Fuji Electric

Innovating Energy Technology

High Performance Inverter

FRENIC-Ace

User's Manual

⚠CAUTION

Thank you for purchasing our multifunction FRENIC-Ace series of inverters.

- This product is designed to drive a three-phase motor under variable speed control. Read through this user's manual and become familiar with the handling procedure for correct use.
- Improper handling might result in incorrect operation, a short life, or even a failure of this product as well as the motor.
- Deliver this manual to the end user of this product. Keep this manual in a safe place until this product is discarded.
- For how to use an optional device, refer to the instruction and installation manuals for that optional device.

24A7-E-0043

The purpose of this user's manual is to provide accurate information in handling, setting up and operating of the FRENIC-Ace series of inverters. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

Preface

Thank you for purchasing our multifunction FRENIC-Ace series of inverters. This product is designed to drive a three-phase induction motor under variable speed control.

This manual provides all the information on the FRENIC-Ace series of inverters including its operating procedure and selection of peripheral equipment. Before use, carefully read this manual for proper use. Improper handling might result in incorrect operation, a short life, or even a failure of this product as well as the motor.

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

Name	Material No.	Description
Catalog	24A1-E-0042	Product scope, features, specifications, external drawings, and options of the product
RS-485 Communication User's Manual	24A7-E-0021*	Overview of functions implemented by using FRENIC-Ace RS-485 communications facility, its communications specifications, Modbus RTU/Fuji general-purpose inverter protocol, function codes and related data formats

*Available soon

The materials are subject to change without notice. Be sure to obtain the latest editions for use.

How this manual is organized

This manual contains Chapters 1 through 13 and Appendices.

Chapter 1 BEFORE USE

This chapter gives the check items to be used before the use of the inverter.

Chapter 2 MOUNTING AND WIRING THE INVERTER

This chapter describes the important points in installing and wiring inverters.

Chapter 3 OPERATION USING THE KEYPAD

This chapter describes keypad operation of the inverter.

Chapter 4 TEST RUN PROCEDURE

This chapter describes basic settings required for making a test run.

Chapter 5 FUNCTION CODES

This chapter explains the table of function code used in FRENIC-Ace, index per purpose, and the detail of each function code

Chapter 6 TROUBLESHOOTING

This chapter describes troubleshooting procedures to be followed when the inverter malfunctions or detects an alarm or a light alarm condition. In this chapter, first check whether any alarm code or the "light alarm" indication (L-AL) is displayed or not, and then proceed to the troubleshooting items.

Chapter 7 MAINTENANCE AND INSPECTION

This chapter describes the maintenance and inspection items of the inverter.

Chapter 8 BLOCK DIAGRAMS FOR CONTROL LOGIC

This chapter describes the main block diagrams of the control section.

Chapter 9 RUNNING THROUGH RS-485 COMMUNICATION

This chapter describes an overview of inverter operation through the RS-485 and CANopen communications. For details of RS-485 communication, refer to the RS-485 Communication User's Manual (24A7-E-0021).

Chapter 10 SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES

This chapter provides you with information about the inverter output torque characteristics, selection procedure, and equations for calculating capacities to help you select optimal motor and inverter models. It also helps you select braking resistors, inverter mode (ND, HD, HND, or HHD), and motor drive control.

Chapter 11 SELECTING PERIPHERAL EQUIPMENT

This chapter describes how to use a range of peripheral equipment and options, FRENIC-Ace's configuration with them, and requirements and precautions for selecting wires and crimp terminals.

Chapter 12 SPECIFICATIONS

This chapter describes the output ratings, input power, basic functions and other specifications of the FRENIC-Ace standard model.

Chapter 13 EXTERNAL DIMENSIONS

This chapter gives external dimensions of the inverter.

Appendices

CONTENTS

■ Safety precautions

Read this manual thoroughly before proceeding with installation, connections (wiring), operation, or maintenance and inspection. Ensure you have sound knowledge of the device and familiarize yourself with all safety information and precautions before proceeding to operate the inverter.

Safety precautions are classified into the following two 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 minor or light bodily injuries and/or substantial property damage.

Failure to heed the information contained under the CAUTION title can also result in serious consequences. These safety precautions are of utmost importance and must be observed at all times.

Application

⚠WARNING

- The FRENIC-Ace is designed to drive a three-phase induction motor. Do not use it for single-phase motors or for other purposes.

  Fire or an accident could occur.

- The FRENIC-Ace may not be used for a life-support system or other purposes directly related to the human safety.
- Though the FRENIC-Ace 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 it.

  An accident could occur.

Installation

⚠WARNING

- Install the inverter on a base made of metal or other non-flammable material.

  Otherwise, a fire could occur.

- Do not place flammable object nearby.

  Doing so could cause fire.

- Inverters FRN0085E2S-4☐ or above, whose protective structure is IP00, involve a possibility that a human body may touch the live conductors of the main circuit terminal block. Inverters to which an optional DC reactor is connected also involve the same. Install such inverters in an inaccessible place.

  Otherwise, electric shock or injuries could occur.

⚠CAUTION

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

  Doing so could cause a drop of the inverter and injuries.

- Prevent lint, paper fibers, sawdust, dust, metallic chips, or other foreign materials from getting into the inverter or from accumulating on the heat sink.
- When changing the positions of the top and bottom mounting bases, use only the specified screws.

  Otherwise, a fire or an accident might result.

- Do not install or operate an inverter that is damaged or lacking parts.

  Doing so could cause fire, an accident or injuries.

Wiring

⚠WARNING

- If no zero-phase current (earth leakage current) detective device such as a ground-fault relay is installed in the upstream power supply line in order to avoid the entire power supply system's shutdown undesirable to factory operation, install a residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) individually to inverters to break the individual inverter power supply lines only.

  Otherwise, a fire could occur.

- When wiring the inverter to the power source, insert a recommended molded case circuit breaker (MCCB) or residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) (with overcurrent protection) in the path of each pair of power lines to inverters. Use the recommended devices within the recommended current capacity.
- Use wires in the specified size.
- Tighten terminals with specified torque.

  Otherwise, a fire could occur.

- When there is more than one combination of an inverter and motor, do not use a multicore cable for the purpose of handling their wirings together.
- Do not connect a surge killer to the inverter's output (secondary) circuit.

  Doing so could cause a fire.

- Be sure to connect an optional DC reactor (DCR) when the capacity of the power supply transformer exceeds 500 kVA and is 10 times or more the inverter rated capacity.

  Otherwise, a fire could occur.

- Ground the inverter in compliance with the national or local electric code.
- Be sure to ground the inverter's grounding terminals ⏚G.

  Otherwise, an electric shock or a fire could occur.

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

  Otherwise, an electric shock could occur.

- Be sure to perform wiring after installing the inverter unit.

  Otherwise, an electric shock or injuries could occur.

- Ensure that the number of input phases and the rated voltage of the product match the number of phases and the voltage of the AC power supply to which the product is to be connected.

  Otherwise, a fire or an accident could occur.

- Do not connect the power supply wires to output terminals (U, V, and W).
- When connecting a DC braking resistor (DBR), never connect it to terminals other than terminals P(+) and DB.

  Doing so could cause fire or an accident.

- In general, sheaths of the control signal wires are not specifically designed to withstand a 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 might break down, which would expose the signal wire to a high voltage of the main circuit. Make sure that the control signal wires will not come into contact with live conductors of the main circuit.

  Doing so could cause an accident or an electric shock.

⚠WARNING⚠

- Before changing the switches or touching the control circuit terminal symbol plate, **turn OFF the power and wait at least five minutes for inverters FRN0072E2S-4☐ or below, or at least ten minutes for inverters FRN0085E2S-4☐ or above**. Make sure that the LED monitor and charging lamp are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC link bus voltage between the terminals P(+) and N(-) has dropped to the safe level (+25 VDC or below).

  Otherwise, an electric shock could occur.

⚠CAUTION

- The inverter, motor and wiring generate electric noise. Be careful about malfunction of the nearby sensors and devices. To prevent them from malfunctioning, implement noise control measures.

  Otherwise an accident could occur.

Operation

⚠WARNING

- Be sure to mount the front cover before turning the power ON. Do not remove the cover when the inverter power is ON.

  Otherwise, an electric shock could occur.

- Do not operate switches with wet hands.

  Doing so could cause electric shock.

- 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 machinery or equipment so that human safety is ensured at the time of restarting.

  Otherwise, an accident could occur.

- If the stall prevention function (current limiter), automatic deceleration (anti-regenerative control), or overload prevention control has been selected, the inverter may operate with acceleration/deceleration or frequency different from the commanded ones. Design the machine so that safety is ensured even in such cases.
- The STOP key on the keypad is effective only when the keypad operation is enabled with function code F02 (= 0, 2 or 3). When the keypad operation is disabled, prepare an emergency stop switch separately for safe operations.

  Switching the run command source from keypad (local) to external equipment (remote) by turning ON the "Enable communications link" command ***LE*** disables the STOP key. To enable the STOP key for an emergency stop, select the STOP key priority with function code H96 (= 1 or 3).
- If any of the protective functions have been activated, first remove the cause. Then, after checking that the all 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.

  Otherwise, an accident could occur.

- If you enable the "Restart mode after momentary power failure" (Function code F14 = 3 to 5), then the inverter automatically restarts running the motor when the power is recovered.
  Design the machinery or equipment so that human safety is ensured after restarting.
- If the user configures the function codes wrongly without completely understanding this User's Manual, the motor may rotate with a torque or at a speed not permitted for the machine.
- Starting auto-tuning involves motor rotation. Sufficiently check that motor rotation brings no danger beforehand.

  An accident or injuries could occur.

- Even if the inverter has interrupted power to the motor, if the voltage is applied to the main circuit input terminals L1/R, L2/S and L3/T, voltage may be output to inverter output terminals U, V, and W.
- Even if the motor is stopped due to DC braking or preliminary excitation, voltage is output to inverter output terminals U, V, and W.

  An electric shock may occur.

- The inverter can easily accept high-speed operation. When changing the speed setting, carefully check the specifications of motors or equipment beforehand.

  Otherwise, injuries could occur.

⚠CAUTION

- Do not touch the heat sink and braking resistor because they become very hot.

  Doing so could cause burns.

- The DC brake function of the inverter does not provide any holding mechanism.

  Injuries could occur.

- Ensure safety before modifying the function code settings.

  Run commands (e.g., "Run forward" ***FWD***), stop commands (e.g., "Coast to a stop" ***BX***), and frequency change commands can be assigned to digital input terminals. Depending upon the assignment states of those terminals, modifying the function code setting may cause a sudden motor start or an abrupt change in speed.
- When the inverter is controlled with the digital input signals, switching run or frequency command sources with the related terminal commands (e.g., ***SS1***, ***SS2***, ***SS4***, ***SS8***, ***Hz2/Hz1***, ***Hz/PID***, ***IVS***, and ***LE***) may cause a sudden motor start or an abrupt change in speed.
- Ensure safety before modifying customizable logic related function code settings (U codes and related function codes) or turning ON the "Cancel customizable logic" terminal command ***CLC***. Depending upon the settings, such modification or cancellation of the customizable logic may change the operation sequence to cause a sudden motor start or an unexpected motor operation.

  An accident or injuries could occur.

Maintenance and inspection, and parts replacement

⚠WARNING⚠
• Before proceeding to the maintenance/inspection jobs, **turn OFF the power and wait at least five minutes for inverters FRN0072E2S-4☐ or below, or at least ten minutes for inverters FRN0085E2S-4☐ or above**. Make sure that the LED monitor and charging lamp are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC link bus voltage between the terminals P(+) and N(-) has dropped to the safe level (+25 VDC or below). **Otherwise, an electric shock could occur.** • Maintenance, inspection, and parts replacement should be made only by qualified persons. • Take off the watch, rings and other metallic objects before starting work. • Use insulated tools. **Otherwise, an electric shock or injuries could occur.** • Never modify the inverter. **Doing so could cause an electric shock or injuries.**

Disposal

⚠CAUTION
• Treat the inverter as an industrial waste when disposing of it. **Otherwise injuries could occur.**

GENERAL PRECAUTIONS
Drawings in this manual may be illustrated without covers or safety shields for explanation of detail parts. Restore the covers and shields in the original state and observe the description in the manual before starting operation.

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.

Chapter 1

BEFORE USE

This chapter gives the check items to be used before the use of the inverter.

Contents

Chapter 1 BEFORE USE

1.1 Acceptance Inspection (Nameplates and Inverter Type)

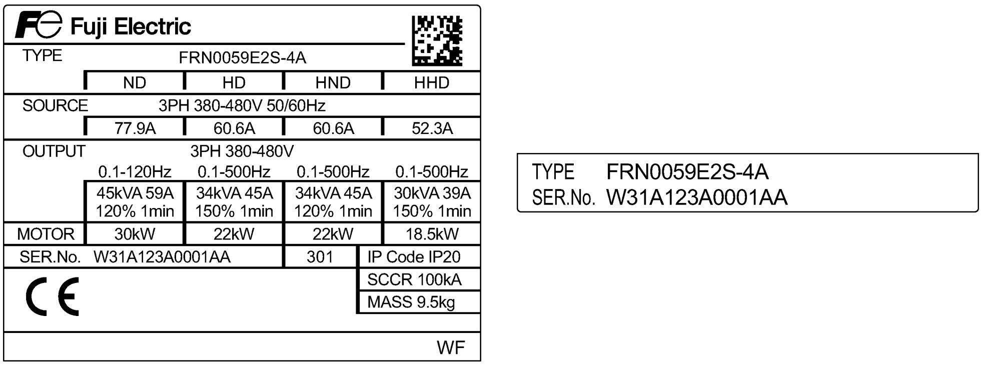
Unpack the package and check the following:

(1) An inverter and the following accessories are contained in the package.

Accessories
- DC reactor (for ND-mode inverters of FRN0139E2S-4☐ or above, HD-/HND-mode inverters of FRN0168E2S-4☐ or above, and HHD-mode inverters of FRN0203E2S-4☐ or above) (Not bundled with the FRN****E2S-4C)
- Keypad rear cover (with three screws for securing the keypad)
- Instruction manual
- CD-ROM (containing the FRENIC-Ace User's Manual)

(2) The inverter has not been damaged during transportation—there should be no dents or parts missing.

(3) The inverter is the type you ordered. You can check the type and specifications on the main nameplate. (The main and sub nameplates are attached to the inverter as shown on Figure 1.2-1.)



(a) Main Nameplate (b) Sub Nameplate

Figure 1.1 Nameplates

TYPE: Type of inverter

FRN 0059 E2S - 4A

Code	Series name
FRN	FRENIC series

Code	Nominal applied motor current (A)			
	ND	HD	HND	HHD
0059	59.0	45.0	45.0	39.0
0072	72.0	60.0	60.0	45.0
0085	85.0	75.0	75.0	60.0
0105	105	91.0	91.0	75.0
0139	139	112	112	91.0
0168	168	150	150	112
0203	203	176	176	150

Code	Applicable area
E	High performance, multifunction for general industry

Code	Development code
2	2

Code	Enclosure
S	Basic type (IP20/IP00)

Code	Power supply voltage
4	Three-phase 400 V

Code	Shipping destination/ Instruction manual language
C	China/Chinese
A	Asia/English
E	Europe/English
U	USA/English

Note: In this manual, inverter types are denoted as "FRN_ _ _ _E2S-4☐."

The FRENIC-Ace is available in four different drive modes--ND (Normal Duty), HD (Heavy Duty), HND (High, Normal Duty), and HHD (High, Heavy Duty). One of these modes should be selected to match the load property of your system. Specifications in each mode are printed on the main nameplate.

ND mode : Designed for general load applications.
Overload capability: 120% for 1 min.

HD mode : Designed for heavy duty load applications.
Overload capability: 150% for 1 min.

HND mode : Designed for general load applications.
Overload capability: 120% for 1 min.

HHD mode : Designed for heavy duty load applications.
Overload capability: 150% for 1 min. and 200% for 0.5 s.

SOURCE : Number of input phases (three-phase: 3PH), input voltage, input frequency, input current

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

SCCR : Short-circuit capacity

MASS : Mass of the inverter in kilogram

SER. No. : Product number

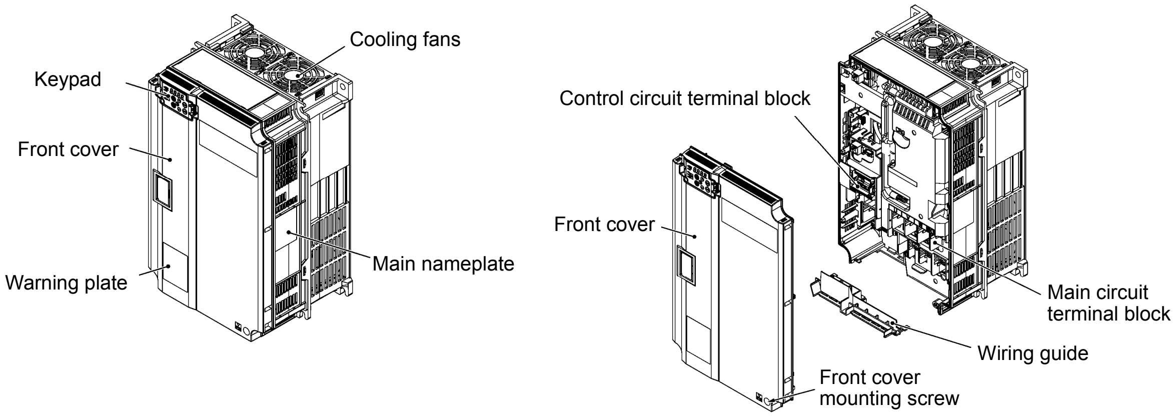
6 8 A 1 2 3 A 0 5 7 9 E BB 6 0 1

- 0 1 — Production week
  This indicates the week number that is numbered from 1st week of January.
  The 1st week of January is indicated as '01'.
- 6 — Production year: Last digit of year
- BB — Product version

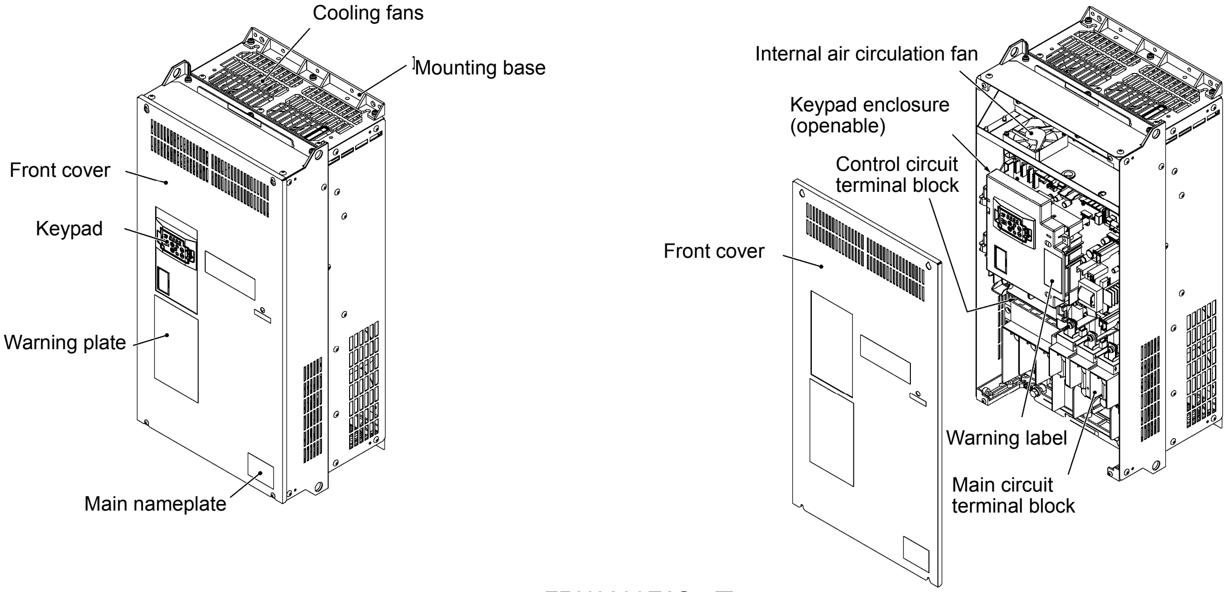
If you suspect the product is not working properly or if you have any questions about your product, contact your Fuji Electric representative.

1.2 External View and Terminal Blocks

(1) Outside and inside views



(a) FRN0072E2S-4☐



(b) FRN0203E2S-4☐

Figure 1.2-1 Outside and Inside Views of Inverters

(2) Warning plates and label

(a) FRN0072E2S-4☐

(b) FRN0203E2S-4☐

Figure 1.2-2 Warning Plates and Label

1.3 Precautions for Using Inverters

This section provides precautions in introducing inverters, e.g. precautions for installation environment, power supply lines, wiring, and connection to peripheral equipment. Be sure to observe those precautions.

1.3.1 Usage environment

Install the inverter in an environment that satisfies the requirements listed in Table 1.3-1.

Table 1.3-1 Usage Environment

Item	Specifications	
Site location	Indoors	
Ambient temperature	-10 to +50°C (14 to 122°F) **(Note 1)**	
Relative humidity	5 to 95% RH (No condensation)	
Atmosphere	The inverter must not be exposed to dust, direct sunlight, corrosive gases, flammable gases, oil mist, vapor or water drops. Pollution degree 2 (IEC60664-1) **(Note 2)** The atmosphere can contain a small amount of salt. (0.01 mg/cm2 or less per year) The inverter must not be subjected to sudden changes in temperature that will cause condensation to form.	
Altitude	1,000 m (3,300 ft) max. **(Note 3)**	
Atmospheric pressure	86 to 106 kPa	
Vibration	FRN0203E2S-4☐ or below	
	3 mm (Max. amplitude)	2 to less than 9 Hz
	9.8 m/s2	9 to less than 20 Hz
	2 m/s2	20 to less than 55 Hz
	1 m/s2	55 to less than 200 Hz

(Note 1) When inverters are mounted side-by-side without any clearance between them (FRN0072E2S-4☐ or below), the ambient temperature should be within the range from -10 to +40°C.

(Note 2) 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 3) If you use the inverter in an altitude above 1,000 m (3,300 ft), you should apply an output current derating factor as listed in Table 1.3-2.

Table 1.3-2 Output Current Derating Factor in Relation to Altitude

Altitude	Output current derating factor
1,000 m or lower (3,300 ft or lower)	1.00
1,000 to 1500 m (3,300 to 4,900 ft)	0.97
1,500 to 2,000 m (4,900 to 6,600 ft)	0.95
2,000 to 2,500 m (6,600 to 8,200 ft)	0.91
2,500 to 3,000 m (8,200 to 9,800 ft)	0.88

Fuji Electric strongly recommends installing inverters in a panel for safety reasons, in particular, when installing the ones whose enclosure rating is IP00.
When installing the inverter in a place out of the specified environmental requirements, it is necessary to derate the inverter or consider the panel engineering design suitable for the special environment or the panel installation location. For details, refer to the Fuji Electric technical information "Engineering Design of Panels" or consult your Fuji Electric representative.
The special environments listed below require using the specially designed panel or considering the panel installation location.

Environments	Possible problems	Sample measures	Applications
Highly concentrated sulfidizing gas or other corrosive gases	Corrosive gases cause parts inside the inverter to corrode, resulting in an inverter malfunction.	Any of the following measures may be necessary. - Mount the inverter in a sealed panel with IP6X or air-purge mechanism. - Place the panel in a room free from influence of the gases.	Paper manufacturing, sewage disposal, sludge treatment, tire manufacturing, gypsum manufacturing, metal processing, and a particular process in textile factories.
A lot of conductive dust or foreign material (e.g., metal powders or shavings, carbon fibers, or carbon dust)	Entry of conductive dust into the inverter causes a short circuit.	Any of the following measures may be necessary. - Mount the inverter in a sealed panel. - Place the panel in a room free from influence of the conductive dust.	Wiredrawing machines, metal processing, extruding machines, printing presses, combustors, and industrial waste treatment.
A lot of fibrous or paper dust	Fibrous or paper dust accumulated on the heat sink lowers the cooing effect. Entry of dust into the inverter causes the electronic circuitry to malfunction.	Any of the following measures may be necessary. - Mount the inverter in a sealed panel that shuts out dust. - Ensure a maintenance space for periodical cleaning of the heat sink in panel engineering design. - Employ external cooling when mounting the inverter in a panel for easy maintenance and perform periodical maintenance.	Textile manufacturing and paper manufacturing.
High humidity or dew condensation	In an environment where a humidifier is used or where the air conditioner is not equipped with a dehumidifier, high humidity or dew condensation results, which causes a short-circuiting or malfunction of electronic circuitry inside the inverter.	- Put a heating module such as a space heater in the panel.	Outdoor installation. Film manufacturing line, pumps and food processing.
Vibration or shock exceeding the specified level	If a large vibration or shock exceeding the specified level is applied to the inverter, for example, due to a carrier running on seam joints of rails or blasting at a construction site, the inverter structure gets damaged.	- Insert shock-absorbing materials between the mounting base of the inverter and the panel for safe mounting.	Installation of an inverter panel on a carrier or self-propelled machine. Ventilating fan at a construction site or a press machine.
Fumigation for export packaging	Halogen compounds such as methyl bromide used in fumigation corrodes some parts inside the inverter.	- When exporting an inverter built in a panel or equipment, pack them in a previously fumigated wooden crate. - When packing an inverter alone for export, use a laminated veneer lumber (LVL).	Exporting.

1.3.2 Storage environment

The storage environment in which the inverter should be stored after purchase differs from the usage environment. Store the inverter in an environment that satisfies the requirements listed below.

[1] Temporary storage

Table 1.3-3 Storage and Transport Environments

Item	Specifications	
Storage temperature *1	During transport: -25 to +70°C (-13 to +158°F)	Places not subjected to abrupt temperature changes or condensation or freezing
	During storage: -25 to +65°C (-13 to +153°F)	
Relative humidity	5 to 95% RH *2	
Atmosphere	The inverter must not be exposed to dust, direct sunlight, corrosive or flammable gases, oil mist, vapor, water drops or vibration. The atmosphere must contain only a low level of salt. (0.01 mg/cm^2 or less per year)	
Atmospheric pressure	86 to 106 kPa (during storage)	
	70 to 106 kPa (during transportation)	

***1** Assuming comparatively short time storage, e.g., during transportation or the like.

***2** Even if the humidity is within the specified requirements, avoid such places where the inverter will be subjected to sudden changes in temperature that will cause condensation or freezing.

<u>Precautions for temporary storage</u>

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

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

(3) If the inverter 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.

[2] Long-term storage

The long-term storage method of the inverter varies largely according to the environment of the storage site. General storage methods are described below.

(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 (14 to 86°F). This is to prevent electrolytic capacitors in the inverter from deterioration.

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

(3) If the inverter has been installed to the equipment or panel at construction sites where it may be subjected to humidity, dust or dirt, then temporarily remove the inverter and store it in the environment specified in Table 1.3-3.

<u>Precautions for storage over 1 year</u>

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

1.3.3 Precautions for connection of peripheral equipment

[1] Phase-advancing capacitors for power factor correction

Do not mount a phase-advancing capacitor for power factor correction in the inverter's input (primary) or output (secondary) circuit. Mounting it in the input (primary) circuit takes no effect. To correct the inverter power factor, use an optional DC reactor (DCR). Mounting it in the output (secondary) circuit causes an overcurrent trip, disabling operation.

An overvoltage trip that occurs when the inverter is stopped or running with a light load is assumed to be due to surge current generated by open/close of phase-advancing capacitors in the power system. An optional DC/AC reactor (DCR/ACR) is recommended as a measure to be taken at the inverter side.

Input current to an inverter contains a harmonic component that may affect other motors and phase-advancing capacitors on the same power supply line. If the harmonic component causes any problems, connect a DCR/ACR to the inverter. In some cases, it is necessary to insert a reactor in series with the phase-advancing capacitors.

[2] Power supply lines (Application of a DC/AC reactor)

Use a DC reactor (DCR) when the capacity of the power supply transformer is 500 kVA or more and is 10 times or more the inverter rated capacity or when there are thyristor-driven loads. If no DCR is used, the percentage-reactance of the power supply decreases, and harmonic components and their peak levels increase. These factors may break rectifiers or capacitors in the converter section of the inverter, or decrease the capacitance of the capacitors.

If the input voltage unbalance rate is 2% to 3%, use an optional AC reactor (ACR).

$$\text{Voltage unbalance (\%)} = \frac{\text{Max. voltage (V)} - \text{Min. voltage (V)}}{\text{Three-phase average voltage (V)}} \times 67 \text{ (IEC/EN61800-3)}$$

[3] DC reactor (DCR) for correcting the inverter input power factor (for suppressing harmonics)

To correct the inverter input power factor (to suppress harmonics), use a DCR. Using a DCR increases the reactance of inverter’s power source so as to decrease harmonic components on the power source lines and correct the power factor of the inverter.

DCR models	Input power factor	Remarks
DCR2/4-□□/□□A/□□B	Approx. 90% to 95%	The last letter identifies the capacitance. These DCR models comply with "Standard Specifications for Public Building Construction" (Electric Equipment, 2010 version) supervised by the Ministry of Land, Infrastructure, Transport and Tourism. (The input power factor is 94% or above when the power factor of the fundamental harmonic is assumed as "1" according to the 2010 version.)
DCR2/4-□□C	Approx. 86% to 90%	Exclusively designed for nominal applied motor of 37 kW or above.

Note
- Select a DCR matching not the inverter capacity but the nominal applied motor. Applicable reactors differ depending upon the selected ND, HD, HND or HHD mode even on the same type of inverters.
- For applied motors of 75 kW or above, be sure to connect a DCR to the inverter.

[4] PWM converter for correcting the inverter input power factor

Using a PWM converter (High power-factor, regenerative PWM converter, RHC series) corrects the inverter power factor up to nearly "1."

When combining an inverter with a PWM converter, disable the main power down detection by setting the function code H72 to "0" (default). If the main power down detection is enabled (H72 = 1, factory default), the inverter interprets the main power as being shut down, ignoring an entry of a run command.

[5] Molded case circuit breaker (MCCB) / residual-current-operated protective device (RCD) / earth leakage circuit breaker (ELCB)

Install a recommended MCCB or RCD/ELCB (with overcurrent protection) in the primary circuit of the inverter to protect the wiring. Since using an MCCB or RCD/ELCB with a lager capacity than recommended ones breaks the protective coordination of the power supply system, be sure to select recommended ones. Also select ones with short-circuit breaking capacity suitable for the power source impedance.

⚠WARNING
If no zero-phase current (earth leakage current) detective device such as a ground-fault relay is installed in the upstream power supply line in order to avoid the entire power supply system's shutdown undesirable to factory operation, install a residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) individually to inverters to break the individual inverter power supply lines only. **Otherwise, a fire could occur.**

[6] Magnetic contactor (MC) in the inverter input (primary) circuit

Avoid frequent ON/OFF operation of the magnetic contactor (MC) in the input circuit; otherwise, the inverter failure may result. If frequent start/stop of the motor is required, use ***FWD***/***REV*** terminal signals or the RUN / STOP keys on the inverter's keypad.

The frequency of the MC's ON/OFF should not be more than once per 30 minutes. To assure 10-year or longer service life of the inverter, it should not be more than once per hour.

Tip

- From the system's safety point of view, it is recommended to employ such a sequence that shuts down the magnetic contactor (MC) in the inverter input circuit with an alarm output signal ***ALM*** issued on inverter's programmable output terminals. The sequence minimizes the secondary damage even if the inverter breaks.

  When the sequence is employed, connecting the MC's primary power line to the inverter's auxiliary control power input makes it possible to monitor the inverter's alarm status on the keypad.

- The breakdown of a braking unit or misconnection of an external braking resistor may trigger that of the inverter's internal parts (e.g., charging resistor). To avoid such a breakdown linkage, introduce an MC and configure a sequence that shuts down the MC if a DC link voltage establishment signal is not issued within three seconds after the MC is switched on.

  For the braking transistor built-in type of inverters, assign a transistor error output signal ***DBAL*** on inverter's programmable output terminals to switch off the MC in the input circuit.

[7] Magnetic contactor (MC) in the inverter output (secondary) circuit

If a magnetic contactor (MC) is inserted in the inverter's output (secondary) circuit for switching the motor to a commercial power or for any other purposes, it should be switched on and off when both the inverter and motor are completely stopped. This prevents the contact point from getting rough due to a switching arc of the MC. The MC should not be equipped with any main circuit surge killer.

Applying a commercial power to the inverter's output circuit breaks the inverter. To avoid it, interlock the MC on the motor's commercial power line with the one in the inverter output circuit so that they are not switched ON at the same time.

[8] Surge absorber/surge killer

Do not install any surge absorber or surge killer in the inverter's output (secondary) lines.

1.3.4 Noise reduction

If noise generated from the inverter affects other devices, or that generated from peripheral equipment causes the inverter to malfunction, follow the basic measures outlined below.

(1) If noise generated from the inverter affects the other devices through power wires or grounding wires:

- Isolate the grounding terminals of the inverter from those of the other devices.
- Connect a noise filter to the inverter power wires.
- Isolate the power system of the other devices from that of the inverter with an insulated transformer.
- Decrease the inverter's carrier frequency (F26). (See **Note** below.)

(2) If induction or radio noise generated from the inverter affects other devices:

- Isolate the main circuit wires from the control circuit wires and other device wires.
- Put the main circuit wires through a metal conduit pipe, and connect the pipe to the ground near the inverter.
- Install the inverter into the metal panel and connect the whole panel to the ground.
- Connect a noise filter to the inverter's power wires.
- Decrease the inverter's carrier frequency (F26). (See **Note** below.)

(3) When implementing measures against noise generated from peripheral equipment:

- For inverter's control signal wires, use twisted or shielded-twisted wires. When using shielded-twisted wires, connect the shield of the shielded wires to the common terminals of the control circuit.
- Connect a surge absorber in parallel with magnetic contactor's coils or other solenoids (if any).

Note: Running a permanent magnet synchronous motor (PMSM) at a low carrier frequency may heat the permanent magnet due to the output current harmonics, resulting in demagnetization. When decreasing the carrier frequency setting, be sure to check the allowable carrier frequency of the motor.

1.3.5 Leakage current

A high frequency current component generated by insulated gate bipolar transistors (IGBTs) switching on/off inside the inverter becomes leakage current through stray capacitance of inverter input and output wires or a motor. If any of the problems listed below occurs, take an appropriate measure against them.

Problem	Measures
An earth leakage circuit breaker* that is connected to the input (primary) side has tripped. *With overcurrent protection	1) Decrease the carrier frequency. (See **Note** above.) 2) Make the wires between the inverter and motor shorter. 3) Use an earth leakage circuit breaker with lower sensitivity than the one currently used. 4) Use an earth leakage circuit breaker that features measures against the high frequency current component (Fuji SG and EG series).
An external thermal relay was falsely activated.	1) Decrease the carrier frequency. (See **Note** above.) 2) Increase the current setting of the thermal relay. 3) Use the electronic thermal overload protection built in the inverter, instead of the external thermal relay.

Note: Running a permanent magnet synchronous motor (PMSM) at a low carrier frequency may heat the permanent magnet due to the output current harmonics, resulting in demagnetization. When decreasing the carrier frequency setting, be sure to check the allowable carrier frequency of the motor.

1.3.6 Precautions in driving a permanent magnet synchronous motor (PMSM)

When using a PMSM, note the following.

- When using a PMSM other than the Fuji standard synchronous motor (GNF2), consult your Fuji Electric representative.
- A single inverter cannot drive two or more PMSMs.
- A PMSM cannot be driven by commercial power.

Chapter 2
INSTALLATION AND WIRING

This chapter describes the important points in installing and wiring inverters.

Table of Contents

Chapter 2 INSTALLATION AND WIRING

2.1 Installation

(1) Installation Environment

Please install **FRENIC-Ace** in locations which meet the conditions specified in “Chapter 1 1.3.1 Operating Environment”.

(2) Installation Surface

Please install the inverter on non-combustible matter such as metals. Also, do not mount it upside down or horizontally.

⚠WARNING
Install on non-combustible matter such as metals. **Risk of fire exists**

(3) Surrounding Space

Secure the space shown in Figure 2.1-1 and Table 2.1-1. When enclosing **FRENIC-Ace** in cabinets, be sure to provide adequate board ventilation, as the surrounding temperature may rise. Do not contain it in small enclosures with low heat dissipation capacity.

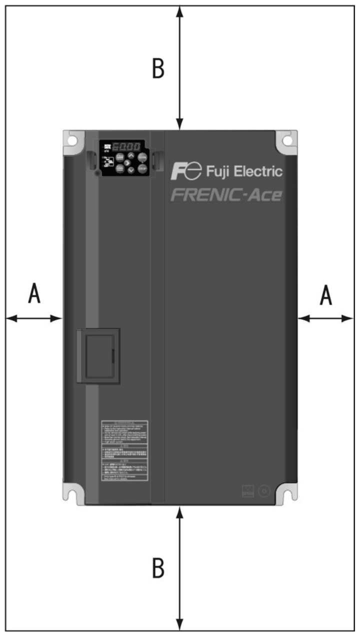


Figure 2.1-1 Installation Direction

■ Installation of Multiple Inverters

When installing 2 or more units in the same equipment or cabinet, generally mount them in horizontally parallel position. When the inverters are mounted vertically, attach partitioning boards to prevent the heat dissipated from the lower inverter to affect the upper inverter.

For types smaller than FRN0072E2S-4☐ and for ambient temperature below 40°C only, the units can be installed horizontally without any spacing in between. (30°C or lower for HND and HHD)

Table 2.1-1 Surrounding Space (mm)

Applicable Capacity	A	B	C
FRN0059/0072E2S-4☐	10	100	0 *1
FRN0085 to 0203E2S-4☐	50		100

*1 A clearance of 50 mm is required to use RJ45 connector.

C: Space in front of the inverter unit

■ Installation with External Cooling

The external cooling form reduces internally generated heat by dissipating approximately 70% of the total heat generated (total heat loss) using the cooling fins protruding outside the equipment or cabinet.

Installation with external cooling is possible for types smaller than FRN0072E2S-4☐ by adding attachments (optional) for external cooling, and for types larger than FRN0085E2S-4☐ by moving the mounting bases.

(Please refer to Chapter 11 Item 11.15 for the outside drawing of the external cooling attachment (optional)).

⚠CAUTION
Prevent lint, wastepaper, wood shavings, dust, metal scrap, and other foreign material from entering the inverter or from attaching to the cooling fins. **Risk of fire and risk of accidents exist**

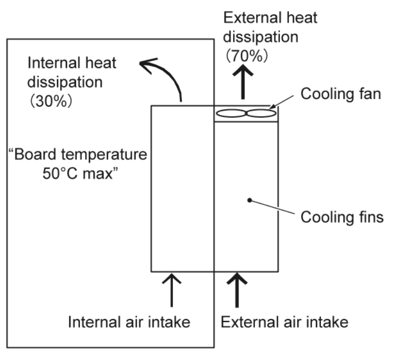


Figure 2.1-2 Installation with External Cooling

To install the FRN0085E2S-4☐ inverter with external cooling, change the mounting position of the mounting bases following the procedure in Figure 2.1-3.

As the type and number of screws differ by inverter type, please review the following table.

Table 2.1-2 Type and Number of Screws, and Tightening Torque

Inverter type	Mounting base fixation screw	Case attachment screw	Tightening torque (N•m)
FRN0085E2S-4☐ to FRN0168E2S-4☐	M6×20 (5 screws on top, 3 screws on bottom)	M6×20 (2 screws on top only)	5.8
FRN0203E2S-4☐	M6×20 (3 screws on top and bottom each)	M6×12 (3 screws on top only)	5.8

1) Remove all of the mounting base fixation screws and the case attachment screws on the top of the inverter.
2) Fix the mounting bases to the case attachment screw holes using the mounting base fixation screws. A few screws should remain after changing the position of the mounting bases.
3) Change the position of the mounting bases on the bottom side following the procedure in 1) and 2).

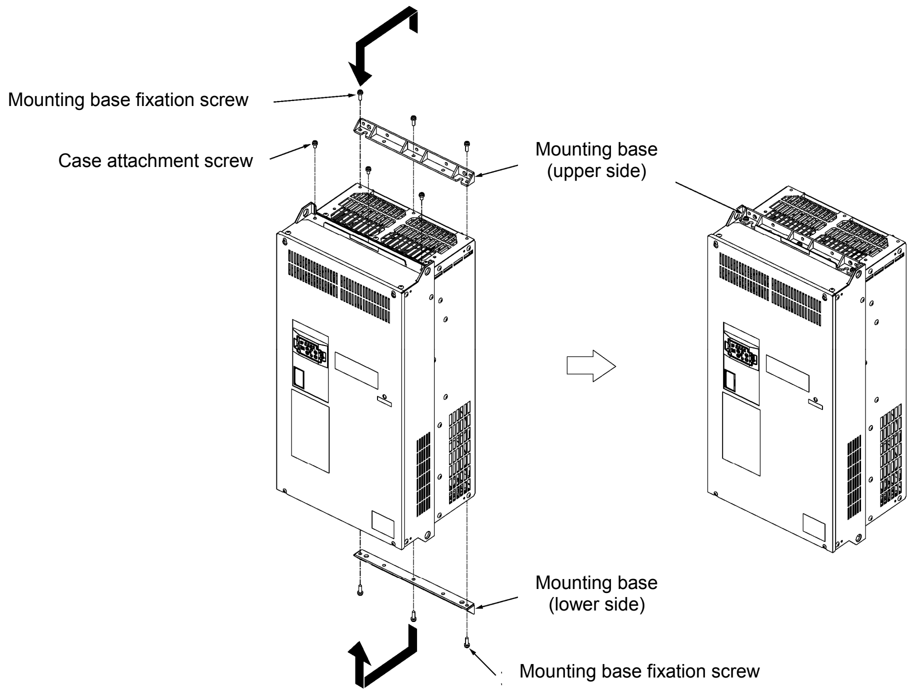


Figure 2.1-3 Method to Change the Mounting Base Positions

⚠CAUTION
Use the specified screws in changing the mounting bases. **Risk of fire and risk of accidents exist**

2.2 Wiring

2.2.1 Basic Connection Diagram

■ Standard terminal block board (with CAN) (FRN○○○E2S-4A, E only)

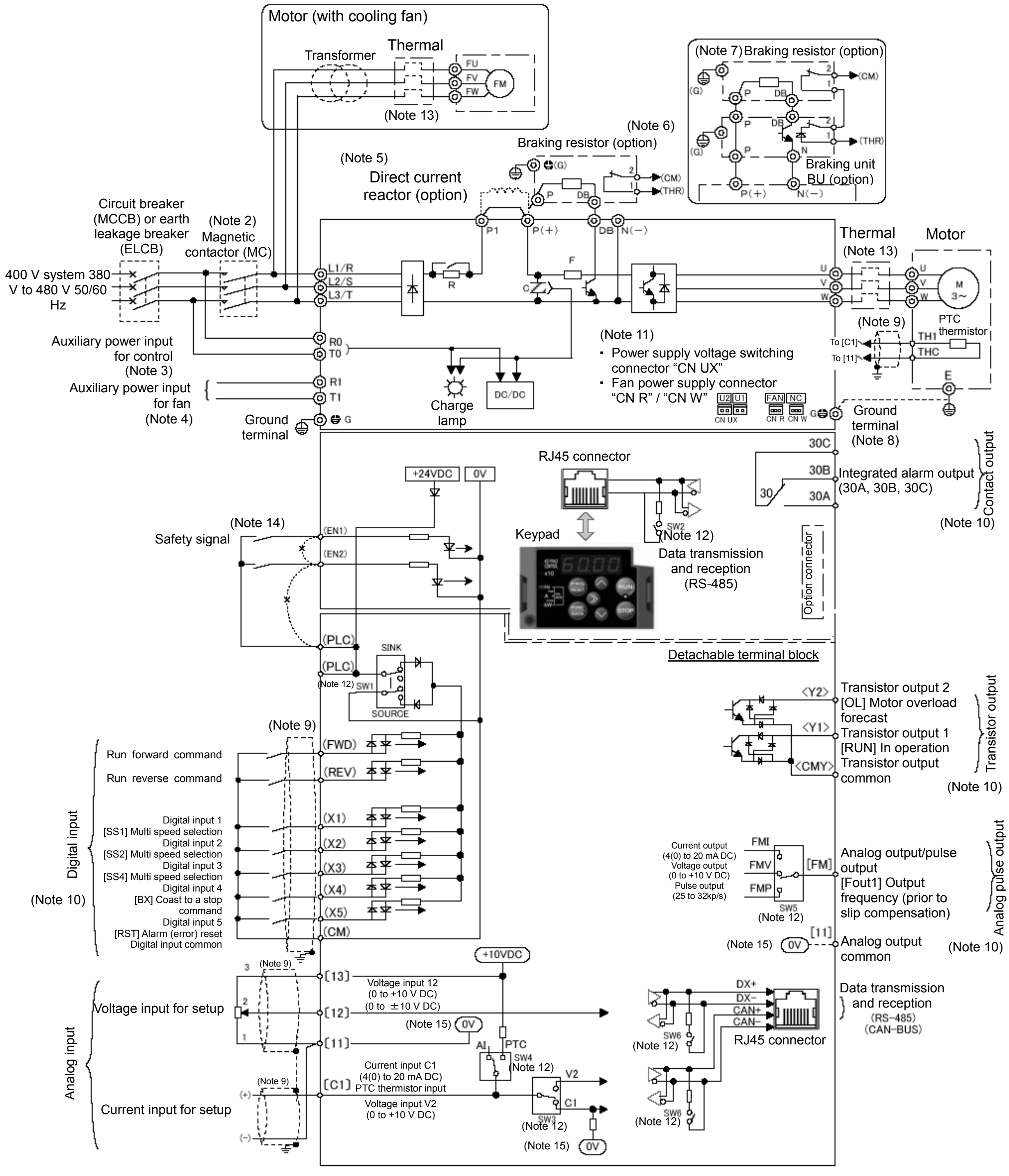


Figure 2.2-1 Standard Terminal Block Board (with CAN)

■ Standard terminal block board (without CAN, with FM2) (FRN○○○E2S-4C only)

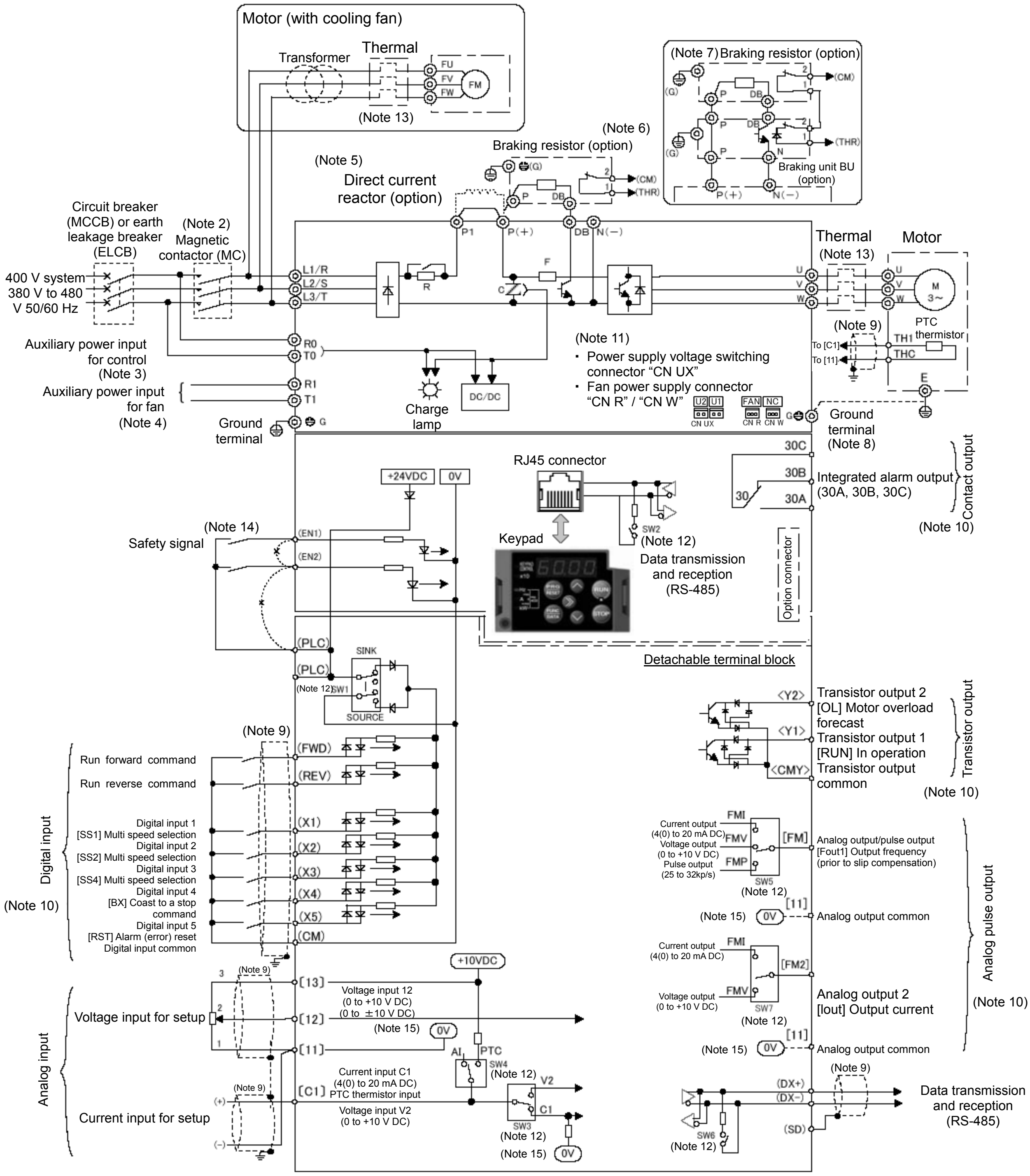


Figure 2.2-2 Standard Terminal Block Board (Without CAN, With FM2)

(Note 1) Install recommended circuit breakers (MCCB) or residual-current-operated protective device (RCD)/ earth leakage breakers (ELCB) (with overcurrent protective function) on the inputs of each inverter (primary side) for wiring protection. Do not use breakers which exceed the recommended rated current.

(Note 2) Install recommended magnetic contactors (MC) as necessary on each inverter as these will be used to disconnect the inverter from the power supply separately from the MCCB or RCD / the ELCB. Additionally, when installing coils such as MC or solenoid close to the inverter, connect surge absorbers in parallel.

(Note 3) When retaining the integrated alarm signal for the activation of the protective function at inverter main power supply shut off is desired, or when continuous display of the keypad is desired, connect this terminal to the power supply. The inverter can be operated without connecting power to this terminal.

(Note 4) The terminal does not need to be connected. Use this terminal when operating in combination with a high power factor regenerative PWM converter (RHC series). (For types larger than FRN0203E2S-4□)

(Note 5) Remove the shorting bar between the inverter main circuit terminals P1-P(+) before connecting the direct current reactor (DCR) (option).
ND mode: Types larger than FRN0139E2S-4□, HD/ HND mode: Types larger than FRN0168E2S-4□, HHD mode: Always connect for FRN0203E2S-4□.
Use the direct current reactor (option) when the power supply transformer capacity is above 500 kVA and the transformer capacity is over 10 times the rated capacity of the inverter, and when “thyristor load exists” in the same power system.

(Note 6) Types smaller than FRN0072E2S-4□ contain braking transistors, allowing direct connection of braking resistors between P(+)-DB.

(Note 7) When connecting braking resistors to types larger than FRN0085E2S-4□, always add the braking unit (option). Connect the braking unit (option) between P(+)-N(-). Auxiliary terminals [1] and [2] have polarity. Please connect as shown in the diagram.

(Note 8) This terminal is used for grounding the motor. Grounding the motor using this terminal is recommended in order to suppress inverter noise.

(Note 9) Use twisted lines or shielded lines for the control signal.
Generally, the shielded line requires grounding, but when the effect of externally induced noise is large, connecting to [CM] may suppress the effect of noise. Separate the line from the main circuit wiring and do not enclose in the same duct. (Separation distance of over 10 cm is recommended.) When crossing the main circuit wiring, make the intersection perpendicular.

(Note 10) The various functions listed for terminals[X1] to [X5](digital input), terminals [Y1] to [Y2](transistor output), and terminal [FM] (monitor output) show the functions assigned as factory default.

(Note 11) These are connectors for switching the main circuit. For details, refer to “2.2.7 Switching connectors”.

(Note 12) The various switches on the control printed circuit board define the setting for the inverter operation. For details, refer to “2.2.8 Switching the Various Switches”.

(Note 13) Make the circuit breakers (MCCB) or the magnetic contactors (MC) trip by the thermal relay auxiliary contacts (manual recovery).

(Note 14) Shorting bars are connected between the safety function terminals [EN1], [EN2], and [PLC] as factory default. Remove the shorting bars when using this function.

(Note 15) 0V and 0V are separated and insulated.

Route the wiring following the steps below. (The inverter is already installed in the descriptions.)

2.2.2 Removal and Attachment of the Front Cover and Wiring Guide

⚠CAUTION
Always remove the RS-485 communication cable from the RJ-45 connector before removing the front cover. **Risk of fire and risk of accidents exist.**

(1) Types smaller than FRN0072E2S-4☐

1) Loosen the screws of the front cover. Hold both sides of the front cover with the hands, slide the cover downward, and pull. Then remove to the upward direction.
2) Push the wiring guide upward and pull. Let the guide slide and remove.
3) After routing the wires, attach the wiring guide and the front cover reversing the steps above.

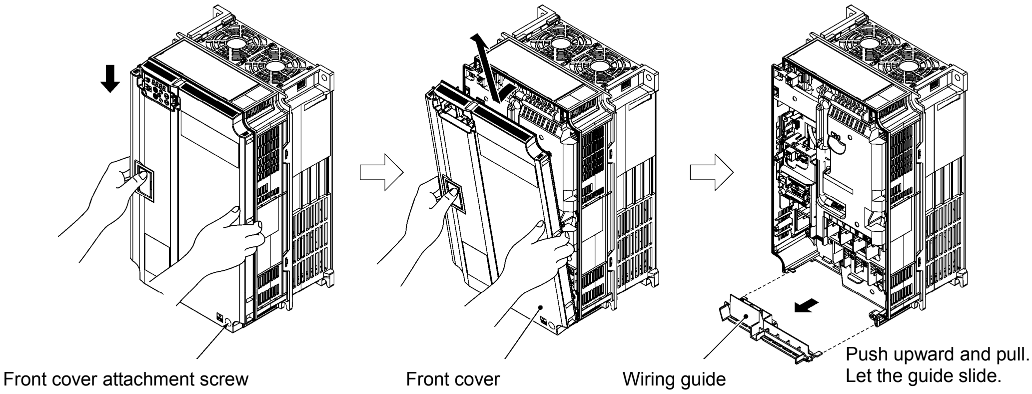
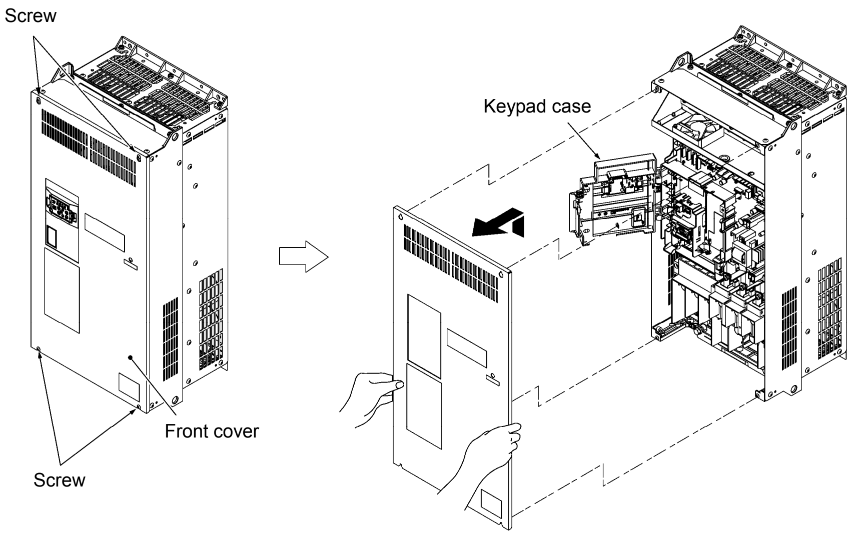


Figure 2.2-3 Removal of the Front Cover and the Wiring Guide (for FRN0072E2S-4☐)

(2) Types larger than FRN0085E2S-4☐

1) Loosen the screws of the front cover. Hold both sides of the front cover with the hands and slide upward to remove.
2) After routing the wires, align the front cover top edge to the screw holes and attach the cover reversing the steps in figure 2.2-4.

Tip Open the keypad case to view the control printed circuit board.



Tightening torque: 1.8 N·m (M4)
3.5 N·m (M5)

Figure 2.2-4 Removal of the front cover (for FRN0203E2S-4☐)

2.2.3 Precautions for Wiring

Exercise caution for the following when wiring.

(1) Confirm that the supply voltage is within the input voltage range described on the rating plate.

(2) Always connect the power lines to the inverter main power input terminals L1/R, L2/S, L3/T (3 phase). (The inverter will be damaged when power is applied while the power lines are connected to the wrong terminals.)

(3) Always route the ground line to prevent accidents such as electric shock and fire and to reduce noise.

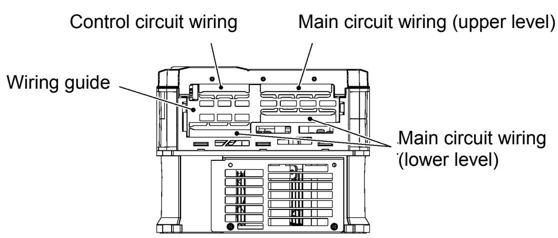
(4) For the lines connecting to the main circuit terminals, use crimped terminals with insulating sleeves or use crimped terminals in conjunction with insulating sleeves for high connection reliability.

(5) Separate the routing of the lines connected to the main circuit terminal input side (primary side) and the output side (secondary side) and the lines connected to the control circuit terminals.
The control circuit terminal lines should be routed as far from the main circuit routing as possible. Malfunction may occur due to noise.

(6) To prevent direct contact with the main circuit live sections (such as the main circuit terminal block), route the control circuit wiring inside the inverter as bundles using cable ties.

(7) After removing the main circuit terminal screw, always restore the terminal screw in position and tighten even if lines are not connected.

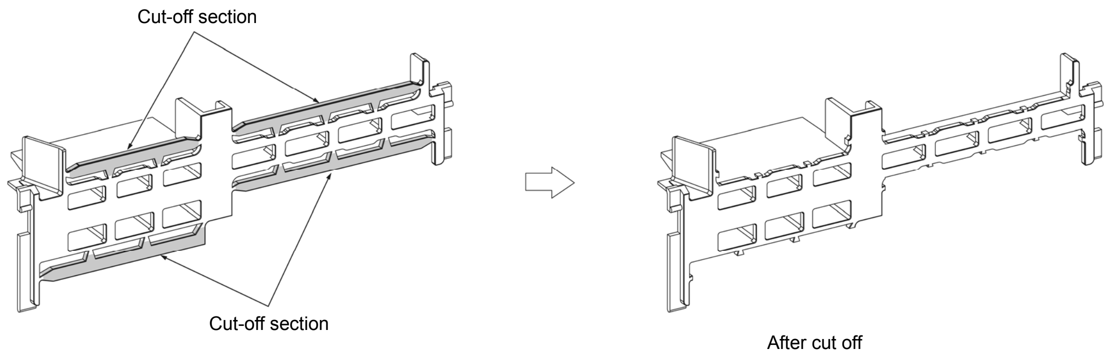
(8) The wiring guide is used to separately route the main circuit wiring and the control circuit wiring. In FRN0072/0085E2S-4☐, the main circuit wiring (lower level), the main circuit wiring (upper level) and the control circuit wiring can be separated. Exercise caution for the order of wiring.



Case of FRN0072E2S-4☐

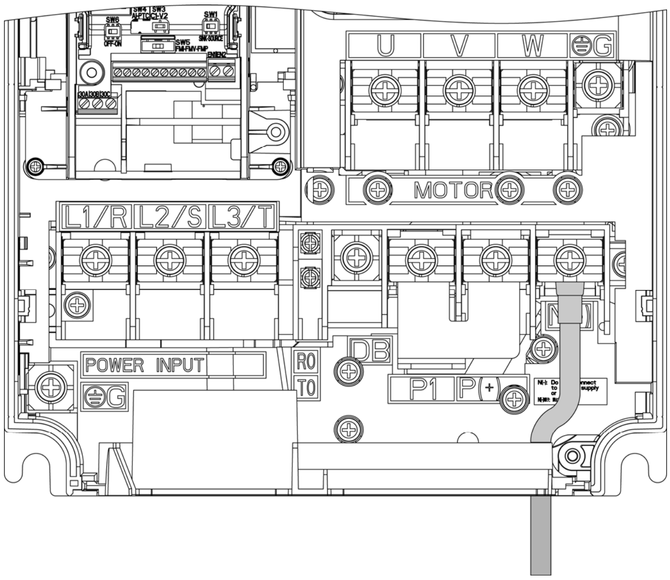
■ **Handling the Wiring Guide**

For inverter types smaller than FRN0072E2S-4☐, the wiring space may become insufficient when routing the main circuit wires, depending on the wire material used. In these cases, the relevant cut-off sections (see the figure below) can be removed using a pair of nippers to secure routing space. Be warned that removing the wiring guide to accommodate the enlarged main circuit wiring will result in non-conformance to IP20 standards.



Wiring Guide (FRN0072E2S-4☐)

(8) Depending on the inverter capacity, straight routing of the main circuit wires from the main circuit terminal block may not be possible. In these cases, route the wires as shown in the figure below and securely attach the front cover.



2.2.4 Precautions for Long Wiring (Between Inverter and Motor)

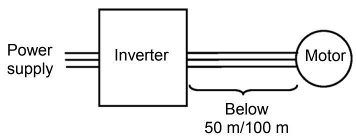
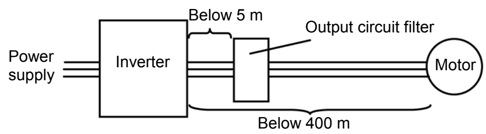
(1) When multiple motors are connected to one inverter, the wiring length is the total of all wire lengths.

(2) Precautions for high frequency leak current

When the wiring length from the inverter to the motor is long, the high frequency current may flow through the stray capacitance between the wires with various phases. The effect may cause the inverter to become overheated, or trip due to overcurrent. Leak current may increase and the accuracy of the displayed current may not be ensured. Depending on the conditions, excessive leak current may damage the inverter. When directly connecting the inverter and motor, the wiring length should be kept to below 100 meters.

To operate in excess of the above mentioned wiring length, reduce the carrier frequency or use an output circuit filter (OFL-☐☐☐-☐A).

When multiple motors are operated in parallel connection configuration (group operation), and especially when shielded cables are used in the connections, the stray capacitance to ground is large. Reduce the carrier frequency or use output circuit filters (OFL-☐☐☐-☐A).

<table>
<tr><th>Without output circuit filter</th><th>With output circuit filter</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

When the output circuit filter is attached, the total wiring length should be below 100 meters (below 400 meters under V/f control).
For motors with encoders, the wiring length between the inverter and motor should be below 100 m. The restriction comes from the encoder specification. For distances beyond 100 m, insulation converters should be used. Please contact Fuji Electric when operating with wiring lengths beyond the upper limit.

(3) Precautions on the surge voltage when driving the inverter (especially for 400 V series motor)
When motors are driven by inverters using the PWM method, the surge voltage generated by the switching of the inverter elements is added to the output voltage and is applied onto the motor terminals. Especially when the motor wiring length is long, the surge voltage can cause insulation degradation in the motor. Please perform one of the countermeasures shown below.

- Use motor with insulation enhancement (Fuji's standard motors have insulation enhancements)
- Connect a surge suppression unit on the motor side (SSU50/100TA-NS)
- Connect an output circuit filter (OFL-☐☐☐-☐A) to the inverter output side (secondary side)
- Reduce the wiring length from the inverter to the motor. (Less than 10 to 20 meters)

(4) When output circuit filters are attached to the inverter or when the wiring length is long, the voltage applied to the motor will decrease due to the voltage drop caused by the filter or wiring. In these cases, current oscillation and lack of torque may occur due to insufficient voltage.

⚠WARNING ⚠

- For each inverter, connect to the power supply via circuit breaker and earth leakage breaker (with overcurrent protective function). Use recommended circuit breakers and earth leakage breakers and do not use breakers which exceed the recommended rated current.
- Always use the specified sizes for the wires.
- Tighten terminals with the defined tightening torque.
- When multiple combinations of inverters and motors exist, do not use multi-core cables for the purpose of bundling the various wires.
- Do not install surge killers on the inverter output side (secondary side)
  Risk of fire exists.
- Perform C type or D type grounding construction according to the inverter input power system.
- Always ground the ground line connected to the inverter grounding terminal [⏚G]
  Risk of electric shock and risk of fire exist.
- Qualified personnel should perform the wiring.
- Perform wiring after confirming that the power is shut off.
  Risk of electric shock exists.
- Perform wiring only after the equipment is installed at the location.
  Risk of electric shock and risk of injury exist.
- Confirm that the phase of the power input and the rated voltage for the product matches with the phase and voltage of the power supply to be connected.
- Do not connect power supply lines to the inverter output terminals (U, V, W).
  Risk of fire and risk of accidents exist.

2.2.5 Main Circuit Terminals

[1] Screw Specifications and Recommended Wire Size (Main Circuit Terminals)

The specifications for the screws used in the main circuit wiring and the wire sizes are shown below. Exercise caution as the terminal position varies by inverter capacity. In the diagram, the two ground terminals [⏚G]are not differentiated for the input side (primary side) and the output side (secondary side).

Also, use crimped terminals with insulating sleeves and compatible for main circuit or terminals with insulating tubes. The recommended wire sizes are shown by board temperature and wire type.

Table 2.2-1 Screw Specifications

Power System	Inverter type	See item [2]	Screw specifications							
			Main circuit		Grounding		Auxiliary power input for control [R0, T0]		Auxiliary power input for fan [R1, T1]	
			Screw size (driver size)	Tightening torque (N•m)	Screw size (driver size)	Tightening torque (N•m)	Screw size	Tightening torque (N•m)	Screw size	Tightening torque (N•m)
3 Phase 400 V	FRN0059E2S-4☐	Fig. A	M6 (No. 3)	5.8	M6 (No.3)	5.8	M3.5	1.2	-	-
	FRN0072E2S-4☐									
	FRN0085E2S-4☐	Fig. B	M8	13.5	M8	13.5				
	FRN0105E2S-4☐									
	FRN0139E2S-4☐									
	FRN0168E2S-4☐									
	FRN0203E2S-4☐	Fig. C	M10	27					M3.5	1.2

⚠WARNING⚠
The following terminals will have high voltage when power is ON. Main circuit: L1/R, L2/S, L3/T, P1, P(+), N(-), DB, U, V, W, R0, T0, R1, T1 Insulation level Main circuit - Casing : Basic insulation (overvoltage category III, degree of contamination 2) Main circuit - Control circuit : Enhanced insulation (overvoltage category III, degree of contamination 2) **Risk of electric shock exists**

The following wires are recommended unless special requirements exist.

■ 600 V vinyl insulation wire (IV wire)

The wire is used in circuits except the inverter control circuit. The wire is difficult to twist and is not recommended for inverter control circuit. The maximum allowable temperature for the insulated wire is 60°C.

■ 600 V type 2 vinyl insulation wire or 600 V polyethylene insulation wire (HIV wire)

In comparison to the IV wire, the wire is smaller, more flexible, and the maximum allowable temperature for the insulated wire is higher at 75°C, making it suitable for both the inverter main circuit and control circuit. However, the wiring distance should be short and the wire must be twisted for use in the inverter control circuit.

■ 600 V cross-linked polyethylene insulation wire (FSLC wire)

The wire is used mainly in the main circuit and the grounding circuits. The size is even smaller than the IV wire or the HIV wire and also flexible. Due to these features, the wire is used to reduce the area occupied by wiring and to improve work efficiency in high temperature areas. The maximum allowable temperature for the insulated wire is 90°C. As a reference, Furukawa Electric Co., Ltd. produces Boardlex which satisfies the requirements.

■ Shielded-Twisted cables for internal wiring of electronic/electric instruments

This product is used in inverter control circuits. Use this wire with high shielding effect when risk of exposure to or effect of radiated noise and induced noise exists. Always use this wire when the wiring distance is long, even within the board. Furukawa Electric's BEAMEX S shielded cables XEBV or XEWV satisfy the requirements.

Table 2.2-2 Recommended Wire Sizes (Common Terminals)

Common terminals	Recommended wire size (mm^2)	Remarks
Auxiliary power input terminal for control circuit R0, T0	2.0	-
Auxiliary power input terminal for fan R1, T1	2.0	FRN0203E2S-4☐

1) Wire sizes conforming to low voltage directive in Europe

Table 2.2-3 Recommended Wire Sizes

ND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)						
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⊕G]		Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor	With DC reactor	Without DC reactor			
3 Phase 400 V	30	FRN0059E2S-4☐	16	25	16	16	16	25	2.5
	37	FRN0072E2S-4☐	25	35	16	16	25	25	2.5
	45	FRN0085E2S-4☐	25	50	16	25	35	35	2.5
	55	FRN0105E2S-4☐	35	70	16	35	50	50	2.5
	75	FRN0139E2S-4☐	70	-	35	35	70	95	2.5
	90	FRN0168E2S-4☐	95	-	50	50	95	120	4
	110	FRN0203E2S-4☐	50×2	-	70	70	50×2	150	6

HD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)						
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⊕G]		Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor	With DC reactor	Without DC reactor			
3 Phase 400 V	22	FRN0059E2S-4☐	10	16	10	16	10	16	2.5
	30	FRN0072E2S-4☐	16	25	16	16	16	25	2.5
	37	FRN0085E2S-4☐	25	35	16	16	25	25	2.5
	45	FRN0105E2S-4☐	25	50	16	25	35	35	2.5
	55	FRN0139E2S-4☐	35	70	16	35	50	50	2.5
	75	FRN0168E2S-4☐	70	-	35	35	70	95	4
	90	FRN0203E2S-4☐	95	-	50	50	95	120	6

The recommended wire sizes for the main circuit terminals assume using 70°C 600 V PVC wire at 40°C ambient temperature.

HND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)						
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]		Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor	With DC reactor	Without DC reactor			
3 Phase 400 V	22	FRN0059E2S-4☐	10	16	10	16	10	16	2.5
	30	FRN0072E2S-4☐	16	25	16	16	16	25	2.5
	37	FRN0085E2S-4☐	25	35	16	16	25	25	2.5
	45	FRN0105E2S-4☐	25	50	16	25	35	35	2.5
	55	FRN0139E2S-4☐	35	70	16	35	50	50	2.5
	75	FRN0168E2S-4☐	70	-	35	35	70	95	2.5
	90	FRN0203E2S-4☐	95	-	50	50	95	120	4

HHD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)						
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]		Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor	With DC reactor	Without DC reactor			
3 Phase 400 V	18.5	FRN0059E2S-4☐	6	16	10	16	10	10	2.5
	22	FRN0072E2S-4☐	10	16	10	16	10	16	2.5
	30	FRN0085E2S-4☐	16	25	16	16	16	25	2.5
	37	FRN0105E2S-4☐	25	35	16	16	25	25	2.5
	45	FRN0139E2S-4☐	25	50	16	25	35	35	2.5
	55	FRN0168E2S-4☐	35	70	16	35	50	50	2.5
	75	FRN0203E2S-4☐	70	-	35	35	70	95	4

The recommended wire sizes for the main circuit terminals assume using 70°C 600 V PVC wire at 40°C ambient temperature.

2) Wire sizes for board temperature: Below 40°C, wire type: 60°C wire

Table 2.2-4 Recommended Wire Sizes

ND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⊕G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	30	FRN0059E2S-4☐	14	22	8[*1]	14	14	2
	37	FRN0072E2S-4☐	14	38	8[*1]	14	22	2
	45	FRN0085E2S-4☐	22	38	8	22	38	2
	55	FRN0105E2S-4☐	38	60	14	38	38	2
	75	FRN0139E2S-4☐	60	-	14	60	60	2
	90	FRN0168E2S-4☐	60	-	14	60	100[*5]	3.5
	110	FRN0203E2S-4☐	100	-	22	100	150	5.5

HD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⊕G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4☐	8[*1]	14	5.5	8[*1]	14	2
	30	FRN0072E2S-4☐	14	22	8[*1]	14	14	2
	37	FRN0085E2S-4☐	14	38	8	22	22	2
	45	FRN0105E2S-4☐	22	38	8	22	38	2
	55	FRN0139E2S-4☐	38	60	14	38	38	2
	75	FRN0168E2S-4☐	60	-	14	60	60	3.5
	90	FRN0203E2S-4☐	60	-	14	60	100	5.5

HND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⊕G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4☐	8[*1]	14	5.5	8[*1]	14	2
	30	FRN0072E2S-4☐	14	22	8[*1]	14	14	2
	37	FRN0085E2S-4☐	14	38	8	22	22	2
	45	FRN0105E2S-4☐	22	38	8	22	38	2
	55	FRN0139E2S-4☐	38	60	14	38	38	2
	75	FRN0168E2S-4☐	60	-	14	60	60	2
	90	FRN0203E2S-4☐	60	-	14	60	100	3.5

The recommended wire sizes for the main circuit terminals assume using 60°C IV wire.
*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.
*5 For compatible crimped terminal, please use model CB100-S8 by JST Mfg. Co., Ltd. or equivalent.

HHD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⊕G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	18.5	FRN0059E2S-4☐	5.5	14	5.5	5.5	8 *1	2
	22	FRN0072E2S-4☐	8 *1	14	5.5	8 *1	14	2
	30	FRN0085E2S-4☐	14	22	8	14	14	2
	37	FRN0105E2S-4☐	14	38	8	22	22	2
	45	FRN0139E2S-4☐	22	38	8	22	38	2
	55	FRN0168E2S-4☐	38	60	14	38	38	2
	75	FRN0203E2S-4☐	60	-	14	60	60	3.5

The recommended wire sizes for the main circuit terminals assume using 60°C IV wire.
*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.

3) Wire sizes for board temperature: Below 40°C, wire type: 75°C wire

Table 2.2-5 Recommended Wire Sizes

ND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⊕G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	30	FRN0059E2S-4☐	8 *1	14	8 *1	8 *1	14	2
	37	FRN0072E2S-4☐	14	14	8 *1	14	14	2
	45	FRN0085E2S-4☐	14	22	8	14	22	2
	55	FRN0105E2S-4☐	22	38	14	22	38	2
	75	FRN0139E2S-4☐	38	-	14	38	38	2
	90	FRN0168E2S-4☐	38	-	14	38	60	2
	110	FRN0203E2S-4☐	60	-	22	60	100	3.5

The recommended wire sizes for the main circuit terminals assume using 75°C 600 V HIV wire.
*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.

HD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4☐	5.5	8[*1]	5.5	5.5	5.5	2
	30	FRN0072E2S-4☐	8[*1]	14	8[*1]	8[*1]	14	2
	37	FRN0085E2S-4☐	14	14	8	14	14	2
	45	FRN0105E2S-4☐	14	22	8	14	22	2
	55	FRN0139E2S-4☐	22	38	14	22	38	2
	75	FRN0168E2S-4☐	38	-	14	38	38	2
	90	FRN0203E2S-4☐	38	-	14	60	60	3.5

HND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4☐	5.5	8[*1]	5.5	5.5	5.5	2
	30	FRN0072E2S-4☐	8[*1]	14	8[*1]	8[*1]	14	2
	37	FRN0085E2S-4☐	14	14	8	14	14	2
	45	FRN0105E2S-4☐	14	22	8	14	22	2
	55	FRN0139E2S-4☐	22	38	14	22	38	2
	75	FRN0168E2S-4☐	38	-	14	38	38	2
	90	FRN0203E2S-4☐	38	-	14	60	60	2

HHD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	18.5	FRN0059E2S-4☐	3.5[*6]	8[*1]	5.5	3.5[*6]	5.5	2
	22	FRN0072E2S-4☐	5.5	8[*1]	5.5	5.5	5.5	2
	30	FRN0085E2S-4☐	8	14	8	8	14	2
	37	FRN0105E2S-4☐	14	14	8	14	14	2
	45	FRN0139E2S-4☐	14	22	8	14	22	2
	55	FRN0168E2S-4☐	22	38	14	22	38	2
	75	FRN0203E2S-4☐	38	-	14	38	38	2

The recommended wire sizes for the main circuit terminals assume using 75°C 600V HIV wire.

*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.

*6 For compatible crimped terminal, please use model R5.5-6 by JST Mfg. Co., Ltd. or equivalent.

4) Wire sizes for board temperature: Below 40°C, wire type: 90°C wire

Table 2.2-6 Recommended Wire Sizes

ND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	30	FRN0059E2S-4□	5.5	8[*1]	8[*1]	5.5	8[*1]	2
	37	FRN0072E2S-4□	8[*1]	14	8[*1]	8[*1]	14	2
	45	FRN0085E2S-4□	14	22	8	14	14	2
	55	FRN0105E2S-4□	14	22	14	14	22	2
	75	FRN0139E2S-4□	22	-	14	22	38	2
	90	FRN0168E2S-4□	38	-	14	38	38	2
	110	FRN0203E2S-4□	38	-	22	38	60	2

HD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4□	3.5[*6]	5.5	5.5	3.5[*6]	5.5	2
	30	FRN0072E2S-4□	5.5	8[*1]	8[*1]	5.5	8[*1]	2
	37	FRN0085E2S-4□	8	14	8	8	14	2
	45	FRN0105E2S-4□	14	22	8	14	14	2
	55	FRN0139E2S-4□	14	22	14	14	22	2
	75	FRN0168E2S-4□	22	-	14	38	38	2
	90	FRN0203E2S-4□	38	-	14	38	38	2

HND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4□	3.5[*6]	5.5	5.5	3.5[*6]	5.5	2
	30	FRN0072E2S-4□	5.5	8[*1]	8[*1]	5.5	8[*1]	2
	37	FRN0085E2S-4□	8	14	8	8	14	2
	45	FRN0105E2S-4□	14	22	8	14	14	2
	55	FRN0139E2S-4□	14	22	14	14	22	2
	75	FRN0168E2S-4□	22	-	14	38	38	2
	90	FRN0203E2S-4□	38	-	14	38	38	2

The recommended wire sizes for the main circuit terminals assume using 75°C 600 V HIV wire.

*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.

*6 For compatible crimped terminal, please use model R5.5-6 by JST Mfg. Co., Ltd. or equivalent.

HHD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	18.5	FRN0059E2S-4□	3.5*6	5.5	5.5	3.5*6	3.5*6	2
	22	FRN0072E2S-4□	3.5*6	5.5	5.5	3.5*6	5.5	2
	30	FRN0085E2S-4□	5.5	8	8	5.5	8	2
	37	FRN0105E2S-4□	8	14	8	8	14	2
	45	FRN0139E2S-4□	14	22	8	14	14	2
	55	FRN0168E2S-4□	14	22	14	14	22	2
	75	FRN0203E2S-4□	22	-	14	38	38	2

The recommended wire sizes for the main circuit terminals assume using 75°C 600 V HIV wire.
*6 For compatible crimped terminal, please use model R5.5-6 by JST Mfg. Co., Ltd. or equivalent.

5) Wire sizes for board temperature: Below 50°C, wire type: 60°C wire

Table 2.2-7 Recommended Wire Sizes

ND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input (Note 1) [L1/R, L2/S, L3/T]		Ground terminal (Note 1) [⏚G]	Inverter output (Note 1) [U, V, W]	For DC reactor connection (Note 1) [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	30	FRN0059E2S-4□	14	22	8*1	14	22	2
	37	FRN0072E2S-4□	22	38	8*1	22	38	2
	45	FRN0085E2S-4□	38	38	8	38	38	2
	55	FRN0105E2S-4□	38	60	14	38	60	2
	75	FRN0139E2S-4□	60	-	14	60	100*5	3.5
	90	FRN0168E2S-4□	100*5	-	14	100*5	100*5	3.5
	110	FRN0203E2S-4□	100	-	22	100	150	5.5

Note 1) The rated current must be reduced for operation (Rated current x 80%). Recommended wire sizes assume these conditions.

The recommended wire sizes for the main circuit terminals assume using 60°C IV wire.
*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.
*5 For compatible crimped terminal, please use model CB100-S8 by JST Mfg. Co., Ltd. or equivalent.

HD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)					
			Main power supply input (Note 1) [L1/R, L2/S, L3/T]		Ground terminal (Note 1) [⏚G]	Inverter output (Note 1) [U, V, W]	For DC reactor connection (Note 1) *[P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4□	8*1	14	5.5	14	14	2
	30	FRN0072E2S-4□	14	22	8*1	14	22	2
	37	FRN0085E2S-4□	22	38	8	22	38	2
	45	FRN0105E2S-4□	38	38	8	38	38	2
	55	FRN0139E2S-4□	38	60	14	38	60	3.5
	75	FRN0168E2S-4□	60	-	14	60	100*5	3.5
	90	FRN0203E2S-4□	100	-	14	100	100	5.5

Note 1) The rated current must be reduced for operation (Rated current x 80%). Recommended wire sizes assume these conditions.

HND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4□	14	22	5.5	14	22	2
	30	FRN0072E2S-4□	22	38	8*1	22	38	2
	37	FRN0085E2S-4□	38	60	8	38	38	2
	45	FRN0105E2S-4□	38	60	8	38	60	2
	55	FRN0139E2S-4□	60	100*5	14	60	100*5	2
	75	FRN0168E2S-4□	100*5	-	14	100*5	100*5	3.5
	90	FRN0203E2S-4□	100	-	14	150*3	150	5.5

HHD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	18.5	FRN0059E2S-4□	14	22	5.5	14	14	2
	22	FRN0072E2S-4□	14	22	5.5	14	22	2
	30	FRN0085E2S-4□	22	38	8	22	38	2
	37	FRN0105E2S-4□	38	60	8	38	38	2
	45	FRN0139E2S-4□	38	60	8	38	60	2
	55	FRN0168E2S-4□	60	100*5	14	60	100*5	3.5
	75	FRN0203E2S-4□	100	-	14	100	100	5.5

The recommended wire sizes for the main circuit terminals assume using 60°C IV wire.
*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.
*3 For compatible crimped terminal, please use model CB150-10 by JST Mfg. Co., Ltd. or equivalent.
*5 For compatible crimped terminal, please use model CB100-S8 by JST Mfg. Co., Ltd. or equivalent.

6) Wire sizes for board temperature: Below 50°C, wire type: 75°C wire

Table 2.2-8 Recommended Wire Sizes

ND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input (Note 1) [L1/R, L2/S, L3/T]		Ground terminal (Note 1) [⊕G]	Inverter output (Note 1) [U, V, W]	For DC reactor connection (Note 1) [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	30	FRN0059E2S-4☐	8*1	14	8*1	8*1	14	2
	37	FRN0072E2S-4☐	8*1	14	8*1	14	14	2
	45	FRN0085E2S-4☐	14	22	8	14	22	2
	55	FRN0105E2S-4☐	22	38	14	22	22	2
	75	FRN0139E2S-4☐	38	-	14	38	38	2
	90	FRN0168E2S-4☐	38	-	14	38	60	2
	110	FRN0203E2S-4☐	60	-	22	60	60	3.5

Note 1) The rated current must be reduced for operation (Rated current x 80%). Recommended wire sizes assume these conditions.

HD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input (Note 1) [L1/R, L2/S, L3/T]		Ground terminal (Note 1) [⊕G]	Inverter output (Note 1) [U, V, W]	For DC reactor connection (Note 1) [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4☐	5.5	8*1	5.5	5.5	5.5	2
	30	FRN0072E2S-4☐	8*1	14	8*1	8*1	14	2
	37	FRN0085E2S-4☐	8	14	8	14	14	2
	45	FRN0105E2S-4☐	14	22	8	14	22	2
	55	FRN0139E2S-4☐	22	38	14	22	22	2
	75	FRN0168E2S-4☐	38	-	14	38	38	2
	90	FRN0203E2S-4☐	38	-	14	38	60	3.5

Note 1) The rated current must be reduced for operation (Rated current x 80%). Recommended wire sizes assume these conditions.

HND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)						
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4☐	5.5	14	5.5	8*1	8*1	2
	30	FRN0072E2S-4☐	14	14	8*1	14	14	2
	37	FRN0085E2S-4☐	14	22	8	14	22	2
	45	FRN0105E2S-4☐	22	38	8	22	22	2
	55	FRN0139E2S-4☐	22	38	14	38	38	2
	75	FRN0168E2S-4☐	38	-	14	60	60	2
	90	FRN0203E2S-4☐	60	-	14	60	100	2

HHD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	18.5	FRN0059E2S-4☐	5.5	8*1	5.5	5.5	5.5	2
	22	FRN0072E2S-4☐	5.5	14	5.5	8*1	8*1	2
	30	FRN0085E2S-4☐	14	14	8	14	14	2
	37	FRN0105E2S-4☐	14	22	8	14	22	2
	45	FRN0139E2S-4☐	22	38	8	22	22	2
	55	FRN0168E2S-4☐	22	38	14	38	38	2
	75	FRN0203E2S-4☐	38	-	14	60	60	2

The recommended wire sizes for the main circuit terminals assume using 75°C 600 V HIV wire.
*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.

7) Wire sizes for board temperature: Below 50°C, wire type: 90°C wire

Table 2.2-9 Recommended Wire Sizes

ND Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input (Note 1) [L1/R, L2/S, L3/T]		Ground terminal (Note 1) [⏚G]	Inverter output (Note 1) [U, V, W]	For DC reactor connection (Note 1) [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	30	FRN0059E2S-4□	5.5	8*1	8*1	5.5	5.5	2
	37	FRN0072E2S-4□	5.5	14	8*1	8*1	8*1	2
	45	FRN0085E2S-4□	8	14	8	8	14	2
	55	FRN0105E2S-4□	14	22	14	14	14	2
	75	FRN0139E2S-4□	22	-	14	22	38	2
	90	FRN0168E2S-4□	22	-	14	38	38	2
	110	FRN0203E2S-4□	38	-	22	38	60	2

Note 1) The rated current must be reduced for operation (Rated current x 80%). Recommended wire sizes assume these conditions.

HD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm^2)					
			Main power supply input (Note 1) [L1/R, L2/S, L3/T]		Ground terminal (Note 1) [⏚G]	Inverter output (Note 1) [U, V, W]	For DC reactor connection (Note 1) [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4□	3.5*6	5.5	5.5	3.5*6	3.5*6	2
	30	FRN0072E2S-4□	5.5	8*1	8*1	5.5	5.5	2
	37	FRN0085E2S-4□	5.5	14	8	8	8	2
	45	FRN0105E2S-4□	8	14	8	14	14	2
	55	FRN0139E2S-4□	14	22	14	14	14	2
	75	FRN0168E2S-4□	22	-	14	22	38	2
	90	FRN0203E2S-4□	22	-	14	38	38	2

Note 1) The rated current must be reduced for operation (Rated current x 80%). Recommended wire sizes assume these conditions.

The recommended wire sizes for the main circuit terminals assume using 75°C 600 V HIV wire.
*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.
*6 For compatible crimped terminal, please use model R5.5-6 by JST Mfg. Co., Ltd. or equivalent.

HND Mode

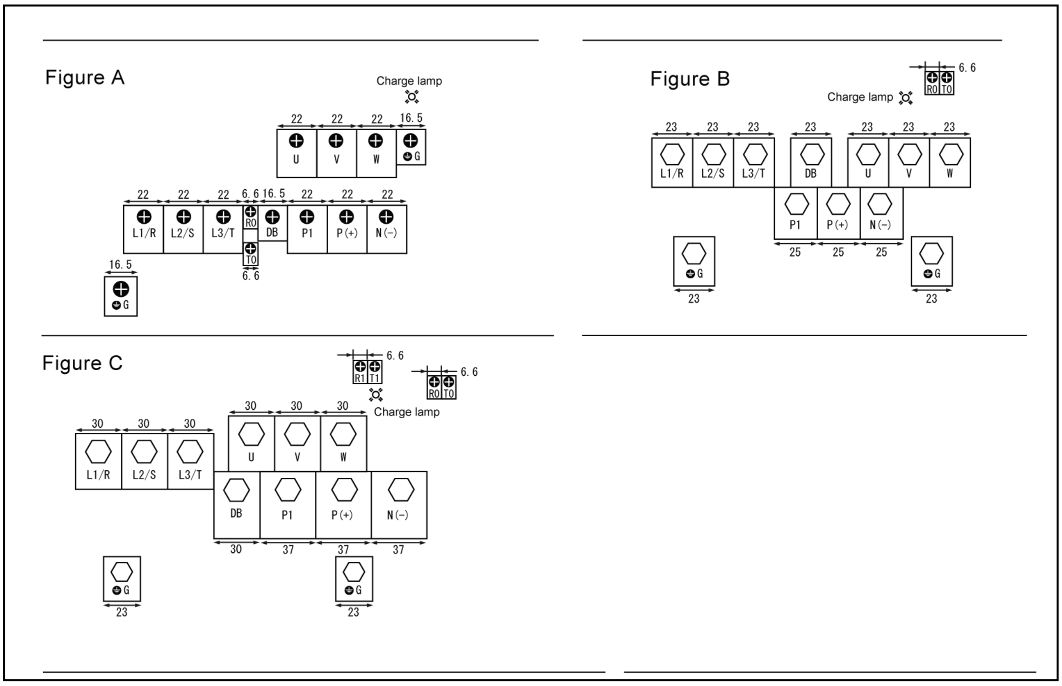
Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	22	FRN0059E2S-4□	5.5	8*1	5.5	5.5	5.5	2
	30	FRN0072E2S-4□	8*1	14	8*1	8*1	8*1	2
	37	FRN0085E2S-4□	8	14	8	14	14	2
	45	FRN0105E2S-4□	14	22	8	14	22	2
	55	FRN0139E2S-4□	22	38	14	22	22	2
	75	FRN0168E2S-4□	38	-	14	38	38	2
	90	FRN0203E2S-4□	38	-	14	38	60	2

HHD Mode

Power System	Std Applicable Motor (kW)	Inverter type	Recommended wire size (mm²)					
			Main power supply input [L1/R, L2/S, L3/T]		Ground terminal [⏚G]	Inverter output [U, V, W]	For DC reactor connection [P1, P(+)]	For braking resistor connection [P(+), DB]
			With DC reactor	Without DC reactor				
3 Phase 400 V	18.5	FRN0059E2S-4□	3.5*6	5.5	5.5	3.5*6	5.5	2
	22	FRN0072E2S-4□	5.5	8*1	5.5	5.5	5.5	2
	30	FRN0085E2S-4□	8	14	8	8	8	2
	37	FRN0105E2S-4□	8	14	8	14	14	2
	45	FRN0139E2S-4□	14	22	8	14	22	2
	55	FRN0168E2S-4□	22	38	14	22	22	2
	75	FRN0203E2S-4□	38	-	14	38	38	2

The recommended wire sizes for the main circuit terminals assume using 75°C 600 V HIV wire.
*1 For compatible crimped terminal, please use model 8-L6 by JST Mfg. Co., Ltd. or equivalent.
*6 For compatible crimped terminal, please use model R5.5-6 by JST Mfg. Co., Ltd. or equivalent.

[2] Terminal Layout Diagram (Main Circuit Terminal)



[3] Description of Terminal Functions (Main Circuit Terminal)

Classification	Terminal symbol	Terminal name	Specification
Main circuit	L1/R, L2/S, L3/T	Main power input	Terminals to connect 3 phase power source.
	U, V, W	Inverter output	Terminals to connect 3 phase motors.
	P (+), P1	For direct current reactor connection	Terminals to connect DC reactor (DCR) for power factor enhancement. ND mode: Types larger than FRN0139E2S-4☐, HD/HND mode: Types larger than FRN0168E2S-4☐, HHD mode: Always connect for FRN0203E2S-4☐.
	P (+), N (-)	For direct current bus connection	Terminals to connect direct current intermediate circuit of other inverters and PWM converters.
	P (+), DB	For braking resistor connection	Terminals to connect P (+) terminal of braking resistor (option) and DB. (Wiring length: Below 5 meters) (Types smaller than FRN0072E2S-4☐)
	⏚ G	For inverter chassis (case) grounding	Grounding terminal for inverter chassis (case).
	R0, T0	Auxiliary power input for brakes	When retaining the integrated alarm signal for the activation of the protective function at inverter main power supply shut off is desired, or when continuous display of the keypad is desired, connect this terminal to the power supply.
	R1, T1	Auxiliary power input for fan	Ordinarily, the terminal does not need to be connected. Connect these terminals to AC power supply when operating with direct current power input (such as in combination with PWM converters).

Follow the steps below when wiring.

(1)Inverter ground terminal (⏚G)
(2)Inverter output terminals (U, V, W), motor ground terminal (⏚G)
(3)Direct current reactor connection terminals (P1, P(+))*
(4)Braking resistor connection terminals (P(+), DB)*
(5)Direct current bus connection terminals(P(+), N(-))*
(6)Main power supply input terminals (L1/R, L2/S, L3/T) or (L1/L, L2/N)
* Connect as necessary

(1) Main power source input terminals L1/R, L2/S, L3/T (3 phase input)

Connect the 3 phase power source.

1) For safety, confirm that the circuit breaker (MCCB) or the magnetic contactor (MC) is OFF prior to wiring the power lines.
2) Connect the power lines (L1/R, L2/S, L3/T) to MCCB or residual-current-operated protective device (RCD)/ the earth leakage breaker (ELCB)*, or connect via MC as necessary. The phase sequence of the power lines and the inverter do not need to be matched.

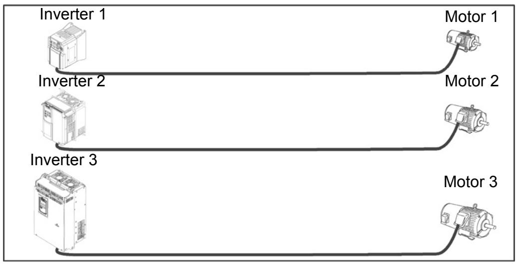
* With overcurrent protection

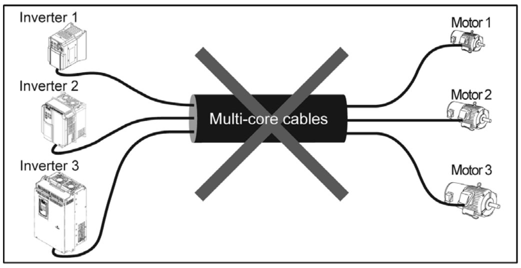
Tip: In emergencies such as when the inverter protective function is activated, disconnecting the inverter from the power source to prevent magnification of failure or accident may be desired. Installation of an MC which allows manual disconnection of the power source is recommended.

(2) Inverter output terminals U, V, W, motor ground terminal ⏚G

1) Connect the 3 phase motor terminals U, V, and W while matching the phase sequence.
2) Connect the ground line of the outputs (U, V, W) to the ground terminal (⏚G).

Note: When multiple combinations of inverters and motors exist, do not use multi-core cables for the purpose of bundling the various wires.





(3) Direct current reactor connection terminals P1, P(+)

Connect the direct current reactor (DCR) for power factor enhancement.

1) Remove the shorting bar from terminals P1-P(+).
   (FRN0203E2S-4☐ will not have the shorting bar connected.)
2) Connect the P1, P(+) terminals for the direct current reactor (option).

Note
- Keep the wiring length below 10 meters.
- Do not remove the shorting bar if the direct current reactor is not used.
- When the capacity of the motor to be used is above 75 kW, always connect the direct current reactor.
- Direct current reactors do not have to be connected when connecting PWM converters.

⚠WARNING

Always connect the direct current reactor (option) when the power supply transformer capacity is above 500 kVA and is over 10 times the rated capacity of the inverter.

Risk of fire exists.

(4) Braking resistor connection terminals P(+) DB (Types smaller than FRN0072E2S-4☐)

1) Connect terminals P(+), DB for the braking resistor (option).
2) Position the inverter main body and the braking resistor such that the wiring length will be less than 5 meters and route the two wires twisted or in contact with each other (parallel).

⚠WARNING

Do not connect to terminals other than P(+)-DB when connecting braking resistors.

Risk of fire exists.

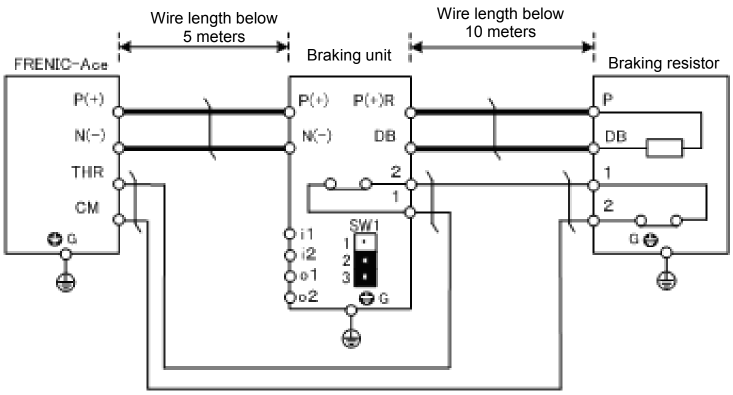
(5) Direct current bus terminals P(+), N(-)

1) Connecting the braking unit/braking resistor (option)

Inverter type	Braking transistor	Additional instruments for connection (option)	Instruments connected/connection terminals
Types larger than FRN0085E2S-4☐	Not equipped	Braking unit	Inverter (P(+), N(-)) - Braking unit (P(+), N(-))
		Braking resistor	Braking unit (P(+) R, DB) - Braking resistor (P, DB)

Braking units are necessary when using braking resistors for types larger than FRN0085E2S-4☐.

Connect terminals P(+), N(-) of the braking unit to the inverter terminals P(+), N(-). Position the equipment such that the wiring length is below 5 meters and route the two wires twisted or in contact with each other (parallel).
Connect the terminals P(+) R, DB of the braking unit to terminals P(+), DB of the braking resistor. Position the equipment such that the wiring length is below 10 meters and route the two wires twisted or in contact with each other (parallel).
For details such as other wirings, refer to the user's manual for the braking unit.



2) Connection of other instruments

The direct current intermediate circuit of other inverters and PWM converters can be connected.

(For connection with the PWM converter, refer to Chapter 11 "11.9 High Power Factor Regenerative PWM Converter (RHC series)").

(6) Inverter ground terminal ⏚G

The terminal is the ground terminal for the inverter chassis (case). Always connect to ground for safety and as a countermeasure for noise. To prevent accidents such as electric shock and fire, the electric facility technical standards require grounding construction for metallic frames in electric instruments.

Follow the steps below in connecting the ground terminal on the power supply side.

1) For 400 V series, connect to the grounding electrode with C type construction, following the electric facility technical standards.
2) The grounding wire should be thick, with large surface area, and as short as possible.

Table 2.2-10 Grounding of instruments according to the electric facility technical standards

Power supply voltage	Type of grounding construction	Ground resistance
3 phase 400 V	C type grounding construction	Below 10 Ω

(7) Auxiliary power input terminals for control circuit R0, T0

The inverter can be operated without power input to the auxiliary power input terminals for control circuit. However, the various inverter output signals and the keypad display will be terminated when the inverter main power is shut off and the control power source is lost.

When retaining the integrated alarm signal for the activation of the protective function at inverter main power supply shut off is desired, or when continuous display of the keypad is desired, connect these terminals to the power supply. When the inverter input side has a magnetic contactor (MC), wire from the input side (primary side) of the magnetic contactor (MC).

Terminal rating: AC 380 to 480 V, 50/60 Hz, maximum current 0.5 A (400 V series)

Note When connecting the earth leakage breaker, connect terminals R0, T0 to the output side of the earth leakage breaker.
When connections are made to the input side of the earth leakage breaker, the earth leakage breaker will malfunction because the inverter input is 3 phase and the terminals R0, T0 are single phase. When connecting to terminals R0, T0 from the input side of the earth leakage breaker, make sure that the insulating transformer is positioned as in the figure below, or make sure to connect the auxiliary B contact of the magnetic contactor.

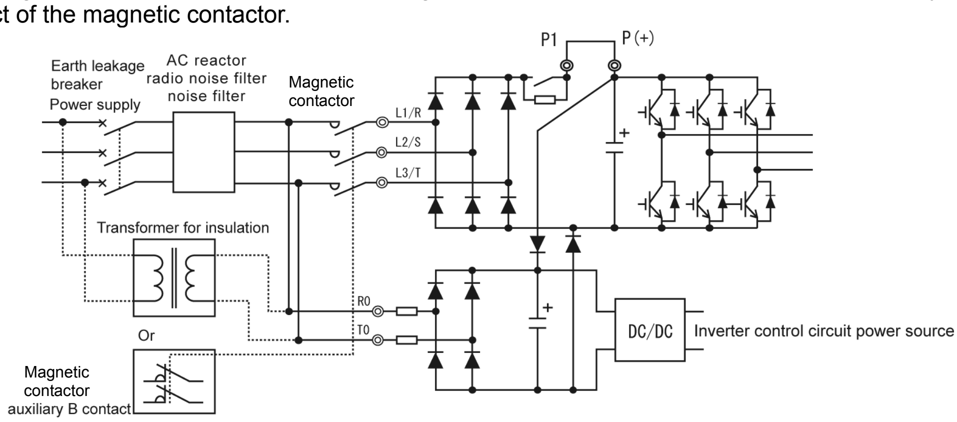


Figure 2.2-5 Connection of the Earth Leakage Breaker

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Note: When connecting with the PWM converter, do not connect power source directly to the inverter's auxiliary power input terminals (R0, T0) for control circuit. Insert an insulating transformer or the auxiliary B contact of a magnetic contactor on the power supply side.
On connection examples for the PWM converter side, refer to Chapter 11 "11.9 High Power Factor Regenerative PWM Converter (RHC series)".

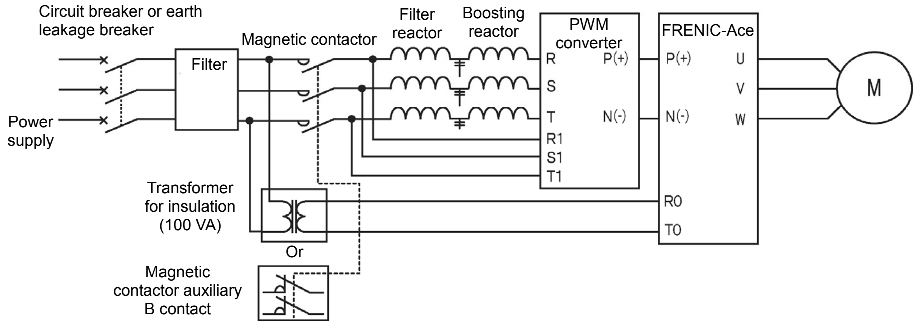


Figure 2.2-6 Example of Grounding in Combination with PWM Converter

(8) Auxiliary power input terminals for fan R1, T1

The terminals are equipped on FRN0203E2S-4☐ but is not used ordinarily.

Connect AC power source when using direct current power supply input (such as in combination with PWM converters).

Also switch the fan power supply switching connectors "CN R", "CN W".

Terminal rating: AC 380 to 440 V/50 Hz, 380 to 480 V/60 Hz, maximum current 1.0 A (400 V series)

2.2.6 Control Circuit Terminals (Common to All Models)

[1] Screw Specifications and Recommended Wire Size (Control Circuit Terminal)

The screw specifications and wire sizes to be used for control circuit wiring are shown below.

The control circuit terminal box differs by destination.

Table 2.2-11 Screw Specifications and Recommended Wire Sizes

Terminal symbol	Screw specification		Allowable wire sizes	Driver (shape of tip)	Removal size of wire cover (ℓ)	Gauge size to insert wire
	Size	Tightening torque				
30A, 30B, 30C EN1, EN2	M3	0.5 to 0.6 N·m	0.14 to 1.5 mm^2 (AWG26 to 16)	Minus (0.6 mm×3.5 mm)	6 mm	A1*1
Others	M2	0.22 to 0.25 N·m	0.14 to 1 mm^2 (AWG26 to 18)	Minus (0.4 mm×2.5 mm)	5 mm	φ1.6

* Recommended rod terminal: Phoenix Contact Refer to Table 2.2-12 for details.

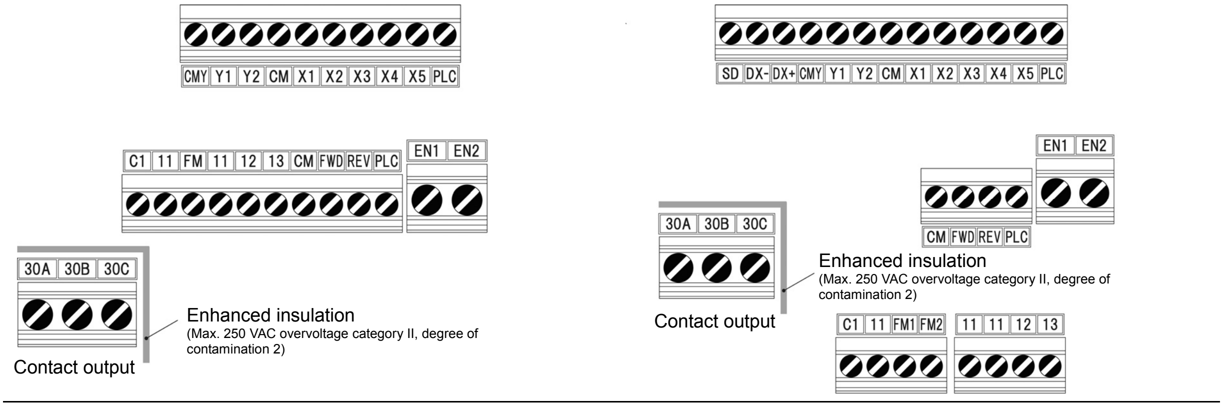
*1 Defined according to IEC/EN 60947-1.

Table 2.2-12 Recommended Rod Terminals

Screw size		Wire size	Type	
			With insulating collar	Without insulating collar
M3	M2	0.25 mm^2 (AWG24)	AI 0.25-6 BU	A 0.25-7
		0.34 mm^2 (AWG22)	AI 0.34-6 TQ	A 0.34-7
		0. 5 mm^2 (AWG20)	AI 0.5-6 WH	A 0.5-6
		0.75 mm^2 (AWG18)	AI 0.75-6 GY	A 0.75-6
		1 mm^2 (AWG18)	AI 1-6 RD	A 1-6
		1.5 mm^2 (AWG16)	AI 1.5-6 BK	A 1.5-7

Note) When sizes exceeding the recommended wire sizes are used, the front cover may be pushed outward depending on the number of wires, causing erroneous operation of the keypad.

[2] Terminal Layout Diagram (Control Circuit Terminal)



Destination: A and E   Destination: C

⚠WARNING⚠

The following terminals will have high voltage when the power is ON.

Control terminals: AUX-contact (30A, 30B, 30C, Y5A, Y5C)

Insulation level

Contact output – control circuit : Enhanced insulation (overvoltage category II, degree of contamination 2)

Risk of electric shock exists

[3] Description of Terminal Functions (Control Circuit Terminal)

⚠WARNING⚠

Generally, the insulation for control signal lines are not enhanced. When the control signal lines come into direct contact with the main circuit live section, the insulation cover may be damaged. High voltage of the main circuit may be applied on the control signal lines, so exercise caution such that the main circuit live sections do not contact the control signal lines.

Risk of accidents and risk of electric shock exist.

⚠CAUTION

Noise is generated by the inverter, motor, and wiring.

Exercise caution to prevent malfunction of peripheral sensors and instruments.

Risk of accidents exists.

Table 2.2-13 shows the functional explanations for the control circuit terminals. The connection method differs for the control circuit terminals depending on the functional code setting matching the purpose of inverter operation.

Properly wire such that the impact of noise generated by the main circuit wiring is reduced.

Table 2.2-13 Functional Description of Control Circuit Terminals

Classification	Terminal symbol	Terminal name	Functional description
Analog input	[13]	Power source for variable resistor	The terminal is used for the power source (DC+10 V 10 mA Max) for the external speed setup device (variable resistor: 1 to 5 kΩ). Connect variable resistors larger than 1/2 W.
	[12]	Analog setup voltage input	(1) Frequency is set up according to the external analog voltage input command value. Normal operation • DC0 to +10 V/0 to 100(%) (DC0 to +5 V/0 to 100%) • DC0 to ±10 V/0 to ±100(%) (DC0 to ±5 V/0 to ±100%) Reverse operation • DC+10 to 0 to -10 V/-100% to 0 to 100(%) • DC-10 to 0 to +10 V/+100% to 0 to -100(%) (2) The terminal can be assigned to PID command, feedback signal of PID control, auxiliary frequency setup, ratio setup, torque limit setup, and analog input monitor aside from the frequency setup by analog input. (3) Hardware specification * Input impedance: 22 (kΩ) * Up to DC±15 V can be input. However, input exceeding DC±10 V will be recognized as DC±10 V.
	[C1]	Analog setup current input (C1 function)	(1) Frequency is set up according to the external analog current input command value. Normal operation • DC4 to 20 mA/0 to 100(%)/-100% to 0 to 100% • DC0 to 20 mA/0 to 100(%)/-100% to 0 to 100% Reverse operation • DC20 to 4 mA/0 to 100(%)/-100% to 0 to 100% • DC20 to 0 mA/0 to 100(%)/-100% to 0 to 100% (2) The terminal can be assigned to PID command, feedback signal of PID control, auxiliary frequency setup, ratio setup, torque limit setup, and analog input monitor aside from the frequency setup by analog input. (3) Hardware specification * Input impedance: 250 (Ω) * Up to DC 30 mA can be input. However, input exceeding DC 20 mA will be recognized as DC 20 mA.

Table 2.2-13 Functional Description of Control Circuit Terminals (continued)

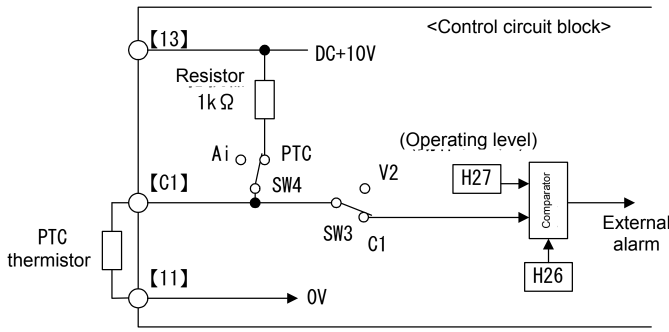
<table>
<tr><th>Classification</th><th>Terminal symbol</th><th>Terminal name</th><th>Functional description</th></tr>
<tr><td rowspan="5">Analog input</td><td rowspan="3">[C1]</td><td>Analog setup voltage input
(V2 function)</td><td>(1) Frequency is set up according to the external analog voltage input command value.
SW3 (refer to "2.2.8 Operating Various Switches") must be switched on the printed circuit board.
Normal operation
• DC0 to +10 V/0 to 100(%) (DC0 to +5 V/0 to 100%)
• DC0 to +10 V/-100 to 0 to 100(%) (DC0 to +5 V/-100 to 0 to 100%)
Reverse operation
• DC+10 to 0 V/0 to 100(%) (DC＋5 V to 0 V/0 to 100%)
• DC+10 to 0 V/-100 to 0 to -100(%) (DC+5 to 0 V/-100 to 0 to 100%)
(2) The terminal can be assigned to PID command, feedback signal of PID control, auxiliary frequency setup, ratio setup, torque limit setup, and analog input monitor aside from the frequency setup by analog input.
(3) Hardware specification
* Input impedance: 22(kΩ)
* Up to DC±15 V can be input. However, input exceeding DC±10 V will be recognized as DC±10 V.</td></tr>
<tr><td>PTC thermistor input
(PTC function)</td><td>(1) PTC (Positive Temperature Coefficient) thermistor for motor protection can be connected. SW3 (C1/V2 Switch) and SW4 (PTC /AI Switch) (refer to "2.2.8 Operating Various Switches") must be switched on the printed circuit board.
The following figure shows the internal circuit when SW3 and SW4 are set for PTC thermistor input. For details on SW3 and SW4, refer to "2.2.8 Operating Various Switches". When SW3 and SW4 are switched to the PTC side, function code H26 also needs to be changed.


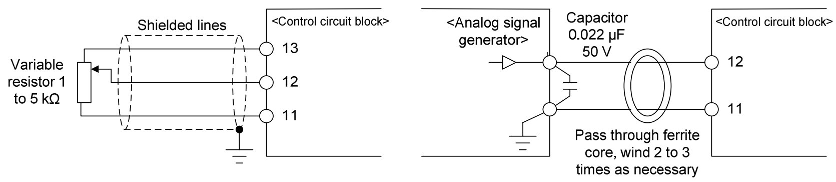
Figure 2.2-7 Internal circuit when SW5 is switched to PTC side</td></tr>
<tr><td>Analog input monitor
(AI function)</td><td>(1) The analog input monitor can be used to monitor the status of peripheral instruments using communication by inputting the analog signals of various sensors such as temperature sensors. Data can be converted to physical property values such as temperature and pressure by using display factors and shown on the keypad display.</td></tr>
<tr><td>[11]</td><td>Analog input common</td><td>The terminal is the common terminal for analog input signals (terminals [12], [13], [C1]).
The terminal is insulated against terminals [CM], [CMY].</td></tr>
<tr><td>Note</td><td colspan="2">• Use shielded lines and keep the wiring to the minimum as possible (below 20 meters) for control signals which are susceptible to external noise. Grounding the external layer of the shielded lines is generally recommended, but if external induction noise is large, connecting to terminal 11 may reduce the noise. The shielded line increases the blocking effect. Always ground one end as shown in figure 2.2-8.
• When creating contacts to analog input signal lines, use twin contacts for small signals. Also, do not insert contacts to terminal 11.
• When external analog signal generators are connected, the analog signal generator circuit may malfunction due to the noise created by the inverter. In these cases, connect ferrite core (toroidal shape or equivalent) to the output terminals of the analog signal generator or connect high frequency capacitors between the control signal lines, as shown in figure 2.2-9.


Figure 2.2-8 Connection Diagram for Shielded Lines, Figure 2.2-9 Example of Noise Countermeasure</td></tr>
</table>

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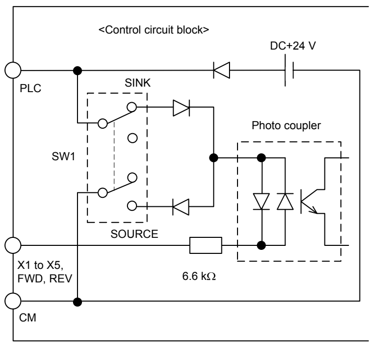
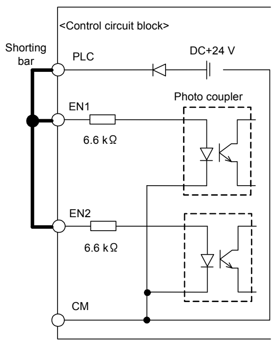
Table 2.2-13 Functional Description of Control Circuit Terminals (continued)

<table>
<tr><th>Classification</th><th>Terminal symbol</th><th>Terminal name</th><th>Functional description</th></tr>
<tr><td rowspan="9">Digital input</td><td>[X1]</td><td>Digital input</td><td rowspan="7">(1) Various signals (coast to a stop command, external alarm, multi-speed selection, etc) set up by function codes E01 to E05, E98, E99 can be set up.
For details, refer to “Chapter 5 Function Codes”.
(2) Input mode, sink/source can be switched using SW1.
(Refer to “2.2.8 Operating Various Switches”)
(3) The operating mode between various digital input terminals and terminal CM can be switched to “ON when shorted (active ON)” or “OFF when shorted (active OFF)”. (SINK side)
(4) Digital input terminal [X5] can be set up as a pulse train input terminal by changing the function code
Maximum wiring length 20 meters
Maximum input pulse
30 kHz: When connected to open collector output pulse generator
(pull-up, pull-down resistors required, refer to caution on page 2-21)
100 kHz: When connected to complementary output pulse generator
For function code settings, refer to “Chapter 5 Function Codes”

<Digital input circuit specification>


<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 at ON
(at input voltage 0 V)
(for [X5] input terminal)</td><td>2.5 mA
(9.7 mA)</td><td>5 mA
(16 mA)</td></tr>
<tr><td colspan="2">Allowable leak current at OFF</td><td>-</td><td>0.5 mA</td></tr>
</table>
Figure 2.2-10 Digital Input Circuit</td></tr>
<tr><td>[X2]</td><td>Digital input 2</td></tr>
<tr><td>[X3]</td><td>Digital input 3</td></tr>
<tr><td>[X4]</td><td>Digital input 4</td></tr>
<tr><td>[X5]</td><td>Digital input 5/pulse train input</td></tr>
<tr><td>[FWD]</td><td>Run forward command</td></tr>
<tr><td>[REV]</td><td>Run reverse command</td></tr>
<tr><td>[EN1]
[EN2]</td><td>Enable input</td><td>(1) When terminals [EN1]-[PLC] or terminals [EN2]-[PLC] are OFF, the inverter output transistors stop functioning. (safe torque off: STO)
Be sure to operate terminals [EN1] and [EN2] simultaneously; otherwise an ECF alarm is issued and the operation of the inverter will be disabled.
To enable the Enable function, remove the short bar.
(2) The input mode for terminals [EN1] and [EN2] is fixed to source. The mode cannot be switched to sink.
(3) Short terminals [EN1]-[PLC] and [EN2] – [PLC] using shorting bars when the enable input function is not used. (Keep the shorting bar connected).
<EN terminal circuit spec>


<table>
<tr><th colspan="2">Item</th><th>Min</th><th>Max</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 at ON
(at input voltage 24 V)</td><td>-</td><td>4.5 mA</td></tr>
<tr><td colspan="2">Allowable leak current at OFF</td><td>-</td><td>0.5 mA</td></tr>
</table></td></tr>
<tr><td>[PLC]</td><td>Programmable controller signal power source</td><td>(1) The terminal is used for connecting the output signal power source of the programmable controller (rated voltage DC +24 V (power supply voltage fluctuation range: DC +22 to +27 V) maximum 100 mA).
(2) The terminal can also be used for the power source for the load connected to the transistor output. For details, refer to the page on transistor output.</td></tr>
</table>

Table 2.2-13 Functional Description of Control Circuit Terminals (continued)

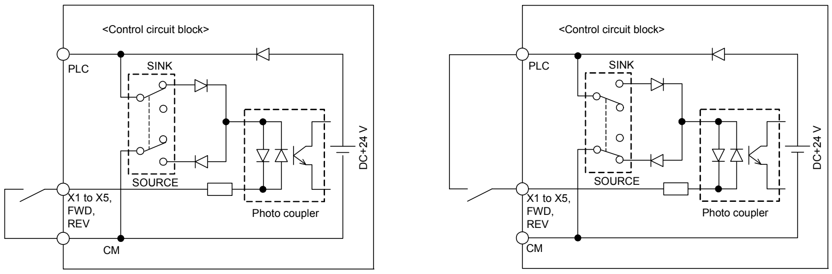
Classification	Terminal symbol	Terminal name	Functional description
Digital Input	[CM]	Digital common	This terminal is the common terminal for digital input signals. This terminal is insulated against terminals [11] and [CMY].

Tip

■ When turning terminals [FWD], [REV], [X1] to [X5] ON and OFF using relay contacts

Figure 2.2-11 shows an example of the circuit configuration using relay contact. Circuit (a) in Figure 2.2-11 shows the switch on the sink side and circuit (b) shows the switch on the source side.

Caution: Use a relay which will not have contact failures (high contact reliability).
(Recommended product: Fuji Electric's control relay type: HH54PW)



(a) Switch on sink side (b) Switch on source side

Figure 2.2-11 Circuit Configuration Example Using Relay Contact

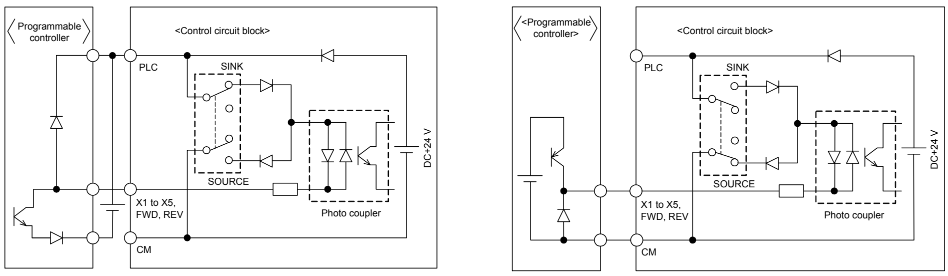
Tip

■ When turning terminals [FWD], [REV], [X1] to [X5] ON and OFF using the programmable controller

Figure 2.2-12 shows an example of the circuit configuration using programmable controller. Circuit (a) in Figure 2.2-12 shows the switch (SW1) on the sink side and circuit (b) shows the switch on the source side.

In circuit (a), terminals [FWD], [REV] , [X1] to [X5] can be turned ON/OFF by shorting/opening the open collector transistor output of the programmable controller using the external power supply. Follow the commands below when using this type of circuit.

- Connect the + side of the external power supply which is insulated from the programmable controller power supply to terminal [PLC].
- Do not connect the inverter's [CM] terminal and the common terminal of the programmable controller.



(a) Switch on the sink side (b) Switch on the source side

Figure 2.2-12 Circuit Configuration Example Using Programmable Controller

Refer to "2.2.8 Operation of Various Switches" for more information on switches.

Table 2.2-13 Functional Description of Control Circuit Terminals (continued)

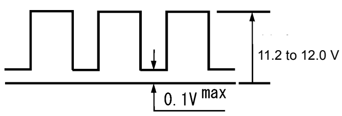
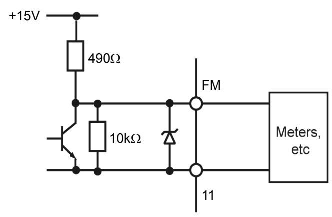
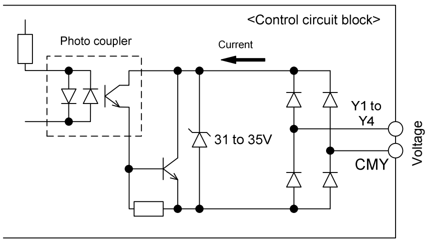
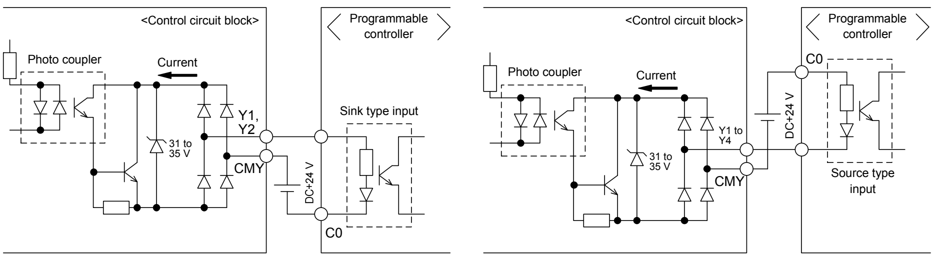
Classification	Terminal symbol	Terminal name	Functional description
Analog output/pulse output	[FM]	Analog monitor FMV function FMI function	The terminal outputs analog direct current voltage DC0 to 10 V or analog direct current/ DC4 to 20 mA monitor signal. The output form (FMV/FMI) can be switched using SW5 on the printed circuit board and function code F29. Refer to “Table 2.2-14 Functional Description of Various Switches”. The signal content can be chosen in the function code F31 data setting among the following items. ・Output frequency (prior to slip compensation) ・Output frequency (after slip compensation) ・Output Current ・Output torque ・Load factor ・Power consumption ・Output voltage ・PID feedback value (PV) ・Direct current intermediate circuit voltage ・Universal AO ・Motor output ・Analog output test ・PID command value (SV) ・PID output (MV) ・Customized logic output 1 to 5 ・Inverter cooling fin temperature * Allowable impedance for connection: Min 5 kΩ (at DC to 10 V output) (up to 2 analog volt meters (DC0 to 10 V, input impedance 10 kΩ) can be connected.) * Allowable impedance for connection: Max 500 Ω (at DC4 to 20 mA/DC0 to 20 mA) (in the case of output) * Gain adjustable range: 0 to 300%
		Pulse monitor FMP function	The terminal outputs pulse signal. Signal content can be chosen as with the FMV function by function code F31 setting. The output form (FMP) can be switched using SW5 on the printed circuit board and function code F29. Refer to “Table 2.2-14 Functional Description of Various Switches”. * Allowable impedance for connection: Min. 5 kΩ (at DC to 10 V output) (up to 2 analog volt meters (DC0 to 10 V, input impedance 10 kΩ) can be connected.) * Pulse duty: Approximately 50%, pulse rate: 25 to 32000 p/s (at full scale) • Pulse output waveform  • FMP output circuit 
	[FM2]	Analog monitor FMV2 function FMI2 function	The terminal outputs analog direct current voltage DC0 to 10 V or analog direct current DC4 to 20 mA monitor signal. The output form (FMV2/FMI2) can be switched using SW7 on the printed circuit board and function code F32. Refer to “Table 2.2-14 Functional Description of Various Switches”. Signal content can be chosen as with the FMV function by function code F35 setting. * Allowable impedance for connection: Min 5 kΩ (at DC to 10 V output) (up to 2 analog volt meters (D0 to 10 V, input impedance 10 kΩ) can be connected.) * Allowable impedance for connection: Max 500 Ω (at DC4 to 20 mA) * Gain adjustable range: 0 to 300% * This terminal is equipped only on FRN○○○E2S-4C.
	[11]	Analog output common terminal	This terminal is the common terminal for analog input/pulse output signals. The terminal is insulated against terminals [CM] and [CMY]. Do not use them as common terminal for [FM], [FM2].

