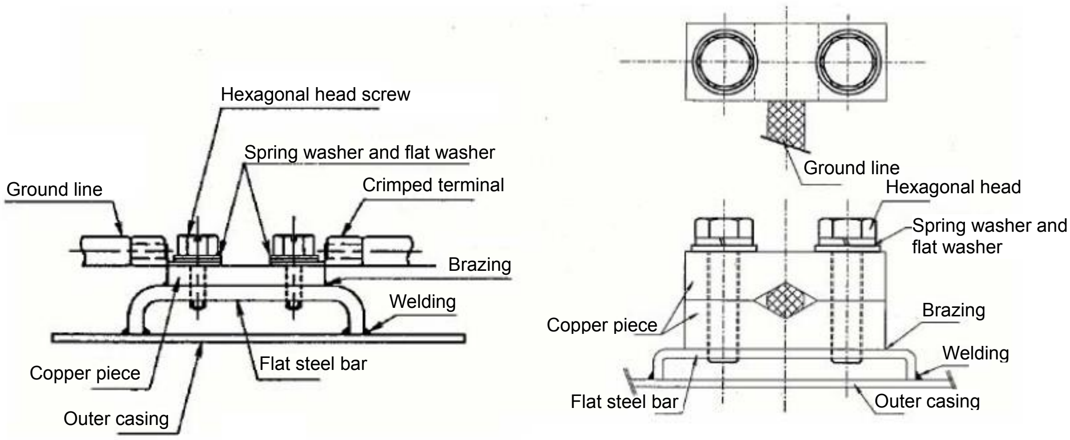


Figure 5: Example of grounding instruments and instrument mounting brackets

2.5 Construction of ground terminal (main body 5)

The crimped terminal tightening type construction cited in the main body uses electrical wires with crimped terminals attached on terminations. The crimped terminals are fastened by metal screws onto the switchboard. A representative example of this construction is defined in JIS C 2811 as “screw terminal block” and “stud terminal block”, and is shown with a sample figure. The wire tightening method fastens wire terminations by using clamping blocks on the switchboard or by fastening with the metal screw tips. A representative example of this construction is defined in **JIS. C. 2811** as “clamp terminal block” and “press-clamping terminal block”, and is shown with a sample figure.

For sharing by grounding types or grounding using combined grounding terminals, refer to **indoor wiring regulations 1350**. Figure 6 shows examples of ground terminals.



a) Example of Crimp Contact Tightening Method **b) Example of Wire Tightening Method**

Figure 6: Examples of ground terminals

2.6 Construction of grounding bus (main body 6)

When cabinets are placed side by side and when a grounding bus is to be created, implement a grounding bus for the group. For the grounding bus size, follow the definitions in **JEM 1265**.

Appendix

2.7 Thickness of cabinet internal grounding wire (main body 7)

The thickness of grounding wires have been defined to match various ground construction details in **Articles 10 and 11 in Guidebook of Electrical Equipment** and Articles **19, 20, 27, and 29 in Interpretation of Guidebook of Electrical Equipment**. To make cabinet internal ground wire effective, considerations are needed not only for the inside of the cabinet but also for ground construction outside the cabinet. The basics on ground construction have been listed in the remarks column of **Table 1** in the **main body**.

Table 1 of the **main body** shows only thickness of grounding wires in terms of cross-section area (mm^2) only. Equivalent diameters (φ mm) are shown in **indoor wiring regulations** 1350-3, **Table 2** and **Table 3**. This standard also considers these values effectively equivalent, and the values should be used in implementation. Table 1 in the main body shows the minimum values of grounding wire thicknesses in the case of copper wire. **Table 2** and **Table 3** show excerpts of selection criteria for thickness, according to **indoor wiring regulations**.

Table 2: Thickness of ground wires for C type and D type constructions (excerpt from Internal line regulations 1350-3)

Smallest rated current capacity of overcurrent breaker installed on the power supply side of the low voltage path in the metal outer casing for instruments to be grounded	Typical cases			When using cords or cabtyre cables for sections requiring flexibility in grounding machines which are moved for use	
	Copper		Aluminum	Thickness of single-core	Thickness of one core when using 2 cores for grounding
Below 20 A	ø1.6 mm or more	2 mm^2 or more	ø2.6 mm or more	1.25 mm^2 or more	0.75 mm^2 or more
Below 30 A	ø1.6 mm or more	2 mm^2 or more	ø2.6 mm or more	2 mm^2 or more	1.25 mm^2 or more
Below 50 A	ø2.0 mm or more	3.5 mm^2 or more	ø2.6 mm or more	3.5 mm^2 or more	2 mm^2 or more
Below 100 A	ø2.6 mm or more	5.5 mm^2 or more	ø3.2 mm or more	5.5 mm^2 or more	3.5 mm^2 or more

Table 3: Thickness of ground wires for A type constructions (excerpt from Internal line regulations 1350-4)

Ground line section of A type grounding construction	Copper		Aluminum
For grounding electric machines used while fixed in location and grounding electric machines used while moving and without requirement for flexibility	ø2.6 mm or more	5.5 mm^2 or more	ø3.2 mm or more

Appendix 3 Characteristics of fan

Understanding the fan characteristics and the route of air is necessary to use the fan. This appendix describes the main points of the characteristics.

Appendix -3.1 Relationship between air volume and air pressure (static)

“Fan characteristic curve” shows the relationship between air volume and air pressure, which is an important characteristic in the fan specification.
This characteristic curve is described in catalogs and technical documentations provided by the fan manufacturer.
(Hereafter, air pressure will be referred to as static pressure, and the fan characteristic curve will be referred to as the P-Q curve Figure 3.1-1.)

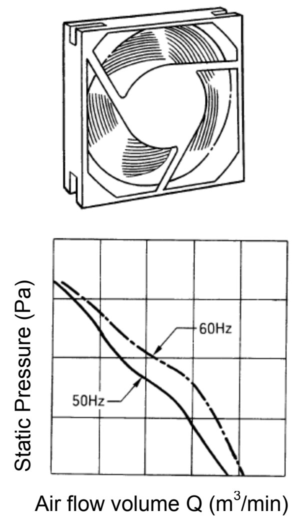


Figure 3.1-1: P-Q curve of a fan

When air passes through the cabinet, pressure loss occurs. The loss is affected by the area, length, and turns of the air path and the congested state of the internal structural parts which result as resistance. The relationship between the pressure loss and air volume expressed as an equation is as follows.

Figure 3.1-2 shows the “Resistance curve” which plots this equation.

$P = KQ^n$ · · · Equation 3-1

P: Pressure loss in [Pa] or {mm•Ag}
K: Constant
Q: Air volume [m^3/min]
n: Constant determined by air volume (use 2 for cabinets)

(Note) Constant K changes depending on the state of the air path, and calculating the value from theoretical formulas is difficult. Estimation from real measurements is the only good way. This is true not only for cabinets but also for other machines and equipment. Using the fan requires accumulation of measurement data, and this accumulated data becomes the know-how of manufacturers.

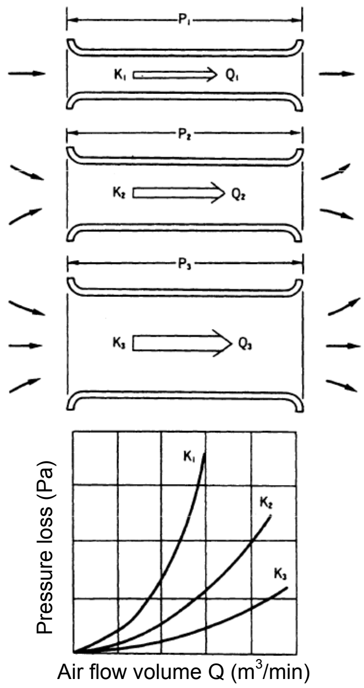


Figure 3.1-2: Air path resistance curve

The relationship between the P-Q curve of the fan and the resistance curve of the air path is as follows.

When the fan rotates, air flows through the air path and pressure loss results.

To create air flow, the air must be pushed with a pressure matching the pressure loss which will occur. This pressure is called the static pressure (Ps).

Therefore, the fan, as shown in Figure 3.1-3, operates at the intersection of the P-Q curve and the resistance curve. This crossing point (point a) is called the operating point, and the fan cannot be operated at any other point. To operate at a combination of air flow volume and static pressure other than at point a, only the following two methods exist.

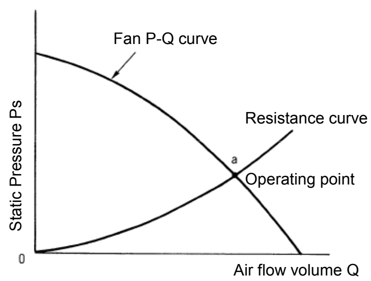


Figure 3.1-3: Operating point

1) Change the property of the resistance curve. (change the flow of air)

2) Change the fan rotation speed, or replace with another fan with different specification and change the P-Q curve (fan characteristics).

Figure 3.1-4 shows case 1) and point b is the operating point.
b' increases resistance characteristics and b" decreases resistance characteristics.
To realize b' characteristic curve, "decrease the area of the air path" or "increase the resistance of the air path by using dampers, etc".
To realize b", "increase the area of air path" or "eliminate the objects which impede air flow".

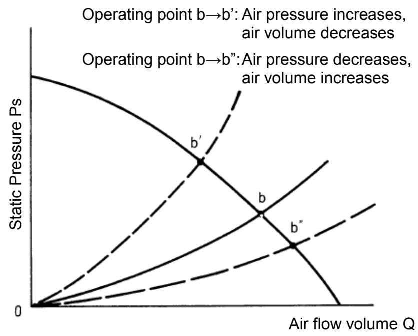


Figure 3.1-4: Changing resistance characteristics

Figure 3.1-5 shows case 2). To realize the characteristic curve of c', "reduce the rotation speed", or "replace with a smaller fan" etc.
To realize c", "increase the rotation speed", or "replace with a larger fan" etc.

Next, the explanation of a countermeasure to problems in installation to real facilities follows.

Select the fan, considering the required air flow in the cabinet and the pressure loss. Attach to the cabinet and test run.
Sometimes, the temperature inside the cabinet rises beyond expectation,

and the characteristic shifts from the calculated curve.
In order to cool according to the calculations, it is recommended to use actual operating data (resistance curves) fully to select the fan.

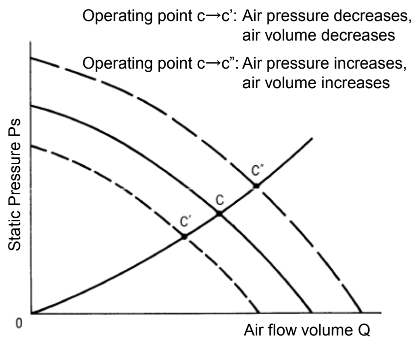


Figure 3.1-5: Changing fan characteristics

When the target air flow level cannot be achieved, re-examine the resistance characteristics in 1) (change the air flow) before reconsidering the fan characteristics in 2). This easy countermeasure is often effective.