Table 2.2-13 Functional Description of Control Circuit Terminals (continued)

<table>
<tr><th>Classification</th><th>Terminal symbol</th><th>Terminal name</th><th>Functional description</th></tr>
<tr><td rowspan="4">Transistor output</td><td>[Y1]</td><td>Transistor output 1</td><td rowspan="2">
(1) Various signals (running signal, frequency reached signal, overload forecast signal, etc) set up by function code E20, E21 can be output. For details, refer to “Chapter 5 Function Codes”.
(2) The operating mode between transistor output terminals [Y1], [Y2] and terminal CMY can be switched to “ON (active ON) at signal output” or “OFF (active OFF) at signal 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>3 V</td></tr>
<tr><td>OFF level</td><td>27 V</td></tr>
<tr><td colspan="2">Max load current at ON</td><td>50 mA</td></tr>
<tr><td colspan="2">Leak current at OFF</td><td>0.1 mA</td></tr>
</table>
Figure 2.2-13 Transistor Output Circuit

Note
• Connect surge absorbing diode on both ends of the excitation coil when connecting control relays.
• When a power source is needed for the circuit to be connected, terminal PLC can be used as a power source terminal (DC24 V (power supply voltage fluctuation range: DC22 to 27 V), maximum 50 mA). In this case, terminal [CMY] must be shorted to terminal [CM].
</td></tr>
<tr><td>[Y2]</td><td>Transistor output 2</td></tr>
<tr><td>[CMY]</td><td>Transistor output common</td><td>This terminal is the common terminal for transistor output signals.
This terminal is insulated against terminals [CM] and [11].</td></tr>
<tr><td colspan="3">
Tip
■ When connecting the programmable controller to terminals [Y1], [Y2].
The circuit configuration example for connecting the inverter transistor output to the programmable controller is shown in Figure 2.2-14. Circuit (a) in figure 2.2-14 shows the programmable controller input circuit as sink input and circuit (b) shows as the source input case.


(a) Connection diagram for sink input type programmable controller
(b) Connection diagram for source input type programmable controller
Figure 2.2-14 Example of Connection Circuit Configuration with Programmable Controller
</td></tr>
<tr><td>Contact output</td><td>[30A/B/C]</td><td>Integrated alarm output</td><td>
(1) When the inverter stops with an alarm, output is generated on the relay contact (1C). Contact capacitance: AC250 V 0.3 A cosϕ = 0.3, DC48 V 0.5 A
(2) Terminals can be switched to “Terminals [30A to 30C] shorted (excitation: active ON) at ON signal output” or “Terminals [30A to 30C] open (non-excitation: active OFF) at ON signal output”
</td></tr>
</table>

Table 2.2-13 Functional Description of Control Circuit Terminals (continued)

<table>
<tr><th>Classification</th><th>Terminal symbol</th><th>Terminal name</th><th>Functional description</th></tr>
<tr><td>Communication</td><td>RJ-45 connector for keypad connection</td><td>RJ-45 connector for keypad connection

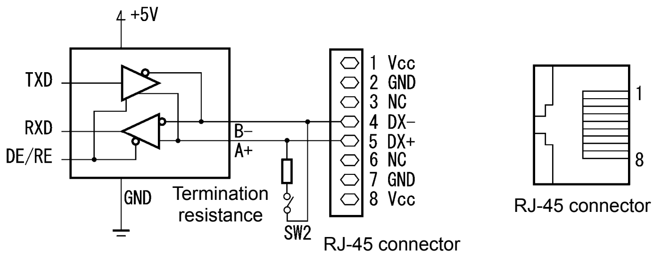
RS-485 communication port 1</td><td>(1) The terminal is used as a connector to connect the keypad. The power to the keypad will be supplied from the inverter via the extended cable for remote operation.
(2) The terminal is a connector to connect the computer, programmable controller, etc by RS-485 communication, after removing the keypad. (On termination resistance, refer to “2.2.8 Operation of Various Switches”).


Figure 2.2-15 RJ-45 Connector Pin-layout

• Pins 1, 2, 7, and 8 are assigned as power supply source for the keypad. When connecting this RJ-45 connector to other instruments, do not use these pins.</td></tr>
<tr><td></td><td>RJ-45 connector for RS-485 /CANopen communica-tion</td><td>RS-485 communication port 2

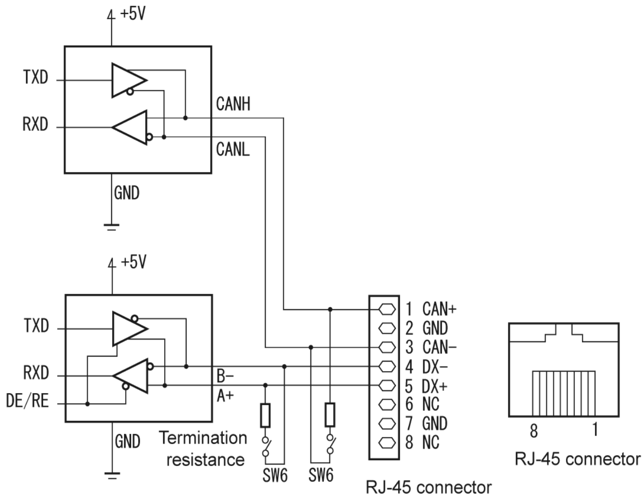
CANopen communication port</td><td>(1) The terminal is a connector to connect the computer, programmable controller, etc by RS-485 communication. (On termination resistance, refer to “2.2.8 Operation of Various Switches”).
(2) The terminal is a connector to connect the computer, programmable controller, etc by CANopen communication. (On termination resistance, refer to “2.2.8 Operation of Various Switches”).


Figure 2.2-16 RJ-45 Connector Pin-layout

* Equipped only on FRN○○○E2S-4A, -4E.</td></tr>
<tr><td></td><td>[DX+ /DX- /SD]</td><td>RS-485 Communication port 2

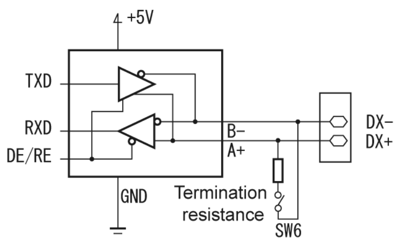
(terminal block)</td><td>The terminal is an I/O terminal to connect the computer, programmable controller, etc by RS-485 communication. (On termination resistance, refer to “2.2.8 Operation of Various Switches”)


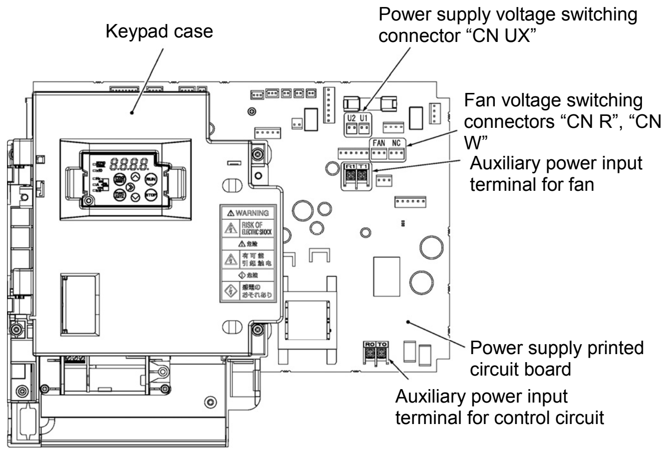
Figure 2.2-17 RS-485 Communication Port 2 Terminal Block Pin-layout

* Equipped only on FRN○○○E2S-4C.</td></tr>
</table>

2.2.7 Switching Connector

■ Position of each connector

The individual switching connectors are positioned on the power supply printed circuit board as shown in the figure below.



(a) Case of FRN0059E2S-4☐ to FRN0203E2S-4☐

Figure 2.2-18 Switching Connector Positions

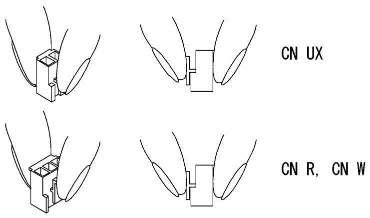


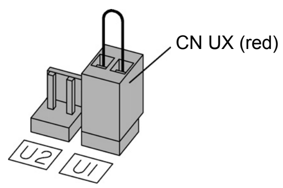
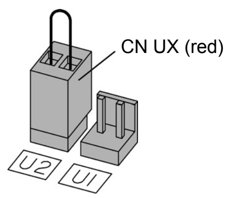
Figure 2.2-19 Attachment and Removal of the Switching Connector

Note: When removing the individual connectors, pinch the upper portion of the connector with the fingers, unlock the fastener, and pull. When inserting the connector, push in until the fastener lock engages with the receiving end with a click.

■ Power supply switching connector "CN UX"（FRN0203E2S-4☐）

The power supply switching connector "CN UX" is equipped on FRN0203E2S-4☐. When the power supply connecting to the main power supply input terminals (L1/R, L2/S, L3/T) or the auxiliary power input terminals for the fan (R1, T1) meets the following requirements, move the connector CN UX to U2 side. Otherwise, leave it on the U1 side, which is the factory default.

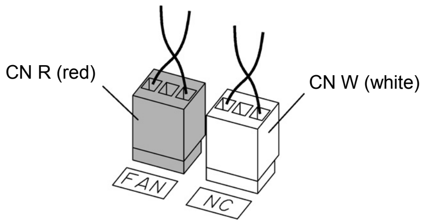
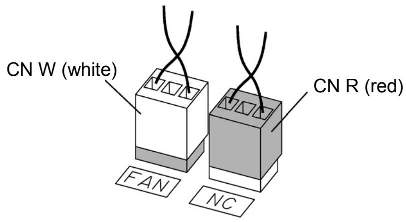
For details on the switching procedure, refer to "Figure 2.2-18 Switching Connector Positions" and "Figure 2.2-19 Attachment and Removal of the Switching Connector".

Setting		
Applicable voltage	398 to 440 V/50 Hz, 430 to 480 V/60 Hz (Factory default)	380 to 398V/50 Hz, 380 to 430 V/60 Hz

■ **Fan power source switching connector "CN R", "CN W" (models larger than FRN0203E2S-4☐)**

FRENIC-Ace supports direct current power supply input with PWM converters in the standard specification. However, FRN0203E2S-4☐ contains parts which are driven by AC power supply such as the AC fan, so AC power must also be supplied. When using DC power for the inverter, move connector "CN R" to NC side, move connector "CN W" to FAN side, and connect an AC power source to the auxiliary power input terminals for the fan (R1, T1).

For details on the switching procedure, refer to "Figure 2.2-18 Switching Connector Positions" and "Figure 2.2-19 Attachment and Removal of the Switching Connector".

Setting		
Purpose	In the case terminals R1 and T1 are NOT used (Factory default)	In the case terminals R1 and T1 are used • DC bus input type • Combination with PWM converter

Note: The fan power source switching connector "CN R" is on FAN and "CN W" is on NC when shipped from the factory. When direct current power supply input is not used, do not alter the setting.

Mistakes in the fan power source switching connector setting may prevent the cooling fan from operating, and alarms such as cooling fin overheat OH1 and charging circuit error PbF may be generated.

2.2.8 Operating Various Switches

⚠WARNING ⚠

Operation of the various switches should be conducted **after more than 5 minutes has elapsed** since power is shut off **for types smaller than FRN0072E2S-4□** and **after more than 10 minutes has elapsed for types larger than FRN0085E2S-4□.** Confirm that the LED monitor and the charge lamp are turned off, and that the direct current intermediate circuit voltage between the main circuit terminals P(+)-N(-) is below the safe voltage (below DC+25 V) with the tester before operating the switches.

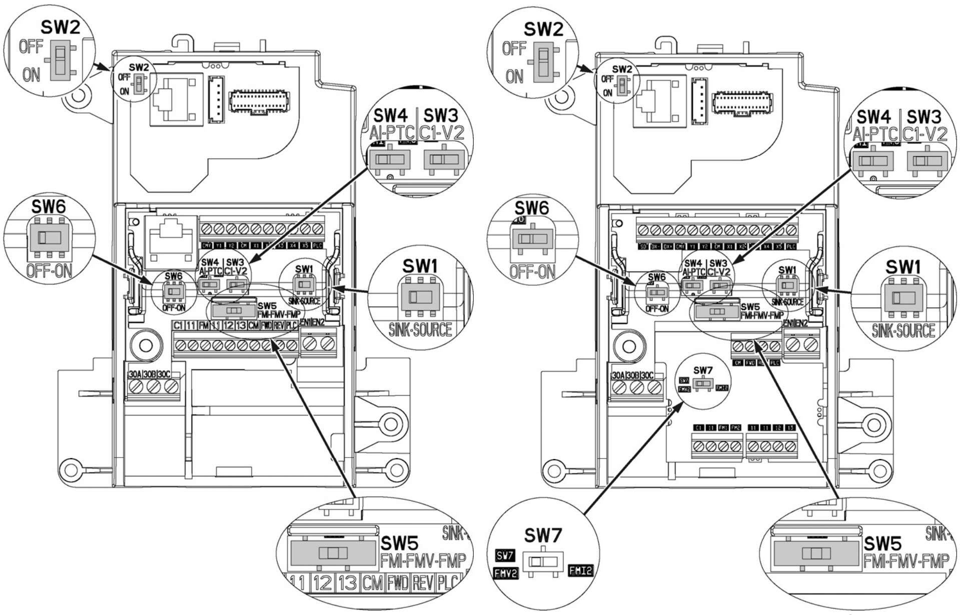
Risk of electric shock exists.

The I/O terminal specification can be changed, such as switching the analog output form, by operating the various slide switches on the printed circuit board (figure 2.2-20 Various Switch Positions on the Control Printed Circuit Board).

To operate the various slide switches, remove the front cover and make the control printed circuit board visible. (For types larger than FRN0085E2S-4□, also open the keypad case).

📖 Refer to "2.2.2 Removal and Attachment of Exterior Cover and Wiring Guide" to remove the front cover and to open/close the keypad case.

The various switch positions on the control printed circuit board are shown below.



Destination: A and E

Destination: C

Figure 2.2-20 Various Switch Positions on the Control Printed Circuit Board

	SW1	SW2	SW3	SW4	SW5	SW6	SW7
Factory default Destination: E	SOURCE	OFF	C1	AI	FMV	OFF	—
Factory default Destination: A and C	SINK	OFF	C1	AI	FMV	OFF	FMV2 Destination: C only
—	SOURCE	ON	V2	PTC	FMI FMP	ON	FMI2 Destination: C only

Note Use pointed devices (such as tweezers) to operate the switches. Avoid touching other electronic parts when moving the switches. The switch will be at open state when the slider is in the middle, so make sure to push the slider to the ends.

Functional description of the various switches is shown in Table 2.2-14 Functional Description of Various Switches.

Table 2.2-14 Functional Description of Various Switches

<table>
<tr><th>Switch symbol</th><th>Functional description</th></tr>
<tr><td>SW1</td><td><Switch to change sink/source setting of digital input terminals>
• This switch determines the type of input (sink or source) to use for digital input terminals [X1] to [X5], FWD, and REV.</td></tr>
<tr><td>SW2</td><td><Switch to change the RS-485 communication termination resistance (RS-485 communication port (on the control PCB))>
• Move to the ON side when RS-485 communication is used and this inverter is connected to the termination.</td></tr>
<tr><td>SW3
SW4</td><td><Switch to change terminal [C1] input setting to current/voltage/PTC thermistor>
This switch changes the input type for terminal [C1].
<table>
<tr><th>Input type</th><th>SW3</th><th>SW4</th><th>E59</th><th>H26</th></tr>
<tr><td>Current input (factory default)</td><td>C1 side</td><td>AI side</td><td>0</td><td>0</td></tr>
<tr><td>Voltage input</td><td>V2 side</td><td>AI side</td><td>1</td><td>0</td></tr>
<tr><td>PTC thermistor input</td><td>C1 side</td><td>PTC side</td><td>0</td><td>1</td></tr>
</table></td></tr>
<tr><td>SW5</td><td><Switch to change terminal [FM] output setting to current/voltage/pulse>
This switch changes the output type for terminal [FM]. When operating this switch, also change function code F29.
<table>
<tr><th>Output type</th><th>SW5</th><th>F29</th></tr>
<tr><td>Current output</td><td>FMI side</td><td>1 or 2</td></tr>
<tr><td>Voltage output (factory default)</td><td>FMV side</td><td>0</td></tr>
<tr><td>Pulse output</td><td>FMP side</td><td>3</td></tr>
</table></td></tr>
<tr><td>SW6</td><td><Switch to change the RS-485 communication termination resistance (RS-485 communication port (on the terminal board))>
* In the case of FRN○○○E2S-4A, -4E
・ Used for the RS-485/CANopen communication. Move the switch to the ON position when the inverter is connected to the terminal. They cannot be used simultaneously.
* In the case of FRN○○○E2S-4C
・ Used for the RS-485 communication. Move the switch to the ON position when the inverter is connected to the termination.</td></tr>
<tr><td>SW7</td><td><Switch to change terminal [FM2] output setting to voltage/current> Equipped only to FRN○○○E2S-4C.
This switch changes the output type for terminal [FM2]. When operating this switch, also change function code F32.
<table>
<tr><th>Output type</th><th>SW7</th><th>F32</th></tr>
<tr><td>Voltage output</td><td>FMV2 side</td><td>0</td></tr>
<tr><td>Current output</td><td>FMI2 side</td><td>3</td></tr>
</table></td></tr>
</table>

Note: Exercise caution as expected operation may not result if the setting above is not conducted accurately.

2.3 Attachment and Connection of Keypad

2.3.1 Parts Required for Connection

The following parts are necessary when attaching the keypad to locations other than the inverter main body.

Part name	Type	Remarks
Keypad extension cable (note 1)	CB-5S, CB-3S, CB-1S	Three lengths available (5 m, 3 m, 1 m)
Keypad attachment screw	M3x□ (note 2)	2 screws required (prepared by user)

(Note 1) When using commercially available LAN cable, use 10BASE-T/100BASE-TX straight cables (below 20 meters) which meet the ANSI/TIA/EIA-568A category 5 standards of U.S.A.

Recommended LAN cable

Manufacturer: Sanwa Supply, Inc.

Type: KB-10T5-01K (for 1 meter)

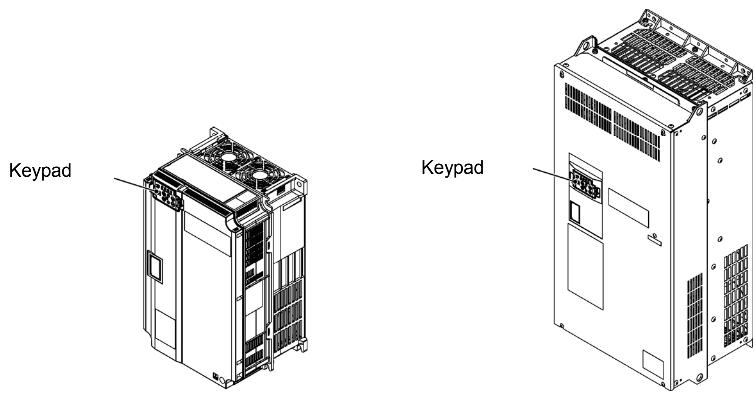
KB-STP-01K (for 1 meter) (shielded cable when conforming to EMC directive)

(Note 2) When attaching to the board, use an attachment screw of length appropriate for the board thickness.

2.3.2 Attachment Procedure

The keypad can be attached in the following forms.

- Attach to the inverter main body (refer to figure 2.3-1(a), (b))
- Attach to the cabinet (refer to figure 2.3-2)
- Operate the panel remotely, close at hand (refer to Figure 2.3-3)



(a) FRN0072E2S-4□ (b) FRN0203E2S-4□

Figure 2.3-1 Attaching the Keypad to the Inverter Main Body

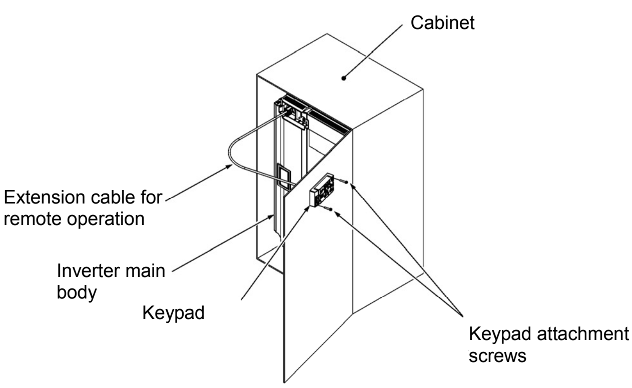


Figure 2.3-2 Attaching the Keypad on the Cabinet

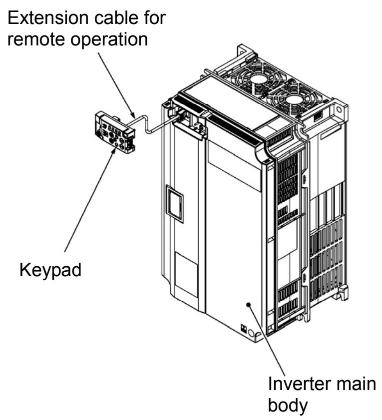


Figure 2.3-3 Operating the Keypad Remotely, Close at Hand

■ **Attachment to the board**

(1) Squeeze the hooks at the arrows and pull as shown in the figure below.

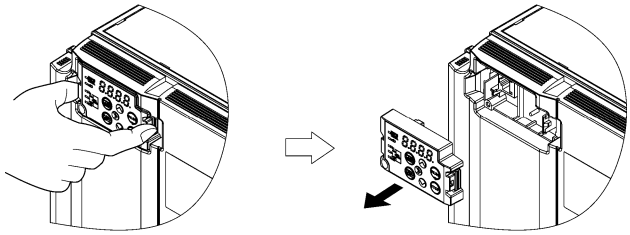


Figure 2.3-4 Removal of the Keypad

(2) Attach the keypad rear cover to the keypad using the included keypad rear cover attachment screw.

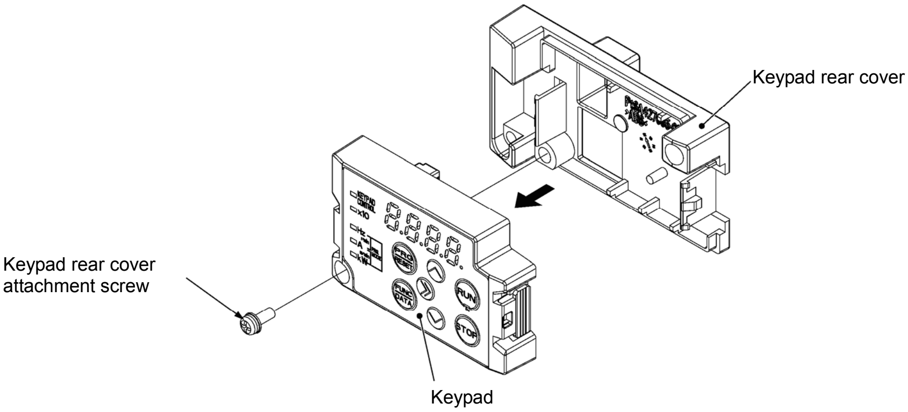


Figure 2.3-5 Attachment of the Keypad

(3) Cut the cabinet to attach the keypad, as shown in figure 2.3-6

(Units: mm)

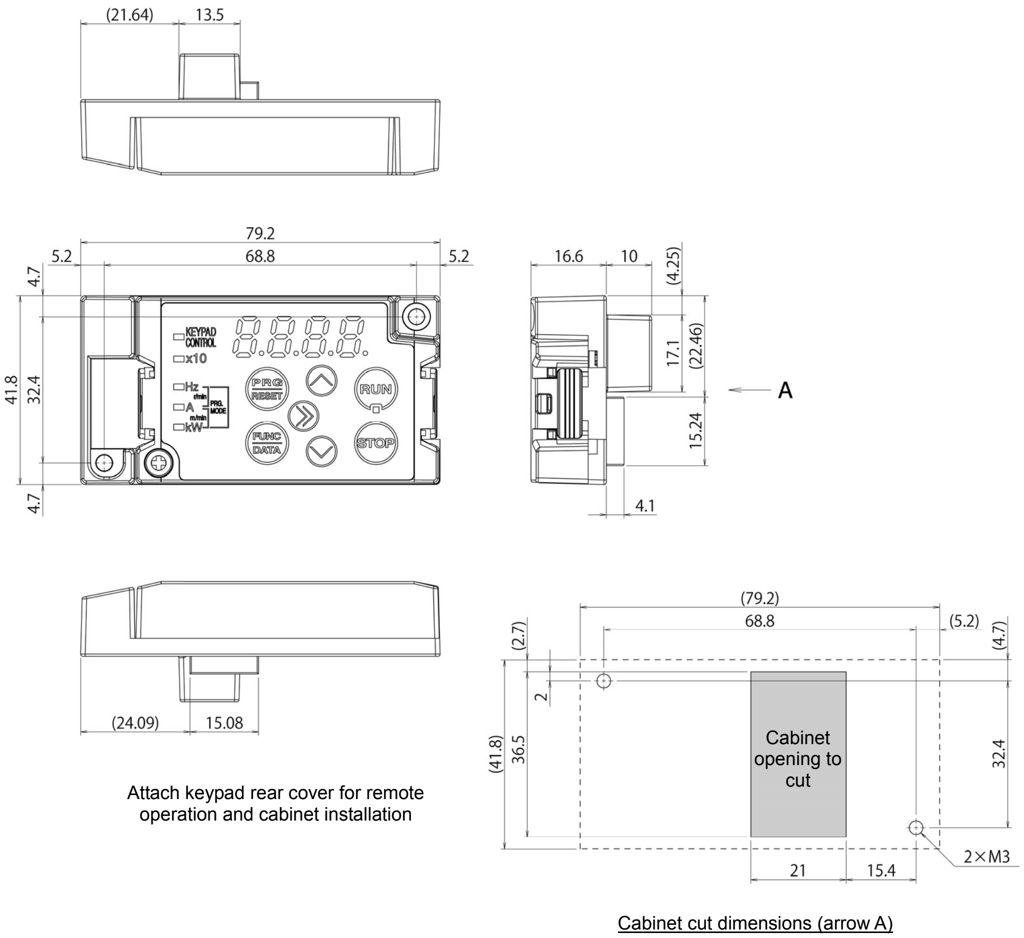


Figure 2.3-6 Attachment Screw Positions and the Dimensions of the Cabinet to Cut

(4) Fix the keypad to the cabinet using 2 keypad rear cover fixation screws. (Refer to figure 2.3-7) (tightening torque: 0.7 N•m)

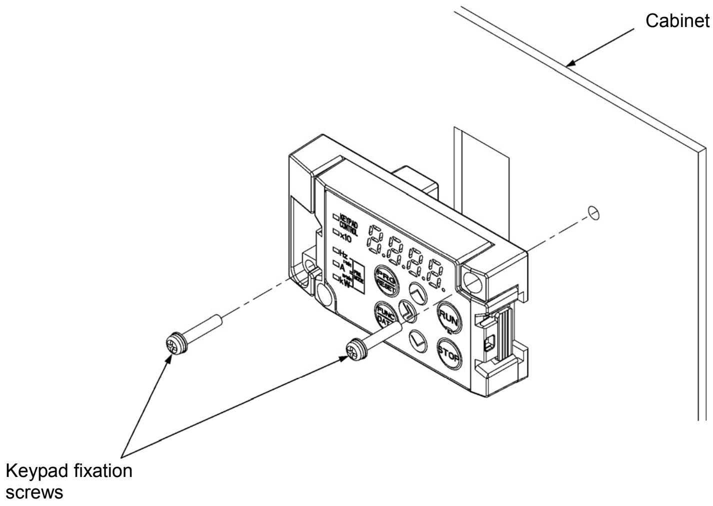


Figure 2.3-7 Attachment of the Keypad

(5) Connect the extended cable for remote operation (CB-5S, CB-3S, CB-1S) or the commercially available LAN cable (straight) to the keypad RJ-45 connector and the inverter main body RJ-45 connector (modular jack). (Refer to Figure 2.3-8.)

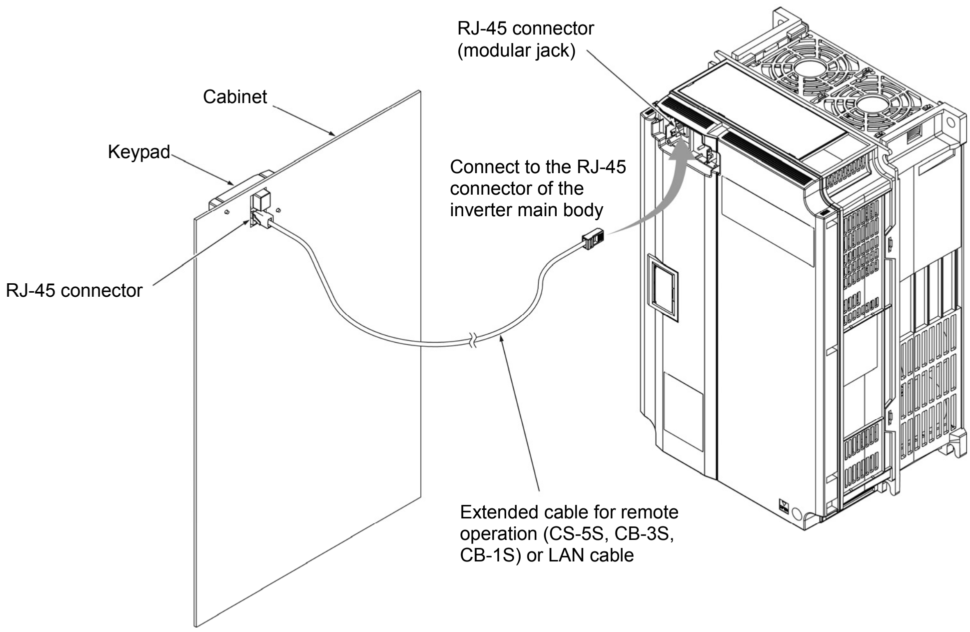


Figure 2.3-8 Connection of the Extension Cable or the Commercially Available LAN Cable to the Keypad and the Inverter Main Body

⚠CAUTION
• The RJ-45 connector for keypad connection is specialized for keypad communication and does not support RS-485 communication. Connection with the PC loader is not possible. • Do not connect the inverter to PC LAN ports, Ethernet hubs, or telephone lines. The inverter and the connected instrument may be damaged. **Risk of fire and risk of accidents exist.**

■ **Operating remotely, close at hand**

Connect following the procedure (5) in “Attachment to the Board”.

2.4 RJ-45 Cover

The opening (RJ-45 connector) for the RS-485 communication cable connection is positioned below the section where the keypad is attached.

* Equipped only on FRN○○○E2S-4A, E.

To connect the RS-485 communication cable, open the RJ-45 cover until the “click” can be heard and connect, as shown in the figure below.

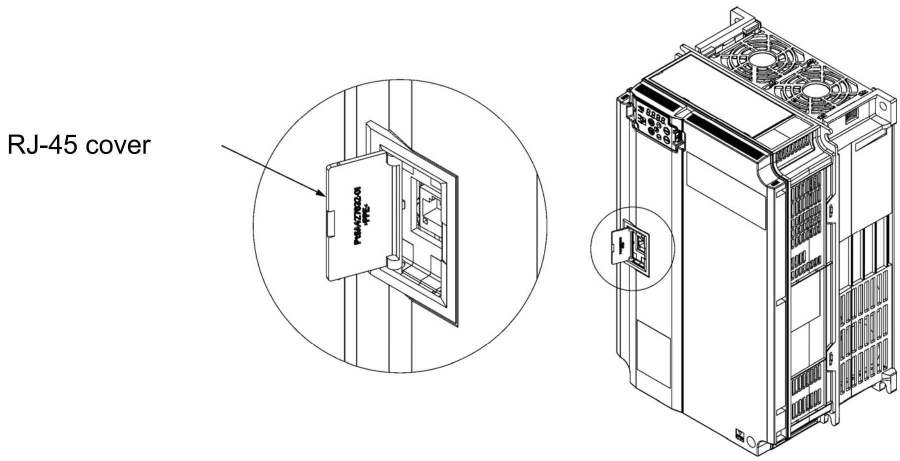


Figure 2.4-1 Connection of the RS-485 Communication Cable

Connect with the PC via the RS-485 converter using the RS-485 communication cable. The PC loader allows editing, confirmation, and management of the inverter function codes, and monitoring of operation data remotely. The operating status and alarms can also be monitored.

Chapter 3

OPERATION USING THE KEYPAD

This chapter describes keypad operation of the inverter.

Contents

Chapter 3 OPERATION USING THE KEYPAD

3.1 Names and Functions of Keypad Components

The keypad allows you to run and stop the motor, display various data, configure function code data, and monitor I/O signal states, maintenance information and alarm information.

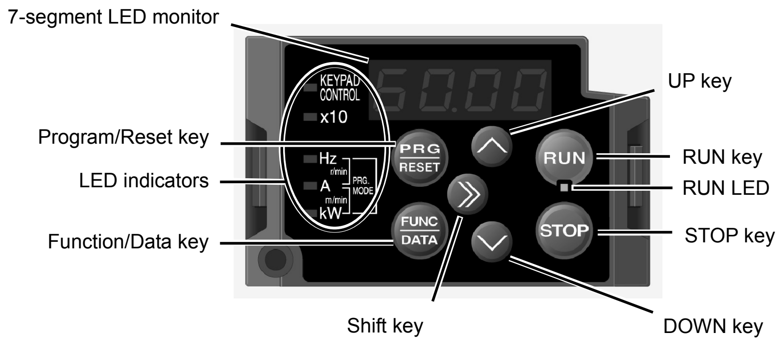


Table 3.1-1 Overview of Keypad Functions

Item	LED Monitor, Keys, and LED Indicators	Functions
LED Monitor	60.00	Four-digit, 7-segment LED monitor which displays the followings according to the operation modes. ■ In Running mode: Running status information (e.g., output frequency, current, and voltage) When a light alarm occurs, L-AL is displayed. ■ In Programming mode: Menus, function codes and their data ■ In Alarm mode: Alarm code, which identifies the alarm factor that has activated the protective function.
Operation Keys	PRG/RESET	Program/Reset key which switches the operation modes of the inverter. ■ In Running mode: Pressing this key switches the inverter to Programming mode. ■ In Programming mode: Pressing this key switches the inverter to Running mode. ■ In Alarm mode: Pressing this key after removing the alarm factor resets the alarm and switches back to Running mode.
	FUNC/DATA	Function/Data key which switches the operations you want to do in each mode as follows: ■ In Running mode: Pressing this key switches the information to be displayed concerning the status of the inverter (output frequency (Hz), output current (A), output voltage (V), etc.). When a light alarm is displayed, holding down this key resets the light alarm and switches back to Running mode. ■ In Programming mode: Pressing this key displays the function code or establishes the data entered with ∧ and ∨ keys. ■ In Alarm mode: Pressing this key displays the details of the problem indicated by the alarm code that has come up on the LED monitor.
	RUN	RUN key. Press this key to run the motor.
	STOP	STOP key. Press this key to stop the motor.
	∧ and ∨	UP and DOWN keys. Press these keys to select the setting items and change the function code data displayed on the LED monitor.
	»	Shift key. Press this key to shift the cursor to the right for entry of a numerical value.

Table 3.1-1 Overview of Keypad Functions (continued)

Item	LED Monitor, Keys, and LED Indicators	Functions
LED Indicators	RUN LED	Lights when running with a run command entered by the (RUN) key, by terminal command ***FWD*** or ***REV***, or through the communications link.
	KEYPAD CONTROL LED	Lights when the inverter is ready to run with a run command entered by the (RUN) key (F02 = 0, 2, or 3). In Programming and Alarm modes, however, pressing the (RUN) key cannot run the inverter even if this indicator lights.
	Unit LEDs (3 LEDs)	These three LED indicators identify the unit of numeral displayed on the LED monitor in Running mode by combination of lit and unlit states of them. Unit: Hz, A, kW, r/min and m/min Refer to Section 3.3.1 "Monitoring the running status" for details. While the inverter is in Programming mode, the LEDs of Hz and kW light. ■Hz □A ■kW
	x10 LED	Lights when the data to display exceeds 9999. When this LED lights, the "displayed value x 10" is the actual value. Example: If data is "12,345," the LED monitor displays 1234 and the x10 LED lights, meaning that "1,234 × 10 = 12,340."

■ LED monitor

In Running mode, the LED monitor displays running status information (output frequency, current or voltage); in Programming mode, it displays menus, function codes and their data; and in Alarm mode, it displays an alarm code which identifies the alarm factor that has activated the protective function.

If one of LED4 through LED1 is blinking, it means that the cursor is at this digit, allowing you to change it.

If the decimal point of LED1 is blinking, it means that the currently displayed data is a value of the PID command, not the frequency data usually displayed.

LED4 LED3 LED2 LED1

Figure 3.1-1 7-Segment LED Monitor

Table 3.1-2 Alphanumeric Characters on the LED Monitor

Character	7-segment	Character	7-segment	Character	7-segment	Character	7-segment
0	0	9	9	i	i	r	r
1	1	A	A	J	J	S	S
2	2	b	b	K	K	T	T
3	3	C	C	L	L	u	u
4	4	d	d	M	M	V	V
5	5	E	E	n	n	W	W
6	6	F	F	o	o	X	X
7	7	G	G	P	P	y	y
8	8	H	H	q	q	Z	Z
Special characters and symbols (numbers with decimal point, minus and underscore)							
0. - 9.	0. - 9.	-	-	_	_		

3.2 Overview of Operation Modes

The FRENIC-Ace features the following three operation modes.

Table 3.2-1 Operation Modes

Operation mode	Description
Running mode	When powered ON, the inverter automatically enters this mode. This mode allows you to specify the reference frequency, PID command value and etc., and run/stop the motor with the RUN / STOP keys. It is also possible to monitor the running status in real time. If a light alarm occurs, the L-AL appears on the LED monitor.
Programming mode	This mode allows you to configure function code data and check a variety of information relating to the inverter status and maintenance.
Alarm mode	If an alarm condition arises, the inverter automatically enters Alarm mode in which you can view the corresponding alarm code* and its related information on the LED monitor. * Alarm code: Indicates the cause of the alarm condition. For details, first see Table 6.1 "Abnormal States Detectable ("Heavy Alarm" and "Light Alarm" Objects)" in Chapter 6, Section 6.1 "Protective Functions," and then read the troubleshooting of each alarm.

Figure 3.2-1 shows the status transition of the inverter between these three operation modes.

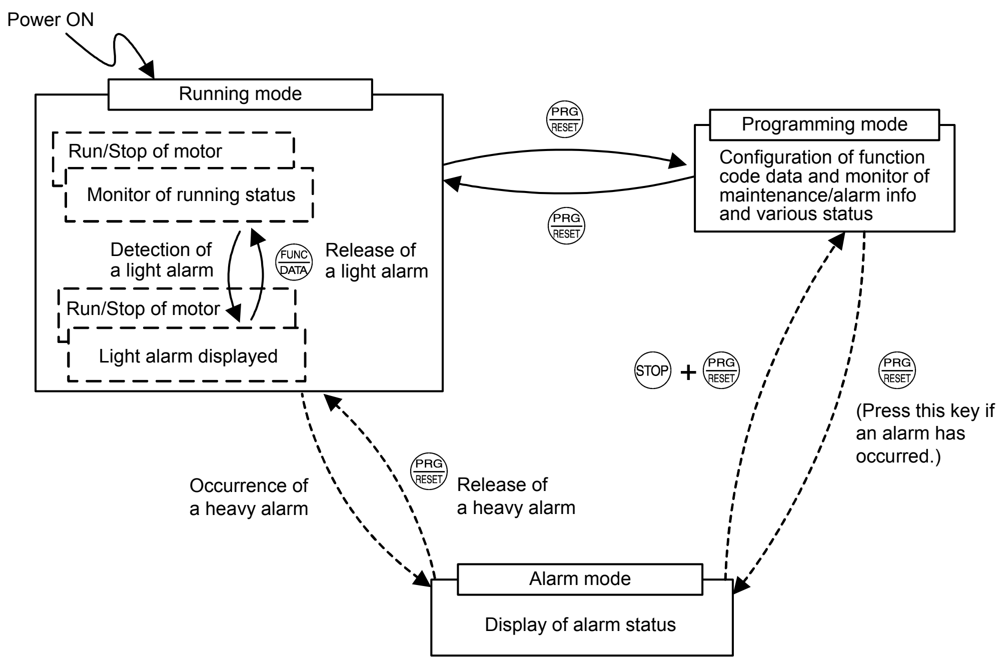


Figure 3.2-1 Status Transition between Operation Modes

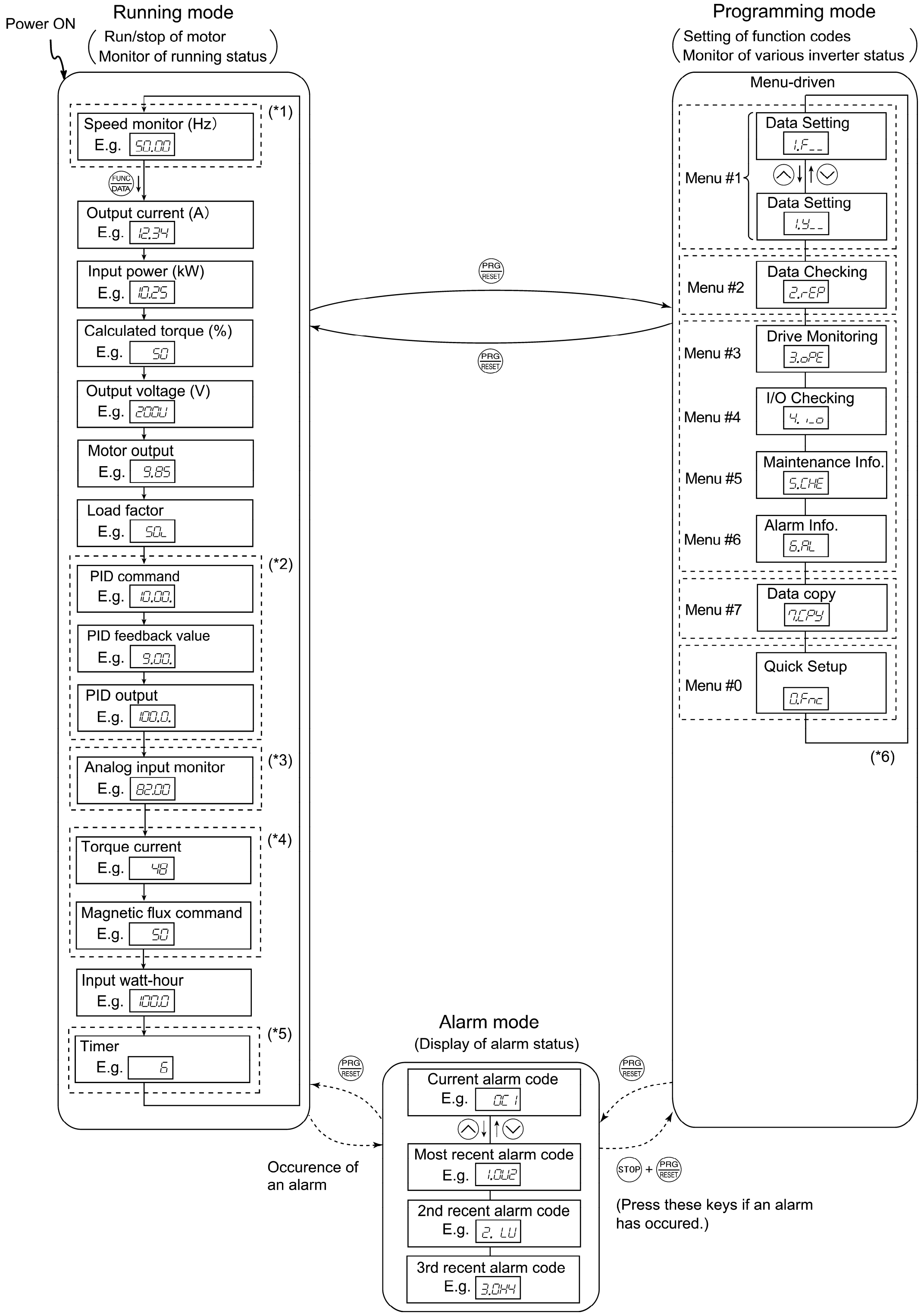
Tip

Simultaneous keying

Simultaneous keying means pressing two keys at the same time. The simultaneous keying operation is expressed by a "+" letter between the keys throughout this manual.

For example, the expression "STOP + PRG/RESET keys" stands for pressing the PRG/RESET key with the STOP key held down.

Figure 3.2-2 illustrates the transition of the LED monitor screen during Running mode, the transition between menu items in Programming mode, and the transition between alarm codes at different occurrences in Alarm mode.



(*1) The speed monitor allows you to select the desired one from the speed monitor items by using function code E48.

(*2) Applicable only when PID control is active (J01 = 1, 2 or 3).

(*3) The analog input monitor can appear only when the analog input monitor function is assigned to one of the analog input terminals by one of function codes E61 to E63 (= 20).

(*4) 0 appears under the V/f control.

(*5) The Timer screen appears only when the timer operation is enabled with function code C21 (C21 = 1).

(*6) Applicable only when the full-menu mode is selected (E52 = 2).

Figure 3.2-2 Transition between Basic Screens in Individual Operation Mode

3.3 Running Mode

3.3.1 Monitoring the running status

In Running mode, the 15 items listed below can be monitored. Immediately after the inverter is turned on, the monitor item specified by function code E43 is displayed. Press the FUNC/DATA key to switch between monitor items.

Table 3.3-1 Monitoring Items

Monitor items	Display sample on the LED monitor *1	LED indicator ■: on, □: off	Unit	Meaning of displayed value	Function code data for E43
Speed monitor	Function code E48 specifies what to be displayed on the LED monitor and LED indicators.				0
Output frequency 1 (before slip compensation)	50.00	■Hz □A □kW	Hz	Frequency actually being output	(E48 = 0)
Output frequency 2 (after slip compensation)	50.00	■Hz □A □kW	Hz	Frequency actually being output	(E48 = 1)
Reference frequency	50.00	■Hz □A □kW	Hz	Reference frequency being set	(E48 = 2)
Motor speed	1500	■Hz ■A □kW	r/min	Output frequency (Hz) $\times \frac{120}{P01}$	(E48 = 3)
Load shaft speed	300.0	■Hz ■A □kW	r/min	Output frequency (Hz) × E50	(E48 = 4)
Line speed	300.0	□Hz ■A ■kW	m/min	Output frequency (Hz) × E50	(E48 = 5)
Constant feeding rate time	50	□Hz □A □kW	min	$\frac{50}{\text{Output frequency (Hz)} \times E39}$	(E48 = 6)
Speed (%)	50.0	□Hz □A □kW	%	$\frac{\text{Output frequency}}{\text{Maximum frequency}} \times 100$	(E48 = 7)
Output current	12.34	□Hz ■A □kW	A	Current output from the inverter in RMS	3
Input power	10.25	□Hz □A ■kW	kW	Input power to the inverter	9
Calculated torque *2	50	□Hz □A □kW	%	Motor output torque (Calculated value)	8
Output voltage *3	200U	□Hz □A □kW	V	Voltage output from the inverter in RMS	4
Motor output *4	9.85	□Hz □A ■kW	kW	Motor output (kW)	16
Load factor *5	50L	□Hz □A □kW	%	Load factor of the motor in % as the rated output being at 100%	15
PID command *6, *7	10.00.	□Hz □A □kW	–	PID command/feedback amount converted to a physical quantity of the object to be controlled (e.g. temperature) Refer to function codes E40 and E41 for details.	10
PID feedback amount *6, *8	9.00.	□Hz □A □kW	–		12
PID output *6, *7	100.0.	□Hz □A □kW	%	PID output in % as the maximum frequency (F03) being at 100%	14
Analog input monitor *9	82.00	□Hz □A □kW	–	An analog input to the inverter in a format suitable for a desired scale. Refer to the following function codes. Terminal [12]: C59, C60 Terminal [C1] (C1 function): C65, C66 Terminal [C1] (V2 function): C71, C72	17
Torque current *10 (Available soon)	48	□Hz □A □kW	%	Torque current command value or calculated torque current	23
Magnetic flux command *10 (Available soon)	50	□Hz □A □kW	%	Magnetic flux command value	24
Input watt-hour	100.0	□Hz □A □kW	kWh	$\frac{\text{Input watt-hour (kWh)}}{100}$	25
Timer *11	50	□Hz □A □kW	s	Remaining time for timer operation	13

*1 A value exceeding 9999 cannot be displayed as is on the 4-digit LED monitor screen, so the LED monitor displays one-tenth of the actual value with the x10 LED lit.

*2 Calculated torque 100% is equal to the motor rated torque. For the calculation formula of the motor rated torque, refer to [2] Calculated formula (1) in Appendix E "Conversion from SI Units."

*3 When the LED monitor displays an output voltage, the 7-segment letter U in the lowest digit stands for the unit of the voltage "V."

*4 When the LED monitor displays the motor output, the unit LED indicator "kW" blinks.

*5 When the LED monitor displays the load factor, the 7-segment letter L in the lowest digit stands for "%."

*6 These PID related items appear only under the PID control specified by function code J01 (= 1, 2 or 3).

*7 When the LED monitor displays a PID command or its output amount, the dot (decimal point) attached to the lowest digit of the 7-segment letter blinks.

*8 When the LED monitor displays a PID feedback amount, the dot (decimal point) attached to the lowest digit of the 7-segment letter lights.

*9 The analog input monitor appears only when the analog input monitor function is assigned to one of the analog input terminals by one of function codes E61 to E63 (= 20). Specify the unit with C58, C64 and C70. When the displayed value is less than -999, the x10 LED is lit.

*10 0 appears under the V/f control.

*11 The Timer screen appears only when the timer operation is enabled with function code C21 (C21 = 1).

Tip The monitoring signals for the monitor items such as output frequency and output current can be filtered with function code E42 (LED display filter). Increase the E42 data if the monitored values are unstable and unreadable due to fluctuation of load.
(📖 Function code E42)

3.3.2 Monitoring light alarms

The FRENIC-Ace identifies abnormal states in two categories--Heavy alarm and Light alarm. If the former occurs, the inverter immediately trips; if the latter occurs, the inverter shows the L-AL on the LED monitor and blinks the KEYPAD CONTROL LED but it continues to run without tripping.

Which abnormal states are categorized as a light alarm ("Light alarm" object) should be defined with function codes H81 and H82 beforehand.

Assigning the ***L-ALM*** signal to any one of the digital output terminals with any of function codes E20 to E24 and E27 (= 98) enables the inverter to output the ***L-ALM*** signal on that terminal upon occurrence of a light alarm.

For details of the light alarm objects, refer to Chapter 6 "TROUBLESHOOTING."

■ How to check a light alarm factor

If a light alarm occurs, L-AL appears on the LED monitor. To check the current light alarm factor, enter Programming mode by pressing the PRG/RESET key and select 5_36 on Menu #5 "Maintenance Information."

It is also possible to check the factors of the last three light alarms 5_37 (last) to 5_39 (3rd last). To check the light alarm factors in Menu #5 "Reading maintenance information," it is necessary to set the data of function code E52 to "2" (Full-menu mode) beforehand.

For details of the menu transition of the maintenance information, refer to Section 3.4.5 "Reading maintenance information."

■ How to reset a light alarm

After checking the current light alarm factor, to switch the LED monitor from the L-AL indication state back to the running status display (e.g., output frequency), press the FUNC/DATA key in Running mode.

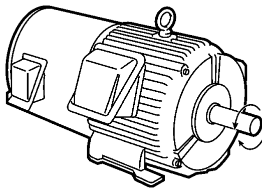
If the light alarm factor has been removed, the KEYPAD CONTROL LED stops blinking and the – signal turns OFF. If not (e.g. DC fan lock), the KEYPAD CONTROL LED continues blinking and the ***L-ALM*** signal remains ON.

3.3.3 Running or stopping the motor

By factory default, pressing the (RUN) key starts running the motor in the forward direction and pressing the (STOP) key decelerates the motor to stop. The (RUN) key is enabled only in Running mode.

When the inverter is running, the RUN LED lights.

To run the motor in the reverse direction or to run it reversibly, change the data of function code F02 to "3" or "0," respectively.



Note: The rotation direction of IEC-compliant motors is opposite to the one shown above.

Table 3.3-2 Motor Rotation Direction Specified by F02

Data for F02	Pressing the (RUN) key runs the motor:
0	In the direction commanded by terminal [FWD] or [REV]
1	Disable (RUN) key (The motor is driven by terminal [FWD] or [REV] command.)
2	In the forward direction
3	In the reverse direction

3.3.4 Setting up reference frequency from the keypad

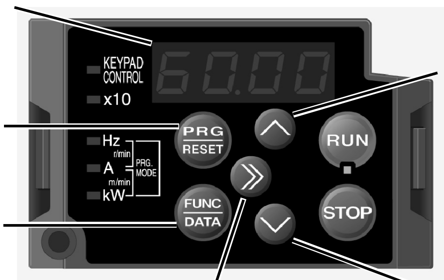
You can set up the desired reference frequency with the (∧) and (∨) keys on the keypad. It is also possible to set up the reference frequency as load shaft speed, motor speed or speed (%) by setting function code E48.

Using the keypad (F01 = 0 (factory default) or 8)

(1) Set function code F01 to "0" (Keypad operation using (∧) / (∨) keys) or "8" (Keypad operation using (∧) / (∨) keys, balanceless-bumpless). Frequency setting with the keypad is disabled in Programming or Alarm mode. To enable it, switch to Running mode.

(2) Press the (∧) / (∨) key to display the current reference frequency. The lowest digit blinks.

(3) To change the reference frequency, press the (∧) / (∨) key again. The new setting can be saved into the inverter's internal memory.



Tip

- Holding down the ∧ / ∨ key changes data in the least significant digit and generates a carry.
- The reference frequency can be saved either automatically by turning the main power OFF or only by pressing the FUNC/DATA key. You can choose either way using function code E64. The factory default is "0" (Automatic saving (when main power is turned OFF)).
- To set the reference frequency, first press the ≫ key once to blink the least significant digit. After that, each time the ≫ key is pressed, the cursor moves to the next higher digit where data can be changed. This cursor movement allows you to easily move the cursor to the desired digit and change the data in higher digits.
- If you have set function code F01 to "0" or "8" but have selected a frequency command source other than frequency command 1 (i.e., frequency command 2, frequency command via communication, or multistep frequency command), then the ∧ and ∨ keys are disabled to change the current frequency command even in Running mode. Pressing either of these keys just displays the current reference frequency.
- Setting F01 data to "8" (Keypad operation using ∧ / ∨ keys, balanceles-bumpless) enables balanceless-bumpless switching.

  Balanceless-bumpless switching refers to the function that makes the inverter inherit the current frequency that has applied before the frequency command source is switched to the keypad from any other source, providing smooth switching and shockless running.

3.3.5 Setting up PID commands from the keypad

You can set up the desired PID commands with the ∧ and ∨ keys on the keypad.

[1] Settings under PID process control

To enable the PID process control, you need to set the J01 data to "1" or "2."

Under the PID control, the items that can be specified or checked with ∧ and ∨ keys are different from those under regular frequency control, depending upon the current LED monitor setting. If the LED monitor is set to the speed monitor (E43 = 0), the item accessible is a manual speed command (reference frequency); if it is set to any other, the item is a PID process command.

<u>Setting the PID process command with ∧ and ∨ keys</u>

(1) Set function code J02 to "0" (∧ / ∨ keys on keypad).

(2) Set the LED monitor to something other than the speed monitor (E43=0) when the inverter is in Running mode. When the keypad is in Programming or Alarm mode, you cannot modify the PID process command with the ∧ / ∨ key. To enable the PID process command to be modified with the ∧ / ∨ key, first switch to Running mode.

(3) Press the ∧ / ∨ key to display the PID process command. The lowest digit and its decimal point blink on the LED monitor.

(4) To change the PID process command, press the ∧ / ∨ key again. The new setting can be saved into the inverter’s internal memory.

Tip

- The PID process command can be saved either automatically by turning the main power OFF or only by pressing the FUNC/DATA key. You can choose either way using function code E64.
- Even if multistep frequency is selected as a PID command (***PID-SS1*** or ***PID-SS2*** = ON), it is possible to set a PID command using the keypad.
- When function code J02 is set to any value other than "0," pressing the ∧ / ∨ key displays, on the LED monitor, the PID command currently selected, but does not allow any change.
- On the LED monitor, the decimal point of the lowest digit is used to discriminate the PID related data from the reference command. The decimal point blinks or lights when a PID command or PID feedback amount is displayed, respectively.

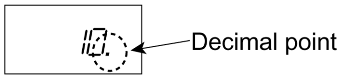


Table 3.3-3 PID Process Command Manually Set with ∧ / ∨ Key and Requirements

PID control (Mode selection) J01	PID control (Remote command SV) J02	LED monitor E43	Multistep frequency ***PID-SS1***, ***PID-SS2***	With ∧ / ∨ key
1 or 2	0	Other than 0	ON or OFF	PID process command by keypad
	Other than 0			PID process command currently selected

Setting up the reference frequency with ∧ and ∨ keys under PID process control

When function code F01 is set to "0" (∧ / ∨ keys on keypad) and frequency command 1 is selected as a manual speed command (when disabling the frequency setting command via communications link, multistep frequency command, and PID control), switching the LED monitor to the speed monitor in Running mode enables you to modify the reference frequency with the ∧ / ∨ keys.

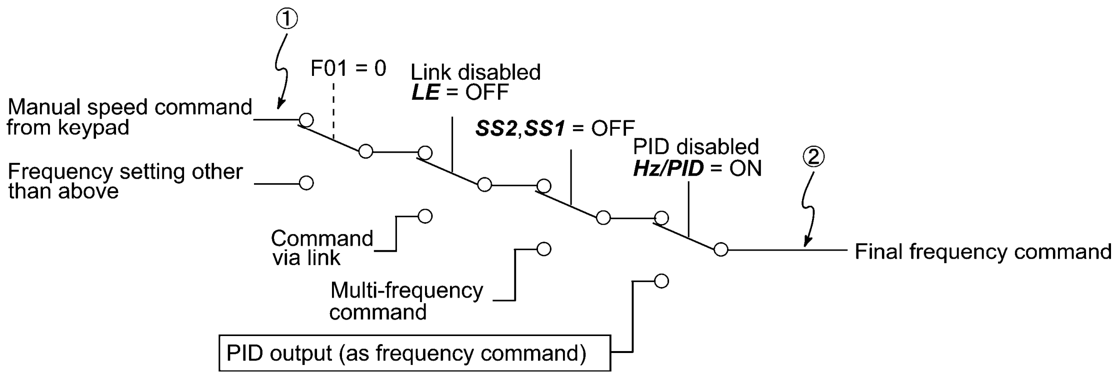
In Programming or Alarm mode, the ∧ / ∨ keys are disabled to modify the reference frequency. You need to switch to Running mode.

Table 3.3-4 lists the combinations of the commands. The figure illustrates how the manual speed command ① entered via the keypad is translated to the final frequency command ②.

The setting procedure is the same as that for setting of a usual reference frequency.

Table 3.3-4 Manual Speed (Frequency) Command Specified with ∧ / ∨ Keys and Requirements

PID control (Mode selection) J01	LED monitor E43	Frequency command 1 F01	Multistep frequency ***SS2***	Multistep frequency ***SS1***	Communi-cations link operation ***LE***	Cancel PID control ***Hz/PID***	Pressing ∧ / ∨ keys controls:
1 or 2	0	0	OFF	OFF	OFF	ON (PID disabled)	Manual speed command (frequency) set by keypad
		Other than the above					Manual speed command (frequency) currently selected
		Don't care				OFF (PID enabled)	PID output (as final frequency command)



[2] Settings under PID dancer control

To enable the PID dancer control, you need to set the J01 data to "3."

Under the PID control, the items that can be specified or checked with ⌃ and ⌄ keys are different from those under the regular frequency control, depending upon the current LED monitor setting. If the LED monitor is set to the speed monitor (E43 = 0), the item accessible is the primary frequency command; if it is set to any other, the item is the PID dancer position command.

<u>Setting the PID dancer position command with the ⌃ and ⌄ keys</u>

(1) Set the J02 data to "0" (⌃ / ⌄ keys on keypad).

(2) Set the LED monitor to something other than the speed monitor (E43=0) when the inverter is in Running mode. When the keypad is in Programming or Alarm mode, you cannot modify the PID dancer position command with the ⌃ / ⌄ key. To enable the PID dancer position command to be modified with the ⌃ / ⌄ key, first switch to Running mode.

(3) Press the ⌃ / ⌄ key to display the PID dancer position command. The lowest digit and its decimal point blink on the LED monitor.

(4) To change the PID dancer position command, press the ⌃ / ⌄ key again. The command you have specified will be automatically saved into the inverter's internal memory as function code J57 data. It is retained even if you temporarily switch to another PID command source and then go back to the via-keypad PID command. Furthermore, you can directly configure the command with function code J57.

Tip

- Even if multistep frequency is selected as a PID command (***PID-SS1*** or ***PID-SS2*** = ON), it is possible to set a PID command using the keypad.
- When function code J02 is set to any value other than "0," pressing the ⌃ / ⌄ key displays, on the LED monitor, the PID command currently selected, but does not allow any change.
- On the LED monitor, the decimal point of the lowest digit is used to discriminate the PID related data from the reference command. The decimal point blinks or lights when a PID command or PID feedback amount is displayed, respectively.

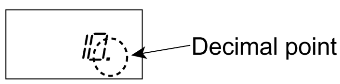


Table 3.3-5 PID Command Manually Set with ∧ / ∨ Key and Requirements

PID control (Mode selection) J01	PID control (Remote command SV) J02	LED monitor E43	Multistep frequency ***PID-SS1***, ***PID-SS2***	With ∧ / ∨ key
3	0	Other than 0	ON or OFF	PID command by keypad
	Other than 0			PID command currently selected

Setting up the primary frequency command with ∧ and ∨ keys under PID dancer control

When function code F01 is set to "0" (∧ / ∨ keys on keypad) and frequency command 1 is selected as a primary frequency command (when disabling the frequency setting command via communications link, multistep frequency command, and PID control), switching the LED monitor to the speed monitor in Running mode enables you to modify the primary frequency command with the ∧ / ∨ keys.

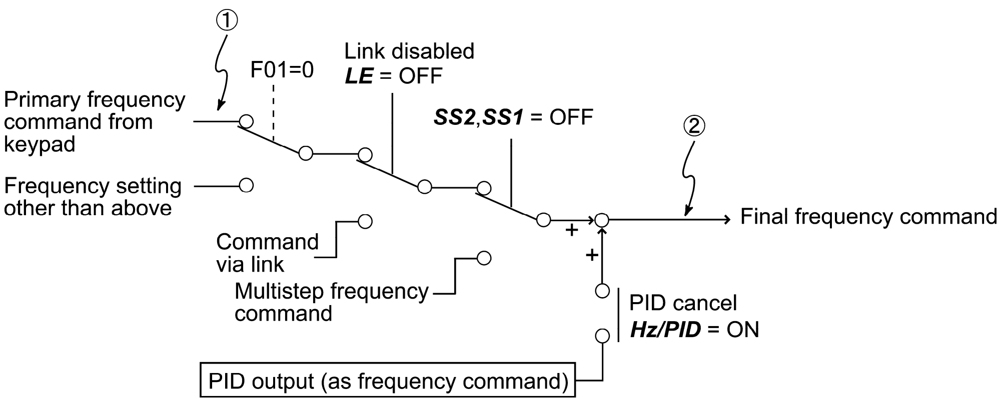
In Programming or Alarm mode, the ∧ / ∨ keys are disabled to modify the primary frequency command. You need to switch to Running mode.

Table 3.3-6 lists the combinations of the commands. The figure illustrates how the primary frequency command ① entered via the keypad is translated to the final frequency command ②.

The setting procedure is the same as that for setting of a usual reference frequency.

Table 3.3-6 Primary Command (Frequency) Specified with ∧ / ∨ Keys and Requirements

PID control (Mode selection) J01	LED monitor E43	Frequency command 1 F01	Multistep frequency ***SS2***	Multistep frequency ***SS1***	Communi-cations link operation ***LE***	Cancel PID control ***Hz/PID***	Pressing ∧ / ∨ keys controls:
3	0	0	OFF	OFF	OFF	ON (PID disabled)	Primary command (frequency) set by keypad
		Other than the above					Primary command (frequency) currently selected
		Don't care				OFF (PID enabled)	PID output (as final frequency command)



3.3.6 Jogging Operation

This section provides the procedure for jogging the motor.

(1) Making the inverter ready to jog with the steps below. The LED monitor should display *jog*.

Enter Running mode (see Section 3.2 "Overview of Operation Modes" on page 3-3) and press the STOP + ∧ keys simultaneously.

The LED monitor displays the jogging frequency for approximately one second and then returns to *jog* again.

Tip
- Function codes C20, H54 and H55 specify the jogging frequency and acceleration/deceleration time, respectively. Use these function codes exclusively for the jogging operation with your needs.
- Using the input terminal command ***JOG*** ("Ready for jogging") switches between the normal operation state and ready-to-jog state.
- Switching between the normal operation state and read-to-jog state with the STOP + ∧ keys is possible only when the inverter is stopped.

(2) Jogging the motor.

Hold down the RUN key during which the motor continues jogging. To decelerate to stop the motor, release the key.

(3) Exiting the ready-to-jog state and returning to the normal operation state.

Press the STOP + ∧ keys simultaneously.

For details, refer to the descriptions of function codes E01 to E05 in Chapter 5, Section 5.2.2 "E codes (Extension terminal functions)."

3.3.7 Remote and local modes

The inverter is available in either remote or local mode. In the remote mode that applies to ordinary operation, the inverter is driven under the control of the data settings stored in the inverter, whereas in the local mode that applies to maintenance operation, it is separated from the control system and is driven manually under the control of the keypad.

- Remote mode: Run and frequency commands are selected by function codes or source switching signals except ***LOC*** ("Select local (keypad) operation").
- Local mode: The command source is the keypad, regardless of the settings specified by function codes. The keypad takes precedence over the settings specified by communications link operation signals.

<u>Run commands from the keypad in local mode</u>

The table below shows the input procedures of run commands from the keypad in the local mode.

<table>
<tr><th>Data for F02</th><th>Input Procedures of Run Commands from Keypad</th></tr>
<tr><td>0: Enable RUN / STOP keys on keypad
(Motor rotation direction from digital terminals [FWD]/[REV])</td><td>Pressing the RUN key runs the motor in the direction specified by command FWD or REV assigned to terminal [FWD] or [REV], respectively. Pressing the STOP key stops the motor.</td></tr>
<tr><td>1: Enable terminal command FWD/REV</td><td rowspan="2">Pressing the RUN key runs the motor in the forward direction only. Pressing the STOP key stops the motor.
No specification of the motor rotation direction is required.</td></tr>
<tr><td>2: Enable RUN / STOP keys on keypad
(Forward)</td></tr>
<tr><td>3: Enable RUN / STOP keys on keypad
(Reverse)</td><td>Pressing the RUN key runs the motor in the reverse direction only. Pressing the STOP key stops the motor.
No specification of the motor rotation direction is required.</td></tr>
</table>

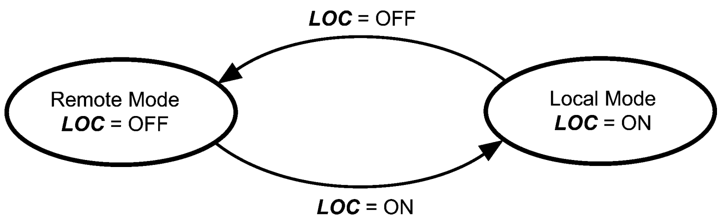
<u>Switching between remote and local modes</u>

The remote and local modes can be switched by a digital input signal provided from the outside of the inverter.

To enable the switching, you need to assign ***LOC*** as a digital input signal to any of terminals [X1] to [X5] by setting "35" to any of E01 to E05, E98 and E99.

Switching from remote to local mode automatically inherits the frequency settings used in remote mode. If the motor is running at the time of the switching from remote to local, the run command will be automatically turned ON so that all the necessary data settings will be carried over. If, however, there is a discrepancy between the settings used in remote mode and ones made on the keypad (e.g., switching from the reverse rotation in remote mode to the forward rotation only in local mode), the inverter automatically stops.

The transition paths between remote and local modes depend on the current mode and the value (ON/OFF) of ***LOC***, as shown in the status transition diagram given below. Also, refer to above table for details



Transition between Remote and Local Modes by ***LOC***

3.4 Programming Mode

The Programming mode provides you with these functions--setting and checking function code data, monitoring maintenance information and checking input/output (I/O) signal status. The functions can be easily selected with the menu-driven system. Table 3.4-1 lists menus available in Programming mode. The leftmost digit (numerals) of each letter string on the LED monitor indicates the corresponding menu number and the remaining three digits indicate the menu contents.

When the inverter enters Programming mode from the second time on, the menu selected last in Programming mode will be displayed.

Table 3.4-1 Menus Available in Programming Mode

Menu #	Menu	LED monitor shows:	Main functions		Refer to:
1	"Data Setting"	1.F__	F codes (Fundamental functions)	Selecting each of these function codes enables its data to be displayed/changed.	Section 3.4.1
		1.E__	E codes (Extension terminal functions)		
		1.C__	C codes (Control functions)		
		1.P__	P codes (Motor 1 parameters)		
		1.H__	H codes (High performance functions)		
		1.H1__	H1 codes (100s) (High performance functions)		
		1.A__	A codes (Motor 2 parameters)		
		1.J__	J codes (Application functions 1)		
		1.J1__	J1 codes (100s) (PID functions)		
		1.d__	d codes (Application functions 2)		
		1.U__	U codes (Customizable logic functions)		
		1.U1__	U1 codes (100s) (Customizable logic functions)		
		1.y__	y codes (Link functions)		
		1.K__	K code (Keypad functions)		
		1.o__	o codes (Optional functions) (Note)		
2	"Data Checking"	2.rEP	Displays only function codes that have been changed from their factory defaults. You can refer to or change those function code data.		Section 3.4.2
3	"Drive Monitoring"	3.oPE	Displays the running information required for maintenance or test running.		Section 3.4.3
4	"I/O Checking"	4. I_o	Displays external interface information.		Section 3.4.4
5	"Maintenance Information"	5.CHE	Displays maintenance information including cumulative run time.		Section 3.4.5
6	"Alarm Information"	6.AL	Displays the recent four alarm codes. You can refer to the running information at the time when the alarm occurred.		Section 3.4.6
0	"Quick Setup"	0.Fnc	Displays only basic function codes to customize the inverter operation.		Section 3.4.7

(Note) The o codes display only when the corresponding option is mounted. For details, refer to the Instruction Manual for the corresponding option.

■ **Selecting menus to display**

The menu-driven system allows you to cycle through menus. To cycle through necessary menus only for simple operation, use function code E52 that provides a choice of the display modes as listed below.

The factory default (E52 = 0) is to display three menus--Menu #1 "Data Setting," Menu #7 "Data Copying," and Menu #0 "Quick Setup," allowing no switching to any other menu.

Table 3.4-2 Keypad Display Mode Selection – Function Code E52

Data for E52	Mode	Menus selectable
0	Function code data editing mode (factory default)	Menu #1 "Data Setting" Menu #7 "Data Copying" Menu #0 "Quick Setup"
1	Function code data check mode	Menu #2 "Data Checking" Menu #7 "Data Copying"
2	Full-menu mode	Menus #0 through #7

Tip: Press the (FUNC/DATA) key to enter Programming mode and display menus. While cycling through the menus with the (∧) / (∨) key, select the desired menu item with the (FUNC/DATA) key. Once the entire menu has been cycled through, the display returns to the first menu item.

3.4.1 Setting up function codes "Data Setting: 1.F _ _ through 1.H _ _"

Menu #1 "Data Setting" (1.F _ _ through 1.H _ _) in Programming mode allows you to configure all function codes.

To use "Data Setting," you need to set function code E52 to "0" (Function code data editing mode) or "2" (Full-menu mode).

Figure 3.4-1 shows the menu transition and the function code data change procedure in "Data Setting."

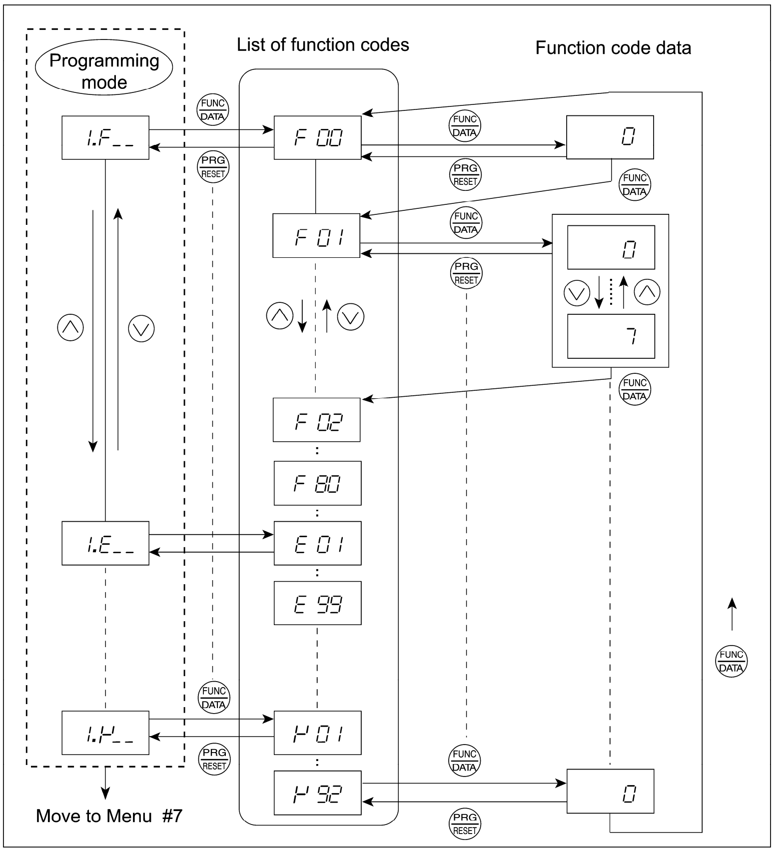


Figure 3.4-1 Menu Transition and Function Code Data Change Procedure in Menu #1 "Data Setting"

Basic key operation

(1) Turn the inverter ON. It automatically enters Running mode in which you press the [PRG/RESET] key to switch to Programming mode. The function selection menu appears.

(2) Use the [∧] and [∨] keys to select the desired function code group from the choices 1.F__ through 1.H__.

(3) Press the [FUNC/DATA] key to proceed to the list of function codes for the selected function code group.

(4) Use the [∧] and [∨] keys to display the desired function code, then press the [FUNC/DATA] key.

The data of this function code appears.

(5) Change the function code data using the [∧] and [∨] keys.

(6) Press the [FUNC/DATA] key to establish the function code data.

The SAVE appears (blinking) and the data will be saved in the memory inside the inverter. After that, the display will return to the function code list and then move to the next function code.

Pressing the [PRG/RESET] key instead of the [FUNC/DATA] key cancels the change made to the data. The data reverts to the previous value, the display returns to the function code list, and the original function code reappears.

(7) Press the [PRG/RESET] key to return to the menu from the function code list.

Tip **Cursor movement**

When changing function code data, pressing the [»] key once blinks the least significant digit. After that, each time the [»] key is pressed, the cursor moves to the next higher digit where data can be changed. This cursor movement allows you to easily move the cursor to the desired digit and change the data in higher digits.

3.4.2 Checking changed function codes "Data Checking: 2.rEP "

Menu #2 "Data Checking" (2.rEP) in Programming mode allows you to check function codes that have been changed. Only the function codes whose data has been changed from the factory defaults are displayed on the LED monitor. You can refer to the function code data and change it again if necessary.

To check function codes in Menu #2 "Data Checking," you need to set function code E52 to "1" (Function code data check mode) or "2" (Full-menu mode).

The menu transition in "Data Checking" is just like that in Menu #1 "Data Setting."

3.4.3 Monitoring the running status "Drive Monitoring: 3.oPE"

Menu #3 "Drive Monitoring" (3.oPE) is used to monitor the running status during maintenance and test running. The display items for "Drive Monitoring" are listed in Table 3.4-3. Figure 3.4-2 shows the menu transition in "Drive Monitoring."

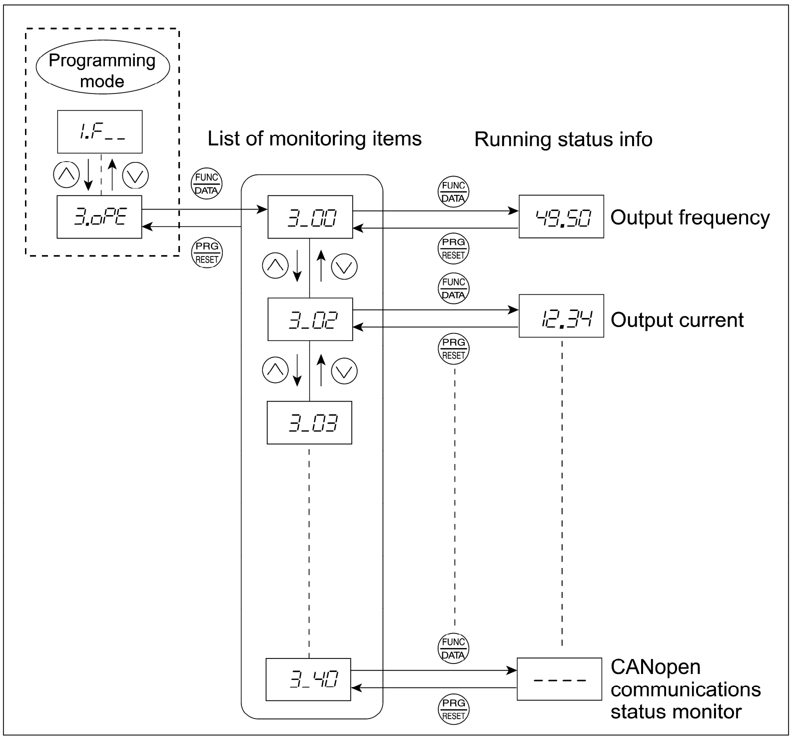


Figure 3.4-2 Menu Transition in Menu #3 "Drive Monitoring"

Basic key operation

To monitor the running status in "Drive monitoring," set function code E52 to "2" (Full-menu mode) beforehand.

(1) Turn the inverter ON. It automatically enters Running mode in which you press the PRG/RESET key to switch to Programming mode. The function selection menu appears. (In this example, 0.Fnc is displayed.)

(2) Use the ∧ and ∨ keys to display "Drive Monitoring" (3.oPE).

(3) Press the FUNC/DATA key to proceed to a list of monitoring items (e.g. 3_00).

(4) Use the ∧ and ∨ keys to display the desired monitoring item, then press the FUNC/DATA key.

The running status information for the selected item appears.

(5) Press the PRG/RESET key to return to the list of monitoring items. Press the PRG/RESET key again to return to the menu.

Table 3.4-3 "Drive Monitoring" Display Items

LED monitor shows:	Item	Unit	Description
3_00	Output frequency 1	Hz	Output frequency before slip compensation
3_01	Output frequency 2	Hz	Output frequency after slip compensation
3_02	Output current	A	Output current
3_03	Output voltage	V	Output voltage
3_04	Calculated torque	%	Calculated output torque of the motor
3_05	Reference frequency	Hz	Frequency specified by a frequency command
3_06	Rotation direction	N/A	Rotation direction of current output F: forward, r: reverse, - - - -: stop
3_07	Running status	N/A	Running status in 4-digit hexadecimal format Refer to "■ Displaying running status (3_07) and running status 2 (3_23)" on the next page.
3_08	Motor speed	r/min	Display value = (Output frequency Hz) × $\frac{120}{\text{(No. of poles)}}$ If the value is 10000 or greater, the x10 LED turns ON and the LED monitor shows one-tenth of the value.
3_09	Load shaft speed	r/min	Display value = (Output frequency Hz) × (Function code E50: Coefficient for speed indication) If the value is 10000 or greater, the x10 LED turns ON and the LED monitor shows one-tenth of the value.
3_10	PID command value	N/A	Virtual physical value (e.g., temperature or pressure) of the object to be controlled, which is converted from the PID command value using function code E40 and E41 data (PID display coefficients A and B) Display value = (PID command value) × (Coefficient A - B) + B If PID control is disabled, "- - - -" appears.
3_11	PID feedback amount	N/A	Virtual physical value (e.g., temperature or pressure) of the object to be controlled, which is converted from the PID feedback amount using function code E40 and E41 data (PID display coefficients A and B) Display value = (PID feedback amount) × (Coefficient A - B) + B If PID control is disabled, "- - - -" appears.
3_12	Torque limit value A	%	Driving torque limit value A (based on motor rated torque)
3_13	Torque limit value B	%	Braking torque limit value B (based on motor rated torque)
3_14	Ratio setting	%	When this setting is 100%, the LED monitor shows 1.00 time of the value to be displayed. If no ratio setting is selected, "- - - -" appears.
3_15	Line speed	m/min	Display value = (Output frequency Hz) × (Function code E50: Coefficient for speed indication) If the value is 10000 or greater, the x10 LED turns ON and the LED monitor shows one-tenth of the value.
3_16	Peripheral speed monitor (Available soon)	—	—
3_17	Target stop position pulse (Available soon)	—	—
3_18	Current position pulse (Available soon)	—	—
3_19	Positioning deviation pulse (Available soon)	—	—
3_20	Positioning control status (Available soon)	—	—
3_21	PID output value	%	PID output value. (100% at the maximum frequency) If PID control is disabled, "----" appears.

Table 3.4-3 "Drive Monitoring" Display Items (Continued)

LED monitor shows:	Item	Unit	Description
3_22	Flux command value (Available soon)	%	Magnetic flux command value.
3_23	Running status 2	N/A	Running status 2 in 4-digit hexadecimal format Refer to "■ Displaying running status (3_07) and running status 2 (3_23)" given below.
3_24	(Not used.)	—	—
3_25	SY synchronous deviation	—	—
3_26	(Not used.)	—	—
3_27	(Not used.)	—	—
3_28	(Not used.)	—	—
3_40	CANopen (built-in) communications status monitor	—	Communications status monitor of CANopen (built-in) For details, refer to Chapter 9, Section 9.2.15 "Keypad LED drive monitoring 3_40.

■ Displaying running status (3_07) and running status 2 (3_23)

To display the running status and running status 2 in 4-digit hexadecimal format, each state has been assigned to bits 0 to 15 as listed in Tables 3.4-4 and 3.4-5. Table 3.4-6 shows the relationship between each of the status assignments and the LED monitor display.

Table 3.4-7 gives the conversion table from 4-bit binary to hexadecimal.

Table 3.4-4 Running Status (3_07) Bit Assignment

Bit	Notation	Content	Bit	Notation	Content
15	BUSY	"1" when function code data is being written.	7	VL	"1" under voltage limiting control.
14	WR	Always "0."	6	TL	"1" under torque limiting control.
13		Always "0."	5	NUV	"1" when the DC link bus voltage is higher than the undervoltage level.
12	RL	"1" when communication is enabled (when ready for run and frequency commands via communications link).	4	BRK	"1" during braking.
11	ALM	"1" when an alarm has occurred.	3	INT	"1" when the inverter output is shut down.
10	DEC	"1" during deceleration.	2	EXT	"1" during DC braking.
9	ACC	"1" during acceleration.	1	REV	"1" during running in the reverse direction.
8	IL	"1" under current limiting control.	0	FWD	"1" during running in the forward direction.

Table 3.4-5 Running Status 2 (3_23) Bit Assignment

Bit	Notation	Content	Bit	Notation	Content
15	—	(Not used.)	7	—	Speed limiting (under torque control) (Available soon)
14			6	—	(Not used.)
13			5	—	Motor selection
12			4	—	00: Motor 1 01: Motor 2
11			3	—	Inverter drive control
10			2	—	0000: V/f control with slip compensation inactive
9			1	—	0001: Vector control without speed sensor (Dynamic torque vector)
8			0	—	0010: V/f control with slip compensation active 0011: V/f control with speed sensor 0100: Dynamic vector control with speed sensor (Available soon) 0110: Vector control with speed sensor (Available soon) 1011: Torque control (Vector control with speed sensor) (Available soon)

Table 3.4-6 Running Status Display

LED No.		LED4				LED3				LED2				LED1			
Bit		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Notation		BUSY	WR	RL		ALM	DEC	ACC	IL	VL	TL	NUV	BRK	INT	EXT	REV	FWD
Example	Binary	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1
	Hexa-decimal on the LED monitor	LED4: 8				LED3: 3				LED2: 2				LED1: 1			

■ Hexadecimal expression

A 4-bit binary number can be expressed in hexadecimal (1 hexadecimal digit). Table 3.4-7 shows the correspondence between the two notations. The hexadecimals are shown as they appear on the LED monitor.

Table 3.4-7 Binary and Hexadecimal Conversion

Binary				Hexadecimal	Binary				Hexadecimal
0	0	0	0	0	1	0	0	0	8
0	0	0	1	1	1	0	0	1	9
0	0	1	0	2	1	0	1	0	A
0	0	1	1	3	1	0	1	1	b
0	1	0	0	4	1	1	0	0	C
0	1	0	1	5	1	1	0	1	d
0	1	1	0	6	1	1	1	0	E
0	1	1	1	7	1	1	1	1	F

3.4.4 Checking I/O signal status "I/O Checking: 4. i_o "

Using Menu #4 "I/O Checking" (4. i_o) displays the I/O status of external signals including digital and analog I/O signals without using a measuring instrument. Table 3.4-8 lists check items available. The menu transition in "I/O Checking" is shown in Figure 3.4-3.

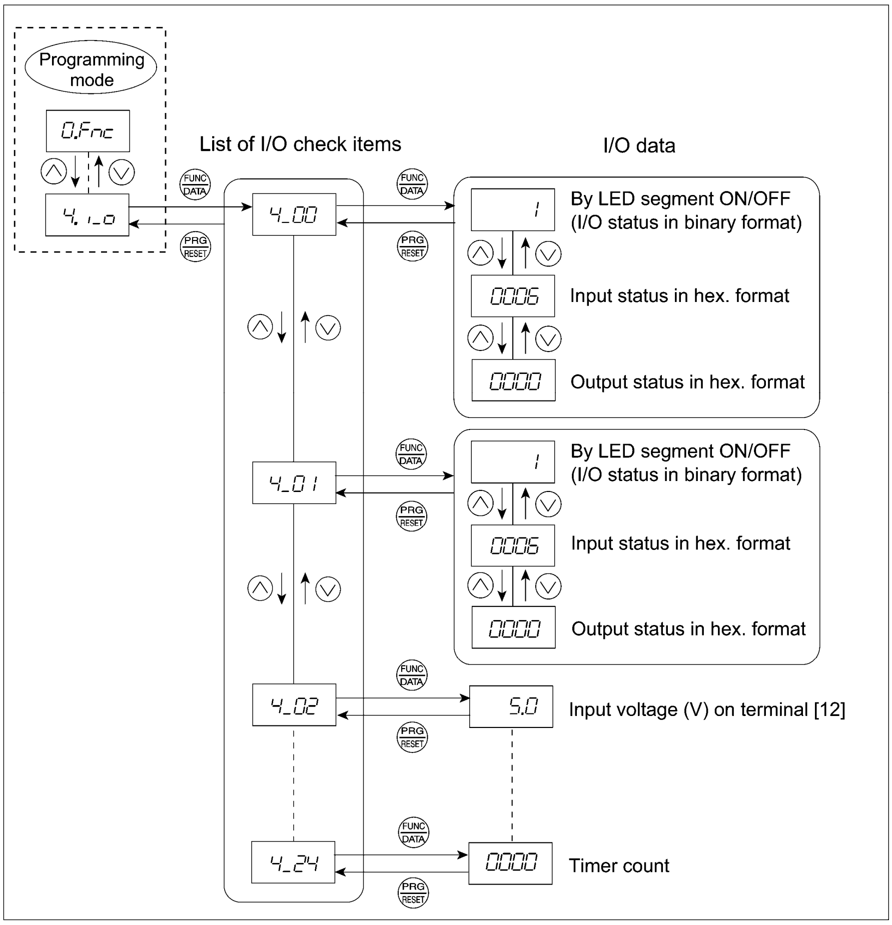


Figure 3.4-3 Menu Transition in Menu #4 "I/O Checking"

<u>Basic key operation</u>

To check the status of the I/O signals, set function code E52 to "2" (Full-menu mode) beforehand.

(1) Turn the inverter ON. It automatically enters Running mode in which you press the PRG/RESET key to switch to Programming mode. The function selection menu appears.

(2) Use the ∧ and ∨ keys to display "I/O Checking" (4. i_o).

(3) Press the FUNC/DATA key to proceed to a list of I/O check items (e.g. 4_00).

(4) Use the ∧ and ∨ keys to display the desired I/O check item, then press the FUNC/DATA key.

The corresponding I/O check data appears. For the item 4_00 or 4_01, using the ∧ and ∨ keys switches the display method between the segment display (for external signal information in Table 3.4-9) and hexadecimal display (for I/O signal status in Table 3.4-10).

(5) Press the PRG/RESET key to return to the list of I/O check items. Press the PRG/RESET key again to return to the menu.

Table 3.4-8 I/O Check Items

LED monitor shows:	Item	Unit	Description
4_00	I/O signals on the control circuit terminals	--	Shows the ON/OFF state of the digital I/O terminals. Refer to "■ Displaying control I/O signal terminals" on the next page for details.
4_01	I/O signals on the control circuit terminals under communications control	--	Shows the ON/OFF state of the digital I/O terminals that received a command via RS-485 or field bus option. Refer to "■ Displaying control I/O signal terminals" and "■ Displaying control I/O signal terminals under communications control" on the following pages for details.
4_02	Input voltage on terminal [12]	V	Shows the input voltage on terminal [12] in volts (V). (signed)
4_03	Input current on terminal [C1] (C1 function)	mA	Shows the input current on terminal [C1] (C1 function) in milliamperes (mA).
4_04	Output voltage on terminal [FM] (FMV)	V	Shows the output voltage on terminal [FM] (FMV) in volts (V).
4_05	Output voltage on terminal [FM2] (FMV2)	V	Shows the output voltage on terminal [FM2] (FMV2) in volts (V). (exclusive to FRN_ _ _ _E2S-4C)
4_06	Output frequency on terminal [FM] (FMP)	p/s	Shows the output pulse rate per unit of time on terminal [FM] (FMP) in (p/s). (If the value is 10000 or greater, the x10 LED turns ON and the LED monitor shows one-tenth of the value.)
4_07	Input voltage on terminal [C1] (V2 function)	V	Shows the input voltage on terminal [C1] (V2 function) in volts (V).
4_08	Output current on terminal [FM] (FMI)	mA	Shows the output current on terminal [FM] (FMI) in milliamperes (mA).
4_09	Output current on terminal [FM2] (FMI2)	mA	Shows the output current on terminal [FM2] (FMI2) in milliamperes (mA). (exclusive to FRN_ _ _ _E2S-4C)
4_10	Option control circuit terminal (I/O) (Available soon)	--	Shows the ON/OFF state of the digital I/O terminals on the digital input and output interface cards (options). Refer to "■ Displaying control I/O signal terminals on options" on page 3-25 for details.
4_11	Terminal [X5] pulse input monitor	--	Shows the pulse rate of the pulse train signal on terminal [X5].
4_15	PG pulse rate (A/B phase signal from the reference PG) (Available soon)	p/s	Shows the pulse rate (p/s) of the A/B phase signal fed back from the reference PG.
4_16	PG pulse rate (Z phase signal from the reference PG) (Available soon)	p/s	Shows the pulse rate (p/s) of the Z phase signal fed back from the reference PG.
4_17	PG pulse rate (A/B phase signal from the slave PG) (Available soon)	p/s	Shows the pulse rate (p/s) of the A/B phase signal fed back from the slave PG.
4_18	PG pulse rate (Z phase signal from the slave PG) (Available soon)	p/s	Shows the pulse rate (p/s) of the Z phase signal fed back from the slave PG.
4_20	Input voltage on terminal [32] (Available soon)	V	Shows the input voltage on terminal [32] on the analog interface card (option) in volts (V).
4_21	Input current on terminal [C2] (Available soon)	mA	Shows the input current on terminal [C2] on the analog interface card (option) in milliamperes (mA).
4_22	Output voltage on terminal [AO] (Available soon)	V	Shows the output voltage on terminal [AO] on the analog interface card (option) in volts (V).
4_23	Output current on terminal [CS] (Available soon)	mA	Shows the output current on terminal [CS] on the analog interface card (option) in milliamperes (mA).
4_24	Customizable logic timer monitor	--	Monitors the timer or counter value in the customizable logic specified by U91.

■ Displaying control I/O signal terminals

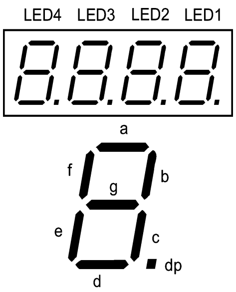
The status of control I/O signal terminals can be displayed in two ways: with ON/OFF of each LED segment and in hexadecimal.

• Displaying the I/O signal status with ON/OFF of each LED segment

As shown in Table 3.4-9 and the figure below, each of segments "a" to "dp" on LED1 and LED2 lights when the corresponding digital input terminal circuit ([FWD], [REV], [X1] to [X5], [EN1] and [EN2]) is closed; it goes OFF when it is open. Segment "a" or "b" on LED3 lights when the circuit between output terminal [Y1] or [Y2] and terminal [CMY] is closed, respectively; it goes OFF when the circuit is open. Segment "a" on LED4 is for terminals [30A/B/C] and lights when the circuit between terminals [30C] and [30A] is short-circuited (ON) and goes OFF when it is open.

Tip If all terminal signals are OFF (open), segments "g" on all of LED1 to LED4 will light ("– – – –").

Table 3.4-9 Segment Display for External Signal Information



Segment	LED4	LED3	LED2	LED1
a	30A/B/C	Y1-CMY	—	FWD
b	—	Y2-CMY	—	REV
c	—	—	—	X1
d	—	—	EN1	X2
e	—	—	EN2	X3
f	—	—	(XF) *	X4
g	—	—	(XR) *	X5
dp	—	—	(RST) *	—

—: No corresponding control circuit terminal exists

* (XF), (XR), and (RST) are assigned for communications control. Refer to "■ Displaying control I/O signal terminals under communications control" on the next page.

• Displaying I/O signal status in hexadecimal

Each I/O terminal is assigned to bit 15 through bit 0 as shown in Table 3.4-10. An unassigned bit is interpreted as "0." Allocated bit data is displayed on the LED monitor as four hexadecimal digits (0 to F each).

On the FRENIC-Ace, digital input terminals [FWD] and [REV] are assigned to bits 0 and 1, respectively. Terminals [X1] through [X5] are assigned to bits 2 through 10. The bit is set to "1" when the corresponding input terminal is short-circuited (ON), and it is set to "0" when the terminal is open (OFF). For example, when [FWD] and [X1] are ON (short-circuited) and all the others are OFF (open), 0005 is displayed on LED4 to LED1.

Digital output terminals [Y1] and [Y2] are assigned to bits 0 through 3. Each bit is set to "1" when the output terminal [Y1] or [Y2] is short-circuited with [CMY] (ON), and "0" when it is open (OFF).

The status of the relay contact output terminals [30A/B/C] is assigned to bit 8. It is set to "1" when the circuit between output terminals [30A] and [30C] is closed, and "0" when the circuit between [30A] and [30C] is open.

For example, if [Y1] is ON, [Y2] is OFF, and the circuit between [30A] and [30C] is closed, then "0101" is displayed on the LED4 through LED1.

Table 3.4-10 presents bit assignment and an example of corresponding hexadecimal display on the 7-segment LED.

Table 3.4-10 Segment Display for I/O Signal Status in Hexadecimal (Example)

LED No.		LED4				LED3				LED2				LED1			
Bit		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Input terminal		(RST)*	(XR)*	(XF)*	EN2	EN1	—	—	—	—	X5	X4	X3	X2	X1	REV	FWD
Output terminal		—	—	—	—	—	—	—	30A/B/C	—	—	—	—	—	—	Y2	Y1
Example	Binary	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Hexa-decimal on the LED monitor	LED4 LED3 LED2 LED1 0 0 0 5															

– No corresponding control circuit terminal exists.

* (XF), (XR), and (RST) are assigned for communications control. Refer to "■ Displaying control I/O signal terminals under communications control" given below.

■ Displaying control I/O signal terminals under communications control

Under communications control, input commands (function code S06) sent via RS-485 or other optional communications can be displayed in two ways: "with ON/OFF of each LED segment" and "in hexadecimal." The content to be displayed is basically the same as that for the control I/O signal terminal status display; however, (XF), (XR), and (RST) are added as inputs. Note that under communications control, the I/O display is in normal logic (using the original signals not inverted)

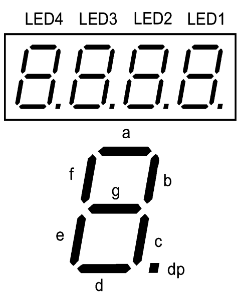
📖 For details about input commands sent through the communications link, refer to the RS-485 Communication User's Manual or the instruction manual of communication-related options as well.

■ Displaying control I/O signal terminals on optional digital input and output interface cards (Available soon)

The LED monitor can also show the signal status of the terminals on the optional digital input and output interface cards, just like the signal status of the control circuit terminals.

Table 3.4-11 lists the assignment of digital I/O signals to the LED segments.

Table 3.4-11 Segment Display for External Signal Information
(Digital input and output interface cards)



Segment	LED4	LED3	LED2	LED1
a	—	O1	I9	I1
b	—	O2	I10	I2
c	—	O3	I11	I3
d	—	O4	I12	I4
e	—	O5	I13	I5
f	—	O6	I14	I6
g	—	O7	I15	I7
dp	—	O8	I16	I8

LED No.	LED4				LED3				LED2				LED1			
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Input terminal	I16	I15	I14	I13	I12	I11	I10	I9	I8	I7	I6	I5	I4	I3	I2	I1
Output terminal	-	-	-	-	-	-	-	-	O8	O7	O6	O5	O4	O3	O2	O1

3.4.5 Reading maintenance information "Maintenance Information: 5.CHE "

Menu #5 "Maintenance Information" (5.CHE) contains information necessary for performing maintenance on the inverter. The menu transition in "Maintenance Information" is just like that in Menu #3 "Drive Monitoring." (Refer to Section 3.4.3.)

Basic key operation

To view the maintenance information, set function code E52 to "2" (Full-menu mode) beforehand.

(1) Turn the inverter ON. It automatically enters Running mode in which you press the PRG/RESET key to switch to Programming mode. The function selection menu appears.

(2) Use the ∧ and ∨ keys to display "Maintenance Information" (5.CHE).

(3) Press the FUNC/DATA key to proceed to the list of maintenance items (e.g. 5_00).

(4) Use the ∧ and ∨ keys to display the desired maintenance item, then press the FUNC/DATA key. The data of the corresponding maintenance item appears.

(5) Press the PRG/RESET key to return to the list of maintenance items. Press the PRG/RESET key again to return to the menu.

Table 3.4-12 Display Items in "Maintenance Information"

LED Monitor shows:	Item	Description
5_00	Cumulative run time	Shows the content of the cumulative power-ON time counter of the inverter. Counter range: 0 to 65,535 hours Display: Upper 2 digits and lower 3 digits are displayed alternately. Example: 0 ⇔ 535H (535 hours) 65⇔ 535H (65,535 hours) The lower 3 digits are displayed with H (hour). When the count exceeds 65,535, the counter will be reset to "0" and start over again.
5_01	DC link bus voltage	Shows the DC link bus voltage of the inverter main circuit. Unit: V (volts)
5_02	Max. temperature inside the inverter	Shows the maximum temperature inside the inverter for every hour. Unit: °C (Temperatures below 20°C are displayed as 20°C.)
5_03	Max. temperature of heat sink	Shows the maximum temperature of the heat sink for every hour. Unit: °C (Temperatures below 20°C are displayed as 20°C.)
5_04	Max. effective output current	Shows the maximum current in RMS for every hour. Unit: A (amperes)
5_05	Capacitance of the DC link bus capacitor	Shows the current capacitance of the DC link bus capacitor (reservoir capacitor) in %, based on the capacitance when shipping as 100%. Refer to Chapter 7 "MAINTENANCE AND INSPECTION" for details. Unit: %
5_06	Cumulative run time of electrolytic capacitors on the printed circuit boards	Shows the content of the cumulative run time counter of the electrolytic capacitors on the printed circuit boards, which is calculated by multiplying the cumulative run time count by the coefficient based on the surrounding temperature condition. Counter range: 0 to 99,990 hours Display range: 0 to 9999 The x10 LED turns ON. Actual cumulative run time of electrolytic capacitors on the printed circuit boards (hours) = Displayed value x 10 When the count exceeds 99,990 the counter stops and the LED monitor sticks to 9999.

Table 3.4-12 Display Items in "Maintenance Information" (Continued)

LED Monitor shows:	Item	Description
5_07	Cumulative run time of the cooling fan	Shows the content of the cumulative run time counter of the cooling fan. This counter does not work when the cooling fan ON/OFF control (function code H06) is enabled and the fan stops. The display method is the same as for 5_06 above.
5_08	Number of startups	Shows the content of the motor 1 startup counter (i.e., the number of run commands issued). Counter range: 0 to 65,530 times Display range: 0 to 9999 If the count exceeds 10,000, the x10 LED turns ON and the LED monitor shows one-tenth of the value. When the count exceeds 65,530, the counter will be reset to "0" and start over again.
5_09	Input watt-hour	Shows the input watt-hour of the inverter. Display range: 0.001 to 9999 Input watt-hour = Displayed value × 100 kWh To reset the integrated input watt-hour and its data, set function code E51 to "0.000." When the input watt-hour exceeds 999,900 kWh, the counter will be reset to "0."
5_10	Input watt-hour data	Shows the value expressed by "input watt-hour (kWh) × E51 (whose data range is 0.000 to 9,999)." Unit: None (Display range: 0.001 to 9999. The count cannot exceed 9999. (It will be fixed at 9,999 once the calculated value exceeds 9999.)) Depending on the value of integrated input watt-hour data, the decimal point on the LED monitor shifts to show it within the LED monitors' resolution. To reset the integrated input watt-hour data, set function code E51 to "0.000."
5_11	Number of RS-485 communications errors (COM port 1)	Shows the total number of errors that have occurred in RS-485 communication (COM port 1, connection to keypad) after the power is turned ON. Once the count exceeds 9999, the counter will be reset to "0."
5_12	Content of RS-485 communications error (COM port 1)	Shows the latest error that has occurred in RS-485 communication (COM port 1) in decimal. For error contents, refer to the RS-485 Communication User's Manual.
5_13	Number of option errors 1	Shows the total number of errors that have occurred in the option. Once the count exceeds 9999, the counter will be reset to "0."
5_14	Inverter's ROM version	Shows the inverter's ROM version as a 4-digit code.
5_15	Keypad's ROM version	Shows the keypad's ROM version as a 4-digit code.
5_17	Number of RS-485 communications errors (COM port 2)	Shows the total number of errors that have occurred in RS-485 communication (COM port 2, connection to terminal block) after the power is turned ON. Once the count exceeds 9999, the counter will be reset to "0."
5_18	Content of RS-485 communications error (COM port 2)	Shows the latest error that has occurred in RS-485 communication (COM port 2, connection to terminal block) in decimal. For error contents, refer to the RS-485 Communication User's Manual.
5_19	Option's ROM version 1	Shows the ROM version of the option as a 4-digit code. If the option has no ROM, "----" appears on the LED monitor.

Table 3.4-12 Display Items in "Maintenance Information" (Continued)

LED Monitor shows:	Item	Description
5_23	Cumulative run time of motor 1	Shows the content of the cumulative power-ON time counter of motor 1. Counter range: 0 to 99,990 hours Display range: 0 to 9999 The x10 LED turns ON. Actual cumulative motor run time (hours) = Displayed value x 10 When the count exceeds 99,990, the counter will be reset to "0" and start over again.
5_24	Temperature inside the inverter (real-time value)	Shows the current temperature inside the inverter. Unit: °C
5_25	Temperature of heat sink (real-time value)	Shows the current temperature of the heat sink inside the inverter. Unit: °C
5_26	Lifetime of DC link bus capacitor (elapsed hours)	Shows the cumulative time during which a voltage is applied to the DC link bus capacitor. When the main power is shut down, the inverter automatically measures the discharging time of the DC link bus capacitor and corrects the elapsed time. The display method is the same as for 5_05 above.
5_27	Lifetime of DC link bus capacitor (remaining hours)	Shows the remaining lifetime of the DC link bus capacitor, which is estimated by subtracting the elapsed time from the lifetime (10 years). The display method is the same as for 5_05 above.
5_28	Cumulative run time of motor 2	Shows the content of the cumulative power-ON time counter of motor 2. The display method is the same as for 5_23 above.
5_31	Remaining hours before the next maintenance 1	Shows the hours remaining before the next maintenance, which is estimated by subtracting the cumulative run time of motor 1 from the maintenance interval specified by H78. (This function applies to motor 1 only.) Display range: 0 to 9999 The x10 LED turns ON. Actual remaining hours before maintenance = Displayed value x 10
5_32	Number of startups 2	Shows the content of the motor 2 startup counter (i.e., the number of run commands issued). The display method is the same as for 5_08 above.
5_35	Remaining startup times before the next maintenance 1	Shows the startup times remaining before the next maintenance, which is estimated by subtracting the number of startups from the preset startup count for maintenance specified by H79. (This function applies to motor 1 only.) The display method is the same as for 5_08 above.
5_36	Light alarm factor (Latest)	Shows the factor of the latest light alarm as an alarm code. For details, refer to Chapter 6, Section 6.1 "Protective Functions."
5_37	Light alarm factor (Last)	Shows the factor of the last light alarm as an alarm code. For details, refer to Chapter 6, Section 6.1 "Protective Functions."
5_38	Light alarm factor (2nd last)	Shows the factor of the 2nd last light alarm as an alarm code. For details, refer to Chapter 6, Section 6.1 "Protective Functions."
5_39	Light alarm factor (3rd last)	Shows the factor of the 3rd last light alarm as an alarm code. For details, refer to Chapter 6, Section 6.1 "Protective Functions."
5_40	Option error factor 1	Shows the factor of the error that has occurred in the option being connected to the A-port.

3.4.6 Reading alarm information "Alarm Information: 6.AL "

Menu #6 "Alarm Information" (6.AL) shows the causes of the past 4 alarms in alarm code. Further, it is also possible to display alarm information that indicates the status of the inverter when the alarm occurred. Figure 3.4-4 shows the menu transition in "Alarm Information" and Table 3.4-13 lists the details of the alarm information.

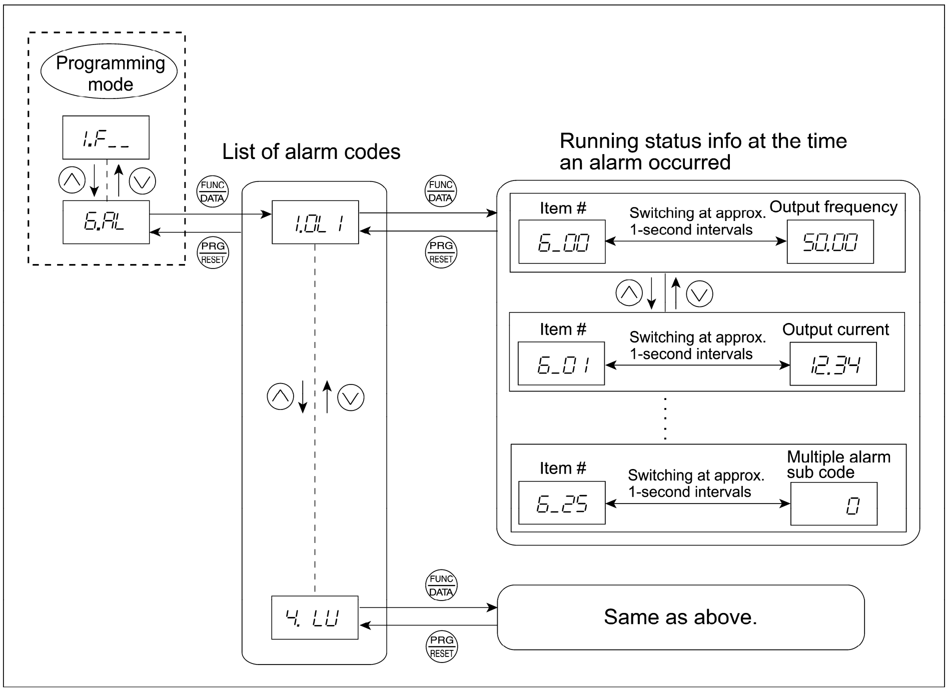


Figure 3.4-4 Menu Transition in Menu #6 "Alarm Information"

<u>Basic key operation</u>

To view the alarm information, set function code E52 to "2" (Full-menu mode) beforehand.

(1) Turn the inverter ON. It automatically enters Running mode in which you press the PRG/RESET key to switch to Programming mode. The function selection menu appears.

(2) Use the ∧ or ∨ key to display "Alarm Information" (6.AL).

(3) Press the FUNC/DATA key to proceed to a list of alarm codes (e.g. 1.OL 1).

In the list of alarm codes, the alarm information for the last 4 alarms is saved as an alarm history.

(4) Each time the ∧ or ∨ key is pressed, the last 4 alarms are displayed beginning with the most recent one in the order of 1., 2., 3. and 4.

(5) Press the FUNC/DATA key with an alarm code being displayed.

The item number (e.g. 6_00) and the inverter status information (e.g. Output frequency) at the time of the alarm occurrence alternately appear at approx. 1-second intervals.

Pressing the ∧ and ∨ keys displays other item numbers (e.g. 6_01) and the status information (e.g. Output current) for that alarm code.

(6) Press the PRG/RESET key to return to the list of alarm codes. Press the PRG/RESET key again to return to the menu.

Table 3.4-13 Display Items in "Alarm Information"

LED monitor shows: (item No.)	Item	Description
6_00	Output frequency	Output frequency before slip compensation
6_01	Output current	Output current Display unit: A (Amperes)
6_02	Output voltage	Output voltage Display unit: V (Volts)
6_03	Calculated torque	Calculated motor output torque
6_04	Reference frequency	Frequency specified by frequency command
6_05	Rotation direction	Shows the current rotation direction. F: forward, r: reverse, ----: stop
6_06	Running status	Running status as four hexadecimal digits. Refer to "■ Displaying running status (3_07) and running status 2 (3_23)" in Section 3.4.3 on page 3-18 for details.
6_07	Cumulative run time	Shows the content of the cumulative power-ON time counter of the inverter. Counter range: 0 to 65,535 hours Display: Upper 2 digits and lower 3 digits are displayed alternately. Example: 0 ⇔ 535H (535 hours) 65 ⇔ 535H (65,535 hours) The lower 3 digits are displayed with H (hour). When the count exceeds 65,535, the counter will be reset to "0" and start over again.
6_08	No. of startups	Shows the content of the motor startup counter (i.e., the number of run commands issued). Counter range: 0 to 65,530 times Display range: 0 to 9999 If the count exceeds 10,000, the x10 LED turns ON and the LED monitor shows one-tenth of the value. When the count exceeds 65,530, the counter will be reset to "0" and start over again.
6_09	DC link bus voltage	Shows the DC link bus voltage of the inverter main circuit. Unit: V (volts)
6_10	Temperature inside the inverter	Shows the temperature inside the inverter. Unit: °C
6_11	Max. temperature of heat sink	Shows the temperature of the heat sink. Unit: °C
6_12	Terminal I/O signal status (displayed with ON/OFF of LED segments)	Shows the ON/OFF states of the digital I/O terminals. For the contents of the display, refer to Table 3.4-9 "Segment Display for External Signal Information" and Table 3.4-10 "Segment Display for I/O Signal Status in Hexadecimal (Example)" in Section 3.4.4 "Checking I/O signal status."
6_13	Terminal input signal status (in hexadecimal)	
6_14	Terminal output signal status (in hexadecimal)	
6_15	No. of consecutive occurrences	Shows how many times the same alarm has occurred consecutively.
6_16	Multiple alarm 1	Simultaneously occurring alarm code (1) ("----" is displayed if no alarm has occurred.)

LED monitor shows: (item No.)	Item	Description
5_17	Multiple alarm 2	Simultaneously occurring alarm code (2) ("----" is displayed if no alarm has occurred.)
5_18	Terminal I/O signal status under communications control (displayed with the ON/OFF of LED segments)	Shows the ON/OFF state of the digital I/O terminals under RS-485 communications control. Refer to "■ Displaying control I/O signal terminals under communications control" in Section 3.4.4 "Checking I/O signal status" for details.
5_19	Terminal input signal status under communications control (in hexadecimal)	
5_20	Terminal output signal status under communications control (in hexadecimal)	
5_21	Error sub code	Secondary error code for an alarm.
5_22	Running status 2	Running status 2 as four hexadecimal digits. For details, refer to Table 3.4-5 "Running Status 2 (3_23) Bit Assignment" in Section 3.4.3 "Monitoring the running status."
5_23	Detected speed	Shows the detected speed value.
5_24	Running status 3	Running status 3 as four hexadecimal digits. For details, refer to Table 3.4-14 "Running Status 3 (3_24) Bit Assignment" given below.
5_25	Multiple alarm sub code	Secondary error code for a multiple alarm.

Note: When the same alarm occurs repeatedly in succession, the alarm information for the first and the most recent occurrences will be preserved and the information for other occurrences in-between will be discarded. The number of consecutive occurrences will be preserved as the first alarm information.

Table 3.4-14 Running Status 3 (3_24) Bit Assignment

Bit	Notation	Content	Bit	Notation	Content
15	—	Always "0."	7	FAN	"1" when the fan is in operation.
14	ID2	"1" when current 2 is detected.	6	KP	"1" during keypad operation.
13	IDL	"1" when low current is detected.	5	OL	"1" when a motor overload early warning is issued.
12	ID	"1" when current is detected.	4	IPF	"1" during auto-restarting after momentary power failure.
11	OLP	"1" under overload prevention control.	3	SWM2	"1" when motor 2 is selected.
10	LIFE	"1" when a lifetime early warning is issued.	2	RDY	"1" when the inverter is ready to run.
9	OH	"1" when a heat sink overheat early warning is issued.	1	FDT	"1" when frequency is detected.
8	TRY	"1" during auto-resetting.	0	FAR	"1" when a frequency arrival signal is issued.

3.4.7 Setting up basic function codes quickly "Quick Setup: 0.Fnc"

Menu #0 "Quick Setup" in Programming mode allows you to quickly display and set up a basic set of function codes specified in Chapter 5, Section 5.1 "Function Code Tables."

To use Menu #0 "Quick Setup," you need to set function code E52 to "0" (Function code data editing mode) or "2" (Full-menu mode).

The predefined set of function codes that are subject to quick setup are held in the inverter.

Figure 3.4-5 shows the menu transition in "Quick Setup" and function code data changing procedure.

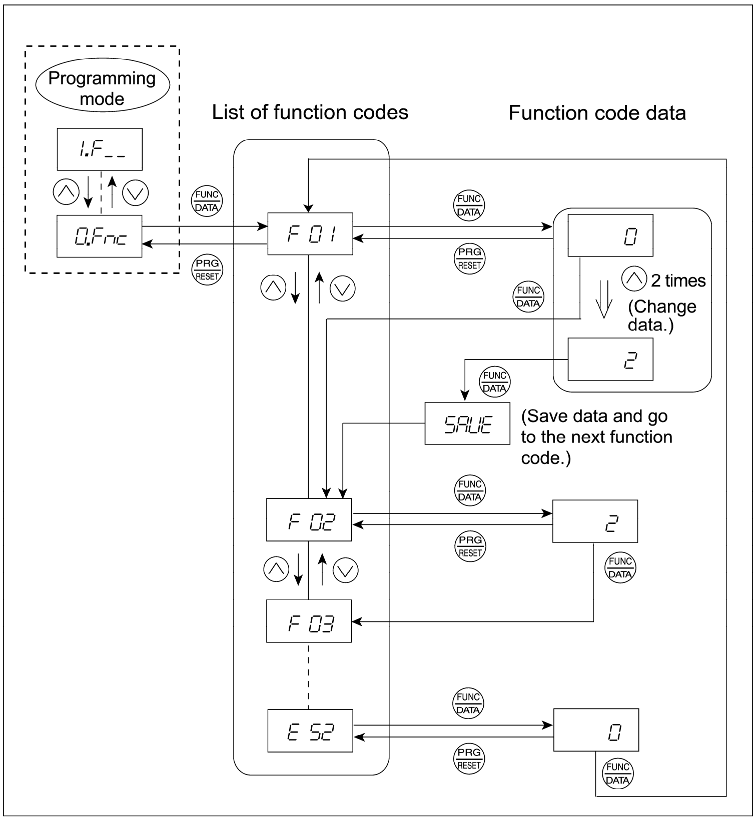


Figure 3.4-5 Menu Transition in Menu #0 "Quick Setup" and Function Code Data Changing Procedure

Basic key operation

This section gives a description of the basic key operation in "Quick Setup," following the example of the function code data changing procedure shown in Figure 3.4-5.

This example shows you how to change function code F01 data (Frequency command source) from the factory default "∧ / ∨ keys on keypad (F01 = 0)" to "Current input to terminal [C1] (C1 function) (4 to 20 mA DC) (F01 = 2)."

(1) Turn the inverter ON. It automatically enters Running mode in which you press the PRG/RESET key to switch to Programming mode. The function selection menu appears. (In this example, 0.Fnc is displayed.)

(2) If anything other than 0.Fnc is displayed, use the ∧ and ∨ keys to display 0.Fnc.

(3) Press the FUNC/DATA key to proceed to the list of function codes.

(4) Use the ∧ and ∨ keys to display the desired function code (F 0 1 in this example), then press the FUNC/DATA key.

The data of this function code appears. (In this example, data 0 of F 0 1 appears.)

(5) Change the function code data using the ∧ and ∨ keys. (In this example, press the ∧ key two times to change data 0 to 2.)

(6) Press the FUNC/DATA key to establish the function code data.

The SAVE appears (blinking) and the data will be saved in the memory inside the inverter. After that, the display will return to the function code list and then move to the next function code. (In this example, F 02.)

Pressing the PRG/RESET key instead of the FUNC/DATA key cancels the change made to the data. The data reverts to the previous value, the display returns to the function code list, and the original function code reappears.

(7) Press the PRG/RESET key to return to the menu from the function code list.

Tip

Cursor movement

When changing function code data, pressing the ≫ key moves the cursor to the desired digit and change the data in that digit in the same say as with the frequency setting. This action is called "Cursor movement."

Tip

It is possible to change or add function code items subject to quick setup. For details, consult your Fuji Electric representatives.

3.5 Alarm Mode

If an abnormal condition arises, the protective function is invoked and issues an alarm, then the inverter automatically enters Alarm mode. At the same time, an alarm code appears on the LED monitor.

3.5.1 Releasing the alarm and switching to Running mode

Remove the cause of the alarm and press the PRG/RESET key to release the alarm and return to Running mode. The alarm can be removed using the PRG/RESET key only when the alarm code is displayed.

3.5.2 Displaying the alarm history

It is possible to display the most recent 3 alarm codes in addition to the one currently displayed. Previous alarm codes can be displayed by pressing the ∧ / ∨ key while the current alarm code is displayed.

3.5.3 Displaying the status of inverter at the time of alarm

When the alarm code is displayed, you may check various running status information (output frequency and output current, etc.) by pressing the FUNC/DATA key. The item number and data for each running information will be displayed alternately.

Further, you can view various pieces of information on the running status of the inverter using the ∧ / ∨ key. The information displayed is the same as for Menu #6 "Alarm Information" in Programming mode. Refer to Table 3.4-13 in Section 3.4.6 "Reading alarm information."

Pressing the PRG/RESET key while the running status information is displayed returns to the alarm code display.

Note When the running status information is displayed after removal of the alarm cause, pressing the PRG/RESET key twice returns to the alarm code display and releases the inverter from the alarm state. This means that the motor starts running if a run command has been received by this time.

3.5.4 Switching to Programming mode

You can also switch to Programming mode by pressing "STOP + PRG/RESET keys" simultaneously with the alarm displayed, and modify the function code data.

Figure 3.5-1 summarizes the possible transitions between different menu items.

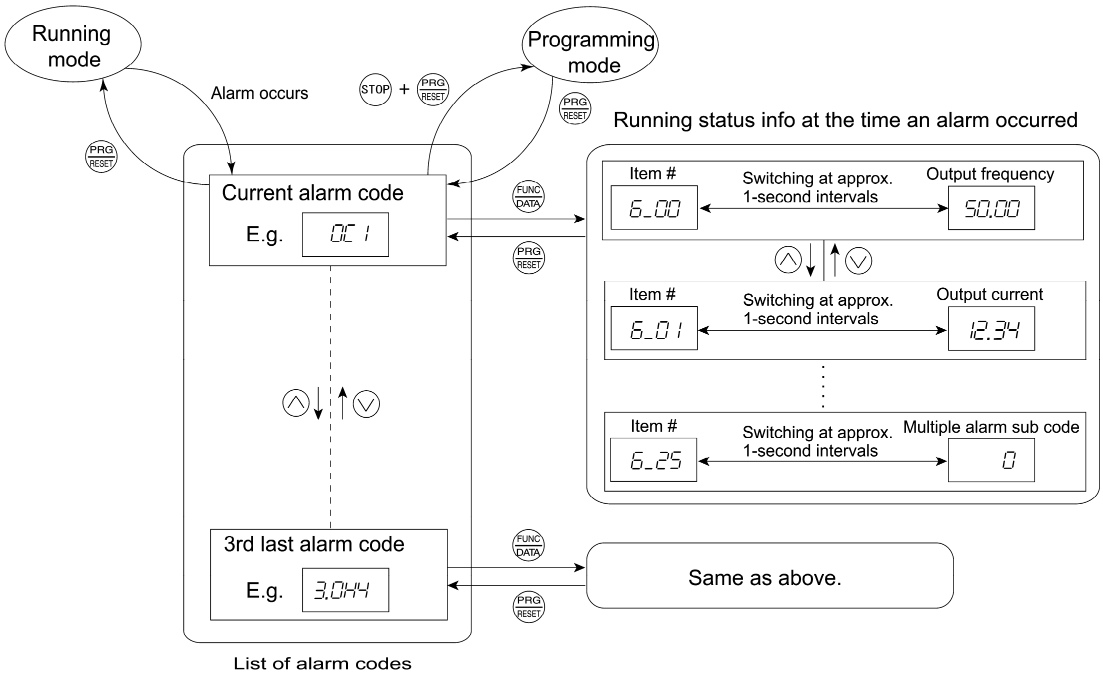


Figure 3.5-1 Menu Transition in Alarm Mode

Chapter 4

TEST RUN PROCEDURE

This chapter describes basic settings required for making a test run.