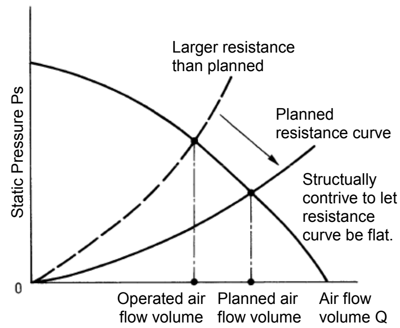


Figure 3.1-6: Insufficient air volume

The following items summarize the main points.

[Main points]

- The fan has the P-Q characteristics and the air flow route has resistance characteristics. Both characteristics exist independently.
- Without changing the air flow route, the resistance characteristics will not change even if the fan may be replaced.
- The fan cannot be operated other than at the operating point. Operating point refers to the intersection of the P-Q curve and the resistance curve.
- When air flow volume is insufficient, check to see if the resistance characteristics of the air flow route differ from the estimation at design.

Appendix -3.2 Serial and parallel operation of the fan

When one fan does not produce enough air flow, multiple fans should be used. However, 1 + 1 does not necessarily mean twice the volume, so care is necessary in the design. The following shows characteristics when two fans are used in parallel or series.

(1) Combined fan characteristics of parallel operation

Figure 3.2-1 shows the characteristic curve when two fans with different P-Q curves are operated in parallel.
Keeping the static pressure constant, seek the air flow value Q1 and Q2 for each fan on the individual P-Q curves. The combination of the two values (Q1+Q2) is the combined fan characteristic point. Combining the P-Q curves for FAN1 and FAN2 will result in the **combined fan P-Q curve**.

When using fans with different characteristics together, and if Ps1 < Ps2 (when the air flow of FAN1 = zero (static pressure of fan at cutoff)), then FAN1 will exhibit “reverse flow characteristics” in this range.
The reverse flow characteristic curves of fans are not described normally in catalogs, so contact the fan manufacturer.

As can be seen from the above, even if ventilation is designed to extremely reduce intake volume and exhaust high volume, adequate ventilation will not occur.

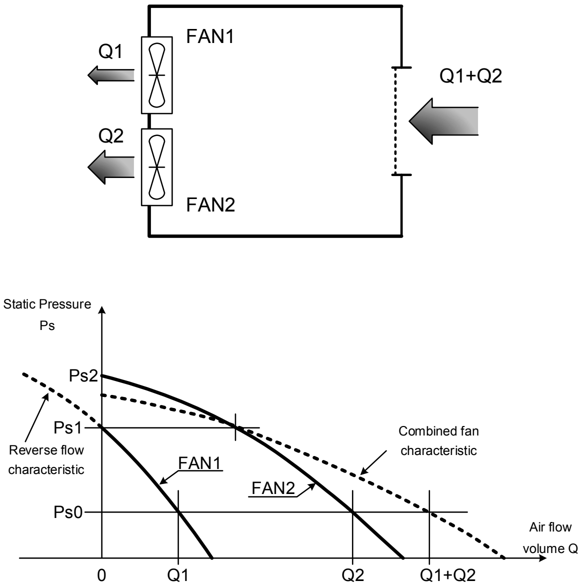


Figure 3.2-1: P-Q curve for parallel operation

(2) Combined fan characteristics of serial operation

Figure 3.2-2 shows the characteristic curve when two fans with different P-Q curves are operated in series. For serial operation, if no crevices exist in the cabinet other than at the fans, then FAN1 and FAN2 will have the same air flow volume. Keeping air flow volume constant, seek the static pressure value Ps1 and Ps2 for each fan on the individual P-Q curves. The combination of the two values (Ps1 + Ps2) is the combined fan characteristic point. Combining the P-Q curves for FAN1 and FAN2 will result in the **combined fan P-Q curve**.

When using fans with different characteristics together, and if Q1 < Q2 (static pressure of FAN1 = zero (fan blowing)), then FAN1 will exhibit “turbine characteristics” in this range.
The reverse flow characteristic curves of fans are not described normally in catalogs, so contact the fan manufacturer.

As can be seen from the above, a cabinet design with extremely low static pressure (very low fan air flow volume due to the relationship between the fan air flow volume and cabinet capacity) will not ventilate adequately.

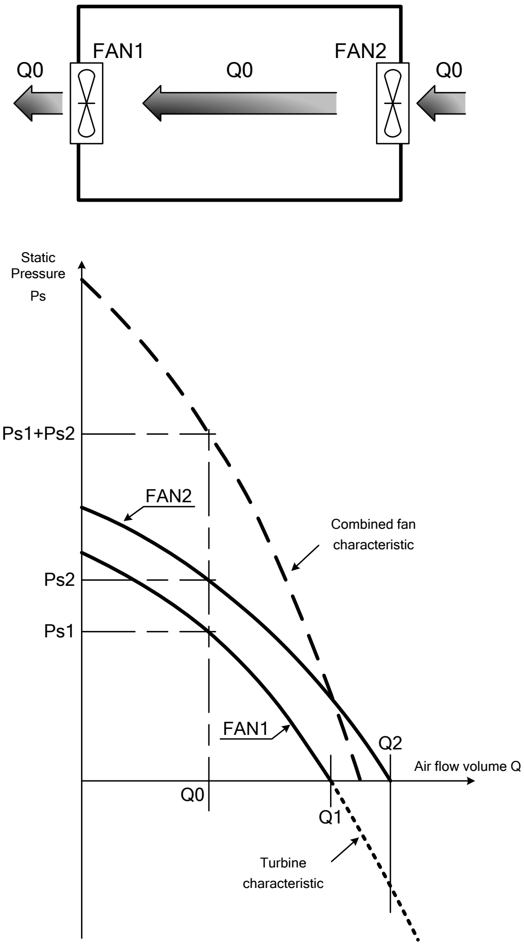


Figure 3.2-2: P-Q curve for serial operation

Appendix

(3) Relationship between combined fan characteristics and resistance characteristic

The explanations in the previous paragraphs ((**1**), (**2**)) consider only the fans in the P-Q curves, but in reality, resistance characteristics exist. For this reason, the air flow volumes verified in real cabinets differ.

The following describes specific effects, using parallel operation as an example.

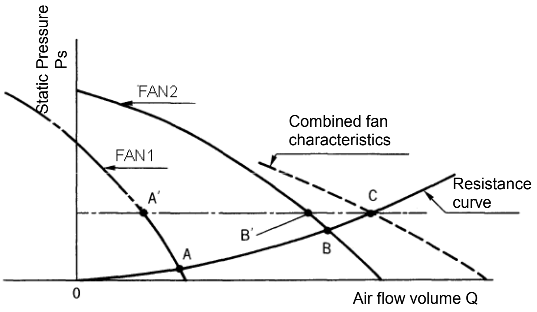


Figure 3.2-3: Air flow volume in parallel operation

Point C in Figure 3.2-3 is the combined fan characteristic operating point for parallel operation. At this point, the fan air flow volumes are A' and B'.
If the fans are operated independently, the air flow volumes will be A and B along the resistance curve.

The relationship can be described as follows.

$$C = A' + B' < A + B$$

Therefore, operating two fans in parallel does not deliver the sum of the two.

This trait becomes more pronounced as the resistance curve rises more steeply. When the resistance of the air flow path is low and the resistance curve rises gradually, along the horizontal axis, the delivered air flow volume becomes approximately the sum of the two.
The air flow volume increase at points C and C' in Figure 3.2-4 show the difference.

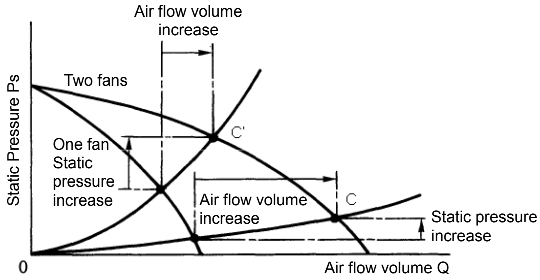


Figure 3.2-4: Parallel operation of 2 identical fans

In the case of serial operation where the operating point will be at the intersection of the resistance curve and the combined fan P-Q curve, the air flow volume of the two fans will be less than the simple addition of air flow volumes of the individual fans.
Refer to C and C' in Figure 3.2-5.

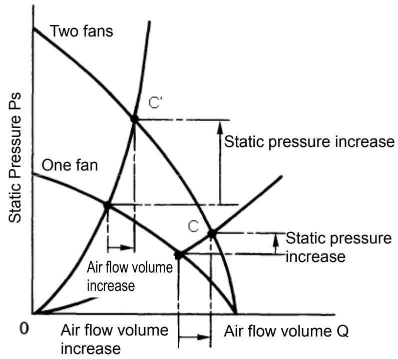


Figure 3.2-5: Serial operation of 2 identical fans

As can be seen from above, when placing fans in parallel or in series, the expected effect cannot be achieved without carefully studying the relationship with resistance characteristics.

Consider the following items prior to cooling by fans in parallel or in series.

(1) Use safety factor to make the combined air flow volume, which can be achieved by serial or parallel operation, lower than the sum of air volumes from individual operations. (Unless the air flow path is fixed, installing two units will not deliver twice the volume of one unit.)

(2) For parallel operation, create cabinet construction which will allow gradual rise of the resistance curve.
(Consider enlarging the area of passage in the cabinet.)

(3) Serial operation is not so effective in terms of air flow volume, but is more effective in increasing static pressure for constructions as the following where the resistance curve rises steeply.
- Cabinet construction which does not allow large intake or exhaust openings
- Cabinets with small passage area inside (cabinet housing instruments at high density)

Also consider using fans with large air flow volume.

(4) Analyze P-Q curves and resistance curves for multiple fan usage also.

(5) Using identical fans are recommended when installing multiple units. When different fans are used, "reverse flow characteristics" may occur in parallel operation and "turbine characteristics" may occur in serial operation.

Appendix 4 Input to inverters

Appendix -4.1 Input current (Harmonic current)

Figure 4.1-1 shows the main circuit of the inverter. The input side consists of a three-phase full wave rectification diode converter. The diode rectification and capacitor Cs perform the conversion to direct current.

In diode converters, distortion wave current as shown in Figure 4.1-2 flows close to the peaks of the power-supply voltage waveform.

The peak input current value ip and the conduction time ton of this distortion wave current depends not only on the power dissipation of the load but also on the size of the power supply side impedance (especially the reactance component).

For example, if the motor load is constant, the smaller the power supply impedance, the higher the peak values and shorter the conduction time become, as in Figure 4.1-2 (a).

On the other hand, the larger the power supply impedance, the lower the peak values and longer the conduction time become, as in Figure 4.1-2 (b).