Contents

Chapter 4 TEST RUN PROCEDURE

4.1 Test Run Procedure Flowchart

Make a test run of the motor using the flowchart given below.

This chapter describes the test run procedure with motor 1 dedicated function codes that are marked with an asterisk (*). For motor 2, replace those asterisked function codes with motor 2 dedicated ones.

For the function codes dedicated to motor 2, see Chapter 5 "FUNCTION CODES."

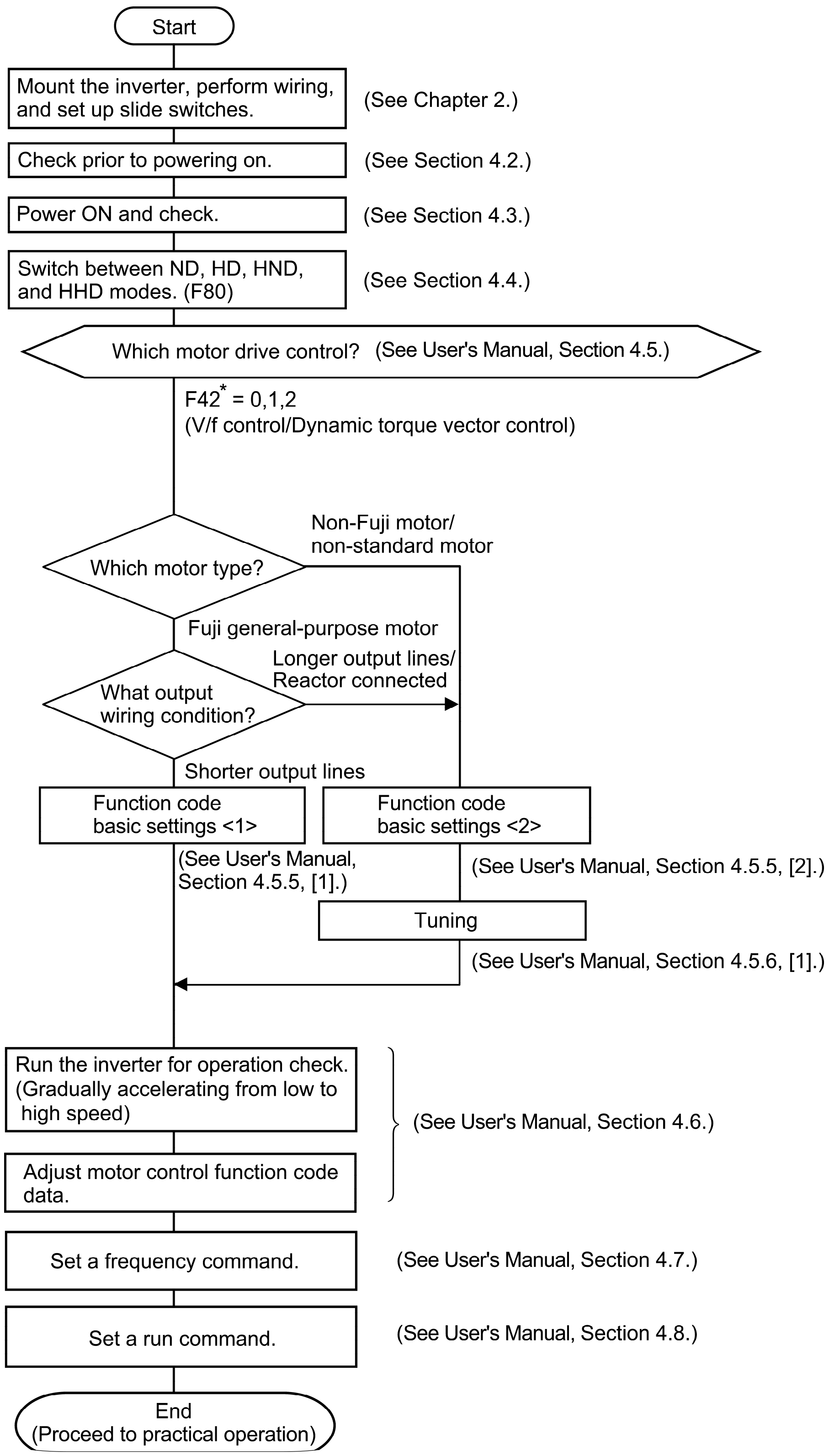


Figure 4.1-1 Test Run Procedure

4.2 Checking Prior to Powering On

Check the following before powering on the inverter.

(1) Check that the wiring is correct.
Especially check the wiring to the inverter input terminals L1/R, L2/S and L3/T and output terminals U, V, and W. Also check that the grounding wires are connected to the grounding terminals (⏚G) correctly. See Figure 4.2-1.

⚠WARNING
• Never connect power supply wires to the inverter output terminals U, V, and W. Doing so and turning the power ON breaks the inverter. • Be sure to connect the grounding wires of the inverter and the motor to the ground electrodes. **Otherwise, an electric shock could occur.**

(2) Check the control circuit terminals and main circuit terminals for short circuits or ground faults.

(3) Check for loose terminals, connectors and screws.

(4) Check that the motor is separated from mechanical equipment.

(5) Make sure that all switches of devices connected to the inverter are turned OFF. Powering on the inverter with any of those switches being ON may cause an unexpected motor operation.

(6) Check that safety measures are taken against runaway of the equipment, e.g., a defense to prevent people from access to the equipment.

(7) Check that a power factor correction DC reactor (DCR) is connected to the DC reactor terminals P1 and P(+). (ND-mode inverters of FRN0139E2S-4☐ or above, HD-/HND-mode ones of FRN0168E2S-4☐ or above, and HHD-mode ones of FRN0203E2S-4☐ or above are provided together with a DCR as standard. Be sure to connect the DCR to the inverter.)

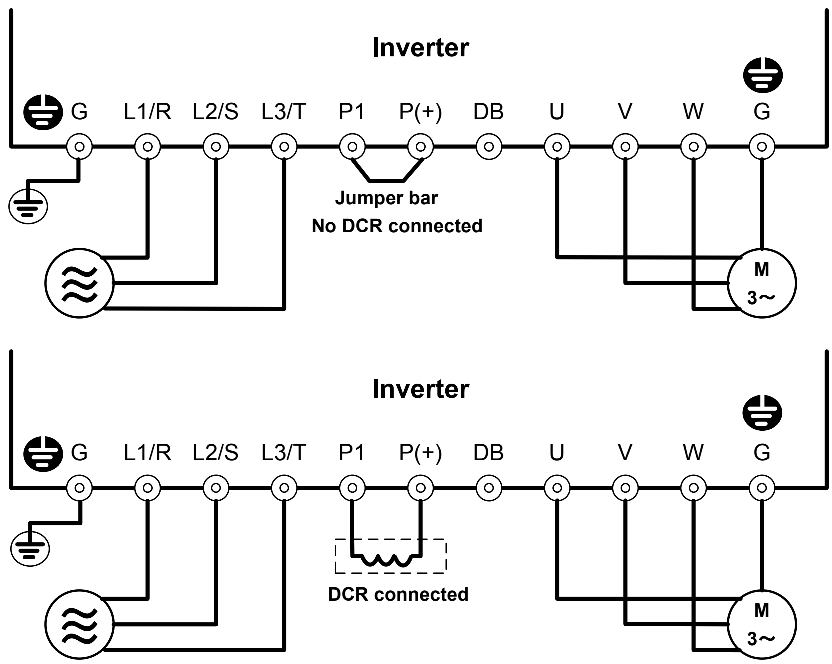


Figure 4.2-1 Connection of Main Circuit Terminals

4.3 Powering ON and Checking

⚠WARNING

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

Otherwise, an electric shock could occur.

Turn the power ON and check the following points. The following is a case when no function code data is changed from the factory defaults.

(1) Check that the LED monitor displays 0.00 (indicating that the reference frequency is 0 Hz) that is blinking. (See Figure 4.3-1.)

(2) Check that the built-in cooling fans rotate.

Figure 4.3-1 Display of the LED Monitor after Power-on

4.4 Switching the Applicable Motor Rank (ND, HD, HND and HHD Modes)

Changing the data of function code F80 switches the applicable motor rank to match load conditions. In HD, HND or HHD mode, the inverter drives a motor whose capacity is one or two ranks lower than the inverter's one.

F80 data	Drive mode	Application	Applicable motor	Overload capability	Maximum frequency	Operating temperature	Application samples
4	ND mode	General load	Motor whose capacity is the same as the inverter's one.	120% for 1 min.	120 Hz	40°C	Fan, pump, blower, compressor, etc.
3	HD mode	Heavy duty load	Motor whose capacity is one rank lower than the inverter's one.	150% for 1 min.	120 Hz	40°C	Wire drawing machine, winding machine, twisting machine, spinning frame, etc.
1	HND mode	General load	Motor whose capacity is one rank lower than the inverter's one.	120% for 1 min.	120 Hz	50°C	Fan, pump, blower, compressor, etc.
0	HHD mode	Heavy duty load	Motor whose capacity is two ranks lower than the inverter's one.	150% for 1 min. 200% for 0.5 s.	500 Hz	50°C	Wire drawing machine, winding machine, twisting machine, spinning frame, hoist, machine tool, etc.

The HD-/HND-/HHD-mode inverter brings out the continuous rated current level which enables the inverter to drive a motor with one or two ranks lower capacity, but its overload capability (%) against the continuous current level or the operating temperature increases. For details, see Chapter 8 "SPECIFICATIONS."

The inverter is subject to restrictions on the function code data setting range and internal processing as listed below.

Function codes	Name	ND mode	HD mode	HND mode	HHD mode	Remarks
F21*	DC braking (Braking level)	Setting range: 0 to 60%	Setting range: 0 to 80%		Setting range: 0 to 100%	In the ND/HD/HND mode, a value out of the range, if specified, automatically changes to the maximum value allowable in the ND/HD/HND mode.
F26	Motor sound (Carrier frequency)	Setting range: 0.75～10kHz (FRN0059E2S-4□) 0.75～6kHz (FRN0072E2S-4□ ～ FRN0203E2S-4□)	Setting range: 0.75～16kHz (FRN0059E2S-4□) 0.75～10kHz (FRN0072E2S-4□～ FRN0168E2S-4□) 0.75～6kHz (FRN0203E2S-4□)		Setting range: 0.75～16kHz (FRN0059E2S-4□ ～ FRN0168E2S-4□) 0.75～10kHz (FRN0203E2S-4□)	
F44	Current limiter (Level)	Initial value: 130%	Initial value: 160%	Initial value: 130%	Initial value: 160%	Switching the drive mode with function code F80 automatically initializes the F44 data to the value specified at left.
F03*	Maximum frequency	Upper limit: 120 Hz	Setting range: 25 to 500 Hz Upper limit: 500 Hz			In the ND/HD/HND mode, if the maximum frequency exceeds 120 Hz, the actual output frequency is internally limited to 120 Hz.
—	Current indication and output	Based on the rated current level for ND mode	Based on the rated current level for HD mode	Based on the rated current level for HND mode	Based on the rated current level for HHD mode	—

Switching between the drive modes does not automatically change the motor rated capacity (P02*) to the one suitable for the rank-changed motor, so configure the P02* data to match the applied motor rating as required.

4.5 Selecting a Desired Motor Drive Control

The FRENIC-Ace supports the following motor drive control.

F42* data	Drive control	Basic control	Speed feedback	Speed control	For configuration, refer to:
0	V/f control with slip compensation inactive	V/f control	Disable	Frequency control	Basic settings <1> (page 4-6) Basic settings <2> (page 4-7) Tuning procedure <1>(page 4-7)
1	Vector control without speed sensor (Dynamic torque vector)			Frequency control with slip compensation	
2	V/f control with slip compensation active				

4.5.1 V/f control with slip compensation inactive

Under this control, the inverter controls a motor with the voltage and frequency according to the V/f pattern specified by function codes. This control disables all automatically controlled features such as the slip compensation, so no unpredictable output fluctuation results, enabling stable operation with constant output frequency.

4.5.2 Vector control without speed sensor (Dynamic torque vector)

To get the maximal torque out of a motor, this control calculates the motor torque for the load applied and uses it to optimize the voltage and current vector output.

Selecting this control automatically enables the auto torque boost and slip compensation function.

This control is effective for improving the system response to external disturbances such as load fluctuation, and the motor speed control accuracy.

Note that the inverter may not respond to a rapid load fluctuation since this control is an open-loop V/f control that does not perform the current control, unlike the vector control. The advantages of this control include larger maximum torque per output current than that the vector control.

Note: Since slip compensation and vector control without speed sensor (dynamic torque vector) use motor parameters, the following conditions should be satisfied; otherwise, full control performance may not be obtained.

- A single motor should be controlled per inverter.
- Motor parameters P02*, P03*, and P06* to P13* should be properly configured or auto-tuning (P04*) should be performed.
- The capacity of the motor to be controlled should be two or more ranks lower (based on the HHD mode) than that of the inverter under the vector control without speed sensor (dynamic torque vector). Otherwise, the inverter may not control the motor due to decrease of the current detection resolution. The wiring distance between the inverter and motor should be 50 m or less. If it is longer, the inverter may not control the motor due to leakage current flowing through stray capacitance to the ground or between wires. Especially, small capacity inverters whose rated current is also small may be unable to control the motor correctly even when the wiring is less than 50 m. In that case, make the wiring length as short as possible or use a wire with small stray capacitance (e.g., loosely-bundled cable) to minimize the stray capacitance.

4.5.3 V/f control with slip compensation active

Applying any load to an induction motor causes a rotational slip due to the motor characteristics, decreasing the motor rotation. The inverter's slip compensation function first presumes the slip value of the motor based on the motor torque generated and raises the output frequency to compensate for the decrease in motor rotation. This prevents the motor from decreasing the rotation due to the slip.
That is, this function is effective for improving the motor speed control accuracy.
The compensation value is specified by combination of function codes P12* (Rated slip frequency), P09* (Slip compensation gain for driving) and P11* (Slip compensation gain for braking).

H68* enables or disables the slip compensation function according to the motor driving conditions.

H68* data	Motor driving conditions		Motor driving frequency zone	
	Accl/Decel	Constant speed	Base frequency or below	Above the base frequency
0	Enable	Enable	Enable	Enable
1	Disable	Enable	Enable	Enable
2	Enable	Enable	Enable	Disable
3	Disable	Enable	Enable	Disable

4.5.4 Performance comparison for drive controls (summary)

Each drive control has advantages and disadvantages. The table below compares the drive controls, showing their relative performance in each characteristic.
Select the one that shows high performance in the characteristics that are important in your machinery. In rare cases, the performance shown below may not be obtained due to various conditions including motor characteristics or mechanical rigidity. The final performance should be determined by adjusting the speed control system or other elements with the inverter being connected to the machinery (load). If you have any questions, contact your Fuji Electric representative.

F42* data	Drive control	Output frequency stability	Speed control accuracy	Speed control response	Maximum torque	Load disturbance	Current control	Torque accuracy
0	V/f control with slip compensation inactive	◎	—	—	◎	—	—	△
1	Vector control without speed sensor (Dynamic torque vector)	△	△	△	◎	△	—	○
2	V/f control with slip compensation active	△	▲	▲	◎	△	—	△

Relative performance symbols ◎: Excellent, ○: Good, △: Effective, ▲: Less effective, —: Not effective

4.5.5 Configuring function codes

[1] Basic settings < 1 >

Driving a Fuji general-purpose motor under the V/f control (F42* = 0 or 2) or vector control without speed sensor (dynamic torque vector) (F42* = 1) requires configuring the following basic function codes.

Select Fuji standard 8- or 6-series motors with the function code P99*.

Configure the function codes listed below according to the motor ratings and your machinery design values. For the motor ratings, check the ratings printed on the motor's nameplate. For your machinery design values, ask system designers about them.

📖 For details on how to modify the function code data, see Chapter 3, Section 3.4.1 "Setting up function codes."

Function code	Name	Function code data	Factory default
F04 *	Base frequency 1	Motor ratings (printed on the nameplate of the motor)	50.0 (Hz)
F05 *	Rated voltage at base frequency 1		Three-phase 200 V: 200 (V) Three-phase 400 V: 400 (V)
P02 *	Motor 1 selection	0: Motor characteristics 0 (Fuji standard motors, 8-series) 3: Motor characteristics 3 (Fuji standard motors, 6-series)	0: Motor characteristics 0 (Fuji standard motors, 8-series)
P03 *	Motor 1 (Rated capacity)	Capacity of motor connected	Nominal applied motor capacity
F03 *	Maximum frequency 1	Machinery design values **(Note)** For a test-driving of the motor, increase values so that they are longer than your machinery design values. If the specified time is short, the inverter may not run the motor properly.	60.0 (Hz)
F07	Acceleration time 1 **(Note)**		FRN0072E2S-4☐ or below: 6.00 (s) FRN0085E2S-4☐ or above: 20.00 (s)
F08	Deceleration time 1 **(Note)**		FRN0072E2S-4☐ or below: 6.00 (s) FRN0085E2S-4☐ or above: 20.00 (s)

After the above configuration, initialize motor 1 with the function code (H03 = 2). It automatically updates the motor parameters P01*, P03*, P06* to P13*, and H46.

Note When accessing the function code P02*, take into account that changing the P02* data automatically updates the data of the function codes P03*, P06* to P13*, and H46.

The motor rating should be specified properly when performing auto-torque boost, torque calculation monitoring, auto energy saving, torque limiting, automatic deceleration (anti-regenerative control), auto search for idling motor speed, slip compensation, torque vector control, droop control, or overload stop.

In any of the following cases, the full control performance may not be obtained from the inverter because the motor parameters differ from the factory defaults, so perform auto-tuning. (Refer to [2].)

- The motor to be driven is not a Fuji product or is a non-standard product.
- The wiring distance between the inverter and the motor is too long (generally 20 m or more).
- A reactor is inserted between the inverter and the motor.

[2] Basic settings < 2 >

Under the V/f control (F42* = 0 or 2) or vector control without speed sensor (dynamic torque vector) (F42* = 1), any of the following cases requires configuring the basic function codes given below and auto-tuning.

- Driving a non-Fuji motor or non-standard motor
- Driving a Fuji general-purpose motor, provided that the wiring distance between the inverter and motor is long or a reactor is connected

Configure the function codes listed below according to the motor ratings and your machinery design values. For the motor ratings, check the ratings printed on the motor's nameplate. For your machinery design values, ask system designers about them.

📖 For details on how to modify the function code data, see Chapter 3, Section 3.4.1 "Setting up function codes."

Function code	Name	Function code data	Factory default
F04*	Base frequency 1	Motor ratings (printed on the nameplate of the motor)	50.0 (Hz)
F05*	Rated voltage at base frequency 1		Three-phase 200 V: 200 (V) Three-phase 400 V: 400 (V)
P02*	Motor 1 (Rated capacity)		Nominal applied motor capacity
P03*	Motor 1 (Rated current)		Rated current of nominal applied motor
F03*	Maximum frequency 1	Machinery design values **(Note)** For a test-driving of the motor, increase values so that they are longer than your machinery design values. If the specified time is short, the inverter may not run the motor properly.	60.0 (Hz)
F07	Acceleration time 1 (Note)		FRN0072E2S-4☐ or below: 6.00 (s) FRN0085E2S-4☐ or above: 20.00 (s)
F08	Deceleration time 1 (Note)		FRN0072E2S-4☐ or below: 6.00 (s) FRN0085E2S-4☐ or above: 20.00 (s)

Note: When accessing the function code P02*, take into account that changing the P02* data automatically updates the data of the function codes P03*, P06* to P13*, and H46.

4.5.6 Auto-tuning motor parameters

[1] Tuning procedure < 1 >

(1) Selection of tuning type

Check the situation of the machinery and select "Tuning with the motor stopped (P04* = 1)" or "Tuning with the motor running (P04* = 2)." For the latter tuning, adjust the acceleration and deceleration times (F07 and F08) and specify the rotation direction that matches the actual rotation direction of the machinery.

P04* data	Tuning type	Motor parameters subjected to tuning	Tuning	Select under the following conditions
1	Tune while the motor stops.	Primary resistance (%R1) (P07*) Leakage reactance (%X) (P08*) Rated slip frequency (P12*) %X correction factor 1 and 2 (P53* and P54*)	Tuning with the motor stopped.	Cannot rotate the motor.
2	Tune while the motor is rotating under V/f control	No-load current (P06*) Primary resistance (%R1) (P07*) Leakage reactance (%X) (P08*) Rated slip frequency (P12*)	Tuning the %R1 and %X, with the motor stopped. Tuning the no-load current and magnetic saturation factor, with the motor running at 50% of the base frequency. Tuning again the rated slip frequency, with the motor stopped.	Can rotate the motor, provided that it is safe. Note that little load should be applied during tuning. Tuning with load applied decreases the tuning accuracy.

The tuning results of motor parameters will be automatically saved into their respective function codes. If P04* tuning is performed, for instance, the tuning results will be saved into P* codes (Motor 1* parameters).

(2) Preparation of machinery

Perform appropriate preparations on the motor and its load, such as disengaging the coupling from the motor and deactivating the safety devices.

(3) Tuning

① Set function code P04* to "1" or "2" and press the FUNC/DATA key. (The blinking of 1 or 2 on the LED monitor will slow down.)

② Enter a run command. The factory default is " RUN key on the keypad for forward rotation." To switch to reverse rotation or to select the terminal signal ***FWD*** or ***REV*** as a run command, change the data of function code F02.

③ The moment a run command is entered, the display of 1 or 2 lights up, and tuning starts with the motor stopped.

(Maximum tuning time: Approx. 40 to 80 s.)

④ If P04* = 2, after the tuning in ③ above, the motor is accelerated to approximately 50% of the base frequency and then tuning starts. Upon completion of measurements, the motor decelerates to a stop.

(Estimated tuning time: Acceleration time + 20 to 75 s + Deceleration time)

⑤ If P04* = 2, after the motor decelerates to a stop in ④ above, tuning continues with the motor stopped.

(Maximum tuning time: Approx. 40 to 80 s.)

⑥ If the terminal signal ***FWD*** or ***REV*** is selected as a run command (F02 = 1), End appears upon completion of the measurements. Turning the run command OFF completes the tuning.

If the run command has been given through the keypad or the communications link, it automatically turns OFF upon completion of the measurements, which completes the tuning.

⑦ Upon completion of the tuning, the subsequent function code appears on the keypad.

■ Tuning errors

Improper tuning would negatively affect the operation performance and, in the worst case, could even cause hunting or deteriorate precision. Therefore, if the inverter finds any abnormality in the tuning results or any error in the tuning process, it displays Er7 and discards the tuning data.

Listed below are possible causes that trigger tuning errors.

Possible tuning error causes	Details
Error in tuning results	- An interphase voltage unbalance or output phase loss has been detected. - Tuning has resulted in an abnormally high or low value of a parameter due to the output circuit opened.
Output current error	An abnormally high current has flown during tuning.
Sequence error	During tuning, a run command has been turned OFF, or ***STOP*** (Force to stop), ***BX*** (Coast to a stop), ***DWP*** (Protect from dew condensation), or other similar terminal command has been received.
Error due to limitation	- During tuning, any of the operation limiters has been activated. - The maximum frequency or the frequency limiter (high) has limited tuning operation.
Other errors	An undervoltage or any other alarm has occurred.

If any of these errors occurs, remove the error cause and perform tuning again, or consult your Fuji Electric representative.

Note: If a filter other than the Fuji optional output filter (OFL-□□□-□A) is connected to the inverter's output (secondary) circuit, the tuning result cannot be assured. When replacing the inverter connected with such a filter, make a note of the old inverter's settings for the primary resistance %R1, leakage reactance %X, no-load current, and rated slip frequency, and specify those values to the new inverter's function codes.

Vibration that may occur when the motor's coupling is elastic can be regarded as normal vibration due to the output voltage pattern applied in tuning. The tuning does not always result in an error; however, run the motor and check its running state.

4.6 Running the Inverter for Motor Operation Check

After completion of preparations for a test run as described above, start running the inverter for motor operation check using the following procedure.

⚠WARNING

If the user configures the function codes wrongly without completely understanding this User's Manual, the motor may rotate with a torque or at a speed not permitted for the machine.

Accident or injury may result.

⚠CAUTION

If any abnormality is found in the inverter or motor, immediately stop operation and investigate the cause referring to Chapter 6, "TROUBLESHOOTING."

4.6.1 Test run procedure

(1) Turn the power ON and check that the reference frequency 0.00 Hz is blinking on the LED monitor.

(2) Set a low reference frequency such as 5 Hz, using ⋀ / ⋁ keys. (Check that the frequency is blinking on the LED monitor.)

(3) Press the RUN key to start running the motor in the forward direction. (Check that the reference frequency is lit on the LED monitor.)

(4) To stop the motor, press the STOP key.

4.6.2 Check points during a test run

(1) Check that the motor is running in the forward direction.

(2) Check for smooth rotation without motor humming or excessive vibration.

(3) Check for smooth acceleration and deceleration.

When no abnormality is found, press the RUN key again to start driving the motor, then increase the reference frequency using ⋀ / ⋁ keys. Check the above points again.

4.6.3 Modification of motor control function code data

Modifying the current function code data sometimes can solve an insufficient torque or overcurrent incident. The table below lists the major function codes to be accessed. For details, see Chapter 5 "FUNCTION CODES" and Chapter 6 "TROUBLESHOOTING."

Function code	Name	Modification key points	Drive control V/f
F 07	Acceleration time 1	If the current limiter is activated due to a short acceleration time and large drive current, prolong the acceleration time.	Y
F 08	Deceleration time 1	If an overvoltage trip occurs due to a short deceleration time, prolong the deceleration time.	Y
F 09 *	Torque boost 1	If the starting motor torque is deficient, increase the torque boost. If the motor with no load is overexcited, decrease the torque boost.	Y
F 44	Current limiter (Mode selection)	If the stall prevention function is activated by the current limiter during acceleration or deceleration, increase the operation level.	Y
P 09 *	Motor 1 (Slip compensation gain for driving)	For excessive slip compensation during driving, decrease the gain; for insufficient one, increase the gain.	Y
P 11 *	Motor 1 (Slip compensation gain for braking)	For excessive slip compensation during braking, decrease the gain; for insufficient one, increase the gain.	Y
H 80 *	Output current fluctuation damping gain 1 (For motor 1)	If the motor vibrates due to current fluctuation, increase the suppression gain.	Y

Y: Modification effective N: Modification ineffective

4.7 Selecting a Frequency Command Source

A frequency command source is the keypad (⌃ / ⌄ keys) by factory default. This section provides the frequency command setting procedures using the frequency command sources of the keypad, external potentiometer, and frequency selection terminal commands.

4.7.1 Setting up a frequency command from the keypad

Follow the procedure given below.

(1) Configure the function codes as listed below.

Function code	Name	Function code data	Factory default
F01	Frequency Command 1	0: Keypad (⌃ / ⌄ keys)	0

Note
- When the inverter is in Programming or Alarm mode, frequency command setting with ⌃ / ⌄ keys is disabled. To enable it, switch to Running mode.
- If any of higher priority frequency command sources (multistep frequency commands and frequency commands via communications link) is specified, the inverter may run at an unexpected frequency.

(2) Press the ⌃ / ⌄ key to display the current frequency command on the LED monitor. The least significant digit blinks.

(3) To change the frequency command, press the ⌃ / ⌄ key again.
When you start specifying the frequency command with the ⌃ / ⌄ key, the least significant digit on the display blinks; that it, the cursor lies in the least significant digit. Holding down the ⌃ / ⌄ key changes data in the least significant digit and generates a carry, while the cursor remains in the least significant digit.

(4) To save the new setting into the inverter's memory, press the FUNC/DATA key.

📖 For details on how to modify the function code data, see Chapter 3, Section 3.4.1 "Setting up function codes."

4.7.2 Setting up a frequency command with an external potentiometer

Follow the procedure given below.

(1) Configure the function codes as listed below.

Function code	Name	Function code data	Factory default
F01	Frequency Command 1	1: Analog voltage input to terminal [12] (0 to ±10 V)	0

Note If terminal [FWD] and [REV] are ON (short-circuited), the F02 data cannot be changed. First turn those terminals OFF and then change the F02 data.

(2) Connect an external potentiometer to terminals [11] through [13] of the inverter.

(3) Rotate the external potentiometer to apply voltage to terminal [12] for a frequency command input.

📖 For precautions in wiring, refer to Chapter 2 "MOUNTING AND WIRING THE INVERTER."
📖 For details on how to modify the function code data, see Chapter 3, Section 3.4.1 "Setting up function codes."

4.7.3 Setting up a frequency command with multistep frequency selection

Follow the procedure given below.

(1) Configure the function codes as listed below.

Function code	Name	Function code data	Factory default
E01 to E05	Terminal [X1] to [X5] Functions	0, 1, 2, 3: Multistep frequency 1 to 15 (0: ***SS1***, 1: ***SS2***, 2: ***SS4***, 3: ***SS8***)	0
C05 to C19	Multistep Frequency 1 to 15	0.00 to 500.00 Hz	0.00

Assign signals ***SS1***, ***SS2***, ***SS4*** and ***SS8*** to four out of five digital input terminals [X1] to [X5] by four out of five function codes E01 to E05 (data = 0, 1, 2 and 3). Specify multistep frequency commands with C05 to C19.

Turning digital signals ***SS1***, ***SS2***, ***SS4*** and ***SS8*** ON or OFF selectively switches the multistep frequency commands specified beforehand.

Combination of input signals				Selected frequency command	
3 ***SS8***	2 ***SS4***	1 ***SS2***	0 ***SS1***		
OFF	OFF	OFF	ON	C05 (Multistep frequency 1)	Related function codes C05 to C19 Data setting range: 0.00 to 500.00
OFF	OFF	ON	OFF	C06 (Multistep frequency 2)	
OFF	OFF	ON	ON	C07 (Multistep frequency 3)	
OFF	ON	OFF	OFF	C08 (Multistep frequency 4)	
OFF	ON	OFF	ON	C09 (Multistep frequency 5)	
OFF	ON	ON	OFF	C10 (Multistep frequency 6)	
OFF	ON	ON	ON	C11 (Multistep frequency 7)	
ON	OFF	OFF	OFF	C12 (Multistep frequency 8)	
ON	OFF	OFF	ON	C13 (Multistep frequency 9)	
ON	OFF	ON	OFF	C14 (Multistep frequency 10)	
ON	OFF	ON	ON	C15 (Multistep frequency 11)	
ON	ON	OFF	OFF	C16 (Multistep frequency 12)	
ON	ON	OFF	ON	C17 (Multistep frequency 13)	
ON	ON	ON	OFF	C18 (Multistep frequency 14)	
ON	ON	ON	ON	C19 (Multistep frequency 15)	

(2) Connect a multistep frequency switch to an X terminal and [CM].

(3) Turn the multistep frequency switch ON (short-circuit). The combination of those input signals switches a multistep frequency command.

📖 For precautions in wiring, refer to Chapter 2 "MOUNTING AND WIRING THE INVERTER."

📖 For details on how to modify the function code data, see Chapter 3, Section 3.4.1 "Setting up function codes."

Note Enabling a multistep frequency command with a multistep frequency switch (ON between X terminal and [CM]) disables the frequency command 1 specified by F01.

4.8 Selecting a Run Command Source

A run command source is the keypad (RUN and STOP keys) by factory default.

4.8.1 Setting up a run command from the keypad

Follow the procedure given below.

(1) Configure the function codes as listed below.

Function code	Name	Function code data	Factory default
F02	Operation Method	0: Keypad operation (Rotation direction input: Terminal block) 2: Keypad operation (Forward direction) 3: Keypad operation (Reverse direction)	2: Keypad operation (Forward direction)

(2) When F02 = 0: Press the RUN key to run the motor. Press the STOP key to stop it.

The rotation direction is specified by terminals [FWD] and [REV]. Connect the run forward switch between terminals [FWD] and [CM] and the run reverse switch between [REV] and [CM].

Note Make sure that the SINK/SOURCE slide switch (SW1) is turned to the SINK position. If SW1 is in the SOURCE position, the inverter cannot run the motor.

(3) When F02 = 2: Press the RUN key to run the motor in the forward direction. Press the STOP key to stop it.

(4) When F02 = 3: Press the RUN key to run the motor in the reverse direction. Press the STOP key to stop it.

For details on how to modify the function code data, see Chapter 3, Section 3.4.1 "Setting up function codes."

4.8.2 Setting up a run command with digital input signals (terminals [FWD] and [REV])

Follow the procedure given below.

(1) Configure the function codes as listed below.

Function code	Name	Function code data	Factory default
F02	Operation Method	1: External digital input signal	0: Keypad operation

Note If terminal [FWD] and [REV] are ON (short-circuited), the F02 data cannot be changed. First turn those terminals OFF and then change the F02 data.

(2) Connect the run forward switch between terminals [FWD] and [CM] and the run reverse switch between [REV] and [CM].

Note Make sure that the SINK/SOURCE slide switch (SW1) is turned to the SINK position. If SW1 is in the SOURCE position, the inverter cannot run the motor.

(3) Turn the run forward switch or run reverse switch ON (short-circuit) to run the motor in the forward or reverse direction, respectively.

For precautions in wiring, refer to Chapter 2 "MOUNTING AND WIRING THE INVERTER."

For details on how to modify the function code data, see Chapter 3, Section 3.4.1 "Setting up function codes."

Chapter 5
FUNCTION CODE

This chapter explains the table of function code used in FRENIC-Ace, index per purpose, and the detail of each function code.

Table of contents

Chapter 5 Function code

5.1 Function code overview

Function code is used for selecting various functions of FRENIC-Ace. Function code comprises 3 digits or 4 digits of alphanumeric character. The first digit categorizes the group of function code alphabetically and the subsequent 2 or 3 digits identify each code within the group by number. Function code comprises 11 groups: Basic function (F code), Terminal function (E code), Control code (C code), Motor 1 parameter (P code), High-level function (H code) (H1 code), Motor 2 parameter (A code), Application function 1 (J code) (J1 code), Application function 2 (d code), Customizable logic (U code) (U1 code), Link function (y code), Keypad functions (k code), and Option function (o code) . The function of each function code is determined according to the data to be set. The following descriptions are for supplementary explanation of function code table. Refer to instruction manual of each option to find the details of the option function (o code).

5.2 Function code table

5.2.1 Supplementary note

■ **Change, reflect, and save function code data during operation**

Function code is categorized into those which data change is enabled during operation of the inverter and those which such change is disabled. The meaning of the code in the "Change during operation" column of the function code table is described in the following table.

Code	Change during operation	Reflect and save data
⊙	Allowed	At the point when data is changed by ⌃/⌄ key, the changed data is immediately reflected on the operation of inverter. However, at this stage, the changed value is not saved to the inverter. In order to save it to the inverter, press FUNC/DATA key. Without saving by FUNC/DATA key and leaving the state of when the change was made by the PRG/RESET key, the data before the change is reflected on the operation of inverter.
○	Allowed	Even if data is changed by the ⌃/⌄ key, the changed data will not be reflected on the operation of the inverter as is; by pressing the FUNC/DATA key, the changed value is reflected on the operation of the inverter and is also saved to the inverter.
x	Not allowed	-

■ **Copying data**

Function code data can be copied collectively by using the keypad (program mode menu number 7 " Data copy"). By using this function, it is possible to read out all function code data and write the same data to a different inverter.

However, if the specification of inverter at the copy source and copy destination is not identical, some function codes may not be copied due to security reason. According to necessity, configure the settings individually for the function code that is not to be copied. The code to categorize these codes is indicated in the "data copy" column in the function code table in the next page and after.

○: to be copied.

△1: When inverter capacity is different, copying will not be performed.

△2: When voltage group is different, copying will not be performed.

×: not to be copied.

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■ Negative logic setting of data

Digital input terminal and transistor/contact output terminal can become a signal for which negative logic is specified by function code data setting. Negative logic is a function to reverse ON and OFF state of input or output, and switch Active ON (function enabled with ON: positive logic) and Active OFF (function enabled with OFF: negative logic). However, negative logic may not be enabled depending on the function of the signal.

Negative logic signal can be switched by setting the data with 1000 added to the function code data of the function to be set. For example, the following example shows when coast to a stop command "BX" is selected by function code E01.

Function code data	Action
7	"BX" is ON and coast to a stop (Active ON)
1007	"BX" is OFF and coast to a stop (Active OFF)

5.2.2 Function code table

The table of function code to be used in FRENIC-Ace is shown.

■ F code: Fundamental Functions (Basic function)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
F00	Data protection	0: No data protection, no digital setting protection 1: With data protection, no digital setting protection 2: No data protection, with digital setting protection 3: With data protection, with digital setting protection	○	○	0	5-29
F01	Frequency setting 1	0: Keypad key operation (∧/∨ key) 1: Analog voltage input (Terminal [12]) (from 0 to ±10 VDC) 2: Analog current input (Terminal [C1] (C1 function)) (4 to 20mA DC) 3: Analog voltage input (Terminal [12]) + Analog current input (Terminal [C1] (C1 function)) 5: Analog voltage input (Terminal [C1] (V2 function)) (0 to 10 VDC) 7: UP/DOWN control 8: Keypad key operation (∧/∨ key) (With balances bumpless) 10: Pattern operation 12: Pulse train input	x	○	0	5-30
F02	Operation	0: Keypad operation (rotation direction input: terminal block) 1: External signal (digital input) 2: Keypad operation (forward rotation) 3: Keypad operation (Reverse rotation)	x	○	2	5-39
F03	Maximum output frequency 1	25.0 to 500.0 Hz	x	○	CE:50.0, UTJK:60.0 A: 200 V class 60.0 A: 400V class 50.0	5-40
F04	Base frequency 1	25.0 to 500.0Hz	x	○	CEJKT:50.0, U:60.0 A: 200 V class 60.0 A: 400 V class 50.0	5-41
F05	Base frequency voltage 1	0: AVR disable (output voltage proportional to power voltage) 80 to 240 V: AVR operation (200V class) 160 to 500V: AVR operation (400V class)	x	△2:	TJK:200/400 A:220/415 C:200/380 E:230/400 U:230/460	
F06	Maximum output voltage 1	80 to 240V: AVR operation (200V class) 160 to 500V: AVR operation (400V class)	x	△2:		
F07	Acceleration time1	0.00 to 6000 s * 0.00 is for acceleration and deceleration time cancel (when performing soft-start and stop externally)	○	○	20.0	5-43
F08	Deceleration time1		○	○		
F09	Torque boost 1	0.0 to 20.0% (% value against base frequency voltage 1)	○	○	*2 U: Entire capacity 0.0	5-45
F10	Electronic thermal 1 (for motor protection) (Characteristics selection)	1: Enable (For a general-purpose motor with self-cooling fan) 2: Enable (For an inverter-driven motor (FV) with separately powered cooling fan)	○	○	1	5-45
F11	(Operation level)	0.00 (disable), current value of 1 to 135% of inverter rated current (Inverter rated current dependent on F80)	○	△1△2	*3	
F12	(Thermal time constant)	0.5 to 75.0 min	○	○	*4	
F14	Momentary power failure restart (Mode selection)	0: Immediately trip 1: Trip at auto-restarting 2: Trip after momentary deceleration is stopped 3: Continue to run (for heavy inertia load or general load) 4: Restart from frequency at power failure (for general load) 5: Restart from starting frequency	○	○	EU:0 ACTJK:1	5-48
F15	Frequency Limiter (upper limit)	0.0 to 500.0Hz	○	○	70.0	5-54
F16	(Lower limit)	0.0 to 500.0Hz	○	○	0.0	
F18	Bias (for frequency setting 1)	-100.00 to 100.00%	⊙	○	0.00	5-55
F20	DC braking 1 (Braking starting frequency)	0.0 to 60.0Hz	○	○	0.0	5-55
F21	(Operation level)	0 to 100% (HHD mode), 0 to 80% (HD/HND mode) 0 to 60% (ND mode 0 to 60% (ND mode))	○	○	0	
F22	(Braking time)	0.00 (Disable): 0.01 to 30.00 s	○	○	0.00	
F23	Starting Frequency 1	0.0 to 60.0Hz	○	○	0.5	5-58
F24	(Holding time)	0.00 to 10.00 s	○	○	0.00	
F25	Stop Frequency	0.0 to 60.0 Hz	○	○	0.2	

Factory default•••A (For Asia), C (for China), E (for Europe), U (For US), T (For Taiwan), J (for Japan), K (for Korea)
▭ indicates quick setup target function code.
*2 Standard value is set per capacitance. Refer to table A.
*3 Rated current of the motor is set. Refer to Table B (function code P03).
*4 Standard applicable electric motor is 5.0 min for 22 kw or lower and 10.0 min for 30 kW or higher.

Function code	Name	Data setting range	Under operation Change	Data Copy	Factory Default	Related page
F26	Motor sound (Carrier frequency)	0.75 to 6 kHz ND: FRN0072 to 0203E2□-4□ 0.75 to 10 kHz ND: FRN0059E2□-4□ HND: FRN0072 to 0203E2□-4□ HND: FRN0072 to 0203E2□-4□ HHD: FRN0203E2□-4□ 0.75 to16 kHz ND: FRN0059E2□4□ HND: FRN0059E2□-4□ HHD: FRN0059 to 0168E2□-4□	○	○	2	5-59
F27	(Tone)	0: Level 0 (Disable) 1: Level 1 2: Level 2 3: Level 3	○	○	0	
F29	Terminal FM (Mode selection)	0: Voltage output (0 to +10 VDC) 1: Current output (4 to 20 mA DC) 2: Current output (0 to 20 mA DC) 3: Pulse output	○	○	0	5-60
F30	(Output gain)	0 to 300%	⊙	○	100	
F31	(Function selection)	0: Output frequency 1 (before slip compensation) 1: Output frequency 2 (after slip compensation) 2: Output current 3: Output voltage 4: Output torque 5: Load factor 6: Consumed power 7: PID feedback value 9: DC intermediate circuit voltage 10: Universal AO 13: Motor output 14: Analog output test (+) 15: PID command (SV) 16: PID output (MV) 18: Inverter cooling fin temperature 111 to 119 Customizable logic output signal 1 to 9	○	○	0	
F32	Terminal FM 2(Mode selection)	0: Voltage output (0 to +10 VDC) 1: Current output (4 to 20 mA DC) 2: Current output (0 to 20 mA DC)	○	○	0	
F33	Terminal FM (Pulse rate)	25 to 32000 p/s (number of pulse at 100%)	⊙	○	1440	5-62
F34	Terminal FM 2 *1 (Output gain)	0 to 300%	⊙	○	100	
F35	(Function selection)	Same as F31 (only 0 to 18 supported)	○	○	2	
F37	Load selection/ Auto torque boost/ Auto energy-saving operation 1	0: Variable torque load 1: Constant torque load 2: Auto torque boost 3: Auto energy-saving operation (variable torque load) 4: Auto energy-saving operation (constant torque load) 5: Auto energy-saving operation (auto torque boost)	x	○	1	5-63
F39	Stop frequency (Holding time)	0.00 to 10.00 s	○	○	0.00	5-65
F40	Torque limiter 1 (Drive)	0 to 300%; 999 (Disable)	○	○	999	5-66
F41	1 (Braking)	0 to 300%; 999 (Disable)	○	○	999	
F42	Drive control selection 1	0: V/f control without slip compensation 1: Vector control without speed sensor (dynamic torque vector) 2: V/f control with slip compensation	x	○	0	5-69
F43	Current limiter (Mode selection)	0: Disable 1: Vector control without speed sensor (dynamic torque vector) 2: At acceleration and constant speed (Disable at deceleration)	○	○	2	5-71
F44	(Operation level)	20 to 200% (inverter rated current standard value)	○	○	JK:160, ACEUT:130	
F50	Electronic thermal (for braking resistor protection) (Discharging capacity)	1 to 9000 kWs OFF (Cancel)	○	△1△2	OFF	5-72
F51	(Allowable average loss)	0.001 to 99.99 kW	○	△1△2	0.001	
F52	(Braking resistance value)	0.00: Resistance not required (FRENIC-Multi compatible operation) 0.01 to 999 Ω	○	△1△2	0.00	
F80	ND/HD/HND/HHD switching	0: HHD mode 1: HND mode 3: HD mode 4: ND mode	x	○	J:0 ACEUKT:4	5-74

Factory default···A (For Asia), C (for China), E (for Europe), U (For US), T (For Taiwan), J (for Japan), K (for Korea)

▭ indicates quick setup target function code.

*1: F34 and F35 only exist for C model (for China).

■ E code: Extension Terminal Functions (Terminal function)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
E01	Terminal X1 (Function selection)	0 (1000): Select multi-frequency (0 to 1 steps) "SS1"	x	○	0	5-75
E02	Terminal X2	1(1001): Select multi-frequency (0 to 3 steps) "SS2"	x	○	1	
E03	Terminal X3	2(1002): Select multi-frequency (0 to 7 steps) "SS4"	x	○	2	
E04	Terminal X4	3(1003): Select multi-frequency (0 to 15 steps) "SS8"	x	○	7	
E05	Terminal X5	4 (1004): Select acceleration/deceleration (2 steps) "RT1"	x	○	8	
		5 (1005): Select acceleration/deceleration (4 steps) "RT2"				
		6 (1006): Select self-hold "HLD"				
		7 (1007): Coast to a stop command "BX"				
		8 (1008): Alarm (Abnormal) reset "RST"				
		9 (1009): External alarm "THR" (9 = Active OFF/ 1009 = Active ON)				
		10 (1010): Jogging operation "JOG"				
		11 (1011): Frequency setting 2/ Frequency setting 1 "Hz2/ Hz1"				
		12 (1012): Motor selection 2 "M2"				
		13: DC braking command "DCBRK"				
		14 (1014): Torque limit 2/ Torque limit 1 "TL2/ TL1"				
		15: Commercial power switching (50 Hz) "SW50"				
		16: Commercial power switching (60 Hz) "SW60"				
		17 (1017): UP command "UP"				
		18 (1018): DOWN command "DOWN"				
		19 (1019): Editing approval command (Data change enabled) "WE-KP"				
		20 (1020): PID control cancel "Hz/PID"				
		21 (1021): Switch normal/ inverse operation "IVS"				
		22 (1022): Interlock "IL"				
		24 (1024): Select link operation (RS-485, BUS option) "LE"				
		25 (1025): Universal DI "U-DI"				
		26 (1026): Select starting mode "STM"				
		30 (1030): Force to stop "STOP" (30 = Active OFF/1030 = Active ON)				
		33 (1033): PID Integer/Differential reset "PID-RST"				
		34 (1034): PID integer hold "PID-HLD"				
		35 (1035): Select local (Keypad) command "LOC"				
		48: Pulse rate input (Only for X5 terminal (E05)) "PIN"				
		49 (1049): Pulse train sign "SIGN" (Other than X5 terminal (E01 to E04))				
		65(1065): Brake check "BRKE"				
		72 (1072): Count the run time of commercial power-driven motor (Motor 1) "CRUN-M1"				
		73 (1073): Count the run time of commercial power-driven motor (Motor 2) "CRUN-M2"				
		76 (1076): Select droop "DROOP"				
		80 (1080): Cancel customizable logic "CLC"				
		81 (1081): Clear all customizable logic timers "CLTC"				
		100: No function assigned "NONE"				
		171 (1171): PID control multistage command 1 "PID-SS1"				
		172 (1172): PID control multistage command 2 "PID-SS2"				
		* Inside the ( ) is the negative logic signal (OFF at short-circuit)				
E10	Acceleration time2	0.00 to 6000 s	○	○	20.0	5-85
E11	Deceleration time2	* 0.00 is for acceleration and deceleration time cancel (when performing soft-start and stop externally)	○	○		
E12	Acceleration time 3		○	○		
E13	Deceleration time 3		○	○		
E14	Acceleration time 4		○	○		
E15	Deceleration time 4		○	○		
E16	Torque limiter 2 (Drive)	0 to 300%; 999 (Disable)	○	○	999	5-85
E17	2 (Braking)	0 to 300%; 999 (Disable)	○	○	999	
E20	Terminal Y1 (Function selection)	0 (1000): During operation "RUN"	x	○	0	5-85
E21	Terminal Y2	1 (1001): Frequency (speed) arrival "FAR"	x	○	7	
E27	Terminal 30A/B/C (Ry output)	2(1002): Frequency (speed) detected "FDT"	x	○	99	
		3 (1003): Undervoltage detected (inverter stopped) "LU"				
		4 (1004): Torque polarity detected "B/D"				
		5 (1005): Inverter output limiting "IOL"				
		6 (1006): Auto-restarting after momentary power failure "IPF"				
		7 (1007): Motor overload early warning signal "OL"				
		8 (1008) Keypad operation enabled "KP"				

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Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
		10 (1010): Inverter ready to run "RDY"				5-85
		15 (1015): AX terminal function "AX"				
		16 (1016): Shift pattern operation stage "TU"				
		17(1017): Complete pattern operation cycle operation "TO"				
		18 (1018): Pattern operation stage 1 "STG1"				
		19 (1019): Pattern operation stage 2 "STG2"				
		20 (1020): Pattern operation stage 4 "STG4"				
		21(1021): Speed arrival 2 “FAR2”				
		22 (1022): Inverter output limiting with delay "IOL2"				
		25 (1025): Cooling Fan ON/OFF control "FAN"				
		26 (1026): Retrying "TRY"				
		27 (1027): Universal DO "U-DO"				
		28 (1028): Cooling fin overheat early warning "OH"				
		30 (1030): Lifetime alarm "LIFE"				
		31(1031): Frequency (speed) detected 2 "FDT2"				
		33 (1033): Command loss detected "REF OFF"				
		35 (1035): Inverter outputting "RUN 2"				
		36 (1036) Overload prevention controlling "OLP"				
		37 (1037): Current detected "ID"				
		38 (1038): Current detected 2 "ID2"				
		39 (1039): Current detected 3 "ID3"				
		41 (1041): Low current detected "IDL"				
		42 (1042): PID alarm output "PID-ALM"				
		43 (1043): Under PID control "PID-CTL"				
		44 (1044): Motor stopped due to slow flow rate under PID control "PID-STP"				
		45 (1045): Low torque detected "U-TL"				
		46 (1046): Torque detected 1 "TD1"				
		47 (1047): Torque detected 2 "TD2"				
		48 (1048): Motor 1 selected "SWM1"				
		49(1049): Motor 2 selected "SWM2"				
		52 (1052): Running forward "FRUN"				
		53 (1053): Running reverse "RRUN"				
		54 (1054): During remote mode "RMT"				
		56 (1056): Thermistor detected "THM"				
		57 (1057): Brake signal "BRKS"				
		58 (1058): Frequency (speed) detected 3 "FDT3"				
		59 (1059): [C1] (C1 function) Terminal wire break detected "C1OFF"				
		72(1072): Frequency (speed) arrival 3 "FAR3"				
		77(1077): Low link bus voltage detection “U-EDC”				
		79 (1079): During decelerating at momentary power failure "iPF2"				
		84 (1084): Maintenance timer "MNT"				
		90 (1090): Alarm content 1 "AL1"				
		91 (1091): Alarm content 2 "AL2"				
		92 (1092): Alarm content 4 "AL4"				
		93 (1093): Alarm content 8 "AL8"				
		98 (1098): Light alarm "L-ALM"				
		99 (1099): Alarm output "ALM"				
		101 (1101): EN terminal detection circuit abnormal "DECF"				
		102 (1102): EN terminal OFF "ENOFF"				
		105 (1105): Braking transistor broken "DBAL"				
		111 (1111): Customizable logic output signal 1 "CLO1"				
		112 (1112): Customizable logic output signal 2 "CLO2"				
		113 (1113): Customizable logic output signal 3 "CLO3"				
		114 (1114): Customizable logic output signal 4 "CLO4"				
		115 (1115): Customizable logic output signal 5 "CLO5"				
		116 (1116): Customizable logic output signal 6 "CLO6"				
		117 (1117): Customizable logic output signal 7 "CLO7"				
		118 (1118): Customizable logic output signal 8 "CLO8"				
		119 (1119): Customizable logic output signal 9 "CLO9"				
		* Inside the ( ) is the negative logic signal. (OFF at short-circuit)				
E29	Frequency arrival delay (FAR2)	0.01 to 10.00 s			0.10	5-94
E30	Frequency arrival detection width (Detection width)	0.0 to 10.0 Hz	○	○	2.5	
E31	Frequency detection (Operation level)	0.0 to 500.0 Hz	○	○	CE: 50.0, JKUT: 60.0 A: 200 V class 60.0 A: 400 V class 50.0	5-96
E32	(Hysteresis width)	0.0 to 500.0 Hz	○	○	1.0	

Factory default･･･A (For Asia), C (for China), E (for Europe), U (For US), T (For Taiwan), J (for Japan), K (for Korea)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
E34	Overload Early Warning/Current detection (Operation level)	0.00 (Disable), 1 to 200% of inverter rated current (Inverter rated current dependent on F80)	○	△1△2	*3	5-96
E35	(Timer time)	0.01 to 600.00 s	○	○	10.00	
E36	Frequency detection 2 (Operation level)	0.0 to 500.0 Hz	○	○	CE: 50.0, JKUT: 60.0 A: 200 V class 60.0 A: 400 V class 50.0	5-97
E37	Current detection 2/ Low current detection (Operation level)	0.00 (Disable), 1 to 200% of inverter rated current (Inverter rated current dependent on F80)	○	△1△2	*3	
E38	(Timer time)	0.01 to 600.00 s	○	○	10.00	
E39	Coefficient for constant rate sending time	0.000 to 9.999	○	○	0.000	
E42	LED Display Filter	0.0 to 5.0 s	○	○	0.5	5-98
E43	LED monitor (Item selection)	0: Speed monitor (Selectable with E48) 3: Output current 4: Output voltage 8: Calculated torque 9: Consumed power 10: PID command 12: PID feedback amount 13: Timer value 14: PID output 15: Load factor 16: Motor output 17: Analog signal input monitor 25: Input watt-hour	○	○	0	5-99
E44	(Display when stopped)	0: Display setting value 1: Display output value	○	○	0	5-100
E48	LED monitor detail (Speed monitor selection)	0: Output frequency 1 (before slip compensation) 1: Output frequency 2 (after slip compensation) 2: Reference frequency 3: Motor rotation speed 4: Load rotation speed 5: Line speed 6: Constant rate sending time 7: Speed (%)	○	○	0	5-100
E50	Coefficient for Speed Indication	0.01 to 200.00	○	○	30.00	5-100
E51	Display Coefficient for Input Watt-hour Data	0.000 (Cancel/Reset). 0.001 to 9999	○	○	0.010	
E52	Keypad (Menu display mode)	0: Function code data setting mode (Menu 0, Menu1, and Menu 7) 1: Function code data check mode (Menu 2 and Menu 7) 2: Full-menu mode	○	○	0	5-101
E54	Frequency detection 3 (Operation level)	0.0 to 500.0Hz	○	○	CE: 50.0, JKUT: 60.0 A: 200 V class 60.0 A: 400V class 50.0	5-101
E55	Current detection 3(Operation level)	0.00 (Disable), 1 to 200% of inverter rated current	○	△1△2	*3	5-101
E56	(Timer time)	0.01 to 600.00 s	○	○	10.00	
E59	Terminal [C1] Function selection	0: Current input (C1 function) 1: Voltage input (V2 function)	○	○	0	5-102
E61	Terminal [12] (Extension function selection)	0: None 1: Auxiliary frequency setting 1 2: Auxiliary frequency setting 2 3: PID process command 1 5: PID feedback amount 6: Ratio setting 7: Analog torque limiter A 8: Analog torque limiter B 20: Analog signal input monitor	x	○	0	5-103
E62	Terminal [C1] (C1 function)		x	○	0	
E63	Terminal[C1] (V2 function)		x	○	0	
E64	Saving of Digital Reference Frequency	0: Auto saving (main power is turned off) 1: Save by turning key ON	○	○	0	5-103
E65	Reference loss detection (Continue to run frequency)	0: Stop deceleration, 20 to 120%, 999: Cancel	○	○	999	5-104
E76	Direct current intermediate voltage detection level	200 to 400 V (200 V class) 400 to 800 V (400 V class)	○	○	235 470	
E78	Torque detection 1 (Operation level)	0 to 300%	○	○	100	5-105
E79	(Timer time)	0.01 to 600.00 s	○	○	10.00	
E80	Torque detection 2/ Low torque detection (Operation level)	0 to 300%	○	○	20	
E81	(Timer time)	0.01 to 600.00 s	○	○	20.00	

Factory default···A (For Asia), C (for China), E (for Europe), U (For US), T (For Taiwan), J (for Japan), K (for Korea)
[shaded box] indicates quick setup target function code.
*3 Rated current of the motor is set. Refer to Table B (function code P03).

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
E98	Terminal FWD (Function selection)	0 (1000): Select multi-frequency (0 to 1 steps) "SS1"	x	○	98	5-105
E99	Terminal REV	1(1001): Select multi-frequency (0 to 3 steps) "SS2"	x	○	99	
		2(1002): Select multi-frequency (0 to 7 steps) "SS4"				
		3(1003): Select multi-frequency (0 to 15 steps) "SS8"				
		4 (1004): Select acceleration/deceleration (2 steps) "RT1"				
		5 (1005): Select acceleration/deceleration (4 steps) "RT2"				
		6 (1006): Select self-hold "HLD"				
		7 (1007): Free run command "BX"				
		8 (1008): Alarm (Abnormal) reset "RST"				
		9 (1009): External alarm "THR" (9 = Active OFF/1009 = Active ON)				
		10 (1010): Jogging operation "JOG"				
		11 (1011): Frequency setting 2/ Frequency setting 1 "Hz2/ Hz1"				
		12 (1012): Motor selection 2 "M2"				
		13: DC braking command "DCBRK"				
		14 (1014): Torque limit 2/ Torque limit 1 "TL2/ TL1"				
		15: Commercial power switching (50 Hz) "SW50"				
		16: Commercial power switching (60 Hz) "SW60"				
		17 (1017): UP command "UP"				
		18 (1018): DOWN command "DOWN"				
		19 (1019): Editing approval command (Data change enabled) "WE-KP"				
		20 (1020): PID control cancel "Hz/PID"				
		21 (1021): Switch normal/ inverse operation "IVS"				
		22 (1022): Interlock "IL"				
		24 (1024): Select link operation (RS-485, BUS option) "LE"				
		25 (1025): Universal DI "U-DI"				
		26 (1026): Select starting mode "STM"				
		30 (1030): Force to stop "STOP" (30 = Active OFF/1030 = Active ON)				
		33 (1033): PID Integer/Differential reset "PID-RST"				
		34 (1034): PID integer hold "PID-HLD"				
		35 (1035): Select local (Keypad) command "LOC"				
		49 (1049): Pulse train sign "SIGN"				
		65(1065): Brake check "BRAKE"				
		72 (1072): Count the run time of commercial power-driven motor (Motor 1) "CRUN-M1"				
		73 (1073): Count the run time of commercial power-driven motor (Motor 2) "CRUN-M2"				
		76 (1076): Select droop "DROOP"				
		80 (1080): Cancel customizable logic "CLC"				
		81 (1081): Clear all customizable logic timers "CLTC"				
		98: Run forward stop command "FWD"				
		99: Run reverse stop command "REV"				
		100: No function assigned "NONE"				
		171 (1171): PID control multistage command 1 "PID-SS1"				
		172 (1172): PID control multistage command 2 "PID-SS2"				
		* Inside the ( ) is the negative logic signal. (OFF at short-circuit)				

■ C code: Control Functions of Frequency (Control function)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
C01	Jump frequency 1	0.0 to 500.0Hz	○	○	0.0	5-106
C02	2		○	○	0.0	
C03	3		○	○	0.0	
C04	(Width)	0.0 to 30.0Hz	○	○	3.0	
C05	Multi-frequency 1	0.00 to 500.00Hz	○	○	0.00	
C06	2		○	○	0.00	
C07	3		○	○	0.00	
C08	4		○	○	0.00	
C09	5		○	○	0.00	
C10	6		○	○	0.00	
C11	7		○	○	0.00	
C12	8		○	○	0.00	
C13	9		○	○	0.00	
C14	10		○	○	0.00	
C15	11		○	○	0.00	
C16	12		○	○	0.00	
C17	13		○	○	0.00	
C18	14		○	○	0.00	
C19	15		○	○	0.00	
C20	Jogging Frequency	0.00 to 500.00 Hz	○	○	0.00	5-107
C21	Pattern operation selection/ Timer operation (Select openmin)	0: 1 cycle operation 1: Repetition operation 2: Low speed operation after 1 cycle operation 3: Timer operation	x	○	0	5-108
C22	(Stage 1)	Special setting: Press FUNC/DATA key three times. 1st: Set run time 0.0 to 6000 s and press F/D key. 2nd: Set rotational direction F (forward) or r (reverse) and press F/D key. 3rd: Set acceleration/deceleration time 1 to 4 and press F/D key.	○	○	1st:0.00 2nd: F 3rd: 1	
C23	(Stage 2)					
C24	(Stage 3)					
C25	(Stage 4)					
C26	(Stage 5)					
C27	(Stage 6)					
C28	(Stage 7)					
C30	Frequency setting 2	0: Keypad ⌃/⌄ key operation 1: Analog voltage input (Terminal [12]) (from 0 to ±10 VDC) 2: Analog current input (Terminal [C1] (C1 function)) (4 to 20mA DC) 3: Analog voltage input (Terminal [12]) + Analog current input (Terminal [C1] (C1 function)) 5: Analog voltage input (Terminal [C1] (V2 function)) (0 to 10 VDC) 7: UP DOWN control 8: Keypad key operation (⌃/⌄key) (With balances bumpless) 10: Pattern operation 12: Pulse train input	x	○	2	5-110
C31	Analog input adjustment (Terminal [12]) (Offset)	-5.0 to 5.0%	⊙	○	0.0	5-111
C32	(Gain)	0.00 to 200.00%	⊙	○	100.00	
C33	(Filter)	0.00 to 5.00 s	○	○	0.05	
C34	(Gain base point)	0.00 to 100.00%	⊙	○	100.00	
C35	(Polarity selection)	0: Bipolar 1: Single polarity	x	○	1	
C36	Analog input adjustment (Terminal [C1] (C1 function)) (Offset)	-5.0 to 5.0%	⊙	○	0.0	
C37	(Gain)	0.00 to 200.00%	⊙	○	100.00	
C38	(Filter)	0.00 to 5.00 s	○	○	0.05	
C39	(Gain base point)	0.00 to 100.00%	⊙	○	100.00	
C40	Terminal [C1] (C1 function) Range selection	0: 4 to 20 mA Single polarity 1: 0 to 20 mA Single polarity 10: 4 to 20 mA Bipolar 11: 0 to 20 mA Bipolar	x	○	0	
C41	Analog input adjustment (Terminal [C1] (V2 function)) (Offset)	-5.0 to 5.0%	⊙	○	0.0	
C42	(Gain)	0.00 to 200.00%	⊙	○	100.00	
C43	(Filter)	0.00 to 5.00 s	○	○	0.05	
C44	(Gain base point)	0.00 to 100.00%	⊙	○	100.00	
C45	(Polarity selection)	0: Bipolar 1: Single polarity	x	○	1	
C50	Bias (for frequency setting 1) (Bias base point)	0.00 to 100.00%	⊙	○	0.00	5-113
C53	Selection of normal/inverse operation(Frequency setting 1)	0: Normal 1: Inverse	○	○	0	5-114
C55	Analog input adjustment (Terminal 12) (Bias)	-100.00 to 100.00%	○	○	0.00	5-111
C56	(Bias base point)	0.00 to 100.00 %	○	○	0.00	

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
C58	(Display unit)	* Same as J105 (However ,Setting range is, 1 to 80)	○	○	2	5-114
C59	(Maximum scale)	-999.00 to 0.00 to 9990.00	○	○	100.00	
C60	(Minimum scale)	-999.00 to 0.00 to 9990.00	○	○	0.00	
C61	Analog input adjustment (Terminal [C1] (C1 function)) (Bias)	-100.00 to 100.00 %	○	○	0.00	5-111
C62	(Bias base point)	0.00 to 100.00 %	○	○	0.00	
C64	(Display unit)	* Same as J105 (However ,Setting range is, 1 to 80)	○	○	2	5-114
C65	(Maximum scale)	-999.00 to 0.00 to 9990.00	○	○	100.00	
C66	(Minimum scale)	-999.00 to 0.00 to 9990.00	○	○	0.00	
C67	Analog input adjustment (Terminal [C1] (V2 function)) (Bias)	-100.00 to 100.00 %	○	○	0.00	5-111
C68	(Bias base point)	0.00 to 100.00 %	○	○	0.00	
C70	(Display unit)	* Same as J105 (However ,Setting range is,1 to 80)	○	○	2	5-114
C71	(Maximum scale)	-999.00 to 0.00 to 9990.00	○	○	100.00	
C72	(Minimum scale)	-999.00 to 0.00 to 9990.00	○	○	0.00	
C89	Frequency compensation 1 by (Numerator)	-32768 to 32767 (Keypad display is 8000 to 7FFFH) (Interpreted as 1 when the value is set to 0)	○	○	0001	
C90	Frequency compensation 2 by (Denominator)	-32768 to 32767 (Keypad display is 8000 to 7FFFH) (Interpreted as 1 when the value is set to 0)	○	○	0001	

■ P code: Motor 1 Parameters (Motor 1 parameter)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
P01	Motor 1 (No. of poles)	2 to 22 poles	x	△1△2	4	5-115
P02	(Capacitance)	0.01 to 1000 kW (At P99 = 0 or 4) 0.01 to 1000 HP (At P99 = 1)	x	△1△2	*6	
P03	(Rated current)	0.00 to 2000A	x	△1△2	*6	
P04	(Auto-tuning)	0: Disable 1: Stop tuning (%R1, %X, Rated slip frequency) 2: Rotation tuning for V/f control (%R1, %X, Rated slip frequency, No-load current)	x	X	0	5-116
P05	(Online tuning)	0: Disable 1: Action	○	○	0	5-117
P06	(No-load current)	0.00 to 2000A	x	△1△2	*6	
P07	(%R1)	0.00 to 50.00%	○	△1△2	*6	
P08	(%X)	0.00 to 50.00%	○	△1△2	*6	
P09	(Slip compensation gain for driving)	0.0 to 200.0%	⊙	○	100.0	5-118
P10	(Slip compensation response time)	0.01 to 10.00 s	○	△1△2	0.5	
P11	(Slip compensation gain for braking)	0.0 to 200.0%	⊙	○	100.0	
P12	(Rated slip frequency)	0.00 to 15.00Hz	x	△1△2	*6	
P13	(Iron loss factor 1)	0.00 to 20.00%	○	△1△2	*6	
P53	(%X correction factor 1)	0 to 300%	○	△1△2	100	
P99	Motor 1 selection	0: Motor characteristics 0 (Fuji standard motors, 8-series) 1: Motor characteristics 1 (HP rating motors) 4: Other motors	x	△1△2	ACEJKT: 0 U;1	5-119

▭ indicates quick setup target function code.
*6 Constant of motor is set per capacitance. Refer to table B.

FUNCTION CODE

Chap. 5

■ H code: High Performance Functions (High level function)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
H03	Data initialization	0: Manual setting value 1: Initial value (factory default value) 2: Initialize motor 1 parameters 3: Initialize motor 2 parameters 11: Limited initialization (Initialization excluding communication function code) 12: Limited initialization (initialize customizable logic)	x	x	0	5-120
H04	Retry (Count)	0: Disable, 1 to 20: Number of retries	○	○	0	5-121
H05	(Interval)	0.5 to 20.0 s	○	○	5.0	
H06	Cooling Fan ON/OFF Control	0: Disable (Alway Fan ON) 1: Enable (ON/OFF control effective)	○	○	0	5-122
H07	Curve acceleration/deceleration	0: Disable (Linear acceleration/deceleration) 1: S-curve acceleration/deceleration (Weak) 2: S-curve acceleration/deceleration (Arbitrary: According to H57 to H60) 3: Curve acceleration/deceleration	○	○	0	5-123
H08	Rotational Direction Limitation	0: Disable 1: Enable (Reverse rotation inhibited) 2: Enable (Forward rotation inhibited)	x	○	0	
H09	Starting Mode (Auto search)	0: Disable 1: Enable (Only at restart after momentary power failure) 2: Enable (At normal start and at restart after momentary power failure)	x	○	0	5-125
H11	Deceleration Mode	0: Normal deceleration 1: Coast to a stop	○	○	0	
H12	Instantaneous Overcurrent Limiting (Mode selection)	0: Disable 1: Enable	○	○	1	
H13	Momentary power failure restart (Interval)	0.1 to 20.0 s	○	△1△2	*2	
H14	(Frequency lowering rate)	0.00: Selected deceleration time, 0.01 to 100.00Hz/s, 999 (According to current limiter)	○	○	999	
H15	(Continue to run level)	200 to 300V: (200 V class) 400 to 600V: (400V class)	○	△2:	235 470	
H16	(Allowable momentary power failure time)	0.0 to 30.0s, 999 (Auto judge by inverter)	○	○	999	
H26	Thermistor (for motor) (Mode selection)	0: Disable 1: PTC: 0H4 trip and stop the inverter 2: PTC: Output the output signal "THM" and continue to run	○	○	0	5-126
H27	(Operation level)	0.00 to 5.00 V	○	○	1.60	
H28	Droop control	-60.0 to 0.0Hz	○	○	0.0	5-127
H30	Link Function (Mode selection)	Frequency command / Run command 0: F01/C30 / F02 1: RS-485 communication (Port 1) / F02 2: F01/C30 / RS-485 Communication (Port 1) 3: RS-485 Communication (Port 1) / RS-485 Communication (Port 1) 4: RS-485 Communication (Port 2) / F02 5: RS-485 Communication (Port 2) / RS-485 Communication (Port 1) 6: F01/C30 / RS-485 Communication (Port 2) 7: RS-485 Communication (Port 1) / RS-485 Communication (Port 2) 8: RS-485 Communication (Port 2) / RS-485 Communication (Port 2)	○	○	0	5-128
H42	Capacitance of DC link bus capacitor	For adjustment at replacement (0000 to FFFF (in hexadecimal))	○	x	-	5-130
H43	Cumulative run time of cooling fan	For adjustment at replacement Displays the cumulative run time of cooling fan in units of ten hours.	○	x	-	
H44	Startup Count for Motor 1	For adjustment at replacement (0000 to FFFF (in hexadecimal))	○	x	-	5-133
H45	Mock AlarmMock alarm	0: Disable 1: Occurrence of mock Alarm	○	x	0	
H46	Starting Mode (Auto search delay time 2)	0.1 to 20.0 s	○	△1△2	*6	
H47	Initial capacitance of DC link bus capacitor	For adjustment at replacement (0000 to FFF (in hexadecimal))	○	x	-	5-134
H48	Printed circuit board capacitor cumulative run time	For adjustment at replacement Change in cumulative motor run time (Reset is enabled) (in units of ten hours)	○	x	-	
H49	Starting Mode (Auto search delay time 1)	0.0 to 10.0 s	○	○	0.0	5-135
H50	Non-linear V/f1 Frequency)	0.0 (Cancel), 0.1 to 500.0 Hz	x	○	0.0	
H51	(Voltage)	0 to 240 V: AVR operation (200 V class) 0 to 500V: AVR operation (400V class)	x	△2:	0	
H52	Non-linear V/f2 (Frequency)	0.0 (Cancel), 0.1 to 500.0 Hz	x	○	0.0	
H53	(Voltage)	0 to 240V: AVR operation (200V class) 0 to 500V: AVR operation (400V class)	x	△2:	0	
H54	Acceleration Time (Jogging operation)	0.00 to 6000 s	○	○	20.0	
H55	Deceleration Time (Jogging operation)	0.00 to 6000 s	○	○		
H56	Deceleration Time for Forced Stop	0.00 to 6000 s	○	○		

Factory default･･･A (For Asia), C (for China), E (for Europe), U (For US), T (for Taiwan), J (for Japan), K (for Korea)
*2 Standard value is set per capacitance. Refer to table A.
*6 Rated current of motor is set per capacitance. Refer to table B.

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
H57	1st S-curve acceleration range (At the start)	0 to 100%	○	○	10	5-134
H58	2nd S-curve acceleration range (At the end)	0 to 100%	○	○	10	
H59	1st S-curve deceleration range (At the start)	0 to 100%	○	○	10	
H60	2nd S-curve deceleration range (At the end)	0 to 100%	○	○	10	
H61	UP/DOWN control initial value setting	0: Initial value is 0.00 Hz 1: Initial value is set frequency with UP/DOWN command right before there is no more run command.	x	○	1	
H63	Low limiter (Mode selection)	0: Lower limit is F16: Continuous to run with limitation by frequency limiter (lower limit) 1: Lower limit is F16: Stop deceleration at or below the frequency limiter (lower limit)	○	○	0	
H64	(Minimum frequency during limiting operation)	0.0: F16: 0.1 to 60.0 Hz dependent on frequency limiter (lower limit)	○	○	1.6	
H65	Non-linear V/f Pattern 3 (Frequency)	0.0 (Cancel), 0.1 to 500.0 Hz	x	○	0.0	
H66	(Voltage)	0 to 240V: AVR operation (200V class) 0 to 500V: AVR operation (400V class)	x	△2:	0	
H68	Slip Compensation 1 (Operating conditions selection)	0: Enable during acceleration/deceleration, enable at base frequency or higher 1: Disable during acceleration/deceleration, enable at base frequency or higher 2: Enable during acceleration/deceleration, disable at base frequency or higher 3: Disable during acceleration/deceleration, disable at base frequency or higher	x	○	0	5-135
H69	Anti-regenerative control (Mode selection)	0: Disable 2: Torque control (Force to stop after elapse of three times of deceleration time) 3: DC intermediate voltage control (Force to stop after elapse of three times of deceleration time) 4: Torque control (Disable force to stop processing) 5: DC intermediate voltage control (Disable force to stop processing)	○	○	0	
H70	Overload prevention control	0.00: Comply with the selected deceleration time 0.01 to 100.00 Hz/s, 999 (Cancel)	○	○	999	5-136
H71	Deceleration characteristics	0: Disable 1: Enable	○	○	0	
H72	Detected the main power shoutdown (Mode selection)	0: Disable 1: Enable	○	○	1	
H76	Torque limiter (Braking) (Frequency increment limit for braking)	0.0 to 500.0Hz	○	○	5.0	5-137
H77	Life of main circuit capacitor (Time remaining before the end of life)	0 to 8760 (in units of ten hours)	○	x	-	
H78	Maintenance Interval (M1)	0 (Disable): 1 to 9999 (in units of ten hours)	○	x	J:8760 ACEUKT:6132	
H79	Preset Startup Count for Maintenance (M1)	0000 (Disable): 0001 to FFFF (in hexadecimal)	○	x	0	5-138
H80	Output current fluctuation damping Gain for Motor 1	0.00 to 1.00	○	○	0.20	
H81	Light Alarm Selection 1	0000 to FFFF (in hexadecimal)	○	○	0000	5-139
H82	Light Alarm Selection 2	0000 to FFFF (in hexadecimal)	○	○	0000	
H89	Reserved for particular manufacturers	0.1	○	○	0	5-141
H90	Reserved for particular manufacturers	0.1	○	○	0	
H91	PID feedback wire break	0.0 (Alarm disable): 0.1 to 60.0 s	○	○	0.0	5-142
H92	Continue to run (P)	0.000 to 10.000 times; 999	○	△1△2	999	
H93	(I)	0.010 to 10.000 s; 999	○	△1△2	999	
H94	Cumulative Motor Run Time 1	0 to 9999 Change in cumulative motor run time (Reset is enabled) (in units of 10 hours)	x	x	-	5-137 5-142
H95	DC Braking (Braking response mode)	0: Slow response 1: Quick response	○	○	1	5-55 5-142
H96	STOP Key Priority/ Start Check Function	0: STOP key priority disable/ Start check function disable 1: STOP key priority enable/ Start check function disable 2: STOP key priority disable/ Start check function enable 3: STOP key priority enable/ Start check function enable	○	○	ACETJK:0 U:3	5-142
H97	Clear Alarm Data	0: Disable 1: Alarm data clear (Automatically return to 0 after clearing data)	○	x	0	5-143
H98	Protection/Maintenance Function (Mode selection)	0 to 255 (Data is displayed in decimal, Meaning of each bit 0: Disable; 1 Enable) Bit 0: Lower the carrier frequency automatically (0: Disable; 1: Enable) Bit 1: Input phase loss protection (0: Disable; 1: Enable) Bit 2: Output phase loss protection (0: Disable; 1: Enable) Bit 3 Main circuit capacitor life judgment selection (0: Factory default referenced; 1 User measurement value standard) Bit 4: Judge the life of main circuit capacitor (0: Disable; 1: Enable) Bit 5: Detect DC fan lock (0: Enable; 1: Disable) Bit 6: Braking transistor error detection (22 kW or below) (0: Disable; 1: Enable)	○	○	FRN0059E2S-4□,FRN0072E2S-4□:83 FRN0085-E2S-4□ to FRN0203E2S-4□:19	
H114	Anti-regenerative control (operation level)	0.0 to 50.0%, 999: disabled	○	○	0.0	5-145
H180	Brake signal (brake operation check time)	0.00 to 10.00 s	○	○	0.00	
H195	DC braking (Braking time at the startup)	0.00 (Disable): 0.01 to 30.00 s	○	○	0.00	5-55 5-145

Factory default···A (For Asia), C (for China), E (for Europe), U (For US), T (For Taiwan), J (for Japan), K (for Korea)

FUNCTION CODE

Chap. 5

■ A code: Motor 2 Parameters (Motor 2 parameter)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
A01	Maximum output frequency 2	25.0 to 500.0Hz	x	○	CE: 50.0, JKUT: 60.0 A: 200 V class 60.0 A: 400V class 50.0	
A02	Base frequency 2	25.0 to 500.0Hz	x	○	CEJKT:50.0,U: 60.0 A: 200 V class 60.0 A: 400V class 50.0	
A03	Base frequency voltage 2	0: AVR disable (output voltage proportional to power voltage) 80 to 240V: AVR operation (200V class) 160 to 500V: AVR operation (400V class)	x	△2:	TJK:200/400 A: 220/415, C: 200/380 E: 230/400, U: 230/460	
A04	Maximum output voltage 2	80 to 240V: AVR operation (200V class) 160 to 500V: AVR operation (400V class)	x	△2:		
A05	Torque boost 2	0.0 to 20.0% (% value against base frequency voltage 2)	○	○	*2	
A06	Electronic thermal 2 (for motor protection)(Characteristics selection)	1: Enable (For a general-purpose motor with self-cooling fan) 2: Enable (For an inverter-driven motor (FV) with separately powered cooling fan)	○	○	1	
A07	(Operation level)	0.00 (disable), current value of 1 to 135% of inverter rated current	○	△1△2	*3	
A08	(Thermal time constant)	0.5 to 75.0 min	○	○	*4	
A09	DC braking 2 (Braking starting frequency)	0.0 to 60.0Hz	○	○	0.0	
A10	(Operation level)	0 to 100% (HHD mode), 0 to 80% (HD/HND mode) 0 to 60% (ND mode)	○	○	0	
A11	(Braking time)	0.00 (Disable): 0.01 to 30.00 s	○	○	0.00	
A12	Starting Frequency 2	0.0 to 60.0Hz	○	○	0.5	
A13	Select load/ Auto torque boost/ Auto energy-saving operation 2	0: Variable torque load 1: Constant torque load 2: Auto torque boost 3: Auto energy-saving operation (variable torque load) 4: Auto energy-saving operation (constant torque load) 5: Auto energy-saving operation (auto torque boost)	x	○	1	
A14	Drive control selection 2	0: V/f control without slip compensation 1: Vector control without speed sensor (Dynamic torque vector control) 2: V/f control with slip compensation	x	○	0	
A15	Motor 2 (No. of poles)	2 to 22 poles	x	△1△2	4	
A16	(Capacitance)	0.01 to 1000 kW (At P39 = 0 to 4) 0.01 to 1000 HP (At P39 = 1)	x	△1△2	*6	
A17	(Rated current)	0.00 to 2000A	x	△1△2	*6	
A18	(Auto-tuning)	0: Disable 1: Stop tuning (%R1, %X, Rated slip frequency) 2: Rotation tuning for V/f control (%R1, %X, Rated slip frequency, No-load current, Magnetic saturation factor 1 to 5, Magnetic saturation extension factor a to c)	x	x	0	
A19	(Online tuning)	0: Disable 1: Enable	○	○	0	
A20	(No-load current)	0.00 to 2000A	x	△1△2	*6	
A21	(%R1)	0.00 to 50.00%	○	△1△2	*6	
A22	(%X)	0.00 to 50.00%	○	△1△2	*6	
A23	(Slip compensation gain for driving)	0.0 to 200.0%	⊙	○	100.0	
A24	(Slip compensation response time)	0.01 to 10.00 s	○	△1△2	0.50	
A25	(Slip compensation gain for braking)	0.0 to 200.0%	⊙	○	100.0	
A26	(Rated slip frequency)	0.00 to 15.00Hz	x	△1△2	*6	
A27	(Iron loss factor 1)	0.00 to 20.00%	○	△1△2	*6	
A39	Motor 2 Selection	0: Motor characteristics 0 (Fuji standard motors, 8-series) 1: Motor characteristics 1 (HP rating motors) 4: Other motors	x	△1△2	ACEJKT:0 U:1	
A40	Slip Compensation 2 (Operating conditions selection)	0: Enable during acceleration/deceleration, enable at base frequency or higher 1: Disable during acceleration/deceleration, enable at base frequency or higher 2: Enable during acceleration/deceleration, disable at base frequency or higher 3: Disable during acceleration/deceleration, disable at base frequency or higher	x	○	0	
A41	Output Current Fluctuation Damping Gain for Motor 2	0.00 to 1.00	○	○	0.20	
A51	Cumulative Motor Run Time 2	0 to 9999 Change in cumulative motor run time (Reset is enabled) (in units of 10 hours)	x	x	-	
A52	Startup Counter for Motor 2	For adjustment at replacement (0000 to FFF (in hexadecimal))	○	x	-	
A53	(%X correction factor 1)	0 to 300%	○	△1△2	100	
A98	Motor 2 (Function selection)	0000H to FFFFH (hex.) bit0 : Current control (F43, F44) (0: Disable; 1: Enable) bit1 : Rotational direction control (H08) (0: Disable; 1: Enable) bit2 : Non-linear V/f (H50 to H53, H65, H66) (0: Disable; 1: Enable) bit3 : PID control (J01 to J62, H91) (0: Disable; 1: Enable) bit4 : Brake signal Bit4 to 15: Empty	x	○	0	5-147

Factory default···A (For Asia), C (for China), E (for Europe), U (For US), T (For Taiwan), J (for Japan), K (for Korea)
*2 Standard value is set per capacitance. Refer to table A.
*3 Rated current of the motor is set. Refer to Table B (function code P03).
*4 Standard applicable electric motor is 5.0 min for 22 kw or lower and 10.0 min for 30 kW or higher.
*6 Rated current of motor is set per capacitance. Refer to table B.

■ J code: Application Functions 1 (Application function 1)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
J01	PID control (Mode selection)	0: Disable 1: For process (normal operation) 2: For process (inverse operation) 3: Speed control (Dancer)	x	○	-	5-148
J02	(Remote command)	0: Keypad key operation (∧/∨ key) 1: PID process command 1 (Analog input: Terminals 12, C1 and V2) 3: UP/DOWN 4: Communication	x	○	–	5-149
J03	P (Gain)	0.000 to 30.000 times	○	○	0.100	5-155
J04	I (Integral time)	0.0 to 3600.0 s	○	○	0.0	
J05	D (Differential time)	0.00 to 600.00 s	○	○	0.00	
J06	(Feedback filter)	0.0 to 900.0 s *1	○	○	0.5	
J10	(Anti-reset windup)	0 to 200%	○	○	200	5-158
J11	(Select alarm output)	0: Absolute-value alarm 1: Absolute-value alarm (with Hold) 2: Absolute-value alarm (with Latch) 3: Absolute-value alarm (with Hold and Latch) 4: Deviation alarm 5: Deviation alarm (with Hold) 6: Deviation alarm (with Latch) 7: Deviation alarm (with Hold and Latch)	○	○	0	
J12	(Upper limit warning (AH))	-100% to 100%	○	○	100	
J13	(Lower limit warning (AL))	-100% to 100%	○	○	0	
J15	(Stop frequency for slow flow rate)	0.0 (Disable): 1.0 to 500.0 Hz	○	○	0.0	5-160
J16	(Slow flow rate level stop latency)	0 to 60 s	○	○	30	
J17	(Starting Frequency)	0.0 to 500.0Hz	○	○	0.0	
J18	(PID output limiter Upper limit)	-150% to 150% ; 999 (Conform to F15)	○	○	999	5-161
J19	(PID output limiter Lower limit)	-150% to 150% ; 999 (Conform to F16)	○	○	999	
J23	PID control (Startup feedback difference at stop frequency for slow flow rate)	0.0 to 100.0%	○	○	0.0	5-160
J24	PID control (Startup delay time at stop frequency for slow flow rate)	0 to 60 s	○	○	0	
J57	(Dancer reference position)	-100 to 0 to 100%	○	○	0	5-162
J58	(Dancer reference position detection width)	0: Cancel PID constant switch 1 to 100%: Manual setting value	○	○	0	
J59	P (Gain) 2	0.000 to 30.000 times	○	○	0.100	
J60	I (Integral time) 2	0.0 to 3600.0 s	○	○	0.0	
J61	D (Differential time) 2	0.00 to 600.00 s	○	○	0.00	
J62	PID Control (PID control block selection)	0 to 3 bit0: PID output characteristics 0=Plus (Addition); 1=Minus (Subtraction) bit1: Select output ratio compensation 0=Correction amount is ratio compensation (Ratio against primary speed) 1=Correction amount is speed command correction (Ratio against the maximum frequency)	x	○	0	
J63	Overload stop (Detected value)	0: Torque, 1: Current	○	○	0	
J64	(Detection level)	20 to 200%	○	○	100	
J63	(Operation selection)	0: No operation 1: Stop after deceleration 2: Free run	○	○	0	
J66	(Operation mode)	0: During constant speed running & deceleration 1: During constant speed running 2: All modes	○	○	0	
J67	(Timer time)	0.00 to 600.00 s	○	○	0.00	
J68	Brake Signal (Brake-OFF current)	0.00 to 300.00%	○	○	100.00	5-164
J69	(Brake-OFF frequency/speed)	0.0 to 25.0 Hz	○	○	1.0	
J70	(Brake-OFF timer)	0.00 to 5.00 s	○	○	1.00	
J71	(Brake-ON frequency/speed)	0.0 to 25.0 Hz	○	○	1.0	
J72	(Brake-ON timer)	0.00 to 5.00 s	○	○	1.00	

*1 Perform it at 0.1 or below if J01 = 3 (dancer control).

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
J105	PID control (Display unit)	0 to 80 0: based on unit/scale of PID control feedback value 1: No unit 2: % 4: r/min 7: kW [Flow rate] 20: m 3/s 21: m3/min 22: m3/s 23: L/s 24: L/min 25: L/h [Pressure] 40: Pa 41: kPa 42: MPa 43: mbar 44: bar 45: mmHg 46: psi PSI (Square inch per weight pound) 47: mWG 48: inWG [Temperature] 60: K 61: °C 62: °F [Concentration] 80: ppm	x	○	0	5-165
J106	PID control (Maximum scale)	-999.0 to 0.00 to 9990	x	○	100.0	
J107	PID control (Minimum scale)	-999.0 to 0.00 to 9990	x	○	0.00	
J136	PID control (Multistage command 1)	-999.0 to 0.00 to 9990	○	○	0.00	
J137	PID control (Multistage command 2)	-999.0 to 0.00 to 9990	○	○	0.00	
J138	PID control (Multistage command 3)	-999.0 to 0.00 to 9990	○	○	0.00	

■ d code: Application Functions 2 (Application function 2)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
d51	For manufacturer *9	0 to 500	x	○	-	5-166
d52	For manufacturer *9	0 to 500	x	○	-	
d55	For manufacturer *9	0000 to 00FF (Display in hexadecimal)	x	○	0000	
d61	Command pulse (Filter time constant)	0.000 to 5.000 s	○	○	0.005	
d62	(Pulse correction factor 1)	1 to 9999	○	○	1	
d63	(Pulse correction factor 2)	1 to 9999	○	○	1	
d69	For manufacturer *9	30.0 to 100.0Hz	○	○	30.0	—
d91	For manufacturer *9	0.00 to 200, 999	○	○	999	5-160
d99	Extension function 1	0 to 31 Bit 0: For manufacturer *9 Bit 1: For manufacturer *9 Bit 2: For manufacturer *9 Bit 3: JOG operation from communication (0: Disable; 1: Enable) Bit 4: For manufacturer *9	○	○	0	

*9 This is function code for manufacturer. Do not change the code.

FUNCTION CODE

Chap. 5

■ U code: Application Functions 3 (Customizable logic)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
U00	Customizable logic (Mode selection)	0: Disable 1: Enable (Customizable logic operation) ECL alarm occurs when the value is changed from 1 to 0 during operation.	○	○	0	5-169
U01	Customizable logic: Step 1 (Block selection)	[Digital] 0: No function assigned 10 to 15: Through output + General-purpose timer 20 to 25: ANDing + General-purpose timer 30 to 35: ORing + General-purpose timer 40 to 45: XORing + General-purpose timer 50 to 55: Set priority flip-flop + General-purpose timer 60 to 65: Reset priority flip-flop + General-purpose timer 70, 72, 73: Rising edge detector + General-purpose timer 80, 82, 83: Falling edge detector + General-purpose timer 90, 92, 93: Rising & falling edges detector + General-purpose timer 100 to 105: Hold + General-purpose timer 110: Increment counter 120: Decrement counter 130: Timer with reset input General-purpose timer function (Least significant digit 0 to 5) _0: No timer _1: On-delay timer _2: Off-delay timer _3: Pulse (1 shot) _4: Retriggerable timer _5 Pulse train output [Analog] 2001: Addition 2002: Subtraction 2003: Multiplication 2004: Division 2005: Limiter 2006: Absolute value 2007: Negative addition 2008: Variable limiter 2009: Linear addition 2051 to 2056: Comparison 1 to 6 2071, 2072 Window comparison 1, 2 2010: Maximum selection 2012: Minimum selection 2013: Average 2051: Function code 2201: Scale reverse conversion 2202: Scale conversion 3001 to 3002: Conversion 1 to 2 [Digital, Analog] 4001: Hold 4002: Negative addition switch 4003, 4004: Selection 1, 2 4005: LPS(Low-pass filter) 4006: Change rate limit 5000: Selection 3 5001 to 5014: Selection 3-1 to 14 5100: Selection 4 5101 to 5114: Selection 4-1 to 14 6001: Read function code 6002: Write function code 6003 : Selection 5 6101 : PID dancer output gain frequency	x	○	0	
U02	Customizable logic: (Input 1)	[Digital] 0 to 105: The same as E20. However, 27, 111 to 115 cannot be selected	x	○	100	
U03	Step 1 (Input 2)	2001 to 2100 (3001 to 3100): Output of Step 1 to 100 "SO01" to"S100" 4001(5001): X1 terminal input signal "X1" 4002(5002): X2 terminal input signal "X2" 4003(5003): X3 terminal input signal "X3" 4004(5004): X4 terminal input signal "X4" 4005 (5005): X5 terminal input signal "X5" 4010 (5010): FWD terminal input signal "FWD" 4011 (5011): REV terminal input signal "REV" 6000(7000): Final run command RUN "FL_RUN" 6001(7001): Final run command FWD "FL_FWD" 6002(7002): Final run command REV "FL_REV" 6003 (7003): Accelerating "DACC" 6004 (7004): Decelerating "DDEC" 6005 (7005): Under anti-regenerative control "REGA" 6006 (7006): Within dancer reference position "DR_REF" 6007 (7007): With/without alarm factor "ALM_ACT" * Inside the ( ) is the negative logic signal. (OFF at short-circuit)				

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
		[Analog] 8000 to 8018 : The value with 8000 added to F31 9001: Analog 12 terminal input signal [12] 9002: Analog C1 terminal input signal [C1] (C1 function) 9003: Analog V2 terminal input signal [C1] (V2 function)				5-169
U04	(Function 1)	-9990 to 0.00 to 9990	x	○	0.00	
U05	(Function 2)		x	○	0.00	

Customizable logic Step 1 to 14 function code is assigned as follows: Setting value is the same as U01 to U05.

	Step1	Step2	Step3	Step4	Step5	Step6	Step7	Step8	Step9	Step10
Logic circuit	U01	U06	U11	U16	U21	U26	U31	U36	U41	U46
Input 1	U02	U07	U12	U17	U22	U27	U32	U37	U42	U47
Input 2	U03	U08	U13	U18	U23	U28	U33	U38	U43	U48
Function 1	U04	U09	U14	U19	U24	U29	U34	U39	U44	U49
Function 2	U05	U10	U15	U20	U25	U30	U35	U40	U45	U50

	Step11	Step12	Step13	Step14
Logic circuit	U51	U56	U61	U66
Input 1	U52	U57	U62	U67
Input 2	U53	U58	U63	U68
Function 1	U54	U59	U64	U69
Function 2	U55	U60	U65	U70

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
U71	Customizable logic Output signal 1(Output selection)	0: Disable 1 to 100: Output of Step 1 to 100 "S001" to "S0100"	x	○	0	5-169
U72	Output signal 2					
U73	Output signal 3					
U74	Output signal 4					
U75	Output signal 5					
U76	Output signal 6					
U77	Output signal 7					
U78	Output signal 8					
U79	Output signal 9					
U80	Output signal 10					
U81	Customizable logic Output signal 1 (Function selection)	0 to 172 (1000 to 1172): Same as E01 8001 to 8018: The value with 8000 added to E61	x	○	100	
U82	Output signal 2					
U83	Output signal 3					
U84	Output signal 4					
U85	Output signal 5					
U86	Output signal 6					
U87	Output signal 7					
U88	Output signal 8					
U89	Output signal 9					
U90	Output signal 10					
U91	Customizable logic Timer monitor (Step selection)	0: Monitor disable 1 to 100: Step 1 to 100	x	x	0	
U92	Customizable logic operation coefficient (Mantissa of KA1)	-9.999 to 9.999	x	○	0.000	
U93	(Exponent part of KA1)	-5 to 5	x	○	0	
U94	(Mantissa of KB1)	-9.999 to 9.999	x	○	0.000	
U95	(Exponent part of KB1)	-5 to 5	x	○	0	
U96	(Mantissa of KC1)	-9.999 to 9.999	x	○	0.000	
U97	(Exponent part of KC1)	-5 to 5	x	○	0	

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
U100	Task process cycle setting	0: Auto select from 2, 5, or 10 ms depending on the number of steps 2: 2 ms (Up to 10 step) 5: 5 ms (Up to 50 step) 10: 10 ms (Up to 100 step)	x	○	0	5-169
U101	Customized logic Operating point of customizable logic reduction 1 (X1)	-999.00 to 0.00 to 9990.00	○	○	0.00	5-169 5-189
U102	Operating point of customizable logic reduction 1 (Y1)					
U103	Operating point of customizable logic reduction 2 (X2)					
U104	Operating point of customizable logic reduction 2 (Y2)					
U105	Operating point of customizable logic reduction 3 (X3)					
U106	Operating point of customizable logic reduction 3 (Y3)					
U107	Auto calculation of customizable logic reduction coefficient	0: Disable 1. Execute calculation (Reduction 1)	x	○	0	
U121	Customized logic (User parameter 1)	-999.00 to 0.00 to 9990.00	○	○	0.00	5-169
U122	(User parameter 2)					
U123	(User parameter 3)					
U124	(User parameter 4)					
U125	(User parameter 5)					
U126	(User parameter 6)					
U127	(User parameter 7)					
U128	(User parameter 8)					
U129	(User parameter 9)					
U130	(User parameter 10)					
U131	(User parameter 11)					
U132	(User parameter 12)					
U133	(User parameter 13)					
U134	(User parameter 14)					
U135	(User parameter 15)					
U136	(User parameter 16)					
U137	(User parameter 17)					
U138	(User parameter 18)					
U139	(User parameter 19)					
U140	(User parameter 20)					
U171	Customized logic (Memory area 1)	-999.00 to 0.00 to 9990.00	○	○	0.00	
U172	(Memory area 2)					
U173	(Memory area 3)					
U190	Customized logic Setting Step (Step number)	15 to 100	x	x	15	
U191	Setting Step (Select circuit)	Same as U01	x	x	0	
U192	Setting Step (Input 1)	Same as U02	x	x	100	
U193	Setting Step (Input 2r)	Same as U03	x	x	100	
U194	Setting Step (Function 1)	Same as U04	x	x	0.00	
U195	Setting Step (Function 2)	Same as U05	x	x	0.00	
U198	Customized logic ROM version (Monitor)	0 to 9999	-	-	-	
U199	Customized logic ROM version (For User setting)	0 to 9999	x	○	○	

■ y code: LINK Functions (Link function)

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
y01	RS-485 setting 1 (Station address)	1 to 255	x	○	1	5-194
y02	(Mode selection upon occurrence of an error)	0: Immediate Er-8 trip 1: Er-8 trip after timer time operation 2: Retry communication during timer time operation and perform Er-8 trip if communication cannot be recovered. When communication is recovered, continue to run. 3: Continue to run	○	○	0	
y03	(Timer time)	0.0 to 60.0 s	○	○	2.0	
y04	(Transmission speed)	0: 2400 bps 1: 4800 bps 2: 9600 bps 3: 19200 bps 4: 38400 bps	○	○	3	
y05	(Data length selection)	0: 8 bits 1: 7 bits	○	○	0	
y06	(Parity bit selection)	0: None (Stop bit: 2 bits) 1: Even number parity (Stop bit: 1 bits) 2: Odd number parity (Stop bit: 1 bits) 3: None (Stop bit: 1 bits)	○	○	0	
y07	(Stop bit selection)	0: 2 bits 1: 1 bit	○	○	0	
y08	(Communication failure detection time)	0: No detection 1 to 60 s	○	○	0	
y09	(Response interval time)	0.00 to 1.00 s	○	○	0.01	
y10	(Protocol selection)	0: Modbus RTU protocol 1: SX protocol (Loader protocol) 2: Fuji general-purpose inverter protocol	○	○	1	
y11	RS-485 setting 2 (Station address)	1 to 255	x	○	1	
y12	(Mode selection upon occurrence of an error)	0: Immediate Er-P trip 1: Er-P trip after timer time operation 2: Retry communication during timer time operation and perform Er-P trip if communication cannot be recovered. When communication is recovered, continue to run. 3: Continue to run	○	○	0	
y13	(Timer time)	0.0 to 60.0 s	○	○	2.0	
y14	(Transmission speed)	0: 2400 bps 1: 4800 bps 2: 9600 bps 3: 19200 bps 4: 38400 bps	○	○	3	
y15	(Data length selection)	0: 8 bits 1: 7 bits	○	○	0	
y16	(Parity bit selection)	0: None (Stop bit: 2 bits) 1: Even number parity (Stop bit: 1 bits) 2: Odd number parity (Stop bit: 1 bits) 3: None (Stop bit: 1 bits)	○	○	0	
y17	(Stop bit selection)	0: 2 bits 1: 1 bit	○	○	0	
y18	(Communication failure detection time)	0: No detection 1 to 60 s	○	○	0	
y19	(Response interval time)	0.00 to 1.00 s	○	○	0.01	
y20	(Protocol selection)	0: Modbus RTU protocol 1: SX protocol (Loader protocol) 2: Fuji general-purpose inverter protocol	○	○	0	
y21	Set embedded CAN (Station address)	1 to 127	x	○	1	5-197
y24	Set embedded CAN (Transmission speed)	0: 125kbps 1: 20kbit/s 2: 50kbit/s 3: 125kbit/s 4: 250kbit/s 5: 500kbit/s 6: 800kbit/s 7 to 255: 1Mbit/s	○	○	0	
y25	Set embedded CAN Assign write function code 1	0000 to FFFF (in hexadecimal) Data mapped I/O (Write)	x	○	0000	
y26	Set embedded CAN Assign write function code 2		x	○	0000	
y27	Set embedded CAN Assign write function code 3		x	○	0000	
y28	Set embedded CAN Assign write function code 4		x	○	0000	
y29	Set embedded CAN Assign write function code 5		x	○	0000	
y30	Set embedded CAN Assign write function code 6		x	○	0000	
y31	Set embedded CAN Assign write function code 7		x	○	0000	
y32	Set embedded CAN Assign write function code 8		x	○	0000	

Function code	Name	Data setting range	Under operation Change	Data copy	Factory Default	Related page
y33	Set embedded CAN (Mode selection)	0: Disable 1: Enable	x	○	0	5-197
y34	Set embedded CAN (Mode selection in the event of transmission abnormal situation	0 to 15 0: Upon occurrence of communication error, immediately perform Er-t trip. 1: After timer time operation from occurrence of communication error, immediately perform Er-t trip. 2: Upon occurrence of communication error, communication cannot be recovered by communication retry during timer time operation, immediately perform Er-t trip. 3: Even if communication error occurred, continue to run without Er5 occurrence. After communication is recovered, operate according to the communication command. 4 to 9: Same as 0. 10: After communication error occurred, stop deceleration and perform Er-t trip. 11: After timer time operation from occurrence of communication error, stop deceleration, and perform Er-t trip. 12: Upon occurrence of communication error, communication cannot be recovered by communication retry during timer time operation, stop deceleration. When communication is recovered, continue to run according to communication command. 13 to 15: Same as 3.	○	○	0	
y35	(Transmission error timer time)	0.0 to 60.0	○	○	0.0	
y95	Select data clear upon occurrence of communication abnormal situation	0: Upon alarm occurrence of communication abnormal state, no function code Sxx data clear (Existing mode compatible) 1: Upon alarm occurrence of communication abnormal state, function code S01, S05, S19 data clear 2: Upon alarm occurrence of communication abnormal state, bit clear for assigning operation command of function code S06 3: Above both 1 and 2 are clear operation * Target alarm is Er-8, Er-P, Er-4, Er-5, Er-U, Er-t	○	○	0	5-198
y97	Communication data storing method selection	0: Store into nonvolatile memory (with restriction on the number of writes) 1: Write into temporary memory (no restriction on the number of writes) 2: All save from temporary memory to nonvolatile memory (After all save, return to Data 1)	○	○	0	
y98	Bus link function(Mode selection)	Frequency command / Run command 0: Follow H30 / Follow H30 1: Command from bus link / Follow H30 2: Follow H30 / Command from bus link 3: Command from bus link / Command from bus link	○	○	0	
y99	Link Function for Support(Mode selection)	Frequency command / Run command 0: Follow H30, y98 / Follow H30, y98 1: Command from FRENIC loader / Follow H30, y98 2: Follow H30, y98 / Command from FRENIC loader 3: Command from FRENIC loader / Command from FRENIC loader	○	x	0	5-199

■ K codes: Keypad functions for TP-A1

Function code	Name	Data setting range	Modification during operation	Data copy	Factory default	Related page
K01	Multifunction keypad TP-A1 (language selection)	0: Japanese 1: English 2: German 3: French 4: Spanish 5: Italian 6: Chinese 8: Russian 9: Greek 10: Turkish 11: Polish 12: Czech 13 Swedish 14: Portuguese 15 Dutch 16 Malay 17: Vietnamese 18: Thai 19: Indonesian 100: User-customized language	○	○	J: O C: 6 AEUKT: 1	-
K02	(Backlight OFF time)	0: Always OFF 1 to 30 min	○	○	5	-
K03	(Backlight brightness adjustment)	0 (dark) - 10 (bright)	○	○	5	-
K04	(Contrast adjustment)	0 (low) - 10 (high)	○	○	5	-
K08	(LCD monitor status display)	0: Not displayed 1: Fully displayed	○	○	1	-
K15	(Sub-monitor display selection)	0: Operation guide display 1: Bar graph display	○	○	0	-
K16	(Sub-monitor 1 display selection)	13: Output current 14: Output voltage 18: Calculated torque 19: Input power 20: PID command value 22: PID feedback value 23: Timer value 24: PID output 25: Load factor 26: Motor output 27: Analog input monitor 35: Input watt-hour	○	○	13	-
K17	(Sub-monitor 2 display selection)		○	○	19	-
K20	(Bar graph 1 display selection)	1: Output frequency 1 (before slip compensation) 13: Output current 14: Output voltage 18: Calculated torque 19: Input power 25: Load factor 26: Motor output	○	○	1	-
K21	(Bar graph 2 display selection)		○	○	13	-
K22	(Bar graph 3 display selection)		○	○	19	-
K91	(< key shortcut selection)	0: disabled 11 to 99: respective mode	○	○	0	-
K92	(> key shortcut selection)		○	○	64	-

The keypad function K codes are used when the multi-function keypad (TP-A1) is connected. For details about the K codes, refer to the instruction manual for the keypad.

FUNCTION CODE

Chap. 5

Table A Factory default value per applicable electric motor capacitance

<table>
<tr><th>Applicable electric motor capacitance [kW]</th><th>Torque boost 1 to 2 F09/ A05</th><th>Momentary power failure restart H13</th><th>Applicable electric motor capacitance [kW]</th><th>Torque boost 1 to 2 F09/ A05</th><th>Momentary power failure restart H13</th></tr>
<tr><td>0.4</td><td>7.1</td><td rowspan="7">0.5</td><td>55</td><td rowspan="14">0.0</td><td rowspan="4">1.5</td></tr>
<tr><td>0.75</td><td>6.5</td><td>75</td></tr>
<tr><td>1.5</td><td>4.9</td><td>90</td></tr>
<tr><td>2.2</td><td>4.5</td><td>110</td></tr>
<tr><td>3.7</td><td>4.1</td><td>132</td><td rowspan="2">2.0</td></tr>
<tr><td>5.5</td><td>3.4</td><td>160</td></tr>
<tr><td>7.5</td><td>2.7</td><td>200</td><td rowspan="3">2.5</td></tr>
<tr><td>11</td><td>2.1</td><td rowspan="6">1.0</td><td>220</td></tr>
<tr><td>15</td><td>1.6</td><td>280</td></tr>
<tr><td>18.5</td><td>1.3</td><td>315</td><td rowspan="2">4.0</td></tr>
<tr><td>22</td><td>1.1</td><td>355</td></tr>
<tr><td>30</td><td rowspan="3">0.0</td><td>400</td><td rowspan="3">5.0</td></tr>
<tr><td>37</td><td>500</td></tr>
<tr><td>45</td><td>1.5</td><td>630</td></tr>
</table>

Table B Motor constant

[1] When Fuji standard motor 8-series, or other motors are selected by motor selection (Function code P99/ A39 = 0 or 4)

■ 3-phase 200V class

Motor capacity Setting range (kW) P02/A16	Applicable motor Capacitance (kW)	Rated current (A) P03/A17	No-load current (A) P06/A20	%R1 (%) P07/A21	%X (%) P08/A22	Rated slip frequency P12/A26	Iron loss factor 1 P13/A27	Starting Mode (Auto search delay time 2) H46
0.01 to 0.09	0.06	0.44	0.40	13.79	11.75	1.77	14.00	0.5
0.10 to 0.19	0.1	0.68	0.55	12.96	12.67	1.77	14.00	
0.20 to 0.39	0.2	1.30	1.06	12.95	12.92	2.33	12.60	
0.40 to 0.74	0.4	2.30	1.66	10.20	13.66	2.40	9.88	
0.75 to 1.49	0.75	3.60	2.30	8.67	10.76	2.33	7.40	
1.50 to 2.19	1.5	6.10	3.01	6.55	11.21	2.00	5.85	
2.20 to 3.69	2.2	9.20	4.85	6.48	10.97	1.80	5.91	0.6
3.70 to 5.49	3.7	15.00	7.67	5.79	11.25	1.93	5.24	0.8
5.50 to 7.49	5.5	22.50	11.00	5.28	14.31	1.40	4.75	1.0
7.50 to 10.99	7.5	29.00	12.50	4.50	14.68	1.57	4.03	1.2
11.00 to 14.99	11	42.00	17.70	3.78	15.09	1.07	3.92	1.3
15.00 to 18.49	15	55.00	20.00	3.25	16.37	1.13	3.32	2.0
18.50 to 21.99	18.5	67.00	21.40	2.92	16.58	0.87	3.34	
22.00 to 29.99	22	78.00	25.10	2.70	16.00	0.90	3.28	
30.00 to 36.99	30	107.0	38.90	2.64	14.96	0.80	3.10	2.3
37.00 to 44.99	37	130.0	41.50	2.76	16.41	0.80	2.30	2.5
45.00 to 54.99	45	156.0	47.50	2.53	16.16	0.80	2.18	
55.00 to 74.99	55	190.0	58.60	2.35	16.20	0.94	2.45	2.6
75.00 to 89.99	75	260.0	83.20	1.98	16.89	0.80	2.33	2.8
90.00 to 109.9	90	310.0	99.20	1.73	16.03	0.80	2.31	3.2
From 110.0	110	376.0	91.20	1.99	20.86	0.66	1.73	3.5

Table B Motor constant (Cont.)

■ 3-phase 400V class

Motor capacity Setting range (kW) P02/A16	Applicable motor Capacitance (kW)	Rated current (A) P03/A17	No-load current (A) P06/A20	%R1 (%) P07/A21	%X (%) P08/A22	Rated slip frequency P12/A26	Iron loss factor 1 P13/A27	Starting Mode (Auto search delay time 2) H46
0.01 to 0.09	0.06	0.22	0.20	13.79	11.75	1.77	14.00	0.5
0.10 to 0.19	0.1	0.35	0.27	12.96	12.67	1.77	14.00	
0.20 to 0.39	0.2	0.65	0.53	12.95	12.92	2.33	12.60	
0.40 to 0.74	0.4	1.15	0.83	10.20	13.66	2.40	9.88	
0.75 to 1.49	0.75	1.80	1.15	8.67	10.76	2.33	7.40	
1.50 to 2.19	1.5	3.10	1.51	6.55	11.21	2.00	5.85	
2.20 to 3.69	2.2	4.60	2.43	6.48	10.97	1.80	5.91	0.6
3.70 to 5.49	3.7	7.50	3.84	5.79	11.25	1.93	5.24	0.8
5.50 to 7.49	5.5	11.50	5.50	5.28	14.31	1.40	4.75	1.0
7.50 to 10.99	7.5	14.50	6.25	4.50	14.68	1.57	4.03	1.2
11.00 to 14.99	11	21.00	8.85	3.78	15.09	1.07	3.92	1.3
15.00 to 18.49	15	27.50	10.00	3.25	16.37	1.13	3.32	2.0
18.50 to 21.99	18.5	34.00	10.70	2.92	16.58	0.87	3.34	
22.00 to 29.99	22	39.00	12.60	2.70	16.00	0.90	3.28	
30.00 to 36.99	30	54.00	19.50	2.64	14.96	0.80	3.10	2.3
37.00 to 44.99	37	65.00	20.80	2.76	16.41	0.80	2.30	2.5
45.00 to 54.99	45	78.00	23.80	2.53	16.16	0.80	2.18	
55.00 to 74.99	55	95.00	29.30	2.35	16.20	0.94	2.45	2.6
75.00 to 89.99	75	130.0	41.60	1.98	16.89	0.80	2.33	2.8
90.00 to 109.9	90	155.0	49.60	1.73	16.03	0.80	2.31	3.2
110.0 to 131.9	110	188.0	45.60	1.99	20.86	0.66	1.73	3.5
132.0 to 159.9	132	224.0	57.60	1.75	18.90	0.66	1.80	4.1
160.0 to 199.9	160	272.0	64.50	1.68	19.73	0.66	1.50	4.5
200.0 to 219.9	200	335.0	71.50	1.57	20.02	0.66	1.36	4.7
220.0 to 249.9	220	365.0	71.80	1.60	20.90	0.58	1.25	
250.0 to 279.9	250	415.0	87.90	1.39	18.88	0.54	1.33	5.0
280.0 to 314.9	280	462.0	93.70	1.36	19.18		1.27	5.5
315.0 to 354.9	315	520.0	120.0	0.84	16.68	0.45	1.81	5.6
355.0 to 399.9	355	580.0	132.0	0.83	16.40	0.43	1.77	
400.0 to 449.9	400	670.0	200.0	0.62	15.67	0.29	1.58	7.5
450.0 to 499.9	450	770.0	270.0	0.48	13.03	0.23	1.84	9.8
500.0 to 559.9	500	835.0		0.51	12.38	0.18	1.80	
560.0 to 629.9	560	940.0		0.57	13.94	0.20	1.61	
630.0 to 709.9	630	1050.0	355.0	0.46	11.77	0.17	1.29	10.5
From 710.0	710	1150.0	290.0	0.54	14.62	0.21	0.97	

Table B Motor constant (Cont.)

[2] When HP display motor is selected by motor selection (Function code P99/A39/b39/r39 = 1)

■ 200V class

Motor capacity Setting range (kW) P02/A16	Applicable motor Capacitance (kW)	Rated current (A) P03/A17	No-load current (A) P06/A20	%R1 (%) P07/A21	%X (%) P08/A22	Rated slip frequency P12/A26	Iron loss factor 1 P13/A27	Starting Mode (Auto search delay time 2) H46
0.01 to 0.11	0.1	0.44	0.40	13.79	11.75	2.50	14.00	0.5
0.12 to 0.24	0.12	0.68	0.55	12.96	12.67	2.50	14.00	
0.25 to 0.49	0.25	1.40	1.12	11.02	13.84	2.50	12.60	
0.50 to 0.99	0.5	2.00	1.22	6.15	8.80	2.50	9.88	
1.00 to 1.99	1	3.00	1.54	3.96	8.86	2.50	7.40	
2.00 to 2.99	2	5.80	2.80	4.29	7.74	2.50	5.85	
3.00 to 4.99	3	7.90	3.57	3.15	20.81	1.17	5.91	0.6
5.00 to 7.49	5	12.6	4.78	3.34	23.57	1.50	5.24	0.8
7.50 to 9.99	7.5	18.6	6.23	2.65	28.91	1.17	4.75	1.0
10.00 to 14.99	10	25.3	8.75	2.43	30.78	1.17	4.03	1.2
15.00 to 19.99	15	37.3	12.7	2.07	29.13	1.00	3.92	1.3
20.00 to 24.99	20	49.1	9.20	2.09	29.53	1.00	3.32	2.0
25.00 to 29.99	25	60.0	16.70	1.75	31.49	1.00	3.34	
30.00 to 39.99	30	72.4	19.80	1.90	32.55	1.00	3.28	
40.00 to 49.99	40	91.0	13.60	1.82	25.32	0.47	3.10	2.3
50.00 to 59.99	50	115.0	18.70	1.92	24.87	0.58	2.30	2.5
37.00 to 44.99	60	137.0	20.80	1.29	26.99	0.35	2.18	
75.00 to 99.99	75	174.0	28.60	1.37	27.09	0.35	2.45	2.6
100.0 to 124.9	100	226.0	37.40	1.08	23.80	0.23	2.33	2.8
125.0 to 149.9	125	268.0	29.80	1.05	22.90	0.35	2.31	3.2
From 150.0	150	337.0	90.40	0.96	21.61	0.39	1.73	3.5

Table B Motor constant (Cont.)

■ 400V class

Motor capacity Setting range (kW) P02/A16	Applicable motor Capacitance (kW)	Rated current (A) P03/A17	No-load current (A) P06/A20	%R1 (%) P07/A21	%X (%) P08/A22	Rated slip frequency P12/A26	Iron loss factor 1 P13/A27	Starting Mode (Auto search delay time 2) H46
0.01 to 0.11	0.1	0.22	0.20	13.79	11.75	2.50	14.00	0.5
0.12 to 0.24	0.12	0.34	0.27	12.96	12.67	2.50	14.00	
0.25 to 0.49	0.25	0.70	0.56	11.02	13.84	2.50	12.60	
0.50 to 0.99	0.5	1.00	0.61	6.15	8.80	2.50	9.88	
1.00 to 1.99	1	1.50	0.77	3.96	8.86	2.50	7.40	
2.00 to 2.99	2	2.90	1.40	4.29	7.74	2.50	5.85	
3.00 to 4.99	3	4.00	1.79	3.15	20.81	1.17	5.91	0.6
5.00 to 7.49	5	6.30	2.39	3.34	23.57	1.50	5.24	0.8
7.50 to 9.99	7.5	9.30	3.12	2.65	28.91	1.17	4.75	1.0
10.00 to 14.99	10	12.7	4.37	2.43	30.78	1.17	4.03	1.2
15.00 to 19.99	15	18.7	6.36	2.07	29.13	1.00	3.92	1.3
20.00 to 24.99	20	24.6	4.60	2.09	29.53	1.00	3.32	2.0
25.00 to 29.99	25	30.0	8.33	1.75	31.49	1.00	3.34	
30.00 to 39.99	30	36.2	9.88	1.90	32.55	1.00	3.28	
40.00 to 49.99	40	45.5	6.80	1.82	25.32	0.47	3.10	2.3
50.00 to 59.99	50	57.5	9.33	1.92	24.87	0.58	2.30	2.5
60.00 to 74.99	60	68.7	10.4	1.29	26.99	0.35	2.18	
75.00 to 99.99	75	86.9	14.3	1.37	27.09	0.35	2.45	2.6
100.0 to 124.9	100	113.0	18.7	1.08	23.80	0.23	2.33	2.8
125.0 to 149.9	125	134.0	14.9	1.05	22.90	0.35	2.31	3.2
150.0 to 174.9	150	169.0	45.2	0.96	21.61	0.39	1.73	3.5
175.0 to 199.9	175	188.5	45.2	0.96	21.61	0.39	1.80	4.1
200.0 to 249.9	200	231.0	81.8	0.72	20.84	0.23	1.50	4.5
250.0 to 299.9	250	272.0	41.1	0.71	18.72	0.35	1.36	4.7
300.0 to 324.9	300	323.0	45.1	0.53	18.44	0.23	1.25	
325.0 to 349.9	325	342.9	45.1	0.53	18.44	0.23	1.33	5.0
350.0 to 399.9	350	375.0	68.3	0.99	19.24	0.46	1.27	5.5
400.0 to 449.9	400	429.0	80.7	1.11	18.92	0.46	1.81	5.6
450.0 to 499.9	450	481.0	85.5	0.95	19.01	0.48	1.77	
500.0 to 599.9	500	534.0	99.2	1.05	18.39	0.45	1.58	7.5
600.0 to 699.9	600	638.0	140.0	0.85	18.38	0.39	1.84	9.8
700.0 to 749.9	700						1.70	
750.0 to 799.9	750							
From 800.0	800							10.5

5.3 Description of function code

This section describes details of function code. In principle, explanation is given for each function code in order of group and numerical order. However, function codes that are strongly related to one function is explained together in the first paragraph.

5.3.1 F code (Basic function)

F00	Data protection

This is a function to protect currently set data by disabling to make changes in function code data (except F00) and each types of command value (frequency setting, PID command) by ⌃/⌄ key operation from keypad.

F00 data	Change of function code		Setting of each types of command value by Keypad operation (⌃/⌄key)
	Change from keypad	Change from communication	
0	○: Change enabled	○: Change enabled	○: Change enabled
1	×: Change disabled*	○: Change enabled	○: Change enabled
2	○: Change enabled	○: Change enabled	×: Change disabled
3	×: Change disabled*	○: Change enabled	×: Change disabled

*Although it is not possible to change function code from keypad, function code F00 can be changed.

F00 data can be changed by the double key operation using "STOPkey +⌃key" or "STOPkey +⌄key".

As a similar function related to data protection, "Editing approval command (Data change enabled) "WE-KP" " for which digital input terminal is assigned, is available. (📖 Function code E01 to E05 Data = 19)

By combining data protection F00, protection of function code functions as follows:

Input signal "WE-KP"	Change in function code	
	Change from keypad	Change from communication
OFF	×: Change disabled	○: Change enabled
ON	Follow setting of F00	

Note

- If "enable data change with keypad' [WE-KP] is set to the terminal by mistake, it is not possible to make changes in function code. In this case, after shortening (ON) the terminal to which temporarily "WE-KP" function is assigned, and the terminal [CM], change to the different function.
- "WE-KP" is the change approval signal of function code and this is not the function to protect frequency setting and PID command by ⌃/⌄ key operation.

FUNCTION CODE

Chap. 5

F01	**Frequency Setting 1** **Related function codes:** **F18 bias (Frequency setting 1)** **C30 frequency setting 2** **C31 to C35 analog input adjustment (Terminal [12])** **C36 to C39 analog input adjustment (Terminal [C1] (C1 function))** **C40 terminal [C1] (C1 function) (Mode selection)** **C41 to C45 analog input adjustment (Terminal [C1] (V2 function))** **C55 to C56 analog input adjustment (Terminal [12]) (Bias･Bias reference point)** **C61 to C62 analog input adjustment (Terminal [C1] (C1 function) (Bias･Bias reference point)** **C67 to C68 analog input adjustment (Terminal [C1] (V2 function)) (Bias･Bias reference point)** **C50 bias (for frequency setting 1) (Bias reference point)** **H61 UP/DOWN control initial value selection** **d59, d61 to d63 command (Pulse train input)**

Select setting method of frequency setting. Set frequency setting 1 by function code F01, frequency setting 2 by C30.

F01, C30 data	Command sources
0	Frequency setting by keypad (refer to the following descriptions to find the setting method)
1	Set by voltage value to be input in the terminal [12] (0 to ±10VDC, Maximum output frequency /DC±10V
2	Setting by current value to be input in the terminal [C1] (C1 function) (4 to 20mADC or 0 to 20 mADC, Maximum output frequency / 20 mADC) (Set slide switch SW4 of printed circuit board to [AI] side (factory default state), SW3 to [C1] side (factory default state), respectively.) (It is necessary to select C1 function (factory default state) by E-59=0) (It is necessary to disable PTC input function by H26=0)
3	Set by the addition result of voltage value to be input in the terminal [12] (0 to ±10VDC, Maximum output frequency /±10 VDC) and current value to be input in the terminal [C1] (C1 function) (4 to 20 mA DC or 0 to 20 mA DC, Maximum output frequency/20 mA DC) When the addition result becomes maximum output frequency or higher, it is restricted by the maximum output frequency)
5	Set by voltage value to be input in the terminal [C1] (V2 function) (0 to +10 VDC, Maximum output frequency /+10 VDC) (Set slide switch SW4 of printed circuit board to [AI] side (factory default state), SW3 to [V2] side, respectively.) (It is necessary to select V2 function by E59 = 1) (It is necessary to disable PTC input function by H26 = 0)
7	Set by UP command "UP" and DOWN command "DOWN" assigned to the digital input terminal It is necessary to assign UP command (Data = 17) and DOWN command (Data =18) to the digital input terminal [X1] to [X5]. (E01 toE05)
8	Frequency setting by keypad (with balanceless bumpless function)
10	Set by pattern operation (C21 to C28)
12	Setting by pulse train input "PIN" (Data = 48), which was assigned to the digital input terminal [X5] Note: When using X5 terminal with pulse train input, it might be affected by noise from other wire. Keep away from other wire from the wire to X5 terminal as far as possible.