The frequency components of the input current are shown in Figure 4.1-3. When the output of the electric motor is 100%, changes in

- Fundamental wave current I1
- Harmonic current I5 to I19 (Various harmonic current from 5th harmonic to 19th harmonic)
- Total effective current Ieff

caused by the power supply reactance is shown.

Fundamental wave current I1 barely changes while the harmonic current and the total effective current vary widely.

The power supply reactance % Xs in Figure 4.1-3 was converted to reference capacity base, assuming inverter capacity as the reference, by using the following equation.

$$\%X_S = \%X_T \times \frac{P_{INV}}{P_T}[\%] \quad \cdots \quad \text{Equation 4-1}$$

$\%X_S$: Power supply reactance based on inverter capacity [%]
$\%X_T$: Power supply reactance [%]
P_{INV} : Inverter rated capacity [kVA]
P_T : Power supply transformer capacity [kVA]

However, when $\%X_T$ is expressed in terms of power supply system reference capacity, P_T will be expressed in terms of power supply system reference capacity.

If the wiring reactance is small and can be neglected, the power supply transformer % reactance becomes $\%X_T$.

This harmonic wave adversely affects the input side power supply system and the electricity generators.

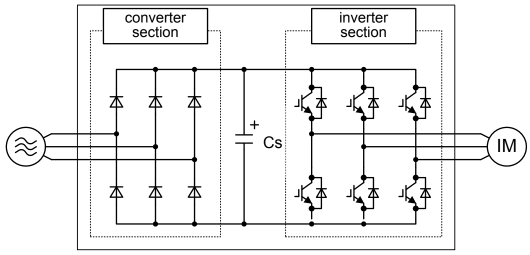


Figure 4.1-1: Inverter main circuit

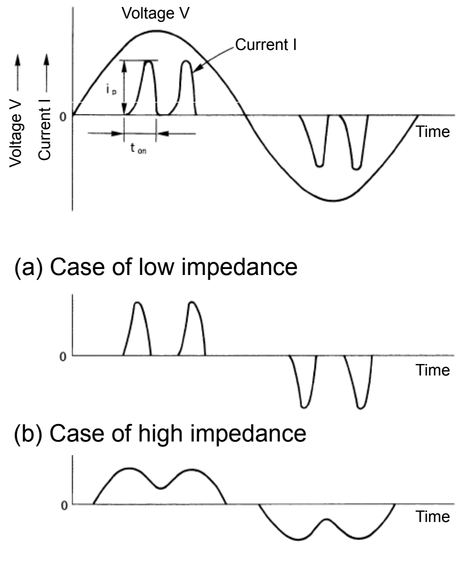


Figure 4.1-2: Inverter input current waveform

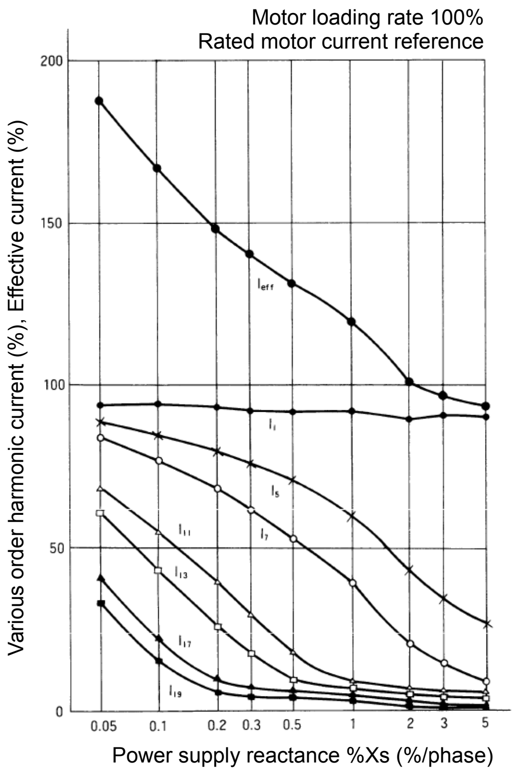


Figure 4.1-3: Power supply reactance-input current characteristics

Appendix -4.2 Input power factor

The input power factor of the inverter is given below.

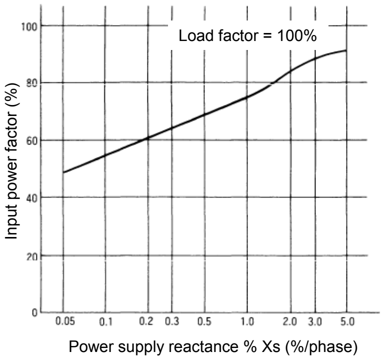


Figure 4.2-1: Inverter input power factor

Inverter input power factor

$$= \frac{\text{Effective power}}{\text{Apparent power}} = \frac{\sqrt{3} \times E \times I_1 \times \cos\theta_1}{\sqrt{3} \times E \times I_{eff}}$$

$$= \frac{I_1 \times \cos\theta_1}{I_{eff}} \quad \text{............. Equation 4-2}$$

E : Effective power supply voltage [V]
I1 : Effective fundamental wave current [Arms]
Ieff : Total effective current [Arms]
cosθ : Fundamental wave power factor

Figure 4.2-1 shows the result of computing Equation 4-2. The figure shows that as the power supply reactance (%Xs) increases, the harmonic component decreases, improving the input power factor.

Appendix -4.3 Improvement of the input power factor

When the inverter is operated, the decrease in power factor on the input power supply side is due to the **inverter input current** described in the **previous section**. It is not due to the phase difference between the voltage and current of the input system, so phase advancing capacitors will not improve power factor. (The phase advancing capacitors may be burned due to this harmonic current.)

To improve input power factor, suppression (reduction) of the harmonic current is necessary. Use a direct current reactor (DCR) as in Figure 4.3-1.

Alternating current reactor (ACR) also improves power factor to a degree, but it is inferior to DCR. For details, refer to "Appendix 7 Harmonics guideline".
Additionally, using Fuji Electric's PWM converter will improve power factor.

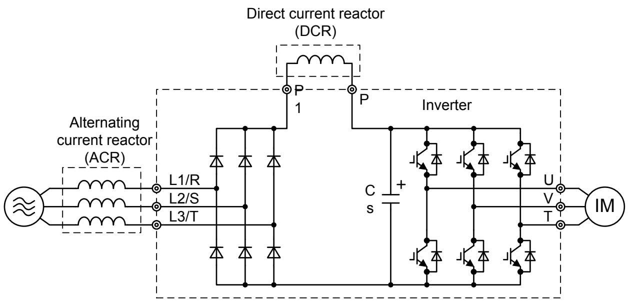


Figure 4.3-1: Locations to insert reactor

Appendix -4.4 Generator (synchronous generator)

When supplying the inverter input power supply using a generator, the harmonic current of the inverter may cause induced current (negative-phase-sequence current) in the damper coils of the generator and cause the generator to burn. "JEM1354 2003: Synchronous land generator for driving diesel engines" states that generators must withstand **negative-phase-sequence current up to 15%.** This negative-phase-sequence current can be computed by converting to negative phase equivalent current using Equation 4-3.

$$I2eg = \sqrt{\sum_{\gamma}\left[\sqrt[4]{\frac{\gamma}{2}} \times I\gamma\right]^2} = \sqrt{\left[\sqrt[4]{\frac{6}{2}}(I_5 + I_7)\right]^2 + \left[\sqrt[4]{\frac{12}{2}}(I_{11} + I_{13})\right]^2 + \left[\sqrt[4]{\frac{18}{2}}(I_{17} + I_{19})\right]^2 + \left[\sqrt[4]{\frac{24}{2}}(I_{23} + I_{25})\right]^2 \cdots} \quad \text{Equation 4-3}$$

I2eg: : Equivalent negative phase current
I5,I.I7.....I25 : nth harmonic current

When using a generator as the power source, the rated current of the generator to select should be approximately three times when using a direct current reactor, and approximately four times when using an alternating current reactor. Some generators have enhanced damper windings, so **contact the generator manufacturer for details**.

LC filters, PWM converters, and active filters can reduce harmonic current.

<Calculation example>

Conditions	Input voltage: 3φ220 VAC／60 Hz Motor: 45 kW Inverter: FRN45VG1S-2□ (DCR2-45)

$$\text{Generator capacity required} = \sqrt{3} \times V \times \frac{I2eg}{15\%} = \sqrt{3} \times 220 \times \frac{89}{0.15}$$
$$= 226[kVA]$$

Generator capacity required is 226 [kVA] or greater.

Using Equation 4-3

$$I2eg = \sqrt{\left[\sqrt[4]{\frac{6}{2}}(I_5 + I_7)\right]^2 \cdots + \left[\sqrt[4]{\frac{24}{2}}(I_{23} + I_{25})\right]^2}$$
$$= \sqrt{\sqrt{3}(I_5 + I_7)^2 + \sqrt{6}(I_{11} + I_{13})^2 + \sqrt{9}(I_{17} + I_{19})^2 + \sqrt{12}(I_{23} + I_{25})^2}$$
$$= \sqrt{\sqrt{3}(39 + 20)^2 + \sqrt{6}(13 + 8.4)^2 + \sqrt{9}(7.5 + 5.5)^2 + \sqrt{12}(5.1 + 4.0)^2}$$
$$= 89[A]$$

Appendix 5 Proficient way to use inverters (on electric noise)

This appendix describes the contents of “Proficient way to use inverters (on preventing electric noise): 2010 revised edition” published by Japan Electrical Manufacturers’ Association with supplementary information. Please implement noise countermeasures referencing this section and **Chapter 7 "EMC Compatible Peripherals"**.

Proficient way to use inverters (on preventing electric noise)

Japan Electrical Manufacturers’ Association (JEMA)

Excerpt from Technical Document (Dec 2010)

Appendix -5.1 Effect of inverters on other instruments

This section describes the effects of the inverter on existing electronic instruments and instruments embedded in the same system as the inverter, and countermeasures. (For details, refer to “Appendix -5.4 Cases of noise countermeasures”.)

1. Effect on AM radios

Phenomenon : When the inverter is operating, noise sometimes enters nearby AM radios. (FM radios and televisions are basically not affected).
Probable Cause : The radio is receiving the noise radiated from the inverter.
Countermeasure: Installing noise filter on the inverter power supply side is effective.

2. Effect on telephones

Phenomenon : When the inverter is operating, noise sometimes enters the telephone in use, making hearing difficult.
Probable Cause : Harmonic leak current from the inverter or motor enters the telephone cable shielded wires, causing noise.
Countermeasure: Connecting the motor grounding terminals to one point in common and attaching the point to inverter grounding terminal is effective.

3. Effect on pressure sensors

Phenomenon : The pressure sensor sometimes malfunctions when the inverter is operating.
Probable Cause : Noise enters the signal line through the grounding wire.
Countermeasure: Installing noise filter on the inverter power supply side and separating the I/O wires, grounding wires, and control circuit wiring are effective.