Setting method of reference frequency

[1] Frequency setting by keypad (F01 = 0 (Factory default state), 8)

(1) Set the data of function code F01 to "0" or "8". When keypad is at program mode or alarm mode, it is not possible to perform frequency setting with ∧/∨ key. In order to enable frequency setting with ∧/∨ key, shift to the operation mode.

(2) When ∧/∨ key is pressed, reference frequency is displayed and the least significant digit of the reference frequency flashes.

(3) By pressing the ∧/∨ key again, it is possible to change the reference frequency. To save the set frequency, press FUNC/DATA key. (E64=1: Factory default state). When the frequency is saved, it is possible to operate with the saved frequency next time the power is turned on.

Tip

- Automatic saving method (Function code E64 = 0) is available other than the above method as a data saving method of frequency setting.
- While the data of function code F01 is set to "0" or '8", when frequency setting method other than frequency setting 1 (frequency setting 2, communication, multi-frequency) is selected as frequency setting, it is not possible to change the reference setting with ∧/∨ key even if keypad is at operation mode. In this case, pressing ∧/∨ key displays the currently selected reference frequency.
- When setting is performed for such as frequency setting with ∧/∨ key, the displayed the least significant digit flashes and the data is changed from the least significant digit and the changing digit gradually shifts to the upper digit.
- In order to perform setting such as reference frequency, press ∧/∨ once and when the least significant digit flashed, push down the ≫ key, and then, the flashing digit will move. Therefore, it is possible to change the large numerical number easily. This operation is called cursor movement.
- When the data of function code F01 is set to "8", balanceless bumpless function becomes enable. when switching to frequency setting with keypad from frequency setting method other than keypad, the switched initial value of frequency setting with keypad succeeds the frequency setting before it is switched. Even if frequency setting is switched by using this function, it is possible to perform operation without shock.

[2] **Setting up a reference frequency using analog input (F01 = 1 to 3, 5)**

It is possible to arbitrarily specify a frequency by multiplying frequency setting 1 (F01) against analog input (voltage value to be input to terminal [12] and terminal [C1] (V2 function) and current value to be input to terminal [C1] (C1 function) by the gain and adding the bias. The polarity can be selected and the filter time constant and offset can be adjusted.

Adjustment element of frequency setting 1

F01 data	Input terminal	Input range	Bias		Gain		Polarity selection	Filter	Offset
			Bias	Base point	Gain	Base point			
1	[12]	0 to +10V, -10 to +10V	F18	C50	C32	C34	C35	C33	C31
2	[C1] (C1 function)	4 to 20 mA 0 to 20 mA	F18	C50	C37	C39	C40	C38	C36
3	[12]+ [C1] (C1 function) (Set by result of addition)	0 to +10V, -10 to +10V	F18	C50	C32	C34	C35	C33	C31
		4 to 20 mA 0 to 20 mA	F18	C50	C37	C39	C40	C38	C36
5	[C1] (V2 function)	0 to +10V	F18	C50	C42	C44	C45	C43	C41

Adjustment element of frequency setting 2

C30 data	Input terminal	Input range	Bias		Gain		Polarity selection	Filter	Offset
			Bias	Base point	Gain	Base point			
1	[12]	0 to +10V, -10 to +10V	C55	C56	C32	C34	C35	C33	C31
2	[C1] (C1 function)	4 to 20 mA 0 to 20 mA	C61	C62	C37	C39	C40	C38	C36
3	[12]+ [C1] (C1 function) (Set by result of addition)	0 to +10V, -10 to +10V	C55	C56	C32	C34	C35	C33	C31
		4 to 20 mA 0 to 20 mA	C61	C62	C37	C39	C40	C38	C36
5	[C1] (V2 function)	0 to +10V	C67	C68	C42	C44	C45	C43	C41

■ Offset (C31, C36, C41)

C31, C36 or C41 configures an offset for an analog voltage/current input. The offset also applies to signals sent from the external equipment.

■ Filter time constant (C33, C38, C43)

C33, C38, and C43 provide the filter time constants for the voltage and current of the analog input. The larger the time constant, the slower the response. Specify the proper filter time constant taking into account the response speed of the machine (load). If the input voltage fluctuates due to line noises, increase the time constant.

■ Polarity selection [12] Terminal (C35)

C35 configures the input range for analog input voltage.

C35 data	Modes for terminal inputs
0	-10 to +10 V
1	0 to +10 V (Negative value of voltage is regarded as 0 V)

■ Selection of terminal [C1] (C1 function) input range (C40)

C40 data	Terminal input range	Handling of when bias value is set to minus
0	4 to 20 mA (Factory default)	Limit below 0 point with 0
1	0 to 20mA	
10	4 to 20mA	Enable below 0 point as minus value.
11	0 to 20mA	

■ Polarity selection [C1] (V2 function) (C45)

C45 data	Modes for terminal inputs
0	0 to +10V When bias value is set to minus, enable below 0 point as a minus value.
1	0 to +10V (factory default) When bias value is set to minus, limit below 0 point by 0.

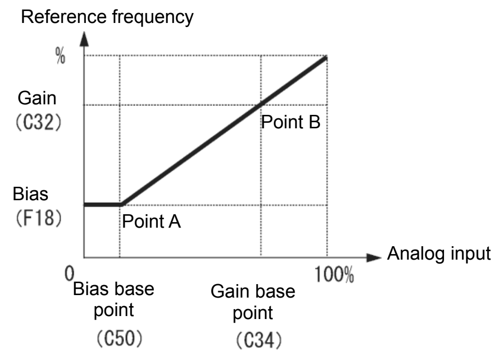
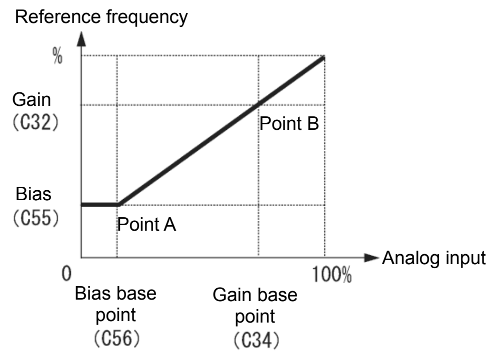
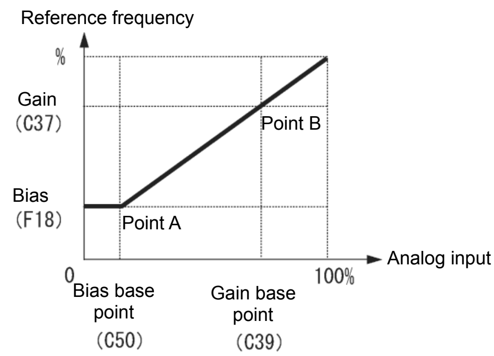
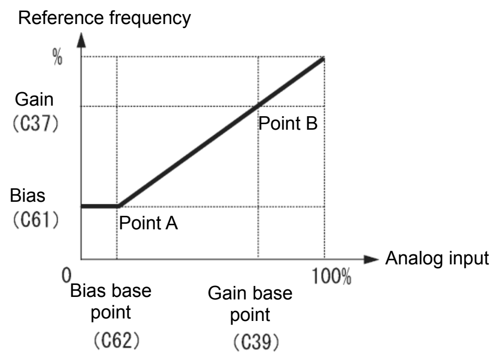
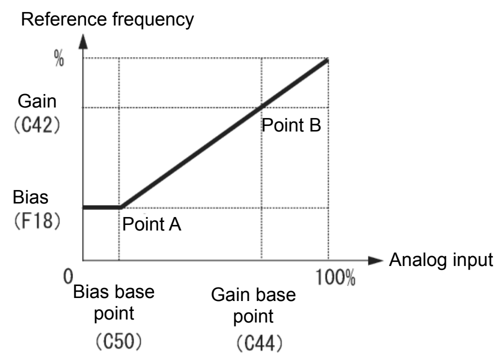
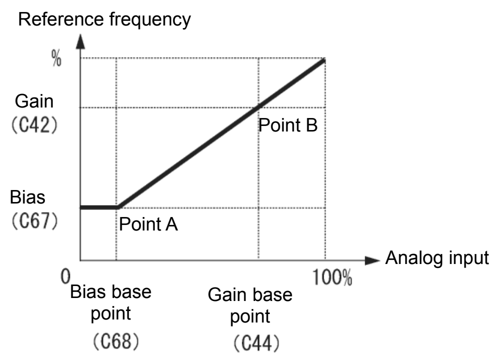
In order to use [C1] terminal in C1 function, V2 function, and PTC function, the following switching is necessary.

[C1] terminal	SW3	SW4	E59	H26	C40
When using C1 function (4 to 20 mA)	C1 side	AI side	0	0	0,10
When using C1 function (0 to 20 mA)	C1 side	AI side	0	0	1,11
When using V2 function (0 to +10V)	V2 side	AI side	1	0	Unmentioned
When using PTC function	C1 side	PTC side	Unmentioned	1, 2	Unmentioned

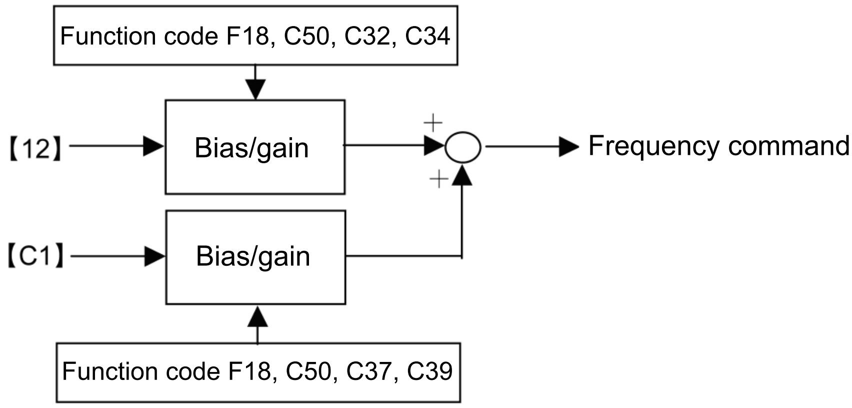
For details of SW3 and SW4, refer to 2.2.8 in Chapter 2.

Caution is necessary that if the above switch setting is not performed accurately, unexpected frequency setting may be performed for the inverter.

■ Gain·Bias

Terminal	<Frequency setting 1: F01>	<Frequency setting 2: C30>
[12]		
[C1] (C1 function)		
[C1] (V2 function)		

Note For [12] + [C1] (C1 function) (setting by the result of addition), bias and gain are reflected to [12] and [C1] (C1 function) individually, and added by frequency command value of the result.



For single polarity (Terminal [12] (C35=1), Terminal [C1] (C1 function), Terminal [C1] (V2 function)

As the above diagram indicates, for reference frequency and analog input of frequency setting 1, it is possible to set arbitrary relationship by A point (determined by bias (F18) and bias reference point (C50)) and B point (determined by the gain corresponding to each analog input and the gain reference point (C32 and C34, C37 and C39, and C42 and C44)).

For reference frequency and analog input of frequency setting 2 (C30), it is possible to set arbitrary relationship by A point (determined by bias and bias reference point (C55 and C56, C61 and C62, and C67 and C68)) and B point (determined by the gain corresponding to each analog input and the gain reference point (C32 and C34, C37 and C39, and C42 and C44)).

Both data of bias and gain are set with 100% as the maximum frequency. The data of bias reference point and gain reference point are set up with full scale of analog input (10V or 20mA) as100%.

By setting the bias to minus value, even if the analog input is single polar, it is possible to perform frequency setting as bipolar. For terminal [C1] (C1 function), C40 is set to 10 or 11, and for terminal [C1] (V2 function), 1 is set to C45, and then, the frequency setting at analog input at or below 0 point becomes negative polarity, as a result, it becomes possible to perform forward and reverse operation only by analog command.

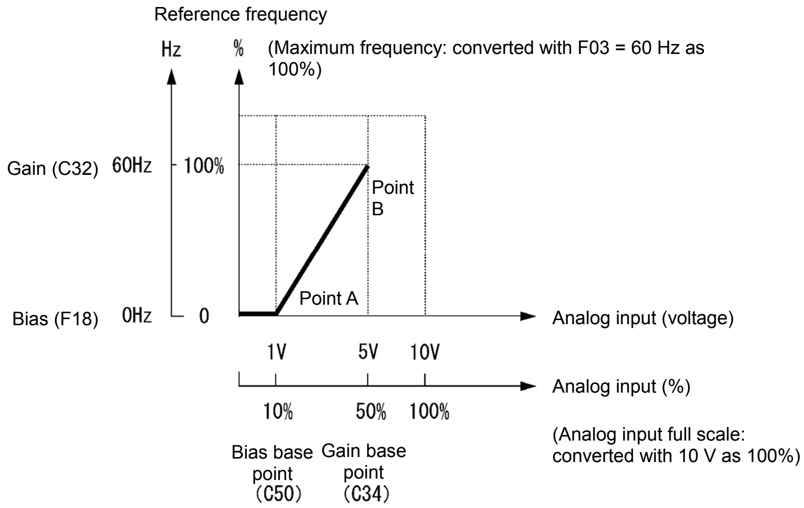
Note <Frequency setting 1: F01>

- Analog input at or below bias reference point (C50) is restricted by bias value (F18).
- When numerical value with which relationship of bias reference point (C50)≥ each gain reference point (C34, C39, C44) is established, it is judged as incorrect setting and reference point becomes 0 Hz.

<Frequency setting 2: C30>

- Analog input at or below bias reference point (C56, C62, and C68) is restricted by bias value (C55, C61 and C67).
- When numerical value with which relationship of bias reference point (C56, C62, C68) ≧ each gain reference point (C34, C39, C44) is established, it is judged as incorrect setting and reference point becomes 0 Hz.

Example) When setting reference frequency to 0 to 60 Hz by analog input (terminal [12]) 1 to 5V
(When maximum frequency is F03=60 Hz)



(A point)

In order to set reference frequency to 0 Hz when analog input is 1V, set bias (F18) to 0%. At this point, 1V becomes the bias reference point and 1V is equivalent to 10% against full scale 10V of terminal [12], therefore, set the bias reference point (C50) to 10%.

(B point)

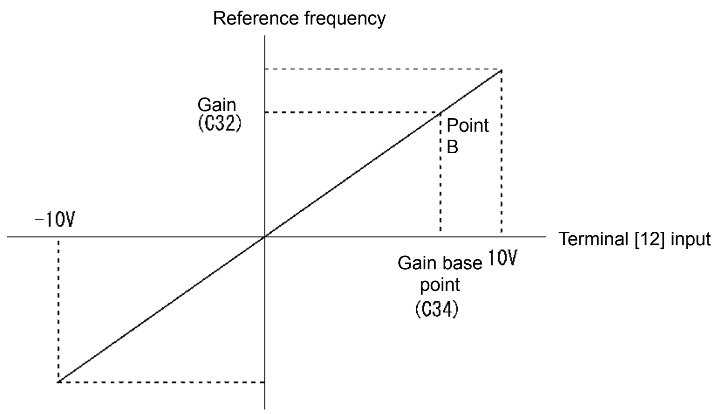
In order to set reference frequency so that the frequency becomes the highest when analog input is 5V, set the gain (C32) to 100%. At this point, 5V becomes the gain reference point and 5V is equivalent to 50% against full scale 10V of terminal [12], therefore, set the gain reference point (C34) to 50%.

Note The setting method without changing reference point and by using gain and bias individually is the same as for our company's existing inverter.

For bipolar (Terminal [12] (C35=0))

For terminal [12], by setting function code C35 to "0", it is possible to use bipolar input (-10V to +10V).

When both bias (F18) and bias reference point (C50) are set to "0", command becomes forward and reverse symmetric as shown in the diagram below.



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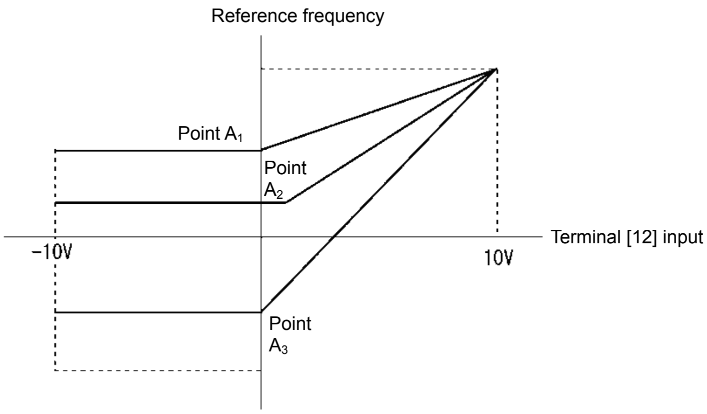
Note · When bias (F18) and bias reference point (C50) is set to arbitrary value (A1 point, A2 point, and A3 point, etc.), as shown in the diagram below, it is restricted by the bias value (F18).

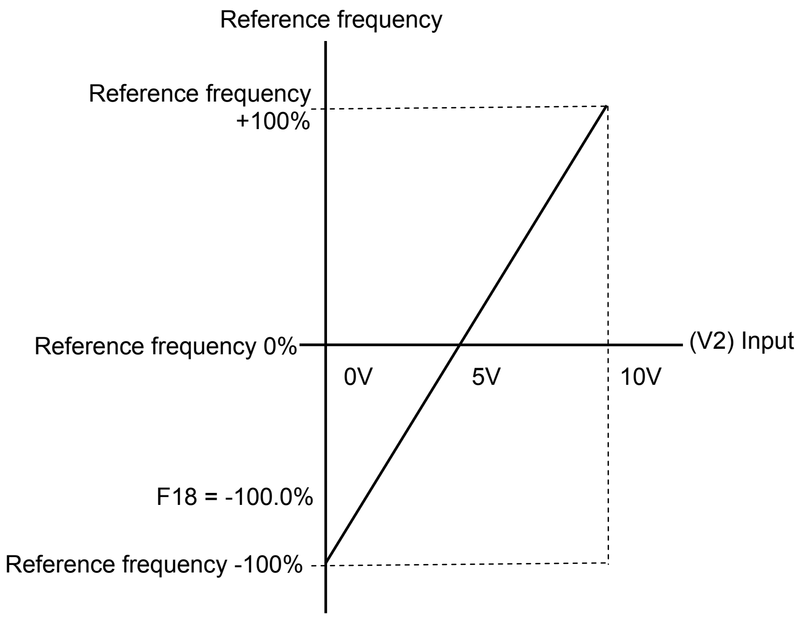


- To input bipolar (0 to ±10 VDC) analog voltage at analog input (terminal [12]), set function code C35 to "0". When the data of C35 is "1", only DC 0 to +10V " is effective and negative polar input DC0 to -10V is regarded as 0 (Zero) V.
- When setting reference frequency by display other than frequency (Hz), it is dependent on the data setting of function code E48 (=3 to 5, and 7) of speed monitor selection.

When operating by single polar analog input as bipolar (terminal [C1] (C1 function) (C40 = 10, 11), terminal [C1] (V2 function) (C45 = 0)

For C1 function set C40 = 10, 11, for V2 function set C45 = 0, and by setting bias value to minus value, it is possible to enter data as negative polarity at or below 0 point.

Example of frequency setting by V2 function when -100% is set to the bias value is shown in the diagram below.



[3] Frequency setting by digital input signal "UP"/"DOWN" (F01=7)

As frequency setting, UP/DOWN control is selected, and when the terminal command UP or DOWN is turned on with Run command ON, the output frequency increases or decreases accordingly, within the range from 0 Hz to the maximum frequency.

To perform frequency setting by UP/DOWN control, it is necessary to set the data of function code F01 to "7" and assign "UP command [UP], down command [DOWN]" to the digital input terminal. (📖 Function code E01 to E05 Data = 17, 18)

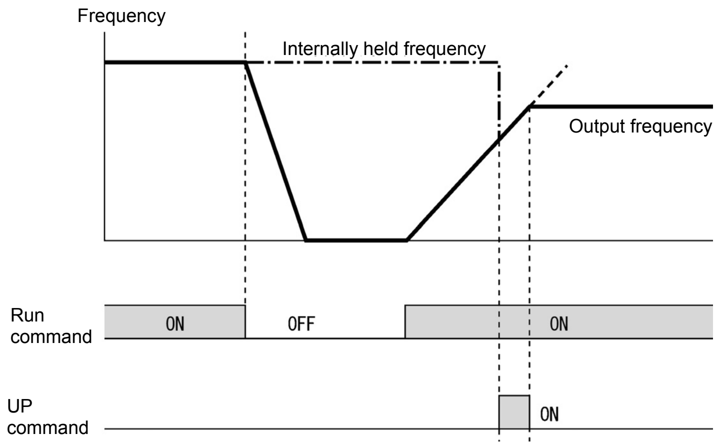
Input signal 'UP"	Input signal "DOWN"	Action
Data = 17	Data = 18	
OFF	OFF	The output frequency will be held
ON	OFF	Increase output frequency by currently selected acceleration time
OFF	ON	Decrease output frequency by currently selected deceleration time
ON	ON	The output frequency will be held

■ UP/DOWN control initial value selection

Set initial value of reference frequency when starting UP/DOWN control.

H61 data	Initial value of frequency setting when starting UP/DOWN control.
0	Mode to fix to "0" When restarting operation (including when the power to the inverter is turned ON), initial value of setting frequency by UP/DOWN control is cleared with "0". Increase speed by UP command.
1	This is the mode to set reference frequency at the previous UP/DOWN control as the initial value. The inverter internally holds the output frequency set by UP/DOWN control and start control from the previous operation frequency at the next restart (including powering ON).

Note At the restart of operation, before the internal frequency reaches the previous output frequency, when UP/DOWN command is input, output frequency at the point is held internally and start UP/DOWN control from the value. Therefore, the previous output frequency data is overwritten and deleted.



< Initial value of UP/DOWN control when setting method of frequency setting is switched>

The initial value when setting method of frequency setting is set to UP/DOWN control is shown in the following table.

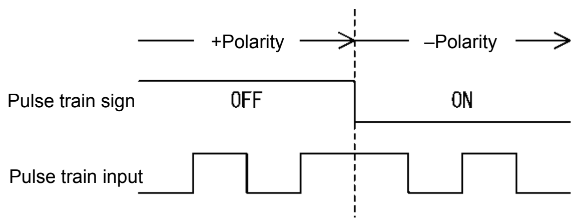
Setting method prior to switching	Switching signal	Initial value of UP/DOWN control	
		H61=0	H61=1
Setting other than UP/DOWN (F01, C30)	Frequency setting 2/ Frequency setting 1	Reference frequency by setting method prior to switching	
PID control	PID Cancel	Reference frequency by PID control (PID output)	
Multi-frequency	Multi-frequency selection	Reference frequency by setting method prior to switching	Reference frequency by previous UP/DOWN control
Communication	Link operation selection		

[4] Frequency setting using pulse train input (F01 = 12)

■ Pulse train input method

Input method of pulse train and operation overview are described below.

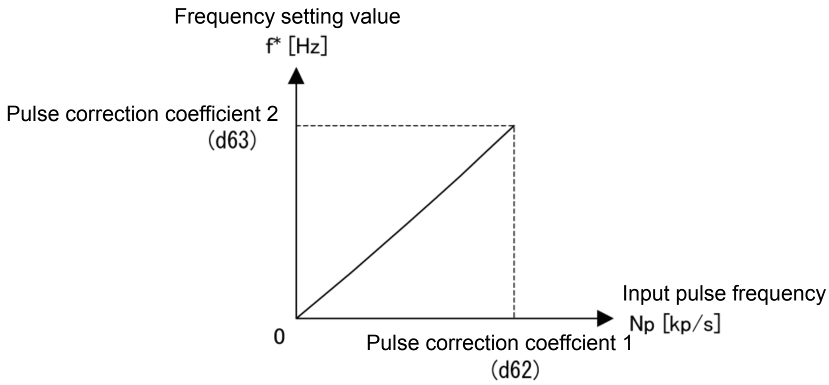
Pulse train input method	Operation overview
Pulse train sign/ Pulse train input	Apply speed command according to frequency of pulse train input to the inverter main unit. In addition, it is possible to set polarity of speed command by pulse train sign. Pulse train input: Assign "PIN" to terminal [X5] (Data = 48) Pulse train sign: Assign "SIGN" to terminal other than terminal [X5] (Data = 49) When "SIGN" is not assigned, the polarity becomes positive.



Pulse train sign/Pulse train input

■ Pulse correction coefficient 1 (d62), pulse correction coefficient 2 (d63)

For pulse train input, set the relationship between input pulse frequency and frequency setting value by function code d62 (Command (pulse train input) pulse correction coefficient 1) and d63 (command (pulse train input) pulse correction coefficient 2).



Relationship between input pulse frequency and frequency setting value

As shown in the figure, set input pulse frequency [kp/s] to function code d62 (command (pulse train input) pulse correction coefficient 1) and set frequency setting value [Hz] at the value set to function code d63 (command (pulse train input) pulse correction coefficient 2) by function code d62. At this time, the relationship formula of input pulse frequency to be entered and frequency setting value f^* (or speed command value) is as follows:

$$f^* \text{ [Hz]} = Np \text{ [kp/s]} \times \frac{\text{Pulse correction coefficient 2 (d63)}}{\text{Pulse correction coefficient 1 (d63)}}$$

f^* [Hz]: Frequency setting value
Np [kp/s]: Input pulse frequency to be input

Depending on the pulse train sign, polarity of the command is determined. Rotation direction of the motor is determined by the polarity of pulse train input and "FWD"/"REV" command. The relationship between the pulse train input polarity and rotation direction is specified in the table.

The relationship between the pulse train input polarity and rotation direction

Polarity according to the pulse train input	Run command	Rotational direction
+	"FWD" (Forward rotation command)	Forward rotation
+	"REV" (Reverse rotation command)	Reverse rotation
-	"FWD" (Forward rotation command)	Reverse rotation
-	"REV" (Reverse rotation command)	Forward rotation

■ Filter time constant (d61)

Set filter time constant for pulse train input. The larger the time constant, the slower the response. Specify the proper filter time constant by taking into account the response speed of the machine. If the pulse is lower and frequency command fluctuates, set larger time constant.

Switching frequency setting

Switch frequency setting 1 (F01) and frequency setting 2 (C30) by the signal "Frequency setting 2/frequency setting 1" "Hz2/ Hz1", which was assigned to the extraneous digital input terminal.

(Refer to Function code E01 to E05 (Data =11) to find the details of "Hz2/ Hz1".

Input signal "Hz2/ Hz1"	Frequency setting method to be selected
OFF	Frequency setting 1 (F01)
ON	Frequency setting 2 (C30)

F02 Operation

Select setting method of run command. Indicate instruction method of run/stop and rotation direction (forward/reverse rotation) for each setting method.

F02 data	Setting method of run command	
	Run/stop	Rotation direction command
0: Keypad operation (Rotation direction input: Terminal block)	RUN/STOP key	"FWD", "REV"
1: External signal (digital input)	"FWD", "REV"	
2: Keypad operation (forward rotation)	RUN/STOP key	Rotation direction command is unnecessary (Forward rotation operation only, reverse rotation operation disabled)
3: Keypad operation (Reverse rotation)	RUN/STOP key	Rotation direction command is unnecessary (Reverse rotation operation only, forward rotation operation disabled)

Digital input signal, "FWD", "REV" needs to be assigned to terminal [FWD], [REV].
(Function code E98, E99 data = 98, 99)

Note
- F02 cannot be changed when "FWD" or "REV" is ON.
- If F02 = 1 and when assignment of terminal [FWD] or [REV] is changed from other function to "FWD" function or "REV" function, turn the terminal [FWD] and [REV] off in advance (motor may rotate due to change in the setting).

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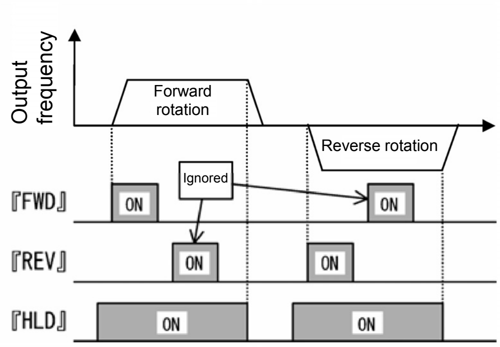
■ 3-wire operation by external signal

Although external signal of "FWD" and "REV" is 2-wire operation at the initial state, by assigning "Self-hold selection (HLD)", it is possible to use as self-hold signal at 3-wire operation by "FWD", "REV" and "HLD" signal. When "HLD" is ON, self-hold "FWD" or "REV" signal, and release the hold state by OFF. If there is no "HOLD" function assignment, only "FWD" and "REV" become 2-wire operation.

Refer to Function code E01 to E05 (Data =6) to find the details of "HLD".



As a setting method of run command, high-priority setting method (remote/local switch (refer to 3.3.7 in Chapter 3), communication, etc.) are available in addition to the above mentioned settings.

F03	Maximum frequency 1

F03 specifies the maximum frequency that the inverter outputs. When the device to be driven is set to rated or higher, the device may be damaged. Make sure to make an adjustment to design mode value of the machinery.

- Data setting range: 25.0 to 500.0 (Hz)

Modes	Control mode	Data setting range	Remarks
HD/HND/HHD mode	V/f control	500 Hz	
ND mode	V/f control	120 Hz	Restricted internally.*

* When setting is performed by exceeding the maximum setting range (for example, 500 Hz), speed setting and analog output (FMA) become input/output mode of full scale/setting value (10V/ 500Hz). However, it is internally restricted (for example, 120Hz), therefore, even if 10V is input for setting value, the value is restricted internally by 2.4 V (equivalent to 120 Hz), not by 500Hz.

Use function code F80 to switch between ND, HD, HND and HHD modes.

⚠WARNING

Inverter can perform setting of high speed operation easily. When changing the setting, make sure to check the motor and machine mode before use.

Injuries could occur. **Failure may occur.**

Note: When changing maximum output frequency (F03) in order to make the operation frequency a larger value, change the frequency limiter (upper limit) (F15) as well.

F04, F05 F06	Base frequency 1, Base frequency voltage 1 Maximum output voltage 1 Related function codes: H50, H51 Non-linear V/f 1 (Frequency, voltage) H52, H53 Non-linear V/f 2 (Frequency, voltage) H65, H66 Non-linear V/f 3 (Frequency, voltage)

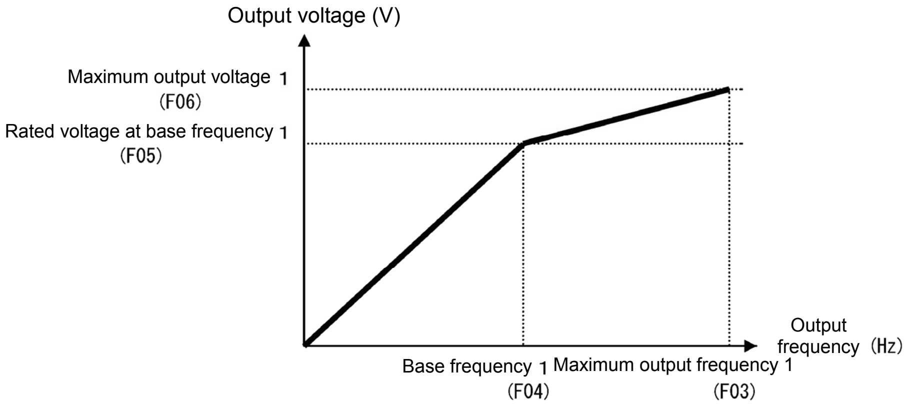
Set the base frequency and base frequency voltage that are essential to operation of the motor. By combining related function code H50 to H53, H65, and H66, it is possible to set non-linear V/f pattern (weak or strong voltage by arbitrary point) and perform setting of V/f characteristics that is suitable for the load.

Impedance of the motor becomes larger with high frequency, and when output voltage becomes less, output torque may be reduced. In order to prevent this, use when increasing voltage by high frequency at the maximum output voltage 1. However, it is not possible to output voltage at or higher than the input power voltage of the inverter.

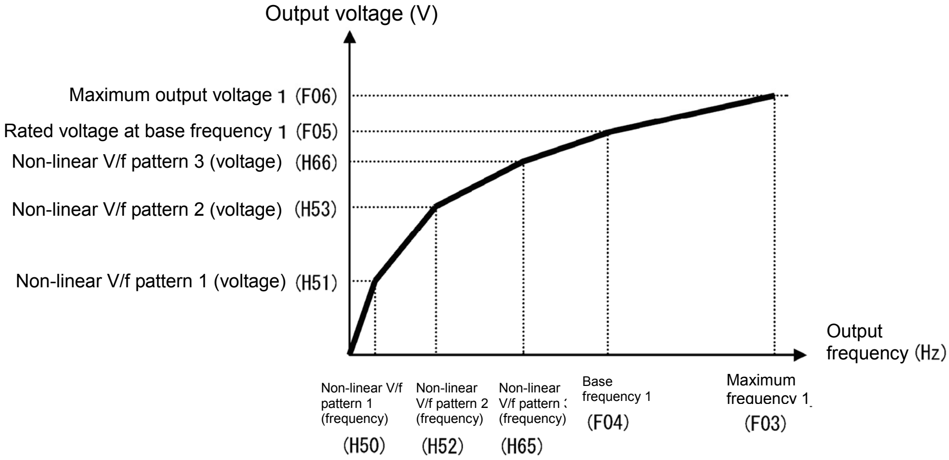
Point of V/f	Function code		Remarks
	Frequency	Voltage	
Maximum output frequency	F03	F06	During auto torque boost, vector without speed sensor, the maximum output voltage setting is disabled.
Base frequency	F04	F05	
Non-linear V/f 3	H65	H66	This code is disabled during auto torque boost, vector without speed sensor.
Non-linear V/f 2	H52	H53	
Non-linear V/f 1	H50	H51	

<Setting example>

■ **Normal V/f pattern setting**



■ **Non-linear V/f pattern setting (3 points)**



■ Base frequency (F04)

Set the data in accordance with rated frequency of the motor (given on the nameplate of the motor).

- Data setting range: 25.0 to 500.0 (Hz) (limited to 120 Hz (max.) with the ND mode)

■ Base frequency voltage (F05)

Set the data in accordance with "0" or rated voltage of the motor (given on the nameplate of the motor).

- Data setting range: 0 : AVR disable
  80 to 240 (V) : AVR operation (at 200 V class)
  160 to 500 (V) : AVR operation (at 400 V class)
- When data is set to "0", the base frequency voltage becomes equivalent to inverter input voltage. When input voltage is fluctuated, output voltage fluctuates as well.
- When data is set to arbitrary voltage other than "0", automatically keep the output voltage constant. When control function such as auto torque boost, auto energy-saving operation, and skip compensation is used, it is necessary to adjust to the rated voltage (given on the nameplate of the motor) of the motor.

Note The voltage that the inverter can output is lower than the input voltage of the inverter. Appropriately set the voltage in accordance with the mode of the motor.

■ Non-linear V/f 1, 2, 3 (Frequency) (H50, H52, H65)

Set frequency at the arbitrary point of non-linear V/f pattern.

- Data setting range: 0.0 (Cancel), 0.1 to 500.00 (Hz)

Note When 0.0 is set, the setting becomes the pattern without using non-linear V/f pattern. (limited to 120 Hz (max.) with the ND mode)

■ Non-linear V/f 1, 2, 3 (Voltage) (H51, H53, H66)

Set voltage at the arbitrary point of non-linear V/f pattern.

- Data setting range: 0 to 240 (V) : AVR operation (at 200 V class)
  0 to 500 (V) : AVR operation (at 400 V class)

■ Maximum output voltage 1 (F06)

Set the voltage at maximum output frequency 1 (F03).

- Data setting range: 80 to 240 (V) : AVR operation (at 200 V class)
  160 to 500 (V) : AVR operation (at 400V class)

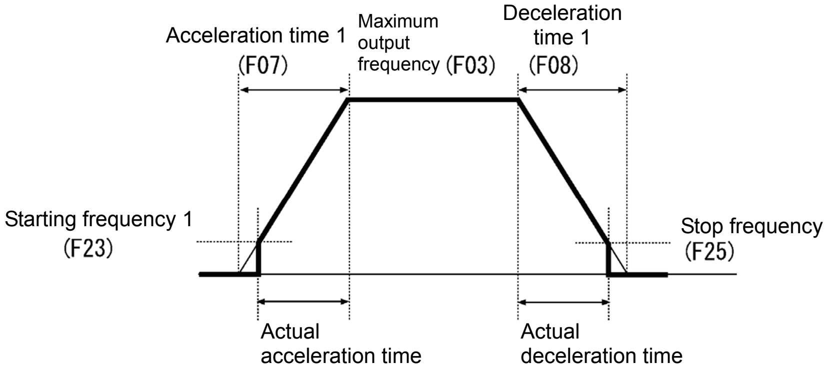
Note When base frequency voltage (F05) is "0", the data of non-linear V/f (H50 to H53, H65, and H66) and F06 becomes invalid (linear V/f for at or below base frequency, and constant voltage for at or higher than base frequency).

F07, F08	**Acceleration time1, Deceleration time 1**	
	Related function codes	**E10, E12, E14 Acceleration time 2, 3, 4** **E11, E13, E15 Deceleration time 2, 3, 4** **H07 Curve acceleration/deceleration** **H56 Deceleration time for Forced stop** **H54, H55 Acceleration/deceleration time (Jogging operation)** **H57 to H60 Acceleration/deceleration time No. 1, No.2 S-curve range**

Acceleration time sets the time when the output frequency reaches the maximum output frequency from 0Hz, and deceleration time sets the time until when the output frequency reaches 0Hz from the maximum.

- Data setting range: 0.00 to 6000 (s)

For V/f control



■ Acceleration/Deceleration time

Type of Acceleration/ deceleration time	Function code		Switching factor of acceleration/deceleration time (📖 Function code E01 to E05)		
	Acceleration time	Deceleration time	"RT2"	"RT1"	
Acceleration/ deceleration time 1	F07	F08	OFF	OFF	Switch by acceleration/deceleration selection "RT1" "RT2". (Data = 4 or 5) When there is no assignment, acceleration/deceleration time 1 (F07, F08) are valid.
Acceleration/ deceleration time 2	E10	E11	OFF	ON	
Acceleration/ deceleration time 3	E12	E13	ON	OFF	
Acceleration/ deceleration time 4	E14	E15	ON	ON	
At jogging	H54	H55	When jogging operation "JOG" is ON, switch to the mode with which jogging operation is possible. (Data = 10) (📖 Function code C20)		
At Force to stop	-	H56	Turning the Force to stop "STOP" command OFF causes the motor to decelerate to a stop in accordance with the deceleration time for forced stop (H56). After the motor stops, the inverter enters the alarm state with the alarm Er-6 displayed. (Data = 30)		

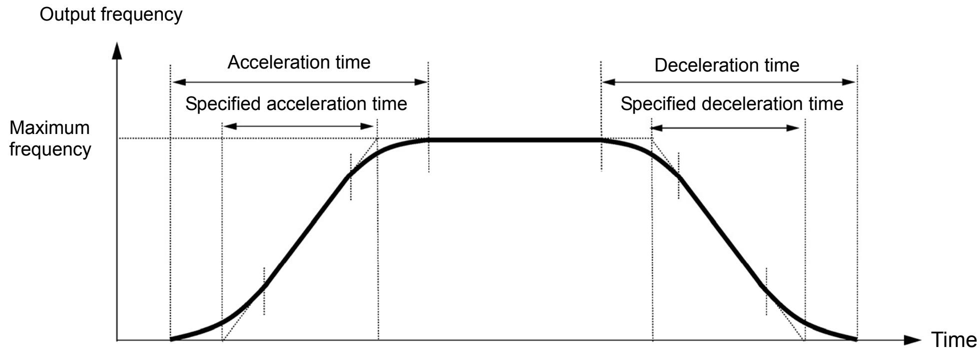
■ Curve acceleration/deceleration (H07)

Select acceleration/deceleration pattern (change pattern of frequency) at acceleration/deceleration

H07 data	Acceleration/deceleration pattern	Action		Function code
0	Disable (Linear acceleration/deceleration)	Acceleration/deceleration with constant acceleration.		-
1	S-curve acceleration/deceleration (Weak)	Smoothen the speed change and reduce shock when starting acceleration and right before the speed becomes constant, as well as when starting deceleration and right before the deceleration stops.	Weak: Fix acceleration/deceleration rate to 5% of the maximum output frequency within each S-curve range.	-
2	S-curve acceleration/deceleration (Arbitrary)		Arbitrary: It is possible to set acceleration/deceleration rate arbitrarily within each S-curve range.	H57, H58 H59, H60
3	Curve acceleration/deceleration	Linear acceleration/deceleration (constant torque) at or below base frequency and acceleration becomes gradually slower at or higher than the base frequency, and acceleration/deceleration with constant load rate (rated output). It is possible to accelerate/decelerate with the maximum capability.		-

S-curve acceleration/deceleration

For the purpose of decreasing the shock on the load machine side, smoothen the speed change at the start of acceleration and right before it becomes constant speed, and at the start of deceleration and right before the stop of deceleration. As for s-curve acceleration/deceleration range, fix with 5% for S-curve acceleration/deceleration (weak), and for S-curve acceleration/deceleration (arbitrary), it is possible to set individually for each 4 locations by function code H57 to 60. The specified acceleration/deceleration time determines acceleration of linear part and the actual acceleration/deceleration time becomes longer than the specified acceleration /deceleration time.



	At the start of acceleration	At the end of acceleration	At the start of deceleration	At the end of deceleration
S-curve (Weak)	5%	5%	5%	5%
S-curve (Arbitrary) Setting range: 0 to 100%	H57 At acceleration No. 1 S-curve range (At the start)	H58 At acceleration No. 2 S-curve range (At the end)	H59 At deceleration No. 1 S-curve range (At the start)	H60 At acceleration No. 2 S-curve range (At the endt)

Acceleration/Deceleration time

< S-curve acceleration/deceleration (Weak): When frequency change is 10% or higher than the maximum frequency>

Acceleration or deceleration time (s) = $(2 \times 5/100 + 90/100 + 2 \times 5/100) \times$ reference acceleration or deceleration time
= $1.1 \times$ reference acceleration or deceleration time

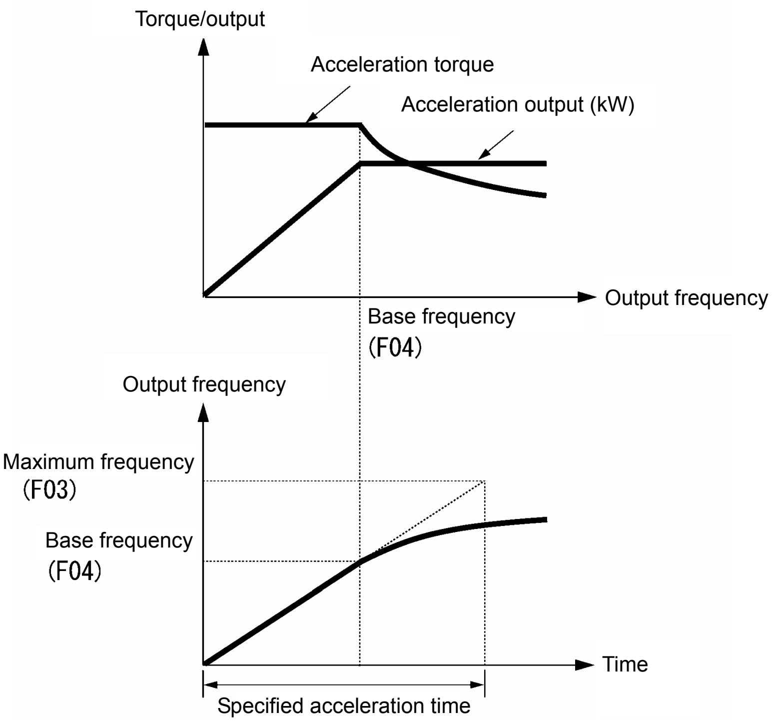
< S-curve acceleration/deceleration (Arbitrary: When 10% at the start, 20% at the end): When frequency change is 30% or higher than the maximum frequency.>

Acceleration or deceleration time (s) = $(2 \times 10/100 + 70/100 + 2 \times 20/100) \times$ (reference acceleration or deceleration time)
= $1.3 \times$ (reference acceleration or deceleration time)

Curve acceleration/deceleration

This is a pattern to perform linear acceleration/deceleration (rated torque) at or below base frequency and acceleration becomes gradually slower at or higher than the base frequency, and acceleration/deceleration with constant load rate (rated output).

It is possible to accelerate/decelerate with the maximum capability of the motor to be driven by the inverter.



The diagram on the left shows pattern at acceleration.
This is the same as at deceleration.

Note
- When S-curve acceleration/deceleration and curve acceleration/deceleration is selected by curve acceleration/deceleration H07, the actual acceleration/deceleration time becomes longer than the set value.
- If acceleration/deceleration time is set shorter than necessary, current limiting function, torque limit or anti-regenerative function may operate and acceleration/deceleration time may become longer than the set value.

F09	Torque boost 1 (Refer to F37)

For details of torque boost 1 setting, refer to the section of function code F37.

F10 to F12	Electronic thermal 1 (for Motor protection) (Characteristics selection, Operation mode, Thermal time constant)

In order to detect overload of motor (electronic thermal function by inverter output current), set temperature characteristics of motor (characteristics selection (F10), thermal time constant (F12), and operation level (F11).

When overload of motor is detected, inverter is turned off, and protect the motor with motor overload alarm OL1.

Note Improper setting of the electronic thermal function may result in a failure to protect the motor from burning.

Note Temperature characteristics of motor is used for motor overload early warning "OL" as well. Even if only overload early warning is used, it is necessary to set temperature characteristics of the motor (F10, F12). (📖 Function code E34)

When setting motor overload alarm as disable, set F11 = 0.00 (Disable).

Note For PTC thermistor built-in motor, by connecting PTC thermistor to terminal [C1], it is possible to protect the motor. Refer to H26 to find the details.

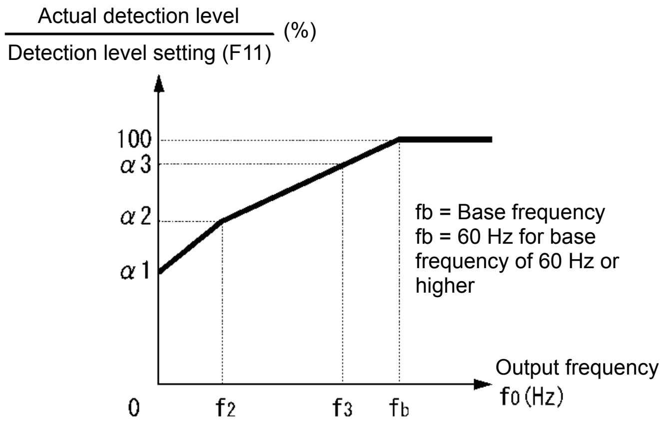
■ Characteristics selection (F10)

F10 selects characteristics of cooling system of the motor.

F10 data	Function
1	Self-cooling fan of general-purpose motor (Self-cooling) (When operating with low frequency, cooling performance decreases.)
2	Inverter-driven motor, High-speed motor with separately powered cooling fan (Keep constant cooling capability irrespective to output frequency)

The following diagram shows electronic thermal operation characteristics diagram when F10=1 is set. The characteristics coefficient α1 and α3 and the switch coefficient f2, f3 differ depending on the characteristics of the motor.

Each coefficient that is set by motor characteristics that is selected by motor capacitance and motor selection (P99) is shown in the table below.



Characteristics diagram of motor cooling system

When P99 = 0, 4 (Motor characteristics 0, Other)

Motor capacitance	Thermal time constant τ (Factory default)	Thermal time constant setting Standard current value Imax	Characteristics coefficient switch frequency		Characteristics coefficient		
			f2	f3	α1	α2	α3
0.4, 0.75 kW	5 min	Continuous allowance current value x 150%	5 Hz	7Hz	75%	85%	100%
1.5 to 3.7 kW					85%	85%	100%
5.5 to 11 kW				6Hz	90%	95%	100%
15 kW				7Hz	85%	85%	100%
18.5, 22 kW				5Hz	92%	100%	100%
30 to 45 kW	10 min		Base frequency × 33%	Base frequency × 83%	54%	85%	95%
55 to 90 kW					51%	95%	95%
110 kW or higher					53%	85%	90%

When P99 = 1 (Motor characteristics 1)

Motor capacitance	Thermal time constant τ (Factory default)	Thermal time constant setting Standard current value Imax	Characteristics coefficient switch frequency		Characteristics coefficient		
			f_2	f_3	α1	α2	α3
0.2 to 22 kW	5 min	Continuous allowance current value x 150%	Base frequency × 33%	Base frequency × 33%	69%	90%	90%
30 to 45 kW	10 min			Base frequency × 83%	54%	85%	95%
55 to 90 kW					51%	95%	95%
110 kW or higher					53%	85%	90%

When F10=2 is set, cooling effect by output frequency will not decrease, therefore, operation level becomes constant value (F11) without decrease.

■ Operation level (F11)

F11 sets operation level of electronic thermal.

- Data setting range: 1 to 135% of the rated current value of inverter (continuous allowance current value)

Normally, set to the motor continuous allowance current (in general, about 1.0 to 1.1 times of motor rated current) when operating at base frequency.

When setting electronic thermal as disable, set (F11 = 0.00: Disable)

■ Thermal time constant (F12)

F12 sets thermal time constant of the motor. For operation level that is set by F11, set the electronic thermal operation time when 150% of current is flowed continuously. Thermal time constant of general-purpose motor of Fuji Electric and general motors is 5 minutes for 22 kW or lower, and 10 minutes (factory default state) for 30kW or higher.

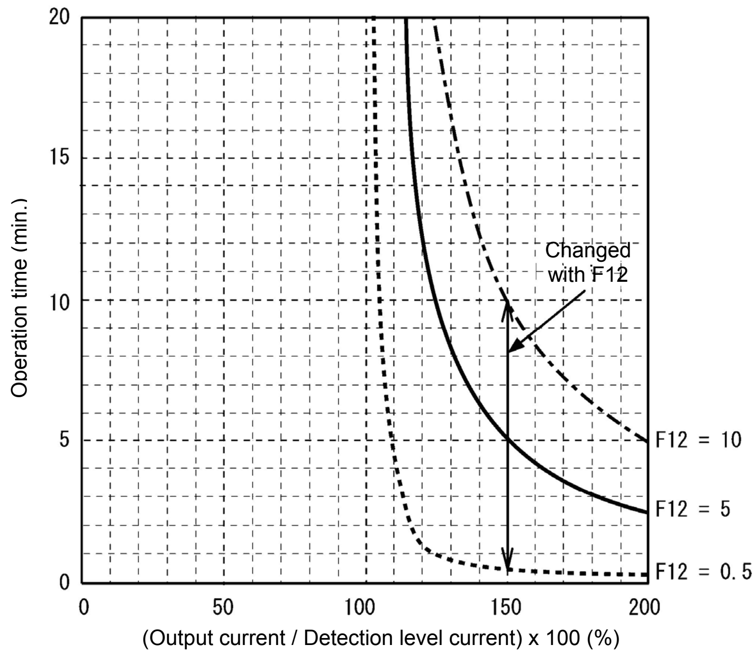
- Data setting range: 0.5 to 75.0 (min)

(Example) When the data of function code F12 is set to "5" (5 minutes).

As shown in the diagram below, when 150% of current of operation level that was set flows for 5 minutes, motor overload (alarm OL1) protection function will operate. In addition, with 120%, it is operated for 12.5 minutes.

The time when alarm actually occurs is shorter than the set data because the time until the current reaches 150% level after exceeding the continuous allowance current (100%) is considered.

<Example of current-operation time characteristics>



F14	**Momentary power failure restart (Operation selection)** **Related function codes** **H13 Momentary power failure restart (Delay time)** **H14 Momentary power failure restart (frequency lowering rate)** **H15 Momentary power failure restart (Continue to run level)** **H16 Momentary power failure restart (Momentary power failure allowance time)** **H92 Continue to run (P)** **H93 Continue to run (I)**

Set the operation for when momentary power failure occurs (trip operation, restart operation method at auto-restarting)

■ Momentary power failure restart (Mode selection) (F14)

<table>
<tr><th rowspan="2">F14 data</th><th colspan="2">Operation contents</th></tr>
<tr><th>Without auto search</th><th>With auto search</th></tr>
<tr><td>0: Immediately trip</td><td colspan="2">When momentary power failure occurs while operating the inverter, and at the time when undervoltage is detected by the DC link bus voltage of the inverter, undervoltage alarm LU is outputted, the inverter output shuts down, and the motor coasts to a stop.</td></tr>
<tr><td>1: Trip at auto-restarting</td><td colspan="2">When momentary power failure occurs while operating the inverter, and at the time when undervoltage is detected by the DC link bus voltage of the inverter , the inverter output shuts down and the motor coasts to stop, but the undervoltage alarm will not be outputted. When auto-started from momentary power failure, undervoltage alarm LU is outputted.</td></tr>
<tr><td>2: after momentary power failure is stopped Trip</td><td colspan="2">When momentary power failure occurs while operating the inverter and start deceleration stop control when DC link bus voltage of the inverter becomes at or drops below the continue to run level. At deceleration stop control, operation energy of inertia moment of the load is regenerated by decelerating, and degeneration operation is continued. After deceleration is stop, output alarm of LU.</td></tr>
<tr><td rowspan="3">3: Continue to run (for heavy inertia load or general load)</td><td colspan="2">When momentary power failure occurs while operating the inverter and start deceleration stop control when DC link bus voltage of the inverter becomes at or drops below the continue to run level. At continue to run control, operation energy of inertia moment of the load is regenerated by decelerating, and operation is continued to wait for auto-restarting. If there is not enough energy for regeneration and when undervoltage is detected, the inverter output shuts down and the motor coasts to a stop.</td></tr>
<tr><td>If run command is entered at auto-restarting, restart from the frequency of when undervoltage is detected.</td><td>If run command is entered at auto-restarting, auto-searching is performed, motor speed is estimated, and restart from the frequency.</td></tr>
<tr><td colspan="2">This setting is most suitable for the fan with large inertia moment of load.</td></tr>
<tr><td rowspan="3">4: from frequency at power failure Restart (for general load)</td><td colspan="2">When momentary power failure occurs while operating the inverter, and at the time when undervoltage is detected by the DC link bus voltage of the inverter, the inverter output shuts down, and the motor coasts to a stop.</td></tr>
<tr><td>If run command is entered at auto-restarting, restart from the frequency of when undervoltage is detected.</td><td>If run command is entered at auto-restarting, auto-searching is performed, motor speed is estimated, and restart from the frequency.</td></tr>
<tr><td colspan="2">This setting is most suitable for the case (fan) when load inertial moment is large, and motor speed does not decrease so much even if the motor coasts to a stop due to momentary power failure.</td></tr>
<tr><td rowspan="3">5: From starting frequency Restart</td><td colspan="2">When momentary power failure occurs while operating the inverter, and at the time when undervoltage is detected by the DC link bus voltage of the inverter, the inverter output shuts down, and the motor coasts to a stop.</td></tr>
<tr><td>If run command is entered at auto-restarting, restart from the starting frequency that was set by function code F23.</td><td>If run command is entered at auto-restarting, auto-searching is performed, motor speed is estimated, and restart from the frequency.</td></tr>
<tr><td colspan="2">This setting is most suitable for the case (pump etc.) when load inertia moment is small, when the load is heavy, and motor speed decreases up to 0 in a short time after the motor coasts to a stop due to momentary power failure.</td></tr>
<tr><td colspan="3">With auto-searching: Auto-searching is selected by starting mode selection "STM' ON or H09 = 1 or 2.
Refer to function code H09 (Starting mode) to find the detail of starting mode selection "STM" ON auto-searching.</td></tr>
</table>

⚠WARNING

When momentary power failure restart operation (F14 = 3 to 5) is selected, operation will resume automatically at auto-restarting. Design your machinery so that safety is ensured even at restarting.

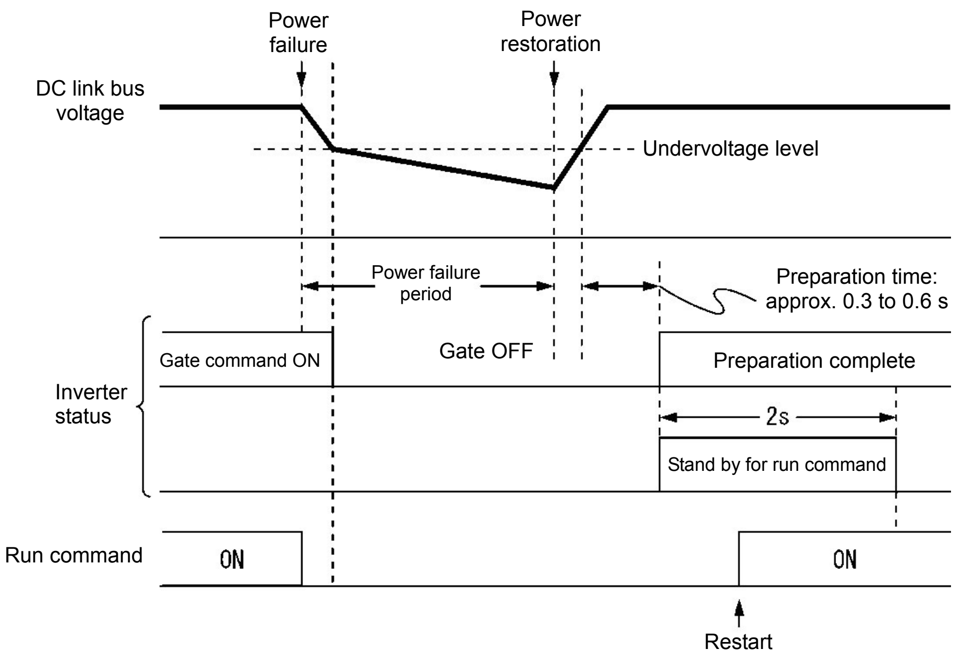
Otherwise an accident could occur.

■ Momentary power failure restart (Basic operation: Without auto-searching setting)

When inverter detected that DC link bus voltage of inverter becomes at or drops below undervoltage level while operating, it is judged as a momentary power failure. When load is light and momentary power failure is very short, momentary power failure may not be detected and motor operation might be continued because DC link bus voltage does not drop so much.

When inverter judges the state as momentary power failure, return to momentary power failure restart mode and prepare for restart. After power is auto-restarted, the inverter becomes at inverter ready to run state after elapse of initial charging time. At momentary power failure, power of external circuit (relay circuit etc.), which controls the inverter, decreases as well, and run command may be turned off. Therefore, when the inverter becomes at inverter ready to run state, wait 2 seconds for input of run command. When input of run command is confirmed within 2 seconds, initiate restarting according to F14 (mode selection). When there is no input of run command at run command input waiting state, momentary power failure restart mode will be released and start from normal starting frequency. Therefore, input run command within 2 seconds after auto-restarting or hold run command by off-delay timer or mechanical latch relay.

When run command is from keypad, input of rotation direction command of the mode (F02 = 0) with which rotation direction command is determined by the terminal, is the same. For rotation direction fixed mode (F02 = 2, 3), run command is held within the inverter, therefore, restart immediately the inverter becomes at inverter ready to run state.



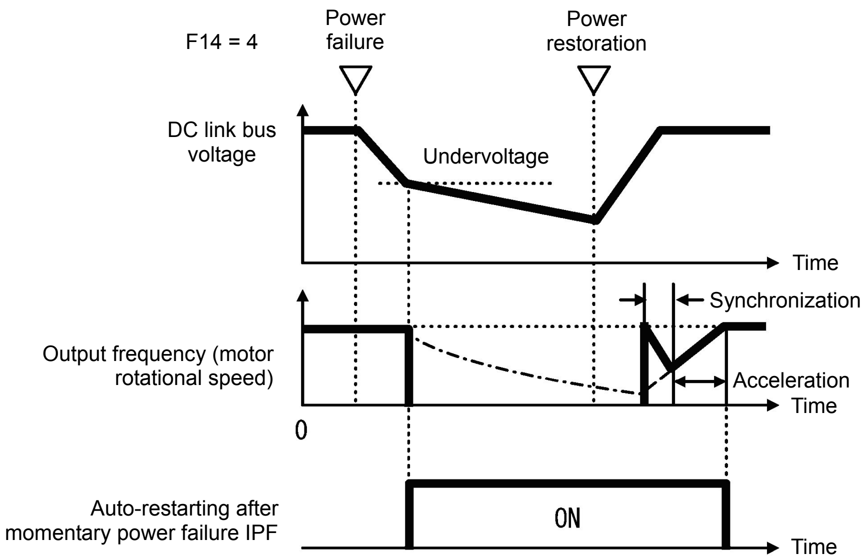
Note

- At auto-restarting, wait 2 seconds for input of run command, however, if momentary power failure allowance time (H16) is elapsed after the state is judged as power failure, the state of run command input waiting for 2 seconds will be canceled and normal starting operation is performed.
- When coasts to a stop command "BX" is entered during power failure, momentary power failure restart waiting state is released and return to normal run mode, and when run command is inputted, start from normal starting frequency.
- Detection of momentary power failure within the inverter is performed by detecting DC link bus voltage drop of the inverter. With the structure in which a magnetic contactor is equipped on the output side of the inverter, there will be no operation power of the magnetic contactor at momentary power failure and the magnetic contactor becomes at open state. When the magnetic contactor becomes open, connection of inverter and motor is released and load of the inverter is shutdown. Therefore, it becomes difficult to decrease DC link bus voltage of the inverter and it may not be judged as a momentary power failure. If this is the case, momentary power failure restart will not be performed normal. As a countermeasure against this case, by connecting auxiliary contact signal of the magnetic contactor to the interlock signal "IL" it is possible to detect momentary power failure without fail.

  Function code E01 to E05 Data = 22

Terminal command “IL”	Meaning
OFF	No momentary power failure has occurred.
ON	A momentary power failure has occurred. (Restart after a momentary power failure enabled)

When motor speed decreases during momentary power failure, and when restarting from frequency of before momentary power failure after power is recovered (auto-restarting), current limiter becomes active and output frequency of the inverter decreases automatically. When output frequency and motor rotation speed synchronize, the speed is accelerated up to the original output frequency. Refer to the figure below. However, it is necessary to enable instantaneous overcurrent limiting (H12 = 1) to bring in synchronization of the motor.



- Auto-restarting after momentary power failure "IPF"

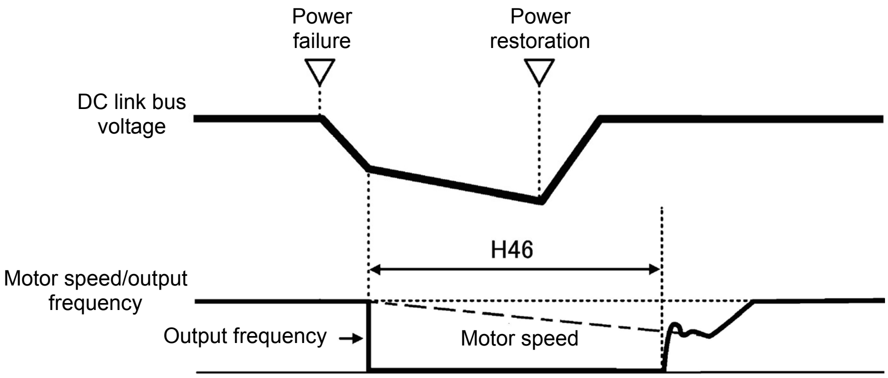
During momentary power failure auto-restarting "IPF" signal is turned on until returning to original frequency after auto-restarting after momentary power failure occurred. When "IPF: is turned ON, motor speed decreases, therefore, take necessary measures. (📖 Function code E20, E21, E27 Data = 6)

■ **Momentary power failure restart (Basic operation: With auto-searching setting)**

Auto-searching is not performed normally if there is residual voltage of the motor.

Therefore, it is necessary to secure the time until residual voltage runs out.

Momentary power failure restart secures the necessary time with function code H46 starting mode (auto-searching delay time 2). Even if starting conditions are satisfied, inverter does not start unless auto-searching delay time elapses after inverter goes into OFF state. Start after elapse of auto-searching delay time. (📖 Function code H09, d67)

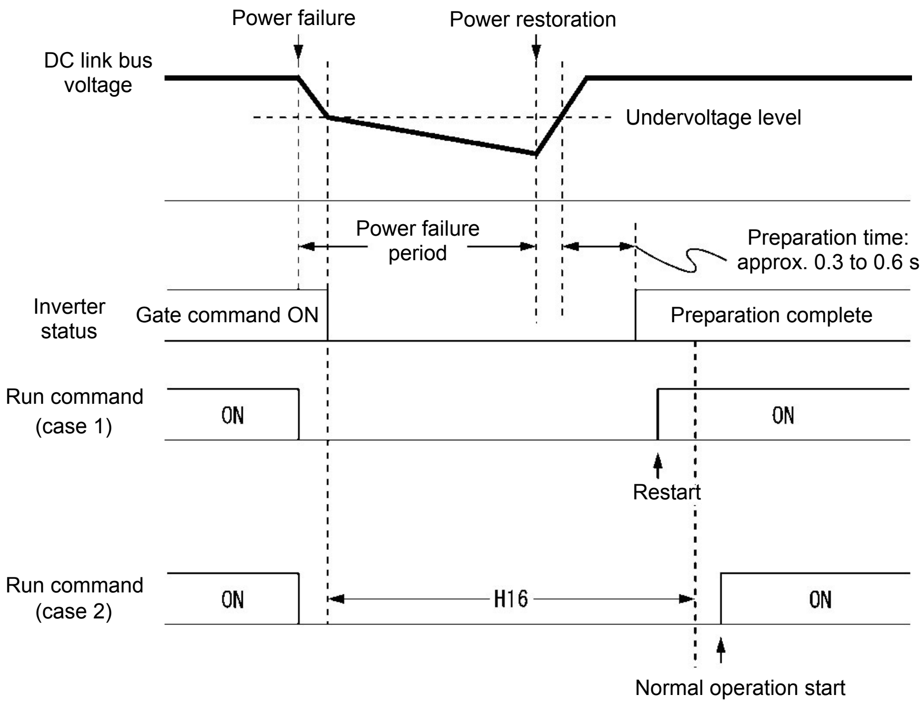


Note

- When operating auto-searching, it is necessary to perform auto-tuning in advance.
- When the estimated speed exceeds the maximum frequency or the upper limit frequency, the inverter disables auto search and starts running the motor with the maximum frequency or the upper limit frequency, whichever is lower.
- During auto search, if an overcurrent or overvoltage trip occurs, the inverter restarts the suspended auto search.
- Use 60 Hz or below for auto-searching
- Note that auto search may not fully provide the performance depending on load conditions, motor parameters, wiring length, and other external factors.
- When output circuit filter OFL-□□□-2, -4 is equipped on the output side of the inverter, auto-searching is disabled. Use OFL-□□□-□A type.

■ **Momentary power failure restart (Momentary power failure allowance time) (H16)**

Set the maximum time for after momentary power failure (undervoltage level) occurs and up until restart (setting range: 0.0 to 30.0 s). Set coast to a stop time which is allowable for machine and equipment. Momentary power failure restart operation is performed within the specified time, however, if the set time is exceeded, the inverter judges the state as a power shut down, and then operates as powering on again without performing momentary power failure restart operation.



When momentary power failure allowance time (H16) is set to "999", momentary power failure restart is performed until DC link bus voltage decreases by momentary power failure restart allowance voltage (50 V (200 V level), 100 V (400 V level), however, if the voltage becomes at or below the momentary power failure allowance voltage, the state is judged as a power shut down. As a result, the inverter operates as powering ON again without performing momentary power failure restart operating.

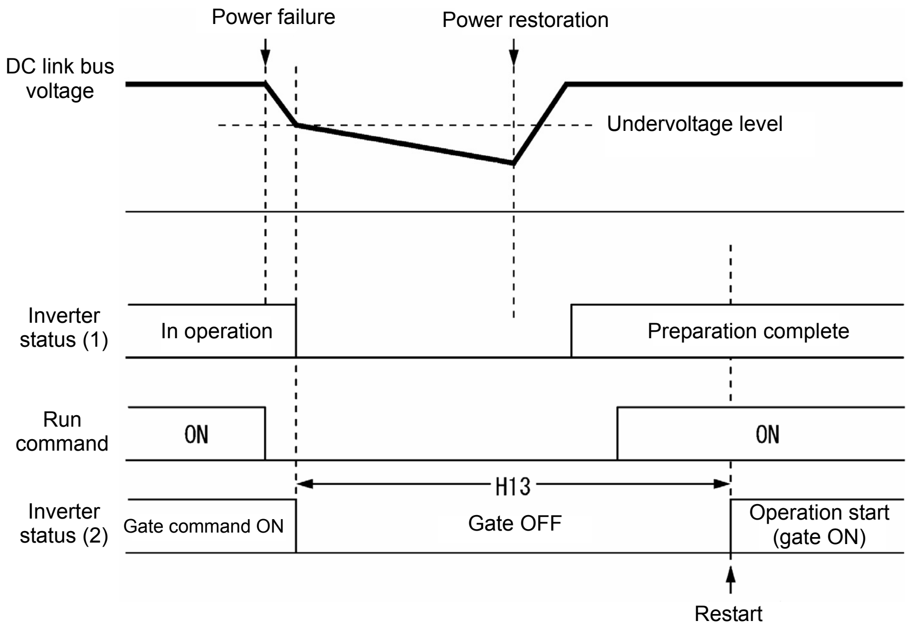
Power supply group	Allowance voltage of momentary power failure restart
200V	50V
400V	100V

Note: The time until voltage decreases to the momentary power failure restart allowance voltage from undervoltage differs greatly depending on the inverter capacitance and with/without option.

■ **Momentary power failure restart (Holding time) (H13)**

H13 set the time until restart is performed after momentary power failure occurred. (At auto-searching setting, use H46 (auto-searching holding time 2)).

Restarting at the state when residual voltage of the motor is high, inrush current becomes greater or temporarily becomes at regeneration state, and overcurrent alarm may occur. For security reason, in order to restart after residual voltage is reduced to some extent, adjust H13. Even if auto-restarted, restart cannot be performed until the holding time (H13) elapses.



Factory default: At the factory default state, setting is performed so that it is appropriate to the standard motor (refer to table A at the end of "5.1 Function code overview"). Basically, there is no need to modify the default setting. However, when problems occur due to the long holding time or decrease in flow rate of pump becomes significant, change to about half of the standard value and make sure that alarm etc. will not occur.

■ Restart Mode after Momentary Power Failure (H14)

At momentary power failure restart operation, when inverter output frequency and motor rotation speed does not synchronize, overcurrent occurs and current limiter will operate. when current limit is detected, automatically decrease the output frequency and synchronize with the motor rotation speed. H14 sets the slope of lowering output frequency (frequency lowering rate (Hz/s)).

H14 data	Output frequency lowering operation
0.00	Decrease by the selected deceleration time.
0.01 to 100.00 (Hz/s)	Decrease by the lowering rate that is set by H14.
999	Depending on the PI processor of current limiting processing (PI constant is fixed value within the inverter), the rate will decrease).

Note When frequency lowering rate is increased, regeneration operation is performed at the moment when output frequency of the inverter and rotation speed of inverter synchronize, and overvoltage trip may occur. When frequency lowering rate is reduced, the time until output frequency of the inverter and motor rotation speed synchronize (current limiting operation) becomes longer, and protection operation of inverter overload may be activated.

■ Restart of momentary power failure (Continue to run level) (H15) Continue to run (P, I) (H92, H93)

- Trip after momentary deceleration is stopped

When trip after deceleration stopped is selected (F14 = 2), at momentary power failure restart operation (Mode selection), momentary power failure occurs while operating the inverter, and deceleration stop control starts when DC link bus voltage of the inverter becomes at or drops below the continuous running level.

Adjust voltage level of DC link bus to start deceleration stop control by H15.

Under decelerate-to-stop control, the inverter decelerates its output frequency keeping the DC link bus voltage constant using the PI processor.

P (proportional) and I (integral) components of the PI processor are specified by H92 and H93, respectively.

For normal inverter operation, it is not necessary to modify data of H15, H92 or H93.

- Continue to run

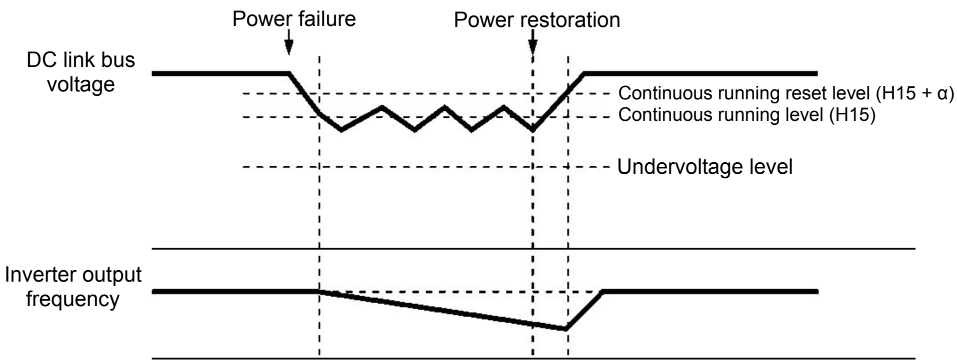
When momentary power failure restart operation (Continue to run) is selected (F14 = 3) at momentary power failure restart (operation selection), momentary power failure occurs while operating the inverter and continue to run control starts when DC link bus voltage of the inverter becomes at or drops below the continue to run level.

Adjust continue to run level to start continue to run control by H15.

Under the continue to run control, the inverter continues to run keeping the DC link bus voltage constant using the PI processor.

P (proportional) and I (integral) components of the PI processor are specified by H92 and H93, respectively.

For normal inverter operation, it is not necessary to modify data of H15, H92 or H93.



Power supply group	α	
	22 kW or below	30 kW or above
200 V	5 V	10 V
400 V	10 V	20 V

Note Even if "Deceleration stop control" or "Continue to run", is selected, the inverter may not be able to do so when the inertia of the load is small or the load is heavy, due to undervoltage caused by a control delay. In such a case, when "Deceleration stop control" is selected, the inverter allows the motor to coast to a stop; when "Continue to run" is selected, the inverter saves the output frequency being applied when the undervoltage alarm occurs and perform momentary power failure restart operation.
When the input power voltage for the inverter is high, setting the continue to run level high makes the control more stable even if the inertia of the load is relatively small. Raising the continuous running level too high, however, might cause the continue to run control activated even during normal operation.
When the input power voltage for the inverter is extremely low, continue to run control might be activated even during normal operation, at the beginning of acceleration or at an abrupt change in load. To avoid this, lower the continuous running level. Lowering it too low, however, might cause undervoltage that results from voltage drop due to a control delay.

Before you change the continuous running level, make sure that the continuous running control will be performed properly, by considering the fluctuations of the load and the input voltage.

F15, F16	**Frequency Limiter (Upper limit), Frequency Limiter (Lower limit)** **Related function codes H63 Lower limit Limiter (Mode selection)**

■ Frequency Limiter (Upper limit) (Lower limit) (F15, F16)

F15 and F16 specify the upper and lower limits of the output frequency or reference frequency, respectively.

Frequency Limiter		Object to which the limit is applied
Frequency Limiter (High)	F15	Output frequency
Frequency Limiter (Low)	F16	Reference frequency
Note	When the limit is applied to the reference frequency or reference speed, delayed responses of control may cause an overshoot or undershoot, and the frequency may temporarily go beyond the limit level.	

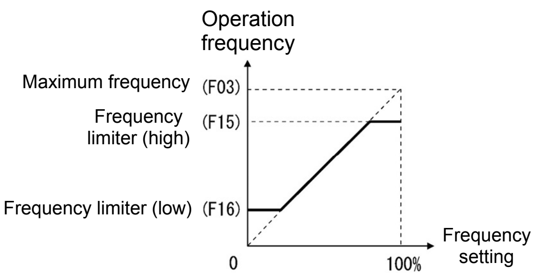
- Data setting range: 0.0 to 500.0 (Hz)

■ Low Limiter (Mode selection) (H63)

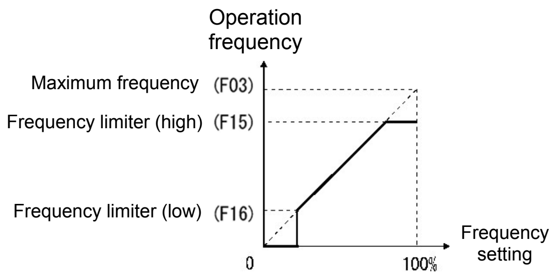
H63 specifies the operation to be carried out when the reference frequency drops below the low level specified by F16, as follows:

H63 data	Action
0	The output frequency will be held at the low level specified by F16.
1	The inverter decelerates to stop the motor.

Refer to the figure below.



(For H63 = 0)



(For H63 = 1)

Note
- When changing the frequency limiter (High) (F15) in order to raise the reference frequency, be sure to change the maximum frequency (F03) accordingly.
- Set each function code related to operation frequency so that the relationship among data becomes the following magnitude relationship.
  - F15>F16, F15>F23, F15>F25
  - F03>F16

  However, F23 is the starting frequency, and F25 is stop frequency
  If any wrong data for these function codes is specified, the inverter may not run the motor at the desired speed, or cannot start it normally.

F18	Bias (for frequency setting 1) (Refer to F01)

Refer to the description of function code F01 to find the details of bias (Frequency setting 1) setting.

F20 to F22 H95 H195	DC braking1 (Starting frequency, Operation level, Time) DC braking (Braking response mode) DC braking time at the Startup

These function codes specify the DC braking that prevents motor 1 from running by inertia during decelerate-to-stop operation.

If the motor enters a decelerate-to-stop operation by turning OFF the run command or by decreasing the reference frequency below the stop frequency, the DC braking starts when output frequency reached the DC braking starting frequency. Set frequency (F20), operation level (F21), and operation time (F22) to start DC braking when deceleration is stopped.

Setting the braking time to "0.00" (F22 = 0) disables the DC braking.

By H195, it is possible to perform DC braking when starting up inverter. By doing so, it is efficient for preventing from falling down when the brake is released and when load is decreased, and prompt torque startup when starting up.

■ Braking starting frequency (F20)

F20 specifies the frequency at which the DC braking starts its operation during motor decelerate-to-stop state.

- Data setting range: 0.0 to 60.0 (Hz)

■ Operation level (F21)

F21 specifies the output current level to be applied when the DC braking is activated. The function code data should be set, assuming the rated output current of the inverter as 100%, in increments of 1%.

- ND:0 to 60(%), HD/HND:0 to 80%,HHD:0 to 100%

Note: The inverter rated output current differs between the ND/HD/HND/HHD modes.

■ Braking time (F22)

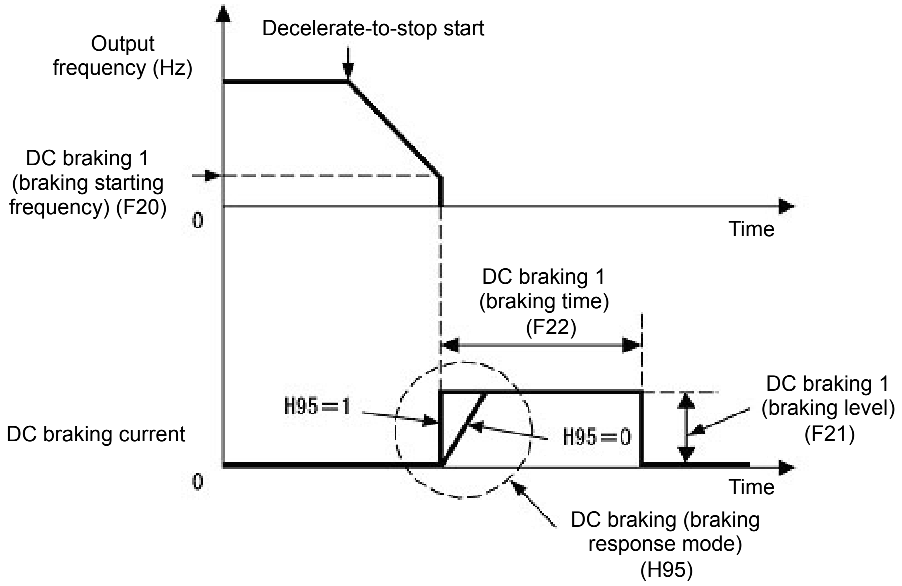
F22 specifies the braking period that activates DC braking.

- Data setting range: 0.00 (Disable), 0.01 to 30.00 (s)

■ Braking response mode (H95)

H95 specifies the DC braking response mode.

H95 data	Characteristics	Note
0	Slow response. Slows the rising edge of the current, thereby preventing reverse rotation at the start of DC braking.	Insufficient braking torque may result at the start of DC braking.
1	Quick response. Quickens the rising edge of the current, thereby accelerating the build-up of the braking torque.	Reverse rotation may result depending on the moment of inertia of the mechanical load and the coupling mechanism.



Tip It is also possible to input DC braking command "DCBRK" by using an external digital input signal as the terminal command. As long as the DCBRK is ON, the inverter performs DC braking, regardless of the braking time specified by F22. (Refer to function code E01 to E05 Data =13 to find the details of "DCBRK")

Turning the “DCBRK” ON even when the inverter is in a stopped state activates the DC braking. This feature allows the motor to be excited before starting, resulting in smoother acceleration (quicker build-up of acceleration torque) (under V/f control).

Note In general, specify data of function code F20 at a value close to the rated slip frequency of motor. If an extremely high value is set, control may become unstable and an overvoltage alarm may result in some cases.

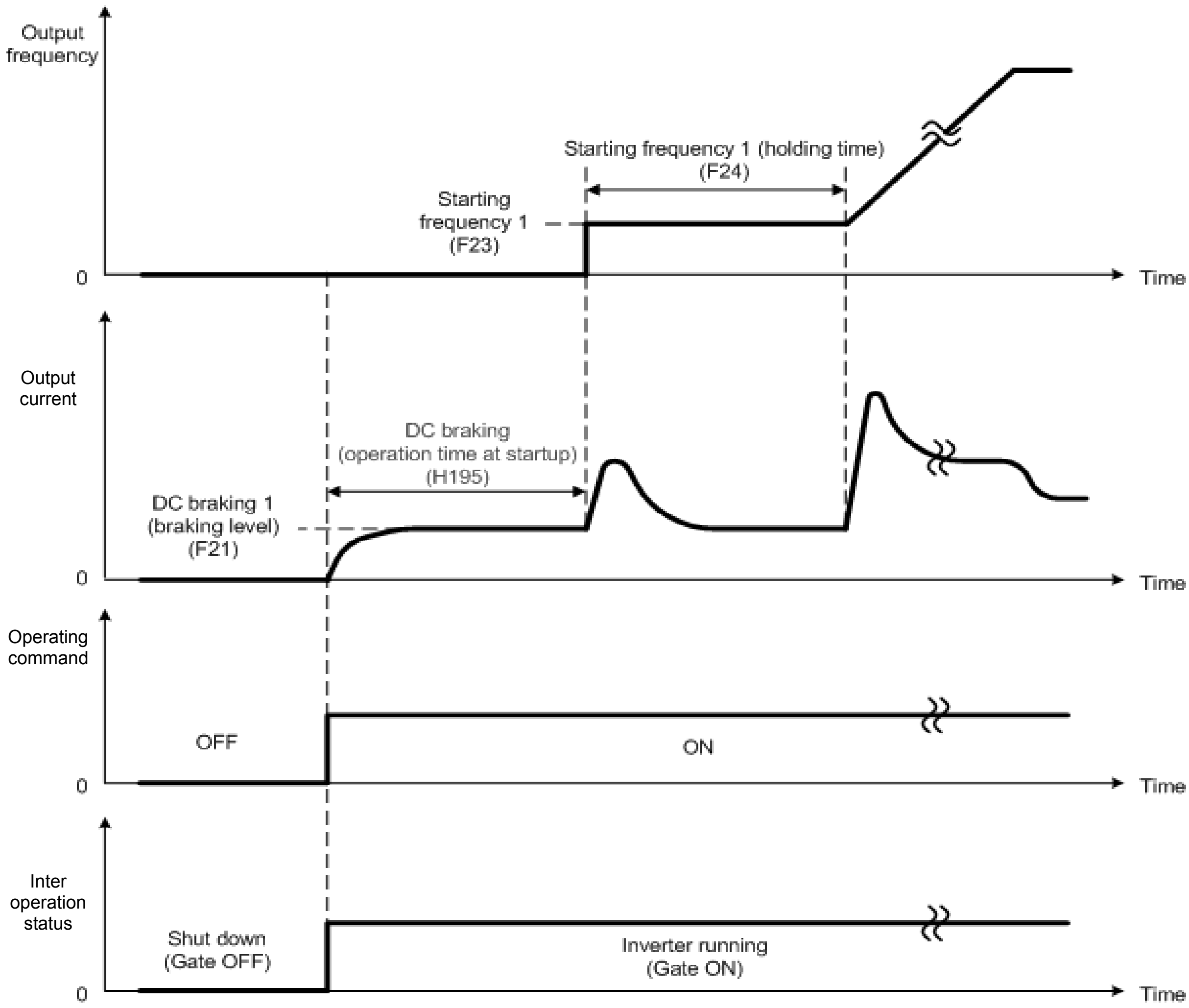
⚠CAUTION
The DC braking function of the inverter does not provide any holding mechanism. **Injuries could occur.**

■ Braking time at the Startup (H195)

When starting up inverter by run command, it is possible to start by operating DC breaking.

This is particularly useful in applications such as hoists and elevators where the inverter runs at low speed braking right after starting up, preventing loads from falling.

- Data setting range: 0.00: No DC braking at the start up 0.01 to 30.00 (s)

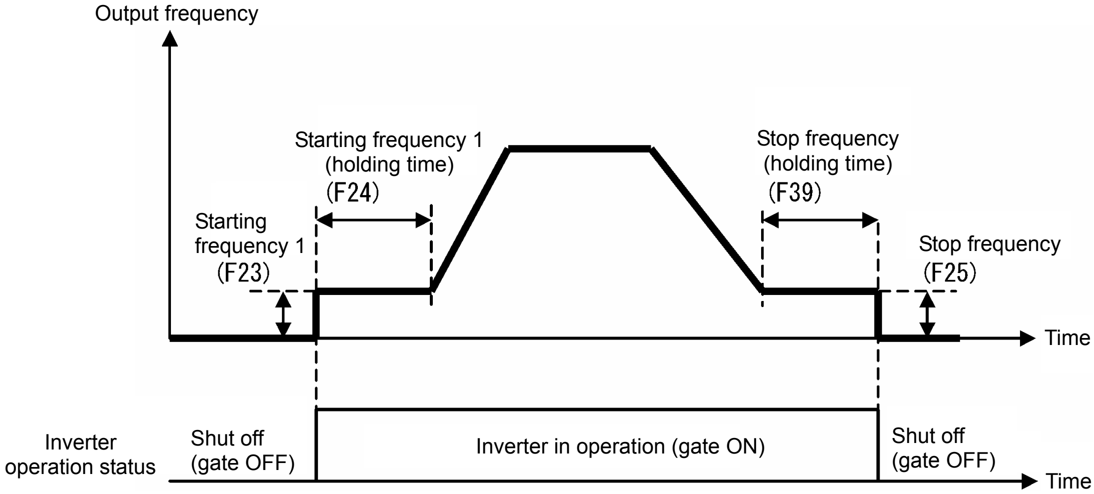


F23 to F25	Starting Frequency1, Starting Frequency 1 (Holding time), Stop frequency Related function codes F38 Stop frequency (Detection method) F39 Stop frequency (Holding time) H92 Continue to run (P) H93 Continue to run (I)

Under V/f control

At the startup of an inverter, the initial output frequency is equal to the starting frequency. The inverter stops its output when the output frequency reaches the stop frequency. Set the starting frequency to a level at which the motor can generate enough torque for startup. Generally, set the rated slip frequency of the motor as the starting frequency.

Specifying the holding time for the starting frequency compensates for the delay time for the establishment of a magnetic flux in the motor; specifying that for the stop frequency stabilizes the motor speed at the stop of the inverter.



■ Starting Frequency 1 (F23)

F23 specifies the starting frequency at the startup of an inverter.

- Data setting range: 0.0 to 60.0 (Hz)
  Under V/f control, even if the stop frequency is set at 0.0 Hz, the inverter stops its output at 0.1 Hz.

■ Starting Frequency 1 (Holding time) (F24)

F24 specifies the holding time for the starting frequency 1.

- Data setting range: 0.00 to 10.00 (s)

■ Stop frequency (F25)

F25 specifies the stop frequency at the stop of the inverter.

- Data setting range: 0.0 to 60.0 (Hz)
  Under V/f control, even if the stop frequency is set at 0.0 Hz, the inverter stops its output at 0.1 Hz.

■ Stop Frequency (Holding time) (F39)

F39 specifies the holding time for the stop frequency.

- Data setting range: 0.00 to 10.00 (s)

Note: If the starting frequency is lower than the stop frequency, the inverter does not output any power as long as the reference frequency does not exceed the stop frequency.

F26, F27	Motor Sound (Carrier frequency, Tone) Related function codes: H98 Protection/Maintenance Function (Mode selection)

■ Motor Sound (Carrier frequency) (F26)

Adjust carrier frequency. By changing carrier frequency, it is possible to reduce an audible noise generated by the motor or electromagnetic noise from the inverter itself, and to decrease a leakage current from the main output (secondary) wiring.

Setting frequency of carrier frequency differs depending on each model overload rating (ND/HD/HND/HHD).

Item	Characteristics			Remarks
Carrier frequency	Low	to	High	
	0.75	to	10kHz	
	0.75	to	6kHz	
Motor sound noise emission	High	↔	Low	
Motor temperature (due to harmonics components)	High	↔	Low	
Ripples in output current waveform	Large	↔	Small	
Leakage current	Low	↔	High	
Electromagnetic noise emission	Low	↔	High	
Inverter loss	Low	↔	High	

Setting range of carrier frequency is as follows.

Modes	0.75 to 6kHz	0.75 to 10kHz	0.75 to 16kHz
FRN□□□□E2□-4□ (ND)	0072 to 0203	0059	Disable
FRN□□□□E2□-4□ (HD) FRN□□□□E2□-4□ (HND)	0203 0203	0072 to 0168 0072 to 0168	0059 0059
FRN□□□□E2□-4□ (HHD)	Disable	0203	0059 to 0168

Note: Specifying a carrier frequency that is too low will cause the output current waveform to have a large amount of ripples. As a result, the motor loss increases, causing the motor temperature to rise. Furthermore, the large amount of ripples tends to cause a current limiting alarm. When the carrier frequency is set to 1 kHz or lower, therefore, reduce the load so that the inverter output current comes to be 80% or less of the rated current.

When a high carrier frequency is specified, the temperature of the inverter may rise due to the ambient temperature rise or an increase of the load. If it happens, the inverter automatically decreases the carrier frequency to prevent the inverter overload (OLU) . With consideration for motor noise, the automatic reduction of carrier frequency can be disabled. Refer to the description of H98.

■ Motor Sound (Tone) (F27)

F27 changes the motor running sound tone (only for motors under V/f control). This setting is effective when the carrier frequency specified by function code F26 is 7 kHz or lower. Changing the tone level may reduce the high and harsh running noise from the motor.

Note: If the tone level is set too high, the output current may become unstable, or mechanical vibration and noise may increase. Also, this function code may not be very effective for certain types of motor.

F27 data	Function
0	Disable (Level 0)
1	Enable (Level 1)
2	Enable (Level 2)
3	Enable (Level 3)

F29 to F35	Terminal [**FM**], **[FM2] (Mode selection, Output gain, Function selection, Pulse rate**)

These function codes allow outputting monitor data such as output frequency and output current to terminal [FM], [FM2] as analog DC voltage, current, and pulse ([FM] only). In addition, voltage and current value to be output to terminal [FM], [FM2] is adjustable.

Note: When switching voltage, current, and pulse, it is necessary to switch both mode selection function code and switch on the PCB.

Terminal [FM2] is mounted only on C (for China).

There is no pulse output function for terminal [FM2]

Terminal	Mode selection function	Gain	Function	Pulse rate	Switch
[FM]	F29	F30	F31	F33	SW5
[FM2]	F32	F34	F35	None	SW7

■ Mode selection (F29, F32)

F29 and F32 selects output form of terminal [FM], [FM2]. Accordingly ,change the switch SW5, SW7 on the PCB.

For details of the switches on the PCB, refer to Chapter 12 "MODES."

F29 data	Terminal [FM] output form	Control PCB switch (SW5)
0	Voltage output (0 to +10 VDC)	FMV side
1	Current output (4 to 20 mA DC)	FMI side
2	Current output (0 to 20mA DC)	
3	Pulse output	FMP side

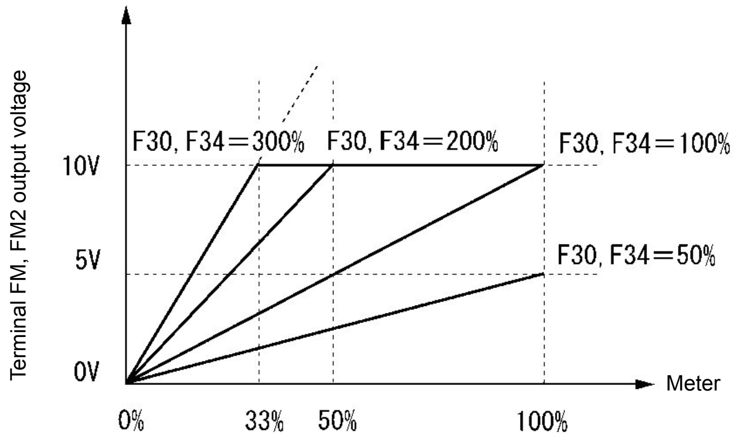
F32 data	Terminal [FM2] Output form	Control PCB switch (SW7)
0	Voltage output (0 to +10 VDC)	FMV side
1	Current output (4 to 20 mA DC)	FMI side
2	Current output (0 to 20mA DC)	

Note: The output current is not isolated from analog input, and does not have an isolated power supply. Therefore, if an electrical potential relationship between the inverter and peripheral equipment has been established, e.g., by connecting an analog, cascade connection of a current output device is not available.

Keep the optimum connection wire length.

■ Output gain (F30, F34)

F30, F34 allows you to adjust the output voltage within the range of 0 to 300%.



■ Function selection (F31, F35)

F31, F35 specifies what is output to the output terminal [FM], [FM2].

F31 data	[FMA] output	Data	Definition of monitor amount 100%
0	Output frequency 1 (before slip compensation)	Output frequency of the inverter (Equivalent to the motor synchronous speed)	Maximum frequency (F03)
1	Output frequency 2 (after slip compensation)	Output frequency of the inverter	Maximum frequency (F03)
2	Output current	Output current (RMS) of the inverter	Twice the inverter rated current
3	Output voltage	Output voltage (RMS) of the inverter	200 V class: 250 V 400 V class: 500 V
4	Output torque	Motor shaft torque	Twice the rated motor torque
5	Load factor	Load factor (Equivalent to the indication of the load meter)	Twice the rated motor load
6	Input power	Input power of the inverter	Twice the rated motor output (HHD mode standard)
7	PID feedback amount	Feedback amount under PID control	100% of the feedback amount
9	DC link bus voltage	DC link bus voltage of the inverter	200 V class: 500 V 400 V class: 1000 V
10	Universal AO	Command from communication (📖 RS-485 communication user manual)	20,000/100%
13	Motor output	Motor output (kW)	Twice the rated motor output P02/A16 setting value standard)
14	Calibration	For meter calibration Full scale output	Always full scale (equivalent to 100%) Output
15	PID command (SV)	Command value under PID control	PID command 100%
16	PID output (MV)	Output level of the PID processor under PID control (Frequency command)	Maximum frequency (F03)

F31 data	[FMA] output	Data	Meter scale (Full scale at 100%)
18	Heat sink temperature	Heat skin detection temperature of inverter	200°C/100%
111	Customizable logic output signal 1	Enable only at analog output	100% to 100%
112	Customizable logic output signal 2	Enable only at analog output	100% to 100%
113	Customizable logic output signal 3	Enable only at analog output	100% to 100%
114	Customizable logic output signal 4	Enable only at analog output	100% to 100%
115	Customizable logic output signal 5	Enable only at analog output	100% to 100%
116	Customizable logic output signal 6	Enable only at analog output	100% to 100%
117	Customizable logic output signal 7	Enable only at analog output	100% to 100%
118	Customizable logic output signal 8	Enable only at analog output	100% to 100%
119	Customizable logic output signal 9	Enable only at analog output	100% to 100%

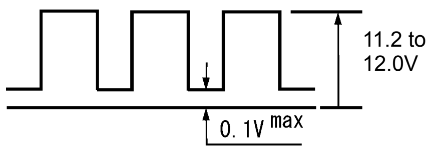
Note If F31 = 16 (PID output), JF01 = 3 (Dancer control), and J62 = 2 or 3 (Ratio compensation enabled), the PID output is equivalent to the ratio against the primary reference frequency and may vary within 300% of the frequency. The monitor displays the PID output in a converted absolute value (%). To indicate the value up to the full-scale of 300%, set F30 data to "33" (%).

■ Pulse rate (F33)

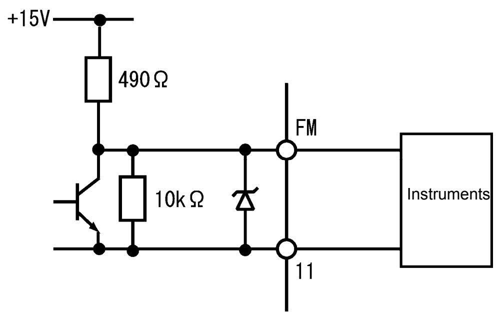
F33 specifies the pulse rate at which the output of the monitored item selected reaches 100%, in accordance with the modes of the counter to be connected.

- Data setting range: 25 to 32000 (pulse/s)

Pulse output waveform



Pulse output circuit



F37	Load Selection/Auto Torque Boost/Auto Energy Saving Operation 1
	Related function codes F09 Torque boost 1 H67 Auto energy-saving operation (Mode selection)

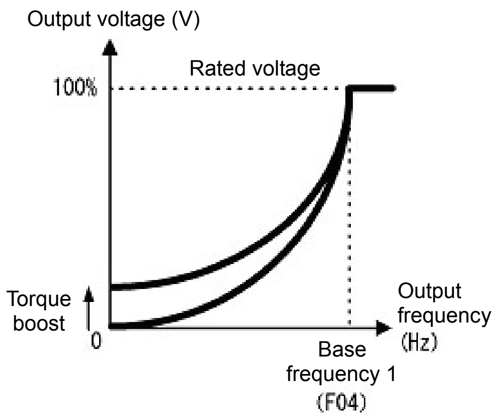
F37 specifies V/f pattern, torque boost type, and auto energy saving operation in accordance with the characteristics of the load.

F37 data	V/f characteristics	Torque boost	Auto Energy-saving Operation	Applicable load
0	Variable torque V/f pattern	By F09 torque boost	Disable	Variable torque load (General-purpose fan and pumps)
1	Linear V/f pattern			Constant torque load
2		Auto torque Boost		Constant torque load (To be selected if a motor may be over-exited at no load)
3	Variable torque V/f pattern	By F09 torque boost	Action	Variable torque load (General-purpose fan and pumps)
4	Linear V/f pattern			Constant torque load
5		Auto torque Boost		Constant torque load (To be selected if a motor may be over-exited at no load)

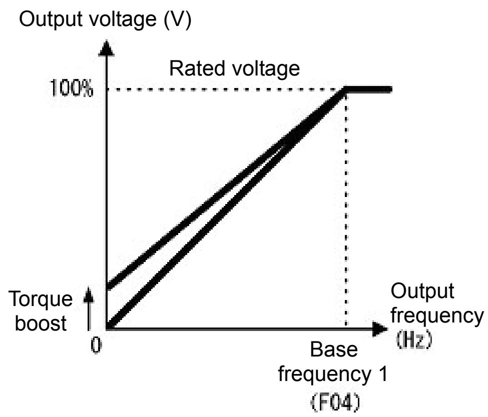
Note: If a required "load torque + acceleration toque" is 50% or more of the rated torque, it is recommended to select the linear V/f pattern. Factory default is set to linear V/f pattern.

■ V/f characteristics

The FRENIC-MEGA series of inverters offer a variety of V/f patterns and torque boosts, which include V/f patterns suitable for variable torque load such as general fans and pumps and for constant torque load (including special pumps requiring high starting torque). Two types of torque boosts are available: manual and automatic.



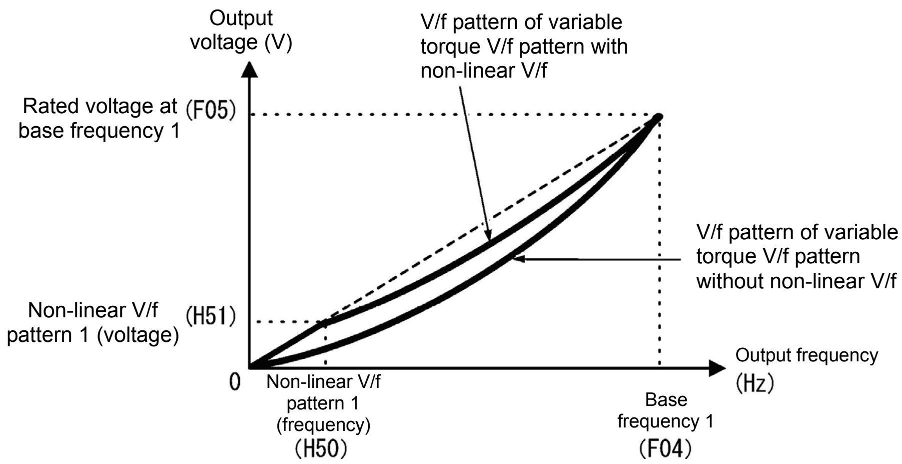
Variable torque V/f pattern (F37 = 0)



Linear V/f pattern (F37 = 1)

Tip: When the variable torque V/f pattern is selected (F37 = 0 or 3), the output voltage may be low at a low frequency zone, resulting in insufficient output torque, depending on the characteristics of the motor and load. In such a case, it is recommended to increase the output voltage at the low frequency zone using the non-linear V/f pattern.

Recommended value: H50 = 1/10 of the base frequency
H51 = 1/10 of the voltage at base frequency



■ **Torque boost**

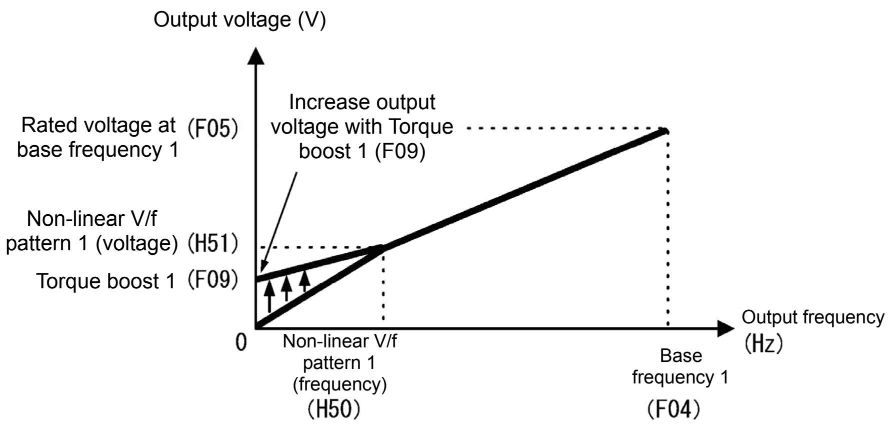
- **Manual torque boost by F09 (Manual adjustment)**
- Data setting range: 0.0 to 20.0 (%), (100%/base frequency voltage)

In torque boost using F09, constant voltage is added to the basic V/f pattern, regardless of the load. To secure a sufficient starting torque, manually adjust the output voltage to optimally match the motor and its load by using F09. Specify an appropriate level that guarantees smooth Startup and yet does not cause over-excitation at no or light load.

Torque boost using F09 ensures high driving stability since the output voltage remains constant regardless of the load fluctuation.

Specify the function code F09 data in percentage to the base frequency voltage. At factory shipment, boost amount with which approx. 100% of starting torque can be assured, is specified.

Note
- Specifying a high torque boost level will generate a high torque, but may cause overcurrent due to over-excitation at no load. If you continue to drive the motor, it may overheat. To avoid such a situation, adjust torque boost to an appropriate level.
- When the non-linear V/f pattern and the torque boost are used together, the torque boost takes effect below the frequency on the non-linear V/f pattern's point.



- **Auto torque boost**

This function automatically optimizes the output voltage to fit the motor with its load. Under light load, auto torque boost decreases the output voltage to prevent the motor from over-excitation. Under heavy load, it increases the output voltage to increase the output torque of the motor.

Note
- This function controls in accordance with motor characteristics. Therefore, set the base frequency 1 (F04), base frequency voltage 1 (F05), and other pertinent motor parameters (P01 through P03 and P06 through P99) in line with the motor capacity and characteristics, or else perform auto-tuning (P04).
- When a special motor is driven or the load does not have sufficient rigidity, the maximum torque might decrease or the motor operation might become unstable. In such cases, do not use auto torque boost but choose manual torque boost using F09 (F37 = 0 or 1).

■ Auto energy saving operation (H67)

This feature automatically controls the supply voltage to the motor to minimize the total power loss of motor and inverter. (Note that this feature may not be effective depending upon the motor or load characteristics. Check the advantage of energy saving before you actually apply this feature to your machinery.)

It is possible to select whether to apply this feature to constant speed operation only or to apply to constant speed operation and accelerating/decelerating operation.

H67 data	Auto energy saving operation
0	Enable only during running at constant speed (In accelerating/decelerating, the torque boost by F09 or the auto torque boost applies depending on the F37 setting.)
1	During running at constant speed or accelerating/decelerating (Note: For accelerating/decelerating, enable only when the load is light.)

If auto energy saving operation is enabled, the response to a motor speed change from constant speed operation may be slow. Do not use this feature for such machinery that requires quick acceleration/deceleration.

Note
- Use auto energy saving only where the base frequency is 60 Hz or lower. If the base frequency is set at 60 Hz or higher, you may get little or no energy saving advantage. The auto energy saving operation is designed for use with the frequency lower than the base frequency. If the frequency becomes higher than the base frequency, the auto energy saving operation will be invalid.
- This function controls in accordance with motor characteristics. Therefore, set the base frequency 1 (F04), base frequency voltage 1 (F05), and other pertinent motor parameters (P01 through P03 and P06 through P99) in line with the motor capacity and characteristics, or else perform auto-tuning (P04).

F38, F39 | Stop Frequency (Detection mode and Holding time) (Refer to F23)

For details about the setting of the stop frequency (detection mode and holding time), refer to the description of F23.

F40, F41	**Torque limiter 1 (Drive), Torque limiter 1 (Braking)** **Related function codes** **E16, E17 Torque limiter 2 (Drive), Torque limiter 2 (Braking)** **H73 Torque limiter (Operating condition selection)** **H76 Torque control (Braking) (Frequency increment limit for braking)**

If the inverter output torque exceeds the specified levels of the torque limiters (F40, F41, E16, E17, and E61 to E63), the inverter controls the output frequency and limits the output torque for preventing a stall.

To use the torque limiters, it is necessary to configure the function codes listed in the table below.

Note In braking, the inverter increases the output frequency to limit the output torque. Depending on the conditions during operation, the output frequency could dangerously increase. H76 (Frequency increment limit for braking) is provided to limit the increasing frequency component.

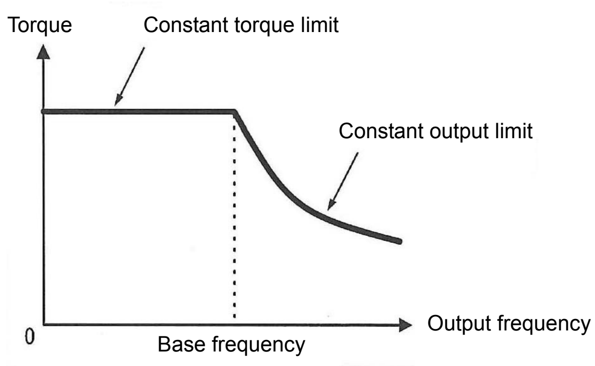
Related function codes

Function code	Name	V/f control	Remarks
F40	Torque limiter 1 (Drive)	○	
F41	Torque limiter 1 (Braking)	○	
E16	Torque limiter 2 (Drive)	○	
E17	Torque limiter 2 (Braking)	○	
H73	Torque Limiter (Operating conditions selection)	○	
H76	Torque Limiter (Frequency increment limit for braking)	○	
E61 to E63	Terminal [12], [C1] (C1 function) • (V2 function) Extension function selection	○	7: Analog torque limit value A 8: Analog torque limit value B

■ Torque limit control mode

Torque limit is performed by limiting torque current flowing across the motor.

The graph below shows the relationship between the torque and the output frequency at the constant torque current limit.



■ Torque limiter (F40, F41, E16, E17) Data setting range: 0 to 300%; 999 (Disable)

These function codes specify the operation level at which the torque limiters become activated, as the percentage of the motor rated torque.

Function code	Name	Torque limit feature
F40	Torque limiter 1 (Drive)	Driving torque current limiter 1
F41	Torque limiter 1 (Braking)	Braking torque current limiter 1
E16	Torque limiter 2 (Drive)	Driving torque current limiter 2
E17	Torque limiter 2 (Braking)	Braking torque current limiter 2

Note Although the setting range of the torque is 300%, the torque limiter determined by the overload current of the unit internally limits the torque current output. Therefore, the torque current output is automatically limited at a value lower than 300%, the maximum setting value.

■ Analog torque limit values (E61 to E63)

The torque limit value can be specified by analog inputs (voltage or current) through terminals [12], [C1] (C1 function), and [C1] (V2 function). Assign by function code E61, E62, E63 (Terminal [12], [C1] (C1 function), [C1] (V2 function)(Extension function selection) as follows.

E61, E62, E63 data	Function	Description
7	Analog torque limit value A	Used when analog inputs are used as torque limiters. Input modes: 300% / 10 V or 20 mA
8	Analog torque limit value B	

If these terminals have been set up to have the same data, the operation priority is given in the following order: E61 > E62 > E63

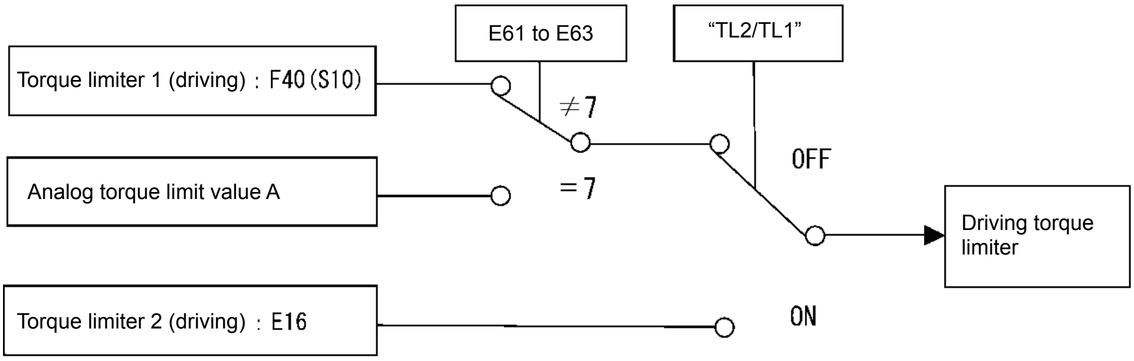
Refer to E59 on how to use terminals [C1] (C1 function) and [C1] (V2 function).

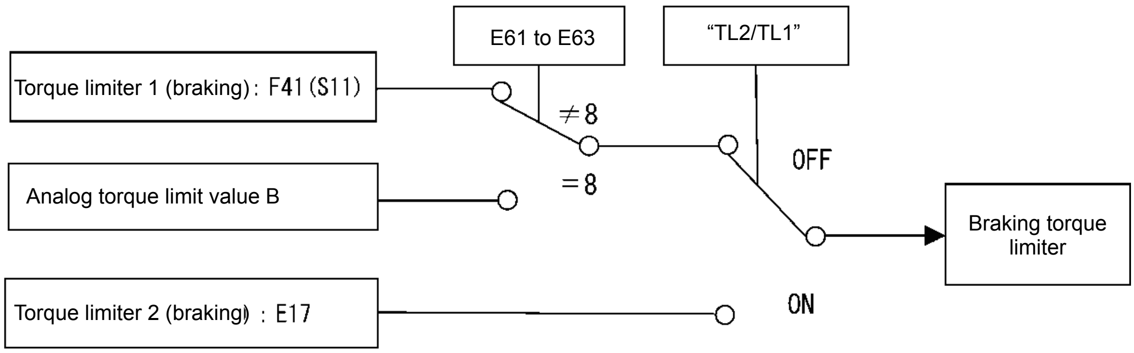
■ Torque limiter levels specified via communications link (S10, S11)

The torque limiter levels can be changed via the communications link. Communication dedicated code S10, S11 interlocks with the function code F40, F41.

■ **Switching torque limiters**

The torque limiters can be switched by the function code setting and the terminal command "TL2/TL1" (Select torque limiter level 2/1) assigned to any of the digital input terminals. To assign the Torque limiter 2/Torque limiter 1, "TL2/TL1" set Data = 14 by function code from E01 toE05. If no "TL2/TL1" is assigned, torque limiter levels 1-1 and 1-2 (F40 and F41) take effect by default.





■ **Torque limiter (Braking) (Frequency increment limit for braking) (H76) Data setting range: 0.0 to 500.0 (Hz)**

H76 specifies the increment limit of the frequency in limiting torque for braking. The factory default is 5.0 Hz. If the increasing frequency during braking reaches the limit value, the torque limiters no longer function, resulting in an overvoltage trip. Such a problem may be avoided by increasing the setting value of H76.

Note The torque limiter and current limiter are very similar in function. If both are activated concurrently, they may conflict with each other and cause hunting. Avoid concurrent activation of these limiters.

F42	Control methodselection 1 Related function codes: H68 Slip Compensation 1 (Operating conditions)

F42 specifies the motor drive control.

F42 data	Control mode	Basic control	Speed feedback	Speed control
0	V/f control: No slip compensation	V/f control	Disable	Frequency control
1	Vector control without speed sensor Dynamic torque vector control (With slip compensation and auto torque boost)			With slip compensation Frequency control
2	V/f control: With slip compensation			

■ V/f control with slip compensation inactive

Under this control, the inverter controls a motor with the voltage and frequency according to the V/f pattern specified by function codes. This control disables all automatically controlled features such as the slip compensation, so no unpredictable output fluctuation occurs, enabling stable operation with constant output frequency.

■ V/f control with slip compensation active

Applying any load to an induction motor causes a rotational slip due to the motor characteristics, decreasing the motor rotation. The inverter's slip compensation function first presumes the slip value of the motor based on the motor torque generated and raises the output frequency to compensate for the decrease in motor rotation. This prevents the motor from decreasing the rotation due to the slip.

That is, this function is effective for improving the motor speed control accuracy.

Function code		Action
P12	Rated slip frequency	Specify the rated slip frequency.
P09	Slip compensation gain for driving	Adjust the slip compensation amount for driving. Slip compensation amount for driving = Rated slip x Slip compensation gain for driving
P11	Slip compensation gain for braking	Adjust the slip compensation amount for braking. Slip compensation amount for braking = Rated slip x Slip compensation gain for braking
P10	Slip compensation response time	Specify the slip compensation response time. Basically, there is no need to modify the setting.

To improve the accuracy of slip compensation, perform auto-tuning.

H68 enables or disables the slip compensation function 1 according to the motor driving conditions.

H68 data	Motor driving conditions		Motor driving frequency zone	
	Accl/Decel	During constant speed	Base frequency or below	Above the base frequency
0	Enable	Enable	Enable	Enable
1	Disable	Enable	Enable	Enable
2	Enable	Enable	Enable	Disable
3	Disable	Enable	Enable	Disable

FUNCTION CODE

Chap. 5

■ Vector control without speed sensor (dynamic torque vector)

To get the maximal torque out of a motor, this control calculates the motor torque matched to the load applied and uses it to optimize the voltage and current vector output.

When the vector control without speed sensor (dynamic torque vector) is selected, automatically auto torque boost and slip compensation become enabled. This control is effective for improving the system response to external disturbances such as load fluctuations, and the motor speed control accuracy.

Note that the inverter may not respond to a rapid load fluctuation.

Note For slip compensation without vector control without speed sensor, constant of motor is used. Therefore, satisfy the following conditions: If the conditions below cannot be satisfied, sufficient control performance may not be able to obtain.

- A single motor is controlled per inverter.
- The prerequisite is that motor parameter P02, P03, P06 to P13 are accurately set or auto-tuning is performed.
- Under control without speed sensor, the capacity of motor to be controlled must be within the capacity of two ranks lower than that of inverter. Otherwise, the inverter may not control the motor due to decrease of the current detection resolution.
- The capacity of motor to be controlled must be the wiring distance between the inverter and motor is 50 m or less. If it is longer, the inverter may not control the motor due to leakage current flowing through stray capacitance to the ground or between wires. Especially, small capacity inverters whose rated current is also small may be unable to control the motor correctly even if the wiring is less than 50 m. In that case, make the wiring length as short as possible or use a wire with small stray capacitance (e.g., loosely-bundled cable) to minimize the stray capacitance.

F43, F44	Current Limiter (Mode selection and Level) Related function codes: H12 Instantaneous Overcurrent Limiting (Mode selection)

When the output current of the inverter exceeds the level specified by the current limiter (F44), the inverter automatically manages its output frequency to prevent a stall and limits the output current. According to limit value based on Inverter's rated current, the default setting of the current limiter is 160% for HHD/HD mode, and 130% for HND/ND mode, respectively (Initial value is automatically written when selecting ND/HD/HND/HHD by function code F80) If overload current, 160% (130%) or more of the current limit level, flows instantaneously so that an output frequency decrease problem arises due to the current limiter, consider increasing the current limit level.

The current limiter mode should be also selected with F43. If F43 = 1, the current limiter is enabled only during constant speed operation. If F43 = 2, it is enabled during both of acceleration and constant speed operation. Choose F43 = 1 if you need to run the inverter at full capability during acceleration and to limit the output current during constant speed operation.

■ Mode selection (F43)

F43 selects the motor running state in which the current limiter becomes active.

F43 data	Running states that enable the current limiter		
	During acceleration	During constant speed	During deceleration
0	Disable	Disable	Disable
1	Disable	Action	Disable
2	Action	Action	Disable

■ Level (F44)

F44 specifies the operation level at which the output current limiter becomes activated, in ratio to the inverter rating.

- Data setting range: 20 to 200 (%) (in ratio to the inverter rating)
  (Inverter's rated current changes according to the setting value of function code F80.)

■ Instantaneous Overcurrent Limiting (Mode selection) (H12)

H12 specifies whether the inverter invokes the current limit processing or enters the overcurrent trip when its output current exceeds the instantaneous overcurrent limiting level. Under the current limit processing, the inverter immediately turns OFF its output gate to suppress the further current increase and continues to control the output frequency.

H12 data	Function
0	Disable (An overcurrent trip occurs at the instantaneous overcurrent limiting level.)
1	Enable (An instantaneous overcurrent limiting operation is activated)

If any problem could occur when the motor torque temporarily drops during current limiting processing, it is necessary to cause an overcurrent trip (H12 = 0) and actuate a mechanical brake at the same time.

Note
- Since the current limit operation with F43 and F44 is performed by software, it may cause a delay in control. If you need a quick response current limiting, also enable the instantaneous overcurrent limiting with H12.
- If an excessive load is applied when the current limiter operation level is set extremely low, the inverter will rapidly lower its output frequency. This may cause an overvoltage trip or dangerous turnover of the motor rotation due to undershooting. Depending on the load, extremely short acceleration time may activate the current limiting to suppress the increase of the inverter output frequency, causing hunting (undesirable oscillation of the system) or activating the inverter overvoltage trip (alarm 0u). When specifying the acceleration time, therefore, you need to take into account machinery characteristics and moment of inertia of the load.

Note
- The torque limiter and current limiter are very similar in function. If both are activated concurrently, they may conflict with each other and cause hunting. Avoid concurrent activation of these limiters.

FUNCTION CODE

Chap. 5

F50 to F52	Electronic Thermal Overload Protection for Braking Resistor (Discharging capability, Allowable average loss and Resistance)

These function codes specify the electronic thermal overload protection feature for the braking resistor.

Set the discharging capability, allowable average loss and resistance to F50, F51 and F52, respectively. These values are determined by the inverter and braking resistor models. For the discharging capability, allowable average loss and resistance, refer to [3] "Modes" in Chapter 11, Section 11.8.4 "Braking resistor (DBR) and braking unit.

The values listed in the tables are for standard models and 10% ED models of the braking resistors which Fuji Electric provides. When using a braking resistor of any other manufacturer, confirm the corresponding values with the manufacture and set the function codes accordingly.

Set 0.00 to F52 when replacing from FRENIC-Multi.

Note: Depending on the thermal marginal characteristics of the braking resistor, the electronic thermal overload protection feature may act so that the inverter issues the overheat protection alarm dbH even if the actual temperature rise is not large enough. If it happens, review the relationship between the performance index of the braking resistor and settings of related function codes.

Tip: Using the standard models of braking resistor or using the braking unit and braking resistor together can output temperature detection signal for overheat. Assign terminal command THR ("Enable external alarm trip") to any of digital input terminals [X1] to [X5], [FWD] and [REV] and connect that terminal and its common terminal to braking resistor's terminals 2 and 1.

Calculating the discharging capability and allowable average loss of the braking resistor and configuring the function code data

When using any non-Fuji braking resistor, inquire of the resistor manufacturer about the resistor rating and then configure the related function codes.

The calculation procedures for the discharging capability and allowable average loss of the braking resistor differ depending on the application of the braking load as shown below.

<Applying braking load during deceleration>

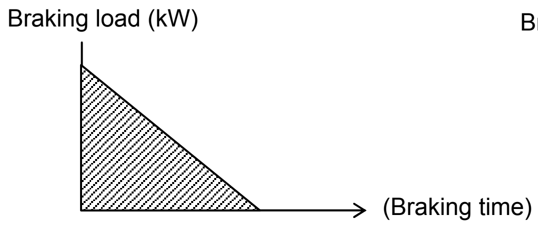
In usual deceleration, the braking load decreases as the speed slows down. In the deceleration with constant torque, the braking load decreases in proportion to the speed.

Use Expressions (1) and (3) given below.

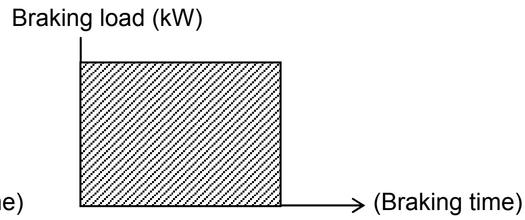
Applying braking load during running at a constant speed

Different from during deceleration, in applications where the braking load is externally applied during running at a constant speed, the braking load is constant.

Use Expressions (2) and (4) given below.



<Applying braking load during deceleration>



<Applying braking load during running at a constant speed>

■ Discharging capability (F50)

The discharging capability refers to kWs allowance for a single braking cycle. It can be calculated from breaking time and motor capacity.

F50 data	Function
1 to 9000	1 to 9000 (kWs)
OFF	Disable the electronic thermal overload protection

$$\text{Discharging capability (kWs)} = \frac{\text{Braking time (s)} \times \text{Motor rated capacity (kW)}}{2} \qquad (1)$$

$$\text{Discharging capability (kWs)} = \text{Braking time (s)} \times \text{Motor rated capacity (kW)} \qquad (2)$$

■ Allowable average loss (F51)

Allowance average loss is the resistor capacitor that enables continuous operation of motor. It can be calculated from ED (%) and motor capacity (kW).

F51 data	Function
0.001 to 99.99	0.001 to 99.99 (kW)

$$\text{Allowable average loss (kWs)} = \frac{\frac{\%\text{ED}(\%)}{100} \times \text{Motor rated capacity (kW)}}{2} \qquad (3)$$

$$\text{Allowable average loss (kWs)} = \frac{\%\text{ED}(\%)}{100} \times \text{Motor rated capacity (kW)} \qquad (4)$$

■ Resistance (F52)

F52 specifies the resistance of the braking resistor.

F52 data	Function
0.00	Braking resistor protection method by FRENIC-Muiti method (Resistance not required)
0.01 to 999	0.01 to 999 (Ω)

F80	ND/ HD/ HND/ HHD switching

HDD is the mode standard for J (for Japanese) mode, therefore, it is possible to use with the one or two frames above the motor reference rated current by switching to HND/HD/ND mode. However, ambient temperature condition, overload capability becomes lower.

ND is the mode standard for modes other than J (for Japanese) mode, therefore, it is possible to alleviate ambient temperature condition and overoad capability by switching to HHD/HND/HD mode. However, rated current becomes one or two frames lower than the motor reference rated current.

To change the data of function code F80 data, double key operation with "STOP key + ∧/∨ key" is necessary.

F80 data	Drive mode	Application	Rated current level	Ambient temperature	Overload capability	Maximum output frequency
0	HHD mode	Heavy load	Capable of driving a motor whose capacity is the same as the inverter capacity.	50°C	150% 1min, 200% 0.5s	500Hz
1	HND mode	Light load	Capable of driving a motor whose capacity is one rank higher than the inverter capacity.	50°C	120% 1 min	500Hz
3	HD mode	Medium load	Capable of driving a motor whose capacity is one rank higher than the inverter capacity.	40°C	150% 1 min	500Hz
4	ND mode	Light load	Capable of driving a motor whose capacity is two rank higher than the inverter capacity.	40°C	120% 1 min	120Hz

For the concrete rated current level, refer to "Chapter 12 " Standard MODES." Factory default is 0: HHD for Japan and 4: ND for other countries.

Note When using by changing the mode of 75kw or higher, make sure to connect direct current reactor (DCR) with the specified capacitance. However, it is not necessary when using PWM converter.

Failure may occur

ND, HD, HND, and HHD-mode inverters are subject to restrictions on the function code data setting range and internal processing as listed below.

Function code	Name	Remarks
F21	DC braking 1 (Operation level)	Upper limit restriction
F26	Motor sound (Carrier frequency)	Upper limit restriction
F44	Current limiter (Operation level)	Default setting, setting value
F03	Maximum frequency	Output enabled frequency range
A10	DC braking 2 (Braking level)	Upper limit
J68	Brake Signal Brake-OFF current	Upper limit

Refer to explanation of each function code and selection guidance in Chapter 10.

5.3.2 E codes (Extension terminal functions)

E01 to E05	Terminals [X1] to [X5] (function selection) Related function codes: Terminal E98 [FWD] (function selection) Terminal E99 [REV] (function selection)

E01 to E05, E98 and E99 assign commands to general-purpose, programmable, digital input terminals, [X1] to [X5], [FWD], and [REV].

These function codes can also switch the logic system between normal and negative to define how the inverter logic interprets the ON or OFF state of each terminal. The factory default setting is normal logic system "Active ON. Functions assigned to digital input terminals [X1] to [X5], [FWD] and [REV] are as shown below. Descriptions that follow are given in normal logic system. The descriptions are, in principle, arranged in the numerical order of assigned data. However, highly relevant signals are collectively described where one of them first appears. Refer to the function codes in the "Related function codes" column, if any.

⚠CAUTION

- Run commands (e.g., Run forward "FWD"), stop commands (e.g., Coast to a stop "BX"), and frequency change commands can be assigned to digital input terminals. Depending on the state of digital input terminals, modifying a function code setting alone may cause abrupt start of operation or significant change of the speed. Ensure safety before modifying the function code settings.
- Functions for switching run or frequency command sources (such as "SS1, SS2, SS4, SS8", "Hz2/Hz1", "Hz/PID", "IVS" and "LE") can be assigned to the digital input terminals. Switching these signals may cause a sudden motor start or an abrupt change in speed depending on the condition.

An accident or physical injury may result.

Data		Terminal commands assigned	Symbol	Related function codes
Active ON	Active OFF			
0	1000	Select multi-frequency (0 to 15 steps)	"SS1"	C05 to C19
1	1001		"SS2"	
2	1002		"SS4"	
3	1003		"SS8"	
4	1004	Select ACC/DEC time (2 steps)	"RT1"	F07, F08, E10 to E15
5	1005	Select ACC/DEC time (4 steps)	"RT2"	
6	1006	Enable 3-wire operation	"HLD"	F02
7	1007	Coast to a Stop	"BX"	—
8	1008	Reset alarm	"RST"	—
1009	9	Enable external alarm trip	"THR"	—
10	1010	Ready for jogging	"JOG"	C20 H54, H55, d09 to d13
11	1011	Select frequency command 2/1	"Hz2/Hz1"	F01, C30
12	1012	Select motor 2	"M2"	A42
13	-	Enable DC braking	"DCBRK"	F20 to F22

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Data		Terminal commands assigned	Symbol	Related function codes
Active ON	Active OFF			
14	1014	Select torque limiter level 2/1	"TL2/TL1"	F40, F41 E16, E17
15	—	Switch to commercial power (50 Hz)	"SW50"	—
16	—	Switch to commercial power (60Hz)	"SW60"	—
17	1017	UP (Increase output frequency)	"UP"	Frequency command: F01, C30 PID command: J02
18	1018	DOWN (Decrease output frequency)	"DOWN"	
19	1019	Enable data change with keypad	"WE-KP"	F00
20	1020	Cancel PID control	"Hz/PID"	J01 to J19, J56 to J62
21	1021	Switch normal/inverse operation	"IVS"	C53, J01
22	1022	Interlock	"IL"	F14
24	1024	Enable communications link (RS-485, BUS option)	"LE"	H30, y98
25	1025	Universal DI	"U-DI"	—
26	1026	Enable auto search for idling motor speed at starting	"STM"	H09, d67
1030	30	Force to stop	"STOP"	F07, H56
33	1033	Reset PID integral and differential components	"PID-RST"	J01 to J19, J56 to J62
34	1034	Hold PID integral component	"PID-HLD"	
35	1035	Select local (keypad) operation	"LOC"	(See Section 7.3.6)
48	—	Pulse train input (available only on terminal [X5])	"PIN"	F01, C30 d62, d63
49	1049	Pulse train sign (available on terminals except [X5])	"SIGN"	
65	1065	Brake check signal	"BRKE"	J68 to 96
72	1072	Count the run time of commercial power-driven motor 1	"CRUN-M1"	H44, H94
73	1073	Count the run time of commercial power-driven motor 2	"CRUN-M2"	
76	1076	Select droop control	"DROOP"	H28
80	1080	Cancel customizable logic	CLC	E01 toE05, U81 to U90
81	1081	Clear all customizable logic timers	CLTC	
98	—	Run forward (Exclusively assigned to [FWD] and [REV] terminals by E98 and E99)	"FWD"	F02
99	—	Run reverse (Exclusively assigned to [FWD] and [REV] terminals by E98 and E99)	"REV"	

Data		Terminal commands assigned	Symbol	Related function codes
Active ON	Active OFF			
100	—	No function assigned	“NONE”	U81 to U90
171	1171	PID multi-step command 1	“PID-SS1”	J136 to J138
172	1172	PID multi-step command 2	“PID-SS2”	

Note: Any negative logic (Active OFF) command cannot be assigned to the functions marked with "-" in the "Active OFF" column.

The "Enable external alarm trip" (data = 1009) and "Force to stop" (data = 1030) are fail-safe terminal commands. In the case of "Enable external alarm trip," when data = 1009, "Active ON" (alarm is triggered when ON); when data = 9, "Active OFF" (alarm is triggered when OFF).

Terminal function assignment and data setting

■ Select multi-frequency – “SS1”, “SS2”, “SS4”, and “SS8” (Function code data = 0, 1, 2, and 3)

The combination of the ON/OFF states of digital input signals “SS1”, “SS2”, “SS4” and “SS8” selects one of 16 different frequency commands defined beforehand by 15 function codes C05 to C19 (Multi-frequency 0 to 15). With this, the inverter can drive the motor at 16 different preset frequencies.

(📖Function codes C05 to C19)

■ Select ACC/DEC time – “RT1” and “RT2” (Function code data = 4 and 5)

These terminal commands switch between ACC/DEC time 1 to 4 (F07, F08 and E10 through E15).

(📖Functions codes F07 and F08)

■ Enable 3-wire operation – “HLD” (Function code data = 6)

Turning this terminal command ON self-holds the forward “FWD”, reverse “REV”, or hold "HLD" run command, to enable 3-wire inverter operation.

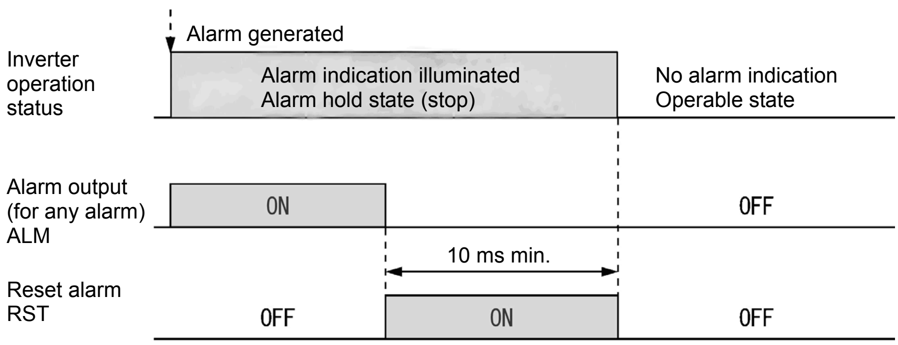
(📖Function code F02)

■ Coast to a stop -- “BX” (Function code data = 7)

Turning “BX” ON immediately shuts down the inverter output. The motor coasts to a stop, without issuing any alarms.

■ Reset alarm – “RST” (Function code data = 8)

Turning this terminal command ON clears the ALM state--alarm output (for any alarm). Turning it OFF erases the alarm display and clears the alarm hold state. When you turn the “RST” command ON, keep it ON for 10 ms or more. This command should be kept OFF for the normal inverter operation.



■ Enable external alarm trip – "THR" (Function code data = 9)

Turning this terminal command OFF immediately shuts down the inverter output (so that the motor coasts to a stop), displays the alarm OH2 and issues the alarm output (for any alarm) ALM. The THR command is self-held, and is reset when an alarm reset takes place.

Tip: Use this alarm trip command from external equipment when you have to immediately shut down the inverter output in the event of an abnormal situation in peripheral equipment.

■ Ready for jogging – "JOG" (Function code data = 10)

This terminal command is used to jog or inch the motor for positioning a workpiece.

Turning this command ON makes the inverter ready for jogging.
(Function code C20)

■ Select frequency command 2/1 – "Hz2/Hz1" (Function code data = 11)

Turning this terminal command ON and OFF switches the frequency command source between frequency command 1 (F01) and frequency command 2 (C30).
(Function code F01)

■ Select motor 2 – "M2" (Function code data = 12)

The terminal command M2 switches to either of the 1st and 2nd motors.

■ Enable DC braking – "DCBRK" (Function code data = 13)

This terminal command gives the inverter a DC braking command through the inverter's digital input.

(Requirements for DC braking must be satisfied.)
(Function codes F20 to F22)

■ Select torque limiter level 2/1 – "TL2/TL1" (Function code data = 14)

This terminal command switches between torque limiter 1 (F40 and F41) and torque limiter 2-1, 2-2 (E16 and E17).
(Function codes F40 and F41)

■ Switch to commercial power for 50 Hz or 60 Hz – "SW50" and "SW60" (Function code data = 15 and 16)

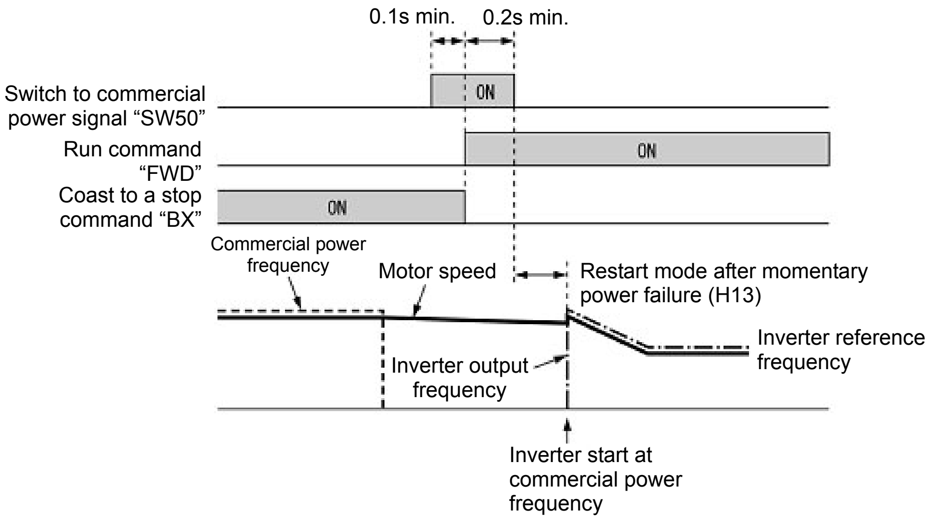
When an external sequence switches the motor drive power from the commercial line to the inverter, the terminal command SW50 or SW60 enables the inverter to start running the motor with the current commercial power frequency, regardless of settings of the reference/output frequency in the inverter. A running motor driven by commercial power is carried on into inverter operation. This command helps you smoothly switch the motor drive power source from the commercial power to the inverter power.

For details, refer to the table below, the operation scheme and an example of external sequence and its operation time scheme on the following pages.

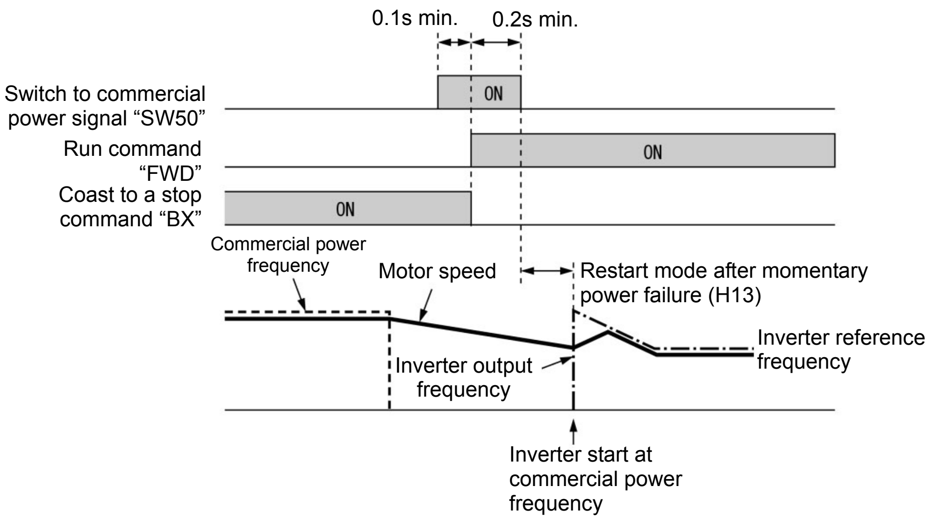
Terminal command assigned	Action	
Switch to commercial power for 50 Hz "SW50"	Starts at 50 Hz.	Note: Do not concurrently assign both SW50 and SW60.
Switch to commercial power for 60 Hz "SW60"	Starts at 60Hz.	

<Operation timing scheme>

- When the motor speed remains almost the same during coast-to-stop:



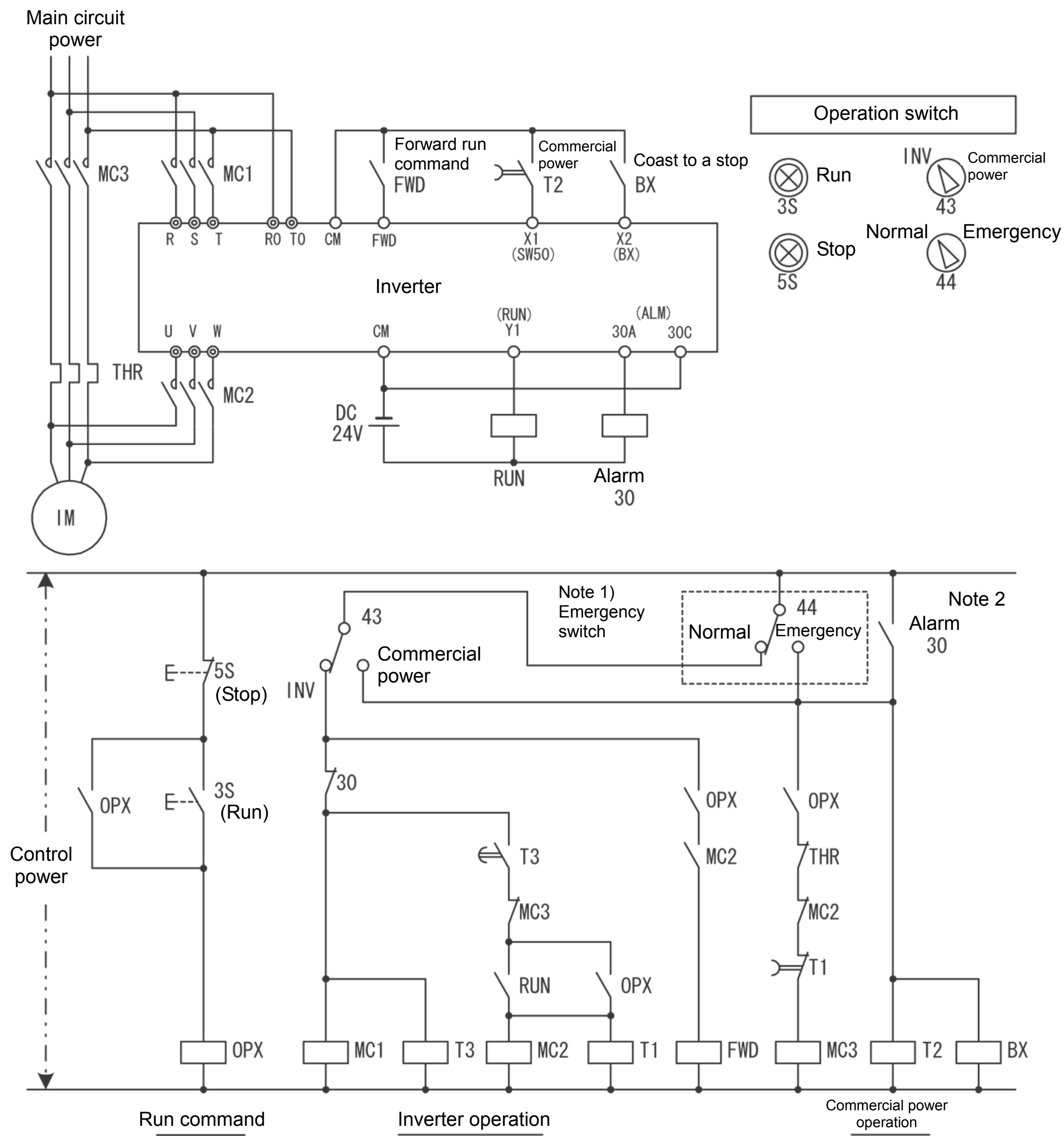
- When the motor speed decreases significantly during coast-to-stop (with the current limiter activated)



Note

- Secure more than 0.1 second after turning ON the "Switch to commercial power" signal before turning ON a run command.
- Secure more than 0.2 second of an overlapping period with both the "Switch to commercial power" signal and run command being ON.
- If an alarm has been issued or BX has been ON when the motor drive source is switched from the commercial power to the inverter, the inverter will not be started at the commercial power frequency and will remain OFF. After the alarm has been reset or "BX" turned OFF, operation at the frequency of the commercial power will not be continued, and the inverter will be started at the ordinary starting frequency.
  If you wish to switch the motor drive source from the commercial line to the inverter, be sure to turn "BX" OFF before the "Switch to commercial power" signal is turned OFF.
- When switching the motor drive source from the inverter to commercial power, adjust the inverter's reference frequency at or slightly higher than that of the commercial power frequency beforehand, taking into consideration the motor speed down during the coast-to-stop period produced by switching.
- Note that when the motor drive source is switched from the inverter to the commercial power, a high inrush current will be generated, because the phase of the commercial power usually does not match the motor speed at the switching. Make sure that the power supply and all the peripheral equipment are capable of withstanding this inrush current.
- If you have enabled "Restart after momentary power failure" (F14 = 3, 4, or 5), keep "BX" ON during commercial power driven operation to prevent the inverter from restarting after a momentary power failure.

Example of Sequence Circuit

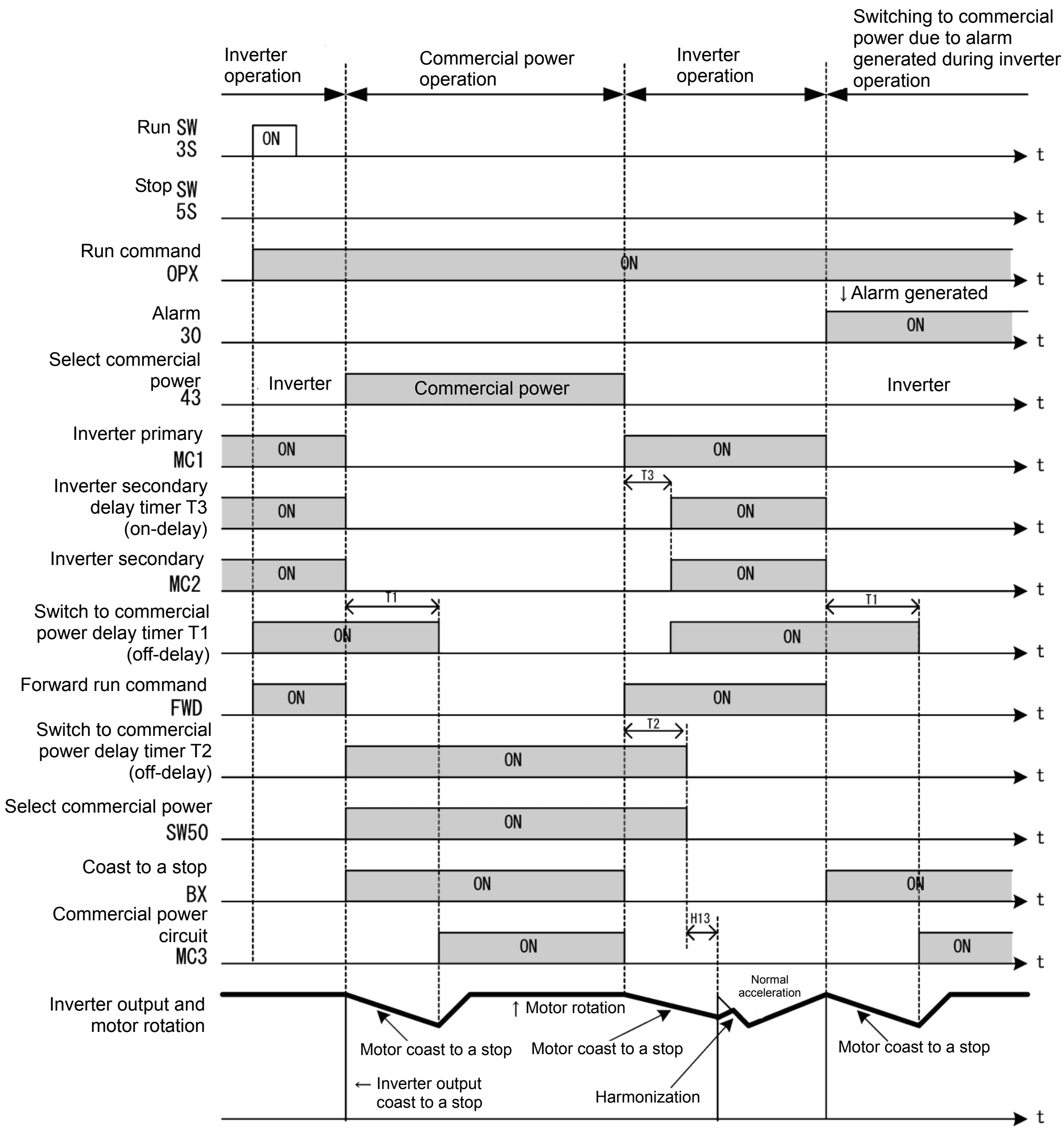


Note 1) Emergency switch

Manual switch provided for the event that the motor drive source cannot be switched normally to the commercial power due to a serious problem of the inverter

Note 2) When any alarm has occurred inside the inverter, the motor drive source will automatically be switched to the commercial power.

Example of Operation Time Scheme



■ "UP" (Increase output frequency) and "DOWN" (Decrease output frequency) commands -- UP and DOWN (Function code data = 17 and 18)

- Frequency command: Turning the terminal command "UP" or "DOWN" ON causes the output frequency to increase or decrease, respectively, within the range from 0 Hz to the maximum frequency. (Function code F01 data = 7)
- PID command: Turning the terminal command "UP" or "DOWN" ON causes the PID command value to increase or decrease, respectively, within the range from 0 to 100%. (Function code J02 (data= 3)

■ Enable data change with keypad – "WE-KP" (Function code data = 19)

Turning the terminal command "WE-KP" ON protects function code data from accidentally getting changed by pressing the keys on the keypad. Only when this terminal command is ON, you can change function code data from the keypad. (Function code F00)

■ **Cancel PID control – “Hz/PID” (Function code data = 20)**

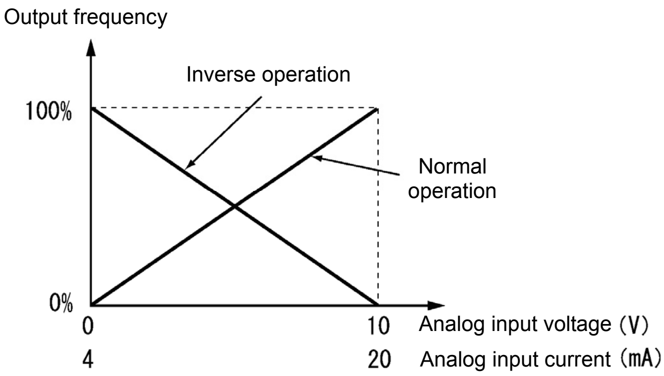
Turning this terminal command “Hz/PID” ON disables PID control. If the PID control is disabled with this command, the inverter runs the motor with the reference frequency manually set by any of the multi-frequency, keypad, analog input, etc.

Terminal command “Hz/PID”	Function
OFF	Enable PID control
ON	Disable PID control (Enable manual settings)

(📖Function codes J01 to J19, J57 to J62)

■ **Switch normal/inverse operation – “IVS” (Function code data = 21)**

This terminal command switches the output frequency control between normal (proportional to the input value) and inverse in analog frequency setting or under PID process control. To select the inverse operation, turn the IVS ON.



Tip The normal/inverse switching operation is useful for air-conditioners that require switching between cooling and heating. In cooling, the speed of the fan motor (output frequency of the inverter) is increased to lower the temperature. In heating, the speed of the fan motor (output frequency of the inverter) is reduced to lower the temperature. This switching is realized by the IVS.

- **When the inverter is driven by an external analog frequency command sources (terminals [12] and [C1] (C1 function) and [C1] (V2 function)):**

Switching normal/inverse operation can apply only to the analog frequency command sources (terminals [12] and [C1] (C1 function) and [C1] (V2 function)) in frequency command 1 (F01) and does not affect frequency command 2 (C30) or UP/DOWN control. As listed below, the combination of the "Selection of normal/inverse operation for frequency command 1" (C53) and the terminal command “IVS” determines the final operation. Combination of C53 and “IVS”

C53 data	Terminal command “IVS”	Action
0: Normal operation	OFF	Normal
0: Normal operation	ON	Inverse
1: Inverse operation	OFF	Inverse
1: Inverse operation	ON	Normal

- **When process control is performed by the PID processor integrated in the inverter:**

The terminal command Hz/PID ("Cancel PID control") can switch PID control between enabled (process is to be controlled by the PID processor) and disabled (process is to be controlled by the manual frequency setting). In either case, the combination of the "PID control" (J01) or "Selection of normal/inverse operation for frequency command 1" (C53) and the terminal command IVS determines the final operation as listed below.

- **When PID control is enabled: The normal/inverse operation selection for the PID processor output (reference frequency) is as follows.**

PID control (Mode selection) (J01)	Terminal command "IVS"	Action
1: Enable (normal operation)	OFF	Normal
	ON	Inverse
2: Enable (inverse operation)	OFF	Inverse
	ON	Normal

- **When PID control is disabled: The normal/inverse operation selection for the manual reference frequency is as follows.**

Selection of normal/inverse operation for frequency command 1 (C53)	Terminal command "IVS"	Action
0: Normal operation	-	Normal
1: Inverse operation	-	Inverse

Note When process control is performed by the PID control facility integrated in the inverter, the "IVS" is used to switch the PID processor output (reference frequency) between normal and inverse, and has no effect on any normal/inverse operation selection of the manual frequency setting.

(📖Function codes J01 to J19, J57 to J62)

■ Interlock – "IL" (Function code data = 22)

In a configuration where a magnetic contactor (MC) is installed in the power output (secondary) circuit of the inverter, the momentary power failure detection feature provided inside the inverter may not be able to accurately detect a momentary power failure by itself. Using a digital signal input with the interlock command IL assures the accurate detection. (📖Function code F14)

Terminal command "IL"	Meaning
OFF	No momentary power failure has occurred.
ON	A momentary power failure has occurred. (Restart after a momentary power failure enabled)

■ Enable communications link via RS-485 or fieldbus (option) – "LE" (Function code data = 24)

Turning this terminal command "LE" ON gives priorities to frequency commands or run commands received via the RS-485 communications link (H30) or the fieldbus option (y98). No LE assignment is functionally equivalent to the "LE" being ON.

No "LE" assignment is functionally equivalent to the "LE" being ON. (📖Function codes H30 and y98)

■ Universal DI -- "U-DI" (Function code data = 25)

Using U-DI enables the inverter to monitor digital signals sent from the peripheral equipment via an RS-485 communications link or a fieldbus option by feeding those signals to the digital input terminals. Signals assigned to the universal DI are simply monitored and do not operate the inverter.

📖 For an access to universal DI via the RS-485 or fieldbus communications link, refer to their respective Instruction Manuals.

■ Enable auto search for idling motor speed at starting – "STM" (Function code data = 26)

This digital terminal command determines, at the start of operation, whether or not to search for idling motor speed and follow it. (📖Function code H09)

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■ Force to stop – "STOP" (Function code data = 30)

Turning this terminal command "STOP" OFF causes the motor to decelerate to a stop in accordance with the H56 data (Deceleration time for forced stop). After the motor stops, the inverter enters the alarm state with the alarm Er6 displayed. (📖Function code F07)

■ Reset PID integral and differential components – "PID-RST" (Function code data = 33)

Turning this terminal command "PID-RST" ON resets the integral and differential components of the PID processor.

(📖Function codes J01 to J19, J23, J24, J56 to J62)

■ Hold PID integral component – "PID-HLD" (Function code data = 34)

Turning this terminal command "PID-HLD" ON holds the integral components of the PID processor.
(📖Function codes J01 to J19, J23, J24, J56 to J62)

■ Select local (keypad) operation – "LOC" (Function code data = 35)

This terminal command "LOC" switches the sources of run and frequency commands between remote and local.

📖 For details of switching between remote and local modes, refer to Chapter 3, Section 3.3.7 "Remote and local modes."

■ Pulse train input – "PIN" (available only on terminal [X5]) (Function code data = 48) Pulse train sign – "SIGN" (available on terminals except [X5]) (Function code data = 49)

Assigning the command "PIN" to digital input terminal [X5] enables the frequency command by the pulse train input. Assigning the command "SIGN" to one of the digital input terminals except [X5] enables the pulse train sign input to specify the polarity of frequency command.

(📖Function code F01)

■ Brake check signal - BRKE (Function code data = 65)

If the status of the brake signal BRKS fails to agree with the status of the brake check signal BRKE during inverter operation, the inverter enters an alarm stop state with Er6.
This signal is used as a feedback signal for the brake signal BRKS. When the mechanical brake does not operate, it causes the inverter to trip to activate the mechanical brake. The response delay time for BRKS and BRKE can be adjusted with H180: Brake response time.
(📖Function codes J68 to J96, H180)

■ Count the run time of commercial power-driven motors 1 and 2 – "CRUN-M1" and "CRUN-M2" (Function code data = 72 and 73)

These terminal commands enable the inverter to count the cumulative run time of the respective motors even when they are driven by commercial power (not by the inverter).

When the "CRUN-M1" or "CRUN-M2" is ON, the inverter judges that the motor 1 or 2 is driven by commercial power, respectively, and counts the run time of the corresponding motor.

■ Select droop control – "DROOP" (Function code data = 76)

This terminal command "DROOP" toggles droop control on and off.

Terminal command "DROOP"	Droop control
ON	Enable
OFF	Disable

(📖Function code H28)

■ Cancel customizable logic – "CLC" (Function code data = 80), Clear all customizable logic timers – "CLTC" (Function code data = 81)

Terminal command "CLC" stops the operation of customizable logic. Terminal command "CLTC" clears all customizable logic timers.

(📖Function codes U codes)

■ PID multi-step 1 – "PID-SS1" (Function code data = 171), PID multi-step 2 – "PID-SS2" (Function code data = 172)

"PID-SS1" and "PID-SS2" can be used to switch PID commands for four steps.

(📖Function codes J136 to J138)

■ Run forward – "FWD" (Function code data = 98)

Turning this terminal command ON runs the motor in the forward direction; turning it OFF decelerates it to stop.

Tip: This terminal command "FWD" can be assigned only by E98 or E99.

■ Run reverse – "REV" (Function code data = 99)

Turning this terminal command "REV" ON runs the motor in the reverse direction; turning it OFF decelerates it to stop.

Tip: This terminal command "REV" can be assigned only by E98 or E99.

■ Assigning no function – "NONE" (Function code data = 100)

It allows the inverter to run unaffected by ON/OFF of signals. It is used when a signal is externally input using customizable logic. It is also used to temporarily disable a terminal function.

E10 to E15	Acceleration time 2 to 4, Deceleration time 2 to 4	(Refer to F07)

Refer to the description of F07.

E16 and E17	Torque limiter 2 (driving), 2 (braking)	(Refer to F40)

For the torque limiter 2 (driving) and 2 (braking) settings, refer to the description of F40.

E20 to E21 E27	Terminals [Y1] to [Y2] (function selection) Terminal [30A/B/C] (Relay output)

E20 through E21 and E27 assign output signals to general-purpose, programmable output terminals, [Y1], [Y2] and [30A/B/C]. These function codes can also switch the logic system between normal and negative to define how the inverter interprets the ON or OFF state of each terminal. The factory default setting is normal logic system "Active ON."

The factory default setting is normal logic system "Active ON." Terminals [Y1] and [Y2] are transistor outputs and terminals [30A/B/C] are contact outputs. In normal logic, if an alarm occurs, the relay will be energized so that [30A] and [30C] will be closed, and [30B] and [30C] opened. In negative logic, the relay will be deenergized so that [30A] and [30C] will be opened, and [30B] and [30C] closed. This may be useful for the implementation of failsafe power systems.

Note:

- When negative logic is employed, all output signals are active (e.g. an alarm would be recognized) while the inverter is powered OFF. To avoid causing system malfunctions by this, interlock these signals to keep them ON using an external power supply. Furthermore, the validity of these output signals is not guaranteed for approximately 1.5 seconds (for 22 kW or below) or 3 seconds (for 30 kW or above) after power-ON, so introduce such a mechanism that masks them during the transient period.
- Terminals [30A/B/C] use mechanical contacts. They cannot stand frequent ON/OFF switching. Where frequent ON/OFF switching is anticipated (for example, limiting a current by using signals subjected to inverter output limit control such as switching to commercial power line or direct-on-line starting), use transistor outputs [Y1] and [Y2] instead.
  The service life of a relay is approximately 200,000 times if it is switched ON and OFF at one-second intervals. For signals expected to be turned ON/OFF frequently, use terminals [Y1] and [Y2] for output.

The tables given on the following pages list functions that can be assigned to terminals [Y1], [Y2], and [30A/B/C]. The descriptions are, in principle, arranged in the numerical order of assigned data. However, highly relevant signals are collectively described where one of them first appears. Refer to the function codes or signals in the "Related function codes/signals (data)" column, if any.

Explanations of each function are given in normal logic system "Active ON."

Data		Terminal commands assigned	Symbol	Related function codes/ Related signals (data)
Active ON	Active OFF			
0	1000	Inverter running	"RUN"	—
1	1001	Frequency (speed) arrival signal	"FAR"	E30
2	1002	Frequency (speed) detection	"FDT"	E31, E32
3	1003	Undervoltage detection (Inverter stopped)	"LU"	—
4	1004	Torque polarity detection	"B/D"	—
5	1005	Inverter output limiting	"IOL"	—
6	1006	Auto-restarting after momentary power failure	"IPF"	F14
7	1007	Motor overload early warning	"OL"	E34, F10, F12
8	1008	Keypad operation enabled	"KP"	—
10	1010	Inverter ready to run	"RDY"	—
15	1015	AX terminal function (For MC on primary side)	"AX"	—
16	1016	Pattern operation stage transition	"TU"	
17	1017	Pattern operation cycle completed	"TO"	
18	1018	Pattern operation stage No. 1	"STG1"	
19	1019	Pattern operation stage No. 2	"STG2"	
20	1020	Pattern operation stage No. 4	"STG4"	
21	1021	Speed arrival 2	"FAR2"	E29
22	1022	Inverter output limiting (with delay)	"IOL2"	IOL (5)
25	1025	Cooling fan ON/OFF control	"FAN"	H06
26	1026	Auto-resetting	"TRY"	H04, H05
27	1027	Universal DO	"U-DO"	—
28	1028	Heat sink overheat early warning	"OH"	—
30	1030	Lifetime alarm	"LIFE"	H42
31	1031	Frequency (speed) detection 2	"FDT2"	E32, E36
33	1033	Reference loss detection	"REF OFF"	E65
35	1035	Inverter output on	"RUN2"	RUN (0)
36	1036	Overload prevention control	"OLP"	H70
37	1037	Current detection	"ID"	E34, E35, E37, E38, E55, E56
38	1038	Current detection 2	"ID2"	
39	1039	Current detection 3	"ID3"	
41	1041	Low current detection	"IDL"	
42	1042	PID alarm	"PID-ALM"	J11 to J13
43	1043	Under PID control	"PID-CTL"	J01

Data		Terminal commands assigned	Symbol	Related function codes/ Related signals (data)
Active ON	Active OFF			
44	1044	Motor stopped due to slow flowrate under PID control	"PID-STP"	J08, J09
45	1045	Low output torque detection	"U-TL"	E78 to E81
46	1046	Torque detection 1	"TD1"	
47	1047	Torque detection 2	"TD2"	
48	1048	Motor 1 selected	"SWM1"	—
49	1049	Motor 2 selected	"SWM2"	
52	1052	Running forward	"FRUN"	—
53	1053	Running reverse	"RRUN"	—
54	1054	In remote operation	"RMT"	(Refer to Section 7.3.6)
56	1056	Detection by thermistor	"THM"	H26, H27
57	1057	Brake signal	"BRKS"	J68 to J72
58	1058	Frequency (speed) detection 3	"FDT3"	E32, E54
59	1059	Terminal [C1] wire break	"C1OFF"	—
72	1072	Frequency (speed) arrival signal 3	"FAR3"	E30
77	1077	Low link bus voltage detection	"U-EDC"	
79	1079	During deceleration in momentary power failure	"IPF2"	
84	1084	Maintenance timer	"MNT"	H44, H78, H79
90	1090	Alarm content 1	"AL1"	
91	1091	Alarm content 2	"AL2"	
92	1092	Alarm content 4	"AL4"	
93	1093	Alarm content 8	"AL8"	
98	1098	Light alarm	"L-ALM"	H81, H82
99	1099	Alarm output (for any alarm)	"ALM"	—
101	1101	EN terminal detection circuit error	"DECF"	
102	1102	EN terminal OFF	"ENOFF"	
105	1105	Braking transistor broken	"DBAL"	H98
111	1111	Customizable logic output signal 1	"CLO1"	U71 to U75, U81 to U90
112	1112	Customizable logic output signal 2	"CLO2"	
113	1113	Customizable logic output signal 3	"CLO3"	
114	1114	Customizable logic output signal 4	"CLO4"	
115	1115	Customizable logic output signal 5	"CLO5"	
116	1116	Customizable logic output signal 6	"CLO6"	
117	1117	Customizable logic output signal 7	"CLO7"	
118	1118	Customizable logic output signal 8	"CLO8"	
119	1119	Customizable logic output signal 9	"CLO9"	

Note Any negative logic (Active OFF) command cannot be assigned to the functions marked with "-" in the "Active OFF" column.

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■ Inverter running – "RUN" (Function code data = 0), Inverter output on – "RUN2" (Function code data = 35)

These output signals tell the external equipment that the inverter is running at a starting frequency or higher. If assigned in negative logic (Active OFF), these signals can be used to tell the "Inverter being stopped" state.

Output signal	Basic function	Remarks
RUN	These signals come ON when the inverter is running. Under V/f control: These signals come ON if the inverter output frequency exceeds the starting frequency, and go OFF if it drops below the stop frequency. The "RUN" signal can also be used as a "Speed valid" signal DNZS.	Goes OFF even during DC braking.
RUN2		Comes ON even during DC braking, pre-exciting, zero speed control.

■ Frequency (speed) arrival signal – "FAR" (Function code data = 1), Frequency (speed) arrival signal 3 – "FAR3" (Function code data = 72)

These output signals come ON when the difference between the output frequency (detected speed) and reference frequency (reference speed) comes within the frequency arrival hysteresis width specified by E30. (Function code E30)

■ Frequency (speed) detection – "FDT" (Function code data = 2), Frequency (speed) detection 2 – "FDT2" (Function code data = 31), Frequency (speed) detection 3 – "FDT3" (Function code data = 58)

The output signal FDT, FDT2 or FDT3 comes ON when the output frequency (detected speed) exceeds the frequency detection level specified by E31, E36 or E54, respectively, and it goes OFF when the output frequency (detected speed) drops below the "Frequency detection level (E31, E36 or E54) - Hysteresis width (E32). (Function codes E31 and E32)

■ Undervoltage detection (Inverter stopped) – "LU" (Function code data = 3)

This output signal comes ON when the DC link bus voltage of the inverter drops below the specified undervoltage level. When this signal is ON, the inverter cannot run even if a run command is given. It goes OFF when the voltage exceeds the level. This signal is ON also when the undervoltage protective function is activated so that the motor is in an abnormal stop state (e.g., tripped).

■ Torque polarity detection – "B/D" (Function code data = 4)

The inverter issues the driving or braking polarity signal to this digital output judging from the internally calculated torque or torque command. This signal goes OFF when the detected torque is a driving one, and it goes ON when it is a braking one.

■ Inverter output limiting – "IOL" (Function code data = 5), Inverter output limiting with delay – "IOL2" (Function code data = 22)

The output signal IOL comes ON when the inverter is limiting the output frequency by activating any of the following actions (minimum width of the output signal: 100 ms). The output signal IOL2 comes ON when any of the following output limiting operation continues for 20 ms or more.

- Torque limiting (F40, F41, E16 and E17, Maximum internal value)
- Current limiting by software (F43 and F44)
- Instantaneous overcurrent limiting by hardware (H12 = 1)
- Automatic deceleration (Anti-regenerative control) (H69)

Note When the "IOL" is ON, it may mean that the output frequency may have deviated from the reference frequency because of the limiting functions above.

■ Auto-restarting after momentary power failure – "IPF" (Function code data = 6)

This output signal is ON either during continuous running after a momentary power failure or during the period after the inverter detects an undervoltage condition and shuts down the output until restart has been completed (the output has reached the reference frequency).

(Function code F14)

■ **Motor overload early warning – "OL" (Function code data = 7)**

The OL signal is used to detect a symptom of an overload condition (alarm code OL 1) of the motor so that the user can take an appropriate action before the alarm actually happens. (📖Function code E34)

■ **Keypad operation enabled – "KP" (Function code data = 8)**

This output signal comes ON when the RUN / STOP keys are specified as the run command source.

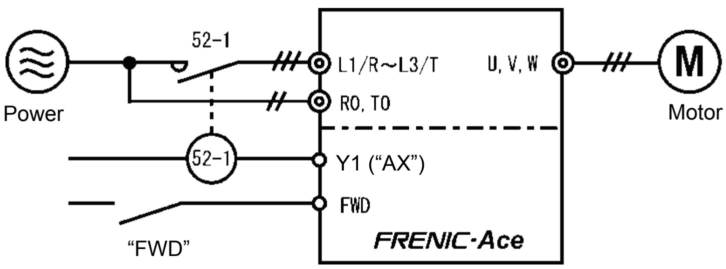
■ **Inverter ready to run – "RDY" (Function code data = 10)**

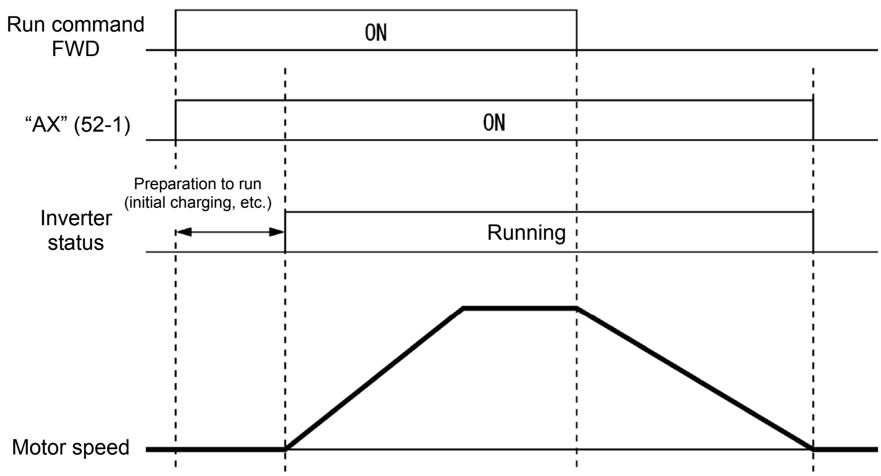
This output signal comes ON when the inverter becomes ready to run by completing hardware preparation (such as initial charging of DC link bus capacitors and initialization of the control circuit) and no protective functions are activated.

■ **Select "AX" terminal function – "AX" (Function code data = 15)**

In response to a run command FWD, this output signal controls the magnetic contactor on the commercial-power supply side. It comes ON when the inverter receives a run command. It goes OFF after the motor decelerates to stop with a stop command received. This signal immediately goes OFF upon receipt of a coast-to-stop command or when an alarm occurs.

"AX" can be selected where there is control power such as with FRN0059E2S-4 or higher.





■ Pattern operation stage No. 1 – "STG1" (Function code data = 18), Pattern operation stage No. 2 – "STG2" (Function code data = 19), Pattern operation stage No. 4 – "STG4" (Function code data = 20)

Outputs the stage (operation process) currently performed during pattern operation.

Operation pattern stage No.	Output terminal signal		
	STG1	STG2	STG4
Stage 1	ON	OFF	OFF
Stage 2	OFF	ON	OFF
Stage 3	ON	ON	OFF
Stage 4	OFF	OFF	ON
Stage 5	ON	OFF	ON
Stage 6	OFF	ON	ON
Stage 7	ON	ON	ON

■ Frequency arrival 2 – "FAR2" (Function code data = 21)

The signals come ON when the difference between the output frequency before torque limiting and reference frequency has entered within the frequency arrival hysteresis width specified by E30 and the frequency arrival delay specified by E29 has elapsed.

(🕮Function codes E29 and E30)

■ Cooling fan ON/OFF control – "FAN" (Function code data = 25)

With the cooling fan ON/OFF control enabled (H06 = 1), this output signal is ON when the cooling fan is in operation, and OFF when it is stopped. This signal can be used to make the cooling system of peripheral equipment interlocked for an ON/OFF control.

(🕮Function code H06)

■ Auto-resetting – "TRY" (Function code data = 26)

This output signal comes ON when auto resetting (resetting alarms automatically) is in progress.

(🕮Function codes H04 and H05)

■ Universal DO -- "U-DO" (Function code data = 27)

Assigning this output signal to an inverter's output terminal and connecting the terminal to a digital input terminal of peripheral equipment via the RS-485 communications link or the fieldbus, allows the inverter to send commands to the peripheral equipment. The universal DO can be used as an output signal independent of the inverter operation.

🕮 For the procedure for access to Universal DO via the RS-485 communications link or fieldbus, refer to the respective instruction manual.

■ Heat sink overheat early warning – "OH" (Function code data = 28)

This output signal is used to issue a heat sink overheat early warning that enables you to take a corrective action before an overheat trip 0H1 actually happens.

ON at [(Overheat trip (0H1) temperature) – 5°C] or higher

OFF at [(Overheat trip (0H1) temperature) - 8°C] or lower

This signal comes ON also when the internal air circulation DC fan (FRN0203 E2S-4 or above for 400 V class series) has locked.

■ **Lifetime alarm – "LIFE" (Function code data = 30)**

This output signal comes ON when it is judged that the service life of any one of capacitors (DC link bus capacitors and electrolytic capacitors on the printed circuit boards) and cooling fan has expired. This signal should be used as a guide for replacement of the capacitors and cooling fan. If this signal comes ON, use the specified maintenance procedure to check the service life of these parts and determine whether the parts should be replaced or not. (📖Function code H42)

This signal comes ON also when the internal air circulation DC fan (FRN0203 E2S-4 or above for 400 V class series) has locked.

■**Reference loss detection – "REF OFF" (Function code data = 33)**

This output signal comes ON when an analog input used as a frequency command source is in a reference loss state (as specified by E65) due to a wire break or a weak connection. This signal goes OFF when the normal operation under the analog input is resumed.

(📖Function code E65)

■**Overload prevention control – "OLP" (Function code data = 36)**

This output signal comes ON when overload prevention control is activated. (The minimum ON-duration is 100 ms.)
(📖Function code H70)

■**Current detection – "ID" (Function code data = 37), Current detection 2 – "ID2" (Function code data = 38), Current detection 3 – "ID3" (Function code data = 39)**

When the inverter output current exceeds the level specified by E34, E37 or E55 for the period specified by E35, E38 or E56, the ID, ID2 or ID3 signal turns ON, respectively. (The minimum ON-duration is 100 ms.)
(📖Function code E34)

■**Low current detection – "IDL" (Function code data = 41)**

When the inverter output current falls to or below the level specified by E34, E37 or E55 for the period specified by E35, E38 or E56, the ID, ID2 or ID3 signal turns ON, respectively. (The minimum ON-duration is 100 ms.)
(📖Function code E34)

■**PID alarm – "PID-ALM" (Function code data = 42)**

Assigning this output signal enables PID control to output absolute-value alarm or deviation alarm.
(📖Function codes J11 to J13)

■**Under PID control – "PID-CTL" (Function code data = 43)**

This output signal comes ON when PID control is enabled ("Cancel PID control" (Hz/PID) = OFF) and a run command is ON.
(📖Function code J01)

Note: When PID control is enabled, the inverter may stop due to the slow flowrate stopping function or other reasons. If that happens, the "PID-CTL" signal remains ON. As long as the "PID-CTL" signal is ON, PID control is effective, so the inverter may abruptly resume its operation, depending on the feedback value in PID control.

⚠WARNING

When PID control is enabled, even if the inverter stops its output during operation because of sensor signals or other reasons, operation will resume automatically. Design your machinery so that safety is ensured even in such cases.

Otherwise an accident could occur.

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■Motor stopped due to slow flowrate under PID control – "PID-STP" (Function code data = 44)

This output signal is ON when the inverter is in a stopped state due to the slow flowrate stopping function under PID control.)
(Function codes J15 to J17, J23 J24)

■Low output torque detection – "U-TL" (Function code data = 45)

This output signal comes ON when the torque value calculated by the inverter or torque command drops below the level specified by E80 (Low torque detection (Level)) for the period specified by E81 (Low torque detection (Timer)). (minimum width of the output signal: 100 ms) (Function codes E78 to E81)

■Torque detection 1 – "TD1" (Function code data = 46),Torque detection 2 – "TD2" (Function code data = 47)

This output signal TD1 or TD2 comes ON when the torque value calculated by the inverter or torque command exceeds the level specified by E78 or E80 (Torque detection (Level)) for the period specified by E79 or E81 (Torque detection (Timer)), respectively. (minimum width of the output signal: 100 ms) (Function codes E78 to E81)

■Motor 1, and 2 selected – "SWM1" and "SWM2" (Function code data = 48 and 49)

The output signal "SWM1" or "SWM2" comes ON corresponding to the motor selected by the signal "M2" or the selected function code group. (Function code A42)

■Running forward – "FRUN" (Function code data = 52) Running reverse – "RRUN" (Function code data = 53)

Output signal	Assigned data	Running forward	Running reverse	Inverter stopped
"FRUN"	52	ON	OFF	OFF
"RRUN"	53	OFF	ON	OFF

■In remote operation – "RMT" (Function code data = 54)

This output signal comes ON when the inverter switches from local to remote mode.

For details of switching between remote and local modes, refer to Chapter 3, Section 3.3.7 "Remote and local modes."

■Motor overheat detection by thermistor – "THM" (Function code data = 56)

Even when the PTC thermistor on the motor detects an overheat, the inverter turns this signal ON and continues to run, without entering the alarm OH4 state. This feature applies only when H26 data is set to "2." (Function codes H26 and H27)

■Brake signal – "BRKS" (Function code data = 57)

This signal outputs a brake control command that releases or activates the brake. (Function codes J68 to J72)

■Terminal [C1] wire break – "C1OFF" (Function code data = 59)

This output signal comes ON when the inverter detects that the input current to terminal [C1] (C1 function) drops below 2 mA interpreting it as the terminal [C1] wire broken.

■Assigning low-to-intermediate voltage detection – "U-EDC" (Function code data = 77)

This output signal comes ON when the DC intermediate voltage drops below E76 (DC intermediate voltage detection level), and it goes OFF when the DC intermediate voltage exceeds E76.
(📖Function code E76)

■Assigning during deceleration in momentary power failure – "IPF2" (Function code data = 79)

When F14 data is set to 2 or 3, this output signal comes ON when the DC intermediate voltage drops below H15 (Continue to run level) and continue to run control starts. When the power returns and the DC intermediate voltage becomes "at least 10 V higher than the voltage specified by H15," the signal goes OFF.
Even when F14 data is set to 4 or 5, the signal comes ON when the DC intermediate voltage drops below the undervoltage level, and it goes OFF when the DC intermediate voltage becomes "at least 10 V higher than the undervoltage level."
(📖Function codes F14 and H15)

■Maintenance timer – "MNT" (Function code data = 84)
Once the inverter's cumulative run time or the startup times for the motor 1 exceeds the previously specified count, this output signal comes ON.
(📖Function codes H78 and H79)

■Alarm content – "AL1", "AL2", "AL4", "AL8" (Function code data = 90, 91, 92, 93)
Outputs the state of operation of the inverter protective functions.

Alarm content (inverter protective function)	Alarm code	Output terminal			
		AL1	AL2	AL4	AL8
Instantaneous overcurrent protection, earth fault protection, fuse blown	OC1 OC2 OC3 EF FUS	ON	OFF	OFF	OFF
Overvoltage protection	OU1 OU2 OU3	OFF	ON	OFF	OFF
Undervoltage protection, input phase loss	LU Lin	ON	ON	OFF	OFF
Motor overload, electronic thermal (motors 1 to 4)	OL1 OL2 OL3 OL4	OFF	OFF	ON	OFF
Inverter overload	OLU	ON	OFF	ON	OFF
INV overheat protection, inverter internal overheat	OH1 OH3	OFF	ON	ON	OFF
External alarm, DB resistor overheat, motor overheat	OH2 dbH OH4	ON	ON	ON	OFF
Memory error, CPU error, undervoltage save error, GAS-related error	Er1 Er3 ErF ErH	OFF	OFF	OFF	ON
Keypad communications error, option communications error	Er2 Er4	ON	OFF	OFF	ON
Option error	Er5 Ert	OFF	ON	OFF	ON
Charging circuit error, operating procedure error, EN circuit error, DB transistor failure detection	PbF Er6 ECF dbA	ON	ON	OFF	ON
Tuning error, output phase loss protection	Er7 OPL	OFF	OFF	ON	ON
RS485 communications error	Er8 ErP	ON	OFF	ON	ON
Overspeed protection, PG error, excessive positioning error Speed mismatch (excessive speed deviation), positioning control error	OS PG ErE dO Ero	OFF	ON	ON	ON
NTC thermistor (motor) wire break detection PID feedback wire break, mock alarm Other alarm	nrb COF Err	ON	ON	ON	ON

*No terminal outputs a signal during normal operation.

■Light alarm – "L-ALM" (Function code data = 98)

This output signal comes ON when a light alarm occurs. (📖Function codes H81 and H82)

■Alarm output (for any alarm) – “ALM” (Function code data = 99)

This output signal comes ON if any of the protective functions is activated and the inverter enters Alarm mode.

■EN terminal detection circuit error – “DECF” (Function code data = 101)

The signal comes ON when any error is generated in the circuit for detecting EN terminal OFF.

■EN terminal OFF – “ENOFF” (Function code data = 102)

The signal comes ON when the EN terminal has turned OFF.

■Braking transistor broken – “DBAL” (Function code data = 105)

If the inverter detects a breakdown of the braking transistor, it displays the braking transistor alarm (dbA. and also issues the output signal “DBAL”. Detection of the breakdown of a braking transistor can be canceled by H98. (FRN0072E2S-4 or below for 400 V class series)
(📖Function code H98)

Note: A breakdown of the braking transistor could lead to a damage of the braking resistor or inverter’s internal units. To prevent the secondary damage, use “DBAL” to cut off power to the magnetic contactor in inverter primary circuits upon detection of a breakdown of the built-in braking transistor.

■Customizable logic output signal 1 to 9 – “CLO1” to “CL09” (Function code data =111 to 119)

Outputs the result of customizable logic operation.
(📖Function codes U codes)

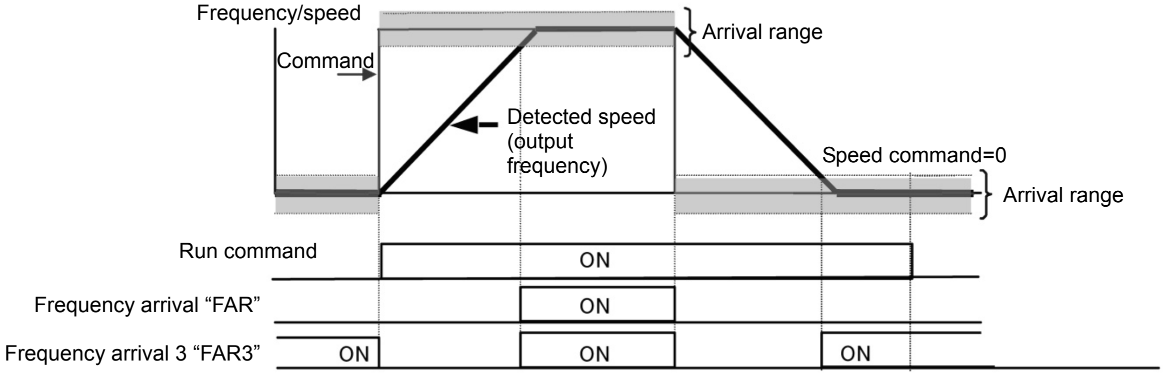
E29 E30	Frequency arrival delay (FAR2) Frequency arrival hysteresis (hysteresis width)

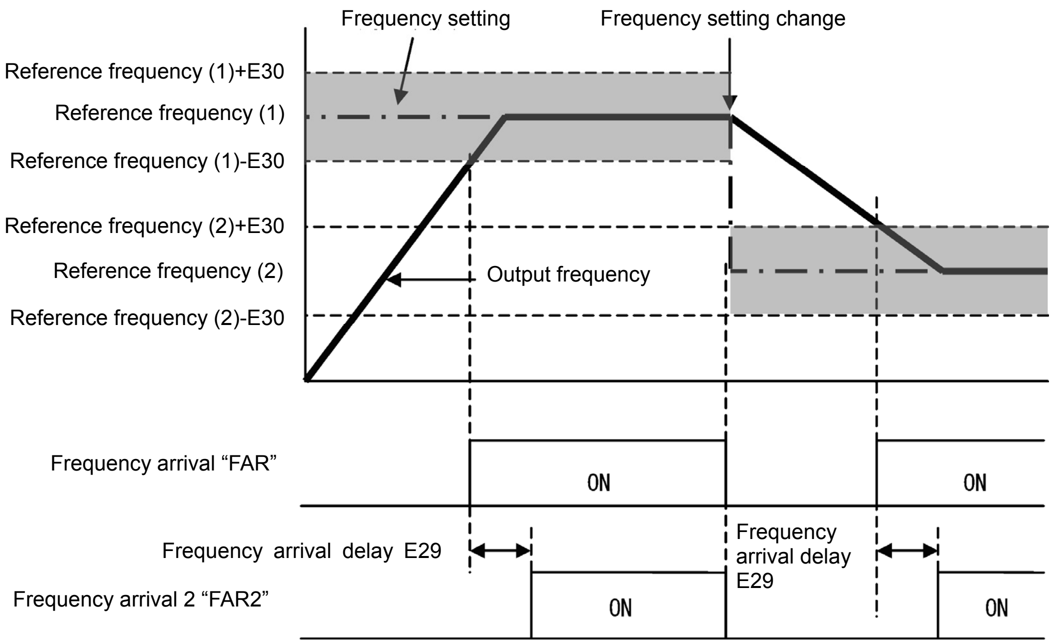
E30 specifies the detection level (hysteresis width) for the Frequency (speed) arrival signal “FAR”, Frequency (speed) arrival signal 2 “FAR2” and the Frequency (speed) arrival signal 3 “FAR3”.

Output signal	E20, E21, E27 assigned data	Operating condition 1	Operating condition 2
“FAR”	1	The signals come ON when the difference between the output frequency (estimated/detected speed) and the reference frequency (reference speed) comes within the frequency arrival hysteresis width specified by E30.	FAR always goes OFF when the run command is OFF or the reference speed is "0."
“FAR3”	72		When the run command is OFF, the inverter regards the reference speed as "0," so FAR3 comes ON as long as the output frequency (estimated/detected speed) is within the range of "0 ± the frequency arrival hysteresis width specified by E30."
“FAR2”	21	The signal comes ON when the difference between the output frequency (before torque and current limiting) and the reference frequency (reference speed) comes within the frequency arrival hysteresis width specified by E30.	This signal always goes OFF when the run command is OFF or the reference speed is "0." The delay can be specified by E29.

- Data setting range: E30: 0.0 to 10.0 (Hz), E29: 0.01 to 10.00 (s)

The operation timings of each signal are as shown below.



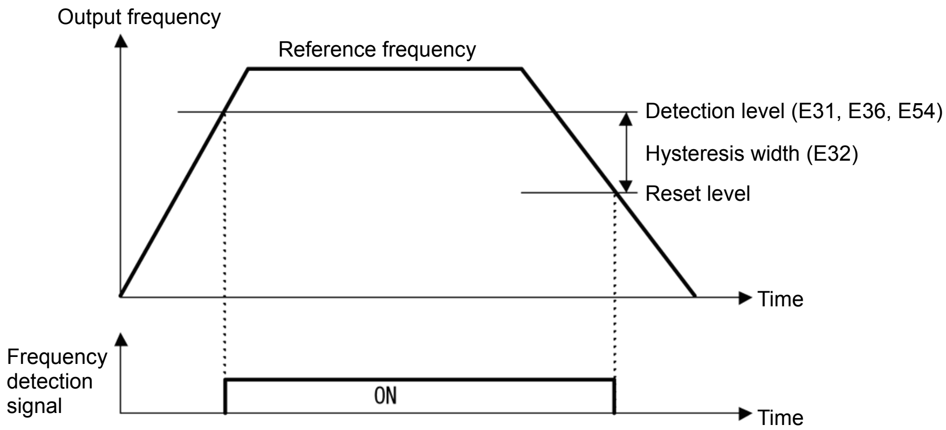


E31,E32	**Frequency detection (level and hysteresis width)** **Related function codes: E36 (Frequency detection 2, level), E54 (Frequency detection 3, level)**

When the output frequency exceeds the frequency detection level specified by E31, the "Frequency (speed) detection signal" comes ON; when it drops below the "Frequency detection level minus Hysteresis width specified by E32," it goes OFF.

The following three settings are available.

Name	Output signal	E20,E21, E27 Assigned data	Operation level	Hysteresis width
			Range: 0.0 to 500.0Hz	Range: 0.0 to 500.0Hz
Frequency detection	“FDT”	2	E31	E32
Frequency detection 2 (level)	“FDT2”	31	E36	
Frequency detection 3 (level)	“FDT3”	58	E54	



E34,E35	**Overload early warning/Current detection (level and timer)** **Related function codes: E37, E38 (Current detection 2/Low current detection level and timer)** **E55, E56 (Current detection 3, level and timer)**

These function codes define the detection level and time for the Motor overload early warning "OL", Current detection "ID", Current detection 2 "ID2", Current detection 3 "ID3", and Low current detection "IDL" output signals.

Output signal	E20,E21, E27 Assigned data	Operation level	Timer	Motor characteristics	Thermal time constant
		Range: See below	Range: 0.01 to 600.00 s	Range: See below	Range: 0.5 to 75.0 min
“OL”	7	E34	-	F10	F12
“ID2	37	E34	E35	-	-
“ID2”	38	E37	E38		
“ID3”	39	E55	E56		
“IDL”	41	E37	E38		

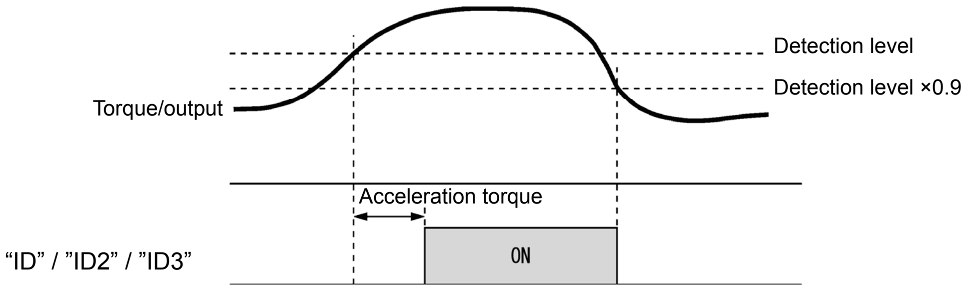
- Data setting range
  Operation level: 0.00 (Disable), 1 to 200% of inverter rated current
  Motor characteristic 1: Enable (For a general-purpose motor with shaft-driven cooling fan)
  2: Enable (For an inverter-driven motor, non-ventilated motor, or motor with separately powered cooling fan)

■Motor overload early warning signal – "OL"

The OL signal is used to detect a symptom of an overload condition (alarm code OL1) of the motor so that the user can take an appropriate action before the alarm actually happens. The OL signal turns ON when the inverter output current exceeds the level specified by E34. In typical cases, set E34 data to 80 to 90% against F11 data (Electronic thermal overload protection for motor 1, Overload detection level). Set the temperature characteristics of the motor with electronic thermal (motor characteristics selection, thermal time constant).

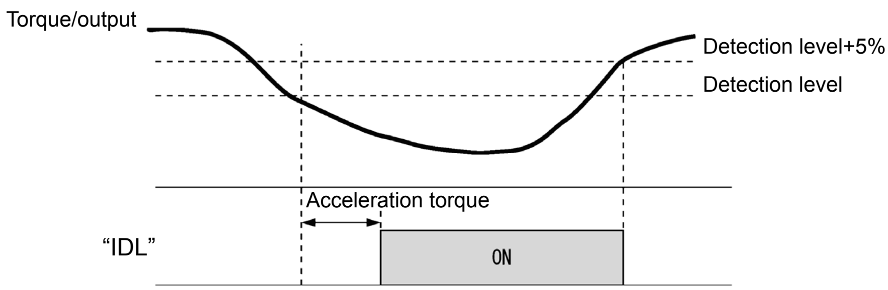
■Current detection, Current detection 2 and Current detection 3 – "ID", "ID2" and "ID3"

When the inverter output current exceeds the level specified by E34, E37 or E55 for the period specified by E35, E38 or E56, the ID, ID2 or ID3 signal turns ON, respectively. When the output current drops below 90% of the rated operation level, the ID, ID2 or ID3 turns OFF. (The minimum ON-duration is 100 ms.)



■Low current detection – "IDL"

This signal turns ON when the output current drops below the level specified by E37 (Low current detection, Level) for the period specified by E38 (Timer). When the output current exceeds the "Low current detection level plus 5% of the inverter rated current," it goes OFF. (The minimum ON-duration is 100 ms.)



E36	Frequency detection 2 (refer to E31)

Refer to the description of E31.

E37, E38	Current detection 2/Low current detection (level and timer) (refer to E34)

For details about Current detection 2/Low current detection (level) (timer), refer to the description of E34.

E39	**Coefficient for constant-rate feeding time** **Related function code: E50 (Coefficient for speed indication)**

E39 specifies the constant-rate feeding time, load shaft speed, coefficient for line speed setting, and coefficient for output status monitor indication.

Formula

$$\text{Constant rate (min)} = \frac{\text{Coefficient for speed indication(E50)}}{\text{Frequency x Coefficient for constant - rate feeding time (E39)}}$$

Load shaft speed = (E50: Coefficient for speed indication) x Frequency (Hz)

Line speed = (E50: Coefficient for speed indication) x Frequency (Hz)

The "Frequency" in the above formula is set frequency when each indication is the setting value (constant-rate feeding time setting, load shaft speed setting, and line speed setting), whereas it is output frequency before slip compensation when the indication is output status monitor.

When the constant-rate feeding time is 999.9 (min) or greater, or the denominator on the right-hand side of the above formula is 0, "999.9" is displayed.

E42	**LED Display filter**

Excluding speed monitor (at E43 = 0), E43 specifies a filter time constant to be applied for displaying the output frequency, output current and other running status monitored on the LED monitor on the keypad. If the display varies unstably so as to be hard to read due to load fluctuation or other causes, increase this filter time constant.

- Data setting range: 0.0 to 5.0 (s)

E43	LED monitor (display selection) Related function code: E48 LED monitor (speed monitor item)

E43 specifies the running status item to be monitored and displayed on the LED monitor. Specifying the speed monitor with E43 provides a choice of speed-monitoring formats selectable with E48 (LED Monitor).

Monitor item		Display sample on the LED monitor	LED indication	Unit	Meaning of displayed value	E43 data
Speed monitor		Function code E48 specifies what to be displayed on the LED monitor and LED indicators.				0
	Output frequency 1 (before slip compensation)	50.00	■ ⊖□ □⊢	Hz	Indicated value = Output frequency (Hz)	(E48 = 0)
	Output frequency 2 (after slip compensation)	50.00	■ ⊖□ □⊢	Hz	Indicated value = Output frequency (Hz)	(E48 = 1)
	Reference frequency	50.00	■ ⊖□ □⊢	Hz	Indicated value = Reference frequency (Hz)	(E48 = 2)
	Motor speed	1500	■ ⊖■ □⊢	min-1	Indicated value = Output frequency (Hz) $\times \frac{120}{P01}$	(E48 = 3)
	Load shaft speed	300.0	■ ⊖■ □⊢	min-1	Indicated value = Output frequency (Hz) x E50	(E48 = 4)
	Line speed	300.0	□ ⊖■ ■⊢	m/min	Indicated value = Output frequency (Hz) x E50	(E48 = 5)
	Constant-rate feeding time	50.00	□ ⊖□ □⊢	min	Indicated value = E50/(Output frequency x E39)	(E48 = 6)
	Display speed (%)	50.0	□ ⊖□ □⊢	%	Indicated value = $\frac{\text{Output frequency}}{\text{Maximum frequency}} \times 100$	(E48 = 7)
Output current		12.34	□ ⊖■ □⊢	A	Current output from the inverter in RMS	3
Output voltage		200U	□ ⊖□ □⊢	V	Output voltage (RMS) of the inverter	4
Calculated torque		50	□ ⊖□ □⊢	%	Motor output torque in % (Calculated value)	8
Input power		10.25	□ ⊖□ ■⊢	kW	Input power to the inverter	9
PID command		10.00.	□ ⊖□ □⊢	-	PID command and its feedback converted into physical quantities of the object to be controlled (e.g. temperature) Refer to function codes E40 and E41 for details.	10
PID feedback value		9.00.	□ ⊖□ □⊢	-		12
Timer value		100	□ ⊖□ □⊢	s	Timer value (remaining run time)	13
PID output		100.0.	□ ⊖□ □⊢	%	PID output in % as the maximum frequency (F03) being at 100%	14
Load factor		50L	□ ⊖□ □⊢	%	Load factor of the motor in % as the rated output being at 100%	15
Motor output		9.85	□ ⊖□ ■⊢	kW	Motor output in kW	16
Analog signal input monitor		82.00	□ ⊖□ □⊢	-	An analog input to the inverter in a format suitable for a desired scale. Refer to function codes E40 and E41 for details.	17
Input watt-hour		100.0	□ ⊖□ □⊢	kWh	Indicated value = $\frac{\text{Input watt-hour (kWh)}}{100}$	25

■ Illuminated, □ Not illuminated

E44	LED monitor (display when stopped)

E44 specifies whether the specified value (data = 0) or the output value (data = 1) to be displayed on the LED monitor of the keypad when the inverter is stopped. The monitored item depends on the E48 (LED monitor, Speed monitor item) setting as shown below.

E48 data	Monitored item	Inverter stopped	
		E44 = 0 Specified value	E44 = 1 Output value
0	Output frequency 1 (before slip compensation)	Reference frequency	Output frequency 1 (before slip compensation)
1	Output frequency 2 (after slip compensation)	Reference frequency	Output frequency 2 (after slip compensation)
2	Reference frequency	Reference frequency	Reference frequency
3	Motor speed	Reference motor speed	Motor speed
4	Load shaft speed	Reference load shaft speed	Load shaft speed
5	Line speed	Reference line speed	Line speed
6	Constant-rate feeding time	Constant-rate feeding time setting	Constant-rate feeding time
7	Display speed (%)	Reference display speed	Display Speed

E48	LED monitor (speed monitor item) (refer to E43)

For details about LED Monitor (Speed monitor item), refer tot he description of E43.

E50	Coefficient for speed indication

E50 specifies the coefficient that is used when the load shaft speed or line speed is displayed on the LED monitor. (Refer to the description of E43.)

Load shaft speed [min^{-1}]=(E50: Coefficient for speed indication) × (Output frequency Hz)

Line speed [m/min] = (E50: Coefficient for speed indication) × (Output frequency Hz)

- Data setting range: 0.01 to 200.00

E51	Display coefficient for input watt-hour data

E51 specifies a display coefficient (multiplication factor) for displaying the input watt-hour data (5_ 10) in a part of maintenance information on the keypad.

Input watt-hour data = Display coefficient (E51 data) × Input watt-hour (kWh)

- Data setting range: 0.000 (cancel/reset) 0.001 to 9999

Note: Setting E51 data to 0.000 clears the input watt-hour and its data to "0." After clearing, be sure to restore E51 data to the previous value; otherwise, input watt-hour data will not be accumulated.

E52	Keypad (menu display mode)

E52 provides a choice of three menu display modes for the standard keypad as listed below.

E52 data	Menu display mode	Menus to be displayed
0	Function code data editing mode	Menus #0, #1 and #7
1	Function code data check mode	Menus #2 and #7
2	Full-menu mode	Menus #0 through #7

E52 specifies the menus to be displayed on the standard keypad. There are eight menus as shown in the table below.

Menu #	LED monitor shows:	Function	Display content
0	0 FnC	Quick setup	Quick setup function code
1	1 F__	Data setting F to o	F to o group function code
2	2 rEP	Data check	Modified function code
3	3 oPE	Operation monitor	Operation status indication
4	4 I_o	I/O check	DIO, AIO status indication
5	5 CHE	Maintenance	Maintenance information indication
6	6 AL	Alarm information	Alarm information indication

For details of each menu item, refer to Chapter 3 "KEYPAD FUNCTIONS."

E54	Frequency detection 3 (level) (refer to E31)

For details, refer to the description of E31.

E55, E56	Current detection 3 (level and timer) (refer to E34)

For details, refer to the description of E34.

E59	Terminal [C1] function selection (C1 function//V2 function)

Specifies whether terminal [C1] is used with current input +4 to +20 mA/0 to 20 mA or voltage input 0 to +10 V. In addition, switch SW7 on the interface board must be switched.

E59 data	Input form	Switch SW7
0	Current input: 4 to 20 mA/0 to 20 mA (C1 function)	C1
1	Voltage input: 0 to 10 V (V2 function)	V2

Note When using terminal [C1] as a PTC thermistor input, specify E59 = 0.

For using terminal [C1] for the C1, V2 or PTC function, switching as shown below is necessary.

Terminal [C1]	SW3	SW4	E59	H26	C40
For use of C1 function (4 to 20 mA)	C1	AI	0	0	0,10
For use of C1 function (0 to 20 mA)	C1	AI	0	0	1, 11
For use of V2 function (0 to +10 V)	V2	AI	1	0	Does not matter
For use of PTC function	C1	PTC	Does not matter	1,2	Does not matter

For details about SW3 and SW4, refer to Chapter 2, Section 2.2.8.

⚠WARNING

Failure to correctly switch as shown above may cause a wrong analog input, possibly reading to unexpected operation of the inverter.

Injuries may occur.

Failure may occur.

E61 to E63 — Terminals [12], [C1] (C1 function), [C1] (V2 function) (extended function)

Select the functions of terminals [12], [C1] (C1 function) and [C1] (V2 function).

There is no need to set up these terminals if they are to be used for frequency command sources.

E61, E62, E63 data	Function	Description
0	None	–
1	Auxiliary frequency command 1	Auxiliary frequency input to be added to the reference frequency given by frequency command 1 (F01). Will not be added to any other reference frequency given by frequency command 2 and multi-frequency commands, etc. 100%/full scale
2	Auxiliary frequency command 2	Auxiliary frequency input to be added to all frequencies. Will be added to frequency command 1, frequency command 2, multi-frequency commands, etc. 100%/full scale
3	PID command 1	Inputs command sources such as temperature and pressure under PID control. You also need to set function code J02. 100%/full scale
5	PID feedback value	Inputs feedback values such as temperature and pressure under PID control. 100%/full scale
6	Ratio setting	Multiplies the final frequency command value by this value, for use in the constant line speed control by calculating the winder diameter or in ratio operation with multiple inverters. 100%/full scale
7	Analog torque limit value A	Used when analog inputs are used as torque limiters. (📖Function code F40) 300%/full scale
8	Analog torque limit value B	Used when analog inputs are used as torque limiters. (📖Function code F40) 300%/full scale
20	Analog signal input monitor	By inputting analog signals from various sensors such as the temperature sensors in air conditioners to the inverter, you can monitor the state of external devices via the communications link. By using an appropriate display coefficient, you can also have various values to be converted into physical quantities such as temperature and pressure before they are displayed. 100%/full scale

Note If these terminals have been set up to have the same data, E61 is given priority. For E62 and E63, only the terminal selected with E59 is enabled.

E64 — Saving of digital reference frequency

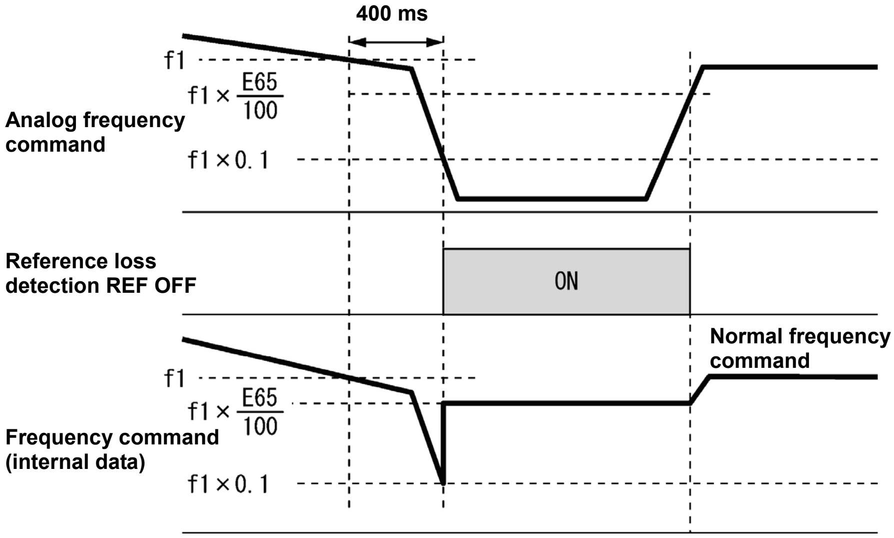
E64 specifies how to save the reference frequency specified in digital formats by the ∧/∨ keys on the keypad as shown below.

E64 data	Function
0	The reference frequency will be automatically saved when the main power is turned OFF. At the next power-on, the reference frequency at the time of the previous power-off applies.
1	Saving by pressing FUNC/DATA key. Pressing the FUNC/DATA key saves the reference frequency. If the control power is turned OFF without pressing the [image] key, the data will be lost. At the next power-ON, the inverter uses the reference frequency saved when the FUNC/DATA key was pressed last.

E65	Reference loss detection (continuous running frequency)

When the analog frequency command (setting through terminal [12], [C1] (C1 function) or [C1] (V2 function) has dropped below 10% of the reference frequency within 400 ms, the inverter presumes that the analog frequency command wire has been broken and continues its operation at the frequency determined by the ratio specified by E65 to the reference frequency.
(📖Function codes E20, E21 and E27, data = 33)

When the frequency command level (in voltage or current) returns to a level higher than that specified by E65, the inverter presumes that the broken wire has been fixed and continues to run following the frequency command.



In the diagram above, f1 is the level of the analog frequency command sampled at any given time. The sampling is repeated at regular intervals to continually monitor the wiring connection of the analog frequency command.

- Data setting range:0 (Decelerate to stop) 20 to 120 % 999 (Disable)

Note

Avoid an abrupt voltage or current change for the analog frequency command. An abrupt change may be interpreted as a wire break.

Setting E65 data at "999" (Disable) allows the REF OFF signal ("Reference loss detected") to be issued, but does not allow the reference frequency to change. (The inverter runs at the analog frequency command as specified.)

When E65 = "0" or "999," the reference frequency level at which the broken wire is recognized as fixed is "f1 × 0.2."

When E65 = "100" (%) or higher, the reference frequency level at which the wire is recognized as fixed is "f1 × 1."

The reference loss detection is not affected by the setting of analog input adjustment (filter time constants: C33, C38, and C43).

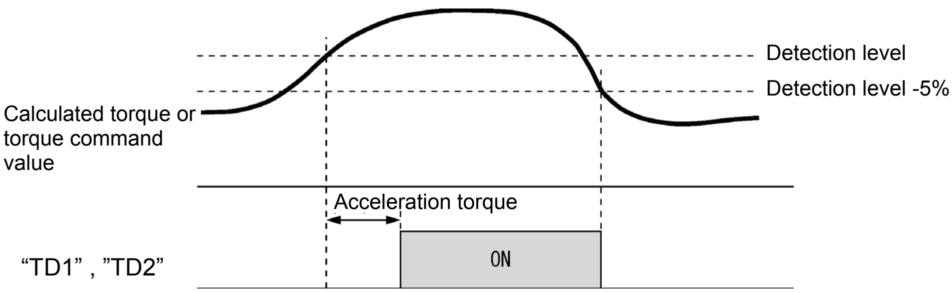
E78, E79 E80, E81	Torque detection 1 (level and timer) Torque detection 2/Low torque detection (level and timer)

E78 specifies the operation level and E79 specifies the timer, for the output signal “TD1”. E80 specifies the operation level and E81 specifies the timer, for the output signal “TD2” or “U-TL”.

Output signal	Assigned data	Operation level Range: 0 to 300%	Timer Range: 0.01 to 600.00 s
“TD1”	46	E78	E79
“TD2”	47	E80	E81
“U-TL”	45	E80	E81

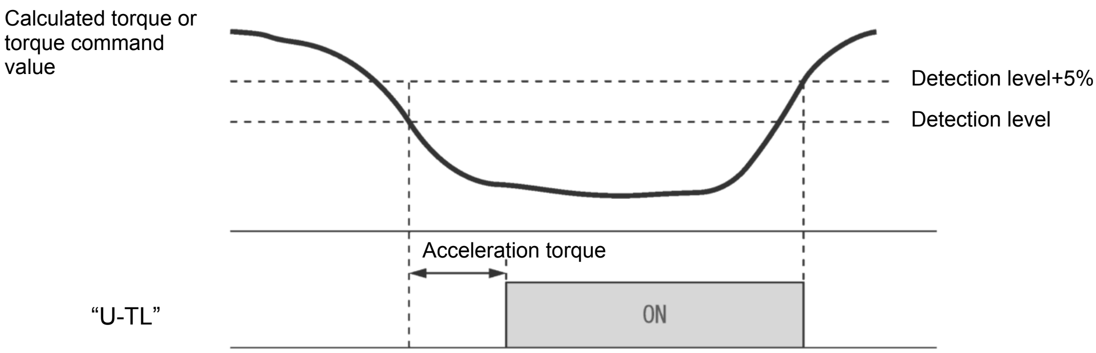
■Torque detection 1 – “TD1”, Torque detection 2 – “TD2”

The output signal TD1 or TD2 comes ON when the torque value calculated by the inverter or torque command exceeds the level specified by E78 or E80 (Torque detection (Level)) for the period specified by E79 or E81 (Torque detection (Timer)), respectively. The signal turns OFF when the calculated torque drops below "the level specified by E78 or E80 minus 5% of the motor rated torque." (The minimum ON-duration is 100 ms.)



■Low output torque detection – “U-TL”

This output signal comes ON when the torque value calculated by the inverter or torque command drops below the level specified by E80 (Low torque detection (Level)) for the period specified by E81 (Low torque detection (Timer)). The signal turns OFF when the calculated torque exceeds "the level specified by E78 or E80 plus 5% of the motor rated torque." (The minimum ON-duration is 100 ms.)



In the inverter’s low frequency operation, as a substantial error in torque calculation occurs, no low torque can be detected within the operation range at less than 20% of the base frequency (F04). (In this case, the result of recognition before entering this operation range is retained.) The U-TL signal goes off when the inverter is stopped.

Since the motor parameters are used in the calculation of torque, it is recommended that auto-tuning be applied by function code P04 to achieve higher accuracy.

E98, E99	Terminal [FWD] (function selection), Terminal [REV] (function selection) (refer to E01 to E05)

For details, refer to the descriptions of E01 to E05.

FUNCTION CODE

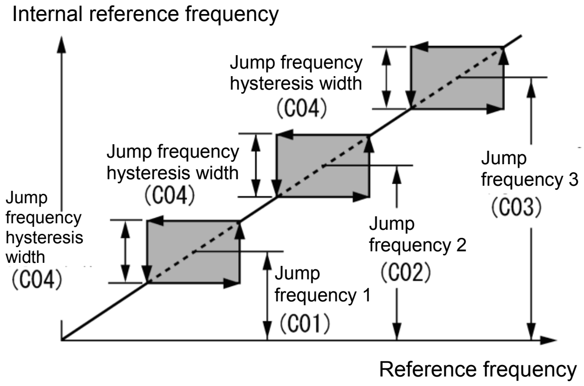
Chap. 5

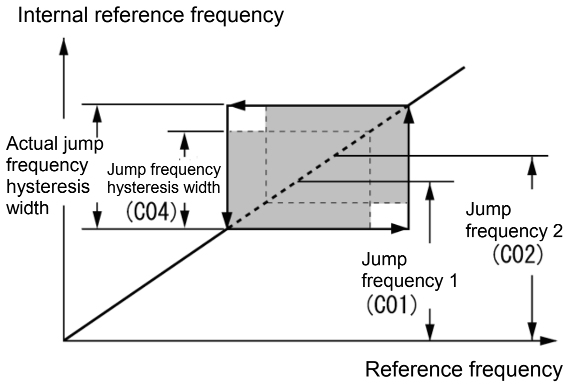
5.3.3 C codes (Control functions)

C01 to C04	Jump frequency 1, 2 and 3, Jump frequency (hysteresis width)

These function codes enable the inverter to jump over three different points on the output frequency in order to skip resonance caused by the motor speed and natural frequency of the driven machinery (load).

- While you are increasing the reference frequency, the moment the reference frequency reaches the bottom of the jump frequency band, the inverter keeps the output at that bottom frequency. When the reference frequency exceeds the upper limit of the jump frequency band, the internal reference frequency takes on the value of the reference frequency. When you are decreasing the reference frequency, the situation will be reversed. Refer to the figure on the lower left.
- When more than two jump frequency bands overlap, the inverter actually takes the lowest frequency within the overlapped bands as the bottom frequency and the highest as the upper limit. Refer to the figure on the lower right.





■Jump frequencies 1, 2 and 3 (C01, C02 and C03)

Specify the center of the jump frequency band.

- Data setting range: 0.0 to 500.0 (Hz) (Setting to 0.0 results in no jump frequency band.)

■Jump frequency hysteresis width (C04)

Specify the jump frequency hysteresis width.

- Data setting range: 0.0 to 30.0 (Hz) (Setting to 0.0 results in no jump frequency band.)

C05 to C19	Multi-frequency 1 to 15

■These function codes specify 15 frequencies required for driving the motor at frequencies 1 to 15.

Turning terminal commands “SS1”, “SS2”, “SS4” and “SS8” ON/OFF selectively switches the reference frequency of the inverter in 15 steps. To use these features, you need to assign “SS1”, “SS2”, “SS4” and “SS8” ("Select multi-frequency") to the digital input terminals with E01 to E05 (data = 0, 1, 2, and 3).

■Multi-frequency 1 to 15 (C05 through C19)

- Data setting range: 0.00 to 500.0 (Hz)

The combination of “SS1”, “SS2”, “SS4” and “SS8” and the selected frequencies are as follows.

“SS8”	“SS4”	“SS2”	“SS1”	Selected frequency command
OFF	OFF	OFF	OFF	Other than multi-frequency*
OFF	OFF	OFF	ON	C05 (Multi-frequency 1)
OFF	OFF	ON	OFF	C06 (Multi-frequency 2)
OFF	OFF	ON	ON	C07 (Multi-frequency 3)
OFF	ON	OFF	OFF	C08 (multi-frequency 4)
OFF	ON	OFF	ON	C09 (multi-frequency 5)
OFF	ON	ON	OFF	C10 (Multi-frequency 6)
OFF	ON	ON	ON	C11 (Multi-frequency 7)
ON	OFF	OFF	OFF	C12 (Multi-frequency 8)
ON	OFF	OFF	ON	C13 (Multi-frequency 9)
ON	OFF	ON	OFF	C14 (Multi-frequency 10)
ON	OFF	ON	ON	C15 (Multi-frequency 11)
ON	ON	OFF	OFF	C16 (Multi-frequency 12)
ON	ON	OFF	ON	C17 (Multi-frequency 13)
ON	ON	ON	OFF	C18 (Multi-frequency 14)
ON	ON	ON	ON	C19 (multi-frequency 15)

*"Other than multi-frequency" includes frequency command 1 (F01), frequency command 2 (C30) and other command sources except multi-frequency commands.

C20 | **Jogging frequency** **Related function codes: H54 and H55 Acceleration/Deceleration time (jogging)**

C20 specifies the operating condition (frequency) to apply in jogging operation.

Function code		Data setting range	Description
C20	Jogging frequency	0.00 to 500.00 (Hz)	Reference frequency for jogging operation
H54	Acceleration Time (Jogging)	0.00 to 6000 s	Acceleration time for jogging operation
H55	Deceleration Time (Jogging)	0.00 to 6000 s	Deceleration time for jogging operation

For details about jogging operation, refer to Chapter 3, Section 3.3.6 "Jogging Operation."

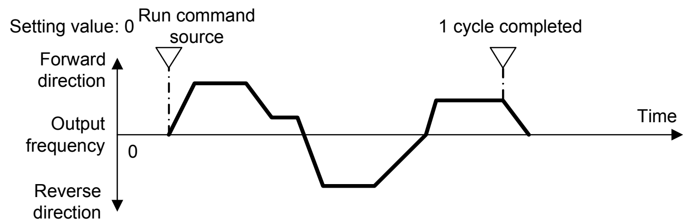
C21 C22 to C28	Pattern operation mode selection Stage 1 to 7 /timer operation

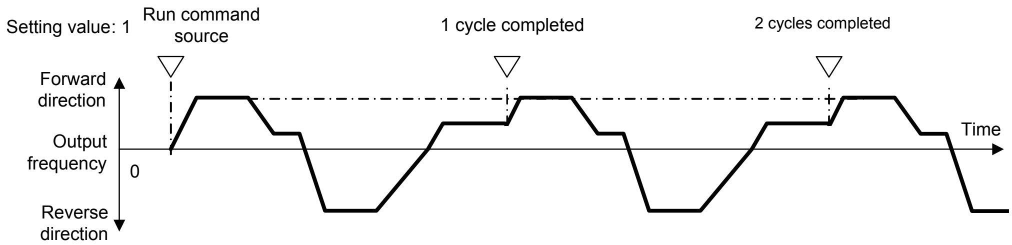
Pattern operation is a function of automatic operation according to the predefined run time, rotational direction, acceleration/deceleration time and reference frequency.

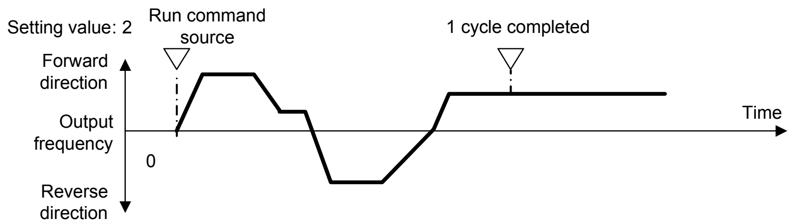
When using this function, set the frequency command (F01) to 10 (pattern operation).

The following operation patterns are available:

C21:Setting	Operation pattern
0	Pattern operation performed for one cycle and stopped after the cycle.
1	Pattern operation repeatedly performed and immediately stopped with a stop command
2	Pattern operation performed for one cycle and operation continued at the reference frequency after the cycle.
3	Timer operation







■ **C22 to C28 Stage 1 to Stage 7**

Specify the run time for Stage 1 to Stage 7.

Press the FUNC/DATA key three times for each function code to set the following three data.

Setting	Description
1st	Specifies the run time between 0.0 and 6000 s.
2nd	2nd: Specifies the rotational direction F (forward) or r (reverse)
3rd	3rd: Specifies the acceleration/deceleration time between 1 and 4. 1: F07/F08 2: E10/E11 3: E12/E13 4: E14/E15

If the PRG key is pressed to exit the function code before the three data are specified by pressing the FUNC/DATA key three times, no data are updated.

For any unused stage, specify 0.0 as the run time. The stage is skipped and the next stage becomes ready for setting.

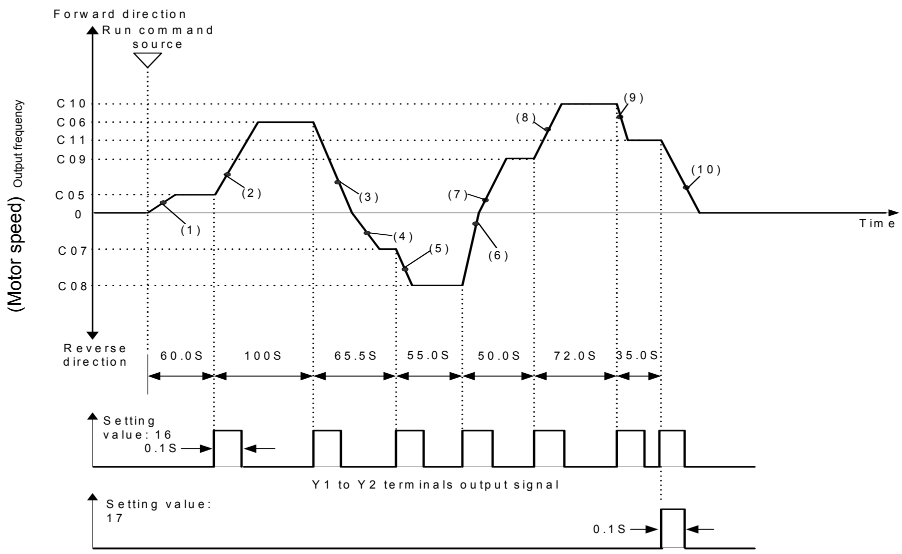
■ **Reference frequency**

Multi-frequency 1 to 7 are assigned to the reference frequency of Stage 1 to 7.

■ Example of pattern operation setting

C21 (Mode selection)	Stage No.	Run time Setting value	Rotational direction Setting value	Acceleration/deceleration time Setting value	Operation (reference) frequency
0	Stage 1	60.0	F	2	C05 Multi-frequency 1
	Stage 2	100	F	1	C06 Multi-frequency 2
	Stage 3	65.5	r	4	C07 Multi-frequency 3
	Stage 4	55.0	r	3	C08 Multi-frequency 4
	Stage 5	50.0	F	2	C09 Multi-frequency 5
	Stage 6	72.0	F	4	C10 Multi-frequency 6
	Stage 7	35.0	F	2	C11 Multi-frequency 7

The figure below illustrates the operation.



Set according to (1) to (10) Acceleration time or deceleration time

(1)	Acceleration time: E10
(2)	Acceleration time: F07
(3)	Deceleration time: E15
(4)	Acceleration time: E14
(5)	Acceleration time: E12
(6)	Deceleration time: E11
(7)	Acceleration time: E10
(8)	Acceleration time: E14
(9)	Deceleration time: E11
(10)	Deceleration time: F08

1 As the deceleration time after the completion of one cycle, the F08 Deceleration time 1 setting is used for deceleration to stop.

◆ To run or stop, use input from the RUN key of the keypad and switching of the control terminal. With the keypad, press the RUN key to run. Press the STOP key to suspend the progression of stages. Press the RUN key again to resume operation according to the stages from the point where it was suspended. For alarm stop, press the PRG/RESET key to reset the inverter protective functions. Then press the RUN key. The suspended progression of the stages resumes. If a need arises for operation from the first stage "C22 (Stage 1 runtime)" and "C82 (Stage 1 rotational direction and acceleration/deceleration time)" during operation, input a stop command and press the PRG/RESET key.

When operation from the first stage is necessary after an alarm stop, press the PRG/RESET key for resetting the protective functions and press the PRG/RESET key again. For the key, use of the "RST" terminal (set "8 (Active ON)" or "1008 (Active OFF)" for any of E01 to E05) functions the same way.

Tip

- Pattern operation can be started by either a forward run command (specify F02 = 2 and press the RUN key, or specify F02 = 1 and turn the FWD terminal ON) or reverse run command (specify F02 = 3 and press the RUN key, or specify F02 = 1 and turn the REV terminal ON). However, the rotational direction is as specified by C82 to C88 whether the operation is started by a forward run command or reverse run command.
- When the FWD or REV terminal is used, the run command self-hold function is disabled. Use an alternate-type switch.

⚠CAUTION

When pattern operation is started by specifying C21 = 0 and turning the FWD (REV) terminal ON, the motor stops after the completion of the last stage even if the FWD (REV) terminal is kept turned ON.
In this case, modifying the value for F01 or C30 or switching the control terminal "Hz2/Hz1" ON/OFF without turning the FWD (REV) terminal OFF causes the operation to be immediately resumed according to the reference frequency after the modification.
An accident or physical injury may result.

■ **Timer operation (C21 = 3)**

Select this for timer operation, in which simply specifying the run time and inputting a run command starts motor operation and stops the operation after the specified period has elapsed.

Tip
- To stop the timer operation, press the STOP key during timer countdown.
- When the timer period is 0, pressing the RUN key does not start operation even if C = 21.
- An external signal (FWD or REV) can also be used to start operation.

Example of timer operation

Preconfiguration

• To indicate the timer value on the LED monitor, set the data for E43 (LED monitor) to "13" (timer) and data for C21 to "3."

• Specify the reference frequency for timer operation. When the reference frequency is specified by keypad operation and the timer value is indicated, press the FUNC/DATA key to switch to speed monitor display and modify the reference frequency.

Timer operation (to start operation with the [FUN] key)

(1) While checking the timer value on the LED monitor, press the ∧/∨ key to specify the timer period (in seconds). (The timer value is indicated as an integer without a decimal point on the LED monitor.)

(2) Press the RUN key to start motor operation. The timer period is counted down. After the timer period has elapsed, the operation stops without the need for pressing the STOP key. (Timer operation is possible even when the LED monitor indication is not the timer value.)

Note For operation by turning the FWD terminal ON, the indication alternates between "end" and LED monitor display (0 for timer value) when the timer operation has been completed with deceleration to stop. Turning FWD OFF brings back the LED monitor display.

C30	Frequency command 2 (refer to F01)

For details of frequency command 2, refer to the description of F01.

C31 to C35 **C36 to C40** **C41 to C45**	**Analog input adjustment (terminal [12]) (offset, gain, filter time constant, gain base point, polarity)** **Analog input adjustment (terminal [C1] C1 function) (offset, gain, filter time constant, gain base point,** **range)** **Analog input adjustment (terminal [C1] V2 function) (offset, gain, filter time constant, gain base point,** **polarity) (refer to F01 for frequency command)**

C55, C56 **C61, C62** **C67, C68**	**Bias (for PID, frequency command 2 (terminal [12])) (bias, bias base point) (refer to F01)** **Bias (for PID, frequency command 2 (terminal [C1]) (C1 function)) (bias, bias base point) (refer to F01)** **Bias (for PID, frequency command 2 (terminal [C1]) (V2 function)) (bias, bias base point) (refer to F01)**

You can adjust the gain, bias, polarity, filter time constant and offset which are applied to analog inputs (voltage inputs to terminals [12] and [C1] (V2 function) and current input to terminal [C1] (C1 function)).

Adjustable items for analog inputs (excluding those for frequency command 1)

Input terminal	Input range	Bias		Gain		Polarity	Filter time constant	Offset
		Bias	Base point	Gain	Base point			
[12]	0 to +10 V, -10 to +10 V	C55	C56	C32	C34	C35	C33	C31
[C1] (C1)	4 to 20 mA, 0 to 20 mA	C61	C62	C37	C39	C40	C38	C36
[C1] (V2)	0 to +10 V	C67	C68	C42	C44	C45	C43	C41

■Offset (C31, C36, C41)

C31, C36 or C41 configures an offset for an analog voltage/current input. The offset also applies to signals sent from the external equipment.

- Data setting range: -5.0 to +5.0 (%)

■Filter time constant (C33, C38, C43)

C33, C38, and C43 provide the filter time constants for the voltage and current of the analog input. The larger the time constant, the slower the response. Specify the proper filter time constant taking into account the response speed of the machine (load). If the input voltage fluctuates due to line noises, increase the time constant.

- Data setting range: 0.00 to 5.00 (s)

■Polarity Terminal [12] (C35)

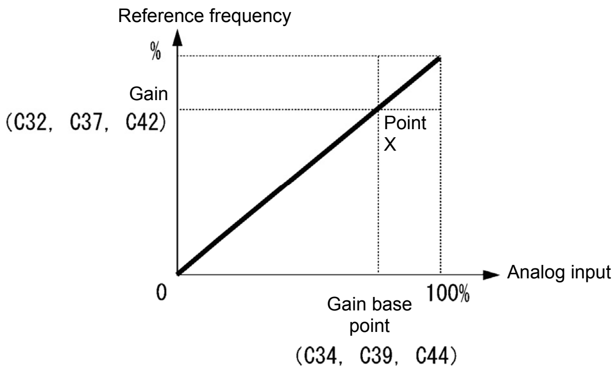
C35 and C45 configure the input range for analog input voltage.

C35 data	Modes for terminal inputs
0	-10 to +10 V
1	0 to +10 V (negative value of voltage is regarded as 0 V)

■ Polarity [C1] (V2 function) (C45)

C45 data	Modes for terminal inputs
0	0 to +10 V When the bias is specified to be a negative value, makes a point less than 0 effective as a negative value.
1	0 to +10 V (factory default) When the bias is specified to be a negative value, limits a point less than 0 to 0.

■Gain



Note To input bipolar analog voltage (0 to ±10 VDC) to terminal [12], set C35 data to "0." Setting C35 data to "1" enables the voltage range from 0 to +10 VDC and interprets the negative polarity input from 0 to -10 VDC as 0 V.

■Terminal [C1] (C1 function) range (C40)

Selects the range of current input terminal [C1](C1 function).

C40 data	Terminal input range	When bias is specified to be negative
0	4 to 20 mA (factory default)	Limits a point less than 0 to 0.
1	0 to 20 mA	
10	4 to 20 mA	Makes a point less than 0 effective as a negative value.
11	0 to 20mA	

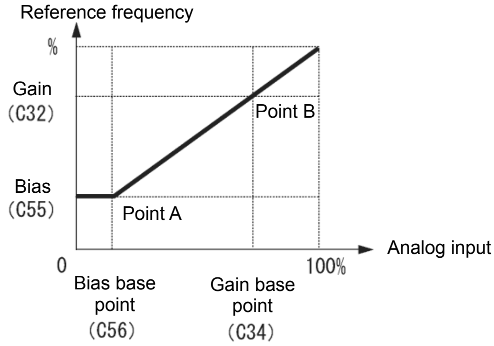
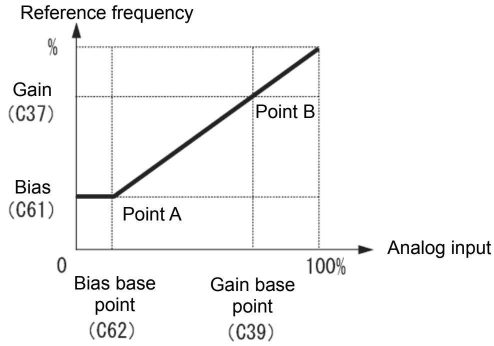
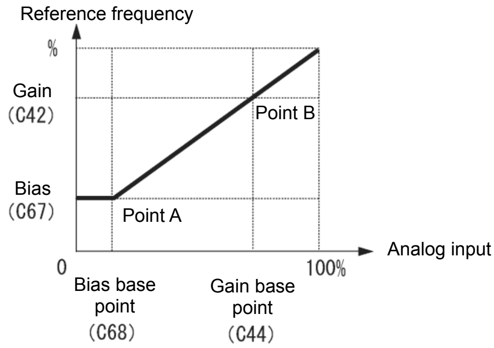
For using terminal [C1] for the C1, V2 or PTC function, switching as shown below is necessary.

Terminal [C1]	SW3	SW4	E59	H26	C40
For use of C1 function (4 to 20 mA)	C1	AI	0	0	0, 10
For use of C1 function (0 to 20 mA)	C1	AI	0	0	1, 11
For use of V2 function (0 to +10V)	V2	AI	1	0	Does not matter
For use of PTC function	C1	PTC	Does not matter	1, 2	Does not matter

For details about SW3 and SW4, refer to Chapter 2, Section 2.2.8.

Expected operation may not be obtained if the settings above are not switched correctly. Use sufficient caution.

■ Gain/bias

<table>
<tr><th>Terminal</th><th>PID command, feedback, analog monitor</th></tr>
<tr><td>[12]</td><td>
</td></tr>
<tr><td>[C1] (C1 function)</td><td>
</td></tr>
<tr><td>[C1] (V2 function)</td><td>
</td></tr>
</table>

These are biases and bias base points used for PID command, PID feedback, frequency command 2 and analog monitor. For details, refer to the description of F01 and J01.

Bias (C55, C61, C67)

- Data setting range: -100.00 to 100.00 (%)

Bias base point (C56, C62, C68)

- Data setting range: 0.00 to 100.00 (%)

Specifying the bias as a negative value allows an input to be specified as bipolar for a unipolar analog input. By setting C40 data to 10 or 11 for terminal [C1] (C1 function) or C45 data to 1 for terminal [C1] (V2 function), an input value for an analog input equal to or less than 0 point is specified to have negative polarity.

C50	Bias (Frequency command 1) (Bias base point) (refer to F01)

Refer to the description of F01.

C58 C64 C70	Analog input adjustment (for analog monitor (terminal [12])) (unit) Analog input adjustment (for analog monitor (terminal [C1])) (C1 function) (unit) Analog input adjustment (for analog monitor (terminal [C1])) (V2 function) (unit)

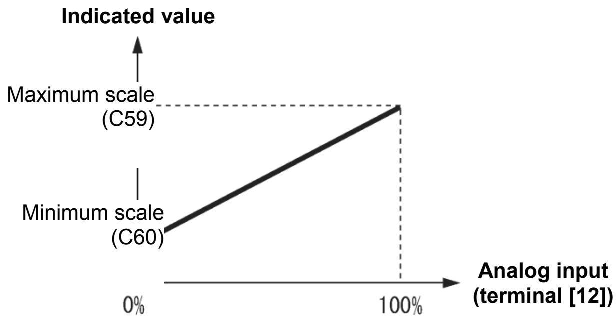
The units for the respective analog inputs can be displayed when a multi-function keypad (TP-A1) is used. Set these codes to use for command and feedback values of the analog input monitor and PID control. Use the multi-function keypad to display the SV and PV values of the analog input monitor and PID control on the main and sub-monitors. Indications are given in the specified units.

C58, C64, C70	Unit	C58, C64, C70	Unit	C58, C64, C70	Unit
-	-	23	L/s (flowrate)	45	mmHg (pressure)
1	No unit	24	L/min (flowrate)	46	Psi (pressure)
2	%	25	L/h (flowrate)	47	mWG (pressure)
4	r/min	40	Pa (pressure)	48	inWG (pressure)
7	kW	41	kPa (pressure)	60	K (temperature)
20	m^3/s (flowrate)	42	MPa (pressure)	61	°C (temperature)
21	m^3/min (flowrate)	43	mbar (pressure)	62	°F (temperature)
22	m^3/h (flowrate)	44	bar (pressure)	80	ppm (concentration)

C59, C60 C65, C66 C71, C72	Analog input adjustment (terminal [12]) (maximum scale, minimum scale) Analog input adjustment (terminal [C1] (C1 function)) (maximum scale, minimum scale) Analog input adjustment (terminal [C1] (V2 function)) (maximum scale, minimum scale)

Values of the analog input monitor (terminals [12] and [C1] (C1 and V2 functions) can be converted into easily recognizable physical quantities for display. This function can also be used for PID feedback and PID command values.

- Data setting range: (maximum scale and minimum scale) -999.00 to 0.00 to 9990.00



C53	Selection of normal/inverse operation (frequency command 1)

Switches between the between normal and inverse operation of frequency command 1 (F01) .

For details, refer to E01 through E05 (data = 21) for the terminal command IVS ("Switch normal/inverse operation").

5.3.4 P codes (Motor 1 parameters)

To use the integrated automatic control functions such as auto torque boost, torque calculation monitoring, auto energy saving operation, torque limiter, automatic deceleration (anti-regenerative control), auto search for idling motor speed, slip compensation, vector control without speed sensor (torque vector), droop control, and overload stop, it is necessary to build a motor model in the inverter by specifying proper motor parameters including the motor capacity and rated current.

The FRENIC-Ace, provides built-in motor parameters for Fuji standard motors 8-series. To use these Fuji motors, it is enough to specify motor parameters for P99 (Motor 1 Selection). If the cabling between the inverter and the motor is long (generally, 20 m or longer) or a reactor is inserted between the motor and the inverter, however, the apparent motor parameters are different from the actual ones, so auto-tuning or other adjustments are necessary.

For the auto-tuning procedure, refer to the FRENIC-Ace Instruction Manual, Chapter 4 " RUNNING THE MOTOR."

When using a motor made by other manufacturers or a Fuji non-standard motor, obtain the datasheet of the motor and specify the motor parameters manually or perform auto-tuning.

P01	Motor 1 (No. of poles)

P01 specifies the number of poles of the motor. Enter the value given on the nameplate of the motor. This setting is used to display the motor speed on the LED monitor and to control the speed (refer to E43). The following expression is used for the conversion.

Motor rotational speed (min^{-1}) = 120/No.of poles x Frequency (Hz)

- Data setting range: 2 to 22 (poles)

P02	Motor 1 (Rated capacity)

P02 specifies the rated capacity of the motor. Enter the rated value given on the nameplate of the motor.

P02 data	Unit	Function
0.01 to 1000	kW	When P99 (Motor 1 Selection) = 0, 4
	HP	When P99 (Motor 1 Selection) = 1

When accessing P02 with the keypad, take into account that the P02 data automatically updates data of P03, P06 through P13, P53 and H46.

P03	Motor 1 (rated current)

P03 specifies the rated current of the motor. Enter the rated value given on the nameplate of the motor.

- Data setting range: 0.00 to 2000 (A)

P04	Motor 1 (auto-tuning)

The inverter automatically detects the motor parameters and saves them in its internal memory. Basically, it is not necessary to perform tuning when a Fuji standard motor is used with a standard connection with the inverter.

There are two types of auto-tuning as listed below. Select appropriate one considering the limitations in your equipment and control mode.

P04 data	Auto-tuning	Action	Motor parameters to be tuned
0	Disable	---	---
1	Tune the motor while it is stopped	Tunes while the motor is stopped.	Primary resistance (%R1) (P07) Leakage reactance (%X) (P08) Rated slip frequency (P12) %X correction factors 1 (P53)
2	Tune the motor while it is rotating under V/f control	After tuning the motor in a stopped state, retunes it running at 50% of the base frequency.	No-load current (P06) Primary resistance (%R1) (P07) Leakage reactance (%X) (P08) Rated slip frequency (P12) %X correction factor 1 (P53)

For details of auto-tuning, refer to the FRENIC-Ace Instruction Manual, Chapter 4 " RUNNING THE MOTOR."

Note: In any of the following cases, perform auto-tuning since the motor parameters are different from those of Fuji standard motors so that the best performance cannot be obtained under some controls.

- The motor to be driven is a non-Fuji motor or a non-standard motor.
- Cabling between the motor and the inverter is long. (Generally, 20 m or longer)
- A reactor is inserted between the motor and the inverter.

Other applicable cases

■ Functions in which the motor parameters affect the running capability

Function	Related function codes (representative)
Auto torque boost	F37
Output torque monitor	F31, F35
Load factor monitor	F31, F35
Auto energy saving operation	F37
Torque limit control	F40
Anti-regenerative control (Automatic deceleration)	H69
Auto search	H09
Slip compensation	F42
Vector control without speed sensor (dynamic torque vector)	F42
Droop control	H28
Torque detection	E78 to E81
Brake Signal (Brake-OFF torque)	J95

P05	Motor 1 (online tuning)

When vector control without speed sensor (dynamic torque vector) or slip compensation control is used for long-time operation, the motor parameters change along with motor temperature rise.

If motor parameters change, the amount of speed compensation may change to cause the motor speed to be different from the initial speed.

Enabling auto-tuning allows the identification of the motor parameters that match the change in the motor temperature, which minimizes the motor speed variation.

To use this function, specify "2" for auto-tuning (P04).

Note: Online tuning is enabled only when F42 = 1 (Vector control without speed sensor) or F42 = 2 (V/f control with slip compensation active) and F37 = 2, 5 (auto torque boost).

P06 to P08	Motor 1 (no-load current, %R1 and %X)

P06 through P08 specify no-load current, %R1 and %X, respectively. Obtain the appropriate values from the test report of the motor or by calling the manufacturer of the motor. Performing auto-tuning automatically sets these parameters.

- No-load current: Input the value obtained from the motor manufacturer.
- %R1: Enter the value calculated by the following expression.

$$\%R1 = \frac{R1 + \text{Cable R1}}{V / (\sqrt{3} \times I)} \times 100 \ (\%)$$

R1: Primary resistance of the motor (Ω)

Cable R1: Resistance of the output cable (Ω)

V: Rated voltage of the motor (V)

I: Rated current of the motor (A)

- %X: Enter the value calculated by the following expression.

$$\%X = \frac{X1 + X2 \times XM / (X2 + XM) + \text{Cable X}}{V / (\sqrt{3} \times I)} \times 100 \ (\%)$$

X1: Primary leakage reactance of the motor (Ω)

X2: Secondary leakage reactance of the motor (converted to primary) (Ω)

XM: Exciting reactance of the motor (Ω)

Cable X: Reactance of the output cable (Ω)

V: Rated voltage of the motor (V)

I: Rated current of the motor (A)

Note: For reactance, use the value at the base frequency (F04).

P09 to P11	Motor 1 (slip compensation gain for driving, slip compensation response time and slip compensation gain for braking)

P09 and P11 determine the slip compensation amount in % for driving and braking individually and adjust the slip amount from internal calculation. Mode of 100% fully compensates for the rated slip of the motor. Excessive compensation (100% or more) may cause hunting (undesirable oscillation of the system), so carefully check the operation on the actual machine.

P10 determines the response time for slip compensation. Basically, there is no need to modify the default setting. If you need to modify it, consult your Fuji Electric representatives.

Function code		Operation (slip compensation)
P09	Slip compensation gain for driving	Adjust the slip compensation amount for driving. Slip compensation amount for driving = Rated slip x Slip compensation gain for driving
P11	Slip compensation gain for braking	Adjust the slip compensation amount for braking. Slip compensation amount for braking = Rated slip x Slip compensation gain for braking
P10	Slip compensation response time	Specify the slip compensation response time. Basically, there is no need to modify the setting.

For details about slip compensation control, refer to the description of F42.

P12	Motor 1 (rated slip frequency)

P12 specifies rated slip frequency. Obtain the appropriate values from the test report of the motor or by calling the manufacturer of the motor. Performing auto-tuning automatically sets these parameters.

- Rated slip frequency: Convert the value obtained from the motor manufacturer to Hz using the following expression and enter the converted value.

(Note: The motor rating given on the nameplate sometimes shows a larger value.)

$$\text{Rated slip frequency (Hz)} = \frac{\text{(Synchronous speed - Rated speed)}}{\text{Synchronous speed}} \times \text{Base frequency}$$

For details about slip compensation control, refer to the description of F42.

P13	Motor 1 (iron loss factor 1)

The combination of P99 (Motor 1 selection) and P02 (Motor 1 rated capacity) data determines the standard value.

Basically, there is no need to modify the setting.

P53	Motor 1 (%X correction factor 1)

This is a factor for correcting the variation of leakage reactance %X. Basically, there is no need to modify the setting.

P99	Motor 1 selection

P99 specifies the motor type to be used.

P99 data	Function
0	Motor characteristics 0 (Fuji standard motors, 8-series)
1	Motor characteristics 1 (HP rating motors)
4	Other motors

To select the motor drive control or to run the inverter with the integrated automatic control functions such as auto torque boost and torque calculation monitoring, it is necessary to specify the motor parameters correctly.

First select the motor type with P99 from Fuji standard motors 8-series and then initialize the motor parameters with H03. This process automatically configures the related motor parameters (P01, P03, P06 through P13,P53 and H46).
The data of F09 (Torque boost 1), H13 (Restart Mode after Momentary Power Failure (Restart time)), and F11 (Electronic thermal overload protection for motor 1 (Overload detection level)) depends on the motor capacity, but the process stated above does not change them. Specify and adjust the data during a test run if needed.

5.3.5 H codes (High performance functions)

H03	Data initialization

Initialize all function code data to the factory defaults. The motor parameters are also initialized.

To change the H03 data, it is necessary to press the STOP + ∧/∨ keys (simultaneous keying).

H03 data	Function
0	Disable initialization (Settings manually made by the user will be retained.)
1	Initialize all function code data to the factory defaults
2	Initialize motor 1 parameters in accordance with P02 (Rated capacity) and P99 (Motor 1 selection)
3	Initialize motor 2 parameters in accordance with A16 (Rated capacity) and A39 (Motor 2 selection)
11	Limited initialization (initialization other than communications function codes): Communication can be continued after initialization.
12	Limited initialization (initialization of customizable logic function U codes only)

- To initialize the motor parameters, set the related function codes as follows.

Step	Item	Data	Function code	
			1st motor	2nd motor
(1)	Motor selection	Selects the motor type	P99	A39
(2)	Motor (rated capacity)	Sets the motor capacity (kW)	P02	A16
(3)	Data initialization	Initialize motor parameters	H03 = 2	H03 = 3
Function code data to be initialized			P01, P03, P06 to P13, P53, H46	A15, A17, A20 to A27, P53

- Upon completion of the initialization, the H03 data reverts to "0" (factory default).
- If P02/A16 data is set to a value other than the standard nominal applied motor rating, data initialization with H03 internally converts the specified value forcibly to the standard nominal applied motor rating. (See Table B given on the last page in "5.2 Function code table.")
- Motor parameters to be initialized are for motors listed below under V/f control. When the base frequency, rated voltage, and the number of poles are different from those of the listed motors, or when non-Fuji motors or non-standard motors are used, change the rated current data to that printed on the motor nameplate.

Motor selection		V/f control data
Data = 0 or 4	Fuji standard motors, 8-series	4 poles 200 V/50 Hz, 400 V/50 Hz
Data = 1	HP rating motors	4 poles 230 V/60 Hz, 460 V/60 Hz

Note: When accessing P02 with the keypad, take into account that the P02 data automatically updates data of P03, P06 through P13, P53 and H46. Also, when accessing function code A16 for the 2nd motor, data of related function codes for each are automatically updated.

H04, H05	Auto-reset (times and reset interval)

H04 and H05 specify the auto-reset function that makes the inverter automatically attempt to reset the tripped state and restart without issuing an alarm output (for any alarm) even if any protective function subject to reset is activated and the inverter enters the forced-to-stop state (tripped state). If the protective function is activated in excess of the times specified by H04, the inverter will issue an alarm output (for any alarm) and not attempt to auto-reset the tripped state.

Listed below are the protective functions subject to auto-reset.

Protective function	LED monitor displays:	Protective function	LED monitor displays:
Overcurrent protection	OC1, OC2, OC3	Motor overheat	OH4
Overvoltage protection	OU1, OU2, OU3	Braking resistor overheat	dbH
Heat sink overheat	OH1	Motor overload	OL1, OL2
Inverter internal overheat	OH3	Inverter overload	OLU

■ Number of reset times (H04)

H04 specifies the number of reset times for the inverter to automatically attempt to escape the tripped state. When H04 = 0, the auto-reset function will not be activated.

- Data setting range: 0 (Disable), 1 to 20 (times)

⚠CAUTION

If the "auto-reset" function has been specified, the inverter may automatically restart and run the motor stopped due to a trip fault, depending on the cause of the tripping. Design the machinery so that human body and peripheral equipment safety is ensured even when the auto-resetting succeeds.

Otherwise an accident could occur.