4. Effect on position detectors (pulse encoder)

Phenomenon : The pulse encoder sometimes malfunctions when the inverter is operating, causing shifts in stop position.
Probable Cause : Phenomenon occurs more readily when the motor power line and the encoder lines are bundled.
Countermeasure: Separately route the motor power line and the encoder lines can reduce the effect of induction noise and radiated noise. Adding noise filter on the I/O terminals of the inverter is also effective.

5. Effect on proximity switches

Phenomenon : When the inverter is operating, proximity switches (static capacitance type) sometimes malfunction.
Probable Cause : Noise immunity of the static capacitance type switches may be low.
Countermeasure: Installing noise filter on the inverter power supply side and attaching grounding capacitors to the zero volt side (common side) of the proximity switch power supplies are effective. Also, replacement to magnetic type switches which have high noise immunity is also effective.

Appendix -5.2 Definition of noise

This section describes the noise generated by the inverter, the principles of occurrence, and the instruments which can be affected by noise readily.

1. Inverter operation principles and noise generation

Figure 5.2-1 shows the overview of an inverter. The inverter converts alternating current to direct current (forward conversion) in the converter section. The control circuit uses the six IGBTs in the inverter section in PWM switching to convert (reverse conversion) to variable voltage and variable frequency alternating current to control the motor at various speeds.

At this time, the high speed switching of the IGBTs turns direct current voltage on and off, creating switching noise. This switching noise flows through the inverter, the I/O wires, and the stray capacitance (C) between the motor and the earth as noise current (i).

The magnitude of the noise current is given by the following:

$$i = C \bullet \frac{dv}{dt}$$

It is related to stray capacitance (C) and dv/dt (switching speed of IGBT). This noise current flows every time IGBT switches on and off, so it depends also on the carrier frequency.

The DC/DC converter also performs switching, so it is also a noise source.

The frequency bandwidth of the noise spans approximately tens of MHz, affecting AM radios, factory radios, telephones, and communication instruments.

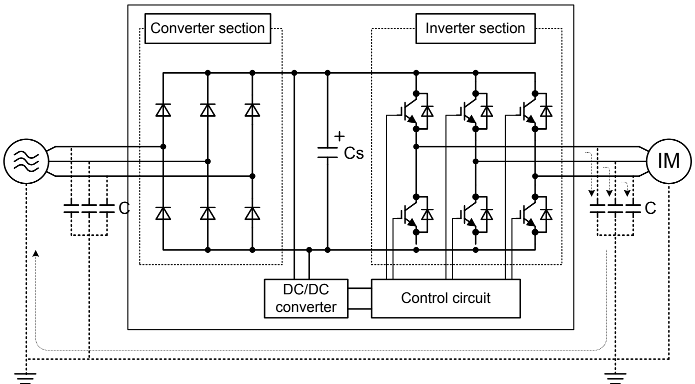


Figure 5.2-1: Inverter overview

2. Types of noise

The switching noise generated by the inverter propagates through the inverter wiring to power supplies and motors, affecting a wide range of instruments from the power transformer to the motor.

Figure 5.2-2 shows the possible various noise transmission routes.

Noise can be categorized into three types: transmission noise, induction noise, and radiated noise.

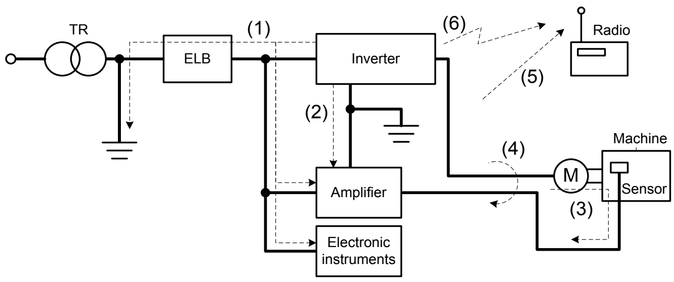


Figure 5.2-2: Noise propagation route

(1)Transmission noise

For transmission noise, the switching noise generated inside the inverter is transmitted to and affects peripheral instruments via electric wires and conductors.

(1) Route through the main circuit and the power supply

(2) Route possible when the grounding wire is used commonly by instruments

(3) Route via sensor signal lines and shielded wires

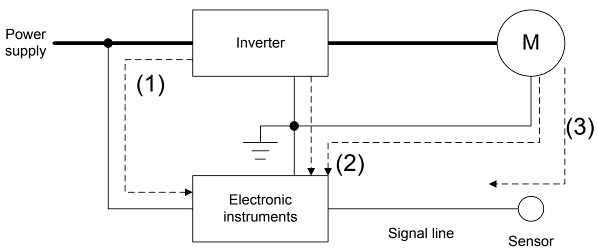


Figure 5.2-3: Transmission noise

(2) Induction noise

The inverter main circuit wires (wiring around the input and output sides) contain current with inverter switching components.

The output side direct current bus (DC bus) carries a lot of switching noise.
Wraparound of distorted electric current caused by harmonics and inverter leak current occurs on the input side.

Therefore, peripherals and signal lines placed close to the main circuit wires are affected by electromagnetic induction noise in Figure 5.2-4 and static induction noise in Figure 5.2-5.

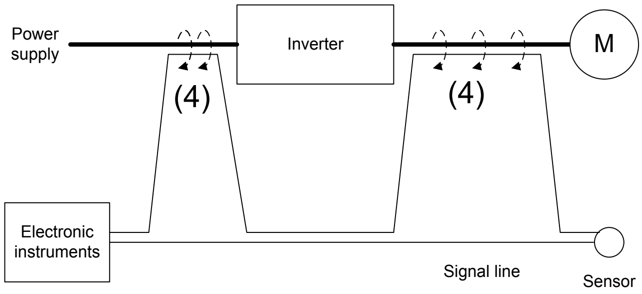


Figure 5.2-4: Electromagnetic induction noise

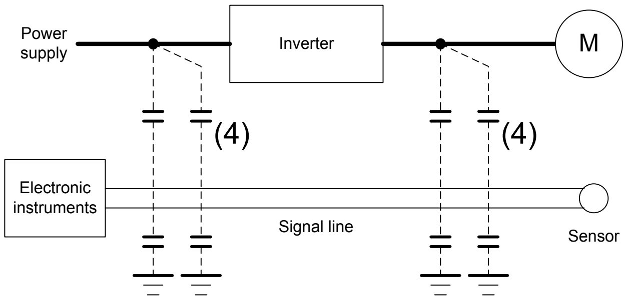


Figure 5.2-5: Static induction noise

(3) Radiated noise

Noise generated inside the inverter uses the power and grounding wires on the input and output sides as antennas to radiate into the air. Peripheral instruments and radio communication are affected by radiated noise (5). Radiated noise uses not only wires, but also the cabinet housing the inverter and the motor surfaces as antennas.

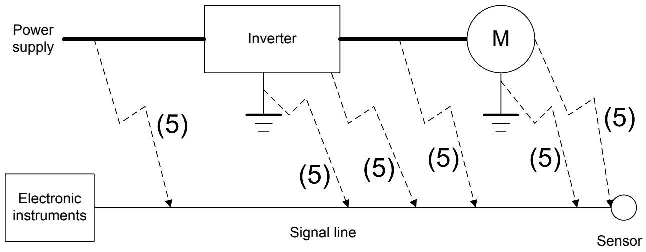


Figure 5.2-6: Radiated noise

Appendix -5.3 Noise countermeasures

The effectiveness of noise countermeasures is proportional to the degree of improvement. However, sometimes simple solutions fit the problems best. Implementing economic measures matching the level of noise and facility conditions is required.

Prior consideration for noise is important even in the case of housing inverters in cabinets. Substantial time and cost will be necessary for resolving troubles, once the troubles caused by noise occur.

(1) Prior treatment

The following lists prior treatments for noise:

1) Separate the wiring of main circuit power lines and control circuit lines.
2) Wire main circuit power lines in metal pipes (conduit pipe).
3) Use shielded wires and twisted shielded wires for control circuit.
4) Construct grounds and ground wiring appropriately.

The above treatments should avoid most of the noise troubles.

(2) Implementation of countermeasures

Noise countermeasures can be implemented on the instruments being affected by noise and on the transmission routes.

(2)-1.1. Instruments affected by noise

1) Separate from the inverter main circuit wiring.
2) When the peripheral instrument requires power, insulate it from the inverter main power supply.
   (Use isolation transformers. Use isolation transformer with short proof shield between primary and secondary coils.)
3) Attach LC filters on power lines for PLC (programmable sequencer) and POD (programmable operation display).

(2)-1.2. Inverter, the noise generation source

1) Attach noise filter to reduce the noise level.
2) Contain noise level by using metal wiring pipes and metal cabinets.
3) Always bundle power lines when wiring. For the input side and the output side direct current buses, wire separately. (Do not bundle.)

Table 5.3-1 summarizes the methods to prevent noise trouble, the purpose, and the noise transmission route which is the target of the countermeasures.

Table 5.3-1 : Noise trouble prevention methods

Methods to prevent noise trouble		Purpose of countermeasure: Make less susceptible to noise	Purpose of countermeasure: Cut off noise propagation	Purpose of countermeasure: Contain noise	Purpose of countermeasure: Reduce noise level	Propagation Route: Transmission noise	Propagation Route: Induction noise	Propagation Route: Radiated noise
Wiring and installation	Separate wiring of main circuit and control circuit	○					○	
	Wiring with minimum wiring distance	○			○		○	○
	Wiring in parallel and avoid bundling	○					○	
	Appropriate grounding	○			○	○	○	
	Use shielded wires and twisted shielded wires	○					○	○
	Use shielded cable for main circuit			○			○	○
	Use metal wiring pipes			○			○	○
Cabinet	Appropriate placement of housed instruments in cabinet	○					○	○
	Metal control board			○			○	○
Instruments for countering noise	Line filter	○			○	○		○
	Isolation transformer		○			○		○
Treatment on instruments affected by noise	Use bypass capacitor on control circuit	○					○	○
	Use ferrite core on control circuit	○			○		○	○
	Line filter	○		○		○		
Other	Separate power systems	○	○			○		
	Lower carrier frequency				△	○	○	○

In the table, ○ mark denotes high effect. △ mark denotes low effect.
Blank denotes no effect.

The following shows trouble countermeasures when constructing inverter drives.

(2)-2.1. Wiring and ground

On the inside and outside of the cabinet housing the inverter, separate the wiring for the main circuit and the control circuit as much as possible. Use wires which are less susceptible to noise, such as shielded wires and twisted shielded wires, for the control circuit wiring and wire at minimum distance. (Refer to Figure 5.3-1: Example of separated wiring.)
Do not bundle the wiring for main circuit and control circuit, and avoid parallel wiring.