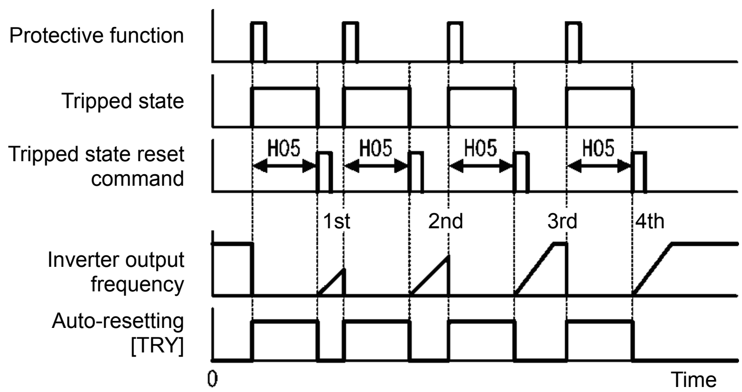
■ Reset interval (H05)

- Data setting range: 0.5 to 20.0 (s)

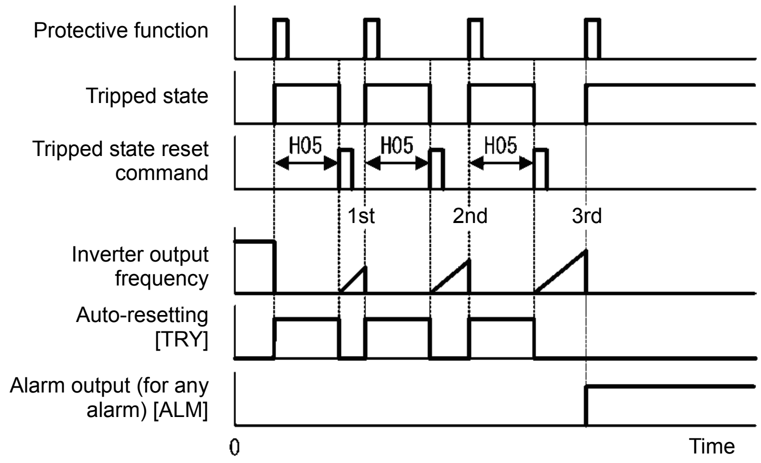
H05 specifies the reset interval time between the time when the inverter enters the tripped state and the time when it issues the reset command to attempt to auto-reset the state. Refer to the timing scheme diagrams below.

<Operation timing scheme>

- In the figure below, normal operation restarts in the 4-th retry.



- In the figure below, the inverter failed to restart normal operation within the number of reset times specified by H04 (in this case, 3 times (H04 = 3)), and issued the alarm output (for any alarm) ALM.



- The auto-reset operation can be monitored from the external equipment by assigning the digital output signal TRY to any of the programmable, output terminals [Y1], [Y2] or [30A/B/C] with any of E20, E21 or E27 (data = 26).

H06	Cooling Fan ON/OFF Control

To prolong the service life of the cooling fan and reduce fan noise during running, the cooling fan stops when the temperature inside the inverter drops below a certain level while the inverter stops. However, since frequent switching of the cooling fan shortens its service life, the cooling fan keeps running for 10 minutes once started.

H06 specifies whether to keep running the cooling fan all the time or to control its ON/OFF.

H06 data	Function
0	Disable (Always in operation)
1	Enable (ON/OFF controllable)

■ Cooling fan in operation -- FAN (E20, E21 and E27, data = 25)

With the cooling fan ON/OFF control enabled (H06 = 1), this output signal is ON when the cooling fan is in operation, and OFF when it is stopped. This signal can be used to make the cooling system of peripheral equipment interlocked for an ON/OFF control

H07	Acceleration/Deceleration pattern (refer to F07)

For details, refer to the description of F07.

H08	Rotational direction limitation

H08 inhibits the motor from running in an unexpected rotational direction due to miss-operation of run commands, miss-polarization of frequency commands, or other mistakes.

H08 data	Function
0	Disable
1	Enable (Reverse rotation inhibited)
2	Enable (Forward rotation inhibited)

H09	Starting mode (auto searchmode) Related function codes: H49 (Starting mode, auto search delay time 1) H46 (Starting mode, auto search delay time 2)

Specify the mode for auto search without stopping the idling motor. The mode can be specified for each restart after momentary power failure and each start of normal operation. The starting mode can be switched by assigning “STM” to a general-purpose digital input signal. If it is not assigned, “STM” is regarded to be OFF. (Data = 26)

■ **H09 (Starting mode, auto search) and terminal command “STM” ("Enable auto search for idling motor speed at starting")**

The combination of H09 data and the “STM” status determines whether to perform the auto search as listed below.

Function code	Drive control	Factory default
H09	V/f control (F42 = 0 to 2)	0: Disable

H09 data	Enable auto search for idling motor speed at starting “STM”	Auto search for idling motor speed at starting	
		For restart after momentary power failure (F14 = 3 to 5)	For normal startup
0: Disable	OFF	Disable	Disable
1: Enable	OFF	Enable	Disable
2: Enable	OFF	Enable	Enable
—	ON	Enable	Enable

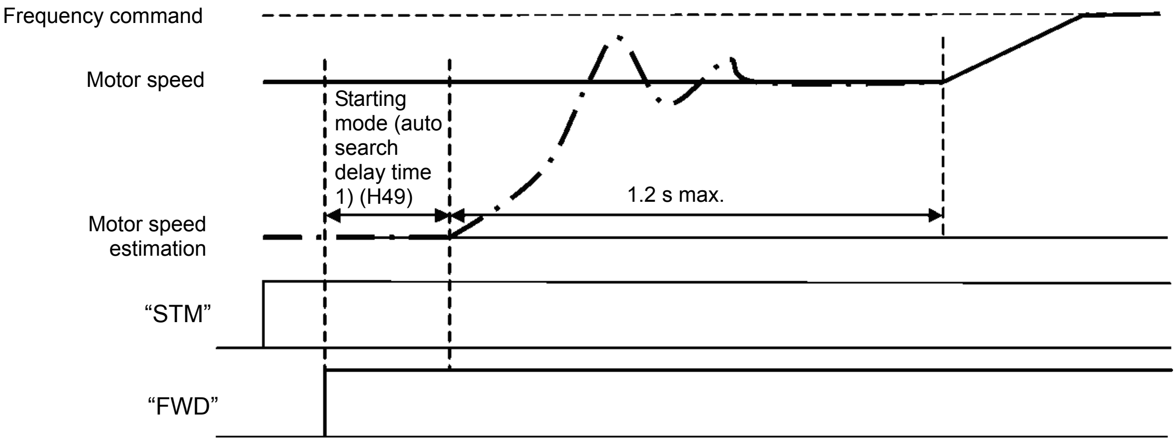
When “STM” is ON, auto search for idling motor speed at starting is enabled regardless of the H09 setting. (📖Function codes E01 to E05, data =26)

FUNCTION CODE

Chap. 5

Auto search for idling motor speed to follow

Starting the inverter (with a run command ON, BX OFF, auto-reset, etc.) with STM being ON searches for the idling motor speed for a maximum of 1.2 seconds to run the idling motor without stopping it. After completion of the auto search, the inverter accelerates the motor up to the reference frequency according to the frequency command and the preset acceleration time.



■ **Starting mode (auto search delay time 1) (H49)**

- Data setting range: 0.0 to 10.0 (s)

Auto search does not function normally when performed with the residual voltage remaining in the motor.

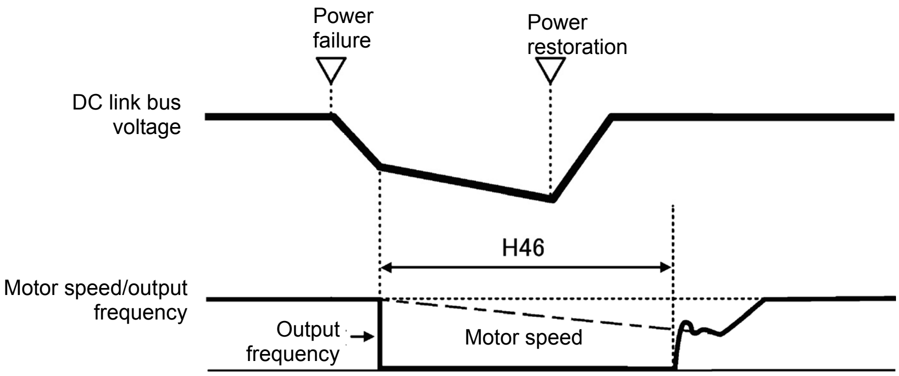
Accordingly, time to allow the residual voltage to disappear must be ensured.

When operation is started by turning a run command ON, auto search is started after the period specified with the starting mode (auto search delay time) (H49) has elapsed. When switching between two inverters for controlling one motor and coasting to stop the motor at the time of switching to start by auto search, specifying H49 eliminates the need for timing the run command.

■ **Starting mode (auto search delay time 2) (H46)**

- Data setting range: 0.1 to 20.0 (s)

At the restart after a momentary power failure, at the start by turning the terminal command "BX" ("Coast to a stop") OFF and ON, or at the restart by auto-reset, the inverter applies the delay time specified by H46. The inverter will not start unless the time specified by H46 has elapsed, even if the starting conditions are satisfied. The inverter starts after the auto search delay time has elapsed.



Under auto search control, the inverter searches the motor speed with the voltage applied at the motor start and the current flowing in the motor, based on the model built with the motor parameters. Therefore, the search is greatly influenced by the residual voltage in the motor.

H46 is available for motor 1 only. At factory shipment, H46 data is preset to a correct value according to the motor capacity for the general-purpose motor, and basically there is no need to modify the data.

Depending on the motor characteristics, however, it may take time for residual voltage to disappear (due to the secondary thermal time constant of the motor). In such a case, the inverter starts the motor with the residual voltage remaining, which will cause an error in the speed search and may result in occurrence of an inrush current or an overvoltage alarm.

If it happens, increase the value of H46 data and remove the influence of residual voltage.
(If possible, it is recommended to set the value around two times as large as the factory default value allowing a margin.)

Note
- Be sure to auto-tune the inverter preceding the start of auto search for the idling motor speed.
- When the estimated speed exceeds the maximum frequency or the upper limit frequency, the inverter disables auto search and starts running the motor with the maximum frequency or the upper limit frequency, whichever is lower.
- During auto search, if an overcurrent or overvoltage trip occurs, the inverter restarts the suspended auto search.
- Perform auto search at 60 Hz or below.

Note Note that auto search may not fully provide the performance depending on load conditions, motor parameters, wiring length, and other external factors.

H11	**Deceleration mode**

H11 specifies the deceleration mode to be applied when a run command is turned OFF.

H11 data	Action
0	Normal deceleration
1	The inverter immediately shuts down its output, so the motor stops according to the inertia of the motor and machinery (load) and their kinetic energy losses.

Note When reducing the reference frequency, the inverter decelerates the motor according to the deceleration commands even if H11 = 1 (Coast-to-stop).

H12	**Instantaneous overcurrent limiting (mode selection)** **(refer to F43)**

Refer to the descriptions of F43 and F44.

H13, H14 **H15, H16**	**Restart mode after momentary power failure (restart time, frequency fall rate)** **Restart mode after momentary power failure (continuous running level, allowable momentary power failure time)** **(refer to F14)**

For how to set these function codes (Restart time, Frequency fall rate, Continuous running level and Allowable momentary power failure time), refer to the description of F14.

H26, H27	Thermistor (for motor) (mode selection and Level)

These function codes specify the PTC (Positive Temperature Coefficient) thermistor embedded in the motor. The thermistor is used to protect the motor from overheating or output an alarm signal.

■ Thermistor (for motor) (mode selection) (H26)

H26 selects the function operation mode (protection or alarm) for the PTC/NTC thermistor as shown below.

H26 data	Action
0	Disable
1	When the voltage sensed by PTC thermistor exceeds the detection level, motor protective function (alarm OH4) is triggered, causing the inverter to enter an alarm stop state.
2	When the voltage sensed by the PTC thermistor exceeds the detection level, a motor alarm signal is output but the inverter continues running. You need to assign the "Motor overheat detected by thermistor" signal (“THM”) to one of the digital output terminals beforehand, by which a temperature alarm condition can be detected by the thermistor (PTC) (E20, E21 and E27, data = 56).

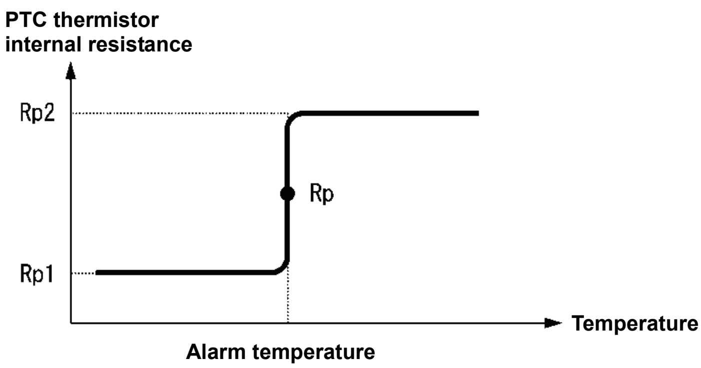
If H26 data is set to "1" or "2" (PTC thermistor), the inverter monitors the voltage sensed by PTC thermistor and protect the motor even when the 2ndmotor is selected.

■ Thermistor (for motor) (level) (H27)

H27 specifies the detection level (expressed in voltage) for the temperature sensed by the PTC thermistor.

- Data setting range: 0.00 to 5.00 (V)

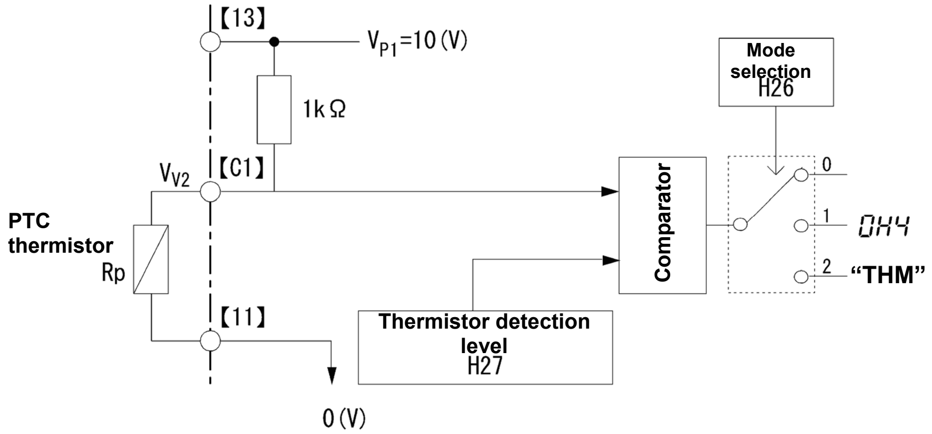
The alarm temperature at which the overheat protection becomes activated depends on the characteristics of the PTC thermistor. The internal resistance of the thermistor will significantly change at the alarm temperature. The detection level (voltage) is specified based on the change of the internal resistance.



Suppose that the internal resistance of the PTC thermistor at the alarm temperature is Rp, the detection level (voltage) V_{v2} is calculated by the expression below. Set the result V_{v2} to function code H27.

$$V_{V2} = \frac{R_p}{1000 + 5 \times R_p} \times 10.5(V)$$

Connect the PTC thermistor as shown below. The voltage obtained by dividing the input voltage on terminal [C1] with a set of internal resistors is compared with the detection level voltage specified by H27.

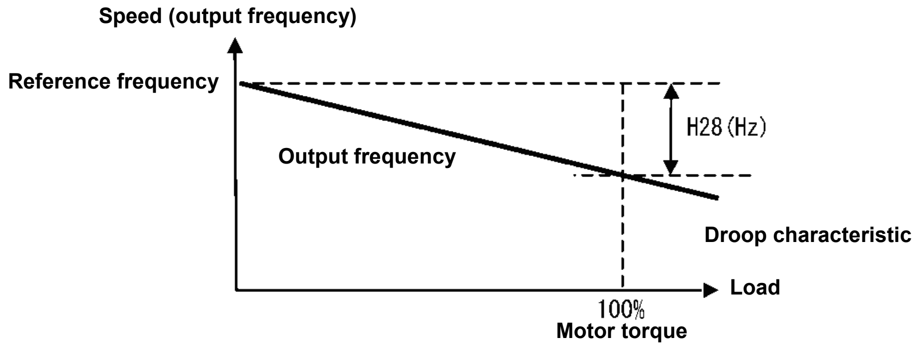


Note When using the terminal [C1] for PTC thermistor input, also turn SW4 on the control printed circuit board to the PTC/NTC side. For details, refer to Chapter 2.

H28	Droop control

In a system in which two or more motors drive single machinery, any speed gap between inverter-driven motors results in some load unbalance between motors. Droop control allows each inverter to drive the motor with the speed droop characteristic for increasing its load, eliminating such kind of load unbalance.

- Data setting range: -60.0 to 0.0 (Hz), (0.0: Disable)



■ Select droop control – "DROOP" (E01 to E05, data = 76)

The terminal command "DROOP" toggles droop control on and off.

The terminal command "DROOP"	Droop control
ON	Enable
OFF	Disable

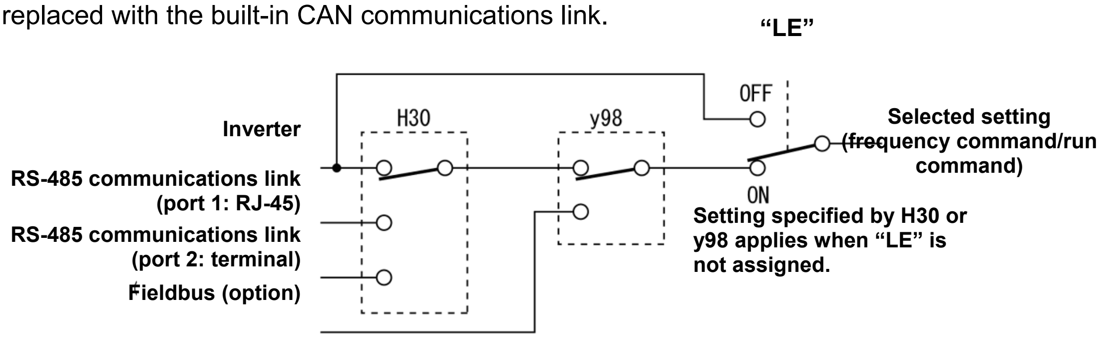
Note To use droop control, be sure to auto-tune the inverter for the motor.

Under V/f control, to prevent the inverter from tripping even at an abrupt change in load, droop control applies the acceleration/deceleration time to the frequency obtained as a result of droop control. This may delay reflection of the frequency compensated during droop control on the motor speed, thereby running the inverter as if droop control is disabled.

H30	Communications link function (mode selection) Related function codes: y98 bus link function (mode selection)

Using the RS-485 communications link, built-in CAN communications link or fieldbus (option) allows you to issue frequency commands and run commands from a computer or PLC at a remote location, as well as monitor the inverter running information and the function code data. Sets the source that specifies the frequency and run commands with H30 and y98. H30 and y98 set the sources that specify RS-485 communications and fieldbus respectively.

When the built-in CAN communications link is enabled with y33 = 1, the fieldbus in the figure below is replaced with the built-in CAN communications link.



Command sources selectable

Command sources	Data
Inverter itself	Sources except RS-485 communications link and fieldbus Frequency command source: Specified by F01/C30, or multi-frequency command Run command source: Via the keypad or digital input terminals selected by F02
Via RS-485 communications link (port 1)	Via the standard RJ-45 port used for connecting a keypad
Via RS-485 communications link (port 2)	C model (for China):Via the terminals DX+, DX- and SD Other than C model (other than for China): Via RJ-12 connector
Via fieldbus (option and built-in CAN)	Via fieldbus (DeviceNet, PROFIBUS DP, etc.) Via built-in CAN communications link

*C model (for China) is not equipped with the CAN communications link.

Command sources specified by H30 (Communications link function, Mode selection)

H30 data	Frequency command	Run command source
0	Inverter itself (F01/C30)	Inverter itself (F02)
1	RS-485 communications link (port 1)	Inverter itself (F02)
2	Inverter itself (F01/C30)	RS-485 communications link (port 1)
3	RS-485 communications link (port 1)	RS-485 communications link (port 1)
4	RS-485 communications link (port 2)	Inverter itself (F02)
5	RS-485 communications link (port 2)	RS-485 communications link (port 1)
6	Inverter itself (F01/C30)	RS-485 communications link (port 2)
7	RS-485 communications link (port 1)	RS-485 communications link (port 2)
8	RS-485 communications link (port 2)	RS-485 communications link (port 2)

Command sources specified by y98 (Bus link function, Mode selection)

y98 data	Frequency command	Run command source
0	Follow H30 data	Follow H30 data
1	Via fieldbus (option)	Follow H30 data
2	Follow H30 data	Via fieldbus (option)
3	Via fieldbus (option)	Via fieldbus (option)

H30 and y98 settings by combination of sources

		Frequency command			
		Inverter itself	Via RS-485 communications link port 1	Via RS-485 communications link port 2	Via fieldbus (option)
Run command source	Inverter itself	H30 = 0 y98 = 0	H30 = 1 y98 = 0	H30 = 4 y98 = 0	H30 = 0 (1, 4) y98 = 1
	Via RS-485 communications link (port 1)	H30 = 2 y98 = 0	H30 = 3 y98 = 0	H30 = 5 y98 = 0	H30 = 2 (3, 5) y98 = 1
	Via RS-485 communications link (port 2)	H30 = 6 y98 = 0	H30 = 7 y98 = 0	H30 = 8 y98 = 0	H30 = 6 (7, 8) y98 = 1
	Via fieldbus (option and built-in CAN)	H30 = 0 (2, 6) y98 = 2	H30 = 1 (3, 7) y98 = 2	H30 = 4 (5, 8) y98 = 2	H30 = 0 (1 to 8) y98 = 3

For details, refer to the RS-485 Communication User's Manual or the Field Bus (Option and Built-in CAN) Instruction Manual.

- When the terminal command “LE” ("Enable communications link via RS-485 or fieldbus") is assigned to a digital input terminal, turning “LE” ON makes the settings of H30 and y98 enabled. When LE is OFF, those settings are disabled so that both frequency commands and run commands specified from the inverter itself take control.

  (Function codes E01 to E05, data = 24)

  No “LE” assignment is functionally equivalent to the “LE” being ON.

FUNCTION CODE

Chap. 5

H42, H43, H48	Capacitance measurement of DC link bus capacitor, Cumulative run time of cooling fan Cumulative run time of capacitors on printed circuit boards Related function codes: H47 Initial capacitance of DC link bus capacitor H98 Protection/maintenance function

■ Life prediction function

The inverter has the life prediction function for some parts which measures the discharging time or counts the voltage applied time, etc. The function allows you to monitor the current lifetime state on the LED monitor and judge whether those parts are approaching the end of their service life. The life prediction function can also issue early warning signals if the lifetime alarm command LIFE is assigned to any of the digital output terminals by any of E20, E21 and E27.
The predicted values should be used only as a guide since the actual service life is influenced by the surrounding temperature and other usage environments.

Object of life prediction	Prediction function	End-of-life criteria	Prediction timing	On the LED monitor
DC link bus capacitor	<u>Calculating the capacitance of DC link bus capacitor</u> Measures the discharging time of the DC link bus capacitor when the main power is shut down and calculates the capacitance.	85% or lower of the initial capacitance at shipment (See "[1] Measuring the capacitance of DC link bus capacitor in comparison with initial one at shipment" on the next page.)	At periodic inspection H98 bit3 = 0	5_05 (Capacitance)
		85% or lower of the reference capacitance under ordinary operating conditions at the user site (See "[2] Measuring the capacitance of DC link bus capacitor under ordinary operating conditions" on page 5-155.)	During ordinary operation H98 bit3 = 1	5_05 (Capacitance)
	<u>ON-time counting of DC link bus capacitor</u> Counts the time elapsed when the voltage is applied to the DC link bus capacitor, while correcting it according to the capacitance measured above.	Exceeding 87,600 hours (10 years) (ND mode: 61,320 hours)	During ordinary operation	5_25 (Elapsed time) 5_27 (Time remaining before the end of life)
Electrolytic capacitors on printed circuit boards	Counts the time elapsed when the voltage is applied to the capacitors, while correcting it according to the surrounding temperature.	Exceeding 87,600 hours (10 years) (ND mode: 61,320 hours)	During ordinary operation	5_06 (Cumulative run time)
Cooling fans	Counts the run time of the cooling fans.	Exceeding 87,600 hours (10 years) (ND mode: 61,320 hours)	During ordinary operation	5_07 (Cumulative run time)

■ Capacitance measurement of DC link bus capacitor (H42)

<u>**Calculating the capacitance of DC link bus capacitor**</u>

- The discharging time of the DC link bus capacitor depends largely on the inverter's internal load conditions, e.g. options attached or ON/OFF of digital I/O signals. If actual load conditions are so different from the ones at which the initial/reference capacitance is measured that the measurement result falls out of the accuracy level required, then the inverter does not perform measuring.
- The capacitance measuring conditions at shipment are extremely restricted, e.g., all input terminals being OFF in order to stabilize the load and measure the capacitance accurately. Those conditions are, therefore, different from the actual operating conditions in almost all cases. If the actual operating conditions are the same as those at shipment, shutting down the inverter power automatically measures the discharging time; however, if they are different, no automatic measurement is performed. To perform it, put those conditions back to the factory default ones and shut down the inverter. For the measuring procedure, see [1] given below.

- To measure the capacitance of the DC link bus capacitor under ordinary operating conditions when the power is turned OFF, it is necessary to set up the load conditions for ordinary operation and measure the reference capacitance (initial setting) when the inverter is introduced. For the reference capacitance setup procedure, see [2] on the next page. Performing the setup procedure automatically detects and saves the measuring conditions of the DC link bus capacitor.

  Setting bit 3 of H98 data to 0 restores the inverter to the measurement in comparison with the initial capacitance measured at shipment.

Note When the inverter uses an auxiliary control power input, the load conditions widely differ so that the discharging time cannot be accurately measured. In this case, measuring of the discharging time can be disabled with the function code H98 (Bit 4 = 0) for preventing unintended measuring. (For details, refer to H98.)

ON-time counting of DC link bus capacitor

- In a machine system where the inverter main power is rarely shut down, the inverter does not measure the discharging time. For such an inverter, the ON-time counting is provided. If the capacitance measurement is made, the inverter corrects the ON-time according to the capacitance measured. The ON-time counting result can be represented as "elapsed time" and "remaining time before the end of life.

[1] Measuring the capacitance of DC link bus capacitor in comparison with initial one at shipment

When bit 3 of H98 data is 0, the measuring procedure given below measures the capacitance of DC link bus capacitor in comparison with initial one at shipment when the power is turned OFF. The measuring result can be displayed on the keypad as a ratio (%) to the initial capacitance.

--Capacitance measuring procedure--

1) To ensure validity in the comparative measurement, put the condition of the inverter back to the state at factory shipment.

- Remove the option card (if already in use) from the inverter.
- In case another inverter is connected via the DC link bus to the P(+) and N(-) terminals of the main circuit, disconnect the wires. (You do not need to disconnect a DC reactor (optional), if any.)
- Disconnect power wires for the auxiliary input to the control circuit (R0, T0).
- In case the standard keypad has been replaced with an optional multi-function keypad TP-A1 after the purchase, put back the original standard keypad.
- Turn OFF all the digital input signals fed to terminals [FWD], [REV], and [X1] through [X5] of the control circuit
- If a potentiometer is connected to terminal [13], disconnect it.
- If an external apparatus is attached to terminal [PLC], disconnect it.
- Ensure that transistor output signals ([Y1] and [Y2]) and relay output signals ([30A/B/C]) will not be turned ON.
- Disable the RS-485 and built-in CAN communications links.

Note If negative logic is specified for the transistor output and relay output signals, they are considered ON when the inverter is not running. Specify positive logic for them.

- Keep the surrounding temperature within 25 ±10°C.

2) Turn ON the main circuit power.

3) Confirm that the cooling fan is rotating and the inverter is in stopped state.

4) Turn OFF the main circuit power.

5) The inverter automatically starts the measurement of the capacitance of the DC link bus capacitor. Make sure that " . . . . " appears on the LED monitor.

Note If " . . . . " does not appear on the LED monitor, the measurement has not started. Check the conditions listed in 1).

6) After " . . . . " has disappeared from the LED monitor, turn ON the main circuit power again.

7) Select Menu #5 "Maintenance Information" in Programming mode and note the reading (relative capacitance (%) of the DC link bus capacitor).

----

[2] Measuring the capacitance of DC link bus capacitor under ordinary operating conditions at power shutdown

When bit 3 of H98 data is 1, the inverter automatically measures the capacitance of the DC link bus capacitor under ordinary operating conditions when the power is turned OFF. This measurement requires setting up the load conditions for ordinary operation and measuring the reference capacitance when the inverter is introduced to the practical operation, using the setup procedure given below.

Function code	Name	Data
H42	Capacitance of DC link bus capacitor	• Capacitance of DC link bus capacitor (measured value) • Start of initial capacitance measuring mode under ordinary operating conditions (0000) • Measurement failure (0001)
H47	Initial capacitance of DC link bus capacitor	• Initial capacitance of DC link bus capacitor (measured value) • Start of initial capacitance measuring mode under ordinary operating conditions (0000) • Measurement failure (0001)

When replacing parts, clear or modify the H42 and H47 data. For details, refer to the maintenance related documents.

-------------------------------------Reference capacitance setup procedure-------------------------------------

1) Set function code H98 (Protection/maintenance function) to enable the user to specify the judgment criteria for the service life of the DC link bus capacitor (Bit 3 = 1) (refer to function code H98).

2) Turn OFF all run commands.

3) Make the inverter ready to be turned OFF under ordinary operating conditions.

4) Set both function codes H42 (Capacitance of DC link bus capacitor) and H47 (Initial capacitance of DC link bus capacitor) to "0000".

5) Turn OFF the inverter, and the following operations are automatically performed.

   The inverter measures the discharging time of the DC link bus capacitor and saves the result in function code H47 (Initial capacitance of DC link bus capacitor).

   The conditions under which the measurement has been conducted will be automatically collected and saved.

   During the measurement, " . . . . " will appear on the LED monitor.

6) Turn ON the inverter again.

   Confirm that H42 (Capacitance of DC link bus capacitor) and H47 (Initial capacitance of DC link bus capacitor) hold right values. Shift to Menu #5 "Maintenance Information" and confirm that the relative capacitance (ratio to full capacitance) is 100%.

Note: If the measurement has failed, "0001" is entered into both H42 and H47. Remove the factor of the failure and conduct the measurement again.

Hereafter, each time the inverter is turned OFF, it automatically measures the discharging time of the DC link bus capacitor if the above conditions are met. Periodically check the relative capacitance of the DC link bus capacitor (%) with Menu #5 "Maintenance Information" in Programming mode.

Note: The condition given above tends to produce a rather large measurement error. If this mode gives you a lifetime alarm, set H98 (Protection/maintenance function) back to the default setting (Bit 3 (Select life judgment threshold of DC link bus capacitor) = 0) and conduct the measurement under the condition at the time of factory shipment.

■ Cumulative run time of capacitors on printed circuit boards (H48)

Function code	Name	Data
H48	Cumulative run time of capacitors on printed circuit boards	Displays the cumulative run time of capacitor on the printed circuit board in units of ten hours. • Data setting range: 0 to 9999 (0 to 99990 hours)

When replacing capacitors on printed circuit boards, clearing or modifying H48 data is required. For details, refer to the maintenance related documents.

■ Cumulative run time of cooling fan (H43)

Function code	Name	Data
H43	Cumulative run time of cooling fan	Displays the cumulative run time of cooling fan in units of ten hours. • Data setting range: 0 to 9999 (0 to 99990 hours)

When replacing the cooling fan, clearing or modifying H43 data is required. For details, refer to the maintenance related documents.

H44 Startup counter for motor 1

H44 counts the number of inverter startups and displays it in hexadecimal format. Check the displayed number on the maintenance screen of the keypad, and use it as a guide for maintenance timing for parts such as belts. To start the counting over again, e.g. after a belt replacement, set the H44 data to "0000."

H45 Mock alarm

Related function codes: H97 (Clear alarm data)

H45 causes the inverter to generate a mock alarm in order to check whether external sequences function correctly at the time of machine setup. Setting the H45 data to "1" displays mock alarm Err on the LED monitor. It also issues alarm output (for any alarm) “ALM” (if assigned to a digital output terminal by any of E20, E21 and E27).

Accessing the H45 data requires simultaneous keying of the STOP key + ∧ key. After that, the H45 data automatically reverts to "0," allowing you to reset the alarm.

Just as data (alarm history and relevant information) of those alarms that could occur in running the inverter, the inverter saves mock alarm data, enabling you to confirm the mock alarm status.

To clear the mock alarm data, use H97. (Accessing the H97 data requires simultaneous keying of the STOP key + ∧ key.) H97 data automatically returns to "0" after clearing the alarm data.

Tip: A mock alarm can be issued also by simultaneous keying of the STOP key + FUNC/DATA key" on the keypad for 5 seconds or more.

H46 Starting mode (auto search delay time 2) (refer to H09)

For details, refer to the description of H09.

H47, H48	**Initial capacitance of DC Link bus capacitor, Cumulative run time of capacitors on printed circuit boards (refer to H42)**

For details, refer to the description of H42.

H49	**Starting mode (auto search delay time 1) (refer to H09)**

For details, refer to the description of H09.

H50, H51 H52, H53	**Non-linear V/f pattern 1 (frequency and voltage) (refer to F04) Non-linear V/f pattern 2 (frequency and voltage)**

For details, refer to the description of F04.

H54, H55 H56 H57 to H60	**Acceleration/Deceleration time (jogging) (refer to F07) Deceleration time for forced stop 1st/2nd S-curve acceleration/deceleration range**

For details, refer to the description of F07.

H61	**UP/DOWN control (initial frequency setting) (refer to F01)**

For details, refer to the description of F01.

H63	**Low limiter (mode selection) (refer to F15)**

For details, refer to the description of F15.

H64	**Low limiter (lower limiting frequency)**

H64 specifies the lower limit of frequency to be applied when the current limiter, torque limiter, or overload prevention control is activated. Normally, it is not necessary to change this data.

- Data setting range: 0.0 to 60.0 (Hz)

H65, H66	**Non-linear V/f pattern 3 (frequency and voltage) (refer to F04)**

For details, refer to the description of F04.

H67	**Auto energy saving operation (mode selection) (refer to F37)**

For details, refer to the description of F37.

H68	Slip compensation 1 (operating conditions) (refer to F42)

For details, refer to the description of F42.

H69	Anti-regenerative control (mode selection) Related function codes: H76 (Torque limiter) (frequency increment limit for braking)

Enable the automatic deceleration (anti-regenerative control) with this function code. In the inverter not equipped with a PWM converter or braking unit, if the regenerative energy returned exceeds the inverter's braking capability, an overvoltage trip occurs.

If anti-regenerative control is selected, the output frequency is controlled to suppress the regenerative energy for avoiding an overvoltage trip.

H69 data	Function	
	Control mode	Force-to-stop with actual deceleration time exceeding three times the specified one
0	Disable automatic deceleration	-
2	Torque limit control	Enable
3	DC link bus voltage control	Enable
4	Torque limit control	Disable
5	DC link bus voltage control	Disable

FRENIC-Ace is equipped with two control modes: torque limiter and DC link bus voltage control. Understand the features of the respective modes and select the appropriate one.

Control mode	Control operation	Operation mode	Characteristics
Torque limiter (H69 = 2, 4)	Controls the output frequency so that the braking torque is approximately 0.	Enabled during acceleration, constant speed operation and deceleration.	Features high response and makes less prone to overvoltage trips under impact load.
DC link bus voltage control (H69 = 3, 5)	Controls the output frequency so that the DC link bus voltage is decreased when it exceeds the limit level.	Enabled only during deceleration Disabled during constant speed operation	Makes use of the regenerative capability of the inverter to allow reduced deceleration time.

■ Torque limiter (frequency increment limit for braking) (H76)

- Data setting range: 0.0 to 500.0 (Hz)

With the torque limiter, the inverter increases the output frequency to limit the output torque. Excessive increase of the output frequency may cause danger and the frequency increment limit for braking (H76) is provided. This prevents the output frequency from increasing to exceed the "reference frequency + H76." If the limit is reached, however, anti-regenerative control is restricted and an overvoltage trip may occur. Increasing the frequency increment limit for braking improves the anti-regenerative capability.

If a run command is turned OFF, the anti-regenerative control causes the frequency to increase and operation may not stop depending on the load conditions. For safety, a function is provided in which the anti-regenerative control is forced to be disabled in three times the deceleration time currently selected to force the operation to stop. The function can be enabled/disabled by the H69 setting.

Note
- The deceleration time may be automatically increased by anti-regenerative control.
- Disable the anti-regenerative control when a braking unit is connected. Otherwise, the anti-regenerative control may be activated at the same time as the operation of the braking unit, resulting in a deceleration time not in accordance with the setting.
- An excessively short deceleration time causes the DC link bus voltage of the inverter to rise too fast for the anti-regenerative control to function. In that case, specify a longer deceleration time.

H70	Overload prevention control

Specifies the rate of decrease of the output frequency of overload prevention control. Before the inverter generates a heat sink overheat or overload trip (alarm OH1 or OLU), the output frequency of the inverter is decreased for avoiding a trip. This is applied when operation is required to continue even if the output frequency decreases in a system in which the load decreases as the output frequency decreases, such as a pump.

H70 data	Function
0.00	Uses the deceleration time currently selected (F08, E11, E13, E15, etc.).
0.01 to 100.0	Decelerates at a deceleration of 0.01 to 100.0 (Hz/s).
999	Cancel overload prevention control

■ **Overload prevention control – “OLP” (E20, E21 and E27, data = 36)**

Outputs “OLP”, which is a signal that turns ON during overload prevention control, in order to show that the overload prevention control has been activated and the output frequency has changed.

Note: No effect can be expected in a system in which the load does not decrease even if the output frequency decreases. Do not use this function.

H71	Deceleration characteristic

Enable hard braking control with this function code.

During motor deceleration, if the regenerative energy returned exceeds the inverter's braking capability, an overvoltage trip occurs. When hard braking control is selected, the motor loss is increased and the deceleration torque is increased during motor deceleration.

H71 data	Function
0	Disable
1	Action

Note: This function suppresses the torque during deceleration and is not effective if braking load is applied. When anti-regenerative control of the torque limiter is enabled (H69 = 2, 4), the deceleration characteristic is disabled.

H72	Main circuit power cutoff detection (mode selection)

This function monitors the AC input power supply of the inverter to see if the AC input power supply (main circuit power) is established and prevents inverter operation when the main circuit power is not established.

H72 data	Function
0	Disables main circuit power cutoff detection
1	Enables main circuit power cutoff detection

With power supply via a PWM converter or DC link bus, there is no AC input. When the data for H72 is "1," the inverter cannot operate. Change the data for H72 to "0."

Note: For single-phase supply, consult your Fuji Electric representatives.

H76	Torque limiter (Frequency increment limit for braking) (refer to H69)

For details, refer to the description of H69.

H77	Life of DC link bus capacitor (time remaining before the end of life)

Indicates the time remaining (in units of ten hours) before the end of service life of the DC link bus capacitor.

Transfer the DC link bus capacitor life data when replacing the printed circuit board.

- Data setting range: 0 to 8760 (in units of 10 hours 0 to 87,600 hours)

H78 H94	Maintenance interval (M1) Cumulative motor run time 1

Specify the maintenance interval in hours with the maintenance interval (M1) (H78).

Specify in units of 10 hours. Up to 9999 x 10 hours can be specified.

- Data setting range: 0 (disable), 1 to 9999 (in units of 10 hours)

■ Maintenance timer – "MNT" (E20, E21 and E27, data = 84)

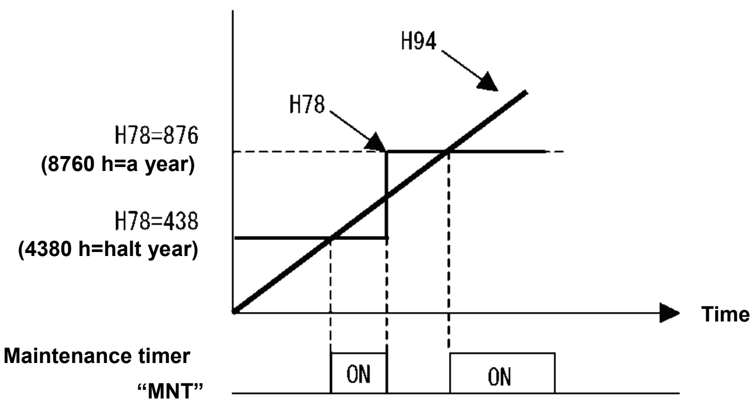
When the cumulative motor run time 1 (H94) reaches the value specified by the maintenance interval (H78), the inverter outputs the maintenance timer signal "MNT".

■ Cumulative motor run time 1 (H94)

The cumulative run time of the motor can be indicated by keypad operation. It can be used for management of the machinery or maintenance. Specifying an arbitrary time for the cumulative motor run time 1 (H94) allows an arbitrary value to be specified for the cumulative motor run time. It can be replaced with the initial data to use as a guide for the replacement of machine parts or inverter. Specifying "0" as the setting allows the cumulative motor run time to be reset.

<For half yearly maintenance>

Cumulative motor run time (H94)



Note: If the maintenance interval is reached, set a new value in H78 and press the FUNC/DATA key to reset the output signal and restart measurement.

This function is exclusively applied to the 1st motor.

■ Count the run time of commercial power-driven motor 1, 2 – "CRUN-M1, 2" (E01 to E05, data = 72, 73)

Even when a motor is driven by commercial power, not by the inverter, it is possible to count the cumulative motor run time 1, 2 (H94, A51) by detecting the ON/OFF state of the auxiliary contact of the magnetic contactor for switching to the commercial power line.

Note: Check the cumulative motor run time with 5_23 on Menu #5 "Maintenance Information" of the keypad.

H79	Preset startup count for maintenance (M1) Related function codes: H44 Startup counter for motor 1

H79 specifies the number of inverter startup times to determine the next maintenance timing, e.g., for replacement of a belt.

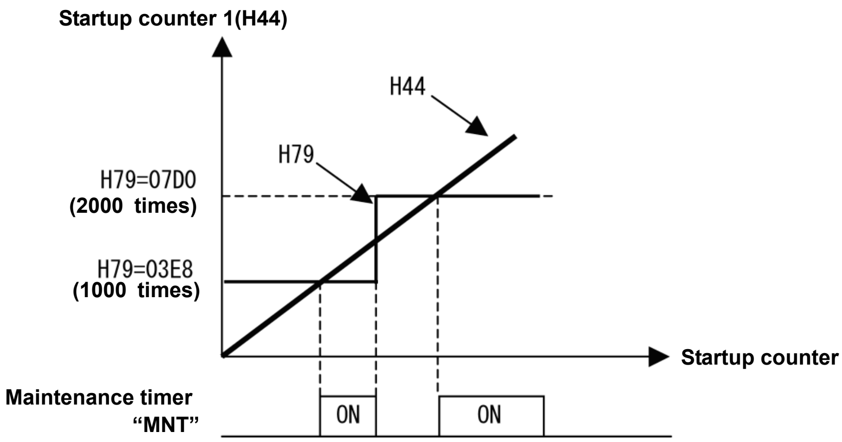
Set the H79 and H44 data in hexadecimal. The maximum setting count is 65,535 (FFFF in hexadecimal.)

- Data setting range: 0000 (disable), 0001 to FFFF (hexadecimal)

■ Maintenance timer – "MNT" (E20, E21 and E27, data = 84)

When the startup counter for motor 1 (H44) reaches the number specified by H79 (Preset startup count for maintenance (M1)), the inverter outputs the maintenance timer signal "MNT" (if assigned to any digital terminal with any to E20 to E24 and E27) to remind the user of the need of the maintenance of the machinery.

< Maintenance every 1,000 times of startups >



Note: If the startup counter reaches the specified value, set a new value for the next maintenance in H79 and press the FUNC/DATA key to reset the output signal and restart counting.

This function is exclusively applied to the 1st motor.

H80	Output current fluctuation damping gain for motor 1

The inverter output current driving the motor may fluctuate due to the motor characteristics and/or backlash in the machinery (load). Modifying the H80 data adjusts the controls in order to suppress such fluctuation. However, as incorrect setting of this gain may cause larger current fluctuation, do not modify the default setting unless it is necessary.

- Data setting range: 0.00 to 1.00

H81, H82 | Light alarm selection 1 and 2

If the inverter detects a minor abnormal state "light alarm", it can continue the current operation without tripping while displaying the "light alarm" indication L-AL on the LED monitor. In addition to the indication l-al, the inverter blinks the KEYPAD CONTROL LED. Function codes H81 and H82 specify which alarms should be categorized as "light alarm."

The table below lists alarms selectable as "light alarm."

Code	Name	Description
OH1	Heat sink overheat	Heat sink temperature increased to the trip level.
OH2	Enable external alarm trip	An error that has occurred in peripheral equipment turned the external alarm signal THR ON.
OH3	Inverter internal overheat	The temperature inside the inverter abnormally has increased.
dbH	Braking resistor overheat	Estimated temperature of the coil in the braking resistor exceeded the allowable level.
OL1 to OL2	Overload of motor 1 to 2	Motor temperature calculated with the inverter output current reached the trip level.
Er-4	Option communications error	Communications error between the inverter and an option.
Er-5	Option error	An option judged that an error occurred.
Er-t	Built-in CAN communications link error	Error generated in built-in CAN communications link
Er-8 Er-P	RS-485 communications error (COM port 1, 2)	RS-485 communications error between the COM ports 1 and 2.
CoF	PID feedback wire break	The PID feedback signal wire(s) is broken.
FAL	Detect DC fan lock	Failure of the air circulation DC fan inside the inverter
OL	Motor overload early warning	Early warning before a motor overload
OH	Heat sink overheat early warning	Early warning before a heat sink overheat trip
LiF	Lifetime alarm	It is judged that the service life of any one of the capacitors (DC link bus capacitors and electrolytic capacitors on the printed circuit boards) and cooling fan has expired. Or, failure of the air circulation DC fan inside the inverter.
rEF	Reference loss	Analog frequency command was lost.
Pid	PID alarm	Warning related to PID control (absolute-value alarm or deviation alarm)
UTL	Low output torque detection	Output torque drops below the low torque detection level for the specified period.
PTC	PTC thermistor activated	The PTC thermistor on the motor detected a temperature.
rTE	Inverter life (Cumulative run time)	The motor cumulative run time reached the specified level.
CnT	Inverter life (Number of startups)	Number of startups reached the specified level.

Set data for selecting "light alarms" in hexadecimal. For details on how to select the codes, see the next page.

- Data setting range: 0000 to FFFF (hexadecimal)

■ Selecting light alarm factors

To set and display the light alarm factors in hexadecimal format, each light alarm factor has been assigned to bits 0 to 15 as listed in Tables 5.1 and 5.2. Set the bit that corresponds to the desired light alarm factor to "1." Table 5.3 shows the relationship between each of the light alarm factor assignments and the LED monitor display.
Table 5.4 gives the conversion table from 4-bit binary to hexadecimal.

Table 5.1 Light Alarm Selection 1 (H81), Bit Assignment of Selectable Factors

Bit	Code	Data	Bit	Code	Data
15	-	-	7	-	-
14	-	-	6	OL2	Overload of motor 2
13	Er-P	RS-485 communications error (COM port 2)	5	OL1	Overload of motor 1
12	Er-8	RS-485 communications error (COM port 1)	4	dbH	Braking resistor overheat
11	Er-5	Option error Built-in CAN communications link error	3	-	-
10	Er-4	Option communications error	2	OH3	Inverter intetrnal overheat
9	-	-	1	OH2	External alarm
8	-	-	0	OH1	Heat sink overheat

Table 5.2 Light Alarm Selection 2 (H82), Bit Assignment of Selectable Factors

Bit	Code	Data	Bit	Code	Data
15	-	—	7	LiF	Lifetime alarm
14	-	—	6	OH	Heat sink overheat early warning
13	Cnt	Inverter life (Number of startups)	5	OL	Motor overload early warning
12	rtE	Inverter life (Cumulative run time)	4	FAL	Detect DC fan lock
11	PtC	PTC thermistor activated	3	CoF	PID feedback wire break
10	UTL	Low output torque detection	2	-	-
9	Pid	PID alarm	1	-	-
8	rEF	Reference loss	0	-	-

Table 5.3 Display of Light Alarm Factor

(Example) Light alarm factors "RS-485 communications error (COM port 2)," "RS-485 communications error (COM port 1)," "Option communications error," "Overload of motor 1" and "Heat sink overheat" are selected by H81.

LED No.		LED 4				LED 3				LED 2				LED 1			
Bit		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Code		-	-	Er-P	Er-8	Er-5	Er-4	-	-	-	OL2	OL1	dbH	-	OH3	OH2	OH1
Sample indication	Binary	0	0	1	1	0	1	0	0	0	0	1	0	0	0	0	1
	Hexadecimal *Refer to conversion table below	3				4				2				1			
	Hexadecimal on the LED monitor	LED4 LED3 LED2 LED1 3 4 2 1															

■ Hexadecimal expression

A 4-bit binary number can be expressed in hexadecimal format (hexadecimal digit). The table below shows the correspondence between the two notations.

Table 5.4 Binary and Hexadecimal Conversion

Binary				Hexadecimal	Binary				Hexadecimal
0	0	0	0	0	1	0	0	0	8
0	0	0	1	1	1	0	0	1	9
0	0	1	0	2	1	0	1	0	A
0	0	1	1	3	1	0	1	1	b
0	1	0	0	4	1	1	0	0	C
0	1	0	1	5	1	1	0	1	d
0	1	1	0	6	1	1	1	0	E
0	1	1	1	7	1	1	1	1	F

Note When H26 = 1 (PTC (The inverter immediately trips with OH4 displayed)), if the PTC thermistor is activated, the inverter stops without displaying l-al, blinking the KEYPAD CONTROL LED, or outputting L-ALM signal, regardless of the assignment of bit 11 (PTC thermistor activated) by H82 (Light Alarm Selection 2).

■ Light alarm – "L-ALM" (E20, E21 and E27, data = 98)

This output signal "L-ALM" comes ON when a light alarm occurs.

H89	Electronic thermal overload protection for motor – data retention

When the electronic thermal overload protection for motor is used, whether to clear the cumulative value of the thermal by inverter power-off or retain the value after power-off can be specified.

Data for H89	Function
0	Clears cumulative value of thermal by inverter power-off.
1	Retains cumulative value of thermal after inverter power-off (factory default).

H90	Reserved for particular manufacturers

H90 is reserved for particular manufacturers. Unless otherwise specified, do not access these function codes.

H91	PID feedback wire break

Using the terminal [C1] (C1 function) (current input) for PID feedback signal enables wire break detection and alarm (CoF) issuance. H91 specifies whether the wire break detection is enabled, or the duration of detection. (The inverter judges an input current to the terminal [C1] below 2 mA as a wire break.)

This function does not work unless C40 is set to 0.

- Data setting range: 0.0 (Disable wire break detection)
  0.1 to 60.0 s (Detect wire break and issue CoF alarm within the time)

H92, H93	Continue to run (P, I) (refer to F14)

Refer to the description of F14.

H94	Cumulative motor run time 1 (refer to H78)

Refer to the description of H78.

H95	DC braking (braking response mode) (refer to F20 to F22)

Refer to the descriptions of F20 through F22.

H96	STOP key priority/Start check function

[STOP] H96 specifies a functional combination of "STOP key priority" and "Start check function" as listed below.

H96 data	[STOP] STOP key priority	Start check function
0	Disable	Disable
1	Enable	Disable
2	Disable	Enable
3	Enable	Enable

■ **STOP key priority**

Even when run commands are entered from the digital input terminals or via the RS-485 communications link (link operation), pressing the [STOP] key forces the inverter to decelerate and stop the motor. After that, Er-6 appears on the LED monitor.

■ **Start check function**

For safety, this function checks whether any run command has been turned ON or not in each of the following situations. If one has been turned ON, the inverter does not start up but displays alarm code Er-6 on the LED monitor.

- When the power to the inverter is turned ON.
- When the [PRG/RESET] key is pressed to release an alarm status or when the digital input terminal command "RST" ("Reset alarm") is turned ON.
- When the run command source is switched by a digital input terminal command such as "LE" ("Enable communications link via RS-485 or fieldbus") or "LOC" ("Select local (keypad) operation").

H97	Clear alarm data	Related function codes: H45 Mock alarm

H97 clears alarm data (alarm history and relevant information) stored in the inverter.

To clear alarm data, simultaneous keying of "STOP key + ∧ key" is required.

H97 data	Function
0	Disable
1	Enable (Setting "1" clears alarm data and then returns to "0.")

H98	Protection/Maintenance function (mode selection)

H98 specifies whether to enable or disable automatic lowering of carrier frequency, input phase loss protection, output phase loss protection, judgment threshold on the life of DC link bus capacitor, judgment on the life of DC link bus capacitor, DC fan lock detection and braking transistor error detection in combination.

Automatic lowering of carrier frequency (Bit 0)

This function should be used for important machinery that requires keeping the inverter running. Even if a heat sink overheat or overload occurs due to excessive load, abnormal surrounding temperature, or cooling system failure, enabling this function lowers the carrier frequency to avoid tripping (OH1, OH3 or OLU). Note that enabling this function results in increased motor noise.

Input phase loss protection (Lin) (Bit 1)

Upon detection of an excessive stress inflicted on the apparatus connected to the main circuit due to phase loss or line-to-line voltage unbalance in the three-phase power supplied to the inverter, this protection feature stops the inverter and displays an alarm Lin.

Note: In configurations where only a light load is driven or a DC reactor is connected, phase loss or line-to-line voltage unbalance may not be detected because of the relatively small stress on the apparatus connected to the main circuit.

Output phase loss protection (OPL) (Bit 2)

Upon detection of output phase loss while the inverter is running, this feature stops the inverter and displays an alarm OPL

Note: Where a magnetic contactor is installed in the inverter output circuit, if the magnetic contactor goes OFF during operation, all the phases will be lost. In such a case, this protection feature does not work.

Judgment threshold on the life of DC link bus capacitor (Bit 3)

Bit 3 is used to select the threshold for judging the life of the DC link bus capacitor between the factory default setting and a user-defined setting.

Note: Before specifying a user-defined threshold, measure and confirm the reference level in advance. (Function code H42)

Judgment on the life of DC link bus capacitor (Bit 4)

Whether the DC link bus capacitor has reached its life is judged by measuring the discharging time after power OFF. The discharging time is determined by the capacitance of the DC link bus capacitor and the load inside the inverter. Therefore, if the load inside the inverter fluctuates significantly, the discharging time cannot be accurately measured. As a result, it may be mistakenly determined that the DC link bus capacitor has reached the end of its life. To avoid such an error, you can disable the judgment based on the discharging time. (Even if it is disabled, the judgment based on the "ON-time counting" while the voltage is applied to the DC link bus capacitor is continued.)

For details about the life prediction function, refer to H42.

Since load may fluctuate significantly in the following cases, disable the judgment on the life during operation. During periodical maintenance, either conduct the measurement with the judgment enabled under appropriate conditions or conduct the measurement under the operating conditions matching the actual ones.

- Auxiliary input for control power is used.
- An option card is used.
- Another inverter or equipment such as a PWM converter is connected to terminals of the DC link bus.

DC fan lock detection (bit 5) (400 V class: FRN0203E2S-4☐ or above)

An inverter may be equipped with the internal air circulation DC fan depending on the capacity. When the inverter detects that the DC fan is locked by a failure or other cause, you can select either continuing the inverter operation or having the inverter enter into the alarm state.

Entering alarm state: The inverter issues the alarm OH1 and allows the motor to coast to a stop.

Continuing operation: The inverter does not enter the alarm state and continues to run the motor.

Note that, however, the inverter turns ON the “OH” and “LIFE” signals on the transistor output terminals whenever the DC fan lock is detected regardless of your selection.

Note: If the ON/OFF control of the cooling fan is enabled (H06 = 1), the cooling fan may stop depending on the operating condition of the inverter. In this case, the DC fan lock detection feature is considered normal (e.g., the cooling fan is normally stopped by the stop fan command.) so that the inverter may turn OFF the LIFE or OH signal output, or enable to cancel the alarm OH1, even if the internal air circulation DC fan is locked due to a failure etc. (When you start the inverter in this state, it automatically issues the run fan command. Then the inverter detects the DC fan lock state, and turns ON the “LIFE” or “OH” output or enters the alarm OH1 state.)

Note that, operating the inverter with the DC fan being locked for a long time may shorten the service life of electrolytic capacitors on the PCBs due to local high temperature inside the inverter. Be sure to check with the “LIFE” signal etc., and replace the broken fan as soon as possible.

Braking transistor error detection (Bit 6) (dbA FRN0072E2S-4☐ or below)

Upon detection of a built-in braking transistor error, this feature stops the inverter and displays an alarm dbA. Set data of this bit to "0" when the inverter does not use a braking transistor and there is no need of entering an alarm state.

To set data of function code H98, assign the setting of each function to each bit and then convert the 8-bit binary to the decimal number. Refer to the assignment of each function to each bit and a conversion example below.

Bit	Function	Data = 0	Data = 1	Factory default
Bit 0	Lower the carrier frequency automatically	Disable	Enable	1: Enable
Bit 1	Detect input phase loss	Continue to run	Enter alarm processing	1: Enter alarm processing
Bit 2	Detect output phase loss	Continue to run	Enter alarm processing	0: Continue to run
Bit 3	Select life judgment threshold of DC link bus capacitor	Factory default	User-defined setting	0: Factory default
Bit 4	Judge the life of DC link bus capacitor	Disable	Enable	1: Enable
Bit 5	Detect DC fan lock	Enter alarm processing	Continue to run	0: Enter alarm processing
Bit 6	Detect braking transistor breakdown	Continue to run	Enter alarm processing	0: Continue to run

Decimal and binary conversion

Decimal = Bit 6 x 2^6 + Bit 5 x 2^5 + Bit 4 x 2^4 + Bit 3 x 2^3 + Bit 2 x 2^2 + Bit 1 x 2^1 + Bit 0 x 2^0

= Bit 7 x 128 + Bit 6 x 64 + Bit 5 x 32 + Bit 4 x 16 + Bit 3 x 8 + Bit 2 x 4 + Bit 1 x 2 + Bit 0 x 1

= 64 + 0 x 32 + 1 x 16 + 0 x 8 + 0 x 4 + 1 x 2 + 1 x 1

= 16 + 2 + 1

= 19

H114 — Anti-regenerative control (level) — Related function code: H69

Allows the adjustment of the level when anti-regenerative control of the torque limiter is performed with H69 = 2, 4. Basically, there is no need to modify the setting.

Data for H114	Function
0.0 to 50.0%	Adjusted level: Increasing the value increases the frequency operation.
999	Standard level

H195 — Braking period for DC braking at startup — Related function code: F21

DC braking can be activated at startup. For details, refer to the description of F21.

5.3.6 A codes (Motor 2 parameters)

FRENIC-Ace enables you to switch among 2 motors for operation using a same inverter.

Function code	"M2"	Motor to drive	Remarks
F/E/P and other codes	OFF	Motor 1	Including function codes commonly applied to motors 1 to 2.
A codes	ON	Motor 2	

Note This manual describes function codes applied to motor 1 only. For ones applied to motor 2, refer to the corresponding function codes prepared for motor 1 in Table 5.5 on the next page.

When motor switching is specified, the function codes in Table 5.5 are switched. Note that the functions listed in Table 5.6 are for the 1st motor only and unavailable when the 2nd motor is selected. However, they can be enabled with A98.

Table 5.5 Function Codes to be Switched

Name	Function code	
	1st motor	2nd motor
Maximum frequency	F03	A01
Base frequency	F04	A02
Rated voltage at base frequency	F05	A03
Maximum output voltage	F06	A04
Torque boost	F09	A05
Electronic thermal overload protection for motor (Select motor characteristics)	F10	A06
(Overload detection level)	F11	A07
(Thermal time constant)	F12	A08
DC braking (Braking starting frequency)	F20	A09
(Overload detection level)	F21	A10
(Braking time)	F22	A11
Starting Frequency	F23	A12
Load selection/ Auto torque boost/ Auto energy saving operation	F37	A13
Drive control selection	F42	A14
Motor parameters (No. of poles)	P01	A15
(Capacitance)	P02	A16
(Rated current)	P03	A17
(Auto-tuning)	P04	A18
(Online tuning)	P05	A19
(No-load current)	P06	A20
(%R1)	P07	A21
(%X)	P08	A22
(Slip compensation gain for driving)	P09	A23
(Slip compensation response time)	P10	A24
(Slip compensation gain for braking)	P11	A25
(Rated slip frequency)	P12	A26
(Iron loss factor 1)	P13	A27
(%X correction factor 1)	P53	A53

Table 5.5 Function Codes to be Switched (cont'd)

Name	Function code	
	1st motor	2nd motor
Motor selection	P99	A39
Slip Compensation (Operating conditions)	H68	A40
Output current fluctuation damping gain for motor	H80	A41
Cumulative motor run time	H94	A51
Startup counter for motor	H44	A52
Reserved for particular manufacturers	d51	d52

Table 5.6 Function Codes Unavailable for the 2nd Motor

Data	Function codes	2nd motor operation
Non-linear V/f pattern	H50 to H53, H65, H66	Disable
Starting frequency 1 (Holding time)	F24	Disable
Stop frequency (Holding time)	F39	Disable
Motor overload early warning	E34, E35	Disable
Droop control	H28	Disable
UP/DOWN control	H61	Fixed at the initial setting (0 Hz)
PID control	J01 to J06, J08 to J13, J15 to J19 J56 to J62, E40, E41, H91	Disable
Brake signal	J68 to J72, J95, J96	Disable
Current limiter	F43, F44	Disable
Rotational Direction Limitation	H08	Disable
Maintenance Interval/ Preset Startup Count for Maintenance	H78, H79	Disable
Braking period (for DC braking at startup)	H195	Disable

A98 Motor 2 (function selection)

Setting range: 0000 to FFFF (hexadecimal)

Of the functions disabled for the 2nd motor shown in Table 5.6, enables the functions below.

Bit	Function	Data = 0	Data = 1	Factory default
Bit 0	Current limitation	Disabled	Enabled	0: Disabled
Bit 1	Rotational direction limitation	Disabled	Enabled	0: Disabled
Bit 2	Non-linear V/f	Disabled	Enabled	0: Disabled
Bit 3	PID control	Disabled	Enabled	0: Disabled
Bit 4	Brake signal	Disabled	Enabled	0: Disabled
Bit 0 to 15	No function assigned	—	—	—

5.3.7 J Codes (Applied Functions)

J01	PID control (Mode selection)

Under PID control, the inverter detects the state of a control target object with a sensor or the similar device and compares it with the commanded value (e.g., temperature control command). If there is any deviation between them, PID control operates so as to minimize it. That is, it is a closed loop feedback system that matches controlled variable (feedback amount).

PID control expands the application area of the inverter to process control (e.g., flow control, pressure control, and temperature control) and speed control (e.g., dancer control).

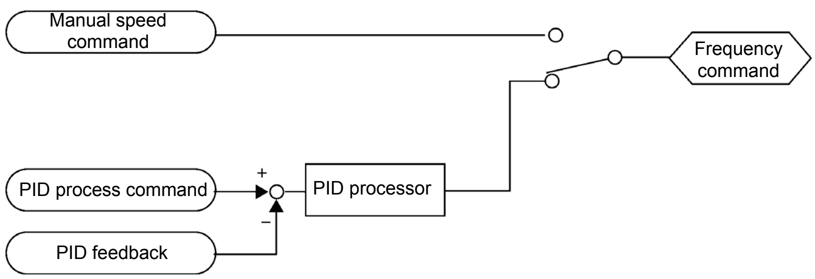
If PID control is enabled (J01 = 1, 2 or 3), the frequency control of the inverter is switched from the drive frequency command generator block to the PID command generator block.

■ **Mode Selection (J01)**

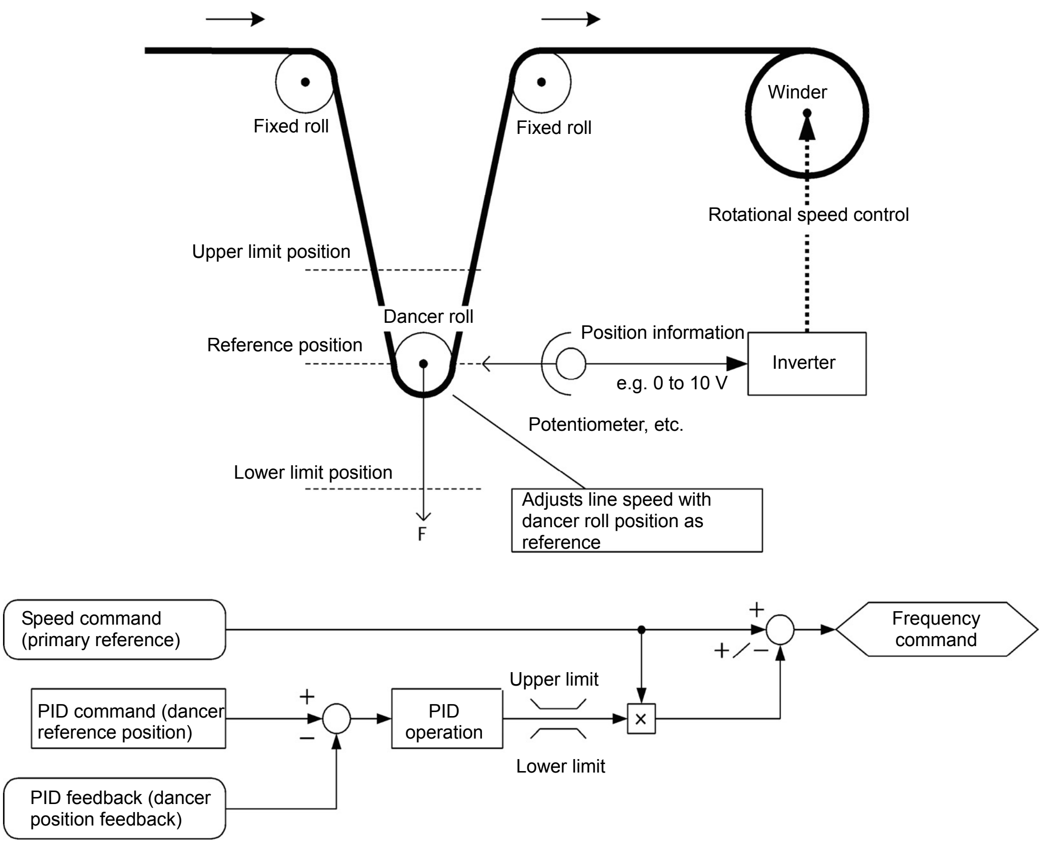
J01 selects the PID control mode.

J01 data	Function
0	Disable
1	Enable (Process control, normal operation)
2	Enable (Process control, inverse operation)
3	Enable (Dancer control)

<PID process control block diagram>



<PID dancer control block diagram>



- Using J01 enables switching between normal and inverse operations against the PID control output, so you can specify an increase/decrease of the motor rotating speed to the difference (error component) between the commanded (input) and feedback amounts, making it possible to apply the inverter to air conditioners. The terminal command IVS can also switch operation between normal and inverse.

For details about the switching of normal/inverse operation, refer to the description of Switch normal/inverse operation IVS (E01 to E05, data = 21).

J02	PID Control (Remote command SV)
	Related function code J105: PID control (display unit) J106: PID control (maximum scale) J107: PID control (minimum scale) J136 to J138: PID control multi-step command 1 to 3

J02 sets the source that specifies the command value (SV) under PID control.

J02 data	Function
0	Keypad Specify the PID command by using the ∧ / ∨ keys on the keypad.
1	PID command 1 (Analog input: Terminals [12], [C1] (C1 function), [C1] (V2 function)) Voltage input to the terminal [12] (0 to ±10 VDC, 100% PID command/ ±10 VDC) Current input to the terminal [C1] (C1 function) (4 to 20 mA DC, 100% PID command/ 20 mA DC) Voltage input to the terminal [C1] (V2 function) (0 to +10 VDC, 100% PID command/ +10 VDC)
3	Terminal command UP/DOWN Using the “UP” or “DOWN” command in conjunction with PID minimum scale to maximum scale (specified by J106 and J107) with which the command value is converted into a physical quantity, etc., you can specify 0 to 100% of the PID command (± 100% for PID dancer control).
4	Command via communications link Use function code S13 that specifies the communications-linked PID command. The transmission data of 20000d (decimal) is equal to 100% (maximum frequency) of the PID command.

[1] PID command with the [Image1] / [Image2] keys on the keypad (J02 = 0, factory default)

Using the ∧ / ∨ keys on the keypad in conjunction with PID minimum / maximum scale (specified by J106 and J107), you can specify 0 to 100% of the PID command (±100% for PID dancer control) in an easy-to-understand, converted command format. "

For details of operation, refer to Chapter 3, Section 3.3.5 "Setting up PID commands using keypad."

[2] PID command by analog inputs (J02 = 1)

When any analog input (voltage input to terminals [12] and [C1] (V2 function), or current input to terminal [C1] (C1 function)) for PID command 1 (J02 = 1) is used, it is possible to arbitrary specify the PID command by multiplying the gain and adding the bias. The polarity can be selected and the filter time constant and offset can be adjusted. In addition to J02 setting, it is necessary to select PID command 1 for analog input (specified by any of E61 to E63, function code data = 3). For details, refer to the descriptions of E61 to E63.

Adjustable elements of PID command

Input terminal	Input range	Bias		Gain		Polarity	Filter	Offset
		Bias	Base point	Gain	Base point			
[12]	0 to +10V, -10 to +10V	C55	C56	C32	C34	C35	C33	C31
[C1] (C1)	4 to 20mA, 0 to 20mA	C61	C62	C37	C39	C40	C38	C36
[C1] (V2)	0 to +10V	C67	C68	C42	C44	C45	C43	C41

■ **Offset (C31, C36, C41)**

C31, C36 or C41 configures an offset for an analog voltage/current input. The offset also applies to signals sent from the external equipment.

■ **Filter time constant (C33, C38, C43)**

C33, C38, and C43 provide the filter time constants for the voltage and current of the analog input. The larger the time constant, the slower the response. Specify the proper filter time constant taking into account the response speed of the machine (load). If the input voltage fluctuates due to line noises, increase the time constant.

■ **Polarity [12] terminals (C35)**

C35 configures the input range for analog input voltage.

C35 data	Modes for terminal inputs
0	-10 to +10V
1	0 to +10 V(negative value of voltage is regarded as 0 V)

■ **Range selection: terminals [C1] (C1 function) (C40)**

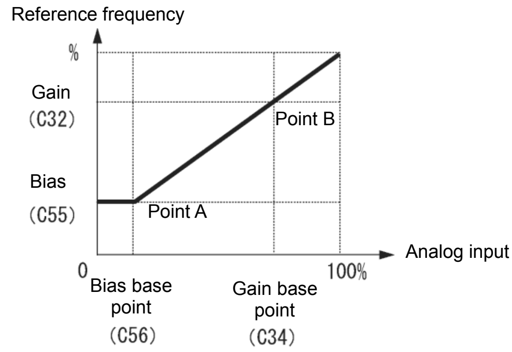
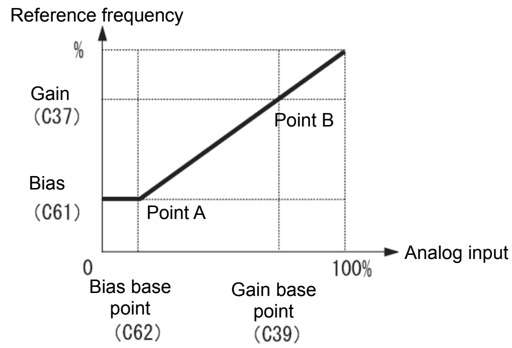
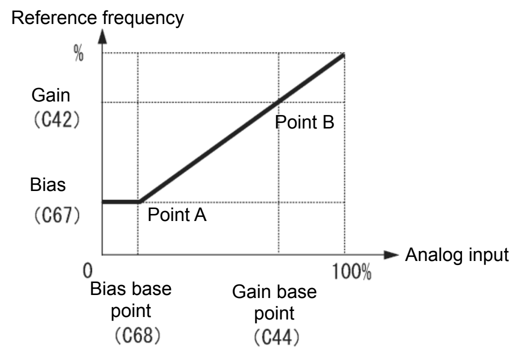
Terminals [C1] (C1 function) configure the input range for analog input current.

C40 data	Range of terminal inputs	Handling when a bias value is configured as minus
0	4 to 20 mA (Factory default)	Limits any values less than 0 to 0.
1	0 to 20 mA	
10	4 to 20 mA	Enables any values less than 0 as minus values.
11	0 to 20 mA	

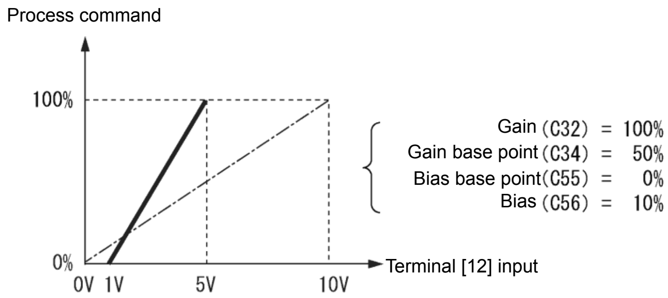
■ **Polarity selection [C1] (V2 function) (C45)**

C45 data	Modes for terminal inputs	When bias is specified to be negative
0	0 to +10V	Makes a point less than 0 effective as a negative value.
1	0 to +10V (factory default)	Limits a point less than 0 to 0.

■ **Gain and bias**

Terminal	Data
[12]	
[C1] (C1) function	
[C1] (V2 function)	

(Example) Mapping the range of 1 through 5 V at terminal [12] to set 0 through 100%



[3] PID command with UP/DOWN control (J02 = 3)

When UP/DOWN control is selected as a PID speed command, turning the terminal command “UP” or “DOWN” ON causes the PID speed command to change within the range from minimum scale to maximum scale.

The PID speed command can be specified in mnemonic physical quantities (such as temperature or pressure) with the minimum scale (J106) and maximum scale (J107).
To select UP/DOWN control as a PID speed command, the “UP” and “DOWN” should be assigned to the digital input terminals [X1] to [X5]. (Function codes E01 to E05 data = 17, 18)

"UP"	"DOWN"	Action
Data = 17	Data = 18	
OFF	OFF	Retain PID speed command value.
ON	OFF	Increase PID speed command value at a rate between 0.1%/0.1 s and 1%/0.1 s.
OFF	ON	Decrease PID speed command value at a rate between 0.1%/0.1 s and 1%/0.1 s.
ON	ON	Retain PID speed command value.

Note The inverter internally holds the PID command value set by UP/DOWN control and applies the held value at the next restart (including powering ON).

[4] PID command via communications link (J02 = 4)

Use function code S13 that specifies the communications-linked PID command. The transmission data of 20000 (decimal) is equal to 100% (maximum frequency) of the PID command. For details of the communications format, refer to the RS-485 Communication User's Manual.

Note
- Other than the remote command selection by J02, the PID multi-step commands 1, 2 or 3 (specified by J106, J137 or J138, respectively) specified by the PID multi-step commands “PID-SS1” and “PID-SS2” can also be selected as a preset value for the PID command.
- In dancer control (J01 = 3), the setting from the keypad interlocks with data of J57 (PID control: Dancer reference position), and is saved as function code data.

Selecting Feedback Terminals

For feedback control, determine the connection terminal according to the type of the sensor output.

- If the sensor is a current output type, use the current input terminal [C1] (C1 function) of the inverter.
- If the sensor is a voltage output type, use the voltage input terminal [12] of the inverter, or switch over the terminal [C1] (V2 function) to the voltage input terminal and use it.

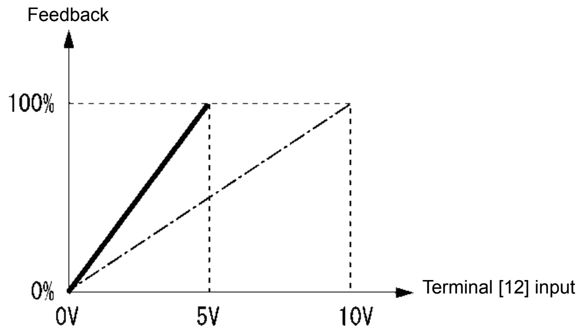
For details, refer to the descriptions of E61 to E63.

<Application example: Process control> (for air conditioners, fans and pumps)

The operating range for PID process control is internally controlled as 0% through 100%. For the given feedback input, determine the operating range to be controlled by means of gain adjustment.

Example: When the output level of the external sensor is within the range of 1 to 5 V:

- Use terminal [12] designed for voltage input.
- Set the gain (C32 for analog input adjustment) at 200% in order to make the maximum value (5 V) of the external sensor's output correspond to 100%. Note that the input mode for terminal [12] is 0 to 10 V corresponding to 0 to 100%; thus, a gain factor of 200% (= 10 V 5 V 100) should be specified. Note also that any bias setting does not apply to feedback control.

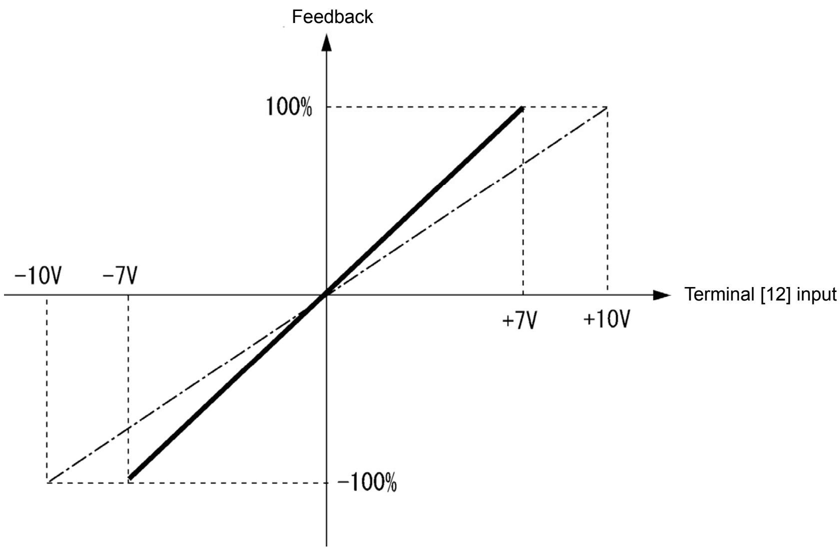


<Application examples: Dancer control> (for winders)

(Example 1) When the output level of the external sensor is ±7 VDC:

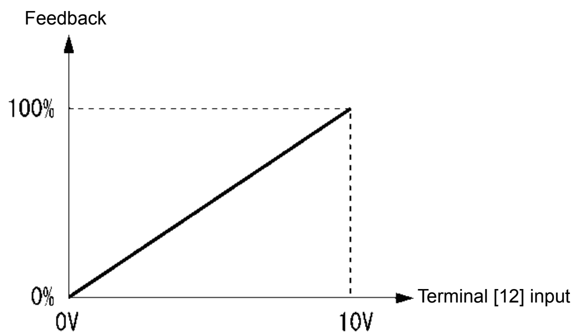
- Use terminal [12] since the voltage input is of bipolar.
- When the external sensor's output is of bipolar, the inverter controls the speed within the range of ±100%. To convert the output ±7 VDC to ±100%, set the gain (C32 for analog input adjustment) as calculated below

$\frac{10\ V}{7\ V} \fallingdotseq 143\%$.



(Example 2) When the output level of the external sensor is 0 to 10 VDC:

- Use terminal [12] designed for voltage input.
- When the external sensor's output is of unipolar, the inverter controls the speed within the range of 0 to 100%.



In this example, it is recommended that the dancer reference position be set around the 5 V (50%) point.

PID Display Coefficient and Monitoring

To monitor the PID command and its feedback value, set the scale to convert the values into easy-to-understand physical quantities such as temperature. Unit is unavailable with the standard keypad. The display unit is used with the multi-function keypad (TP-A1).

	Display unit	Maximum scale	Minimum scale
Terminal [12]	C58	C59	C60
Terminal [C1] (C1)	C64	C65	C66
Terminal [C1] (V2)	C70	C71	C72

Refer to function codes C59, C60, C65, C66, C71 and C72 for details on scales, and to E43 for details on monitoring.

■ Display unit (J105)

The unit can be displayed when a multi-function keypad (TP-A1) is used.

Use the factory default value (0) if the unit selected in the feedback is used.

J105	Display unit	J105	Display unit	J105	Display unit
0	* (Factory default)	23	L/s (flow)	45	mmHg (pressure)
1	No unit	24	L/min (flow)	46	Psi (pressure)
2	%	25	L/h (flow)	47	mWG (pressure)
4	r/min	40	Pa (pressure)	48	inWG (pressure)
7	kW	41	kPa (pressure)	60	K (temperature)
20	m^3/s (flow)	42	MPa (pressure)	61	°C (temperature)
21	m^3/min (flow)	43	mbar (pressure)	62	°F (temperature)
22	m^3/h (flow)	44	bar (pressure)	80	ppm (density)

* Follows the unit/scale of the feedback value.

■ Maximum scale/minimum scale (J106, J107)

The PID control displayed can be converted to a physical amount that is easy to recognize. Use J106 to set the maximum scale "display when the PID command value is 100%", and J107 to set "display when the PID command is 0%". The display value is determined as follows:

Display value = (PID command value (%))/100×(Max. scale - Min. scale)+Min. scale

- Data setting range: (Max. scale and min. scale) -999.00 to 0.00 to 9990.00

If using the feedback signal's scale/unit, use J105=0 (factory default); then, it is unnecessary to set J106 and J107.

■ PID multi-step command 1 to 3 (J136, J137 and J138)

A PID command value can be given by a digital input multiple-step command. Assign the digital input terminals with 171: PID-SS1 and 172: PID-SS2.

PID-SS2	PID-SS1	PID multi-step command
OFF	OFF	Not selected
OFF	ON	J136: PID multi-step command 1 Modification range: -999.0 to 0.00 to 9990
ON	OFF	J137: PID multi-step command 2 Modification range: -999.0 to 0.00 to 9990
ON	ON	J138: PID multi-step command 3 Modification range: -999.0 to 0.00 to 9990

J03 to J06	PID Control P (Gain), I (Integral time), D (Differential time), Feedback filter

■ **P gain (J03)**

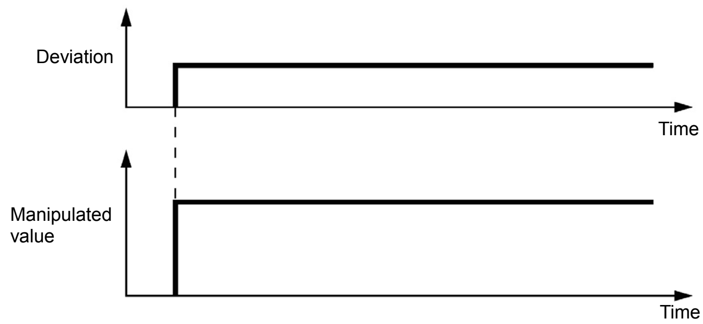
J03 specifies the gain for the PID processor.

- Data setting range: 0.000 to 30.000 (times)

P (Proportional) action

An operation in which the MV (manipulated value: output frequency) is proportional to the deviation is called P action, which outputs the MV in proportion to deviation. However, P action alone cannot eliminate deviation.

Gain is data that determines the system response level against the deviation in P action. An increase in gain speeds up response, but an excessive gain may oscillate the inverter output. A decrease in gain delays response, but it stabilizes the inverter output.



■ **I integral time (J04)**

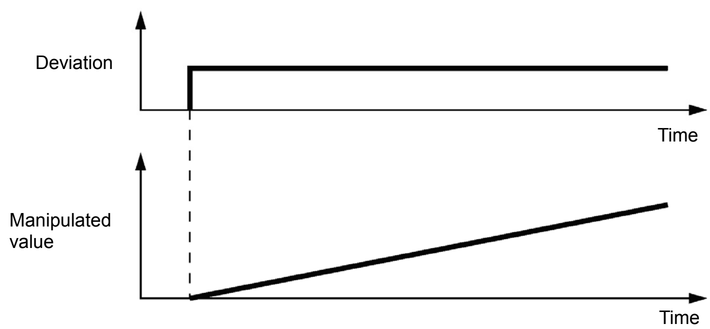
J04 specifies the integral time for the PID processor.

- Data setting range: 0.0 to 3600.0 (s)
  0.0 indicates that the integral component is ineffective

I (Integral) action

An operation in which the change rate of the MV (manipulated value: output frequency) is proportional to the integral value of deviation is called I action, which outputs the MV that integrates the deviation. Therefore, I action is effective in bringing the feedback amount close to the commanded value. For the system whose deviation rapidly changes, however, this action cannot make it respond quickly.

The effectiveness of I action is expressed by integral time as parameter, that is J04 data. The longer the integral time, the slower the response. The reaction to the external disturbance also becomes slow. The shorter the integral time, the faster the response. Setting too short integral time, however, makes the inverter output tend to oscillate against the external disturbance.



FUNCTION CODE

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■ D differential time (J05)

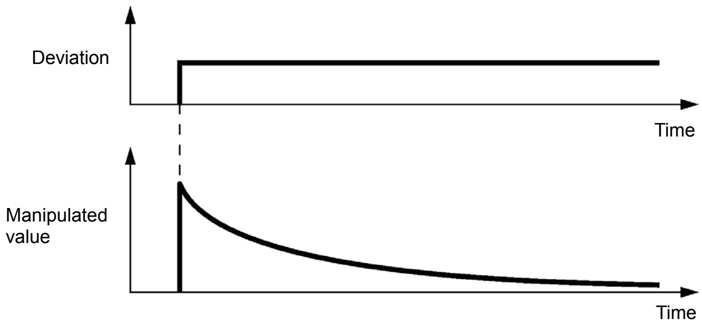
J05 specifies the differential time for the PID processor.

- Data setting range: 0.00 to 600.00 (s)
  0.00 indicates that the differential component is ineffective.

D (Differential) action

An operation in which the MV (manipulated value: output frequency) is proportional to the differential value of the deviation is called D action, which outputs the MV that differentiates the deviation. D action makes the inverter quickly respond to a rapid change of deviation.

The effectiveness of D action is expressed by differential time as parameter, that is J05 data. Setting a long differential time will quickly suppress oscillation caused by P action when a deviation occurs. Too long differential time makes the inverter output oscillation more. Setting short differential time will weakens the suppression effect when the deviation occurs.



The combined uses of P, I, and D actions are described below.

(1) PI control

PI control, which is a combination of P and I actions, is generally used to minimize the remaining deviation caused by P action. PI control always acts to minimize the deviation even if a commanded value changes or external disturbance steadily occurs. However, the longer the integral time of I action, the slower the system response to quick-changed control. P action can be used alone for loads with very large part of integral components.

(2) PD control

In PD control, the moment that a deviation occurs, the control rapidly generates greater MV (manipulated value: output frequency) than that generated by D action alone, to suppress the deviation increase. When the deviation becomes small, the behavior of P action becomes small. A load including the integral component in the controlled system may oscillate due to the action of the integral component if P action alone is applied. In such a case, use PD control to reduce the oscillation caused by P action, for keeping the system stable. That is, PD control is applied to a system that does not contain any damping actions in its process.

(3) PID control

PID control is implemented by combining P action with the deviation suppression of I action and the oscillation suppression of D action. PID control features minimal control deviation, high precision and high stability. In particular, PID control is effective to a system that has a long response time to the occurrence of deviation.

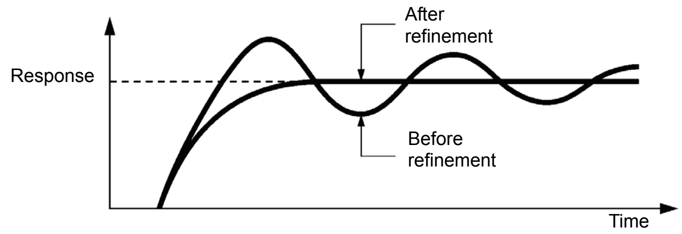
Follow the procedure below to set data to PID control function codes.

It is highly recommended that you adjust the PID control value while monitoring the system response waveform of the PID feedback with an oscilloscope or equivalent. Repeat the following procedure to determine the optimal solution for each system.

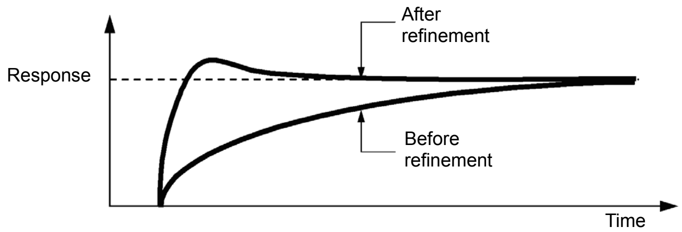
- Increase the data of J03 (PID control P (Gain)) within the range where the feedback signal does not oscillate.
- Decrease the data of J04 (PID control I (Integral time)) within the range where the feedback signal does not oscillate.
- Increase the data of J05 (PID control D (Differential time)) within the range where the feedback signal does not oscillate.

Refining the system response waveforms is shown below.

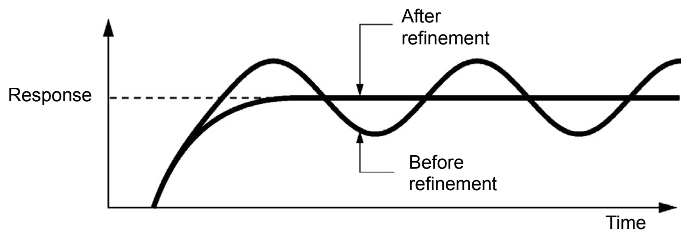
1) Suppressing overshoot
Increase the data of J04 (Integral time) and decrease that of J05 (Differential time).



2) Quick stabilizing (Moderate overshoot is allowable.)
Decrease the data of J03 (Gain) and increase that of J05 (Differential time).

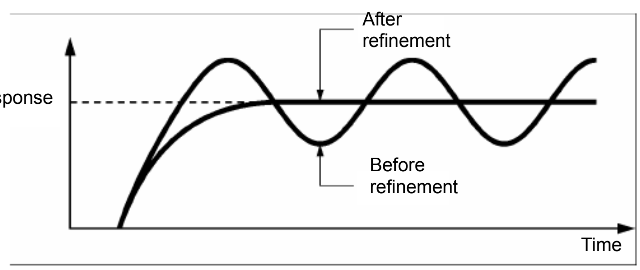


3) Suppressing oscillation whose period is longer than the integral time specified by J04
Increase the data of J04 (Integral time).



4) Suppressing oscillation whose period is approximately the same as the time specified by J05 (Differential time)
Decrease the data of J05 (Differential time).

Decrease the data of J03 (Gain), if the oscillation cannot be suppressed even though the differential time is set at 0 sec.



■ **Feedback filter (J06)**

J06 specifies the time constant of the filter for feedback signals under PID control.

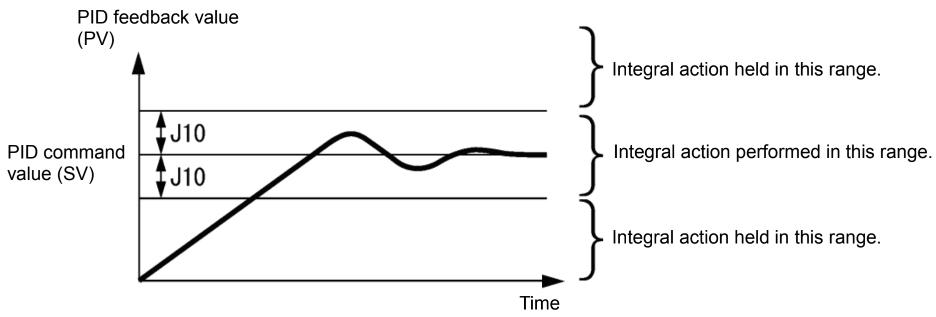
- Data setting range:0.0 to 900.0 (s)
- This setting is used to stabilize the PID control loop. Setting too long a time constant makes the system response slow.

Note Under PID dancer control, the filter time constant setting of up to 0.1 s is recommended. To specify the filter time constant more finely, apply filter time constants for analog input (C33, C38 and C43) with J06 = 0.0.

J10	PID Control (Anti-reset windup)

J10 suppresses overshoot in control with the PID processor. As long as the deviation between the feedback and the PID command is beyond the preset range, the integrator holds its value and does not perform integration operation.

- Data setting range: 0 to 200 (%)



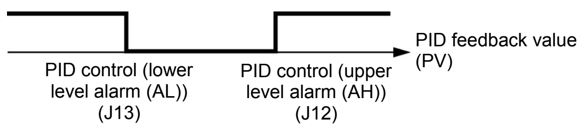
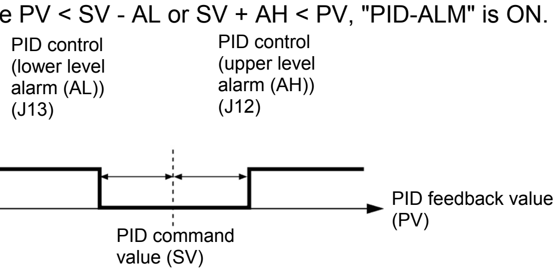
J11 to J13	PID Control (Select alarm output, Upper level alarm (AH) and Lower level alarm (AL))

The inverter can output two types of alarm signals (absolute-value and deviation alarms) associated with PID control if the digital output signal "PID-ALM" is assigned to any of the programmable, output terminals with any of E20, E21 and E27 (data = 42).

J11 specifies the alarm output types. J12 and J13 each specify the upper and lower limits for alarms.

■ PID Control (Select alarm output) (J11)

J11 specifies one of the following alarms available.

J11 data	Alarm	Data
0	Absolute-value alarm	While PV < AL or AH < PV, "PID-ALM" is ON 
1	Absolute-value alarm (with Hold)	Same as above (with Hold)
2	Absolute-value alarm (with Latch)	Same as above (with Latch)
3	Absolute-value alarm (with Hold and Latch)	Same as above (with Hold and Latch)
4	Deviation alarm	While PV < SV - AL or SV + AH < PV, "PID-ALM" is ON. 
5	Deviation alarm (with Hold)	Same as above (with Hold)
6	Deviation alarm (with Latch)	Same as above (with Latch)
7	Deviation alarm (with Hold and Latch)	Same as above (with Hold and Latch)

Hold: During the power-on sequence, the alarm output is kept OFF (disabled) even when the monitored quantity is within the alarm range. Once it goes out of the alarm range, and comes into the alarm range again, the alarm is enabled.

Latch: Once the monitored quantity comes into the alarm range and the alarm is turned ON, the alarm will remain ON even if it goes out of the alarm range. To release the latch, perform a reset by using the PRG/RESET key on keypad or turning the terminal command RST ON. Resetting can be done by the same way as resetting an alarm.

■ PID Control (Upper limit alarm) (AH) (J12)

J12 specifies the upper limit of the alarm (AH) in percentage (%) of the feedback amount.

■ PID Control (Lower limit alarm) (AL) (J13)

J13 specifies the lower limit of the alarm (AL) in percentage (%) of the feedback amount.

Note: The value displayed (%) is the ratio of the upper/lower limit to the full scale (10 V or 20 mA) of the feedback amount (in the case of a gain of 100%).

Upper level alarm (AH) and lower level alarm (AL) also apply to the following alarms.

Alarm	Data	How to handle the alarm	
		Select alarm output (J11)	Parameter setting
Upper limit (absolute)	ON when AH < PV	Absolute-value alarm	AL = 0
Lower limit (absolute)	ON when PV < AL		AH = 100%
Upper limit (deviation)	ON when SV + AH < PV	Deviation alarm	AL = 100%
Lower limit (deviation)	ON when PV < SV - AL		AH = 100%
Upper/lower limit (deviation)	ON when |SV - PV| > AL		AL = AH
Upper/lower range limit (deviation)	ON when SV - AL < PV < SV + AL	Deviation alarm	A negative logic signal should be assigned to "PID-ALM".
Upper/lower range limit (absolute)	ON when AL < PV < AH	Absolute-value alarm	
Upper/lower range limit (deviation)	ON when SV - AL < PV < SV + AH	Deviation alarm	

J15	**PID control (slow flowrate stop/operating frequency level)**
J16	**PID control (slow flowrate stop/stop latency)**
J17	**PID control (slow flowrate stop/starting frequency)**
J23	**PID control (slow flowrate stop - feedback deviation for startup)**
J24	**PID control (slow flowrate stop - startup delay time)**

Slow flowrate stopping function (J15 to J17, J23, J24)

J15 to J17 configure the slow flowrate stopping function in pump control, a function that stops the inverter when the discharge pressure increases, causing the volume of water to decrease.

When the discharge pressure has increased, decreasing the reference frequency (output of the PID processor) below the stop frequency for slow flowrate level (J15) for the period of slow flowrate level stop latency (J16), the inverter decelerates to stop, while PID control itself continues to operate. When the discharge pressure decreases, increasing the reference frequency (output of the PID processor) above the starting frequency (J17), the inverter resumes operation.

The restarting conditions can be adjusted with J23 and J24 based on the time and pressure deviation.

■ PID control (Stop frequency for slow flowrate) (J15)

J15 specifies the frequency which triggers slow flowrate stop of inverter.

■ PID control (Slow flowrate level stop latency) (J16)

J16 specifies the period from when the PID output drops below the frequency specified by J15 until the inverter starts deceleration to stop.

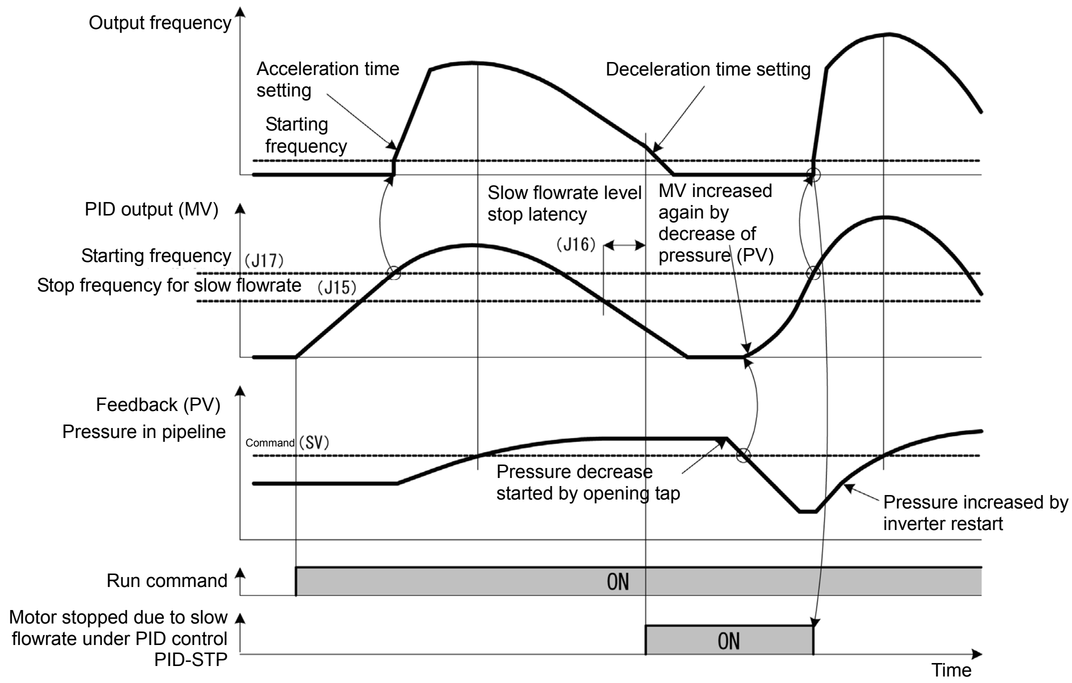
■ PID control (Starting frequency) (J17)

J17 specifies the starting frequency. Set J17 to a frequency higher than the stop frequency for slow flowrate (J15). If the specified starting frequency is lower than the stop frequency for slow flowrate, the latter stop frequency is ignored; the slow flowrate stopping function is triggered when the output of the PID processor drops below the specified starting frequency.

■ Assignment of "PID-STP" ("Motor stopped due to slow flowrate under PID control") (E20, E21 and E27, data = 44)

"PID-STP" ("Motor stopped due to slow flowrate under PID control") is ON when the inverter is in a stopped state due to the slow flowrate stopping function under PID control. PID-STP should be assigned if it is necessary to output a signal to indicate that the inverter is stopped.

For the slow flowrate stopping function, see the chart below.

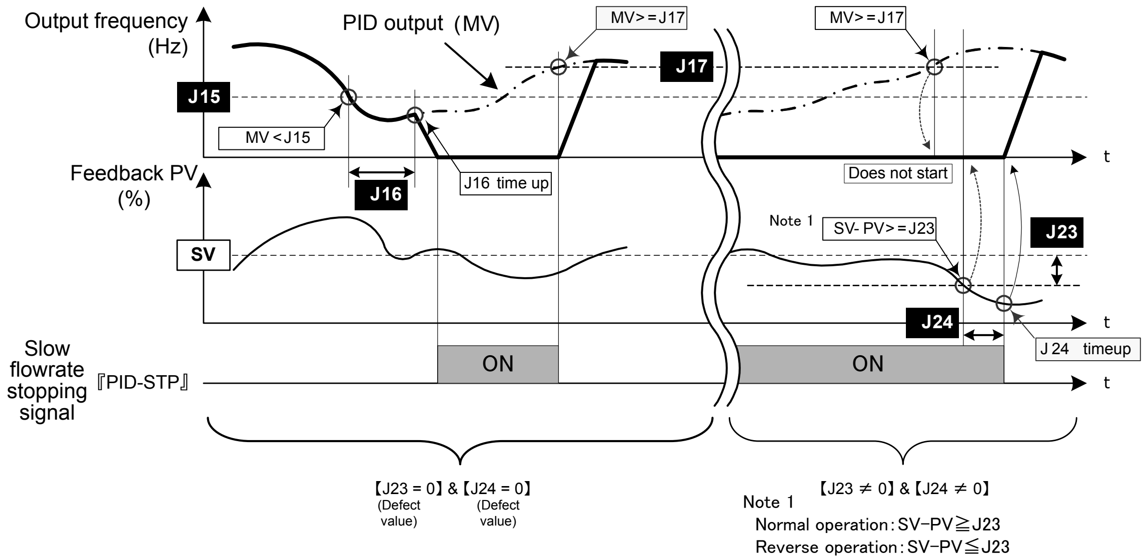


■ PID control (slow flowrate stop - feedback deviation for startup) (J23)

■ PID control (slow flowrate stop - startup delay time) (J24)

When both of the two conditions below are satisfied (AND), the inverter is restarted.

- The discharge pressure has decreased, increasing the frequency (output of the PID processor) to or above the starting frequency (J17) and the startup delay time (J24) has elapsed.
- The difference between the SV (command value) and PV (feedback value) has increased to the level of feedback deviation for startup (J23) or higher and the startup delay time (J24) has elapsed.



J18, J19	PID Control (Upper limit of PID process output, Lower limit of PID process output)

The upper and lower limiters can be specified to the PID output, exclusively used for PID control. The settings are ignored when PID cancel "Hz/PID" is enabled and the inverter is operated at the reference frequency previously specified.
(📖 Function codes E01 to E05 data = 20)

■ **PID Control (Upper limit of PID process output) (J18)**

J18 specifies the upper limit of the PID processor output limiter in %. If you specify "999", the setting of the frequency limiter (High) (F15) will serve as the upper limit.

■ **PID Control (Lower limit of PID process output) (J19)**

J19 specifies the lower limit of the PID processor output limiter in %. If you specify "999", the setting of the frequency limiter (Low) (F16) will serve as the lower limit.

J57	PID Control (Dancer reference position)

J57 specifies the dancer reference position in the range of -100% to +100% for dancer control. If J02 = 0 (keypad) is selected, this function code is enabled as the dancer reference position.

It is also possible to modify the PID command with the ⌃ / ⌄ keys on keypad. If it is modified, the new command value is saved as J57 data.

For the setting procedure of the PID command, refer to Chapter 3, Section 3.3.5 "Setting up frequency and PID commands."

J58 J59 to J61	PID Control (Detection width of dancer position deviation) PID Control P (Gain) 2, I (Integral time) 2 and D (Differential time) 2

The moment the feedback value of dancer roll position comes into the range of "the dancer reference position detection width of dancer position deviation (J58)" the inverter switches PID constants from the combination of J03, J04 and J05 to that of J59, J60 and J61, respectively in its PID processor. Giving a boost to the system response by raising the P gain may improve the system performance in the dancer roll positioning accuracy.

■ **PID Control (Detection width of dancer position deviation) (J58)**

J58 specifies the bandwidth in the range of 1 to 100%. Specifying "0" does not switch PID constants.

■ **PID Control P (Gain) 2 (J59)**

■ **PID Control I (Integral time) 2 (J60)**

■ **PID Control D (Differential time) 2 (J61)**

Descriptions for J59, J60, and J61 are the same as those of PID control P (Gain) (J03), I (Integral time) (J04), and D (Differential time) (J05), respectively.

J62	PID Control (PID control block selection)

J62 allows you to select either adding or subtracting the PID dancer processor output to or from the primary speed command. Also, it allows you to select either controlling the PID dancer processor output by the ratio (%) against the primary speed command or compensating the primary speed command by the absolute value (Hz).

J62 data			Block selection	
Decimal	Bit 1	Bit 0	Control value type	Operation for the primary speed command
0	0	0	Ratio (%)	Addition
1	0	1	Ratio (%)	Subtraction
2	1	0	Absolute value (Hz)	Addition
3	1	1	Absolute value (Hz)	Subtraction

J63	Overload stop function (detected value)
J64	Overload stop function (detection level)
J65	Overload stop function (mode selection)
J66	Overload stop function (operation mode)
J67	Overload stop function (timer)

Detects an overload status and if it exceeds the specified detection level (J64) for the specified timer duration (J67), the operation is stopped based on the selected action (J65). It is used to protect the system when an unacceptable overload is applied or to lock the motor shaft by mechanically hitting it to the stopper.

■ Detected Value (J63)

Select a target (detected value) to monitor the load status.

J63 data	Detected value	Function overview
0	Torque	To improve the accuracy of calculated torque, perform auto-tuning. It is targeted for the driving torque.
1	Current	No-load current flows even at no load; therefore, consider the no-load current and set the value accordingly.

■ Detection Level (J64)

Set the value, assuming that the motor rated torque and current are 100%.

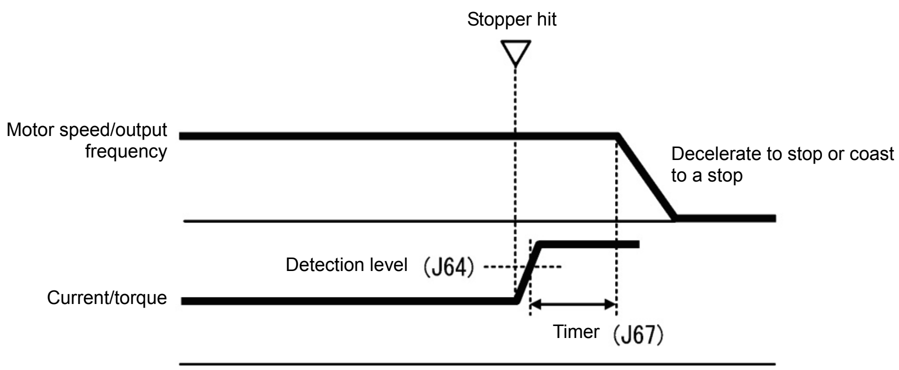
■ Mode Selection (J65)

Select an operation when the load exceeds the value specified in J64.

J65 data	Action	Function overview
0	Disable	Overload stop function operation cancellation
1	The inverter decelerates to stop the motor.	Decelerates to stop the motor, as specified in deceleration time.
2	Coast to stop	Immediately shuts down the inverter, allowing the motor to coast to a stop.

Note
- When the system enters the overload stop function operation, the mode is maintained and you cannot re-accelerate the inverter. To perform re-acceleration, turn OFF the run command and turn it ON again.

<Mode selection J65=1, 2>



■ Operation Mode (J66)

Specifies an operation status where the overload stop function is triggered.

Make sure that a malfunction does not occur in unnecessary status.

J66 data	Operation mode
0	Enabled during constant speed or in deceleration time.
1	Enabled during constant speed
2	Enabled in all modes

■ Timer (J67)

Sets the timer to prevent the overload stop function from being triggered due to instantaneous, unintended load fluctuation. The overload stop function starts the operation when the operation condition of overload stop function is satisfied for a period of the timer (if J65=1, 2).

J68 to J70 **J71, J72** **J95**	**Brake signal (Brake-OFF current, Brake-OFF frequency/speed and Brake-OFF timer)** **Brake signal (Brake-ON frequency/speed and Brake-ON timer)** **Brake signal (Brake-OFF torque)** **Related function code: A98: Motor 2 (function selection)**

These function codes are for the brake releasing/turning-on signals of vertical carrier machines.

It is possible to set the conditions of the brake releasing/turning-on signals (current and frequency) so that a hoisted load does not fall down at the start or stop of the operation, or so that the load applied to the brake is reduced.

■ Brake signal BRKS (E20, E21 and E27, data = 57)

This signal outputs a brake control command that releases or activates the brake.

Releasing the Brake

When any of the inverter output current and output frequency exceeds the specified level of the brake signal (J68/J69/J95) for the period specified by J70 (Brake signal (Brake-OFF timer)), the inverter judges that required motor torque is generated and turns the signal BRKS ON for releasing the brake.

This prevents a hoisted load from falling down due to an insufficient torque when the brake is released.

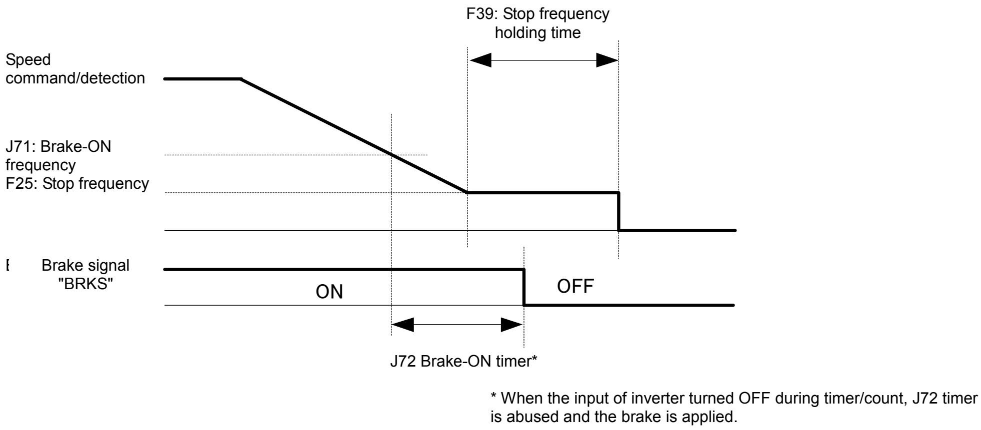
Function code	Name	Data setting range	Remarks
J68	Brake-OFF current	0.00 to 300.00%:	Set it putting the inverter rated current at 100%.
J69	Brake-OFF frequency/speed	0.0 to 25.0 Hz	
J70	Brake-OFF timer	0.00 to 5.00s	

Turning the Brake ON

When the run command is OFF and the output frequency drops below the level specified by J71 (Brake signal (Brake-ON frequency/speed)) and stays below the level for the period specified by J72 (Brake signal (Brake-ON timer)), the inverter judges that the motor rotation is below a certain level and turns the signal "BRKS" OFF for activating the brake.

This operation reduces the load applied to the brake, extending lifetime of the brake.

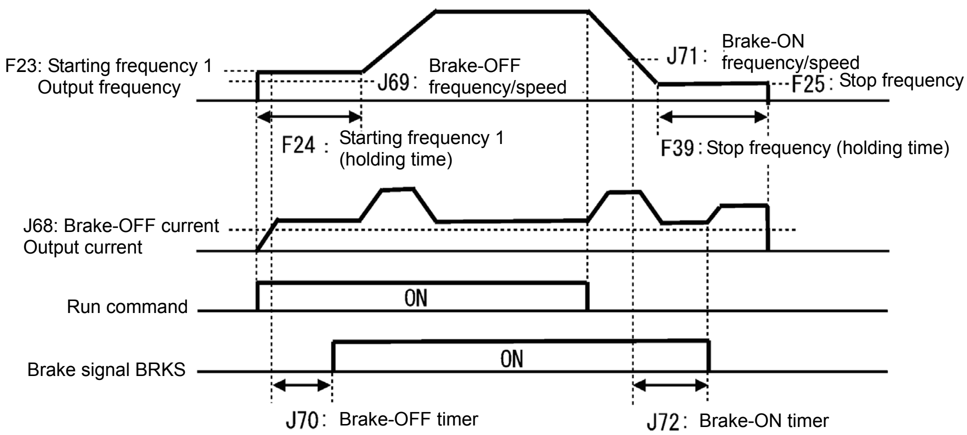
Function code	Name	Data setting range	Remarks
J71	Brake-ON frequency/speed	0.0 to 25.0 Hz	
J72	Brake-ON timer	0.00 to 5.00s	



Note

- The brake signal applies only in the 1st motor. When the 2nd motor is selected, switch the motor to apply the brake signal. However, it can be enabled with A98.
- When the inverter is shut down due to an alarm status or coast-to-stop command, the brake signal is immediately applied.
- The stop is determined after the output frequency exceeds "F25 stop frequency + E30 frequency arrival hysteresis width", and then the output frequency falls below F25.
  To inch the motor (repeatedly turn ON and OFF the run command in a short time), adjust F25 and E30.

Operation time chart



Note

- After releasing the brake (BRKS ON), operating for a while, and then activating the brake (BRKS OFF) to stop the motor, if you want to release the brake (BRKS ON), turn the inverter's run command OFF and then ON.
- No brake release signal is output during auto-tuning (stop mode).

J105 to J107	PID control 1 (display unit, maximum scale, minimum scale)

Refer to the description of J02.

J136 To J138	PID control 1 (PID multi-step command 1 to 3)

For details, refer to the description of J02.

5.3.8 d Codes (Applied Functions 2)

d51, d52 d55, d69, d91	**Reserved for particular manufacturers**

Function codes are reserved for particular manufacturers. Unless otherwise specified, do not access these function codes.

d61 to d63	**Command (Pulse Rate Input) (Filter time constant, Pulse count factor 1 and Pulse count factor 2) (Refer to F01.)**

Refer to the description of the function code F01 for details on the pulse rate input.

d99	**Extended function 1**

To enable the jogging operation "***JOG***" from communication, set bit 3=1 for this function.

Note: Other value than bit 3 for this function code is for manufacturers. Do not change this function code.

5.3.9 U Codes (Customizable logic operation)

The customizable logic function allows the user to form a logic or operation circuit for digital/analog input/output signals, customize those signals arbitrarily, and configure a simple relay sequence inside the inverter.

In the customizable logic, one step (component) is composed of:

1) Digital 2 input, digital 1 output + logical operation (including timer)
2) Analog 2 input, analog 1 output/digital 1 output + numerical operation
3) Analog 1 input, digital 1 input, analog 1 output + numerical operation, logical operation

and a total of 100 steps can be used to configure a sequence.

■ **Modes**

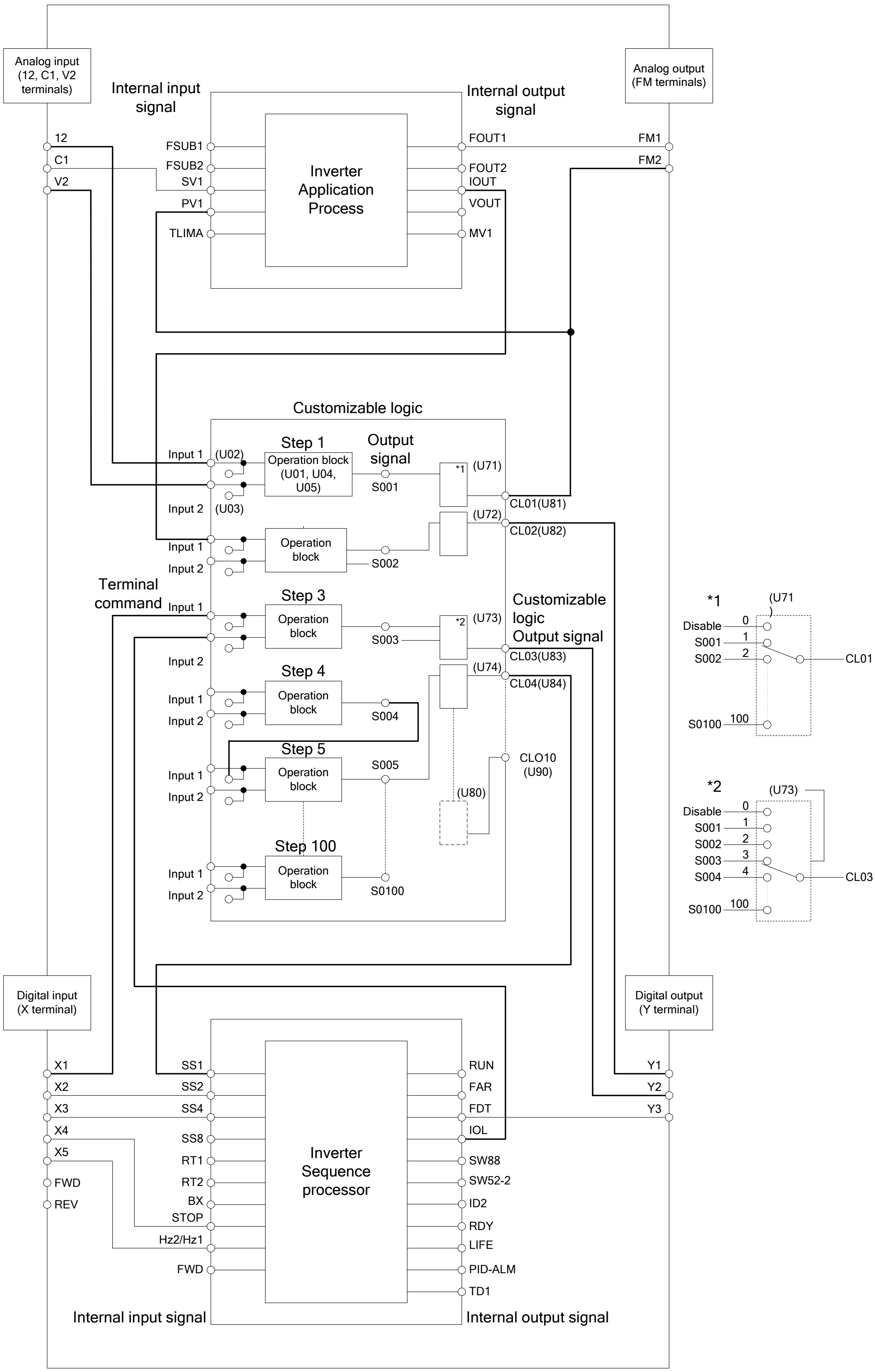
Item	Modes		
Terminal command	Digital 2 input	Analog 2 input	Analog 1 input Digital 1 input
Operation block	Logical operation, counter, etc.: 13 types Timer: 5 types	Numerical operation, comparator, limiter, etc.: 25 types	Selector, hold, etc.: 12 types
Output signal	Digital 1 output	Analog 1 output/ Digital 1 output	Analog 1 output
Number of steps	100 steps		
Customizable logic output signal	9 outputs		
Customizable logic processing time	2 ms (max. 10 steps), 5 ms (max. 50 steps), 10 ms (max. 100 steps) Can be selected with the function codes.		
Customizable logic cancellation command "CLC"	Enables to stop all the customizable logic operations by assigning "CLC" to a general-purpose input terminal to turn it ON. It is used when you want to deactivate the customizable logic temporarily.		
Customizable logic timer cancellation command "CLTC"	Resets the timer, counter and all the previous values used in customizable logic by assigning "CLTC" to a general-purpose input terminal to turn it ON. It is used when a customizable logic is changed or if you want to synchronize it with external sequence.		

Note If you use the customizable logic cancellation command and customizable logic timer cancellation command, the inverter can unintentionally start because the speed command is unmasked, depending on the structure of the customizable logic. Be sure to turn OFF the operation command to turn it ON.

A physical injury may result.

A damage may result.

■ Block diagram



Note: Mode selection function codes for enabling customizable logic can be modified during operation but the customizable logic output may become temporarily unstable due to the setting modification. Therefore, since unexpected operation can be performed, change the settings if possible when the inverter is stopped.

A physical injury may result.

A damage may result.

U00	**Customizable logic (mode selection)**
U01 to U70	**Customizable logic: step 1 to 14 (mode setting)**
U71 to U80	**Customizable logic: output signal 1 to 10 (output selection)**
U81 to U90	**Customizable logic: output signal 1 to 10 (function selection)**
U91	**Customizable logic: Customizable logic timer monitor (No. selection)**
U92 to U97	**Customizable logic: conversion factor**
U100	**Customizable logic: task process setting**
U101 to U107	**Customizable logic: operating point 1 to 3. Factor auto-calculation**
U121 to U140	**Customizable logic: User parameter 1 to 20**
U171 to U173	**Customizable logic: Storage area 1 to 3**
U190 to U195	**Customizable logic: step 15 to 100 setting**

■ Customizable Logic (Mode selection) (U00)

U00 specifies whether to enable the sequence configured with the customizable logic function or disable it to run the inverter only via its input terminals and others.

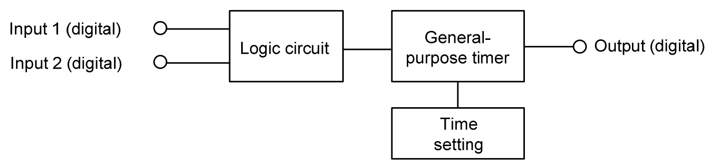
U00 data	Function
0	Disable
1	Enable (Customizable logic operation)

The ECL alarm occurs when changing U00 from 1 to 0 during operation.

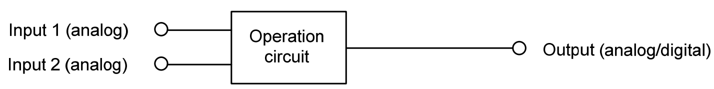
■ Customizable Logic (Mode Setting) (U01 to U70, U190 to U195)

In a customizable logic, one step is categorized into the following three components:

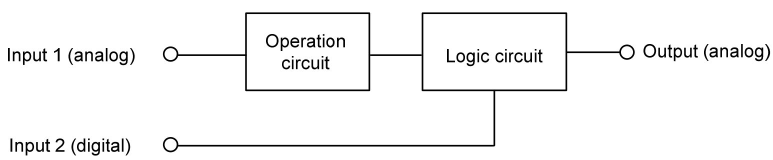
[Input: digital] Block selection (U01, U06, U11, etc.) = 1 to 1999



[Input: analog] Block selection (U01, U06, U11, etc.) = 2001 to 3999



[Input: digital, analog] Block selection (U01, U06, U11, etc.) = 4001 to 5999



The function code settings for each step are as follows:

- Step 1 to 14

Step No.	Control function	Input 1	Input 2	Function 1	Function 2	Output Note)
Step 1	U01	U02	U03	U04	U05	"SO01"
	= 1 to 1999	Digital input 1	Digital input 2	Time setting	Not required	Digital output
	= 2001 to 3999	Analog input 1	Analog input 2	Value 1	Value 2	Analog/digital output
	= 4001 to 6999	Analog input 1	Digital input 2	Value 1	Value 2	Analog output
Step 2	U06	U07	U08	U09	U10	"SO02"
Step 3	U11	U12	U13	U14	U15	"SO03"
Step 4	U16	U17	U18	U19	U20	"SO04"
Step 5	U21	U22	U23	U24	U25	"SO05"
Step 6	U26	U27	U28	U29	U30	"SO06"
Step 7	U31	U32	U33	U34	U35	"SO07"
Step 8	U36	U37	U38	U39	U40	"SO08"
Step 9	U41	U42	U43	U44	U45	"SO09"
Step 10	U46	U47	U48	U49	U50	"SO10"
Step 11	U51	U52	U53	U54	U55`	"SO11"
Step 12	U56	U57	U58	U59	U60	"SO12"
Step 13	U61	U62	U63	U64	U65	"SO13"
Step 14	U66	U67	U68	U69	U70	"SO14"

Note) Output is not a function code. It indicates the output signal symbol.

- Step 15 to 100

Specify a step number in U190, and set the block selection to function 2 in U191 to U195.