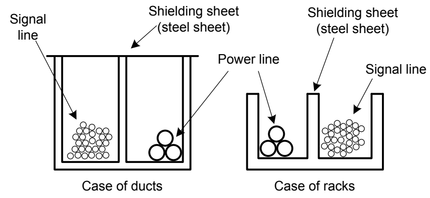


Figure 5.3-1: Example of separated wiring

Use metal wiring pipes for the main circuit wiring and ground the metal pipe to prevent propagation of noise (refer to Figure 5.3-2).

For the shield sheath (net) of the shielded wire, always connect only one point to the signal ground line reference (common) side to avoid creating loops with multiple point connection. (Refer to Figure 5.3-3.)

Grounding is effective in preventing electric shock due to earth leakage, noise penetration and noise radiation. Construct ground according to the main circuit voltage, using Type 3 Ground Construction (300 VAC or lower) or Special Type 3 Ground Construction (300 VAC to 600 VAC) rules. Create dedicated grounds or lay individual ground lines for the various ground wiring.

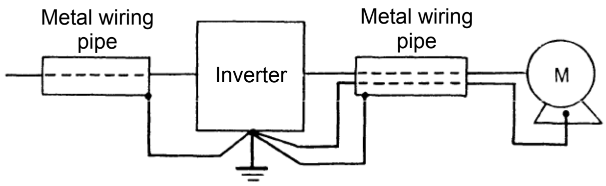
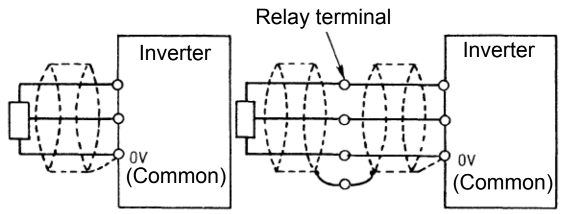


Figure 5.3-2: Grounding metal wiring



a) Without a relay terminal b) With a relay terminal

Figure 5.3-3: Treatment of shielded wires

(2)-2.2. Control cabinet

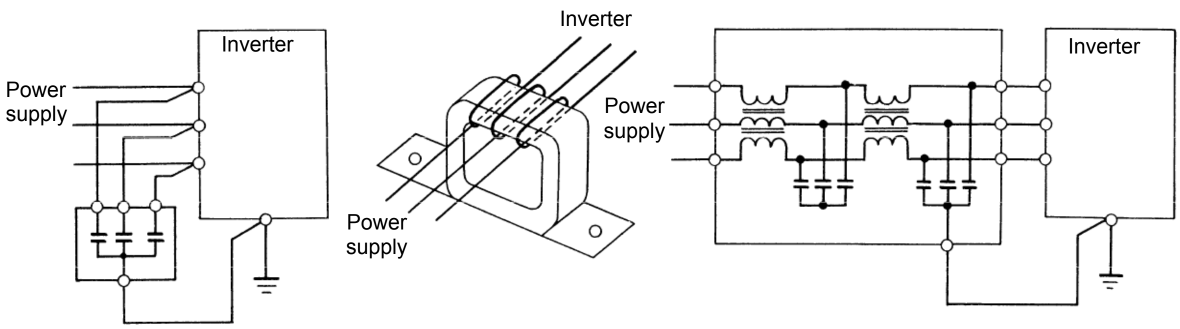
Cabinets housing inverters are typically made of metal. Installation of the metal box shields the surroundings from radiated noise of the inverter.

When attaching electronic instruments such as the programmable controller to the cabinet, exercise caution on the placement of each instrument. Installation of shielding plates between the inverter and the peripheral instruments may be necessary in some cases.

(2)-2.3. Instruments for noise countermeasures

Line filters and power transformers are used to reduce transmission noise which propagates along the wiring, noise which propagates along the electric circuit and noise which radiates to the air from the main circuit wiring (refer to Figure 5.3-4).

Simple types of filter include capacitive filters which are connected in parallel to power lines and inductive filters which are connected in series. More elaborate filters (LC filter) corresponding to radio noise regulations also exist, and the filters are selected according to the target noise reduction effect. Power transformer types include the typical isolation transformers, shield transformers, and noise cut transformers, delivering different effects in preventing noise transmission.



(a) Capacitive filter (b) Inductive filter (zero phase reactor) (c) LC filter

Figure 5.3-4: Various filter and connection methods

(2)-3. Treatment on instruments affected by noise

Noise immunity enhancement is important for the electronic instruments housed in the same cabinet as the inverter or installed in the periphery. Use line filters, shielded wires, and twisted shielded wires for the signal lines of these instruments to prevent intrusion of noise. Additionally,

(1) Reduce circuit impedance by adding capacitors and resistors in parallel to the I/O terminals of the signal circuit.

(2) Insert choke coils in series to the signal circuit and route wire through ferrite core beads to increase the impedance against noise. Enlarging the signal reference line (OV line) and the grounding wire are also effective noise countermeasures.

(2)-4. Others

The level of the noise which propagates (occurs) is also dependent on the carrier frequency. Higher carrier frequencies make higher noise generation levels. For inverters which allow carrier frequency change, reducing the carrier frequency while keeping balance with the noise level generated by the motor when driving, will reduce the occurrence of noise.

Appendix -5.4 Cases of noise countermeasures

This section describes cases implemented against noise generated by inverters.

Table 5.4-1: Cases of noise countermeasures

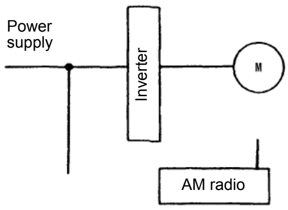
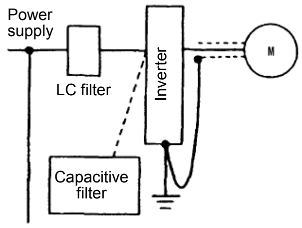
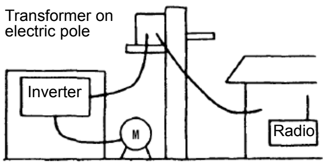
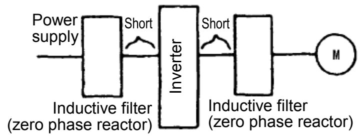
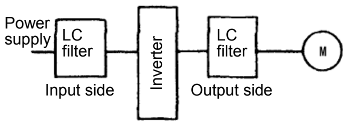
No.	Target instrument	Phenomenon	Countermeasure	Points
1	AM radio	When the inverter was operated, noise appeared on AM radio broadcast (500 to 1500 kHz).  <Probable cause> AM radio probably received the noise radiated from the power supply side or the output side wiring of the inverter.	1) Install LC filter on the power supply side of the inverter. (Simple attachment of capacitive filter may be also done) 2) Use metal wiring pipe between the motor and inverter.  Note) The wiring between the LC filter and inverter will be shortened (to within 1 m).	• Reduce the radiated noise from the wiring. • Reduce transmission noise to the power supply side. • Or, use shielded wires. Note) Adequate improvement may not result in areas where radio waves are weak, such as in the mountains.
2	AM radio	When the inverter was operated, noise appeared on AM radio broadcast (500 to 1500 kHz).  <Probable cause> AM radio probably received the noise radiated from the power lines of the inverter power supply side.	1) Attach inductive filters (zero phase reactor) to the input and output sides of the inverter.  Note) Maximize the number of windings on the zero phase reactor. Also make the wiring between the inverter and inductive filter short. (within 1 m). 2) For even more improvement, attach LC filter.  	Reduce the radiated noise from the wiring.

Table 5.4-1: Cases of noise countermeasures (Continued)

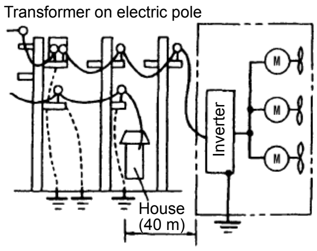
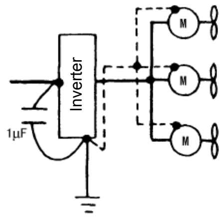
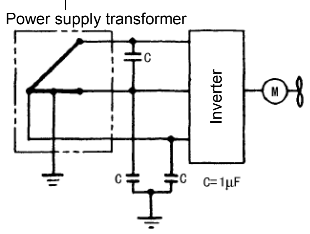
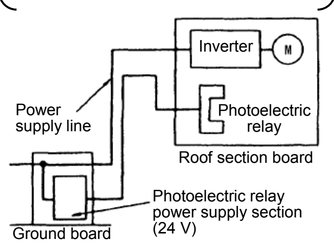
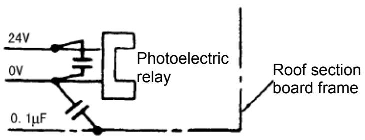
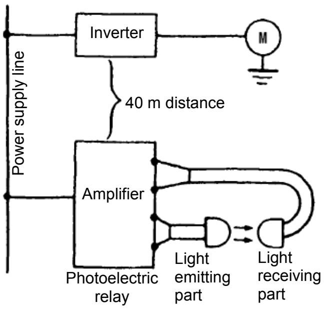
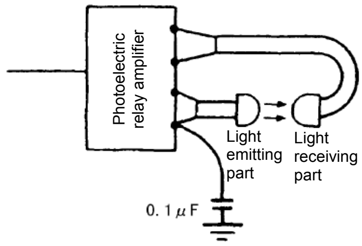
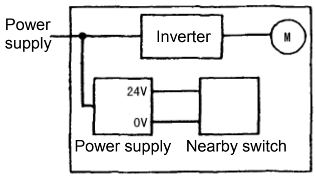
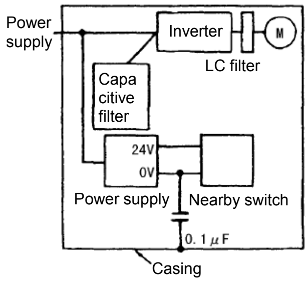
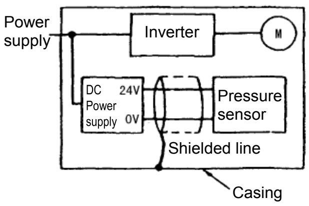
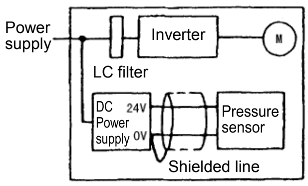
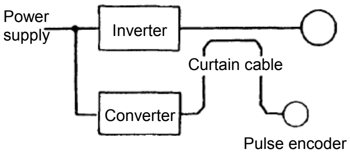
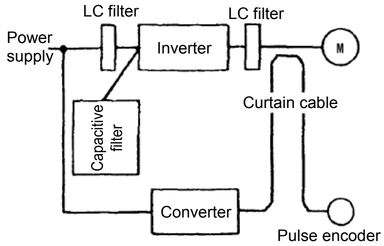
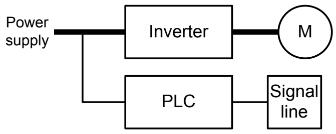
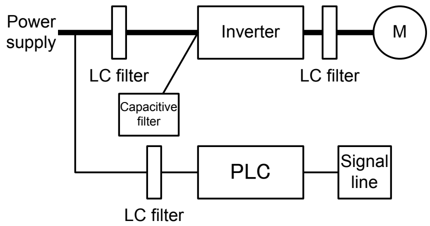
No.	Target instrument	Phenomenon	Countermeasure	Points
3	Telephone (A house 40 m away)	When the ventilator was driven by the inverter, noise appeared on the telephone of a house 40 m away.  <Probable cause> The high frequency leakage current from the inverter and motor flowed into the shield ground section of the telephone cable when returning through the ground of the transformer on the electric pole. Static induction probably occurred and created noise in the telephone line.	2) Connect the grounding terminals of the motors in common and connect to the inverter board. 3) Attach 1μF grounding capacitor to the inverter input terminal.  	• Inductive filters and LC filters may not be appropriate in the voice frequency band. • If the power transformer forms a V-connection and is a 200V system, due to the difference in voltage to ground, caution must be exercised in connecting the capacitors as in the diagram below. 
4	Photoelectric relay	When the inverter was operated, the photoelectric relay malfunctioned. (The inverter and motor were installed in the same place (for overhead operation).)  <Probable cause> The wiring of the inverter power input line and the photoelectric relay were wired in parallel for 30 to 40 m with 25 mm spacing. Induction noise is estimated to have caused the malfunction. (The installation conditions do not allow separation of wiring.)	1) As a temporary measure, attach a 0.1 μF capacitor between the 0 V terminal of the power circuit (belonging to the detection section of the photoelectric relay in the roof section) and the roof section board frame.  2) As a permanent measure, move the 24 V power supply on the ground to the roof section, and use contact signals to the ground.	• Wire separately. (30 cm or more). • When separation is not possible, use dry contact signals to transmit and receive signals. • Parallel wiring of power system wires and small signal lines in close spacing must be avoided.

Table 5.4-1: Cases of noise countermeasures (Continued)

No.	Target instrument	Phenomenon	Countermeasure	Points
5	Photoelectric relay	When the inverter was operated, the photoelectric relay malfunctioned.  <Probable cause> The inverter and the photoelectric relay are adequately separated. Because the power supply is connected in common, however, transmission noise probably entered from the power lines.	Attach 0.1 μF capacitor between the output common terminal of the photoelectric relay amplifier and the frame. 	Low cost countermeasure is sometimes possible and relatively easy. Focus on the weak section of the circuit belonging to the malfunctioning instrument.
6	Proximity switch (static capacitance type)	Proximity switch malfunctioned.  <Probable cause> Static capacitance type proximity switch has low noise immunity. The switch may be susceptible to electric circuit transmission noise and radiated noise.	1) Install LC filter on the inverter output side. 2) Install capacitive filter on the inverter input side. 3) Connect the DC supply 0 V (common) line of the proximity switch and the casing of the machine via a capacitor. 	• Reduce the generated noise at the inverter side. • Replace with a proximity switch (such as magnetic type) which has high noise immunity.
7	Pressure sensor	Pressure sensor malfunctioned.  <Probable cause> Noise wrapped around from the casing via the shielded wire and caused the pressure sensor to malfunction.	1) Install LC filter on the inverter input side. 2) Switch the connection of the pressure sensor shielded wire from the machine casing to the pressure sensor 0 V line (common). 	• Connect the shielded wire of sensor signals to the common point of the system. • Reduce the transmission noise from the inverter.

Appendix

Table 5.4-1: Cases of noise countermeasures (Continued)

No.	Target instrument	Phenomenon	Countermeasure	Points
8	Position detector (Pulse encoder)	The pulse encoder output an erroneous pulse which shifted the crane stop position.  <Probable cause> The motor line and the encoder signal line were bundled in the wiring. Induction noise probably distorted the pulse waveform.	1) Install LC filter and capacitive filter on the inverter input side. 2) Install LC filter on the inverter output side.  	• This countermeasure is for cases when power lines and signal lines cannot be separated. • Reduce the induction noise and radiated noise on the inverter output side.
9	Programmable controller (PLC)	PLC program failed in operation.  <Probable cause> Noise probably propagated to PLC through the power supply, since the power supplies of the inverter and PLC use the same power system.	1) Install LC filter and capacitive filter on the inverter input side. 2) Install LC filter on the inverter output side. 3) Lower the carrier frequency of the inverter. 4) Install LC filter on the PLC power supply.  	Reduce overall electric circuit transmission noise and induced noise.

Appendix 6 Grounding as noise countermeasure and ground noise

Signal ground (hereafter referred to as SG) establishes the reference potential (zero potential) of electronic circuits and enables stable operation. Frame ground (hereafter referred to as FG) is the construction, such as the casing (metal) of the equipment, which provides a shield protecting SG from noise. By connecting these grounds to the earth (grounding), noise entering from the outside, such as the input power supply, is transmitted to the earth to reduce noise interference. In another case, internally generated noise is prevented from transmission to the outside to reduce noise interference. However, grounds may generate noise related to grounding.

(1) Noise due to difference in ground potential

Impedance consisting of direct current resistance and inductance exists between the earth, SG and FG. The voltage of the earth differs by location because the earth is a resistor with conductivity. Therefore, when leakage current flows to the grounding wire or the earth, the reference potential changes and creates potential difference, which may cause noise.

To prevent this noise, the potential difference between the electronic circuit reference potential (SG) and the earth must be eliminated. In other words, the impedance of the grounding circuit must be minimized.

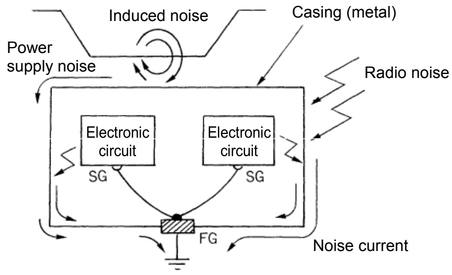


Figure 6-1: SG and FG

(2) Noise due to common impedance of the grounding circuit

When the grounding wire is connected as in Figure 6-2, the inverter and the electronic instrument will share the common impedance. When common impedance exists in the grounding circuit, leakage current (ground potential) shift on one side affects the ground potential on the other side, generating noise though mutual interference.

Therefore, separate the grounding circuit for each instrument and avoid sharing common impedance.

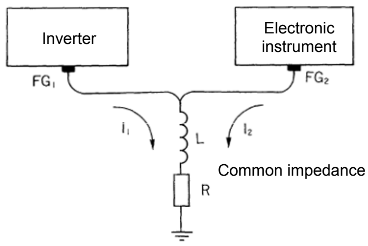


Figure 6-2: Common impedance in grounding circuit

(3) Noise due to inductive coupling

When long grounding wires are wired in parallel to other wires such as power lines, induction voltage (induction noise) results in the grounding wires due to static capacitance C or mutual inductance M. (Refer to Figure 6-3.)

Induction voltage has high frequency and increases as the wires get closer. To avoid induction voltage, wire separately from wires which are noise sources.

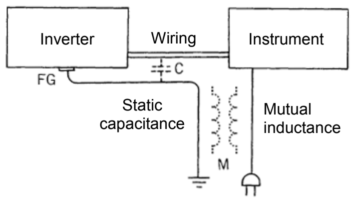


Figure 6-3: Inductive coupling

(4) Example of ground noise generation

For example, when leak current I_1 flows in the inverter grounding wire as in Figure 6-4, ground voltage Vg_1 is generated. When frequency f_1 of current I_1 rises, impedance ($2\pi f_1 L_1$) of inductance L_1 increases and Vg_1 rises.

When I_1 or f_1 vary, Vg_1 also varies, generating noise due to ground potential difference.

Additionally, when an electronic instrument is connected, rise in Vg_1 increases the potential difference with FG_2. Then, current I_3 flows through the signal line casing (shield cover of shielded wires) and the common impedance $L_2 \cdot R_2$ and noise is generated by the common impedance.

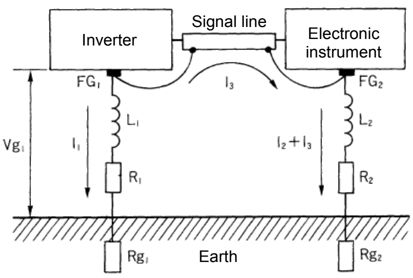


Figure 6-4: Leakage current

When I_3 flows, induction noise occurs by the voltage induced in the core wire due to inductive coupling between the signal line casing and the core wire (signal line).

Appendix 7 Harmonics guideline

Appendix -7.1 How to comply with "Guideline on measures to suppress harmonics for users serviced by high voltage or special-high voltage" (general-purpose inverters)

The following two notifications were issued by the Ministry of International Trade and Industry, Agency for Natural Resources and Energy, Public Utilities Department on September 30, 1994.

(1) “Guideline on measures to suppress harmonics in home Appliances and General Purpose Products”

(2) “Guideline on measures to suppress harmonics for users serviced by high voltage or special high voltage”

The use of electronic instruments generating harmonic current is expected to increase. The aim of these guidelines is to prevent harmonic interference to instruments connected to the system by providing regulations beforehand. These guidelines apply to all electric and electronic instruments generating harmonic current operated on commercial power supplies, but the following explanation is limited to “general purpose inverters”.

Appendix -7.1.1 Application of the “general purpose inverter”

[1] Case of “other than special users”

The ”Guideline on measures to suppress harmonics in home appliances and general purpose products” issued by the Ministry of Economy, Trade, and Industry in September 1994 states that general purpose inverters (input current under 20 A) are not subject to the regulation from January 2004. Users who do not fall under the “Guideline on measures to suppress harmonics for users serviced by high voltage or special high voltage” are recommended to attach “direct current reactor” as described in the past on inverter catalogs and user manuals.

[2] Case of “Guideline on measures to suppress harmonics for users serviced by high voltage or special high voltage”

Users of high voltage or special high voltage power services are corresponded using the “Guideline on measures to suppress harmonics for users serviced by high voltage or special high voltage”. Harmonic current generating instruments, such as the “general purpose inverters”, are not directly controlled, but the regulation is enforced by users of electricity. Calculation of the amount of harmonic current generated is necessary for each instrument.

(1) Targets of regulation

Regulation applies when the following two conditions are satisfied.

- Receiving voltage is either high voltage or special high voltage.
- “Equivalent capacity” of the converter loading exceeds the reference value for the receiving voltage (50 kVA for 6.6 kV receiving voltage).

For calculating the “equivalent capacity” according to the guideline, supplementary explanation is available in the B.2 “[1] “Calculation of equivalent capacity”.”

(2) Regulating method

The magnitude (calculated value) of the harmonic current flowing to the system from the user’s point of receiving voltage is controlled. The regulated value is proportional to the contract demand. The regulated values of the guideline are shown in Table 7.1-1.