Step No.	U190	Control function	Input 1	Input 2	Function 1	Function 2	Output
Step 15	15						"SO15"
Step 16	16						"SO16"
···	···	U191	U192	U193	U194	U195	···
Step 99	99						"SO99"
Step 100	100						"SO100"

[Input: digital] Block function code setting

■ Block selection (U01 etc.)

Any of the following items can be selected as a logic circuit (with general-purpose timer):
The data can be logically inverted by adding 1000.

Data	Logic circuit	Description
0	No function assigned	Output is always OFF.
10	Through output + General-purpose timer (No timer)	Only a general-purpose timer. No logic circuit exists.
11	(On-delay timer)	Turning an input signal ON starts the on-delay timer. When the period specified by the timer has elapsed, an output signal turns ON. Turning the input signal OFF turns the output signal OFF.
12	(Off-delay timer)	Turning an input signal ON turns an output signal ON. Turning the input signal OFF starts the off-delay timer. When the period specified by the timer has elapsed, the output signal turns OFF.
13	(One-shot pulse output)	Turning an input signal ON issues a one-shot pulse whose length is specified by the timer.
14	(Retriggerable timer)	Turning an input signal ON issues a one-shot pulse whose length is specified by the timer. If an input signal is turned ON again during the preceding one-shot pulse length, however, the logic circuit issues another one-shot pulse.
15	(Pulse train output)	If an input signal turns ON, the logic circuit issues ON and OFF pulses (whose lengths are specified by the timer) alternately and repeatedly. This function is used to flash a luminescent device.
20 to 25	ANDing + General-purpose timer	AND circuit with 2 inputs and 1 output, plus general-purpose timer.
30 to 35	ORing + General-purpose timer	OR circuit with 2 inputs and 1 output, plus general-purpose timer.
40 to 45	XORing + General-purpose timer	XOR circuit with 2 inputs and 1 output, plus general-purpose timer.
50 to 55	Set priority flip-flop + General-purpose timer	Set priority flip-flop with 2 inputs and 1 output, plus general-purpose timer.
60 to 65	Reset priority flip-flop + General-purpose timer	Reset priority flip-flop with 2 inputs and 1 output, plus general-purpose timer.
70, 72, 73	Rising edge detector + General-purpose timer	Rising edge detector with 1 input and 1 output, plus general-purpose timer. This detects the rising edge of an input signal and outputs the ON signal for 5 ms (*1).
80, 82, 83	Falling edge detector + General-purpose timer	Falling edge detector with 1 input and 1 output, plus general-purpose timer. This detects the falling edge of an input signal and outputs the ON signal for 5 ms (*1).
90, 92, 93	Rising & falling edges detector + General-purpose timer	Rising and falling edge detector with 1 input and 1 output, plus general-purpose timer. This detects both the falling and rising edges of an input signal and outputs the ON signal for 5 ms (*1).
100 to 105	Hold + General-purpose timer	Hold function of previous values of 2 inputs and 1 output, plus general-purpose timer. If the hold control signal is OFF, the logic circuit outputs input signals; if it is ON, the logic circuit retains the previous values of input signals.

*1: Equals the task cycle: 2 ms for a task cycle of 2 ms, 5 ms for 5 ms and 10 ms for 10 ms.

FUNCTION CODE

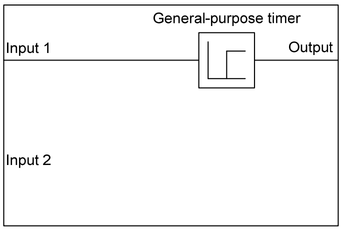
Chap. 5

Data	Logic circuit	Description
110	Increment counter	Increment counter with reset input. By the rising edge of an input signal, the logic circuit increments the counter value by one. When the counter value reaches the target one, the output signal turns ON. Turning the reset signal ON resets the counter to zero.
120	Decrement counter	Decrement counter with reset input. By the rising edge of an input signal, the logic circuit decrements the counter value by one. When the counter value reaches zero, the output signal turns ON. Turning the reset signal ON resets the counter to the initial value.
130	Timer with reset input	Timer output with reset input. If an input signal turns ON, the output signal turns ON and the timer starts. When the period specified by the timer has elapsed, the output signal turns OFF, regardless of the input signal state. Turning the reset signal ON resets the current timer value to zero and turns the output OFF.

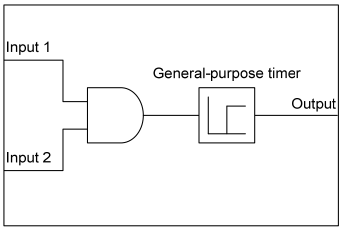
The data can be logically inverted by adding 1000.

The block diagrams for individual functions are given below.

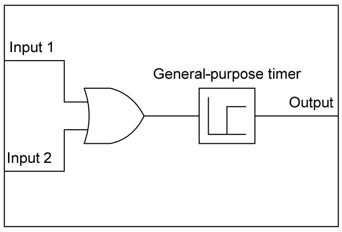
(Data=1☐) Through output



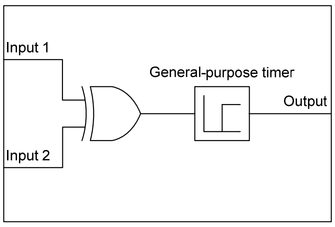
(Data=2☐) AND



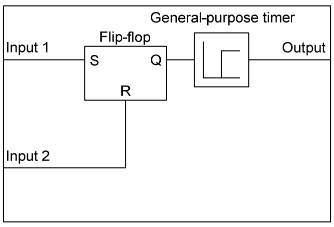
(Data=3☐) OR



(Data=4☐) XOR

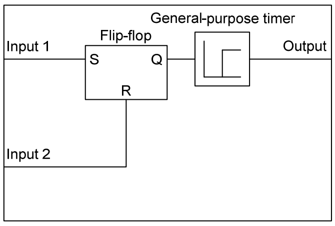


(Data=5☐) Set priority flip-flop



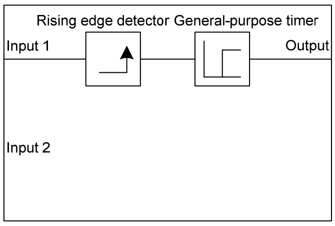
<table>
<tr><th>Input 1</th><th>Input 2</th><th>Previous output</th><th>Output</th><th>Remarks</th></tr>
<tr><td rowspan="3">OFF</td><td rowspan="2">OFF</td><td>OFF</td><td>OFF</td><td rowspan="2">Hold previous value</td></tr>
<tr><td>ON</td><td>ON</td></tr>
<tr><td>ON</td><td>–</td><td>OFF</td><td></td></tr>
<tr><td>ON</td><td>–</td><td>–</td><td>ON</td><td>Set priority</td></tr>
</table>

(Data=6□) Reset priority flip-flop

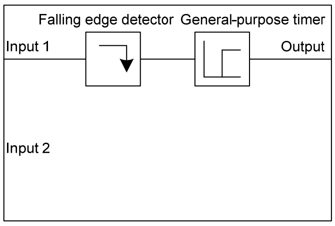


Input 1	Input 2	Previous output	Output	Remarks
OFF	OFF	OFF	OFF	Hold previous value
		ON	ON	
-	ON	-	OFF	Reset priority
ON	OFF	-	ON	

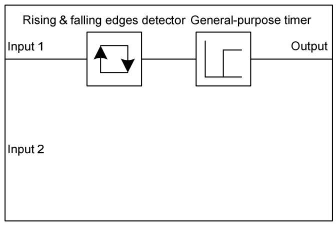
(Data=7□) Rising edge detector



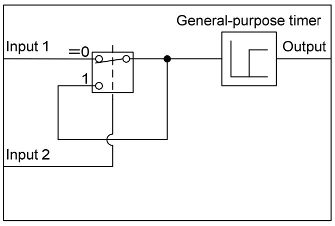
(Data=8□) Falling edge detector



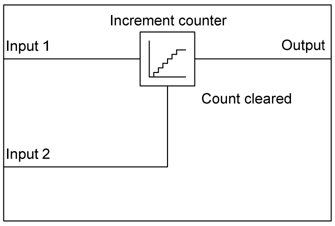
(Data=9□) Rising & falling edges detector



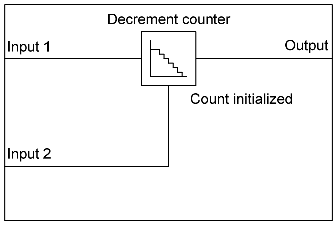
(Data=10□) Hold



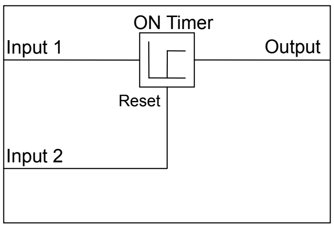
(Data=110) Increment counter

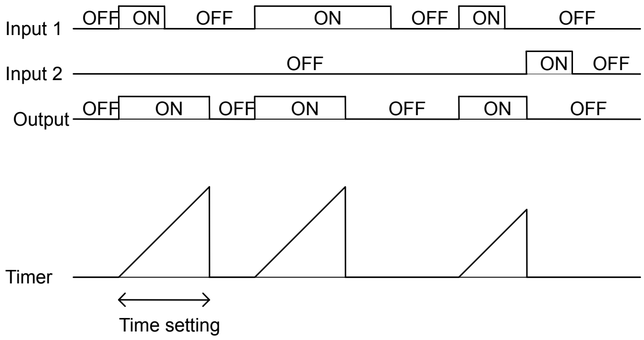


(Data=120) Decrement counter



(Data=130) Timer with reset input

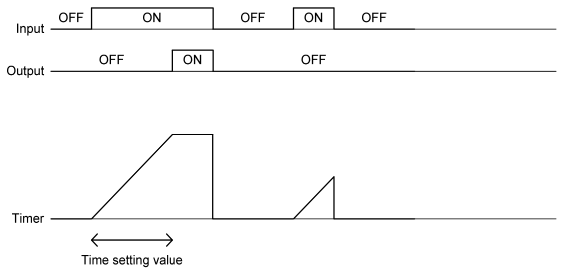




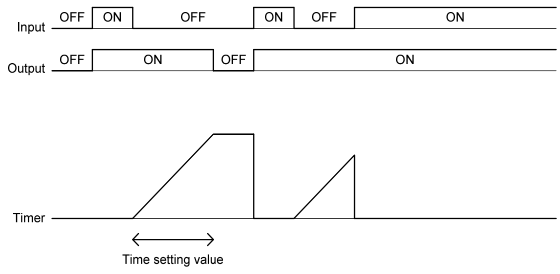
■ Operation of general-purpose timer

The operation schemes for individual timers are shown below.

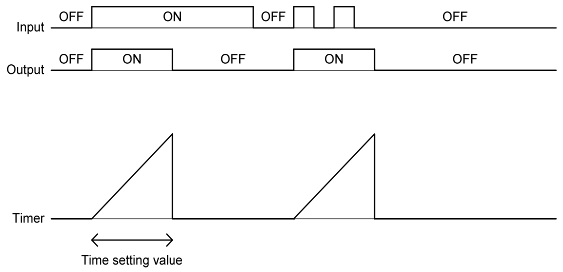
(End 1) On-delay timer



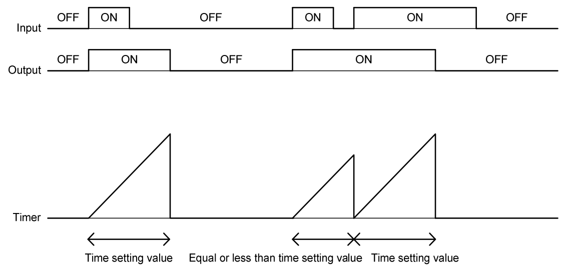
(End 2) Off-delay timer



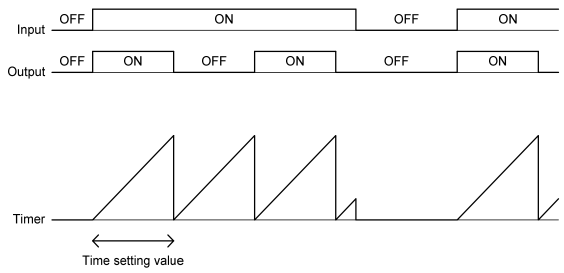
(End 3) One-shot pulse output



(End 4) Retriggerable timer



(End 5) Pulse train output



■ Inputs 1 and 2 (U02, U03, etc.)

The following digital signals are available as input signals. Value in ( ) is a negative logic.

Data	Selectable Signals
0000 (1000) to 0105 (1105)	General-purpose output signals Same as the ones specified by E20, e.g., "RUN" (Inverter running), FAR (Frequency (speed) arrival signal), "FDT" (Frequency (speed) detected), "LU" (Undervoltage detected (Inverter stopped)), "B/D" (Torque polarity detected) Note: 27 (Universal DO) is not available. Note: Customizable logic output signals for 111 (1111) to 119 (1119) cannot be selected.
2001 (3001) to 2100 (3100)	Output of step 1 "SO01" to Output of step 100 "SO100"
4001 (5001)	Terminal X1 input signal "X1"
4002 (5002)	Terminal X2 input signal "X2"
4003 (5003)	Terminal X3 input signal "X3"
4004 (5004)	Terminal X4 input signal "X4"
4005 (5005)	Terminal X5 input signal "X5"
4010 (5010)	Terminal FWD input signal FWD
4011 (5011)	Terminal REV input signal REV
6000 (7000)	Final RUN command "FL_RUN" (ON when a run command is given)
6001 (7001)	Final FWD run command "FL_FWD" (ON when a run forward command is given)
6002 (7002)	Final REV run command "FL_REV" (ON when a run reverse command is given)
6003 (7003)	During acceleration "DACC" (ON during acceleration)
6004 (7004)	During deceleration "DDEC" (ON during deceleration)
6005 (7005)	Under anti-regenerative control "REGA" (ON under anti-regenerative control)
6006 (7006)	Within dancer reference position "DR_REF" (ON when the dancer position is within the reference range)
6007 (7007)	Alarm factor presence “ALM_ACT” (ON when there is no alarm factor)

■ Function 1 (U04 etc.)

U05 and other related function codes specify the general-purpose timer period or the increment/decrement counter value.

Data	Function	Description
0.00 to +600.00	Timer	The period is specified by seconds.
	Counter value	The specified value is multiplied by 100 times. (If 0.01 is specified, it is converted to 1.)
-9990.00 to -0.01	-	The timer or counter value works as 0.00. (No timer)
+601.00 to +9990.00	−	The timer or counter value works as 600.

FUNCTION CODE

Chap. 5

[Input: analog] Block function code setting

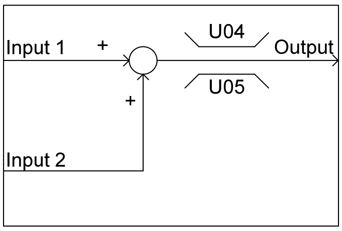
■ Block selection, function 1, function 2 (U01, U04, U05, etc.)

The following items are available as operation circuit.
Note that if the upper and lower limits are the same value, there are no upper and lower limits.

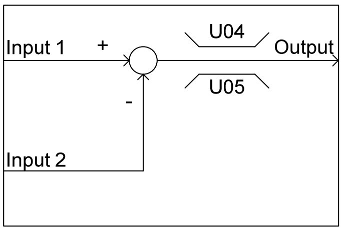
Block selection (U01 etc.)	Operation circuit	Description	Function 1 (U04 etc.)	Function 2 (U05 etc.)
0	No function assigned	Output is always 0% (or OFF).	Not required	Not required
2001	Addition	Addition circuit with two inputs and one output.	Upper limit	Lower limit
2002	Subtraction	Subtraction circuit with two inputs and one output.	Upper limit	Lower limit
2003	Multiplication	Multiplication circuit with two inputs and one output.	Upper limit	Lower limit
2004	Division	Division circuit with two inputs and one output.	Upper limit	Lower limit
2005	Limiter	Upper and lower limiter circuit with one input and one output.	Upper limit	Lower limit
2006	Absolute value	Absolute value circuit with one inputs and one output.	Upper limit	Lower limit
2007	Reverse addition	Reverse addition circuit with one input and one output.	Addition value (former)	Addition value (latter)
2008	Variable limiter	Variable limiter circuit with one input and one output. One input for upper limiter value and two inputs for lower limit value.	Step number	Not required
2009	Linear conversion	Linear conversion circuit with one input and one output. It satisfies the following expression. The output is limited with a range between -9990 and 9990 by the internal limiter. $y = K_A \times x + K_B$	Factor KA -9990.0 to +9990.0	Factor KB -9990.0 to +9990.0
2051	Comparison 1	Digitally outputs a comparison of two input deviations.	Deviation	Hysteresis width
2052	Comparison 2	Digitally outputs a comparison of two input deviations.	Deviation	Hysteresis width
2053	Comparison 3	Digitally outputs a comparison of two input deviations (absolute values).	Deviation	Hysteresis width
2054	Comparison 4	Digitally outputs a comparison of two input deviations (absolute values).	Deviation	Hysteresis width
2055	Comparison 5	Digitally outputs a comparison of one input and one reference value.	Reference value	Hysteresis width
2056	Comparison 6	Digitally outputs a comparison of one input and one reference value.	Reference value	Hysteresis width
2071	Window comparison 1	Outputs a comparison of one input and upper/lower limits.	Upper threshold	Lower threshold
2072	Window comparison 2	Outputs a comparison of one input and upper/lower limits.	Upper threshold	Lower threshold
2101	Maximum selection	Circuit to output a larger value of two inputs.	Upper limit	Lower limit
2102	Minimum selection	Circuit to output a smaller value of two inputs.	Upper limit	Lower limit
2103	Average	Circuit to output an average value of two inputs.	Upper limit	Lower limit
2151	Function code	Takes the function code S13(%) value as input.	Maximum scale	Minimum scale
2201	Scale reverse conversion	Circuit to convert the analog 1 input to 0-100.00 in the scale setting value. Use it to connect to analog output terminals. Maximum used number is two steps.	Maximum scale	Minimum scale
2202	Scale conversion	Circuit to convert the analog 1 input to 0-100.00 in the scale setting value. Signal selection of input 1 can be used only for the setting values 8000 to 8085. Maximum used number is two steps.	Maximum scale	Minimum scale
3001	Conversion 1	$K_A \times (\text{Input 1})^2 + K_B \times \text{Input 1} + K_C$ U92 to U97 are used for the factors Maximum used number is one step in either (3001) or (3002).	Upper limit	Lower limit
3002	Conversion 2	$\sqrt{\frac{\text{Input 1} + K_A}{K_B} \times K_C}$ U92 to U97 are used for the factors Maximum used number is one step in either (3001) or (3002).	Upper limit	Lower limit

The block diagrams for each operation circuit are given below. The setting value for functions 1 and 2 is indicated with U04 and U05.

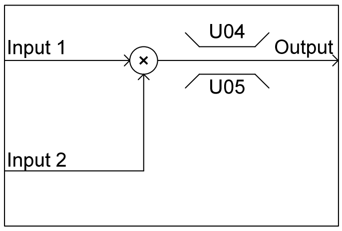
(2001) Addition



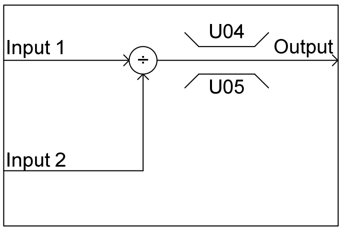
(2002) Subtraction



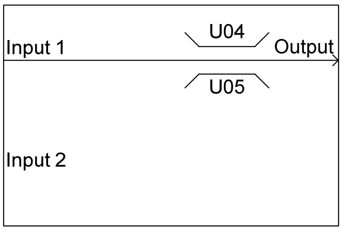
(2003) Multiplication



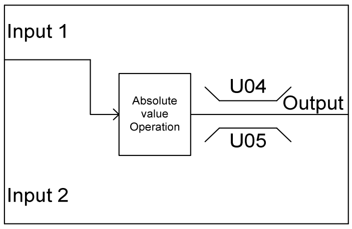
(2004) Division



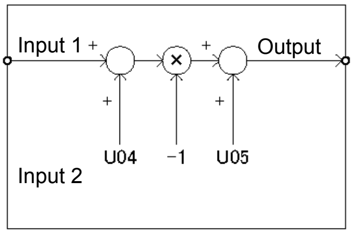
(2005) Limiter



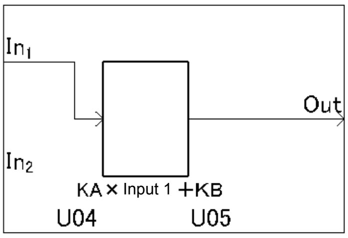
(2006) Absolute value



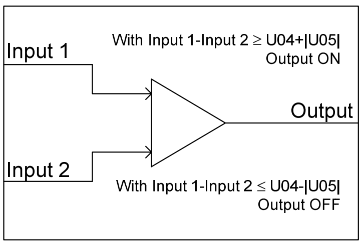
(2007) Reverse addition



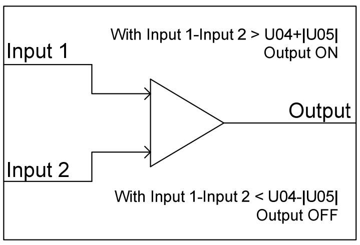
(2009) Linear conversion



(2051) Comparison 1

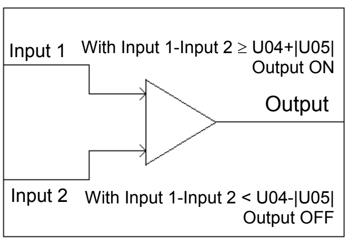


(2052) Comparison 2

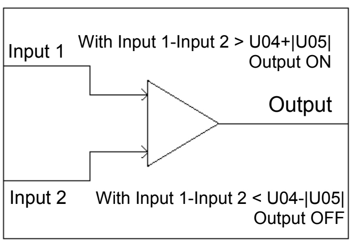


ON is prioritized when both of the conditions are satisfied.

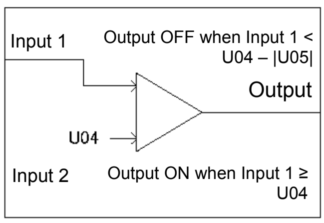
(2053) Comparison 3



(2054) Comparison 4

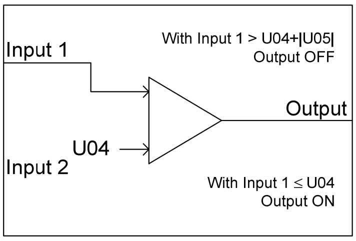


(2055) Comparison 5

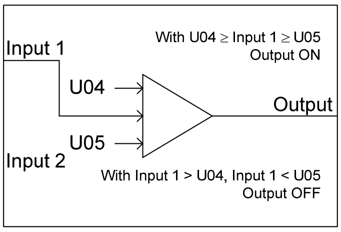


ON is prioritized when both of the conditions are satisfied.

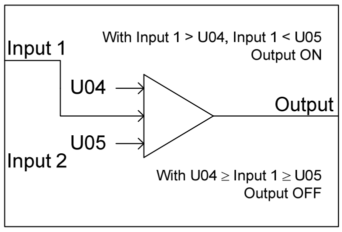
(2056) Comparison 6



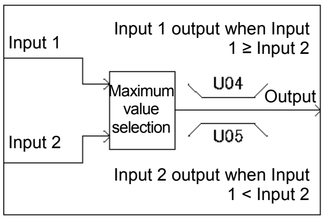
(2071) Window comparison 1



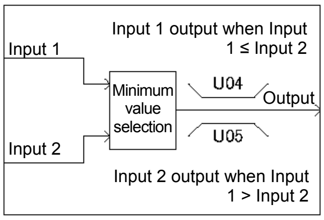
(2072) Window comparison 2



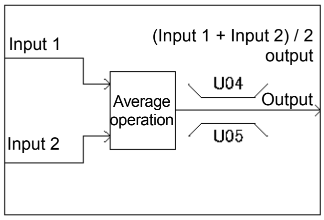
(2101) Maximum value selection



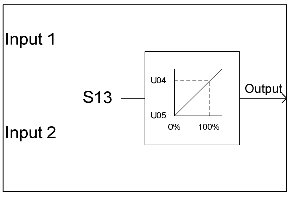
(2102) Minimum value selection



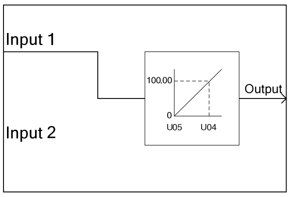
(2103) Average



(2151) Function code input

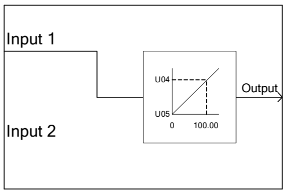


(2201) Scale reverse conversion



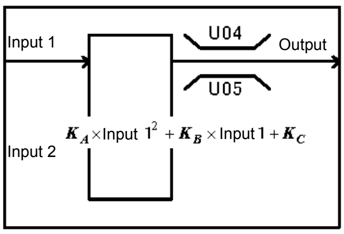
- * Use it to connect to analog output terminals.
- * Maximum used number is two steps.

(2202) Scale conversion

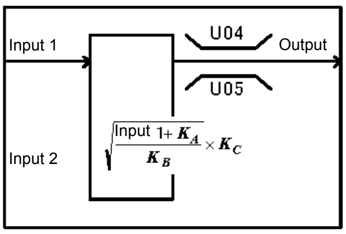


- * Signal selection of input 1 can be used only for the setting values 8000 to 8085.
- * Maximum used number is two steps.

(3001) Conversion 1



(3002) Conversion 2



* Maximum used number is one step in either (3001) or (3002).

■ Inputs 1 and 2 (U02, U03, etc.)

The following signals are available as analog input signals.

Data	Selectable Signals
8000 to 8018	General-purpose analog output signal (same as signals selected in F31 and F35: output frequency 1, output current, output torque, power consumption, DC link bus voltage, etc.) Example: For maximum frequency of output frequency 1, 100.00 is input as 100%. Example: For output current, 100.00 is input with 200% of the inverter rated current. Note: 10 (Universal AO) is not available.
2001 to 2100	Output of step 1 to 100 "SO01" to "SO101"
9001	Analog 12 terminal input signal [12]
9002	Analog C1 terminal input signal [C1] (C1 function)
9003	Analog C1 terminal input signal [C1] (V2 function)

■ Function 1, Function 2 (U04, U05, etc.)

Sets the upper limit and lower limit of operation circuit.

Data	Function	Description
-9990.00 to 0.00 to +9990.00	Reference value Hysteresis width Upper limit Lower limit Upper threshold Lower threshold Setting value Maximum scale Minimum scale	Setting value for the operation circuit selected in an operation setting such as U01

■ Conversion factor setting (U92 to U97)

Sets the factor of conversion function (3001, 3002) of operation circuit.

Function code	Name	Data setting range	Factory default
U92	Significand of the conversion factor K_A	Significand: -9.999 to 9.999	0.000
U93	Exponent part of the conversion factor K_A	Exponent part: -5 to 5	0
U94	Significand of the conversion factor K_B		0.000
U95	Exponent part of the conversion factor K_B		0
U96	Significand of the conversion factor K_c		0.000
U97	Exponent part of the conversion factor K_c		0

U92 to U97 can automatically be calculated based on measured data. For details, refer to the descriptions of U101 to U107 (P5-XX).

FUNCTION CODE

Chap. 5

[Input: digital, analog] Block function code setting

■ Lock selection, function 1, function 2 (U01, U04, U05, etc.)

The following items are available as operation circuit/logic circuit.

Note that if the upper and lower limits are identical, there are no upper and lower limits.

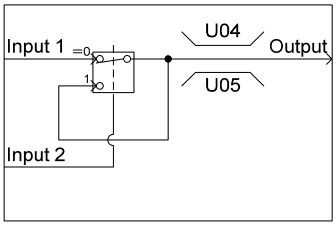
Block selection (U01 etc.)	Operation circuit	Description	Function 1 (U04 etc.)	Function 2 (U05 etc.)
4001	Hold	Circuit to hold analog 1 input based on digital 1 input.	Upper limit	Lower limit
4002	Reverse addition switch	Circuit to reverse analog 1 input based on digital 1 input.	Addition value (former)	Addition value (latter)
4003	Selection 1	Circuit to select analog 1 input and setting value based on digital 1 input.	Setting value	Not required
4004	Selection 2	Circuit to select setting value 1/2 based on digital 1 input.	Setting value 1	Setting value 2
4005	LPF (Low pass filter)	Value of an analog 1 input is filtered through LPF (time constant U04) when the digital 1 input is "1". When the digital 1 input is "0", the analog 1 input is directly output. (LPF maintains the previous output value. Therefore, when the digital 1 input changes from 0 to 1, the output will be the value with the previous output value added as the initial value of LPF.) (No upper/lower limiter)	Time constant 0: No filter 0.01 to 5.00s	Fixed as 0
4006	Change rate limit	Value of an analog input is limited with change rate specified in functions 1 and 2 when the digital 1 input is "1". When the digital 1 input is "0", the analog 1 input is directly output. When setting the initial value, carry out an operation with the initial value for input 1 and 0 for input 2. Then, reflect the result as the initial value (= previous output value) with 1 applied to input 2. During the initialization or when the CLC terminal is ON, the previous output value is cleared to 0.	Upward change rate Time taken to change 100% 0: No limit 0.01 to 600 s	Downward change rate Time taken to change 100% 0: The same change rate as function 1 0.01 to 600 s
5000	Selection 3	Circuit to select analog 2 input based on "SO01" to "SO100".	Step No.	Not required
5001	Selection 3-1	Circuit to select analog 2 input based on "SO01".	Not required	Not required
⋮	• • •	• • •		
5014	Selection 3-14	Circuit to select analog 2 input based on "SO14".	Not required	Not required
5100	Selection 4	Circuit to select analog 1 input and "SO01" to "SO100" based on digital 1 input.	Step No.	Not required
5101	Selection 4-1	Circuit to select analog 1 input and "SO01" based on digital 1 input.	Not required	Not required
⋮	• • •	• • •		
5114	Selection 4-14	Circuit to select analog 1 input and "SO14" based on digital 1 input.	Not required	Not required

Block selection (U01 etc.)	Operation circuit	Description	Function 1 (U04 etc.)	Function 2 (U05 etc.)
6001	Reading function codes	Circuit to output the content of arbitrary function code. Use function1 (such as U04) to specify a function code category, and function 2 (such as U05) to specify the last two digits of the function code number. Data formats that can be read correctly are as follows (the values are restricted between -9990 and 9990 and, for [29], 20000 is indicated as 100%): [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [12], [22], [24], [29], [35], [37], [45], [61], [67], [68], [74], [92] and [93] Data formats other than the above cannot be read correctly. Do not use any other format.	0 to 255	0 to 99
6002	Writing function codes	Reflect the input 1 value in a specific function code (U171 to U173) when the input 2 is 1. When the input 2 is 0, the specific function code maintains the previous value. The input 1 value is written to the function code when the inverter detects undervoltage. Do not use more than one instance of this operation circuit for one function code.	39	71 to 73
6003	Function code switch	Circuit to select a value on memory of a specific function code (appendix) among values of function 2 and input 1. Specify a function code category in function 1 (U04). Specify the last two digits of a function code number in function 2 (U05). When the input 2 is 0, the current value is reflected in the value on a memory of the function code. When the input 2 is not 0, the value of the input 1 is reflected. Note that when no specific function code (such as U04 and U05) is specified, data 0 is reflected. For details on appendix and this function, refer to P5-188. This operation circuit is intended for switching of the value of a specific function code. Do not use this as the input of other LE. Do not use more than one instance of this operation circuit for switching one function code.	0 to 255	0 to 99
6101	PID dancer output gain frequency	Circuit to switch either to calculate a frequency correction where 100% of PID output shall be the maximum frequency, or to calculate a frequency correction where a specified frequency (specified in the line speed command). Use the input 1 to set whether to activate this circuit. Use the input 2 and gain ratio to select a frequency correction. Output: Frequency correction = (PID output)×(Line speed command) ••• (Input 2 OFF, U04≠0%) Frequency correction amount = (PID output×Gain ratio (U04))×(Maximum output frequency) ••• (Input 2 ON, U04 ≠ 0%) Note that when the gain ratio is set to 0%, the following applies regardless of the input 2: Output: Frequency correction amount = (PID output)×(Line speed command) This circuit is used with the PID control.	Gain ratio 0 to 200%	Lower frequency limit 0 to 500Hz

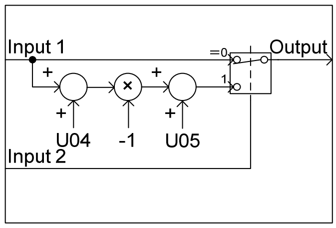
FUNCTION CODE

Chap. 5

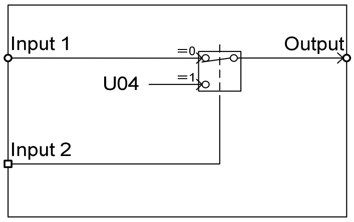
(4001) Hold



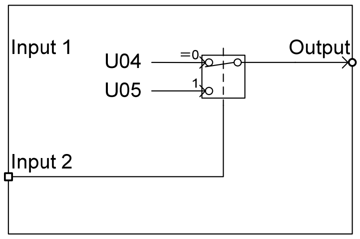
(4002) Reverse addition switch



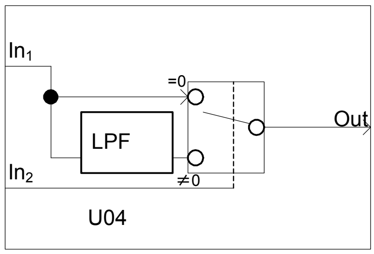
(4003) Selection 1



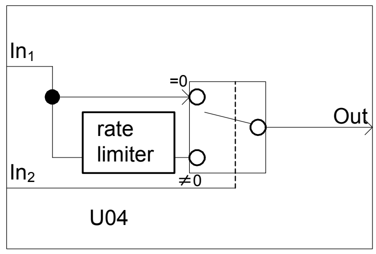
(4004) Selection 2



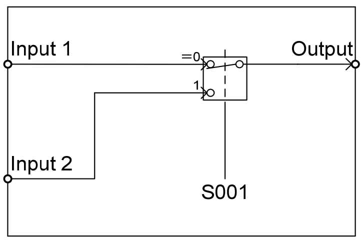
(4005) Low pass filter



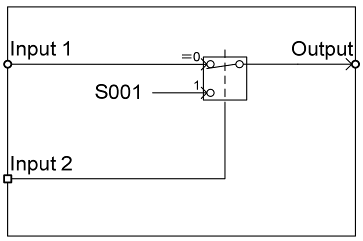
(4006) Change rate limit



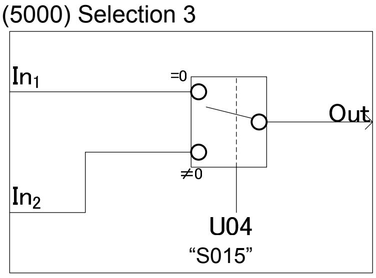
(5001 to 5014) Selection 3-1 to 3-14



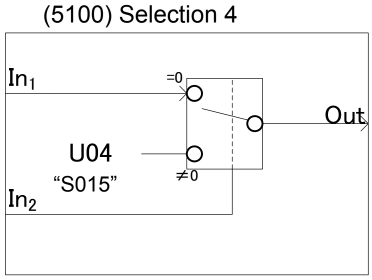
(5101 to 5114) Selection 4-1 to 4-14



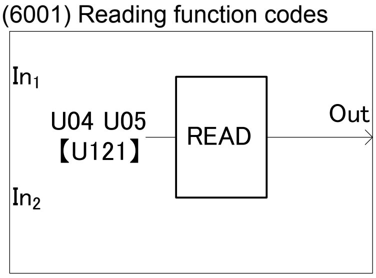
(5000) Selection 3



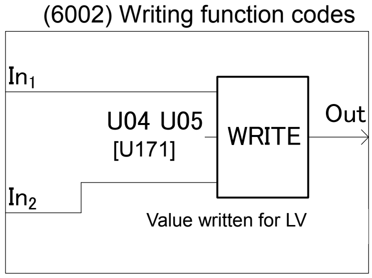
(5100) Selection 4



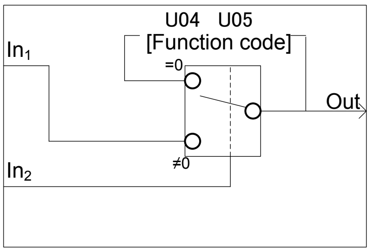
(6001) Reading function codes



(6002) Writing function codes



(6003) Selection 5



■ Output signal

In a customizable logic, outputs from steps 1 to 10 are issued to SO01 to SO100, respectively.

SO01 to SO100 differ in configuration depending upon the connection destination, as listed below. (To relay those outputs to any function other than the customizable logic, route them via customizable logic outputs CL01 to CLO010.)

Connection destination of each step output	Configuration	Function code
Input of customizable logic	Select one of the internal step output signals “SO01” to “SO100” in customizable logic input setting.	Such as U02 and U03
Input of inverter sequence processor (such as multi-step speed “SS1” or operation command “FWD”)	Select one of the internal step output signals “SO01” to “SO100” to be connected to customizable logic output signals 1 to 10 (“CL01” to “CLO10”).	U71 to U80
	Select an inverter's sequence processor input function to which one of the customizable logic output signals 1 to 10 (“CL01” to “CLO10”) is to be connected. (Same as in E01)	U81 to U90
Analog input (such as auxiliary frequency commands or PID process commands)	Select one of the internal step output signals “SO01” to “SO100” to be connected to customizable logic output signals 1 to 10 (“CL01” to “CLO10”).	U71 to U80
	Select an analog input function to which one of the customizable logic output signals 1 to 10 (“CL01” to “CLO10”) is to be connected. (Same as in E61)	U81 to U90
General-purpose digital output ([Y] terminals)	Select one of the internal step output signals “SO01” to “SO100” to be connected to customizable logic output signals 1 to 10 (“CL01” to “CLO10”).	U71 to U80
	To specify a general-purpose digital output function (on [Y] terminals) to which one of the customizable logic output signals 1 to 10 (“CL01” to “CLO10”) is to be connected, select one of “CL01” to “CL10” by specifying the general-purpose digital output function on any Y terminal.	E20, E21, E27
General-purpose analog output ([FM] terminals)	Select one of the internal step output signals “SO01” to “SO100” to be connected to customizable logic output signals 1 to 10 (“CL01” to “CLO10”).	U71 to U80
	To specify a general-purpose analog output function (on [FM] terminals) to which one of the customizable logic output signals 1 to 10 (“CL01” to “CLO10”) is to be connected, select one of “CL01” to 10 “CLO10” by specifying the general-purpose digital output function on any [FM] terminal.	F31, F35

Note General-purpose digital outputs (on [Y] terminals) are updated every 5 ms. To securely output a customizable logic signal via [Y] terminals, include on- or off-delay timers in the customizable logic. Otherwise, short ON or OFF signals may not be reflected on those terminals.

Function codes	Name	Data setting range	Factory default
U71	Customizable logic output signal 1 (Output selection)	0: Disable 1: Output of step 1, "SO01" 2: Output of step 2, "SO02" ••• 99: Output of step 99, "SO99" 100: Output of step 100, "SO100"	0
U72	Customizable logic output signal 2 (Output selection)		0
U73	Customizable logic output signal 3 (Output selection)		0
U74	Customizable logic output signal 4 (Output selection)		0
U75	Customizable logic output signal 5 (Output selection)		0
U76	Customizable logic output signal 6 (Output selection)		0
U77	Customizable logic output signal 7 (Output selection)		0
U78	Customizable logic output signal 8 (Output selection)		0
U79	Customizable logic output signal 9 (Output selection)		0
U80	Customizable logic output signal 10 (Output selection)		0
U81	Customizable logic output signal 1 (Function selection)	■ **If a step output is digital** **The same value as E98 can be specified.** 0(1000): Select multi-frequency (0 to 1 steps) "SS1" 1(1001): Select multi-frequency (0 to 3 steps) "SS2" 2(1002): Select multi-frequency (0 to 7 steps) "SS4" 3(1003): Select multi-frequency (0 to 15 steps) "SS8" 4(1004): Select ACC/DEC time (2 steps) "RT1" 5(1005): Select ACC/DEC time (4 steps) "RT2" 6(1006): Enable 3-wire operation "HLD" 7(1007): Coast-to-stop command "BX" 8(1008): Reset alarm "RST" 9(1009): Enable external alarm trip "THR" (9=Active OFF/1009=Active ON) and so on. ■ **If a step output is analog** 8001: Auxiliary frequency command 1 8002: Auxiliary frequency command 2 8003: PID process command 1 8005: PID feedback amount 1 8006: Ratio setting 8007: Analog torque limit value A 8008: Analog torque limit value B	100
U82	Customizable logic output signal 2 (Function selection)		100
U83	Customizable logic output signal 3 (Function selection)		100
U84	Customizable logic output signal 4 (Function selection)		100
U85	Customizable logic output signal 5 (Function selection)		100
U86	Customizable logic output signal 6 (Function selection)		100
U87	Customizable logic output signal 7 (Function selection)		100
U88	Customizable logic output signal 8 (Function selection)		100
U89	Customizable logic output signal 9 (Function selection)		100
U90	Customizable logic output signal 10 (Function selection)		100

■ Specific function codes

The following function codes helps change values on memory using the customizable logic "Function code switch (6003)". Overwritten values are cleared with power off.

Number	Name	Number	Name
F07	Acceleration Time 1	J03	PID Control P (Gain)
F08	Deceleration Time 1	J04	PID Control I (Integral time)
F15	Frequency Limiter (Upper)	J05	PID Control D (Differential time)
F16	Frequency Limiter (Lower)	J06	PID Control (Feedback filter)
F21	DC Braking 1 (Braking level)	J10	PID Control (Anti-reset windup)
F22	DC Braking 1 (Braking time)	J12	PID Control (Upper limit alarm (AH))
F23	Starting Frequency 1	J13	PID Control (Lower limit alarm (AL))
F24	Starting Frequency 1 (Holding time)	J15	PID Control (Stop frequency for slow flowrate)
F25	Stop Frequency	J16	PID Control (Slow flowrate level stop latency)
F39	Stop Frequency (Holding time)	J17	PID Control (Starting frequency)
F40	Torque Limiter 1 (Driving)	J18	PID Control (Upper limit of PID process output)
F41	Torque Limiter 1 (Braking)	J19	PID Control (Lower limit of PID process output)
F44	Current Limiter (Level)	J58	PID Control (Detection width of dancer position deviation)
C05	Multi-Frequency 1	J59	PID Control P (Gain) 2
C06	Multi-Frequency 2	J60	PID Control I (Integral time) 2
C07	Multi-Frequency 3	J61	PID Control D (Differential time) 2
C08	Multi-Frequency 4	J72	Brake Signal (Brake-ON timer)
C09	Multi-Frequency 5		
H28	Droop control		
H50	Non-linear V/f Pattern 1 (Frequency)		
H51	Non-linear V/f Pattern 1 (Voltage)		
H52	Non-linear V/f Pattern 2 (Frequency)		
H53	Non-linear V/f Pattern 2 (Voltage)		
H65	Non-linear V/f Pattern 3 (Frequency)		
H66	Non-linear V/f Pattern 3 (Voltage)		
H91	PID Feedback Wire Break		

FUNCTION CODE

Chap. 5

■ Function codes for the customizable logic

Function code number	Name	Range	Minimum unit	Remarks
U121 to U140	User parameter 1 to 20	-999.00 to 9990.00 Effective number 3 digits	0.01 to 10	
U171 to U173	Storage area 1 to 3	-999.00 to 9990.00 Effective number 3 digits	0.01 to 10	Memorizes the data when powered off.

■ Configuration of function codes

Set a code value in the following table to function 1 (such as U04) and set the last two digits of the function code number to function 2 (such as U05) to specify individual function codes.

Group	Code		Name	Group	Code		Name
F	0	00_H	Basic function	M	8	08_H	Monitor data
E	1	01_H	Terminal function	J	13	$0D_H$	Applied function 1
C	2	02_H	Control function	d	19	13_H	Applied function 2
H	4	04_H	High performance function	U	11	$0B_H$	Customizable logic
U1	39	27_H	For customizable logic	W	15	$0F_H$	Monitor 2

■ Task process setting (U100)

U100 data	Data
0	Automatically adjusts the task cycle in 2 ms to 10 ms depending on the number of used steps. This is the factory default. It is recommended to use this value.
2	2 ms: Up to 10 steps. If it exceeds 10 steps, the customizable logic does not work.
5	5 ms: Up to 50 steps. If it exceeds 50 steps, the customizable logic does not work.
10	10 ms

Note that if it exceeds the steps defined in 2 or 5, the customizable logic does not work.

■ Operating precautions

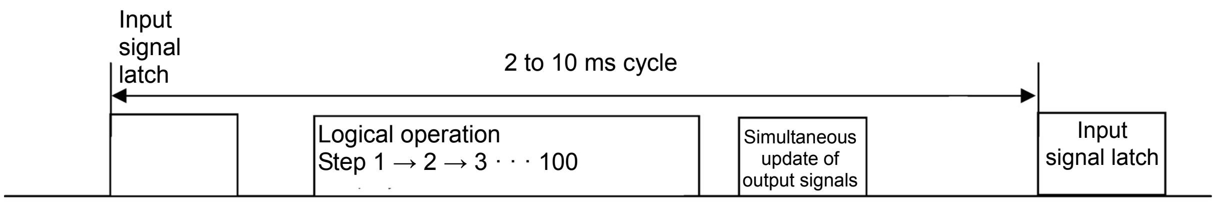
The customizable logics are calculated by 2 ms to 10 ms (according to U100) and processed in the following procedure:

(1) First, latch the external input signals for all the customizable logics in step 1 to 100 to maintain synchronism.

(2) Perform logical operations sequentially from step 1 to 100.

(3) If an output of a step is an input to the next step, outputs of step with high priority can be used in the same process.

(4) The customizable logic simultaneously updates 10 output signals.



Note that if you do not consider the process order of customizable logic when configuring a logic circuit, the signal delay can be an issue due to a slow process of logical operation; you may not be able to obtain an expected output; the operation can be slower; or a hazard signal can occur.

⚠WARNING
If you change a function code related to the customizable logic (such as U code) or turn ON the customizable logic signal "CLC", the operation sequence can change, which suddenly starts an operation that causes unexpected actions. Ensure the safety before performing the operation. **An accident or physical injury may result.**

■ Customizable logic timer monitor (step selection) (U91, X89 to X93)

The monitor function codes can be used to monitor the I/O status or timer's operation state in customizable logics.

Selection of monitor timer

Function code	Function	Remarks
U91	0: Monitor not active (the monitor data is 0) 1 to 100: set the step No. to monitor	The setting value is cleared to 0 when powered off.

Monitor method

Monitor method	Function code	Data
Communication	X89 customizable logic (digital I/O)	Digital I/O data for steps defined in U91 (only for monitoring)
	X90 customizable logic (timer monitor)	Data of the timer/counter value defined in U91 (only for monitoring)
	X91 customizable logic (analog input 1)	Analog input 1 data for steps defined in U91 (only for monitoring)
	X92 customizable logic (analog input 2)	Analog input 2 data for steps defined in U91 (only for monitoring)
	X92 customizable logic (analog input)	Analog output data for steps defined in U91 (only for monitoring)

■ Customizable logic cancellation "CLC" (function codes E01 to E05 Data = 80)

Customizable logic operations can temporarily be disabled so that you can operate it without a customizable logic's logical circuit and timer operation, for example during maintenance.

"CLC"	Function
OFF	Customizable logic enabled (according to U00 setting)
ON	Customizable logic disabled

Note If you turn ON the customizable logic cancellation signal "CLC", a sequence by the customizable logic is cleared, which can suddenly start an operation depending on the setting. Ensure the safety and check the operation before switching the setting.

■ Customizable logic all timers clear "CLTC" (function codes E01 to E05 Data = 81)

If the CLTC terminal function is assigned to a general-purpose input terminal to turn it ON, all the general-purpose timers and counters in the customizable logic are reset. It is used to reset and restart the system, when, for example, the timing of external sequence cannot be consistent with internal customizable logic due to a momentary power failure.

"CLTC"	Function
OFF	Normal operation
ON	Resets all the general-purpose timers and counters in the customizable logic. (To reactivate it, turn it OFF again.)

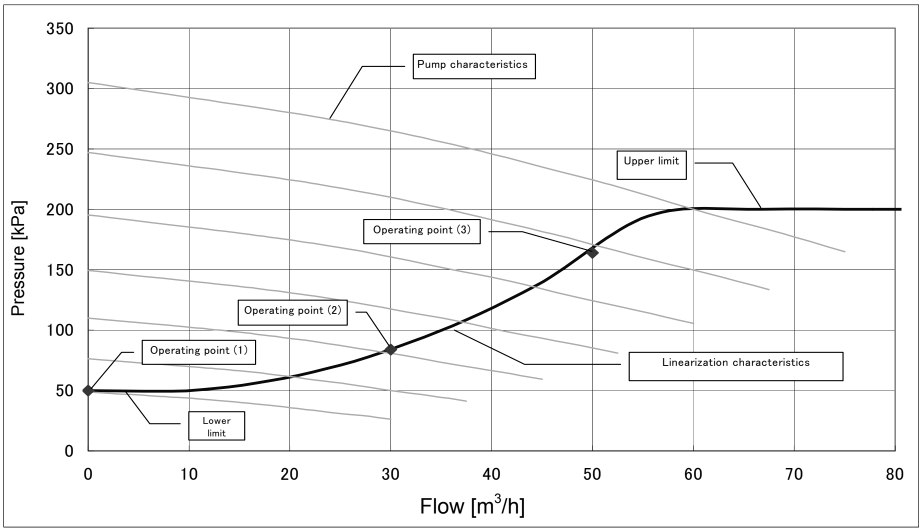
5.3.10 U1 codes (Customizable logic operation)

U101 to U106	Customizable logic (conversion operating point 1 (X1, Y1), conversion operating point 2 (X2, Y2), conversion operating point 3 (X3, Y3))

Operation circuit: sets the three operating points to auto-calculate the factors (K_A, K_B, K_C) when using conversion 1 ($K_A \times Input1^2 + K_B \times Input1 + K_C$). Input signal (such as flow signal) and factors (K_A, K_B, K_C) are used to create the target signal (such as target pressure). (Linearization function)

Data setting range: -999.00 to 0.00 to 9990.00

Example of linearization characteristics



U107	Customizable logic (conversion factor auto-calculation)

Auto-calculates the factors (K_A, K_B, K_C) from three operating points defined in U101 to U106.

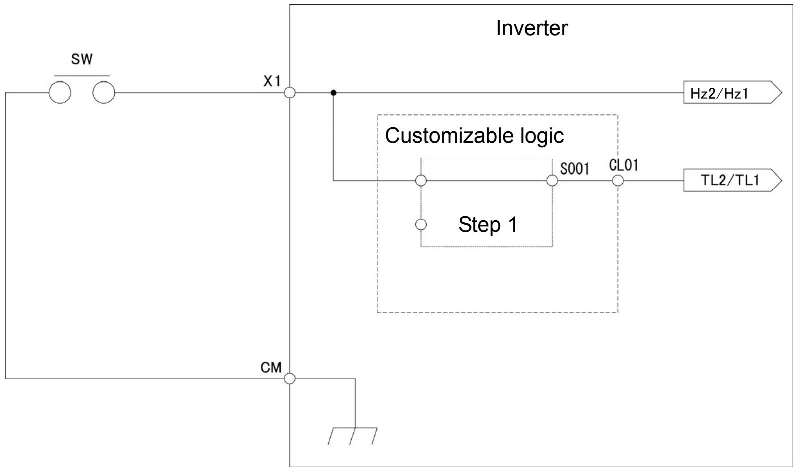
The calculated results are stored in U92 to U97, and U107 will be "0".

U107 data	Function
0	Disable
1	Auto-calculation (operation circuit: conversion 1 (3001)) $K_A \times Input\ 1^2 + K_B \times Input\ 1 + K_C$

■ Setting examples of customizable logic

Setting example 1: Use one switch to change among multiple signals

If you use one switch to change among the frequency setting 2/frequency setting 1 and torque limit 2/torque limit 1 simultaneously, replace an external circuit that is conventionally needed with a customizable logic to reduce the general-purpose input terminals to be used to a single terminal.

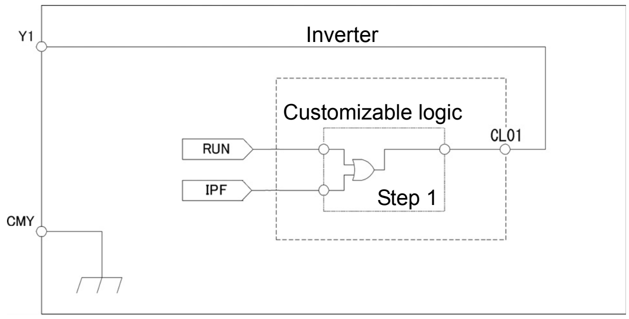


To configure this customizable logic, set the function codes as follows. (Timer selection) and (Timer setting) do not need to be modified if no change is made.

Function code			Setting value	Settings	Remarks
E01	Terminal X1 (Function selection)		11	Select frequency command 2/1 “Hz2/Hz1”	Can be used in parallel as general-purpose input terminals
U00	Customizable Logic (Mode selection)		1	Action	
U01	Customizable logic: Step 1	(Block selection)	10	Through output + General-purpose timer	Mode selection
U02		(Input 1)	4001	Terminal [X1] input signal X1	
U71	Customizable logic: Output signal 1	(Output selection)	1	Output of step 1, “SO01”	
U81		(Function selection)	14	Select torque limiter level 2/1 “TL2/TL1”	

Setting example 2: Bring multiple output signals in a single signal

If the general-purpose RUN signal is kept ON at restart after momentary power failure, replace an external circuit that is conventionally needed with a customizable logic to reduce the general-purpose output terminals and external relays.

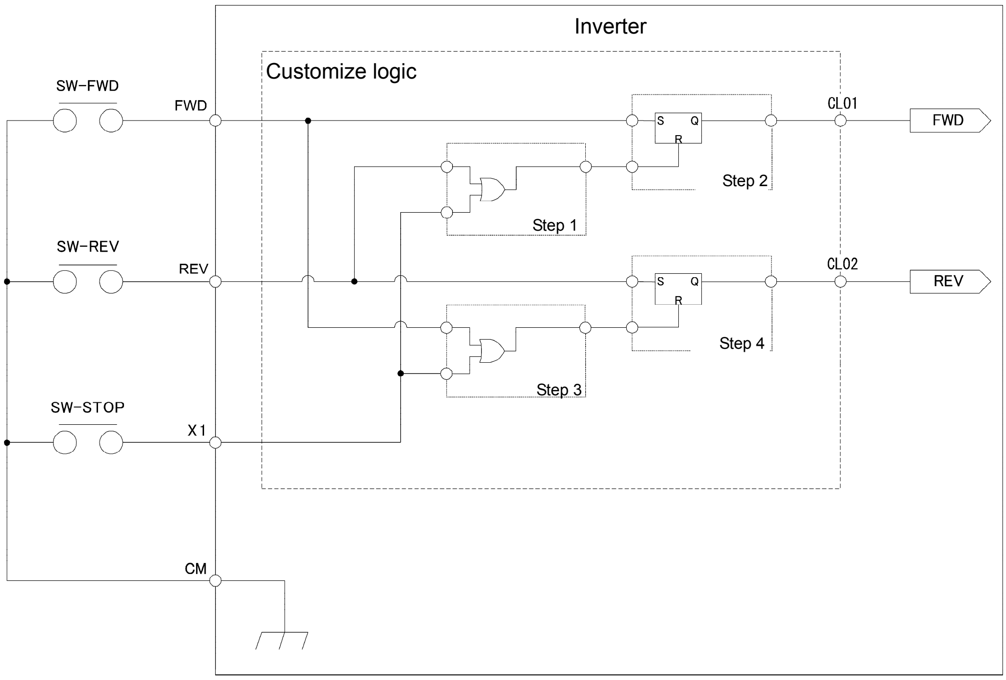


To configure this customizable logic, set the function codes as follows. (Timer selection) and (Timer setting) do not need to be modified if no change is made.

Function code			Setting value	Settings	Remarks
E20	Terminal Y1 (Function selection)		111	Customizable logic output signal 1 “CL01”	
U00	Customizable Logic (Mode selection)		1	Action	
U01	Customizable logic: Step 1	(Block selection)	30	ORing + General-purpose timer	Mode selection
U02		(Input 1)	0	During operation “RUN”	
U03		(Input 2)	6	Auto-restarting after momentary power failure “IPF”	
U71	Customizable logic output signal 1	(Output selection)	1	Output of step 1, “SO01”	
U81		(Function selection)	100	No function assigned “NONE”	

Setting example 3: One-shot operation

If the SW-FWD or SW-REV switch is short-circuited to start the operation and the SW-STOP switch is short-circuited to stop the operation (equivalent to FWD/REV key/STOP key on keypad), replace an external circuit that is conventionally needed with a customizable logic.



To configure this customizable logic, set the function codes as follows. (Timer selection) and (Timer setting) do not need to be modified if no change is made.

Function code			Setting value	Settings	Remarks
F02	Operation 1		1	External signal	
E01	Terminal X1 (Function selection)		100	No function assigned “NONE”	
E98	Terminal FWD (Function selection)		100	No function assigned “NONE”	
E99	Terminal REV (Function selection)		100	No function assigned “NONE”	
U00	Customizable Logic (Mode selection)		1	Action	
U01	Customizable logic: Step 1	(Block selection)	30	ORing + General-purpose timer	Mode selection
U02		(Input 1)	4011	Terminal REV input signal “REV”	
U03		(Input 2)	4001	Terminal X1 input signal “X1”	
U06	Customizable logic: Step 2	(Block selection)	60	Reset priority flip-flop + General-purpose timer	Mode selection
U07		(Input 1)	4010	Terminal FWD input signal “FWD”	
U08		(Input 2)	2001	Output of step 1 “SO01”	
U11	Customizable logic: Step 3	(Block selection)	30	ORing + General-purpose timer	Mode selection
U12		(Input 1)	4010	Terminal FWD input signal “FWD”	
U13		(Input 2)	4001	Terminal X1 input signal “X1”	
U16	Customizable logic: Step 4	(Block selection)	60	Reset priority flip-flop + General-purpose timer	Mode selection
U17		(Input 1	4011	Terminal REV input signal “REV”	
U18		(Input 2)	2003	Output of step 3 “SO03”	

Function code			Setting value	Settings	Remarks
U71	Customizable logic output signal 1	(Output selection)	2	Output of step 2 “SO02”	“FWD” command
U72	Customizable logic output signal 2		4	Output of step 4 “SO04”	“REV” command
U81	Customizable logic output signal 1	(Function selection)	98	Run forward/stop command “FWD”	
U82	Customizable logic output signal 2		99	Run reverse/stop command “REV”	

5.3.11 y codes (Link function)

y01 to y20	RS-485 setting 1, RS-485 setting 2

In the RS-485 communication, two systems can be connected.

System	Connection method	Function code	Equipment that can be connected
1 system	Via RS-485 communication link (port 1) (RJ-45 connector to connect keypad)	y01 to y10	Standard keypad Inverter supporting loader Host equipment (upper equipment)
2 systems	Via RS-485 communications link (port 2) Other than C model (for China) RJ-45 (shared with CAN communication) C (for China) Via digital input terminal blocks (DX+, DX-, SD)	y11 to y20	Host equipments (upper equipments) Inverter supporting loader

Overview of the equipments is given below.

(1) Standard keypad

Standard keypads can be connected to operate and monitor the inverter.

Regardless of the y code settings, standard keypads are available.

(2) Inverter supporting loader (FRENIC loader)

Inverter supporting (monitor, function code editing, test operation) can be performed by connecting a computer with the FRENIC loader installed.

For the y codes setting, refer to the function codes y01 to y10.

(3) Host equipments (upper equipments)

Host equipments (upper equipments) such as PLC and controller can be connected to control and monitor the inverter. Modbus RTU* protocol or Fuji general-purpose inverter protocol can be selected for communication.

* Modbus RTU is a protocol defined by Modicon.

For details, refer to the RS-485 Communication User's Manual.

■ **Station addresses (y01, y11)**

Set the station addresses for the RS-485 communication. The setting range varies on each of the protocols.

Protocol	Range	Broadcast
Modbus RTU	1 to 247	0
Protocol for loader commands	1 to 255	-
Fuji general-purpose inverter	1 to 31	99

- When specifying a value out of range, no response is returned.
- The settings to use inverter supporting loader should be matched with the computer's settings.

■ Mode selection when error occurs (y02, y12)

Select an operation when an error occurs for the RS-485 communication.

The RS-485 errors are logical errors such as address error, parity error and framing error, transmission errors and disconnection errors specified in y08 and y18. Any of them are determined only when operating the inverter for the configuration where the operation command or frequency command is issued via the RS-485 communication. If the operation command or frequency command is not issued via the RS-485 communication, and when the inverter is stopped, the system does not determine an error.

y02, y12 data	Function
0	Displays the RS-485 communication error (Er-8 for y02, Er-P for y12), and immediately stops the operation (alarm stop).
1	Operates for a period specified in the error process timer (y03, y13), and then displays the RS-485 communication error (Er-8 for y02, Er-P for y12), and stop the operation (alarm stop).
2	Retries the communication for a period specified in the error process timer (y03, y13), and if the communication is recovered, the operation is continued. Displays the RS-485 communication error (Er-8 for y02, Er-P for y12) if the communication is not recovered, and immediately stops the operation (alarm stop).
3	Continues the operation if a communication error occurs.

For details, refer to the RS-485 Communication User's Manual.

■ Timer operation time (y03, y13)

Sets the error process timer. If the value passes the timer value specified when a response request is issued due to any reasons such as no response from the counterpart. Also refer to the section of disconnection detection time (y08, y18).

- Data setting range: 0.0 to 60.0 (s)

■ Transmission speed (y04, y14)

Sets the transmission speed.

- For inverter supporting loader (via RS-485): Match the value with the computer setting.

y04 and y14 data	Function
0	2400 bps
1	4800 bps
2	9600 bps
3	19200 bps
4	38400 bps

■ Data length selection (y05, y15)

Sets the character length.

- For inverter supporting loader (via RS-485): The value does not need to be set since it automatically becomes 8 bit.
(It also applies to Modbus RTU.)

y05 and y15 data	Function
0	8 bits
1	7 bits

■ Parity bit selection (y06, y16)

Sets the parity bit.

- For inverter supporting loader (via RS-485): The value does not need to be set since it automatically becomes even parity.

y06 and y16 data	Function
0	No parity bit (2 bits of stop bit for Modbus RTU)
1	Even parity (1 bit of stop bit for Modbus RTU)
2	Odd parity (1 bit of stop bit for Modbus RTU)
3	No parity bit (1 bits of stop bit for Modbus RTU)

■ Stop bit selection (y07, y17)

Sets the stop bit.

- For inverter supporting loader (via RS-485): The value does not need to be set since it automatically becomes 1 bit.

  For Modbus RTU: The value does not need to be set since it is automatically determined in conjunction with the parity bit.

y07 and y17 data	Function
0	2 bits
1	1 bit

■ Disconnection detection time (y08, y18)

Sets a period from the time when the system detects no-access status for any reason such as disconnection in equipment facilities that always accesses to the station in a specific time during the operation using the RS-485 communication, until the time when the system processes the communication errors.

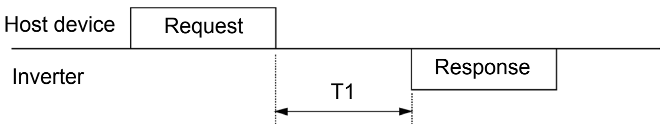
For details on processing communication errors, refer to y02 and y12.

y08 and y18 data	Function
0	Disconnection is not detected.
1 to 60	Detection time from 1 to 60 (s)

■ Response interval time (y09, y19)

Sets a period from the time when the system receives a request from host equipment (upper equipment) such as computer or PLC until the time when it returns a response. Even for the host equipments that are slow to process the task from completed transmission to completed reception preparation, a timing can be synchronized by setting a response interval time.

- Data setting range: 0.00 to 1.00 (s)



T1 = Response interval time + α

α: Processing time inside the inverter. It varies depending on the timing and command.

For details, refer to the RS-485 Communication User's Manual.

Note: To set an inverter by the inverter supporting loader via the RS-485 communication, consider the performance and condition of the computer and converter (such as USB-RS-485 converter). (Some converters monitor communication status and switch transmission and reception with timer.)

■ Protocol selection (y10, y20)

Selects a communication protocol.

y10 and y20 data	Function
0	Modbus RTU protocol
1	Loader protocol
2	Fuji general-purpose inverter protocol

y21 to y35	CANopen communication setting

For details, refer to Chapter 9, Section 9.2 "CANopen communications."

y95 — Data clear selection at communication error

If any of the communication error alarms (Er8, ErP, Er4, Er5, ErU) occurs in RS-485, CANopen communication or bus option, the data of communication command function codes (S codes) can automatically be cleared.

Since the frequency and operation commands are also disabled when the data is cleared, the inverter does not start unintentionally when an alarm is released.

y95 data	Function
0	When a communication error alarm occurs, the function code Sxx data is not cleared (compatible with the conventional mode).
1	When a communication error alarm occurs, the function codes S01, S05 and S19 data is cleared.
2	When a communication error alarm occurs, the bit assigned by the function code S06's operation command is cleared.
3	Clear operations of 1 and 2 above are performed.

y97 — Communication data storage method selection

The inverter memory (non-volatile memory) has a limited number of writes (100 thousand to 1 million times). If the count immoderately increases, the data cannot be modified or saved, causing a memory error.

If the data should frequently be overwritten via communication, it can be saved in the temporary memory instead of the non-volatile memory. This enables you to reduce the number of writes to the non-volatile memory, which can avoid a memory error.

If y97 is set to "2", the data saved in the temporary memory is stored (All Saved) in the non-volatile memory.

To change the y97 data, it is necessary to press the STOP + ∧/∨ keys (simultaneous keying).

y97 data	Function
0	Saved in the non-volatile memory (the number of writes is limited)
1	Saved in the temporary memory (the number of writes is not limited)
2	The data All Saved from the temporary memory to the non-volatile memory (After the All Save is performed, the y97 data is returned to 1)

y98 — Bus function (mode selection) (Refer to H30)

For details on setting the y98 bus function (mode selection), refer to the description of H30.

y99 Supporting link function (mode selection)

Function code to switch the links for the inverter supporting loader. Rewriting y99 with the inverter supporting loader (FRENIC loader) enables the frequency command and operation command from the inverter supporting loader. You do not need to use the keypad since the data is rewritten from the inverter supporting loader.

If the operation command is configured to be given from the inverter supporting loader, and if a computer starts to go out of control during the operation and a stop command from the loader is ignored, remove a communication cable connected to the computer that runs the inverter supporting loader, and connect the keypad to set the y99 data to 0. By setting the y99 data to 0, the operation is isolated from the inverter supporting loader's commands, switching to the commands of inverter's own settings (such as function code H30).

The y99 data is not saved in the inverter; the setting is lost and returned to 0 when powered off.

y99 data	Function	
	Frequency command	Run command source
0	From function codes H30 and y98	From function codes H30 and y98
1	Command issued from FRENIC loader	From function codes H30 and y98
2	From function codes H30 and y98	Command issued from FRENIC loader
3	Command issued from FRENIC loader	Command issued from FRENIC loader

Chapter 6 TROUBLESHOOTING

This chapter describes troubleshooting procedures to be followed when the inverter malfunctions or detects an alarm or a light alarm condition. In this chapter, first check whether any alarm code or the "light alarm" indication (L-AL) is displayed or not, and then proceed to the troubleshooting items.

Contents

Chapter 6 TROUBLESHOOTING

6.1 Protective function

FRENIC-Ace is provided with various protective functions shown in Table below to prevent system down or to shorten a downtime. The protective functions marked with an asterisk (*) in the table are disabled by factory default. Enable them according to your needs.
The protective functions include, for example, the "heavy alarm" detection function which, upon detection of an abnormal state, displays the alarm code on the LED monitor and causes the inverter to trip, the "light alarm" detection function which displays the alarm code but lets the inverter continue the current operation, and other warning signal output functions.
If any problem arises, understand the protective functions listed below and follow the procedures given in Sections 6.2 and onwards for troubleshooting.

Protective function	Description	Relative function code
"Heavy alarm" detection	This function detects an abnormal state, displays the corresponding alarm code, and causes the inverter to trip. See Table 6.3-1 “Various failure detections (heavy alarm objects) for alarm codes.” For details of each alarm code, see the corresponding item in the troubleshooting in Section 6.3. The inverter retains the last four alarm codes and their factors together with their running information applied when the alarm occurred, so it can display them.	H98
"Light alarm" detection*	This function detects an abnormal state categorized as a "light alarm," displays L-AL and lets the inverter continue the current operation without tripping. Details of light alarms are selectable. Selectable details (codes) are codes shown in Table 6.4-1 "Various failure detections (light alarm objects)." See Section 6.4 for the confirming method and releasing method of the light alarms.	H81 H82
Stall prevention	When the output current exceeds the current limiter level (F44) during acceleration/ deceleration or constant speed running, this function decreases the output frequency to avoid an overcurrent trip.	F44
Overload prevention control*	Before the inverter trips due to a cooling fin overheat (OH1) or inverter overload (OLU), this function decreases the output frequency of the inverter to reduce the load.	H70
Anti-regenerative control*	If regenerative energy returned exceeds the inverter's braking capability, this function automatically increases the deceleration time or controls the output frequency to avoid an overvoltage trip.	H69
Deceleration characteristics* (Improvement of braking performance)	During deceleration, this function increases the motor energy loss and decreases the regenerative energy returned to avoid an overvoltage trip (OU).	H71
Reference loss detection*	This function detects a frequency reference loss (due to a broken wire, etc.), issues the alarm, and continues the inverter operation at the specified frequency.	E65
Automatic lowering of carrier frequency	Before the inverter trips due to an abnormal surrounding temperature or output current, this function automatically lowers the carrier frequency to avoid a trip.	H98
Motor overload early warning*	When the inverter output current has exceeded the specified level, this function issues the "Motor overload early warning" signal before the thermal overload protection function causes the inverter to trip for motor protection. (Only for the 1st motor)	E34 E35
Retry*	When the inverter has stopped because of a 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.))	H04 H05
Forced stop*	Upon receipt of the "Force to stop" terminal command STOP, this function interrupts the run and other commands currently applied in order to forcedly decelerate the inverter to a stop.	H56
Surge protection	This function protects the inverter from a surge voltage invaded between main circuit power lines and the ground.	-
Momentary power failure protection*	• If a momentary power failure for 15 ms or longer occurs, a protective operation (inverter stop) is activated. • When momentary power failure restart is selected, the inverter is restarted responding to voltage restoration within a set-up time (momentary power failure permissible time).	F14

6.2 Before Proceeding with Troubleshooting

⚠WARNING

- If any of the protective functions has been activated, first remove the cause. Then, after checking that the all 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.

  Injury may occur.
- Even though the inverter has interrupted power to the motor, if the voltage is applied to the main circuit input terminals L1/R, L2/S and L3/T, voltage may be output to inverter output terminals U, V, and W.
- Turn OFF the power and wait for at least five minutes for inverters with a capacity of FRN0072E2S-4☐ or below, or at least ten minutes for inverters with a capacity of FRN0085E2S-4☐ or above. Make sure that the LED monitor and charging lamp are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC intermediate circuit voltage between the 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) Is wire connection correct?
See Chapter 2 "2.2.1 Basic connection diagram."

(2) Check whether an alarm code or the "light alarm" indication (L-AL) is displayed on the LED monitor.

- When an alarm code (excluding light alarms) is displayed — To Section 6.3
- If the “Light Alarm” Indication (L-AL) Appears on the LED Monitor — To Section 6.4
- When codes other than alarm codes and light alarm indication (L-AL) are displayed — To Section 6.5

  Abnormal motor operation — To Section 6.5.1

  6.5.1 [1] The motor does not rotate.
  6.5.1 [2] The motor rotates, but the speed does not increase.
  6.5.1 [3] The motor runs in the opposite direction to the command.
  6.5.1 [4] Speed fluctuation or current oscillation (e.g., hunting) occurs during running at constant speed.
  6.5.1 [5] Unpleasant noises are emitted from motor or noises fluctuate.
  6.5.1 [6] The motor is not accelerated or decelerated according to set-up acceleration or deceleration time.
  6.5.1 [7] The motor does not restart even after the power recovers from a momentary power failure.
  6.5.1 [8] Motor generates heat abnormally.
  6.5.1 [9] The motor does not run as expected.
  6.5.1 [10] Motor stalls during acceleration.

  Problems with inverter settings — To Section 6.5.2

  6.5.2 [1] Nothing appears on the LED monitor.
  6.5.2 [2] The desired menu is not displayed.
  6.5.2 [3] Display of under bars(_ _ _ _)
  6.5.2 [4] Display of cenfer bars(- - -)
  6.5.2 [5] [ ] Display of parenthesis
  6.5.2 [6] Data of fuction codes cannot be changed.
  6.5.2 [7] Function code data are not changeable (change from link functions)

If any problems persist after the above recovery procedure, contact your Fuji Electric representative.

6.3 If an Alarm Code Appears on the LED Monitor

6.3.1 Alarm code list

When an alarm is detected, check an alarm code displayed on 7-segment LED of keypad.

When one alarm code has plural factors, alarm subcodes are provided to make it easy to identify causes. When a factor is one, the alarm subcode is displayed as "-" and described as "-."

* See (Chapter 3 “3.4.6 To See Alarm Information”) for the check method of the alarm codes.

* With regard to alarm details having alarm subcodes name“for manufacturer”, inform us of the alarm subcodes, too, when contacting us or requesting an inverter repair.

Table 6.3-1 Various failure detections (Heavy failure objects)

Alarm code	Alarm code name	Heavy failure object	Light alarm selectable	Retry object	Alarm subcode*	Alarm subcode name	Reference page
CoF	PID feedback wire break	○	○	-	-	-	6-6
dbA	Braking transistor broken	○	-	-	-	-	6-6
dbH	Braking resistor overheat (FRN0072E2S-4□ or below)	○	○	○	0	DB resistor overheat	6-6
					1	For manufacturer	
ECF	EN circuit failure	○	-	-	10	ASIC alarm for functional safety	6-7
					3000	Erroneous detection of STO input	
					Other than above	For manufacturer	
ECL	Customized logic failure	○	-	-	-	-	-
EF	Ground fault (FRN0085E2S-4□ or above)	○	-	-	-	-	6-7
Er1	Memory error	○	-	-	1 to 16	For manufacturer	6-7
Er2	Keypad communications error	○	-	-	1 to 2	For manufacturer	6-8
Er3	CPU error	○	-	-	1 to 9000	For manufacturer	6-8
Er4	Option communications error	○	○	-	1	For manufacturer	6-8
Er5	Option error (To be responded soon.)	○	○	-	0	Time-out	6-8
					1 to 10	For manufacturer	
Er6	Operation error	○	-	-	1	STOP key priority/forced stop (STOP terminal)	6-9
					2	Start check function	
					3	Start check function (when operation is permitted)	
					4	Start check function (when reset is turned on)	
					5	Start check function (when the power recovers in powering on)	
					6	Start check function (TP connection)	
					8 to 14	For manufacturer	

Continuation of Table 6.3-1

<table>
<tr><th>Alarm code</th><th>Alarm code name</th><th>Heavy failure object</th><th>Light alarm selectable</th><th>Retry object</th><th>Alarm subcode*</th><th>Alarm subcode name</th><th>Reference page</th></tr>
<tr><td rowspan="14">Er 7</td><td rowspan="14">Tuning error</td><td rowspan="14">○</td><td rowspan="14">-</td><td rowspan="14">-</td><td>7</td><td>Operation command OFF during motor tuning</td><td rowspan="14">6-9</td></tr>
<tr><td>8</td><td>Forced stop during motor tuning</td></tr>
<tr><td>9</td><td>BX command during motor tuning</td></tr>
<tr><td>10</td><td>Hardware current limit during motor tuning</td></tr>
<tr><td>11</td><td>Occurrence of low voltage (LV) during motor tuning</td></tr>
<tr><td>12</td><td>Failure due to prevention of reverse rotation during motor tuning</td></tr>
<tr><td>13</td><td>Over upper limit frequency during motor tuning</td></tr>
<tr><td>14</td><td>Switching to commercial power during motor tuning</td></tr>
<tr><td>15</td><td>Occurrence of alarm during motor tuning</td></tr>
<tr><td>16</td><td>Change of run command source during motor tuning</td></tr>
<tr><td>18</td><td>Over acceleration time during motor tuning</td></tr>
<tr><td>24</td><td>EN terminal failure during motor tuning</td></tr>
<tr><td>Other than above</td><td>For manufacturer</td></tr>
<tr><td>Er8</td><td>RS-485 communications error (Communication port 1)</td><td>○</td><td>○</td><td>-</td><td>-</td><td>-</td><td>6-10</td></tr>
<tr><td>Erd</td><td>Detection of step-out (To be responded soon.)</td><td>○</td><td>-</td><td>-</td><td>5001 to 5008</td><td>For manufacturer</td><td>6-10</td></tr>
<tr><td rowspan="4">ErE</td><td rowspan="4">Speed inconsistency/ excessive speed deviation (To be responded soon.)</td><td rowspan="4">○</td><td rowspan="4">○</td><td rowspan="4">-</td><td>1</td><td>Signs of speed command and speed detection are inconsistent.</td><td rowspan="4">6-11</td></tr>
<tr><td>3</td><td>In the case of excessive speed deviation (|detected speed|>|speed command|)</td></tr>
<tr><td>5</td><td>Detected speed remains 0Hz irrespective of speed command.</td></tr>
<tr><td>7</td><td>In the case of excessive speed deviation (|detected speed|<|speed command|)</td></tr>
<tr><td>ErF</td><td>Data saving error during undervoltage</td><td>○</td><td>-</td><td>-</td><td>-</td><td>-</td><td>6-12</td></tr>
<tr><td>Ero</td><td>Positioning control error
(To be responded soon.)</td><td>○</td><td>○</td><td>-</td><td>1 to 5</td><td>For manufacturer</td><td>6-12</td></tr>
<tr><td>ErP</td><td>RS-485 communications error (Communication port 2)</td><td>○</td><td>○</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Err</td><td>Simulated failure</td><td>○</td><td>-</td><td>-</td><td>-</td><td>-</td><td>6-12</td></tr>
<tr><td>Ert</td><td>CAN communications failure</td><td>○</td><td>-</td><td>-</td><td>1 to 2</td><td>For manufacturer</td><td>6-12</td></tr>
<tr><td>FUS</td><td>DC fuse-blowing
(The capacity is not determined yet.)</td><td>○</td><td>-</td><td>-</td><td>-</td><td>-</td><td>6-12</td></tr>
</table>

Continuation of Table 6.3-1

Alarm code	Alarm code name	Heavy failure object	Light alarm selectable	Retry object	Alarm subcode*	Alarm subcode name	Reference page
Lin	Input phase loss	○	-	-	1-2	For manufacturer	6-13
LU	Undervoltage	○	-	-	1	Occurrence of low voltage during gate on (F14=0)	6-13
					2	Timer time and run command ON during low voltage (F14=0, 2)	
					3	LV trip on power recovery from a momentary power failure (F14=1)	
					4 to 5	For manufacturer	
OC1	Instantaneous overcurrent	○	-	○	1 to 5001	For manufacturer	6-14
OC2							
OC3							
OH1	Cooling fin overheat	○	○	○	6	Detection of fan stop	6-15
					Other than above	For manufacturer	
OH2	External alarm	○	○	?	-	-	6-15
OH3	Inverter internal overheat	○	○	○	0	Interior air overheat	6-15
					1	Charging resistor overheat	
					Other than above	For manufacturer	
OH4	Motor protection (PTC thermistor)	○	-	○	-	-	6-16
OL1	Motor 1 overload	○	○	○	-	-	6-16
OL2	Motor 2 overload	○	○	○	-	-	
OLU	Inverter overload	○	-	○	1	IGBT protection	6-17
					2	Inverter overload	
					10	For manufacturer	
OPL	Output phase-failure detection	○	-	-	1 to 10	For manufacturer	6-17
OS	Overspeed protection	○	-	-	-	-	6-18
OU1	Overvoltage	○	-	○	1 to 12	For manufacturer	6-18
OU2							
OU3							
PbF	Charging circuit failure (FRN0203E2S-4□ or above)	○	-	-	1 to 2	For manufacturer	6-19
PG	PG wire break (To be responded soon.)	○	-	-	10 to 20	For manufacturer	6-19

NB)
- If a control power supply voltage drops to such a level that the operation of the inverter control circuit cannot be maintained, all protective functions are automatically reset.
- By OFF → ON operation between RST key or X terminal (assigned to RST) and CM of the keypad, the protection stop state can be released. In a state that an alarm factor is not removed, however, resetting operation fails to become effective.
- If two or more alarms are occurring, the resetting operation remains ineffective until all the alarm factors are removed.
(Alarm factors not removed can be checked from the keypad.)
- When assigned to light alarms, "30A/B/C" do not work.

6.3.2 Causes, Checks and Measures of Alarms

[1] CoF PID feedback wire break

Phenomena The signal line of PID feedback is broken.

Possible Causes	Check and Measures
(1) The PID feedback signal wire is broken.	Check whether the PID feedback signal wires are connected correctly. ➔ Check whether the PID feedback signal wires are connected correctly. Or, tighten up the related terminal screws. ➔ Check whether any contact part bites the wire sheath.
(2) The inverter was affected by strong electrical noise.	Check whether 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. ➔ Separate the signal wires from the main power wires as far as possible.

[2] dbA Braking transistor error

Phenomena Faulty operation of the braking transistor was detected.

Possible Causes	Check and Measures
The braking transistor is broken.	Check whether resistance of the braking resistor is correct or there is a misconnection of the resistor. ➔ Consult your Fuji Electric representative for repair.

[3] dbH Braking resistor overheated

Phenomena The electronic thermal protection for the braking resistor has been activated.

Possible Causes	Check and Measures
(1) Braking load is too heavy. [Subcode: 0]	Reconsider the relationship between the braking load estimated and the real load. ➔ Lower the real braking load. ➔ Review the selection of the braking resistor and increase the braking capability. (Modification of related function code data (F50, F51, and F52) is also required.)
(2) Specified deceleration time is too short. [Subcode: 0]	Recalculate the deceleration torque and time needed for the load currently applied, based on a moment of inertia for the load and the deceleration time. ➔ Increase the deceleration time (F08, E11, E13, E15, and H56). ➔ Review the selection of the braking resistor and increase the braking capability. (Modification of related function code data (F50, F51, and F52) is also required.)
(3) Incorrect setting of function code data F50, F51, and F52. [Subcode: 0]	Recheck the modes of the braking resistor. ➔ Review data of function codes F50, F51, and F52, then modify them.

Note The inverter issues an overheat alarm of the braking resistor by monitoring the magnitude of the braking load, not by measuring its surface temperature.

When the braking resistor is used so frequently as to exceed the settings made by function codes F50, F51, and F52, therefore, the inverter issues an overheat alarm even if the surface temperature of the braking resistor does not rise. To squeeze out full performance of the braking resistor, configure function codes F50, F51, and F52 while actually measuring the surface temperature of the braking resistor.

[4] ECF EN circuit failure

Phenomena Enable circuit state was diagnosed and a circuit failure was detected.

Possible Causes	Check and Measures
(1) Contact defect on interface substrate [Subcode: 10]	Confirm that the interface substrate is firmly mounted on the body. ➔ Alarm is released by turning on again.
(2) Enable circuit logic failure [Subcode: 3000]	Confirm that outputs from safety switch etc. are inputted by the same logic (High/High or Low/Low) with EN1 terminal/EN2 terminal. ➔ Alarm is released by turning on again.
(3) A failure (single failure) of enable circuit (safety stop circuit) was detected.	If the circuit failure is not removable by the procedures above, the inverter is out of order. ➔ Contact your Fuji Electric representative.

[5] ECL Customized logic failure

Phenomena A setting failure of customized logic was detected.

Possible Causes	Check and Measures
(1) Setting of the selection of customized logic operation was changed during operation.	Check whether the selection (Function code U00) of customized logic operation is changed during operation. ➔ Do not change the selection of customized logic operation during operation to prevent a danger.

[6] EF Ground fault

Phenomena A ground fault current flew from the output terminal of the inverter.

Possible Causes	Check and Measures
(1) Inverter output terminal(s) grounded (ground fault).	Disconnect the wiring from the output terminals (U, V, and W) and perform a Megger test. ➔ Remove the grounded parts (including replacement of the wires, relay terminals and motor).

[7] Er1 Memory error

Phenomena Error occurred in writing the data to the memory in the inverter.

Possible Causes	Check and Measures
(1) When writing data (especially initializing or copying data), the inverter was shut down so that the voltage to the control PCB has dropped.	Initialize data by data initialization (H03), and check whether an alarm can be released by PRG/RESET key after finishing the initialization. ➔ Revert the initialized function code data to their previous settings, then restart the operation.
(2) The inverter was affected by strong electrical noise when writing data (especially initializing).	Check if appropriate noise control measures have been implemented (e.g., correct grounding and routing of control and main circuit wires). Also, perform the same check as described in (1) above. ➔ Implement noise control measures. Revert the initialized function code data to their previous settings, then restart the operation.
(3) The control PCB failed.	Initialize data by data initialization (H03), and check whether an alarm continues even when the release of the alarm is attempted by PRG/RESET key after finishing the initialization. ➔ The control PCB (on which the CPU is mounted) is defective. Contact your Fuji Electric representative.

[8] Er-2 Keypad communications error

Phenomena A communications error occurred between the keypad and the inverter.

Possible Causes	Check and Measures
(1) Broken communications cable or poor contact.	Check continuity of the cable, contacts and connections. ➔ Re-insert the connector firmly. ➔ Replace the cable.
(2) Connecting many control wires hinders the front cover from being mounted, lifting the keypad.	Check the mounting condition of 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) The inverter was 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). ➔ Implement noise control measures. (For details, refer to Appendix A.)
(4) A keypad failure occurred.	Replace the keypad with another one and check whether a communications error (Er-2) occurs. ➔ Replace the keypad.

[9] Er-3 CPU error

Phenomena A CPU error (e.g. erratic CPU operation) occurred.

Possible Causes	Check and Measures
(1) The inverter was 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.

[10] Er-4 Option communications error

Phenomena A communications error occurred between the option card and the inverter.

Possible Causes	Check and Measures
(1) There was a problem with the connection between the option card and the inverter.	Check whether the connector on the option card is properly engaged with that of the inverter. ➔ Reload the option card into the inverter.
(2) The inverter was affected by strong electrical noise.	Check whether 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.

[11] Er-5 Option error (To be responded soon.)

An error detected by the option card.
Refer to the instruction manual of the option card for details.

[12] Er-6 Operation error

Phenomena An incorrect operation was attempted.

Possible Causes	Check and Measures
(1) STOP key was pressed when the STOP key is effective (H96=1, 3). [Subcode:1]	Check whether the STOP key was pressed in a state that a run command is inputted via terminal block or communications. ➔ If this was not intended, check the setting of H96.
(2) The start check function was activated when H96 = 2 or 3. [Subcode:2to6]	Check that any of the following operations has been performed with a run command being entered. • Power on • Release of alarm • Switching to link operation command ➔ Review the running sequence to avoid input of a Run command when this error occurs. If this was not intended, check the setting of H96. (Turn the run command OFF before releasing the alarm.)
(3) The forced stop (digital input terminal) STOP was turned OFF. [Subcode:1]	Check that the forced stop "STOP" is turned off. ➔ If this was not intended, check the settings of E01 through E05 for terminals [X1] through [X5].

[13] Er-7 Tuning error

Phenomena Auto-tuning failed.

Possible Causes	Check and Measures
(1) A phase was missing in the connection between the inverter and the motor.	➔ Properly connect the motor to the inverter.
(2) V/f or the rated current of the motor was not properly set.	Check whether the data of function codes (F04*, F05*, H50, H51, H52, H53, H65, H66, P02*, P03*) agree with the motor modes.
(3) The wiring length between the inverter and the motor was too long.	Check whether the wiring length between the inverter and the motor exceeds 50 m. (Inverters with a small capacity are greatly affected by the wiring length.) ➔ Review, and if necessary, change the layout of the inverter and the motor to shorten the connection wire. Alternatively, minimize the wiring length without changing the layout. ➔ Disable both auto-tuning and auto-torque boost (set data of F37* to "1").
(4) The rated capacity of the motor was significantly different from that of the inverter.	Check whether the rated capacity of the motor is three or more ranks lower, or two or more ranks higher than that of the inverter. ➔ Replace the inverter with one with an appropriate capacity. ➔ Set motor constants (P06*, P07*, P08*) manually. ➔ Disable both auto-tuning and auto-torque boost (set data of F37* to "1").
(5) The motor was a special type such as a high-speed motor.	➔ Disable both auto-tuning and auto-torque boost (set data of F37* to "1").
(6) Tuning (P04*=2) operation was performed of rotating a motor in a state that braking is applied to the motor.	➔ Specify the tuning that does not involve the motor rotation (P04* = 1). ➔ Perform the tuning (P04*=2) with the braking released.

[14] Er8 RS-485 communications error (Communications port 1)/ ErP RS-485 communications error (Communications port 2)

Phenomena A communications error occurred during RS-485 communications.

Possible Causes	Check and Measures
(1) Communications conditions of the inverter do not match that of the host equipment.	Compare the settings of the function codes (y01 to y10, y11 to y20) with those of the host equipment. ➔ Correct any settings that differ.
(2) Even though no-response error detection time (y08, y18) has been set, communications is not performed within the specified cycle.	Check the host equipment. ➔ Change the settings of host equipment software or disable the no-response error detection (y08, y18 = 0).
(3) The host equipment did not operate due to defective software, settings, or defective hardware.	Check the host equipment (e.g., PLCs and personal computers). ➔ Remove the cause of the 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). ➔ Change the various RS-485 converter settings, reconnect the wires, or replace hardware with recommended devices as appropriate.
(5) Broken communications cable or poor contact.	Check the continuity of the cables, contacts and connections. ➔ Replace the cable.
(6) The inverter was 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). ➔ Implement noise control measures. ➔ Implement noise reduction measures on the host side. ➔ Replace the RS-485 converter with a recommended insulated one.
(7) Terminating resistor is not properly configured.	Check that the inverter serves as a terminating device in the network. ➔ Set terminal resistor changeover switches for RS-485 communications (SW2/SW6) correctly. (That is, turn the switch (es) to ON.)

[15] Erd Step-out detection/detection failure of magnetic pole position at startup
(To be responded soon.)

Phenomena The step-out of PM motor was detected. The magnetic pole position at startup failed to be detected.

Possible Causes	Check and Measures
(1) Function code settings do not agree with the motor characteristics.	Check whether F04, F05, P01, P02, P03, P60, P61, P62, P63, P64 agree with the motor constant. ➔ Perform auto-tuning of the inverter for every motor to be used.
(2) Magnetic pole position detection method is not appropriate.	Confirm that the magnetic pole position detection method matches the motor type. ➔ Match the magnetic pole position detection method selection (P30) to the motor type.
(3) Starting frequency (continuation time) (F24) is insufficient. (In PM sensorless vector control)	Check whether a starting frequency (continuation time) (F24) is set optimally, after setting the magnetic pole position detection method selection (P30) to "0" or "3." ➔ Set a period of time during which motor can rotate by one or more revolutions. F24≥P01/2/F23 (P01: Number of poles, F23: Starting frequency)
(4) Starting torque is insufficient.	Check the data of acceleration times (F07, E10, E12, E14) and a current command value on a start (P74). ➔ Change the acceleration time to match the load. ➔ Increase the current command value at startup.
(5) Load is small.	Check the data of a current command value at startup (P74). ➔ Decrease the current command value at startup. Set it to 80% or lower when running a motor single unit in a test run etc.

[16] Er-E Speed inconsistency / Excessive speed deviation (To be responded soon.)

Phenomena An excessive deviation appears between the speed command and the detected speed.

Possible Causes	Check and Measures
(1) Incorrect setting of function code data.	Check the motor parameter "Number of poles" (P01*). ➔ Specify the P01* data in accordance with the motor to be used.
(2) Overload.	Measure the inverter output current. ➔ Reduce the load.
	Check whether any mechanical brake is working. ➔ Release the mechanical brake.
(3) The motor speed does not increase due to the current limiter operation.	Check the data of function code F44 (Current limiter (Level)). ➔ Change the F44 data correctly. Or, set the F43 data to "0" (Disable) if the current limiter operation is not needed.
	Check the data of the function codes (F04*, F05*, P01*-P12*) to see if V/f is set correctly. ➔ Match the V/f pattern setting with the motor ratings. ➔ Change the function code data in accordance with the motor parameters.
(4) Function code settings do not match the motor characteristics.	Confirm that P01*, P02*, P03*, P06*, P07*, P08*, P09*, P10*, P12* match the motor constant. ➔ Perform auto-tuning of the inverter, using the function code P04*.
(5) Wiring to the motor is incorrect.	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.
(6) The motor speed does not increase due to the torque limiter operation.	Check the data of F40 (Torque limiter (Level)). ➔ Change the F40 data correctly. Or, set the F40 data to "999" (Disable) if the torque limiter operation is not needed.

[17] Er-F Data saving error during undervoltage

Phenomena The inverter failed to save data such as the frequency commands and PID commands (which are specified through the keypad), or the output frequencies modified by the UP/DOWN signal commands when the power was turned OFF.

Possible Causes	Check and Measures
(1) During data saving performed when the power was turned OFF, the voltage fed to the control PCB dropped in an abnormally short period due to the rapid discharge of the DC intermediate circuit.	Check how long it takes for the DC intermediate circuit voltage to drop to the preset voltage when the power is turned OFF. ➔ Remove whatever is causing the rapid discharge of the DC intermediate circuit voltage. After pressing the PRG/RESET key and releasing the alarm, return the data of the relevant function codes (such as the frequency commands and PID commands (specified through the keypad) or the output frequencies modified by the UP/DOWN signal commands) back to the original values and then restart the operation.
(2) The inverter operation was affected by strong electrical noise during data saving performed when the power was turned OFF.	Check if appropriate noise control measures have been implemented (e.g., correct grounding and routing of control and main circuit wires). ➔ Implement noise control measures. After pressing the PRG/RESET key and releasing the alarm, return the data of the relevant function codes (such as the frequency commands and PID commands (specified through the keypad) or the output frequencies modified by the UP/DOWN signal commands) back to the original values and then restart the operation.
(3) The control circuit failed.	Check if Er-F occurs each time the power is turned ON. ➔ The control PCB (on which the CPU is mounted) is defective. Contact your Fuji Electric representative.

[18] Ero Positioning control error (To be responded soon)

Phenomena Excessive position deviation occurred on a servo-lock.

Possible Causes	Check and Measures
(1) Insufficient gain in positioning control system	Readjust the settings of J97 (Servo-lock (Gain)) and d03 (Speed control 1 P (Gain)).
(2) Incorrect control completion width	Check whether the setting of J99 (Servo-lock (Completion width)) is correct. ➔ Correct the setting of J99.
(3) Position deviation is excessive.	Check whether the detection width of excessive deviation (d78) is set up properly.

[19] Err Simulated failure

Phenomena The LED displays the alarm Err.

Possible Causes	Check and Measures
(1) Keep STOP key + FUNC DATA key pressed for five seconds or longer.	➔ To escape from this alarm state, press the PRG RESET key.

[20] Ert CAN communications failure

Phenomena Communications error occurred in CAN bus communications.

Possible Causes	Check and Measures
(1) Transmission speed settings differ.	Check the data of transmission speed (y23) and setting details of host equipment side. ➔ Correct any settings that differ.
(2) Defect of host controllers (including programmable controller, personal computer, etc.) (Defects of control software, setting and hardware)	Check the host equipment. ➔ Remove the cause of the equipment error.
(3) Break and contact failure of communications cables	Check the continuity of the cables, contacts and connections. ➔ Replace the cable.
(4) The inverter was 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). ➔ Implement noise control measures. ➔ Implement noise reduction measures on the host side.

[21] FUS DC fuse-blowing

Phenomena The fuse inside the inverter blew.

Possible Causes	Check and Measures
(1) The fuse blew due to short-circuiting inside the inverter.	Check whether there has been any excess surge or noise coming from outside. ➔ Take measures against surges and noise. ➔ Consult your Fuji Electric representative for repair.

[22] Lin Input phase loss

Phenomena Input phase loss occurred, or interphase voltage unbalance rate was large.

Possible Causes	Check and Measures
(1) Breaks in wiring to the main power input terminals.	Measure the input voltage. ➔ Repair or replace the main circuit power input wires or input devices (MCCB, MC, etc.).
(2) The screws on the main power input terminals are loosely tightened.	Check if the screws on the main power input terminals have become loose. ➔ Tighten the terminal screws to the recommended torque.
(3) Interphase voltage unbalance among three phases was too large.	Measure the input voltage. ➔ Connect an AC reactor (ACR) to lower the voltage unbalance between input phases. ➔ Increase the inverter capacity.
(4) Overload cyclically occurred.	Measure the ripple wave of the DC intermediate circuit voltage. ➔ If the ripple is large, increase the inverter capacity.
(5) Single-phase voltage was input to the three-phase input inverter.	Check the inverter type. ➔ Apply three-phase power.

Note The input phase loss protection can be disabled with the function code H98.

[23] LU Undervoltage

Phenomena DC intermediate circuit voltage has dropped below the undervoltage detection level.

Possible Causes	Check and Measures
(1) A momentary power failure occurred. [Subcode:1] [Subcode:3]	➔ Release the alarm. ➔ If you want to restart running the motor without treating this condition as an alarm, set F14 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). [Subcode:2]	Check if the power to the inverter was switched back to ON 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 did not reach the inverter's mode range.	Measure the input voltage. ➔ Increase the voltage to within the specified range.
(4) Peripheral equipment for the power circuit malfunctioned, or the connection was incorrect.	Measure the input voltage to find which peripheral equipment malfunctioned or which connection is incorrect. ➔ Replace any faulty peripheral equipment, or correct any incorrect connections.
(5) Any other loads connected to the same power supply has required a large starting current, causing a temporary voltage drop.	Measure the input voltage and check the voltage fluctuation. ➔ Reconsider the power supply system configuration.
(6) Inverter's inrush current caused the power voltage drop because the power supply transformer capacity was insufficient.	Check if the alarm occurs when a molded case circuit breaker (MCCB), earth leakage circuit breaker (ELCB) (with overcurrent protection) or magnetic contactor (MC) is turned ON. ➔ Reconsider the capacity of the power supply transformer.

[24] OCn Instantaneous overcurrent

Phenomena The inverter momentary output current exceeded the overcurrent level.

OC1 Overcurrent occurred during acceleration.

OC2 Overcurrent occurred during deceleration.

OC3 Overcurrent occurred during running at a constant speed.

Possible Causes	Check and 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 wires, relay terminals and motor).
(2) Ground faults have occurred at the inverter output lines.	Disconnect the wiring from the output terminals (U, V, and W) and perform a Megger test. ➔ Remove the grounded 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 instantaneous overcurrent limiting (H12 = 1).
(4) Excessive torque boost specified. (The manual torgue boost when (F37* = 0, 1, 3, or 4))	Check whether decreasing the torque boost (F09*) decreases the output current but does not stall the motor. ➔ If no stall occurs, decrease the torque boost (F09*).
(5) The specified 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, E10 through E15, and H56). ➔ Enable the current limiter (F43) and torque limiter (F40, F41, E16, and E17). ➔ Increase the inverter capacity.
(6) Malfunction caused by noise.	Check if appropriate noise control measures have been implemented (e.g., correct grounding and routing of control and main circuit wires). ➔ Implement noise control measures. For details, refer to Appendix A. ➔ Enable the retry (H04). ➔ Connect a surge absorber to magnetic contactor's coils or other solenoids (if any) causing noise.

[25] OH1 Cooling fin overheat

Phenomena Temperature around heat sink has risen abnormally.

Possible Causes	Check and Measures
(1) The surrounding temperature exceeded the inverter's mode limit.	Measure the surrounding temperature. ➔ Lower the temperature (e.g., ventilate the panel where the inverter is mounted).
(2) Ventilation paths are blocked.	Check if there is sufficient clearance around the inverter. ➔ Change the mounting place to ensure the clearance.
	Check if the fin is not clogged. ➔ Clean the fin.
(3) Cooling fan's airflow volume decreased due to the service life expired or failure.	Check the cumulative run time of the cooling fan. (See Chapter 3 "3.4.5 To see maintenance information.") ➔ Replace the cooling fan.
[Subcode:6]	Visually check that the cooling fan rotates normally. ➔ Replace the cooling fan.
(4) Overload.	Measure the inverter output current. ➔ Reduce the load (Reduce the load before reaching an overload using cooling fin overheat forecast (E01-E05)/overload forecast (E34)). ➔ Decrease the motor sound (carrier frequency) (F26). ➔ Enable overload prevention control (H70).

[26] OH2 External alarm

Phenomena External alarm was inputted (THR).
(when the "Enable external alarm" signal THR has been assigned to any of digital input terminals)

Possible Causes	Check and Measures
(1) An alarm function of external equipment was activated.	Check the operation of external equipment. ➔ Remove the cause of the alarm that occurred.
(2) Wrong connection or poor contact in external alarm signal wiring.	Check if the external alarm signal wiring is correctly connected to the terminal to which the "Enable external alarm" has been assigned (Any of E01 to E05, E98, and E99 should be set to "9."). ➔ Connect the external alarm signal wire correctly.
(3) Incorrect setting of function code data.	Check whether an “external alarm” is assigned to a terminal not used yet among E01 to E05, E98, E99. ➔ Correct the assignment.
	Check whether the logic of [THR] set up at E01 to E05, E98, E99 agrees with that (positive/negative) of external signals. ➔ Ensure the matching of the logic.

[27] OH3 Inverter internal overheat

Phenomena Temperature inside the inverter has exceeded the allowable limit.

Possible Causes	Check and Measures
(1) The surrounding temperature exceeded the inverter's mode limit. [Subcode:0]	Measure the surrounding temperature. ➔ Lower the temperature around the inverter (e.g., ventilate the panel where the inverter is mounted).

[28] OH4 Motor protection (PTC thermistor)

Phenomena Temperature of the motor has risen abnormally.

Possible Causes	Check and Measures
(1) The temperature around the motor exceeded the motor's mode range.	Measure the surrounding temperature. ➔ Lower the temperature around the motor.
(2) Cooling system for the motor is defective.	Check if the cooling system of the motor is operating normally. ➔ Repair or replace the cooling system of the motor.
(3) Overload.	Measure the inverter output current. ➔ Reduce the load (e.g. Use the overload early warning (E34) and reduce the load before the overload protection is activated.). (In winter, the load tends to increase.) ➔ Lower the temperature around the motor. ➔ Increase the motor sound (Carrier frequency) (F26).
(4) The activation level (H27) of the PTC thermistor for motor overheat protection was set inadequately.	Check the PTC thermistor modes and recalculate the detection voltage. ➔ Modify the data of function code H27.
(5) The setting of the PTC thermistor is not adequate.	Check thermistor (operation selection) (E59) (H26) and the changeover switches (SW3) (SW4) of terminal [C1]. ➔ Change the settings to E59=0, H26=1, and set SW3 to C1 side and SW4 to PTC side.
(6) Excessive torque boost specified (F09*)	Check whether decreasing the torque boost (F09*) does not stall the motor. ➔ If no stall occurs, decrease the F09* data.
(7) The V/f pattern did not match the motor.	Check if the base frequency (F04*) and the voltage at base frequency (F05*) match the rated values on the motor's nameplate. ➔ Match the function code data with the values on the motor's nameplate.
(8) Incorrect setting of function code data.	Although PTC thermistor is not used, the thermistor (operation selection) (H26) is in the operation state. ➔ Set the H26 data to "0" (Disable).

[29] OLn Motor overloads 1 to 2

Phenomena Electronic thermal function for motor overload detection of motors 1-2 worked.

OL1 Motor 1 overload

OL2 Motor 2 overload

Possible Causes	Check and Measures
(1) The electronic thermal characteristics do not match the motor overload characteristics.	Check the motor characteristics. ➔ Review the data of function codes (P99*, F10*, F12*). ➔ Use an external thermal relay.
(2) Activation level for the electronic thermal protection was inadequate.	Check the continuous allowable current of the motor. ➔ Reconsider and change the data of function code F11*.
(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, F08, E10 through E15, and H56).
(4) Overload.	Measure the inverter output current. ➔ Reduce the load (e.g. Use the overload early warning (E34) and reduce the load before the overload protection is activated.). (In winter, the load tends to increase.)
(5) Excessive torque boost specified (F09*)	Check whether decreasing the torque boost (F09*) does not stall the motor. ➔ If no stall occurs, decrease the F09* data.

[30] OLU Inverter overload

Phenomena Temperature inside inverter has risen abnormally.

Possible Causes	Check and Measures
(1) The surrounding temperature exceeded the inverter's mode limit.	Measure the surrounding temperature. ➔ Lower the temperature (e.g., ventilate the panel where the inverter is mounted).
(2) Excessive torque boost specified (F09*)	Check whether decreasing the torque boost (F09*) does not stall the motor. ➔ If no stall occurs, decrease the F09* data.
(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, F08, E10 to E15, and H56).
(4) Overload.	Measure the inverter output current. ➔ Reduce the load (e.g. Use the overload early warning (E34) and reduce the load before the overload protection is activated.). (In winter, the load tends to increase.) ➔ Decrease the motor sound (Carrier frequency) (F26). ➔ Enable overload prevention control (H70).
(5) Ventilation paths are blocked.	Check if there is sufficient clearance around the inverter. ➔ Change the mounting place to ensure the clearance.
	Check if the fin is not clogged. ➔ Clean the fin.
(6) Cooling fan's airflow volume decreased due to the service life expired or failure.	Check the cumulative run time of the cooling fan. (See Chapter 3 "3.4.5 To see maintenance information.") ➔ Replace the cooling fan.
	Visually check that the cooling fan rotates normally. ➔ Replace the cooling fan.
(7) The wires to the motor are too long, causing a large leakage current from them.	Measure the leakage current. ➔ Insert an output circuit filter (OFL).

[31] OPL Output phase-failure detection

Phenomena Output phase loss occurred.

Possible Causes	Check and Measures
(1) Inverter output wires are broken.	Measure the inverter output current. ➔ Replace the output wires.
(2) The motor winding is broken.	Measure the inverter output current. ➔ Replace the motor.
(3) The terminal screws for inverter output were not tight enough.	Check if any screws on the inverter output terminals have become loose. ➔ Tighten the terminal screws to the recommended torque.
(4) A single-phase motor has been connected.	➔ The inverter cannot be used. (FRENIC-Ace is for driving 3-phase induction motors.)

[32] OS Overspeed protection

Phenomena Motor rotated at excessive speed. (When motor speed≥(F03×1.2))

Possible Causes	Check and Measures
(1) Incorrect setting of function code data.	Check the motor parameter "Number of poles" setting (P01*). ➔ Specify the P01* data in accordance with the motor to be used.
	Check the maximum frequency setting (F03*). ➔ Specify the F03* data in accordance with the output frequency.

[33] OUn Overvoltage

Phenomena The DC intermediate circuit voltage was over the detection level of overvoltage.

OU1 Overvoltage occurred during acceleration.

OU2 Overvoltage occurred during deceleration.

OU3 Overvoltage occurred during running at constant speed.

Possible Causes	Check and Measures
(1) The power supply voltage exceeded the inverter's mode range.	Measure the input voltage. ➔ Decrease the voltage to within the specified range.
(2) A surge current entered the input power supply.	In the same power line, if a phase-advancing capacitor is turned ON/OFF or a thyristor converter is activated, a surge (momentary large increase in the voltage or current) may be caused in the input power. ➔ Install a DC reactor.
(3) The deceleration time was too short for the moment of inertia for load.	Recalculate the deceleration torque based on the moment of inertia for the load and the deceleration time. ➔ Increase the deceleration time (F08, E11, E13, E15, and H56). ➔ Enable the anti-regenerative control (H69), or deceleration characteristics (H71). ➔ Set torque limit (F40, F41, E16, E17) in effect. ➔ Set the voltage at base frequency (F05*) to "0" to improve the braking capability. ➔ Consider the use of a braking resistor.
(4) The acceleration time was too short.	Check if the overvoltage alarm occurs after rapid acceleration. ➔ Increase the acceleration time (F07, E10, E12, and E14). ➔ Select the S-curve pattern (H07). ➔ Consider the use of a braking resistor.
(5) Braking load is too heavy.	Compare the braking torque of the load with that of the inverter. ➔ Set the voltage at base frequency (F05*) to "0" to improve the braking capability. ➔ Consider the use of a braking resistor.
(6) Malfunction caused by noise.	Check if the DC intermediate circuit voltage was below the protective level when the overvoltage alarm occurred. ➔ Implement noise control measures. For details, refer to Appendix A. ➔ Enable the retry (H04). ➔ Connect a surge absorber to magnetic contactor's coils or other solenoids (if any) causing noise.

[34] PbF Charger circuit fault

Phenomena The magnetic contactor for short-circuiting the charging resistor failed to work.

Possible Causes	Check and Measures
(1) The control power was not supplied to the magnetic contactor intended for short-circuiting the charging resistor.	Check that, in normal connection of the main circuit (not a connection via the DC link bus), the connector (CN R) on the power printed circuit board (power PCB) is not inserted to NC. ➔ Insert the connector (CN R) to FAN .
	Check whether you quickly turned the circuit breaker ON and OFF to confirm safety after cabling/wiring. ➔ Wait until the DC intermediate circuit voltage has dropped to a sufficiently low level and then release the current alarm. After that, turn ON the power again. (Do not turn the circuit breaker ON and OFF quickly.) (Turning ON the circuit breaker supplies power to the control circuit to the operation level (lighting the LEDs on the keypad) in a short period. Immediately turning it OFF even retains the control circuit power for a time, while it shuts down the power to the magnetic contactor intended for short-circuiting the charging resistor since the contactor is directly powered from the main power. Under such conditions, the control circuit can issue a turn-on command to the magnetic contactor, but the contactor not powered can produce nothing. This state is regarded as abnormal, causing an alarm.)

[35] Pg PG wire break (To be responded soon.)

Phenomena The pulse generator (PG) wire has been broken somewhere in the circuit.

Possible Causes	Check and Measures
(1) The wire between the pulse generator (PG) and the option card has been broken.	Check whether the pulse generator (PG) is correctly connected to the option card or any wire is broken. ➔ Check whether the PG is connected correctly. Or, tighten up the related terminal screws. ➔ Check whether any contact part bites the wire sheath. ➔ Replace the wire.
(2) The inverter was affected by strong electrical noise.	Check whether 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. ➔ Separate the control circuit wires from the main power wires as far as possible.

6.4 If the "Light Alarm" Indication (L -AL) Appears on the LED Monitor

If the inverter detects a minor abnormal state, it can continue the current operation without tripping while displaying the "light alarm" indication (L -AL) on the LED monitor. In addition to the indication l-al, the inverter blinks the KEYPAD CONTROL LED and outputs the "light alarm" signal L-ALM to a digital output terminal to alert the peripheral equipment to the occurrence of a light alarm. (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 E20 to E21 and E27 to "98.")

Function codes H81 and H82 specify which alarms should be categorized as "light alarm." Selectable factors (codes) are the codes of light alarm objects shown in Table 6.4-1.

To display the "light alarm" factor and escape from the light alarm state, follow the instructions below.

■ Check method of light alarm factors

1) Press the PRG/RESET key to enter Programming mode.

2) Check the light alarm factor in 5_36 (Light alarm factor (latest)) under Menu #5 "Maintenance Information" in Programming mode. The light alarm factor is displayed in alarm codes. See Table 6.3-1 for code details.

📖 See Chapter 3 "3.4.5 To see Maintenance Information" for the details of screen transition in the "Maintenance Information." It is possible to display the factors of most recent 3 light alarms in 5_37 (Light alarm factor (last)) to 5_39 (Light alarm factor (3rd last)).

■ Switching the LED monitor from the light alarm to normal display

If it is necessary to return the LED monitor to the normal display state (showing the running status such as reference frequency) temporarily before removing the light alarm factor because it takes a long time to remove the light alarm factor, for example, follow the steps below.

1) Press the PRG/RESET key to return the LED monitor to the light alarm indication (L -AL).

2) Press FUNC/DATA key in a state of light alarm display (L -AL). Keypad display returns from light alarm display (L -AL) to monitor display (including frequency display) in the ordinary running state. KEYPAD CONTROL LED continues blinking, though.

■ Release method of light alarms

1) See function codes (H81, H82) corresponding to light alarm factors (codes) checked in the Maintenance Information to remove the occurrence factors of light alarms.

2) To return the LED monitor from the L -AL display to the normal display state (showing the running status such as reference frequency), press the FUNC/DATA key in Running mode.

   If the light alarm factor(s) has been successfully removed in step 1) above, the KEYPAD CONTROL LED stops blinking and the digital output L-ALM also goes OFF. If any light alarm factor persists (e.g., detecting a DC fan lock), the KEYPAD CONTROL LED continues blinking and the L-ALM remains ON.

Table 6.4-1 Various failure detections (Light alarm objects)

Code	Name
CnT	Inverter life (Number of startups)
CoF	PID feedback wire break
dbH	Braking resistor overheat
Er-4	Option communications error
Er-4	Option communications error
Er-8 Er-P	RS-485 communications error (Communications ports 1, 2)
Er-E (To be responded soon.)	Speed inconsistency or excessive speed deviation
Er-o (To be responded soon.)	Excessive positional deviation
Er-t	CAN communications failure
FAL	DC fan locked
LiF	Lifetime alarm
OH	Cooling fin overheat early warning
OH1	Cooling fin overheat
OH2	External alarm
OH3	Inverter internal overheat
OL	Overload early warning
OL1 to OL2	Motors 1to2 overload
Pid	PID alarm output
PTC	PTC thermistor activated
rEF	Reference command loss detected
rTE	Machine life (Cumulative motor running hours)
UTL	Low torque detection

6.5 When codes other than alarm codes and light alarm indication (L-AL) are displayed

This section describes the troubleshooting procedure based on function codes dedicated to motor 1. When motor 2 is used, it is necessary to read respective corresponding function codes by conversion. The function codes that need to be read by conversion are marked with "*."

For the function codes to be read by conversion, see Chapter 5 "FUNCTION CODES."

6.5.1 Abnormal motor operation

[1] The motor does not rotate.

Possible Causes	Check and Measures
(1) No power supplied to the inverter.	Check the input voltage and interphase voltage unbalance. ➔ Switch on a molded-case circuit breaker, an earth-leakage circuit breaker (with overcurrent protective function) or a magnetic contactor. ➔ 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.
(2) No forward/reverse operation command was inputted, or both the commands were inputted simultaneously (external signal operation).	Check the input status of the forward/reverse command with Menu "I/O Checking" using the keypad. ➔ Input a run command. ➔ Set either the forward or reverse operation command to OFF. ➔ Correct the run command source. (Set F02 data to "1.") ➔ Correct the assignment error of terminals [FWD], [REV]. (E98, E99) ➔ Connect the external circuit wires to control circuit terminals [FWD] and [REV] correctly. ➔ Make sure that the sink/source slide switch (SW1) on the control printed circuit board (control PCB) is properly configured.
(3) No rotational direction is instructed. (Keypad operation)	Check the input status of the forward/reverse rotation direction command with Menu "I/O Checking" using the keypad. ➔ Input the rotation direction (F02 = 0), or select the keypad operation with which the rotation direction is fixed (F02 = 2 or 3).
(4) The inverter could not accept any run commands from the keypad since it was in Programming mode.	Check which operation mode the inverter is in, using the keypad. ➔ Shift the operation mode to Running mode and enter a run command.
(5) A run command with higher priority than the one attempted was active, and the run command was stopped.	Based on the run command block diagram (See Chapter 8 BLOCK DIAGRAMS FOR CONTROL LOGIC.), check a higher priority run command by function code data check and I/O checking from Menu using the keypad. ➔ Correct any incorrect function code data settings such as link function (Mode selection) (H30) and bus function (Mode selection) (y98) or cancel the higher priority run command.
(6) No analog frequency command input.	Check that a reference frequency has been entered correctly, using Menu "I/O Checking" on the keypad. ➔ Connect external circuit wirings of terminals [13], [12], [11], [C1] correctly.

Possible Causes	Check and Measures
(7) The reference frequency was below the starting or stop frequency.	Check that a reference frequency has been entered correctly, using Menu "I/O Checking" on the keypad. ➔ Set the reference frequency at the same or higher than that of the starting and stop frequencies (F23* and F25). ➔ Reconsider the starting and stop frequencies (F23* and F25), and if necessary, change them to the lower values. ➔ Inspect the external frequency command potentiometers, signal converters, switches, and relay contacts. Replace any ones that are faulty. ➔ Connect external circuit wirings of terminals [13], [12], [11], [C1] correctly.
(8) A frequency command with higher priority than the one attempted was active.	Based on the frequency setting block diagram (See Chapter 8.), check the data by function code data check and I/O checking from Menu using the keypad. ➔ Correct any incorrect function code data (e.g. cancel the higher priority run command).
(9) The upper and lower frequencies for the frequency limiters were set incorrectly.	Check the data of function codes F15 (Frequency limiter (High)) and F16 (Frequency limiter (Low)). ➔ Change the settings of F15 and F16 to the correct ones.
(10) The coast-to-stop command was effective.	Check the data of the function codes (E01E05, E98, E99), and check an input state by I/O checking. ➔ Release the coast-to-stop command setting.
(11) Broken wires, incorrect connection or poor contact with the motor.	Check the wiring (Measure the output current). ➔ Repair the wires to the motor, or replace them.
(12) Overload.	Measure the inverter output current. ➔ Reduce the load (In winter, the load tends to increase.)
	Check whether any mechanical brake is working. ➔ Release the mechanical brake.
(13) Torque generated by the motor was insufficient.	Check that the motor starts running if the value of the torque boost (F09*) is increased. ➔ Increase the value of torque boost (F09*).
	Check the data of function codes (F04*, F05*, H50, H51, H52, H53, H65, and H66). ➔ Change the V/f pattern to match the motor's characteristics.
	Check that the motor switching signal (selecting motor 1 - 2) is correct and the data of function codes matches each motor. ➔ Correct the motor switching signal. ➔ Modify the function code data to match the connected motor.
	Check whether the reference frequency is below the slip-compensated frequency of the motor. ➔Change the reference frequency so that it becomes higher than the slip-compensated frequency of the motor.
(14) Wrong connection or poor contact of DC reactor (DCR)	Check the wiring. DC reactor is a standard accessory for inverters of ND modes: FRN0139E2S-4☐ or above and HD, HHD modes: FRN0168E2S-4☐ or above, HHD modes FRN203E2S-4☐ or above respectively. These inverters cannot run without a DCR. ➔ Connect the DCR correctly. Repair or replace DCR wires.
(15) No speed command is set up. (Keypad operation)	Check a speed set value of tough panel. ➔ Press [↑] key to change the speed set value.
(16) No enable inputs [EN1], [EN2] are entered.	Check the EN terminal input state by I/O checking. ➔ Connect the terminals [EN1], [EN2]. (See Chapter 2 "2.2.6 [3] Explanation of terminal functions" [EN1], [EN2].)

[2] The motor rotates, but the speed does not increase.

Possible Causes	Check and Measures
(1) The maximum frequency currently specified was too low.	Check the data of function code F03* (Maximum frequency). ➔ Correct the F03* data.
(2) The data of frequency limiter (High) currently specified was too low.	Check the data of function code F15 (Frequency limiter (High)). ➔ Correct the F15 data.
(3) Speed setting is not changing. (Analog setting)	Check that the reference frequency has been entered correctly, using Menu "I/O Checking" on the keypad. ➔ Increase the reference frequency. ➔ Inspect the external frequency command potentiometers, signal converters, switches, and relay contacts. Replace any ones that are faulty. ➔ Connect external circuit wirings of terminals [13], [12], [11], [C1] correctly.
(4) A frequency command (e.g., multi-frequency or via communications) with higher priority than the one attempted was active and its reference frequency was too low.	Based on the frequency setting block diagram (See Chapter 8 BLOCK DIAGRAMS FOR CONTROL LOGIC.), check the inputted frequency command by function code data check and I/O checking from Menu using the keypad. ➔ Correct any incorrect data of function codes (e.g. cancel the higher priority frequency command).
(5) The acceleration time was too long or too short.	Check the data of acceleration times (F07, E10, E12, E14, H54). ➔ Change the acceleration time to match the load.
(6) Overload.	Measure the inverter output current. ➔ Reduce the load.
	Check whether any mechanical brake is working. ➔ Release the mechanical brake.
(7) Function code settings do not agree with the motor characteristics.	When automatic torque boost and automatic energy-saving operations are performed, confirm that P02*, P03*, P06*, P07*, P08* agree with motor constant. ➔ Perform auto-tuning of the inverter for every motor to be used.
(8) The output frequency does not increase due to the current limiter operation.	Make sure that F43 (Current limiter (Mode selection)) is set to "2" and check the data of F44 (Current limiter (Level)). ➔ Change the F44 data correctly. Or, set the F43 data to "0" (Disable) if the current limiter operation is not needed.
	Decrease the value of torque boost (F09*), then run the motor again and check if the speed increases. ➔ If no stall occurs, decrease the F09* data.
	Check the data of function codes (F04*, F05*, H50, H51, H52, H53, H65, and H66) to ensure that the V/f pattern setting is right. ➔ Match the V/f pattern setting with the motor ratings.
(9) The output frequency does not increase due to the torque limiter operation.	Check whether the data of torque control levels (F40, F41, E16, E17) are set to appropriate values. Also, check whether torque limit 2/1 switching signal [TL2/TL1] is correct. ➔ Correct the data of F40, F41, E16 and E17 or reset them to the factory defaults. ➔ Set the TL2/TL1 correctly.
(10) Bias and gain incorrectly specified.	Check the data of the function codes (F18, C50, C32, C34, C37, C39, C42, C44, C55-C72). ➔ Readjust the bias and gain to appropriate values.
(11) External wirings of terminals [X1]-[X5] are not connected correctly. Or settings are not correct.	Check that the reference frequency has been entered correctly, using Menu "I/O Checking" on the keypad. ➔ Connect the external circuit wirings of terminals [X1]-[X5] correctly. ➔ Set up the data of E01-E05 correctly. ➔ Set up the data of C05-C19 correctly. (Setting of multi-step speed)
(12) Speed set value is not changing. (Keypad operation)	Check whether it changes by changing the speed command value of keypad. ➔ Press [↑][↓] keys to change the speed command value.

[3] The motor runs in the opposite direction to the command.

Possible Causes	Check and Measures
(1) Wiring to the motor is incorrect.	Check the wiring to the motor. ➔ Connect terminals U, V, and W of the inverter to the U, V, and W terminals of the motor, respectively.
(2) Incorrect connection and settings for run commands and rotation direction commands (FWD and REV).	Check the data of function codes (E98 and E99) and the connection. ➔ Correct the data of the function codes and the connection.
(3) A run command (with fixed rotational direction) from the keypad is active, but the rotational direction setting is incorrect.	Check the data of function code F02 (Run command). ➔ Change the data of function code F02 to "2: / keys on keypad (forward)" or "3: / keys on keypad (reverse)."
(4) The rotation direction mode of the motor is opposite to that of the inverter.	The rotation direction of IEC-compliant motors is opposite to that of incompliant motors. ➔ Switch the FWD/REV signal setting.
(5) The function code data related to the speed command are incorrect.	Check the function code data. (See "Chapter 8 BLOCK DIAGRAMS FOR CONTROL LOGIC.") ➔ Set correct data.

[4] Speed fluctuation or current oscillation (e.g., hunting) occurs during running at constant speed.