Supplementary explanation for calculating “harmonic current” according to the guideline is available in Appendix -7.1.2 (Correspondence to “Guideline on measures to suppress harmonics for users serviced by high voltage or special high voltage”).

Table 7.1-1: Maximum harmonic current outflow per 1 kW of contract demand (mA/kW)

Receiving voltage	5th	7th	11th	13th	17th	19th	23rd	Beyond 25th
6.6 kV	3.5	2.5	1.6	1.3	1.0	0.90	0.76	0.70
22 kV	1.8	1.3	0.82	0.69	0.53	0.47	0.39	0.36

(3) Implementation timing

Application of the new guidelines has already begun.

With the application of the new guidelines, the calculation of the “voltage distortion rate” which was formerly performed when signing the power contract, is no longer needed.

Appendix -7.1.2 Correspondence to "Guideline on measures to suppress harmonics for users serviced by high voltage or special high voltage"

When calculating for the "general purpose inverter" according to the guideline, please compute in the following fashion. The contents described in this section are based on the **"Technical guide on harmonic suppression measures"** (JEAG 9702-1995) issued by Japan Electric Association.

[1] "Calculation of equivalent capacity"

Equivalent capacity is computed by (rated input capacity) x (conversion factor). However, general purpose inverter catalogs in the past do not specify the rated input capacity value, so it is described below.

(1) "Inverter rated capacity" which corresponds to "Pi"

- In the guidelines, a 6-pulse converter is defined as the reference with conversion factor 1. The rated input capacity of general purpose inverters must be expressed in terms of harmonic current corresponding to conversion factor 1.
- Specifically, the fundamental harmonic input current I_1 is computed from the load motor's rated kW, motor efficiency, and inverter efficiency. Then, calculate rated input capacity = $\sqrt{3}$ x (Supply voltage) x I_1 x 1.0228/1000 (kVA). 1.0228 is (effective current) / (fundamental harmonic current) for the 6-pulse converter.
- When general purpose motors and inverter motors are used, the values in Table 7.1-2 can be used. Use the rated kW of the motor used regardless of inverter type in selecting the value.

Note Be cautioned that the "rated input capacity" mentioned here can be used only for the calculation in harmonic guidelines and cannot be used in selecting inverter supply side instruments and wiring size.

📖 Refer to the manufacturer's catalog or technical documents for selecting the capacity of peripheral instruments.

Table 7.1-2: General purpose inverter "rated input capacity" determined by the applied motor

Applied motor (kW)		0.4	0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5
Pi (kVA)	200 V	0.57	0.97	1.95	2.81	4.61	6.77	9.07	13.1	17.6	21.8
	400 V	0.57	0.97	1.95	2.81	4.61	6.77	9.07	13.1	17.6	21.8

Applied motor (kW)		22	30	37	45	55	75	90	110	132	160
Pi (kVA)	200 V	25.9	34.7	42.8	52.1	63.7	87.2	104	127		
	400 V	25.9	34.7	42.8	52.1	63.7	87.2	104	127	153	183

Applied motor (kW)		200	220	250	280	315	355	400	450	500	630
Pi (kVA)	200 V										
	400 V	229	252	286	319	359	405	456	512	570	718

(2) Magnitude of "Ki (conversion factor)"

Use the conversion factors included in the document attached to the guideline, according to the use of optional ACR (alternating current reactor) and DCR (direct current reactor). The magnitude of the conversion factor is shown in Table 7.1-3.

Table 7.1-3: General purpose inverter "conversion factor Ki" determined by reactor

Circuit category	Circuit classification		Conversion factor Ki	Major use cases
3	3 phase bridge (capacitor smoothing)	No reactor	K31 = 3.4	• General purpose inverter
		With reactor (AC side)	K32 = 1.8	• Elevator
		With reactor (DC side)	K33 = 1.8	• Refrigeration and air conditioning equipment
		With reactor (AC and DC sides)	K34 = 1.4	• Other general purpose equipment

Note Be cautioned that some models come with a reactor as standard.
When the converter you use is a diode rectifier (RHD-D series), a DCR (direct current reactor) is contained in the diode rectifier. Therefore, the conversion factor K33=1.8 with a reactor (on the DC side) as shown in Table 7.1-3 should be used in calculation. Also, the conversion factor K34=1.4 can be applied when an optional ACR (alternate current reactor) is added.

[2] "Calculation of harmonic current"

(1) Magnitude of "fundamental harmonic current"

- "Fundamental harmonic current" needs to be computed separately when performing calculations using "Table 2, in the document attached to the guideline".
- Use Table 7.1-4 below according to the rated kW of the motor used, regardless of inverter type and availability of reactors.

Note When the input voltage differs, values are calculated in inverse proportion to the voltage value.

Table 7.1-4: "Fundamental harmonic input current" of general purpose inverters determined by applied motor

Applied motor (kW)		0.4	0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5
Fundamental harmonic input current (A)	200 V	1.62	2.74	5.50	7.92	13.0	19.1	25.6	36.9	49.8	61.4
	400 V	0.81	1.37	2.75	3.96	6.50	9.55	12.8	18.5	24.9	30.7
6.6 kV conversion value (mA)		49	83	167	240	394	579	776	1121	1509	1860

Applied motor (kW)		22	30	37	45	55	75	90	110	132	160
Fundamental harmonic input current (A)	200 V	73.1	98.0	121	147	180	245	293	357		
	400 V	36.6	49.0	60.4	73.5	89.9	123	147	179	216	258
6.6 kV conversion value (mA)		2220	2970	73.5	4450	5450	7450	8910	10850	13090	15640

Applied motor (kW)		200	220	250	280	315	355	400	450	500	630
Fundamental harmonic input current (A)	200 V										
	400 V	323	355	403	450	506	571	643	723	804	1013
6.6 kV conversion value (mA)		19580	21500	24400	27300	30700	34600	39000	43800	48700	61400

(2) Calculation of harmonic current

Generally, use "Table 2-3 in the document attached to the guideline, 3 phase bridge (capacitor smoothing)" to compute. The contents of the document attached to the guideline are shown in Table 7.1-5.

Table 7.1-5: Amount of harmonic current generated (%) 3 phase bridge (capacitor smoothing)

Order	5^{th}	7^{th}	11^{th}	13^{th}	17^{th}	19^{th}	23^{rd}	25^{th}
No reactor	65	41	8.5	7.7	4.3	3.1	2.6	1.8
With reactor (AC side)	38	14.5	7.4	3.4	3.2	1.9	1.7	1.3
With reactor (DC side)	30	13	8.4	5.0	4.7	3.2	3.0	2.2
With reactor (AC and DC sides)	28	9.1	7.2	4.1	3.2	2.4	1.6	1.4

- AC side reactor : 3%
- DC side reactor : Accumulated energy corresponds to 0.08 to 0.15 ms (100% load conversion)
- Smoothing capacitor : Accumulated energy corresponds to 15 to 30 ms (100% load conversion)
- Load : 100%

$$\text{nth order harmonic current (A)} = \text{fundamental harmonic current (A)} \times \frac{\text{amount of nth order harmonic current generated (\%)}}{100}$$

Compute harmonic current for each order as shown above

.

(3) Maximum rate of operation

- For elevators where the loading requires intermittent operation and where the design uses overrated motors, the "maximum rate of operation" is multiplied to reduce the current.
- According to the document attached to the guideline, "The maximum rate of operation for instruments is the ratio of the total capacity of the equipment generating harmonics to the capacity which maximizes the actual operation of the instrument. The capacity of the actually operating equipment is the average value in 30 minutes" .
- Generally, calculation is performed according to this definition. However, for building facilities, the standard values in Table 7.1-6 are recommended. The values can probably be referenced for similar facilities.

Table 7.1-6: Rate of operation for building facility inverters (standard values)

Type of facility	Instrument capacity	Stand-alone instrument rate of operation
Air conditioning facility	200 kW or less	0.55
	Over 200 kW	0.60
Sanitary pump	—	0.30
Elevator	—	0.25
Refrigeration and freezing equipment	50 kW or less	0.60
UPS (6 pulse)	200 kVA	0.60

Correction factor according to scale of contract demand

When scale increases such as in buildings, the overall rate of operation decreases. In such cases, calculation of harmonic reduction using correction factor β in Table 7.1-7 is approved.

Table 7.1-7: Correction factor by scale

Contract demand (kW)	Correction factor β
300	1.00
500	0.90
1,000	0.85
2,000	0.80

(Note) When the contract demand is between the numbers shown in Table 7.1-7, then calculate by interpolation.

(Note) For users whose receiving voltage is especially high or over 2000 kW, value must be determined in discussions with the power company.

(4) Harmonic order to calculate

The characteristic for the amount of harmonic current generated by general purpose inverters decreases as the order increases. The characteristic corresponds to the "case which does not cause special problems" which is shown in 3. (3) in the document attached to the guideline.
Therefore, only "5th and the 7th components of the harmonic current need to be calculated".

[3] Specific calculation examples

(1) Calculation example for “equivalent capacity”

Sample load	Input capacity	Conversion factor	Equivalent capacity
[Ex 1] 400 V, 3.7 kW, 10 units With AC and DC reactors	4.61 kVA x 10 units	K32 = 1.4	4.61 × 10 × 1.4 = 64.54 kVA
[Ex 2] 400 V, 1.5 kW, 15 units With AC reactors	2.93 kVA x 15 units	K34 = 1.8	2.93 × 15 × 1.8 = 79.11 kVA
	Refer to Table 7.1-2.	Refer to Table 7.1-3.	

(2) Calculation example for “harmonic current for various orders”

Example 1: 400 V, 3.7 kW, 10 units (with AC reactor), max rate of operation 0.55

Fundamental harmonic current on 6.6 kV side (mA)	Harmonic current on 6.6 kV side (mA)							
394 × 10 = 3940 3940 × 0.55 = 2167	5th (38%)	7th (14.5%)	11th (7.4%)	13th (3.4%)	17th (3.2%)	19th (1.9%)	23rd (1.7%)	25th (1.3%)
	823.5	314.2						
Refer to Table 7.1-4 and Table 7.1-6.	Refer to Table 7.1-5.							

Example 2: 400 V, 3.7 kW, 15 units (with AC and DC reactors), max rate of operation 0.55

Fundamental harmonic current on 6.6 kV side (mA)	Harmonic current on 6.6 kV side (mA)							
394 × 15 = 5910 5910 × 0.55 = 3250.5	5th (28%)	7th (9.1%)	11th (7.2%)	13th (4.1%)	17th (3.2%)	19th (2.4%)	23rd (1.6%)	25th (1.4%)
	910.1	295.8						
Refer to Table 7.1-4 and Table 7.1-6.	Refer to Table 7.1-5.							

Appendix 8 Effect on insulation when driving general purpose motor with a 400 V class inverter

Japan Electrical Manufacturers’ Association (JEMA)

Excerpt from technical document (March 1995)

When the inverter drives the motor, surge voltage created by IGBT switching superposes on the inverter output voltage and is applied on the motor terminals. When this surge voltage is high, the motor insulation can be affected, leading to damage in some cases.

This document describes the inverter surge voltage generation mechanism and the countermeasure in order to prevent these instances.

For the inverter operating principles, refer to Appendix 5 "Proficient way to use inverters (on electric noise) ".

Appendix -8.1 Surge voltage generation mechanism

The inverter rectifies and smooths commercial power supply. The direct voltage E is approximately $\sqrt{2}$ times the commercial power supply voltage (approximately 620 V for 440 VAC input). The peak value of the output voltage is normally around this direct voltage.

However, inductance (L) and stray capacitance (C) exist in the wiring between the inverter and the motor. The voltage changes caused by the switching of the inverter components resonate with LC, causing surge voltage. This surge voltage applies high voltage on the motor terminals. (Refer to Figure 8.1-1.)

This voltage, which varies depending on the switching speed of inverter components and wiring conditions, can reach up to approximately twice the inverter direct current voltage (620 V x 2 = 1200 V approximately).

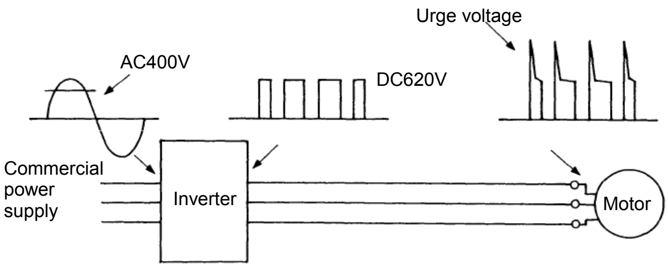
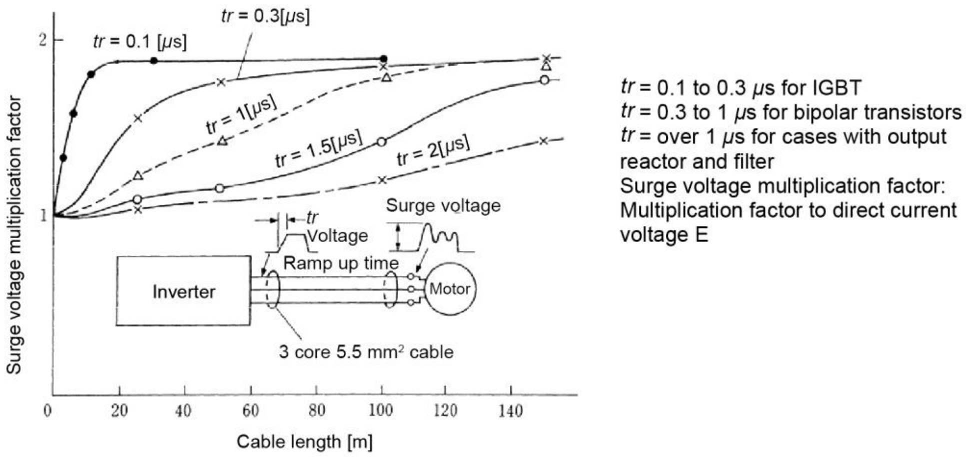


Figure 8.1-1: Voltage waves of various parts

“Figure 8.1-2: Actual measurement sample of wiring length and voltage peak value at motor terminal” shows an actually measured example of the relationship between the wiring length between the inverter and motor and the voltage peak value at the motor terminal. This figure shows that the peak value of the motor terminal voltage rises as the wiring lengthens, saturating at approximately twice the inverter direct current voltage. Also, shorter ramp time increases the motor terminal voltage, even for short wiring length.



Excerpt from [Institute of Electrical Engineers of Japan (IEEJ) journal, volume 107 issue 7, 1987]

Figure 8.1-2: Actual measurement sample of wiring length and voltage peak value at motor terminal

Appendix -8.2 Effect of surge voltage

The surge voltage generated by LC resonation of the wiring is applied on the motor input terminals. Depending on the magnitude of the surge voltage, motor insulation may be damaged. When driving with 200 V class inverters, the direct current voltage is around 300 V. At this level, insulation strength will not cause problems even if the motor terminal voltage peak values due to surge voltage reach twice the DC voltage.

However, when driving with 400 V class inverters, the direct current voltage becomes approximately 600 V. The surge voltage can magnify depending on the wiring length and may lead to insulation damage.

Appendix -8.3 Countermeasure for surge voltage

The following methods exist as countermeasures for insulation damage due to surge voltage when driving motors with 400 V class inverters.

Appendix -8.3.1 Suppressing surge voltage

Surge voltage can be suppressed by suppressing the ramp up of voltage and by suppressing the peak value.

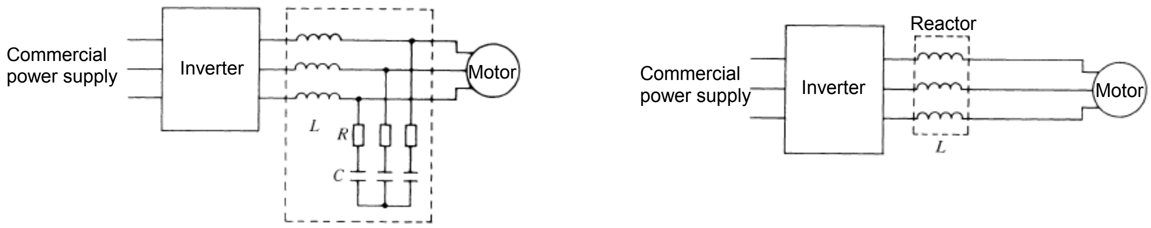
(1) Output LC filter (OFL filter)

Including cases of long wiring, generally, motor terminal voltage peak values are suppressed by installing LC filter (OFL filter) on the output side of inverters.

For details, refer to Chapter 7 "EMC Compatible Peripherals".

(2) Output reactor

When the wiring is relatively short, install AC reactor on the inverter output side to suppress the ramp up of voltage (dv/dt) to reduce surge voltage.



(1) Output LC Filter (OFL filter) (2) AC reactor

Figure 8.3-1: Methods to suppress surge voltage

Appendix -8.3.2 Using motors with enhanced insulation

The insulation in motor windings can be strengthened to improve surge durability.

Appendix -8.3.3 On existing products

Case of motors already driven by 400 V class inverters

Research for the past five years on motor insulation damage instances due to inverter generated surge voltages reveal that the occurrence rate is 0.013%. When damages occur, the voltages are above 1100 V and they tend to occur within a few months after inverter driven operation begins.

Therefore, the probability of insulation damage in motors which have been in operation for more than a few months is considerably low.

Case of driving existing motor with a new 400 V class inverter

Suppressing surge voltage by using the method described in "Appendix -8.3.1 Suppressing surge voltage" is recommended.

Appendix 9 Wire permissible current (IEC 60364-5-52)

Appendix -9.1 Permissible current based on ambient temperature, cable laying method

Table 9.1-1: Permissible current of a PVC (polyvinyl chloride) wire (maximum permissible temperature 70°C)
(for 3-core cables with copper conductor)

Wire size [mm²]	Aerial wiring (number of cables: 1)			Electric duct wiring (number of cables: 2)			Electric duct wiring (number of cables: up to 9)		
	30°C (Io) [A]	**40°C** (Io×0.87) [A]	**50°C** (Io×0.71) [A]	**30°C** (Io2=Io×0.87) [A]	**40°C** (Io2×0.87) [A]	**50°C** (Io2×0.71) [A]	**30°C** (Io3=Io×0.78) [A]	**40°C** (Io3×0.87) [A]	**50°C** (Io3×0.71) [A]
1.5	18.5	16	13	16	14	11	14	13	10
2.5	25	22	18	22	19	15	20	17	14
4	34	30	24	30	26	21	27	23	19
6	43	37	31	37	33	27	34	29	24
10	60	52	43	52	45	37	47	41	33
16	80	70	57	70	61	49	62	54	44
25	101	88	72	88	76	62	79	69	56
35	126	110	89	110	95	78	98	86	70
50	153	133	109	133	116	95	119	104	85
70	196	171	139	171	148	121	153	133	109
95	238	207	169	207	180	147	186	162	132
120	276	240	196	240	209	170	215	187	153
150	319	278	226	278	241	197	249	216	177
185	364	317	258	317	276	225	284	247	202
240	430	374	305	374	325	266	335	292	238
300	497	432	353	432	376	307	388	337	275

* Io: Reference value for permissible current

* Shows the permissible current for each of the ambient temperatures of 30°C, 40°C, and 50°C and for each of 1-, 2-,and 9-cable configurations.
If the use conditions are different, refer to IEC 60364-5-52:2001(JIS C 60364-5-52:2006).

Table 9.1-2: Permissible current of an XLPE (cross-linked polyethylene) and EP (ethylene-propylene rubber) wires
(maximum permissible temperature 90°C) (for 3-core cables with copper conductor)

Wire size [mm²]	Aerial wiring (number of cables: 1)			Electric duct wiring (number of cables: 2)			Electric duct wiring (number of cables: up to 9)		
	30°C (Io) [A]	**40°C** (Io×0.87) [A]	**50°C** (Io×0.71) [A]	**30°C** (Io2=Io×0.87) [A]	**40°C** (Io2×0.87) [A]	**50°C** (Io2×0.71) [A]	**30°C** (Io3=Io×0.78) [A]	**40°C** (Io3×0.87) [A]	**50°C** (Io3×0.71) [A]
1.5	23	20	16	20	17	14	18	16	13
2.5	32	28	23	28	24	20	25	22	18
4	42	37	30	37	32	26	33	29	23
6	54	47	38	47	41	33	42	37	30
10	75	65	53	65	57	46	59	51	42
16	100	87	71	87	76	62	78	68	55
25	127	110	90	110	96	78	99	86	70
35	158	137	112	137	120	98	123	107	88
50	192	167	136	167	145	119	150	130	106
70	246	214	175	214	186	152	192	167	136
95	298	259	212	259	226	184	232	202	165
120	346	301	246	301	262	214	270	235	192
150	399	347	283	347	302	246	311	271	221
185	456	397	324	397	345	282	356	309	253
240	538	468	382	468	407	332	420	365	298
300	621	540	441	540	470	384	484	421	344

* Io: Reference value for permissible current

* Shows the permissible current for each of the ambient temperatures of 30°C, 40°C, and 50°C and for each of 1-, 2-, and 9-cable configurations.
If the use conditions are different, refer to IEC 60364-5-52:2001(JIS C 60364-5-52:2006).

High Performance Vector Control Inverter

FRENIC-VG

User's Manual (Stack type edition)

First Edition, March 2013
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