Possible Causes	Check and Measures
(1) Analog speed setting is fluctuating.	Check the signals for the frequency command with Menu "I/O Checking" using the keypad. (See Chapter 3 "3.4.4 To check input/output signal state.") ➔ Increase the filter constants (C33, C38, and C43) for the frequency command.
(2) An external frequency command potentiometer is used for frequency setting.	Check that there is no noise in the control signal wires from external sources. ➔ Separate the signal wires from the main power wires as far as possible. ➔ Use shielded or twisted wires for control signals.
	Check whether the external frequency command potentiometer is malfunctioning due to noise from the inverter. ➔ Connect a capacitor to the output terminal of the potentiometer or insert a ferrite core on the signal wire. (See Chapter 2 Fig. 2.2-9 Countermeasure against noises.)
(3) Frequency switching or multi-frequency command was enabled.	Check whether the relay signal for switching the frequency command is chattering. ➔ If the relay contact is defective, replace the relay.
(4) The wiring length between the inverter and the motor is too long.	Check whether auto-torque boost, auto-energy saving operation, or dynamic torque vector control is enabled. ➔ Perform auto-tuning of the inverter for every motor to be used. ➔ Disable the automatic control systems by setting F37* to "1" (Constant torque load) and F42* to "0" (V/f control), then check that the motor vibration stops. ➔ Make the output wires as short as possible.
(5) The machinery is hunting due to vibration caused by low rigidity of the load. Or the current is irregularly oscillating due to special motor parameters.	Once disable all the automatic control systems such as auto torque boost, auto energy saving operation, overload prevention control, current limiter, torque limiter, anti-regenerative control, auto search for idling motor speed, slip compensation, dynamic torque vector control, droop control, overload stop function, speed control, online tuning, notch filter, and observer, and then check that the motor vibration comes to a stop. ➔ Disable the functions causing the vibration. ➔ Readjust the output current fluctuation damping gain (H80*).
	Check that the motor vibration is suppressed if you decrease the level of F26 (Motor sound (Carrier frequency)) or set F27 (Motor sound (Tone)) to "0." ➔ Decrease the carrier frequency (F26) or set the tone to "0" (F27 = 0).

[5] Unpleasant noises are emitted from motor or noises fluctuate.

Possible Causes	Check and Measures
(1) The specified carrier frequency is too low.	Check the data of motor operation noise (carrier frequency) (F26) and motor operation noise (tone) (F27). ➔ Increase the carrier frequency (F26). ➔ Change the setting of F27 to appropriate value.
(2) Ambient temperature of inverter is high. (In the selection of carrier frequency automatic reduction function (H98))	Measure the temperature inside the panel where the inverter is mounted. ➔ If it is over 40°C, lower it by improving the ventilation. ➔ Lower the temperature of inverter by reducing a load. (In the case of funs/pumps, lower frequency limiter (upper limit) (F15).) NB) The release of H98 causes alarms OH1, OH3, OLU in some cases.
(3) Resonance with the load.	Check the machinery mounting accuracy or check whether there is resonance with the mounting base. ➔ Sort out a resonance cause by running the motor independently, and improve the characteristics at the cause side. ➔ Avoid continuous running at the frequency range where the resonance occurs by regulating the jump speed (C01-C04)

[6] Motor is not accelerated or decelerated according to set-up acceleration or deceleration time.

Possible Causes	Check and Measures
(1) The inverter runs the motor with S-curve or curvilinear pattern.	Check the data of function code H07 (Acceleration/deceleration pattern). ➔ Set linear acceleration/deceleration. (H07=0) ➔ Shorten the acceleration/deceleration time (F07, F08, E10 through E15).
(2) The current limiting operation prevented the output frequency from increasing (during acceleration).	Make sure that F43 (Current limiter (Mode selection)) is set to 2, then check that the setting of F44 (Current limiter (Level)) is reasonable. ➔ Readjust the setting of F44 to appropriate value, or disable the function of current limiter with F43. ➔ Increase the acceleration/deceleration time (F07, F08, E10 through E15).
(3) The anti-regenerative control is enabled (during deceleration).	Check the data of function code H69 (Anti-regenerative control (Mode selection)). ➔ Increase the deceleration time (F08, E11, E13, and E15).
(4) Overload.	Measure the inverter output current. ➔ Reduce the load (For fans or pumps, decrease the frequency limiter (upper limit) (F15).) (In winter, the load tends to increase.)
(5) Torque generated by the motor was insufficient.	Check that the motor starts running if the value of the torque boost (F09*) is increased. ➔ Increase the value of the torque boost (F09*).
(6) An external frequency command potentiometer is used for frequency setting.	Check that there is no noise in the control signal wires from external sources. ➔ Separate the signal wires from the main power wires as far as possible. ➔ Use shielded or twisted wires for control signals. ➔ Connect a capacitor to the output terminal of the potentiometer or insert a ferrite core on the signal wire. (See Chapter 2 "2.2.6 [3] Explanation of terminal functions (Control circuit terminals) [12], [C1].")
(7) The output frequency is limited by the torque limiter.	Check whether the data of torque limit levels (F40, F41, E16, E17) are set to appropriate values. Also, check whether torque limit 2/1 switching signal [TL2/TL1] is correct. ➔ Correct the data of F40, F41, E16 and E17 or reset them to the factory defaults. ➔Set the TL2/TL1 correctly. ➔Increase the acceleration/deceleration time (F07, F08, E10 through E15).
(8) The specified acceleration or deceleration time was incorrect.	Check the terminal commands RT1 and RT2 for acceleration/ deceleration times. ➔ Correct the RT1 and RT2 settings.

[7] The motor does not restart even after the power recovers from a momentary power failure.

Possible Causes	Check and 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 function code 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 Checking" using the keypad. (See Chapter 3 "3.4.4 To check input/output signal state.") ➔ 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 a 3-wire operation, momentary power failure duration is long so that control circuit power source of inverter is shut off once. Also, self-hold selection signal [HOLD] is switched 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] Motor generates heat abnormally.

Possible Causes	Check and Measures
(1) Excessive torque boost specified.	Check whether decreasing the torque boost (F09*) decreases the output current but does not stall the motor. ➔ If no stall occurs, decrease the torque boost (F09*).
(2) Continuous running in extremely slow speed.	Check the running speed of the inverter. ➔ Change the speed setting or replace the motor with a motor exclusively designed for inverters.
(3) Overload.	Measure the inverter output current. ➔ Reduce the load. (In the case of funs/pumps, lower frequency limiter (upper limit) (F15).) (In winter, the load tends to increase.)

[9] The motor does not run as expected.

Possible Causes	Check and 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.

[10] Motor stalls during acceleration.

Possible Causes	Check and Measures
(1) The acceleration time was too short.	Check the data of acceleration times (F07, E10, E12, E14, H57, H58). ➔ Extend the acceleration times.
(2) Inertial moment of load is large.	Measure the inverter output current. ➔ Reduce the moment of inertia of the load. ➔ Increase the inverter capacity.
(3) Voltage drop of wiring is large.	Check the terminal voltage of motor. ➔ Increase the diameter or shorten the distance of wirings between the inverter and motor.
(4) Torque of load is large.	Measure the inverter output current. ➔ Reduce the torque of load. ➔ Increase the inverter capacity.
(5) Torque generated by the motor was insufficient.	Check whether the inverter is started when torque boosts (F09, F37, H51) are increased. ➔ Increase F09, F37, H51.

6.5.2 Problems with inverter settings

[1] Nothing appears on the LED monitor.

Possible Causes	Check and Measures
(1) No power (neither main power nor auxiliary control power) is supplied to the inverter.	Check the input voltage and interphase voltage unbalance. ➔ Switch on a molded-case circuit breaker, an earth-leakage circuit breaker (with overcurrent protective function) or a magnetic contactor. ➔ Check for voltage drop, phase loss, poor connections, or poor contacts and fix them if necessary.
(2) The power for the control PCB did not reach a sufficiently high level.	Check if the shorting bar has been removed between terminals P1 and P(+) or if there is a poor contact between the shorting bar and those terminals. ➔ Mount a shorting bar or a DC reactor between terminals P1 and P(+). For poor contact, tighten up the screws.
(3) 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 menu is not displayed.

Possible Causes	Check and Measures
(1) The menu display mode is not selected appropriately.	Check the data of function code E52 (Keypad (Menu display mode)). ➔ Change the E52 data so that the desired menu appears.

[3] Display of under bars (_ _ _ _)

Phenomena Although FWD key, run forward command [FWD], or REV key, run reverse command [REV], was pressed, the motor did not rotate and under bars were displayed.

Possible Causes	Check and Measures
(1) The voltage of the DC intermediate circuit was low.	Select 5_01 from Menu #5 "Maintenance Information" in the program mode of keypad to check the DC intermediate circuit voltage. (3-phase 200V: 200VDC or less, 3-phase 400V: 400VDC or less) ➔ Connect the inverter to a power supply that meets its input modes.
(2) The main power is not ON, while the auxiliary input power to the control circuit is supplied.	Check whether the main power is turned ON. ➔ Turn on the main power. Check if the shorting bar has been removed between terminals P1 and P(+) or if there is a poor contact between the shorting bar and those terminals. ➔ Mount a shorting bar or a DC reactor between terminals P1 and P(+). For poor contact, tighten up the screws.
(3) AC power source is not connected due to the connection of DC power supply, but the detection of main power interruption is activated (H72=1).	Check the connection to the main power and check if the H72 data is set to "1" (factory default). ➔ Review the data of H72.
(4) Breaks in wiring to the main power input terminals.	Measure the input voltage. ➔ Repair or replace the main circuit power input wires or input devices (MCCB, MC, etc.).

[4] Display of center bars (----)

Phenomena A center bar (----) appeared on the LED monitor.

Possible Causes	Check and Measures
(1) When PID control had been disabled (J01 = 0), you changed E43 (LED Monitor (Item selection)) to 10 or 12. With the PID being enabled (J01 = 1, 2, or 3), you disabled PID control (J01 = 0) when the LED monitor had been set to display the PID command or PID feedback amount by pressing the FUNC/DATA key.	Make sure that when you wish to view other monitor items, E43 is not set to "10: PID command" or "12: PID feedback amount." ➔ Set E43 to a value other than "10" or "12." Make sure that when you wish to view a PID command or a PID feedback amount, J01 (PID control) is not set to "0: Disable." ➔ Set J01 to "1: Enable (Process control normal operation)," "2: Enable (Process control inverse operation)," or "3: Enable (Dancer control)."
(2) The keypad was poorly connected.	Prior check: Even when FUNC/DATA key is pressed, the display is not switched. Check continuity of the extension cable used in remote operation. ➔ Replace the cable.

[5] [ ] Display of parenthesis

Phenomena [ ] was displayed during speed monitoring by keypad.

Possible Causes	Check and Measures
(1) The display data overflows the LED monitor.	Check whether the product of the output frequency and the display coefficient (E50) exceeds 99,999. ➔ Correct the E50 data.

[6] Data of function codes cannot be changed.

Possible Causes	Check and 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 "Drive Monitoring" using the keypad and then confirm whether the data of the function codes can be changed when the motor is running by referring to the function code tables. ➔ Stop the motor 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 a data protection state (F00=1 or 3) to a data changeable state (F00=0 or 2).
(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 the function codes (E01-E05, E98, E99), and check an input state by I/O checking from Menu using keypad. ➔ Input a WE-KP command through a digital input terminal.
(4) The FUNC/DATA key was not pressed.	Check whether FUNC/DATA key was pressed after changing the data of the function codes. ➔ Press FUNC/DATA key after changing the data. Check that SAVE is displayed on the LED monitor.
(5) The data of the function codes F02, E01-E05, E98, E99 are not changeable.	Either one of the FWD and REV terminal commands is turned ON. ➔ Turn OFF both FWD and REV.
(6) The function code(s) to be changed does not appear.	If Menu #0 "Quick Setup" (0.Fnc) is selected, only the particular function codes appear. ➔ Call the menu of 1.F_ to 1.Y_ by ∧ key from the quick setup (0.Fnc) state on the Menu to display an intended function code and to change the codes. (See Chapter 3 Section 3.4 Table 3.4-1 "Menu of program mode" for the details.)

[7] Function code data are not changeable (change from link functions)

Possible Causes	Check and 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 "Drive Monitoring" using the keypad and then confirm whether the data of the function codes can be changed when the motor is running by referring to the function code tables. ➔ Stop the motor then change the data of the function codes.
(2) The setting of the function code y33 (incorporated CAN) is wrong.	Check whether the setting of the function code y33 (incorporated CAN) is correct. ➔ Set y33 correctly.
(3) The data of the function code F02 is not changeable.	Either one of the FWD and REV terminal commands is turned ON. ➔ Turn OFF both FWD and REV.

Chapter 7

MAINTENANCE AND INSPECTION

This chapter describes the maintenance and inspection items of the inverter.

Contents

Chapter 7 MAINTENANCE AND INSPECTION

Perform daily and periodic inspections to avoid trouble and keep reliable operation of the inverter for a long time. When performing inspections, follow the instructions given in this chapter.

⚠WARNING ⚠

- Before proceeding to the maintenance/inspection jobs, **turn OFF the power and wait at least five minutes for inverters FRN0072E2S-4☐ or below, or at least ten minutes for inverters FRN0085E2S-4☐ or above**. Make sure that the LED monitor and charging lamp are turned OFF. Further, make sure, using a multimeter or a similar instrument, that the DC link bus voltage between the terminals P(+) and N(-) has dropped to the safe level (+25 VDC or below).

  Electric shock may occur.
- Maintenance, inspection, and parts replacement should be made only by authorized persons.
- Take off the watch, rings and other metallic objects before starting work.
- Use insulated tools.
- Never modify the inverter.

  Electric shock or injuries could occur.

7.1 Inspection Interval

Table 7.1-1 lists the inspection intervals and check items, as a guide.

Table 7.1-1 List of Inspections

Inspection type	Inspection interval	Check items
Daily inspection	Every day	See Section 7.2.
Periodic inspection	Every year	See Section 7.3.
Decennial inspection *1	Every 10 years *2	Replacement of cooling fans *3 Replacement of DC link bus capacitors and close checks

*1 The decennial inspection (except replacement of cooling fans) should be performed only by the persons who have finished the Fuji Electric training course. Contact the sales agent where you purchased the product or your nearest Fuji Electric representative.

*2 Every 7 years for ND-mode inverters.

*3 For the standard replacement interval of cooling fans, refer to Section 0 "List of Periodic Replacement Parts."

Note: The replacement intervals are based on the inverter's service life estimated at an ambient temperature of 40°C at 100% (HHD-mode inverters) or 80% (ND-/HD-/HND-mode inverters) of full load. In environments with an ambient temperature above 40°C or a large amount of dust or dirt, the replacement intervals may be shorter.

Standard replacement intervals mentioned above are only a guide for replacement, not a guaranteed service life. Refer to Section 7.4 "List of Periodic Replacement Parts."

7.2 Daily Inspection

Visually inspect the inverter for operation errors from the outside without removing the covers when the inverter is running or the power is ON.

Table 7.2-1 lists daily inspection items.

Table 7.2-1 Daily Inspection List

Check part	Check item	How to inspect	Evaluation criteria
Environment	1) Check the surrounding temperature, humidity, vibration and atmosphere (dust, gas, oil mist, or water drops). 2) Check that tools or other foreign materials or dangerous objects are not left around the equipment.	1) Check visually or measure using apparatus. 2) Visual inspection	1) The usage environment given in Chapter 1, Section 1.3.1 must be satisfied. 2) No foreign or dangerous objects are left.
External appearance and others	1) Check that the bolts securing the wires to the main circuit terminals and control circuit terminals are not loose before turning the power ON. 2) Check for traces of overheat, discoloration and other defects. 3) Check for abnormal noise, odor, or excessive vibration.	1) Retighten before turning the power ON. 2) Visual inspection 3) Auditory, visual, and olfactory inspection	1) No looseness. If loose, retighten the screws. 2), 3) No abnormalities
Cooling fans	Check for abnormal noise or excessive vibration when the cooling fans are in operation.	Auditory and visual inspections	No abnormalities
Keypad	Check for alarm indication.	Visual inspection	If any alarm is displayed, refer to Chapter 6.
Performance	Check that the inverter provides the expected performance (as defined in the standard specifications).	Check the monitor items shown on the keypad.	No abnormalities in the output speed, current and voltage and other running data.

7.3 Periodic Inspection

[1] Periodic inspection 1--Before the inverter is powered ON or after it stops running

Perform periodic inspections according to the items listed in Table 7.3-1. Before performing periodic inspection 1, shut down the power and then remove the front cover.

Even if the power has been shut down, it takes the time for the DC link bus capacitor to discharge. After the charging lamp is turned OFF, therefore, make sure that the DC link bus voltage has dropped to the safe level (+25 VDC or below) using a multimeter or a similar instrument.

Table 7.3-1 Periodic Inspection List 1

Check part		Check item	How to inspect	Evaluation criteria
Structure such as frame and cover		Check for: 1) Loose bolts (at clamp sections). 2) Deformation and breakage 3) Discoloration caused by overheat 4) Contamination and accumulation of dust or dirt	1) Retighten. 2), 3), 4) Visual inspection	1), 2), 3), 4) No abnormalities (If any section is stained, clean it with a soft cloth.)
Main circuit	Common	1) Check that bolts and screws are tight and not missing. 2) Check the devices and insulators for deformation, cracks, breakage and discoloration caused by overheat or deterioration. 3) Check for contamination or accumulation of dust or dirt.	1) Retighten. 2), 3) Visual inspection	1), 2), 3) No abnormalities (If any section is stained, clean it with a soft cloth.)
Main circuit	Conductors and wires	1) Check conductors for discoloration and distortion caused by overheat. 2) Check the sheath of the wires for cracks and discoloration.	1), 2) Visual inspection	1), 2) No abnormalities
Main circuit	Terminal blocks	Check that the terminal blocks are not damaged.	Visual inspection	No abnormalities
Main circuit	DC link bus capacitor	1) Check for electrolyte leakage, discoloration, cracks and swelling of the casing. 2) Check that the safety valve does not protrude remarkably.	1), 2) Visual inspection	1), 2) No abnormalities
Main circuit	Braking resistor	1) Check for abnormal odor or cracks in insulators caused by overheat. 2) Check for wire breakage.	1) Olfactory and visual inspection 2) Check the wires visually, or disconnect either one of the wires and measure the conductivity with a multimeter.	1) No abnormalities 2) Within ±10% of the resistance of the braking resistor
Control circuit	Printed circuit board	1) Check for loose screws and connectors. 2) Check for odor and discoloration. 3) Check for cracks, breakage, deformation and remarkable rust. 4) Check the capacitors for electrolyte leaks and deformation.	1) Retighten. 2) Olfactory and visual inspection 3), 4) Visual inspection * Judgment on service life using "Menu #5 Maintenance Information" in Section 3.4.5.	1), 2), 3), 4) No abnormalities
Cooling system	Cooling fan	1) Check for engagement or abnormal vibration. 2) Check for loose bolts. 3) Check for discoloration caused by overheat.	1) Turn by hand. (Be sure to turn the power OFF beforehand.) 2) Retighten. 3) Visual inspection * Judgment on service life using "Menu #5 Maintenance Information" in Section 3.4.5.	1) Smooth rotation 2), 3) No abnormalities
Cooling system	Ventilation path	Check the heat sink, intake and exhaust ports for clogging and foreign materials.	Visual inspection	No clogging or accumulation of dust, dirt or foreign materials. Clean it, if any, with a vacuum cleaner.

[2] Periodic inspection 2--When the inverter is ON or it is running

Visually inspect the inverter for operation errors from the outside without removing the covers when the inverter is ON or it is running.

Perform periodic inspections according to the items listed in Table 7.3-2

Table 7.3-2 Periodic Inspection List 2

Check part		Check item	How to inspect	Evaluation criteria
Input voltage		Check that the input voltages of the main and control circuits are correct.	Measure the input voltages using a multimeter or the like.	The standard specifications must be satisfied.
Structure such as chassis and covers		Check for abnormal noise or excessive vibration when the inverter is running.	Visual and auditory inspections	No abnormalities
Main circuit	Transformers and reactors	Check for abnormal roaring noise or odor when the inverter is running.	Auditory, visual, and olfactory inspections	No abnormalities
	Magnetic contactors and relays	Check for chatters when the inverter is running.	Auditory inspection	No abnormalities
	DC link bus capacitor	Measure the capacitance if necessary.	Judgment on service life using "Menu #5 Maintenance Information (5.CHE)" in Chapter 3, Section 3.4.5.	Capacitance ≥ Initial value x 0.85
Cooling fans		Check for abnormal noise or excessive vibration when the inverter is running.	Visual and auditory inspections	No abnormalities

Additional notes

(1) The inspection interval (every year) of check items given in Table 7.3-1 and Table 7.3-2 is merely a guide. Make the interval shorter depending on the usage environment.

(2) Store and organize the inspection results to utilize them as a guide for operation and maintenance of the equipment and service life estimation.

(3) At the time of an inspection, check the cumulative run times on the keypad to utilize them as a guide for replacement of parts. (Refer to Section 7.4.1 "Judgment on service life.")

(4) The inverter has cooling fans inside to ventilate itself for discharging the heat generated by the power converter section. This will accumulate dust or dirt on the heat sink depending on the ambient environment.

In a dusty environment, the heat sink requires cleaning in a shorter interval than that specified in periodic inspection. Neglecting cleaning of the heat sink can rise its temperature, activating protective circuits to lead to an abrupt shutdown or causing the temperature rise of the surrounding electronic devices to adversely affect their service life.

7.4 List of Periodic Replacement Parts

Each part of the inverter has its own service life that will vary according to the environmental and operating conditions. It is recommended that the following parts be replaced at the specified intervals.

When the replacement is necessary, consult your Fuji Electric representative.

Table 7.4-1 Replacement Parts

Part name	Standard replacement intervals (See **Note** below.)
DC link bus capacitor	10 years (7 years in the ND mode)
Electrolytic capacitors on printed circuit boards	10 years (7 years in the ND mode)
Cooling fans	10 years (7 years in the ND mode)
Fuses	10 years (7 years in the ND mode)

Note These replacement intervals are based on the inverter's service life estimated at a surrounding temperature of 40°C at 100% (HHD-mode inverters) or 80% (ND-/HD-/HND-mode inverters) of full load. In environments with an ambient temperature above 40°C or a large amount of dust or dirt, the replacement intervals may be shorter.

Notes for periodic replacement of parts

(1) The replacement intervals listed above are a guide for almost preventing parts from failure if those parts are replaced with new ones at the intervals. They do not guarantee the completely fault-free operation.

(2) The table above does not apply to unused spare parts being kept in storage.

It applies only when they are stored under the temporary and long-term storage conditions given in Chapter 1, Section 1.3.2 "Storage environment" and energized approximately once a year.

(3) Cooling fans can be replaced by users. As for other parts, only the persons who have finished the Fuji Electric training course can replace them. For the purchase of spare cooling fans and the request for replacement of other parts, contact the sales agent where you purchased the product or your nearest Fuji Electric representative.

7.4.1 Judgment on service life

The inverter has the life prediction function for some parts which measures the discharging time or counts the voltage applied time, etc. The function allows you to monitor the current lifetime state on the LED monitor and judge whether those parts are approaching the end of their service life.

The life prediction function can also issue early warning signals if the life time alarm command ***LIFE*** is assigned to any of the digital output terminals. (Refer to Chapter 3, Section 3.4.5 "Reading maintenance information.")

Table 7.4-2 lists the parts whose service life can be predicted and details the life prediction function. The predicted values should be used only as a guide since the actual service life is influenced by the ambient temperature and other usage environments.

Table 7.4-2 Life Prediction

Object of life prediction	Prediction function	End-of-life criteria	Prediction timing	"5: MAINTENANCE" on the LED monitor
DC link bus capacitor	Measurement of discharging time Measures the discharging time of the DC link bus capacitor when the main power is shut down and calculates the capacitance.	85% or lower of the initial capacitance at shipment	At periodic inspection (H98: Bit 3 = 0)	5_05 (Capacity)
		85% or lower of the reference capacitance under ordinary operating conditions at the user site	During ordinary operation (H98: Bit 3 = 1)	5_05 (Capacity)
	ON-time counting Counts the time elapsed when the voltage is applied to the DC link bus capacitor, while correcting it according to the capacitance measured above.	Exceeding 87,600 hours (10 years)	During ordinary operation	5_26 (Elapsed time) 5_27 (Time remaining before the end of life)
Electrolytic capacitors on printed circuit boards	Counts the time elapsed when the voltage is applied to the capacitors, while correcting it according to the surrounding temperature.	Exceeding 87,600 hours (10 years)	During ordinary operation	5_06 (Cumulative run time)
Cooling fans	Counts the run time of the cooling fans.	Exceeding 87,600 hours (10 years)	During ordinary operation	5_06 (Cumulative run time)

The service life of the DC link bus capacitor can be judged by the "measurement of discharging time" or "ON-time counting."

[1] Measurement of discharging time of the DC link bus capacitor

- The discharging time of the DC link bus capacitor depends largely on the inverter's internal load conditions, e.g. options attached or ON/OFF of digital I/O signals. If actual load conditions are so different from the ones at which the initial/reference capacitance is measured that the measurement result falls out of the accuracy level required, then the inverter does not perform measuring.

  When the inverter is connected with a converter or with another inverter via DC common connection, it performs no measurement.

- The capacitance measuring conditions at shipment are drastically restricted, e.g., all input terminals being OFF in order to stabilize the load and measure the capacitance accurately. Those conditions are, therefore, different from the actual operating conditions in almost all cases. If the actual operating conditions are the same as those at shipment, shutting down the inverter power automatically measures the discharging time; however, if they are different, no automatic measurement is performed. To perform it, put those conditions back to the factory default ones and shut down the inverter. Refer to the measuring procedure given below.

- To measure the capacitance of the DC link bus capacitor *under ordinary operating conditions* when the power is turned OFF, it is necessary to set up the load conditions for ordinary operation and measure the reference capacitance (initial setting) when the inverter is introduced. For the reference capacitance setup procedure, see (2) on page 7-8. Performing the setup procedure automatically detects and saves the measuring conditions of the DC link bus capacitor.

  Setting bit 3 of H98 data at "0" restores the inverter to the measurement in comparison with the initial capacitance measured at shipment.

- In a machine system where the inverter main power is rarely shut down, the inverter does not measure the discharging time. For such an inverter, the ON-time counting is provided. The ON-time counting result can be represented as "elapsed time"(5_26) and "time remaining before the end of life" (5_27) as shown in the "DC link bus capacitor" section in Table 7.4-2.

Note When the inverter uses an auxiliary control power input, the load conditions widely differ so that the discharging time cannot be accurately measured. In this case, measuring of the discharging time can be disabled with the function code H98 (Bit 4 = 0) for preventing unintended measuring.

[2] ON-time counting of DC link bus capacitor

(1) Measuring the capacitance of DC link bus capacitor in comparison with initial one at shipment

The measuring procedure given below measures the capacitance of DC link bus capacitor in comparison with initial one at shipment when the power is turned OFF. The measuring result can be displayed on the keypad as a ratio (%) to the initial capacitance.

-- **Capacitance measuring procedure** --

1) To ensure validity in the comparative measurement, put the condition of the inverter back to the state at factory shipment.
   - Remove the option card (if already in use) from the inverter.
   - In case another inverter is connected via the DC link bus to the P(+) and N(-) terminals of the main circuit, disconnect the wires. (You do not need to disconnect a DC reactor (optional), if any.)
   - Disconnect power wires for the auxiliary input to the control circuit (R0, T0).
   - Mount the keypad.
   - Turn OFF all the digital input signals fed to terminals [FWD], [REV], and [X1] through [X5] of the control circuit.
   - If an external speed command potentiometer is connected to terminal [13], disconnect it.
   - If an external apparatus is attached to terminal [PLC], disconnect it.
   - Ensure that transistor outputs [Y1] and [Y2] and Relay output terminals [30A/B/C] will not be turned ON.
   - Disable the RS-485 communications link and CANopen communications link.

   Note If negative logic is specified for the transistor output and relay output signals, they are considered ON when the inverter is not running. Specify positive logic for them.

2) Turn ON the main circuit power.
3) Confirm that the DC cooling fan is rotating and the inverter is in stopped state. Disable the cooling fan ON/OFF control (H06 = 0).
4) Shut down the main circuit power.
5) The inverter automatically starts the measurement of the capacitance of the DC link bus capacitor.

   Note If " . . . . " does not appear on the LED monitor, the measurement has not started. Check the conditions listed in 1).

6) After " . . . . " has disappeared from the LED monitor, turn ON the main circuit power again.
7) Select Menu #5 "Maintenance Information" in Programming mode and check the capacitance (%) of the DC link bus capacitor (5_05).

----

(2) Measuring the capacitance of the DC link bus capacitor under ordinary operating conditions

The inverter automatically measures the capacitance of the DC link bus capacitor under ordinary operating conditions when the power is turned OFF. This measurement requires setting up the load conditions for ordinary operation and measuring the reference capacitance when the inverter is introduced to the practical operation, using the setup procedure given below

-- **Reference capacitance setup procedure** ---

1) Set bit 3 of function code H98 at "1" (User mode) to enable the user to specify the judgment criteria for the service life of the DC link bus capacitor.
2) Turn OFF all run commands.
3) Make the inverter ready to be turned OFF under ordinary operating conditions.
4) Set each of function codes H42 (Capacitance of DC Link Bus Capacitor) and H47 (Initial Capacitance of DC Link Bus Capacitor) at "0000."
5) Turn OFF the inverter, and the following operations are automatically performed.

   The inverter measures the discharging time of the DC link bus capacitor and saves the result in function code H47 (Initial Capacitance of DC Link Bus Capacitor).

   The conditions under which the measurement has been conducted will be automatically collected and saved.
6) Turn ON the inverter again.

   Confirm that H47 (Initial Capacitance of DC Link Bus Capacitor) holds right values. Switch to Menu #5 "Maintenance Information" in Programming mode and confirm that the main capacitor capacity is 100% (5_05 = 100%).

   Note: If the measurement has failed, "0001" is entered into each of H42 and H47. Remove the factor of the failure and conduct the measurement again.

Hereafter, each time the inverter is turned OFF, it automatically measures the discharging time of the DC link bus capacitor if the above conditions are met. Periodically check the capacitance (%) of the DC link bus capacitor (5_05) with Menu #5 "Maintenance Information" in Programming mode.

Note: The condition given above produces a rather large measurement error. If this mode gives you a lifetime alarm, revert bit 3 of H98 (Select life judgment threshold of CD link bus capacitor) to the default setting (Bit 3 = 0) and conduct the measurement under the condition at the time of factory shipment.

(3) Early warning of lifetime alarm

For the components listed in Table 7.4-2, the inverter can issue an early warning of lifetime alarm LIFE at one of the transistor output terminals [Y1] and [Y2] and Relay output terminals [30A/B/C] as soon as any one of the levels specified in Table 7.4-2 has been exceeded.

The early warning signal is also turned ON when a lock condition on the internal air circulation DC fan (provided on FRN0203E2S-4☐ or above) has been detected.

7.5 Measurement of Electrical Amounts in Main Circuit

Because the voltage and current of the power supply (input, primary circuit) of the main circuit of the inverter and those of the motor (output, secondary circuit) contain harmonic components, the readings may vary with the type of the meter. Use meters indicated in Table 7.5-1 when measuring with meters for commercial frequencies.

The power factor cannot be measured by a commercially available power-factor meter that measures the phase difference between the voltage and current. To obtain the power factor, measure the power, voltage and current on each of the input and output sides and use the following formula.

■ Three-phase input

$$\text{Power factor} = \frac{\text{Electric power (W)}}{\sqrt{3} \times \text{Voltage (V)} \times \text{Current (A)}} \times 100\ \%$$

Table 7.5-1 Meters for Measurement of Main Circuit

Item	Input (primary) side			Output (secondary) side			DC link bus voltage (P(+)-N(-))
Waveform	Voltage	Current		Voltage	Current		
Name of meter	Ammeter AR, AS, AT	Voltmeter VR, VS, VT	Wattmeter WR, WT	Ammeter AU, AV, AW	Voltmeter VU, VV, VW	Wattmeter WU, WW	DC voltmeter V
Type of meter	Moving iron type	Rectifier or moving iron type	Digital AC power meter	Digital AC power meter	Digital AC power meter	Digital AC power meter	Moving coil type
Symbol of meter			—	—	—	—	

Note: It is not recommended that meters other than a digital AC power meter be used for measuring the output voltage or output current since they may cause larger measurement errors or, in the worst case, they may be damaged.

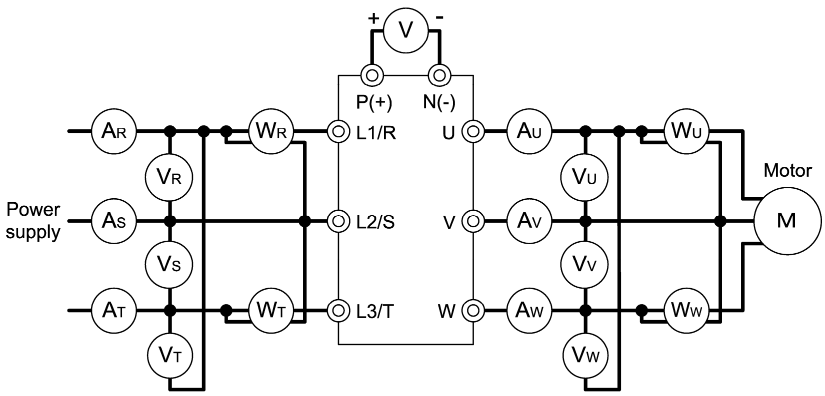


Figure 7.5-1 Connection of Meters

7.6 Insulation Test

Since the inverter has undergone an insulation test before shipment, avoid making a Megger test at the customer's site.

If a Megger test is unavoidable for the main circuit, observe the following instructions; otherwise, the inverter may be damaged.

A withstand voltage test may also damage the inverter if the test procedure is wrong. When the withstand voltage test is necessary, consult your Fuji Electric representative.

(1) Megger test of main circuit

1) Use a 500 VDC Megger and shut off the main power supply without fail before measurement.
2) If the test voltage leaks to the control circuit due to the wiring, disconnect all the wiring from the control circuit.
3) Connect the main circuit terminals with a common line as shown in Figure 7.6-1.
4) The Megger test must be limited to across the common line of the main circuit and the ground (⏚).
5) Value of 5 MΩ or more displayed on the Megger indicates a correct state. (The value is measured on an inverter alone.)

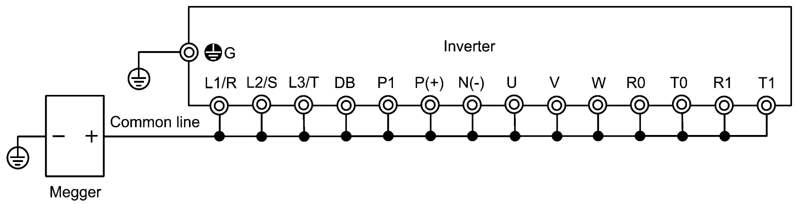


Figure 7.6-1 Main Circuit Terminal Connection for Megger Test

(2) Insulation test of control circuit

Do not make a Megger test or withstand voltage test for the control circuit. Use a high resistance range tester for the control circuit.

1) Disconnect all the external wiring from the control circuit terminals.
2) Perform a continuity test to the ground. One MΩ or a larger measurement indicates a correct state.

(3) Insulation test of external main circuit and sequence control circuit

Disconnect all the wiring connected to the inverter so that the test voltage is not applied to the inverter.

7.7 Inquiries about Product and Guarantee

7.7.1 When making an inquiry

Upon breakage of the product, uncertainties, failure or inquiries, inform your Fuji Electric representative of the following information.

1) Inverter type (Refer to Chapter 1, Section 1.1 "Acceptance Inspection (nameplates and Inverter Type.")
2) SER No. (serial number of equipment) (Refer to Chapter 1, Section 1.1 "Acceptance Inspection (Nameplates and Inverter Type.")
3) Function codes and their data that you changed (Refer to Chapter 3, Section 3.4.2 "Checking changed function codes."
4) ROM version (Refer to the maintenance item 5_14 in Chapter 3, Section 3.4.5 "Reading maintenance information."
5) Date of purchase
6) Inquiries (for example, point and extent of breakage, uncertainties, failure phenomena, and other circumstances)

7.7.2 Product warranty

To all our customers who purchase Fuji Electric products included in this documentation:

Please take the following items into consideration when placing your order.

When requesting an estimate and placing your orders for the products included in these materials, please be aware that any items such as specifications which are not specifically mentioned in the contract, catalog, specifications or other materials will be as mentioned below.

In addition, the products included in these materials are limited in the use they are put to and the place where they can be used, etc., and may require periodic inspection. Please confirm these points with your sales representative or directly with this company.

Furthermore, regarding purchased products and delivered products, we request that you take adequate consideration of the necessity of rapid receiving inspections and of product management and maintenance even before receiving your products.

[1] Free of charge warranty period and warranty range

(1) Free of charge warranty period

1) The product warranty period is "1 year from the date of purchase" or 24 months from the manufacturing date imprinted on the name place, whichever date is earlier.
2) However, in cases where the use environment, conditions of use, use frequency and times used, etc., have an effect on product life, this warranty period may not apply.
3) Furthermore, the warranty period for parts restored by Fuji Electric's Service Department is "6 months from the date that repairs are completed."

(2) Warranty range

1) In the event that breakdown occurs during the product's warranty period which is the responsibility of Fuji Electric, Fuji Electric will replace or repair the part of the product that has broken down free of charge at the place where the product was purchased or where it was delivered. However, if the following cases are applicable, the terms of this warranty may not apply.

① The breakdown was caused by inappropriate conditions, environment, handling or use methods, etc. which are not specified in the catalog, operation manual, specifications or other relevant documents.

② The breakdown was caused by the product other than the purchased or delivered Fuji's product.

③ The breakdown was caused by the product other than Fuji's product, such as the customer's equipment or software design, etc.

④ Concerning the Fuji's programmable products, the breakdown was caused by a program other than a program supplied by this company, or the results from using such a program.

⑤ The breakdown was caused by disassembly, modifications or repairs affected by a party other than Fuji Electric.

⑥ The breakdown was caused by improper maintenance or replacement using consumables, etc. specified in the operation manual or catalog, etc.

⑦ The breakdown was caused by a science or technical problem that was not foreseen when making practical application of the product at the time it was purchased or delivered.

⑧ The product was not used in the manner the product was originally intended to be used.

⑨ The breakdown was caused by a reason which is not this company's responsibility, such as lightning or other disaster.

2) Furthermore, the warranty specified herein shall be limited to the purchased or delivered product alone.

3) The upper limit for the warranty range shall be as specified in item (1) above and any damages (damage to or loss of machinery or equipment, or lost profits from the same, etc.) consequent to or resulting from breakdown of the purchased or delivered product shall be excluded from coverage by this warranty.

(3) Trouble diagnosis

As a rule, the customer is requested to carry out a preliminary trouble diagnosis. However, at the customer's request, this company or its service network can perform the trouble diagnosis on a chargeable basis. In this case, the customer is asked to assume the burden for charges levied in accordance with this company's fee schedule.

[2] Exclusion of liability for loss of opportunity, etc.

Regardless of whether a breakdown occurs during or after the free of charge warranty period, this company shall not be liable for any loss of opportunity, loss of profits, or damages arising from special circumstances, secondary damages, accident compensation to another company, or damages to products other than this company's products, whether foreseen or not by this company, which this company is not be responsible for causing.

[3] Repair period after production stop, spare parts supply period (holding period)

Concerning models (products) which have gone out of production, this company will perform repairs for a period of 7 years after production stop, counting from the month and year when the production stop occurs. In addition, we will continue to supply the spare parts required for repairs for a period of 7 years, counting from the month and year when the production stop occurs. However, if it is estimated that the life cycle of certain electronic and other parts is short and it will be difficult to procure or produce those parts, there may be cases where it is difficult to provide repairs or supply spare parts even within this 7-year period. For details, please confirm at our company's business office or our service office.

[4] Transfer rights

In the case of standard products which do not include settings or adjustments in an application program, the products shall be transported to and transferred to the customer and this company shall not be responsible for local adjustments or trial operation.

[5] Service contents

The cost of purchased and delivered products does not include the cost of dispatching engineers or service costs. Depending on the request, these can be discussed separately.

[6] Applicable scope of service

Above contents shall be assumed to apply to transactions and use of the country where you purchased the products.

Consult the local supplier or Fuji for the detail separately.

Chapter 8
BLOCK DIAGRAMS FOR CONTROL LOGIC

This chapter describes the main block diagrams of the control section.

Contents

Chapter 8 BLOCK DIAGRAMS FOR COTNROL LOGIC

The high-performance and compact inverter FRENIC-Ace is provided with various functions for enabling operations that meet purposes. Refer to “Chapter 5 FUNCTION CODES” for details of each function code.

Function codes are mutually related and priority order is given depending on the function codes and data thereof.

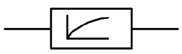
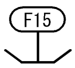
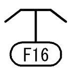
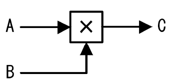
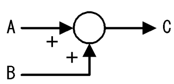
This chapter shows major internal control block diagrams. Understand the diagrams together with the explanation of each function code to correctly set up each function code.

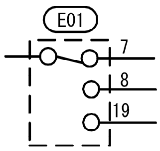
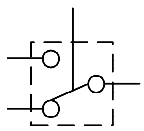
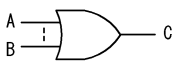
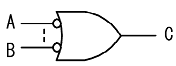
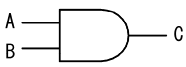
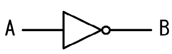
Note that the internal control block diagrams show only the function codes mutually related. Refer to “Chapter 5 FUNCTION CODES” for function codes operated individually and each function code explanation.

8.1 Meanings of symbols used in the control block diagrams

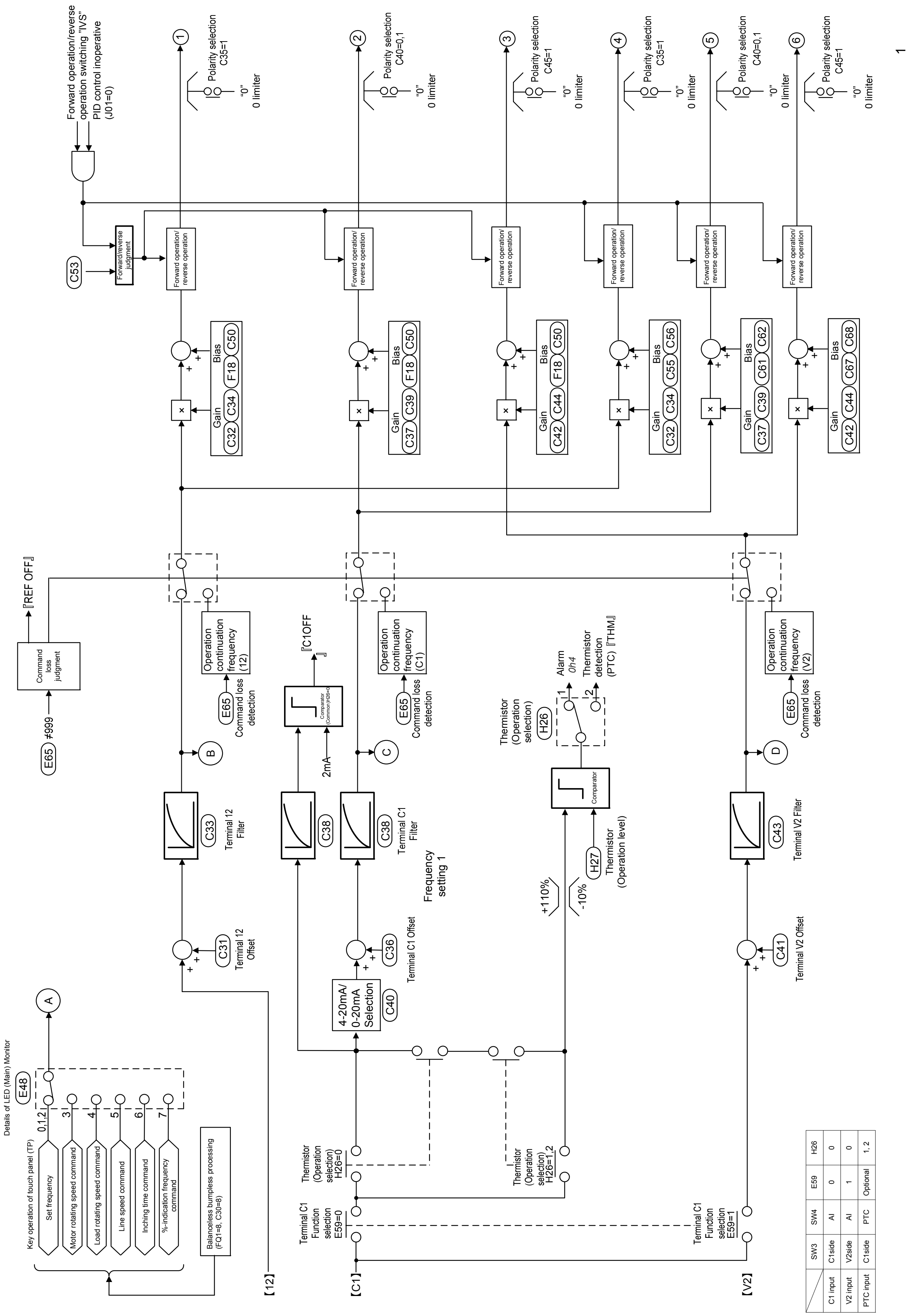
This section explains major codes, with examples, used in the block diagrams from the next item.

Table 8.1-1 Codes and Meanings

Symbol	Meaning
[FWD], [Y1], etc.	These symbols denote general-purpose input/output terminals of the inverter control circuit terminal blocks.
“FWD”, “REV”, etc.	These symbols denote control signals (input) or state signals (output) allocated to the control circuit terminals.
	This is low-pass filter. Time constant is changeable based on function code data.
SET FREQUENCY	This symbol denotes control command used inside the inverter.
	This indicates upper limit limiter. This limits an upper limit value by function code setting or a constant.
	This indicates lower limit limiter. This limits a lower limit value by function code setting or a constant.
 “0”	This is 0 (zero) limiter. This prevents data from becoming minus.
	This denotes a set frequency given by a current or a voltage. This is a gain analog multiplier for an analog output signal etc., calculated by C=A×B.
	This denotes an adder of two signals or amounts, calculated by C=A+B. This becomes a subtracter when B is a minus sign, calculated by C=A-B.

Symbol	Meaning
F01	This denotes a function code.
	This indicates a switch controlled by a function code. Figures of switch terminals indicate function code data.
LINK OPERATION SELECTION “LE” 	This indicates a switch controlled by an internal function control command. An example at left indicates a link operation selection command “LE” allocated to a digital input terminal.
	This denotes a logical sum (OR) circuit. In the case of the positive logic, when any one of inputs is ON, C=ON, and when all inputs are OFF, C=OFF.
	This denotes an NOR (NOR-OR) circuit. In the case of the positive logic, when any one of inputs is OFF, C=ON, and when all inputs are ON, C=OFF.
	This denotes a conjunction (AND) circuit. In the case of the positive logic, only when A=ON and B=ON, C=ON, and C=OFF under other conditions.
	This denotes a logical negation (NOT) circuit. In the case of the positive logic, when A=ON, B=OFF, and when A=OFF, B=ON.

8.2 Frequency setting section



	SW3	SW4	E59	H26
C1 input	C1side	AI	0	0
V2 input	V2side	AI	1	0
PTC input	C1side	PTC	Optional	1, 2

Fig. 8.2-1Frequency setting section block diagram

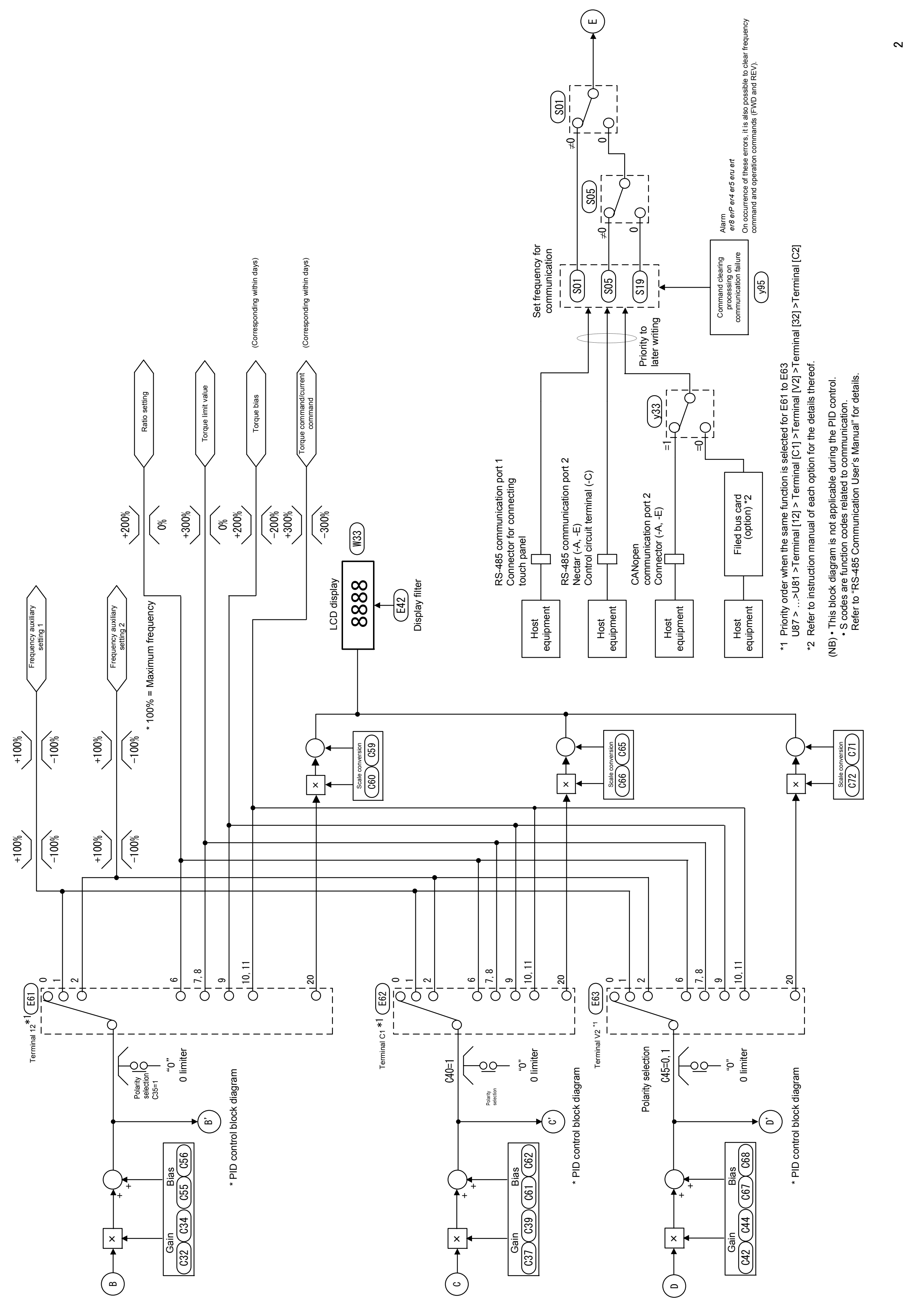


Fig. 8.2-2 Frequency setting section block diagram

Chap. 8 CONTROL BLOCK DIAGRAMS

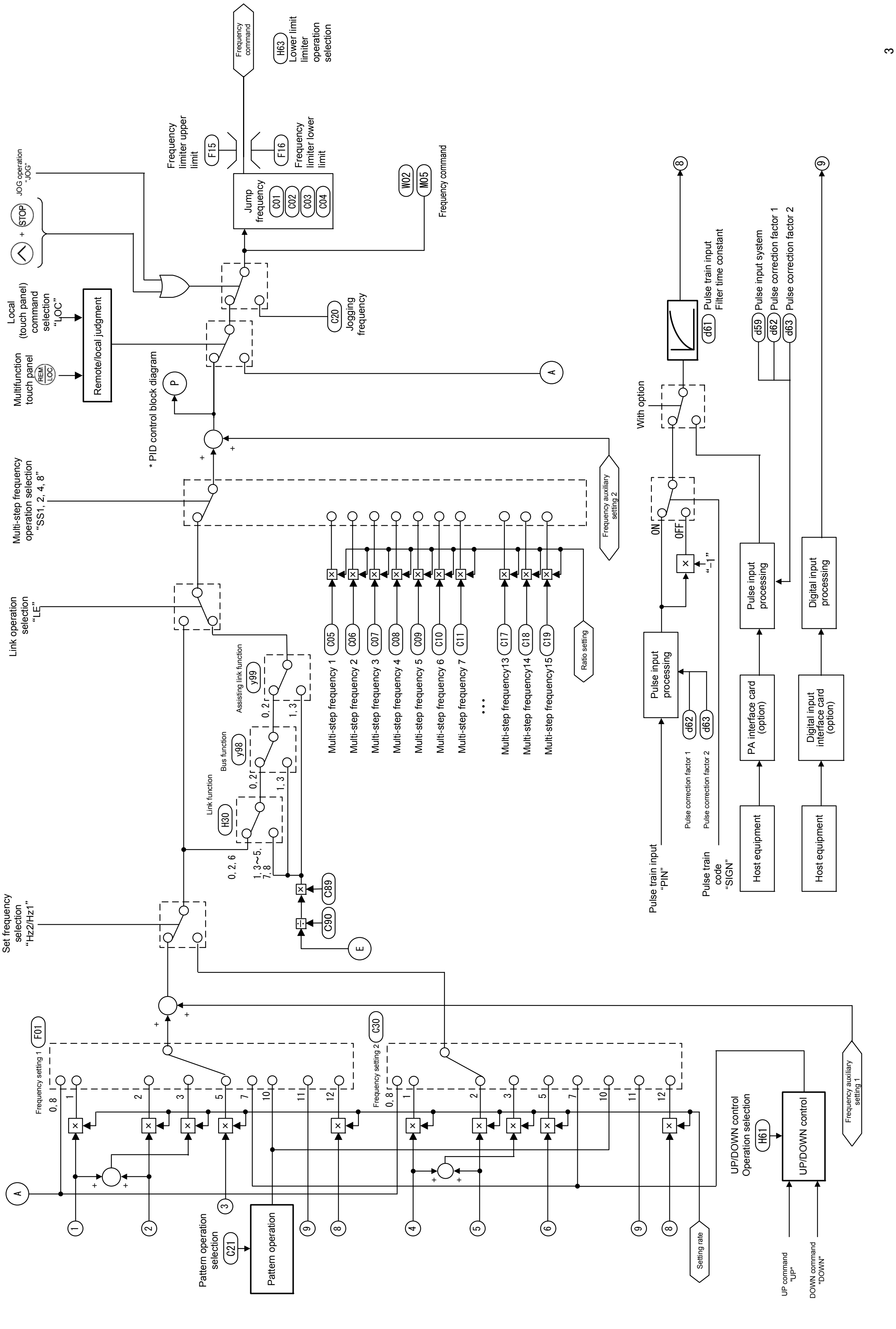
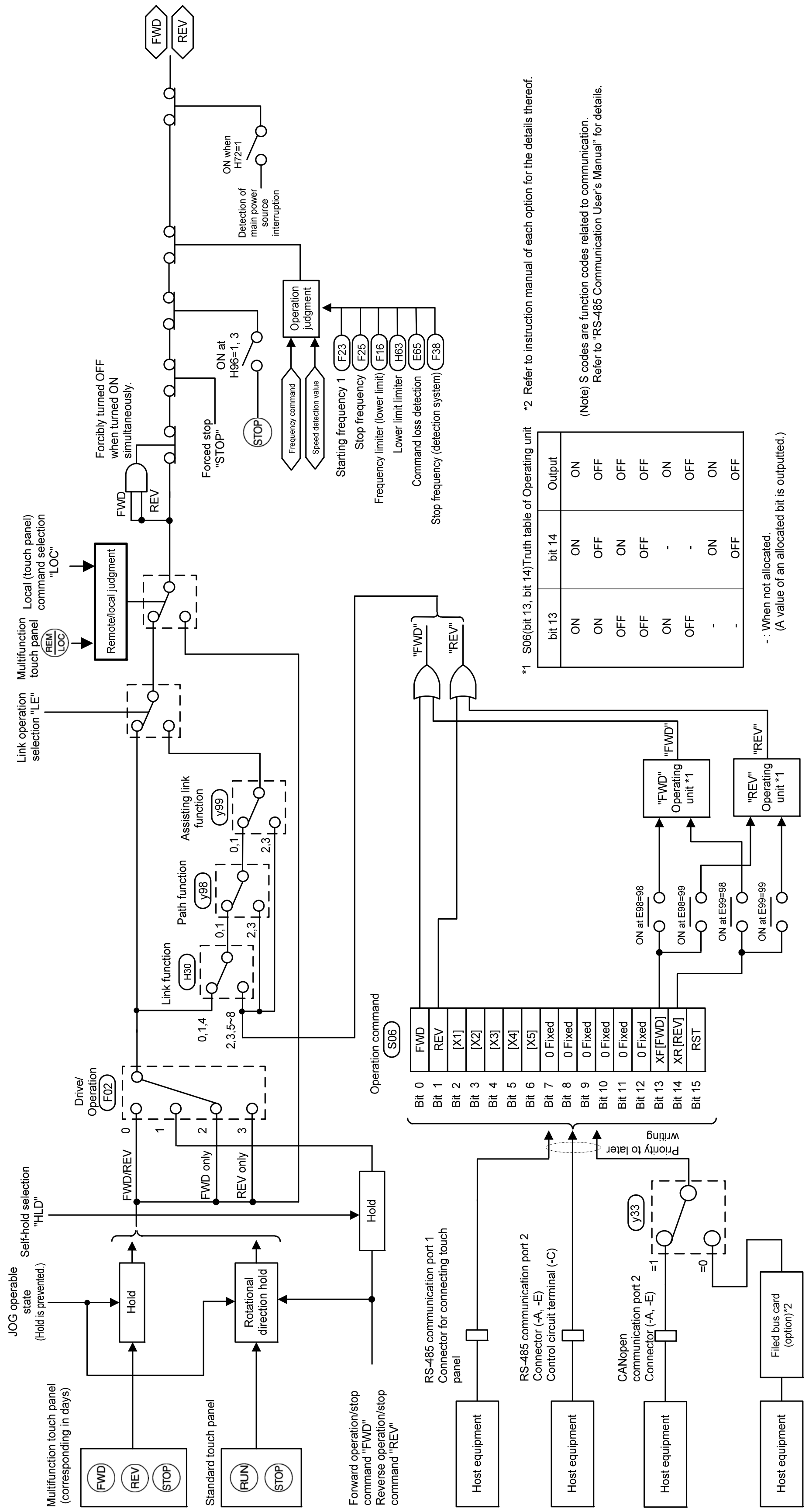


Fig. 8.2-3 Frequency setting section block diagram

8.3 Operation command section



bit 13	bit 14	Output
ON	ON	ON
ON	OFF	OFF
OFF	ON	OFF
OFF	OFF	OFF
ON	-	ON
OFF	-	OFF
-	ON	ON
-	OFF	OFF

Fig. 8.3-1 Operation command section block diagram

CONTROL BLOCK DIAGRAMS

Chap. 8

8.4 PID Control Section (for Processing)

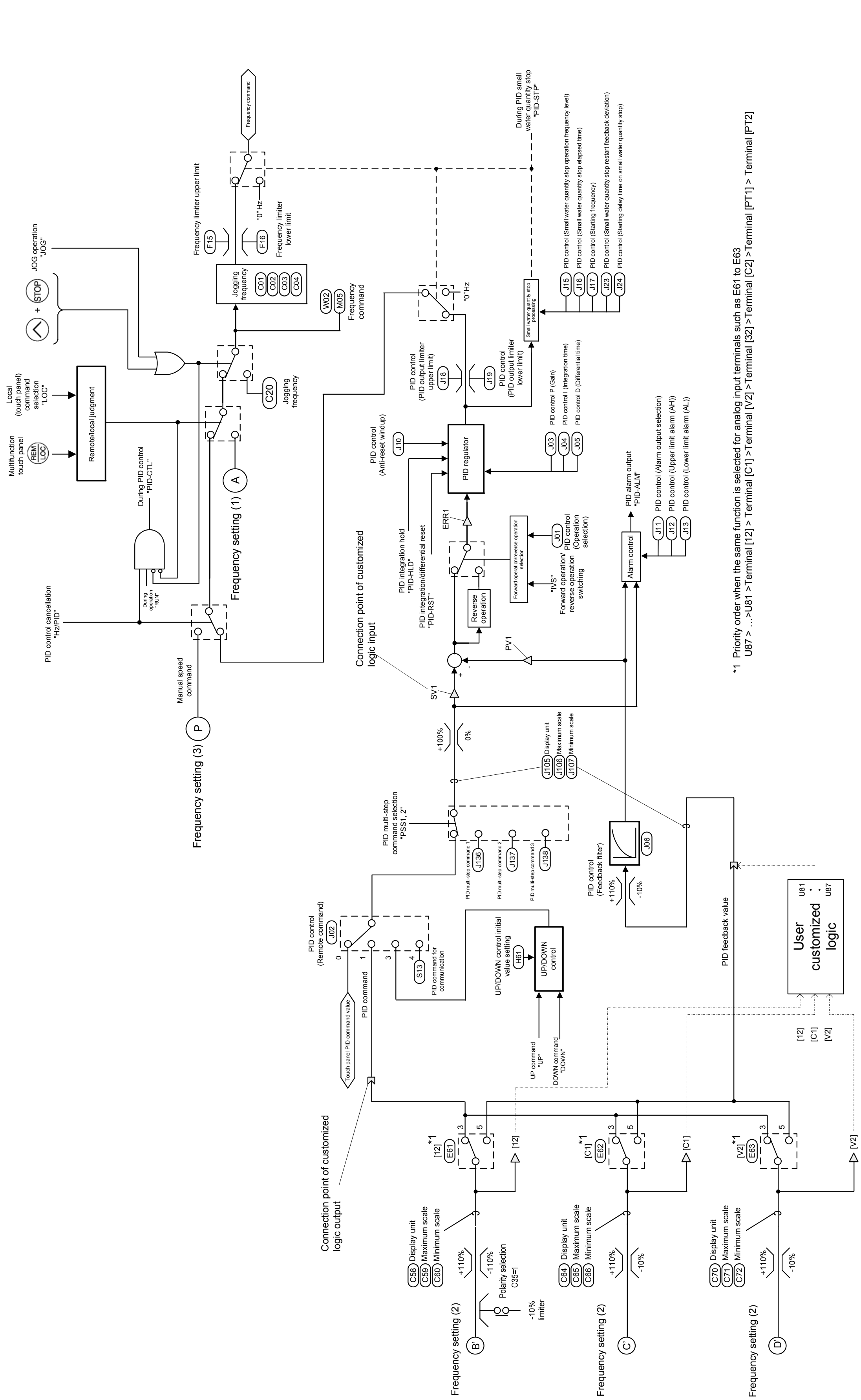


Fig. 8.4-1 PID control section (for processing) block diagram

8.5 PID Control Section (for Dancer)

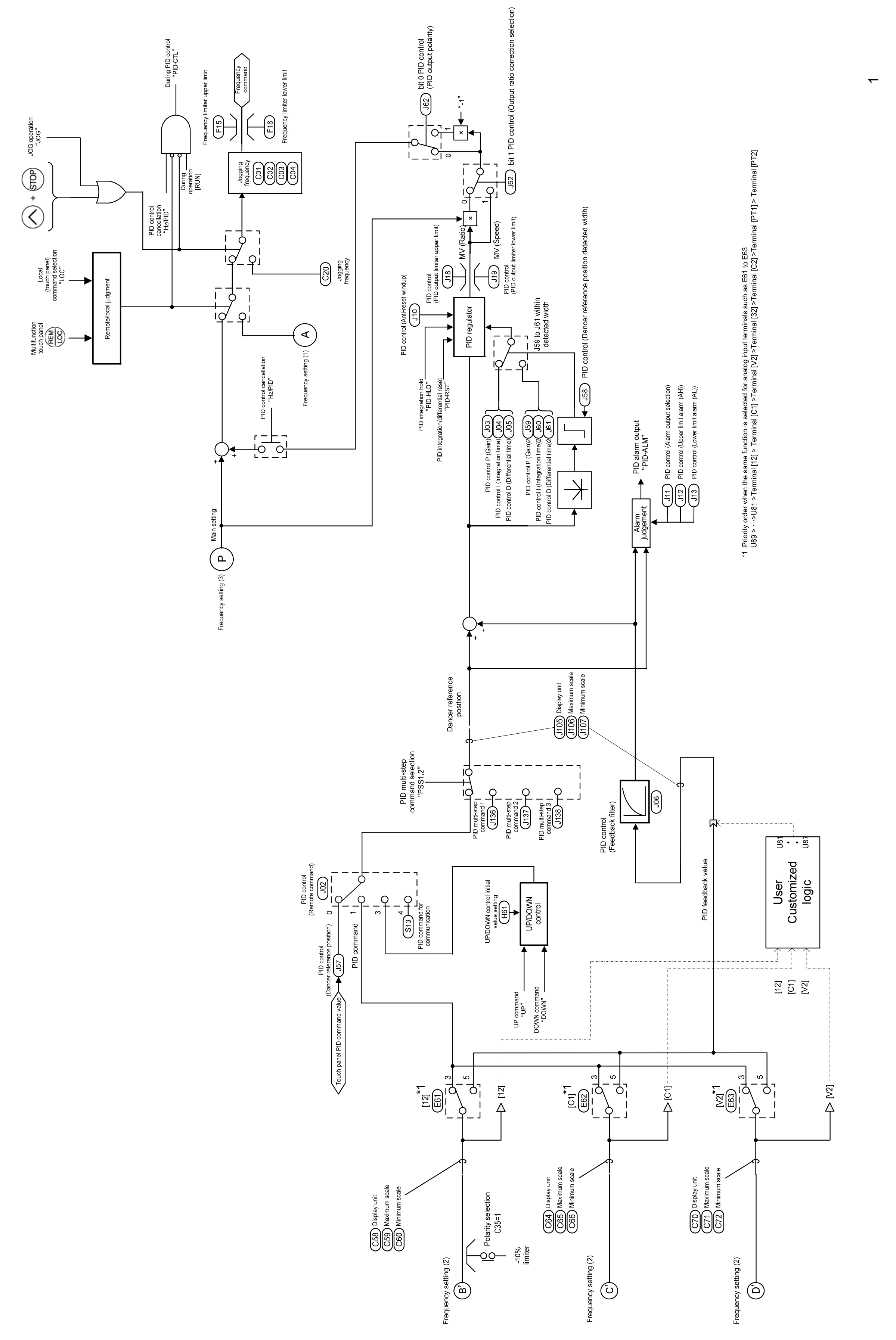


Fig. 8.5-1 PID control section (for dancer) block diagram

8.6 Control Section

8.6.1 V/f Control

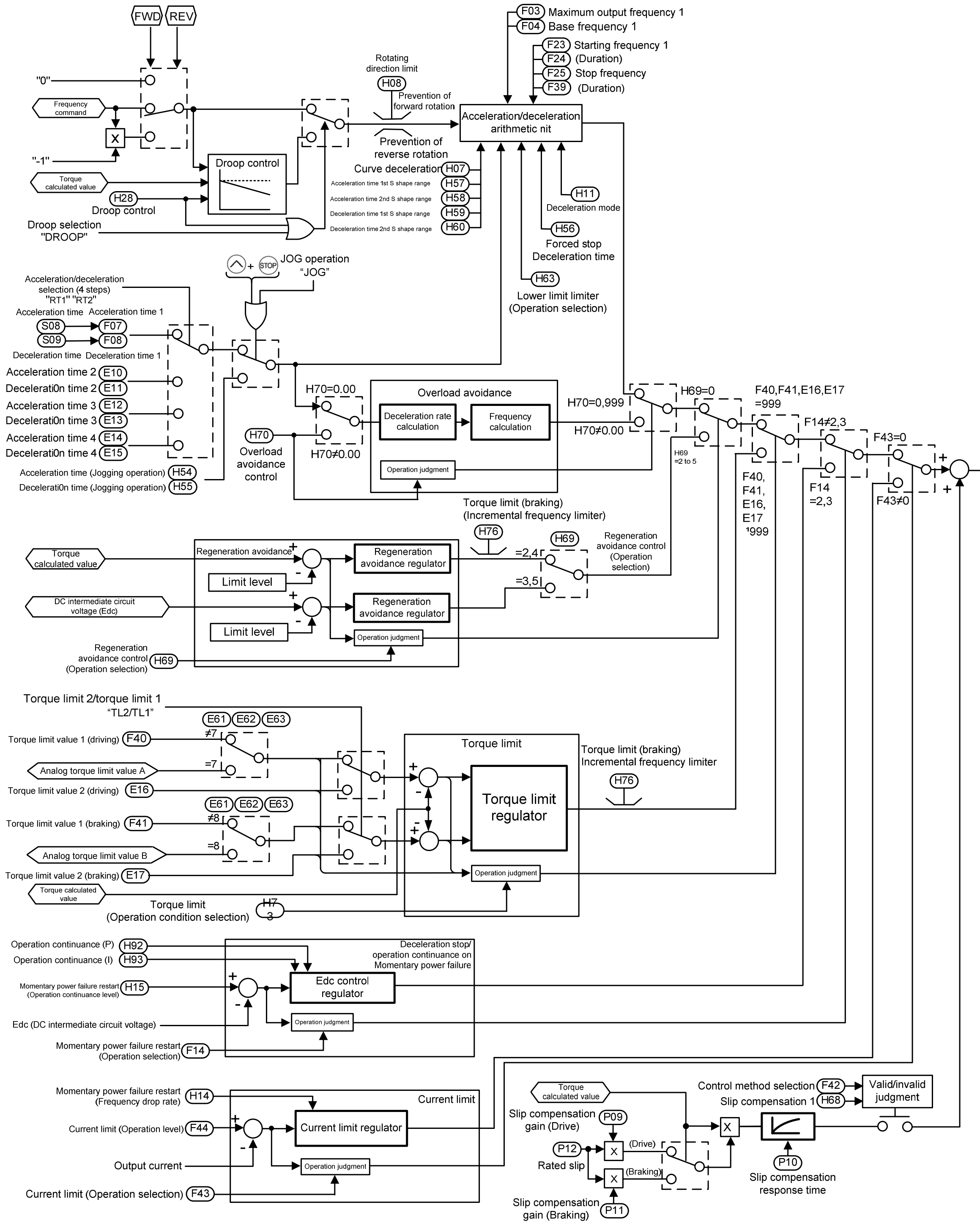


Fig. 8.6-1 V/f control section block diagram

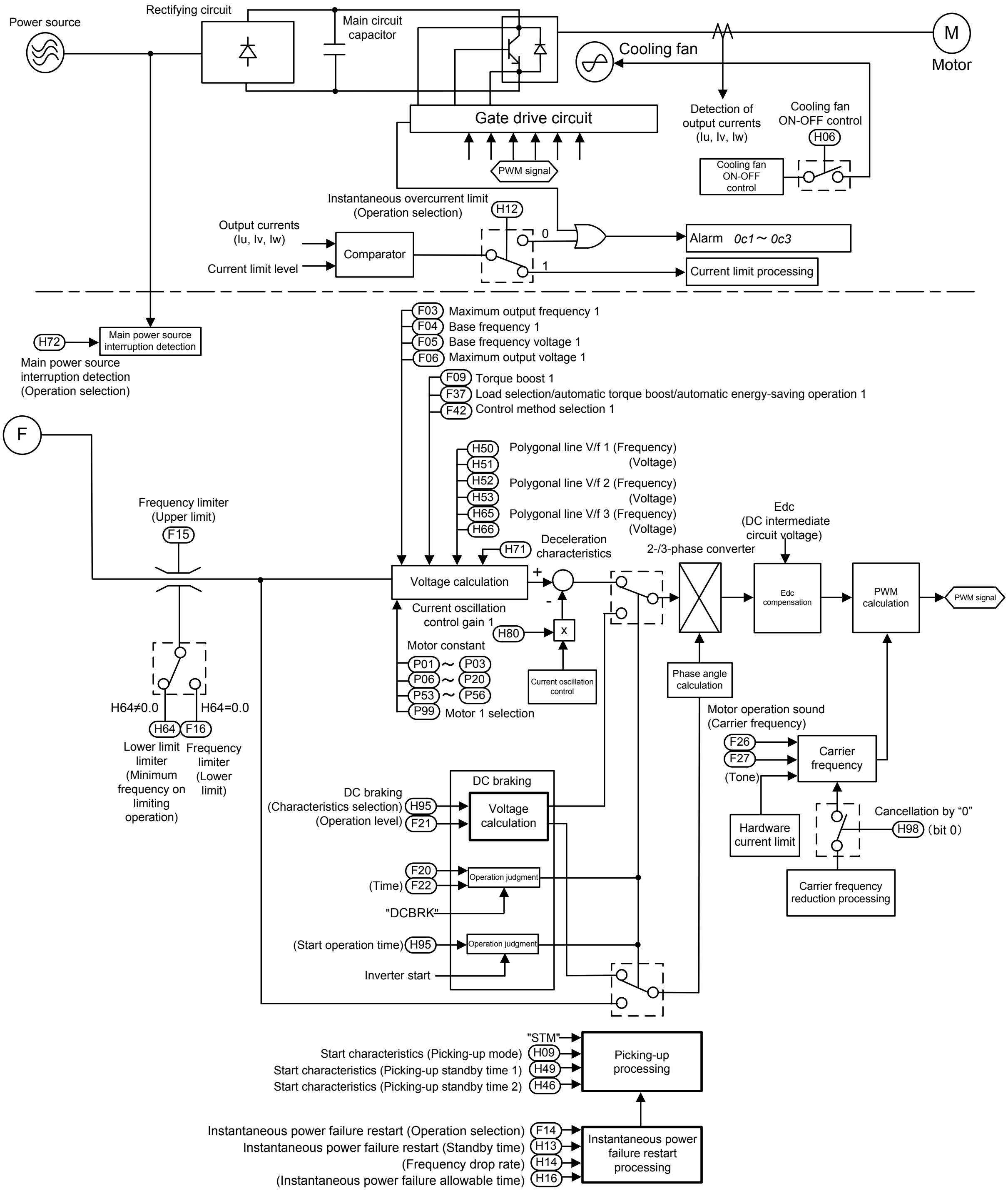


Fig. 8.6-2 V/f control section block diagram

CONTROL BLOCK DIAGRAMS

Chap. 8

8.7 FM Output Section

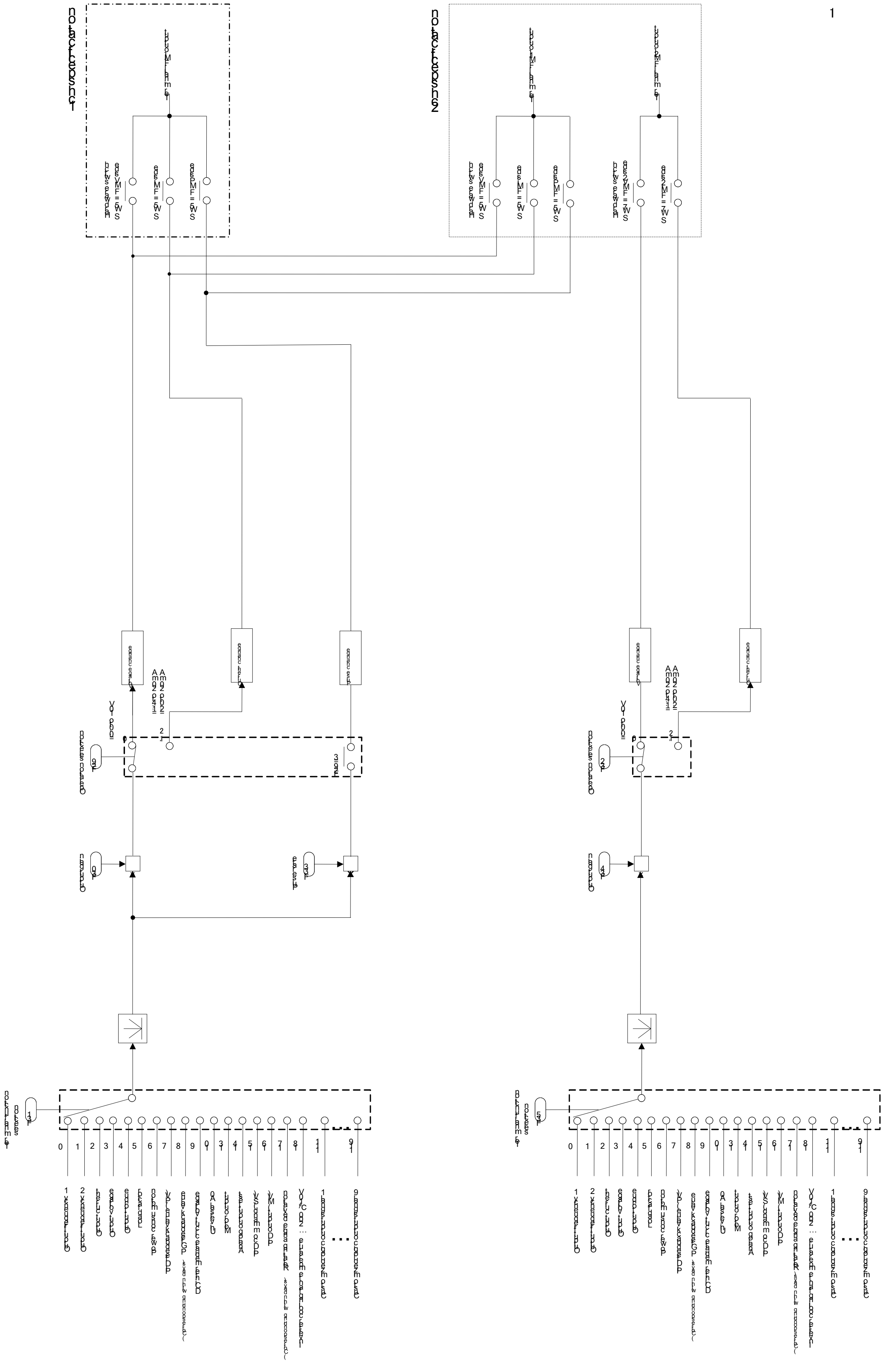


Fig. 8.7-1 FM output section block diagram

Chapter 9
COMMUNICATION FUNCTIONS

This chapter describes an overview of inverter operation through the RS-485 and CANopen communications.
For details of RS-485 communication, refer to the RS-485 Communication User's Manual.

Contents

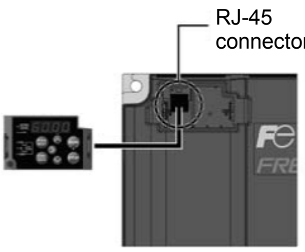
Chapter 9 COMMUNICATION FUNCTIONS

9.1 Overview of RS-485 Communication

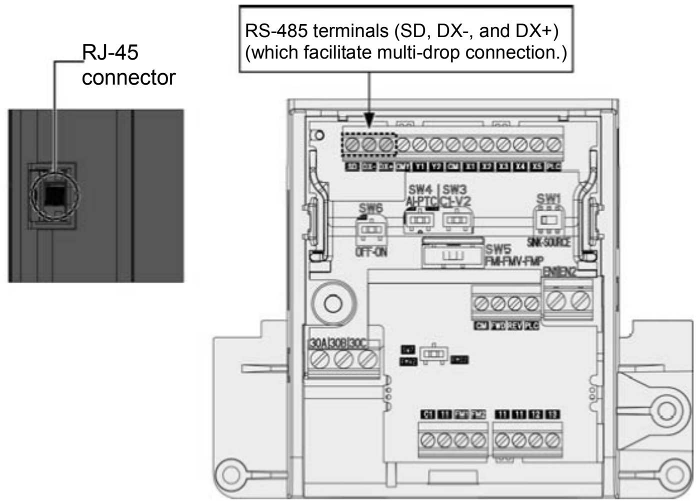
The FRENIC-Ace has two RS-485 communication ports at the locations shown below.

(i) Communication port 1: RJ-45 connector for the keypad (modular jack)

(ii) Communication port 2: RJ-45 connector for RS-485 communication (modular jack) * only for FRN-E2S-4A, E, RS-485 terminals (control circuit terminals SD, DX-, DX+) * only for FRN-E2S-4C



COM port 1



COM port 2

Using the RS-485 communication ports shown above enables the extended functions listed below.

- Remote operation from a keypad at the remote location (COM port 1)

  The standard keypad enables remote operation by mounting the keypad on a remote panel and connecting the keypad to RJ-45 connector with an extension cable. (maximum cable length: 20 m)

- Operation by FRENIC loader (COM ports 1, 2)

  It is possible to edit and monitor the function codes by connecting the RJ-45 connector (RS-485 communication) in the inverter and PC and using the inverter support loader (FRENIC Loader, see "8.2 Overview of FRENIC Loader").

- Control via host equipment (COM ports 1 and 2)

  Connecting the inverter to the host equipment (upper controller), such as a computer and programmable controller (PLC), enables to control the inverter as a subordinate device.

  Besides the communication port 1 (RJ-45 connector) shared with the keypad, the FRENIC-Ace has the RS-485 communication port 2 by default.

  The protocols for controlling inverters support the Modbus RTU protocol (compliant to the protocol established by Modicon Inc.) that is widely used and the Fuji Electric's general-purpose inverter protocol that is common to Fuji Electric's inverters including conventional series.

Note
- Connecting the keypad to the COM port 1 automatically switches to the keypad protocol; there is no need to modify the function code setting.
- When using FRENIC Loader, which requires a special protocol for handling Loader commands, you need to set up some communication function codes accordingly.

  For details, refer to the FRENIC Loader Instruction Manual.

For details of RS-485 communication, refer to the RS-485 Communication User's Manual.

9.1.1 RS-485 common modes

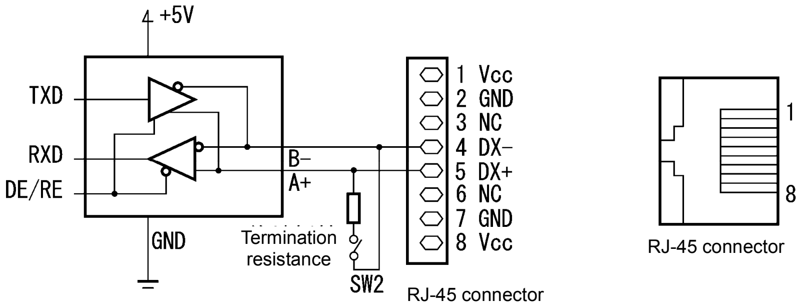
Item	Modes		
Protocol	FGI-BUS	Modbus RTU	FRENIC Loader (support only for standard)
Compliance	Fuji general-purpose inverter protocol	Modicon Modbus RTU-compliant (only in RTU mode)	Dedicated protocol (Not disclosed)
Connection quantity	Host device: 1, Inverters: Up to 31		
Electrical mode	EIA RS-485		
Connection to RS-485	RJ-45 connector or terminal block		
Synchronization	Asynchronous		
Communication system	Half-duplex		
Transmission speed (bps)	2400, 4800, 9600, 19200 and 38400 bps		
Max. transmission cable length	500 m		
Station No.	1 to 31	1 to 247	1 to 255
Message frame format	FGI-BUS	Modbus RTU	FRENIC Loader
Frame synchronization	Header character detection (SOH)	Detection of no-data time (for 3 characters period)	Header character detection (Start code: 96_H)
Frame length	Normal transmission:16 bytes (fixed) High-speed transmission:8 or 12 bytes	Variable length	Variable length
Max. transfer data	Write: 1 word Read: 1 word	Write: 50 words Read: 50 words	Write: 41 words Read: 41 words
Messaging system	Polling/Selecting/Broadcast		Command message
Transmission character format	ASCII	Binary	Binary
Character length	8 or 7 bit Selectable with the function code	8 bits (fixed)	8 bits (fixed)
Parity	Even, Odd, or None (selectable by the function code)		Even (fixed)
Stop bit length	1 or 2 bit Selectable with the function code	Parity none: 2/1 bit Parity: 1 bit Select by parity setting.	1 bits (fixed)
Error checking	Sum-check	CRC-16	Sum-check

9.1.2 Terminal mode

[1] RS-485 communication port 1 (for connecting the keypad) mode

The port designed for a standard keypad uses an RJ-45 connector having the following pin assignment:

Pin	Signal name	Description
1	Vcc	Power source for the keypad (5 V)
2	GND	Ground signal
3	NC	Not connected
4	DX-	RS-485 signal, low side *2
5	DX+	RS-485 signal, high side *2
6	NC	Not connected
7	GND	Ground signal
8	Vcc	Power source for the keypad (5 V)



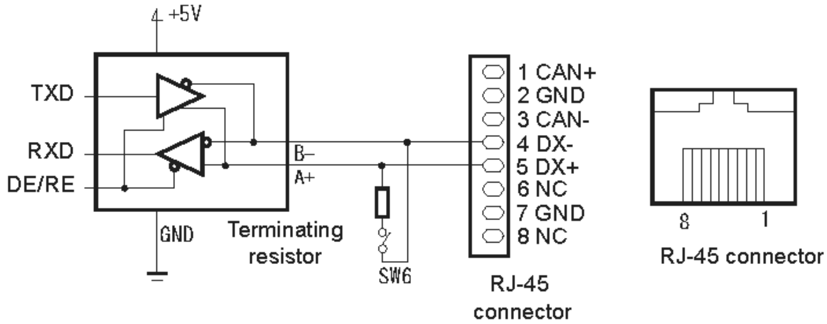
* The terminating resistance 112 Ω is built in. Open/close with SW2. *
For details about SW6, refer to Chapter 2, "2.4.2 Setting up the slide switches."

Note: The power supply for keypad is connected to the RJ-45 connector for RS-485 communication (Pins 1, 2, 7, and 8). When connecting other devices to the RJ-45 connector, take care not to use those pins. Use pins **4 and 5 only**.

[2] RS-485 communication port 2 mode (only for FRN-E2S-4A, E)

The port designed for a standard keypad uses an RJ-45 connector having the following pin assignment:

Pin	Signal name	Description
1	CAN+	CAN signal, high side
2	GND	Ground signal
3	CAN-	CAN signal, low side
4	DX-	RS-485 signal, low side
5	DX+	RS-485 signal, high side
6	NC	Not connected
7	GND	Ground signal
8	NC	Not connected

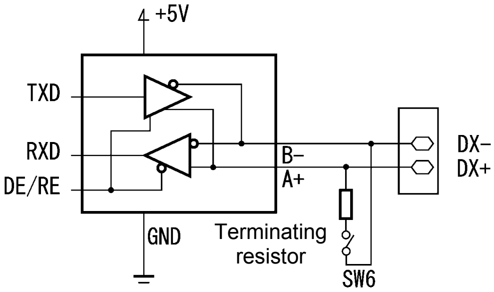


* The terminating resistance 112 Ω is built in. Open/close with SW2. *
For details about SW6, refer to Chapter 2, "2.4.2 Setting up the slide switches."

[3] RS-485 communication port 2 (terminal block) mode (only for FRN-E2S-4C)

The FRENIC-Ace has terminals for RS-485 communication in the control circuit terminal. The details of each terminal are shown below.

Terminal symbol	Description	Remarks
SD	Shield terminal	
DX-	RS-485 signal, low side	Built-in terminating resistor: 112 Ω Open/close with SW2*
DX+	RS-485 signal, high side	



* The terminating resistance 112 Ω is built in. Open/close with SW2. *
For details about SW6, refer to Chapter 2, “2.4.2 Setting up the slide switches.”

9.1.3 Connection method

- Up to 31 inverters can be connected to one host equipment.
- The protocol is commonly used in the FRENIC series of general-purpose inverters, so programs for similar host equipment can run/stop the inverter.
  (The parameters modes may differ depending on the equipment.)
- Fixed-length transmission frames facilitate developing communication control programs for hosts.

For details of RS-485 communication, refer to the RS-485 Communication User's Manual (MEH448).

Multi-drop connection using the RS-485 communication port 1 (for connecting the keypad)

For connecting inverters in multi-drop connection, use the branch adapters for multi-drop connection as shown below.

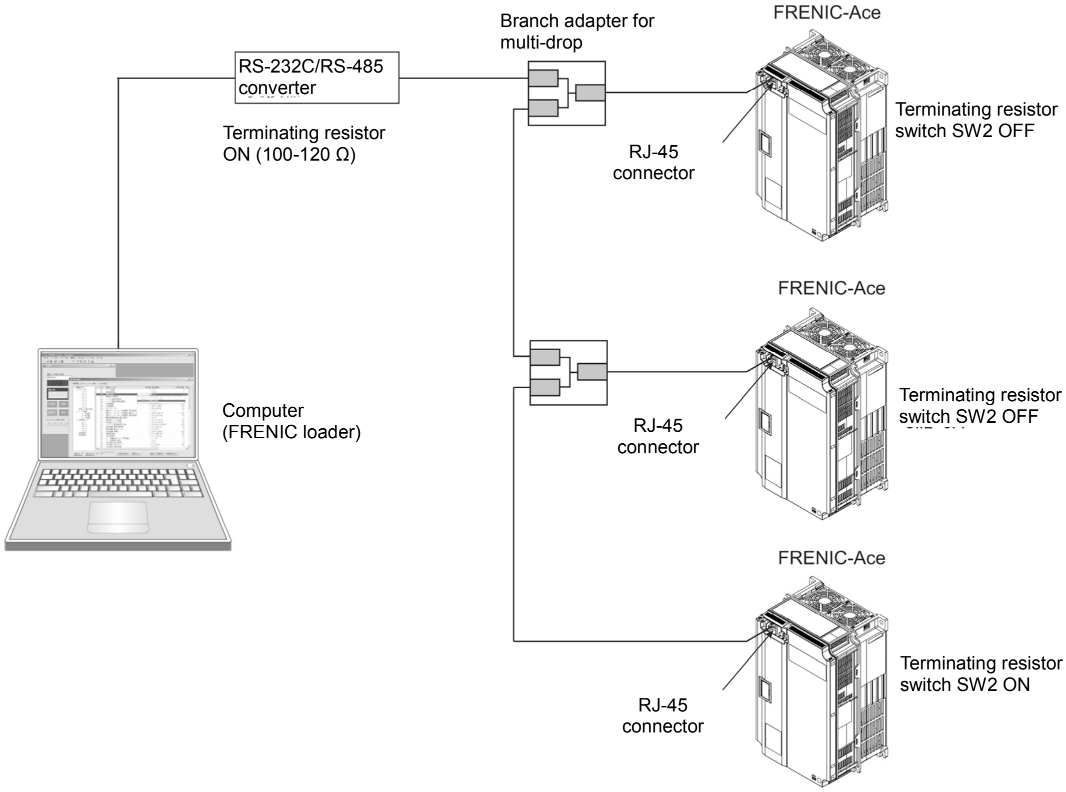


Figure 9.1.3-1 Multi-drop connection for RS-485 communication port 1 (using the RJ-45 connector)

Note
- The power supply for keypad is connected to the RJ-45 connector for RS-485 communication (COM port 1) (pins 1, 2, 7 and 8). When connecting other devices to the RJ-45 connector, take care not to use those pins. Use pins **4 and 5 only**. (refer to 9.1.2 Terminal mode for RS-485 communication)
- When selecting additional devices to prevent the damage or malfunction of the control PCB caused by external noises or eliminate the influence of common mode noises, be sure to see the Section "9.1.4 RS-485 connection devices."
- The maximum wiring length must be 500 m.
- Use the cables and converters meeting the modes for connecting the RS-485 communication ports. (Refer to [2] "Requirements for the cable (COM port 1: for RJ-45 connector)" in the Section 9.1.4 "RS-485 connection devices")

Multi-drop connection using the RS-485 communication port 2 (RJ-45 connector) (only for FRN-E2S-4A, E)

For connecting inverters in multi-drop connection, use the branch adapters for multi-drop connection as shown below.

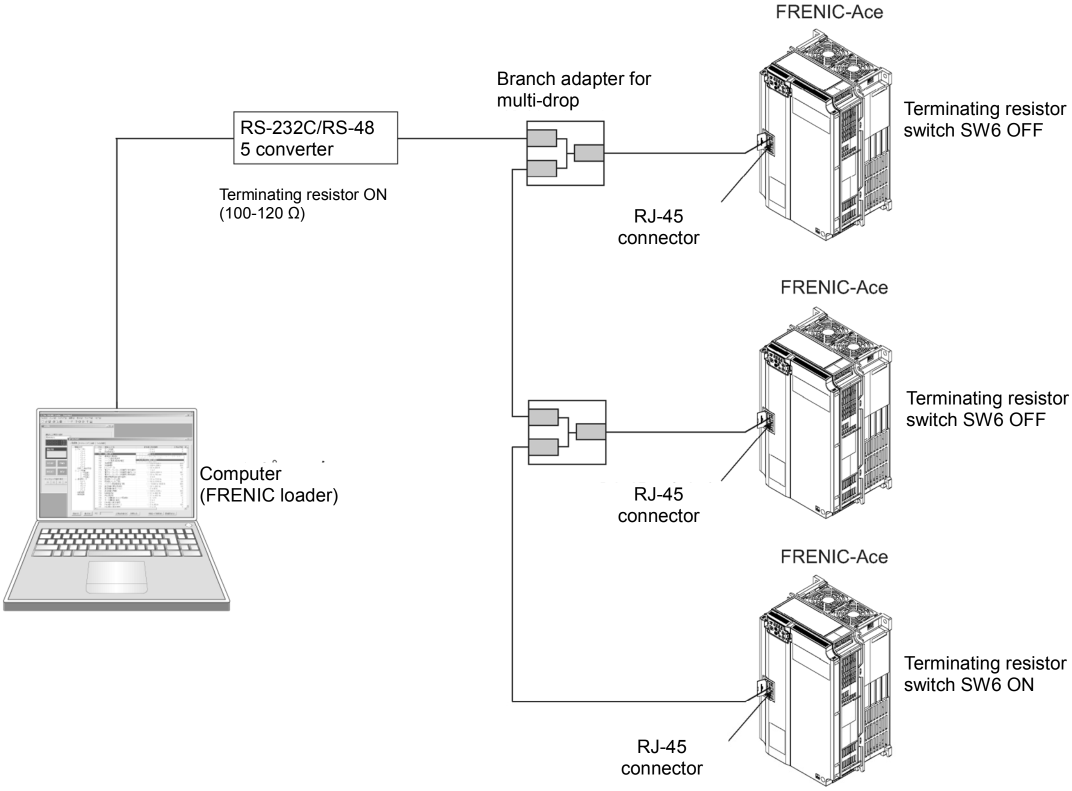


Figure 9.1.3-2 Multi-drop connection for RS-485 communication port 2 (using the RJ-45 connector)

Note

Use the cables and converters meeting the modes for connecting the RS-485 communication ports.
(Refer to [3] “Requirements for the cable (COM port 2: for RJ-45 connector)” in the Section 9.1.4 “RS-485 connection devices”)

COMMUNICATION FUNCTIONS

Chap.9

Multi-drop connection using the RS-485 communication port 2 (on the terminal block) (only for FRN-E2S-4C)

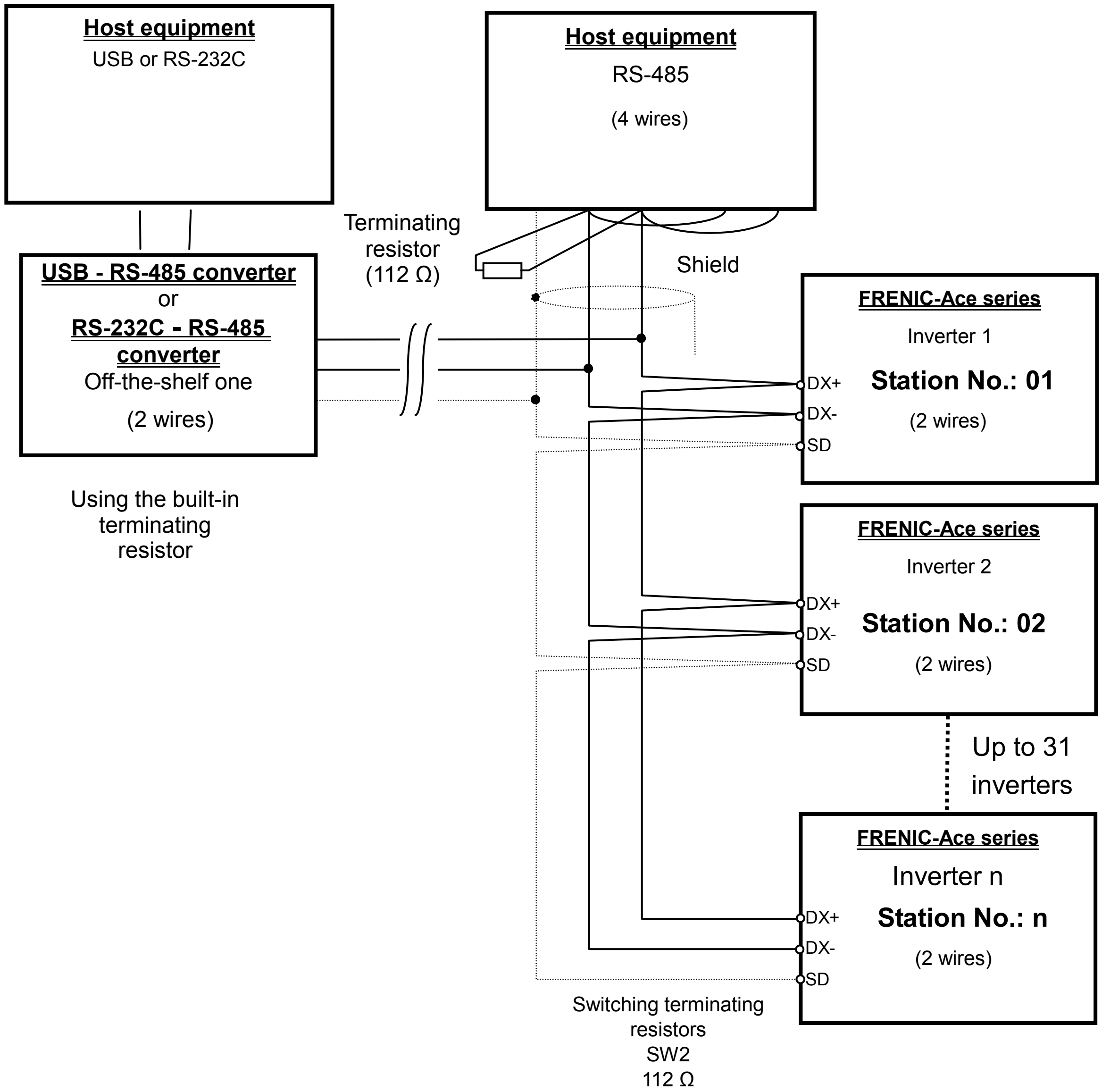


Figure 9.1.3-3 Multi-drop connection diagram (connecting to the terminal block)

Note: Use the cables and converters meeting the modes for connecting the RS-485 communication ports.
(Refer to [3] “Requirements for the cable (COM port 2: for RJ-45 connector)” in the Section 9.1.4 “RS-485 connection devices”)

9.1.4 RS-485 connection devices

This section describes the devices required for connecting the inverter to a PC having no RS-485 interface or for connecting two or more inverters in multi-drop network.

[1] Converter

In general, PC is not equipped with an RS-485 port. Therefore, an RS-232C–RS-485 or USB–RS-485 converter is required. To use the equipment properly, be sure to use the converter which meets the mode below. Be careful that a converter not recommended may not work properly.

Requirements for recommended converters

Send/receive switching system:	Auto-switching by monitoring the transmission data at PC (RS-232C)
Electric isolation:	Electrically isolated from the RS-485 port
Fail-safe:	Fail-safe facility (*)
Other requirements:	Superior noise immunity

Note: The fail-safe function refers to a feature that ensures the RS-485 receiver's output is at “logic high” even if the RS-485 receiver's input is opened or short-circuited or all the RS-485 drivers are inactive. (Refer to Figure 8.3 “Communication level conversion”.)

Recommended converters

System Sacom Sales Corporation (Japan) : KS-485PTI (RS-232C-RS-485 converter)
: USB-485I RJ45-T4P (USB-RS-485 converter)

Send/receive switching system

The RS-485 communication system of the inverter acts in half-duplex mode (2-wire), so the converter must have a send/receive switching function. Generally, the switching system may be either one of the followings.

(1) Auto-switching by monitoring the transmitted data
(2) Switching by RS-232C control signal (RTS or DTR) from the computer

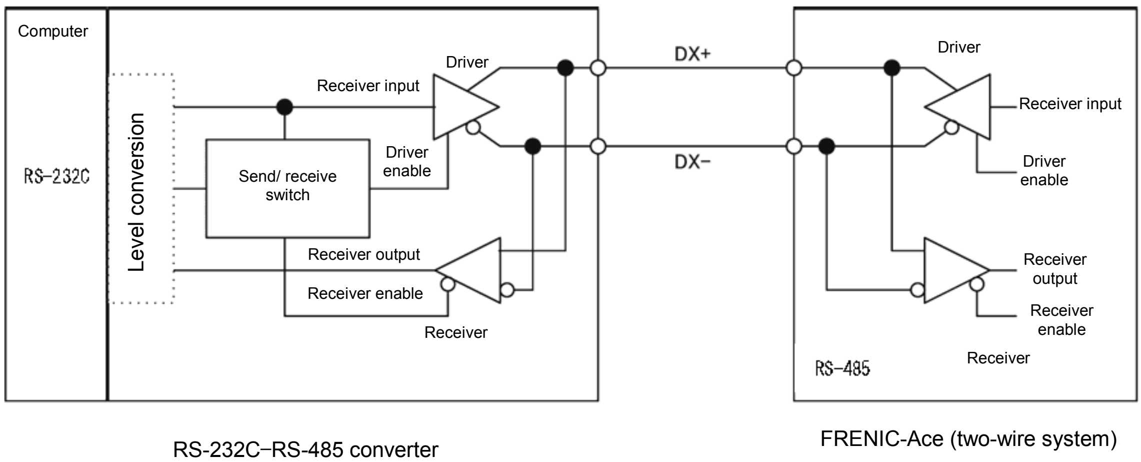


Figure 9.1.4-1 Communication level conversion

[2] Requirements for the cable (COM port 1: for RJ-45 connector)

Use a standard 10BASE-T/100BASE-TX LAN cable (US ANSI/TIA/EIA-568A category 5 compliant, straight cable).

Note: The power supply for keypad is connected to the RJ-45 connector for RS-485 communication (COM port 1) (pins 1, 2, 7 and 8). When connecting other devices to the RJ-45 connector, take care not to use those pins. Use pins **4 and 5 only**.

[3] Requirements for the cable (COM port 2: for RS-485 connector)

To ensure the reliability of connection, use twisted pair shield cables for long distance transmission AWG 16 to 26.

Recommended LAN cable manufacturer: FURUKAWA Electric Co., LTD AWM2789 cable for long distance connection

Type (Product code): DC23225-2PB

[4] Branch adapter for multi-drop

The RJ-45 connector is used as the communication connector. To use a standard LAN cable for multi-drop connection, use the branch adapter for the RJ-45 connector.

Recommended branch adapter

SK Koki (Japan): MS8-BA-JJJ

9.1.5 RS-485 noise suppression

Depending on the operating environment, the malfunction may occur due to the noise generated by the inverter. Possible measures to prevent such malfunction are: separating the wiring, use of shielded cable, isolating the power supply, and adding an inductance component. The description shown below is an example of adding an inductance.

Refer to the RS-485 Communication User's Manual, Chapter 2, Section 2.2.4 “Noise suppression” for details.

Adding inductance components

Keep the impedance of the signal circuit high against the high-frequency noises by inserting an inductance component, such as by inserting a choke coil in series or passing the signal line through a ferrite core.

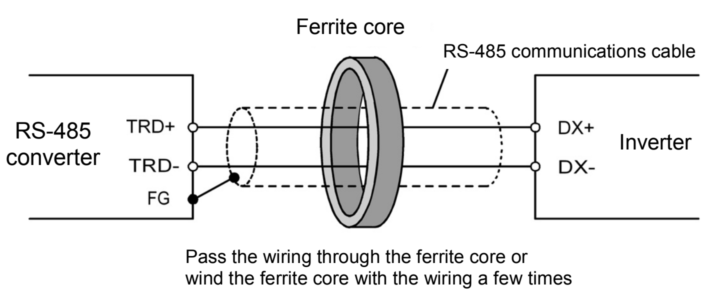


Figure 9.1.5-1 Adding an inductance component

9.2 CANopen communication

9.2.1 Modes

The Table 9.2.1-1 lists the CANopen mode. The CANopen mode will apply to the items not contained in the table below.

Table 9.2.1-1 CANopen mode

Item	Modes	Remarks
Physical layer	CAN (ISO11898) (High speed)	
Node ID	1 to 127	Sets the inverter function code y21 / o31
Baud rate	20k, 50k, 125k, 250k, 500k, 800k, 1Mbit/s	Sets the inverter function code y24 / o32
Maximum cable length	Refer to Table 9.2.2-2	Twisted pair cable (shielded)
No. of connection units	30 (MAX)	Loop bus
Protocol version	Standard format (2.0A)	
Profile	Compliant with the following profiles; • CiA DS 301 Ver.4.02 • CiA DSP 402 Ver.2.0 Velocity Mode	
PDO	- Reception PDO and Transmission PDO, three types each - PDO assignment cannot be changed	Refer to 9.2.5
SDO	- Supports one Server SDO	Refer to 9.2.6
Other services	- Network Management(NMT) Start_Remote_Node, Stop_Remote_Node, Enter_Pre-Operational, Reset_Communication, Reset_Node - Heartbeat (Producer and Consumer) - Node Guarding - Emergency (EMCY)	Refer to 9.2.7

9.2.2 Connection method

⚠WARNING⚠
• Before the connection, shut off the inverter's power source and take 5 min (FRN0072E2S-4□) or 10 min (FRN0085E2S-4□) or more. Furthermore, confirm that the LED monitor and charge lamp are turned off and that the DC link bus voltage of main circuit terminals between P (+) and N (-) indicates the safety value (+25 VDC or less) by using a tester. • A qualified specialist should perform the wiring work. **An electric shock may occur.** • In general, since the cover of the control signal line is not reinforcedly insulated, direct current flow in the control signal line in the main circuit's live part may destroy the insulation cover. If this is the case, the control signal line my be applied by high voltage in the main circuit. Be careful lest main circuit's live part comes into contact with the control signal line. **It may cause an accident or fire.**

⚠CAUTION
The noise may be generated from the inverter, motor, and cables. Be careful about malfunction of surrounding sensor and equipment. **Otherwise an accident could occur.**

[1] Basic connection configuration

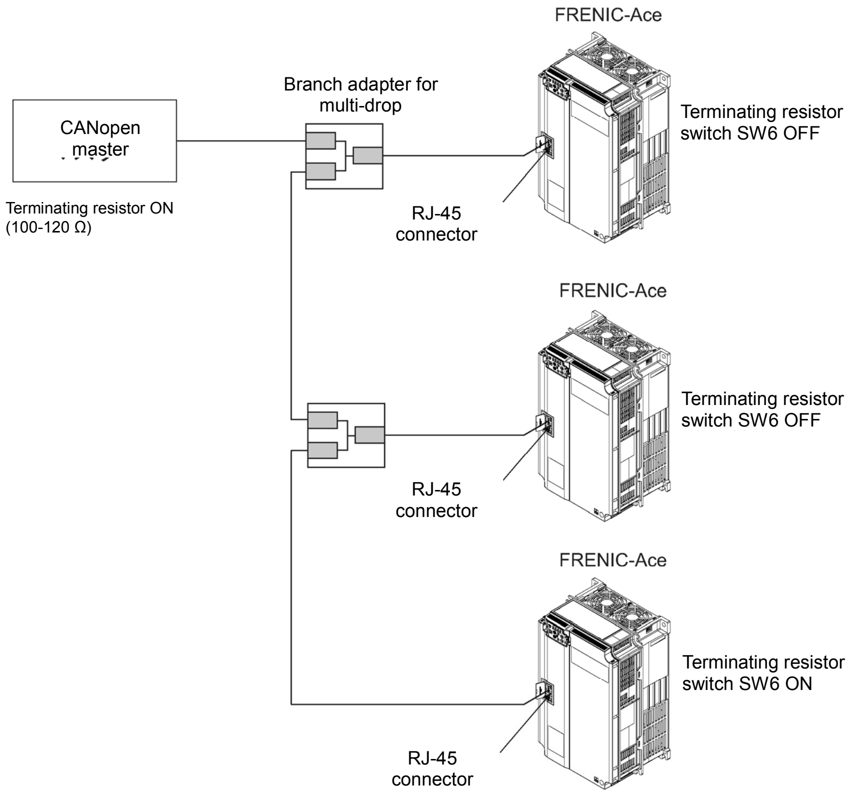


Figure 9.2.2-1 Multi-drop connection for CANopen communication port 2 (using the RJ-45 connector)

[2] Terminal mode

(1) RJ-45 connector (COM port 2) for CANopen communication

The Figure 9.2.2-2 and Table 9.2.2-1 show the pinout and signal description.

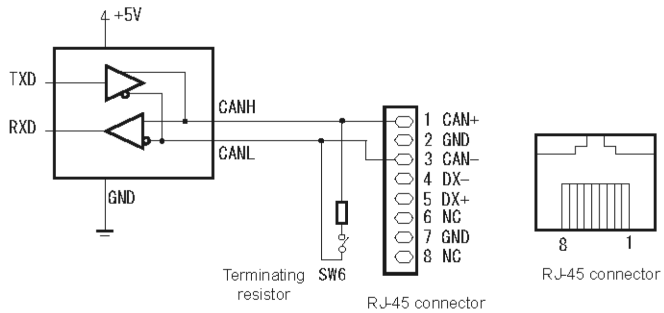


Figure 9.2.2-2 RJ-45 connector's pinout for CANopen communication

Table 9.2.2-1 CANopen's signals

Pin	Signal name	Description
1	CAN+	CAN signal, high side *1
2	GND	Ground signal
3	CAN-	CAN signal, low side *1
4	DX-	RS-485 signal, low side *2
5	DX+	RS-485 signal, high side *2
6	NC	Not connected
7	GND	Ground signal
8	NC	Not connected

*1: The pins used in the CANopen communication are the pin nos 1 and 3.
*2: The pin nos 4 and 5 are for RS-485 communication.

(2) CANopen communication cable

Use a standard LAN cable (US ANSI/TIA/EIA-568A category 5 compliant, straight cable) for the communication. The Table 9.2.2-2 lists the maximum cable lengths.

Table 9.2.2-2 Maximum CANopen cable length

Baud rate (bit/s)	20 k	50 k	125 k	250 k	500 k	800 k	1 M
Maximum cable length	2500m	1000m	500 m	250m	100m	50m	25m

(4) Connecting terminating resistor

When the inverter is connected to either end of CANopen communication cable, set the terminating resistor (SW6=ON) shown below.

9.2.3 Inverter function codes related to CANopen setting

In order to use this communication card for the CANopen communication, it is required to set the inverter function code listed in Table 9.2.3-1 shown below. Also, Table 9.2.3-2 lists the related inverter function codes. Set the code, if necessary.

Table 9.2.3-1 Inverter function codes necessary for CANopen communication

<table>
<tr><th>Function code</th><th>Description</th><th>Default setting</th><th>Function code data to be set</th><th>Remarks</th></tr>
<tr><td>y21 / o31 *1</td><td>Sets the node ID (station No)</td><td>0</td><td>1 to 127</td><td></td></tr>
<tr><td>y24 / o32 *2</td><td>Sets a baud rate</td><td>0</td><td>0 to 7
0: 125 kbit/s, 1: 20 kbit/s,
2: 50 kbit/s, 3: 125 kbit/s,
4: 250 kbit/s, 5: 500 kbit/s,
6: 800 kbit/s, 7: 1 Mbit/s,
8 or more: 1 Mbit/s,</td><td>Set the same value as the master's baud rate.</td></tr>
<tr><td>y33</td><td>Built-in CAN settings (operation selection)</td><td>0</td><td>0: Operation disabled (bus option enabled)
1: Operation enabled (built-in CAN enabled; bus option disabled)</td><td></td></tr>
<tr><td>y98 *3</td><td>Selects running/frequency command source</td><td>0</td><td>Select from the following choices:
<table>
<tr><th>y98</th><th>Frequency</th><th>Operation</th></tr>
<tr><td>0</td><td>Inverter</td><td>Inverter</td></tr>
<tr><td>1</td><td>CANopen</td><td>Inverter</td></tr>
<tr><td>2</td><td>Inverter</td><td>CANopen</td></tr>
<tr><td>3</td><td>CANopen</td><td>CANopen</td></tr>
</table></td><td>The setting y98=3 is recommended.</td></tr>
<tr><td>C89</td><td>Frequency correction via communication, 1 (numerator)</td><td>1</td><td>The data set with 604B is written in the inverter.</td><td></td></tr>
<tr><td>C90</td><td>Frequency correction via communication, 2 (denominator)</td><td>1</td><td>The data set with 604B is written in the inverter.</td><td></td></tr>
</table>

*1: If y21/ o31 is set, in order to reflect the setting in the inverter, restart the inverter or issue the ResetNode service to inverter from the CANopen master.

*2: If y24/ o32 is set, in order to reflect the setting in the inverter, restart the inverter.

*3: Besides y98, there is an inverter function code to select the running & frequency command source. These settings enable to select the running & frequency command source in detail. For more information, refer to the H30 and y98 pages in Chapter 5 “Function Codes”.

Table 9.2.3-2 Related function Codes

Function code	Description	Default setting	Data setting range	Remarks
y34 / o27 *1	Selects the behavior on CANopen communication error	0	0 to 15	
y35 / o28 *1	Timer on CANopen communication error	0.0 s	0.0 s to 60.0 s	
y25 to y28 / o40 to o43 *2	Sets the inverter function code (write) to be mapped to TPDO No. 3	0 (no mapping)	0000 to FFFF (hex)	This setting is used in PDO No. 3.
y29 to y32 / o48 to o51 *2	Sets the inverter function code (read) to be mapped to RPDO No. 3	0 (no mapping)	0000 to FFFF (hex)	

*1: For more information on y34 / o27 and y35 / o28, refer to 9.2.12 “Behavior upon detection of CANopen network disconnection”.

*2: For information on how to set y25 to y28 / o40 to o43 and y29 to y32 / o48 to o51, refer to “9.2.5 [2] Reception PDO (from master to inverter)”, “(4) How to set the inverter function codes y25 to y32/o40 to o43, o48 to o51 and Indexes 5E00, 5E01”.
After the setup, in order to reflect the settings in the inverter, restart the inverter or issue the ResetNode service to inverter from the CANopen master.

9.2.4 Procedures to establish CANopen communication

This chapter describes the procedures to connect the CANopen communication between the master and inverter.

The procedure are the steps 1 to 5.

1. Set the CANopen master
2. Set the node ID and baud rate of inverter by specifying the inverter function codes.
3. Restart the inverter and put the inverter in a pre-operational state
4. Set the object for detecting disconnection (Heartbeat or Node Guarding)
5. Transmit the Start Remote Node command from the master to the inverter to put the inverter in an operational state

From now on, describes the procedures 1 to 5.

1. Set the CANopen master
   - Set the node ID and baud rate of the master.
   - Use the inverter's EDS file for the CANopen communication to register it with the master.

🕮For information about how to set the CANopen master, refer to the master's user's manual.

Note The EDS file does not come with inverter.
Download the EDS file from the following Web site. (required to subscribe (charge-free))
URL: http://www.fujielectric.com/products/#/tab2/tab1

2. Set the node ID and baud rate of inverter by specifying the inverter function codes.
   - Set the node ID with y21 / o31 and the baud rate with y24 / o32. Set the same values as those registered in the master.
   - If necessary, set the inverter function codes y34 / o27, y35 / o28.

🕮 For more information on y34 /o27 and y35 / o28, refer to 9.2.12 “Behavior upon detection of CANopen network disconnection”.

3. Restart the inverter and put the inverter in a pre-operational state
   If the settings of the CANopen master and inverter are correct on the inverter restart and the wiring is proper, the inverter automatically enters into a pre-operational state, enabling to communicate with the master.
   In this state, RUN LED blinks in green and ERR LED turns off or blinks in red in this communication card.

4. Set the object for detecting disconnection (Heartbeat or Node Guarding)
   In order to detect the disconnection, set Heartbeat or Node Guarding in both master and inverter.

🕮 For information about Heartbeat or Node Guarding, refer to “9.2.11 Heartbeat and Node Guarding”.

Note The object for detecting disconnection in the CANopen device is invalid by default. Unless the setting is enabled, the CANopen network including inverter can not detect a disconnection even if the disconnection occurs. We strongly recommend to enable the setting.

5. Transmit the Start Remote Node command from the master to inverter to put the inverter in an operational state
   After receiving this command, the inverter enters the operational state. This enables the master to control and monitor the inverter real time through the PDO communication.

🕮 For information about the format of PDO communication, refer to “9.2.5 PDO protocol”.

9.2.5 PDO protocol

[1] About PDO protocol

The PDO (Process Data Object) protocol is used for communicating the process data between the CANopen master and inverter periodically (example: running command, speed monitoring). As shown in Table 9.2.5-1 and Table 9.2.5-2, CANopen communication of inverter supports three types of reception PDO (RPDO: from master to inverter) and transmission PDO (TPDO: from inverter to master) each.

Table 9.2.5-1 Reception PDO (RPDO, from master to inverter)

PDO No.	Initial value of COB-ID	Description
1	0x200 + node ID	Controls the state change of DS-402
2	0x300 + node ID	Controls the state change of DS-402 and the speed command
3	0x400 + node ID	Writes four types of mapped inverter function codes

Table 9.2.5-2 Transmission PDO (TPDO, from inverter to master)

PDO No.	Initial value of COB-ID	Description
1	0x180 + node ID	Controls the state change of DS-402
2	0x280 + node ID	Controls the state change of DS-402 and the speed command
3	0x380 + node ID	Reads four types of mapped inverter function codes

Note

Timing to transmit transmission PDO

The factory default is “Transmit PDO upon data change and at the time specified by Event timer”. Since the transmission is not synchronized with the command from the reception PDO but is done when the data changes, three transmission PDOs my be transmitted continuously, as the case may be. (for example, while the master issues a command with PDO No.2, the answers are returned from PDO Nos. 1 and 3.) To prevent this, it is possible to disable each transmission PDO. For information about the method, refer to “9.2.5 [2] Reception PDO (from master to inverter)”, “(2) COB-ID”. Besides, it is possible to set the transmission timing to periodical, for example. For information on this, refer to “9.2.5 [5] Communication parameters of transmission PDO”, “(3) Transmission type”.

Note

Enable/disable setting of PDO

All PDOs are enabled by default. Set the bit 31 in COB-ID of each PDO to one to disable the PDO (nonresponse).

Note

The PDO protocol is available for use only in operational state.

It is recommended to change the PDO protocol when the inverter is in the Pre-Operational state.

[2] Reception PDO (from master to inverter)

(1) Reception PDO No.1

PDO No.	Default COB-ID	Name	Re-map
1	0x200+Node ID	Control word (Default)	Yes
		User-defined	Yes
		User-defined	Yes
		User-defined	Yes

Controlword: Controls the inverter's operation by operating the state machine with DSP 402

For information about Controlword and state machine with DSP 402, refer to “9.2.10 [1] Operation according to CANopen's drive profile (DSP 402)”.

(2) Reception PDO No.2

PDO No.	Default COB-ID	Name	Re-map
2	0x300+Node ID	Control word (Default)	Yes
		vl target velocity (r/min) (Default)	
		User-defined	Yes
		User-defined	Yes

Controlword: Controls the inverter's operation by operating the state machine with DSP 402
vl target velocity: Speed command (r/min)

For information about Controlword, vl control effort, and state machine with DSP 402, refer to “9.2.10 [1] Operation according to CANopen's drive profile (DSP 402)”.

Note When you give the speed command (r/min), set the number of motor poles (P01/A15) properly according to the applicable motor; otherwise the speed command (r/min) will be off.

(3) Reception PDO No.3

The format for writing the mapped control codes by the inverter function codes y25 to y28/o40 to o43 in advance. There are four types of mapped function codes.

PDO No.	Default COB-ID	Name	Re-map
3	0x400+Node ID	Writing function code 1 (function code data specified by y25/o40)	No
		Writing function code 2 (function code data specified by y26/o41)	
		Writing function code 3 (function code data specified by y27/o42)	
		Writing function code 4 (function code data specified by y28/o43)	

For information on how to set y25 to y28/o40 to o43, refer to “9.2.5 [2] (4) How to set the inverter function codes y25 to y32/o40 to o43, o48 to o51 and Indexes 5E00, 5E01”.

For information about data format of the mapped inverter function codes, refer to RS-485 Communication User's Manual, Chapter 5, “5.2 Data Format”.

Note When the same function code is assigned by multiple inverter function codes, only the assignment by the y / o code of the minimum number will be valid. (example: If the same function code is mapped by both o40 and o43, only the mapping with y25 / o40 becomes effective. y28 / o43 is assumed that nothing is mapped.)

Note After the setup of y25 to y28 / o40 to o43, in order to reflect the settings in the inverter, restart the inverter or issue the ResetNode service to the inverter from the CANopen master.

Note The object's Indexes 5E00 sub 1 to 4 also can map the inverter function codes. In this case, the mappings become effective immediately after the change. However, if the inverter is restarted or the ResetNode service is issued, the mappings by y25 to y28 /o40 to o43 become effective.

Note The reflection timing of each reception PDO can be changed. Refer to “9.2.5 [4] Communication parameters of reception PDO”, “(3) Transmission type”. The “change is reflected in the inverter immediately after reception” by factory default.

(4) How to set the inverter function codes y25 to y32/o40 to o43, o48 to o51 and Indexes 5E00, 5E01

Specify the function code type (Table 9.2.5-3) and number in a 4-digit hexadecimal notation.

□□□□

Function code No. (hexadecimal notation)
Function code type (according to Table 7.3)

Table 9.2.5-3 Function code types

Type	Group code	Type	Group code	Type	Group code
—	—	W	0x10 (16)	H1	0x20 (32)
—	—	X	0x11 (17)	o1	0x21 (33)
S	0x02 (2)	Z	0x12 (18)	U1	0x22 (34)
M	0x03 (3)	b	0x13 (19)	M1	0x23 (35)
F	0x04 (4)	d	0x14 (20)	J1	0x24 (36)
E	0x05 (5)	—	—	J2	0x25 (37)
C	0x06 (6)	—	—	J3	0x26 (38)
P	0x07 (7)	W1	0x17 (23)	J4	0x27 (39)
H	0x08 (8)	W2	0x18 (24)	J5	0x28(40)
A	0x09 (9)	W3	0x19 (25)	J6	0x29(41)
o	0x0A (10)	X1	0x1A (26)	d1	0x2A (42)
L	0x0B (11)	X2	0x1B (27)		
r	0x0C (12)	Z1	0x1C (28)		
L1	0x0D (13)	K	0x1D(29)		
J	0x0E (14)	T	0x1E(30)		
y	0x0F (15)	E1	0x1F (31)		

Example: For F26 F ⇒ group code 04
26 ⇒ 1A (hexadecimal notation) } "041A"

[3] Transmission PDO (from inverter to master)

(1) Transmission PDO No.1

PDO No.	Default COB-ID	Name	Re-map
1	0x180+Node ID	Status word (Default)	Yes
		User-defined	Yes
		User-defined	Yes
		User-defined	Yes

Statusword: Display the status of state machine with DSP 402

📖 For information about Statusword and state machine with DSP 402, refer to “9.2.10 [1] Operation according to CANopen's drive profile (DSP 402)”.

(2) Transmission PDO No.2

PDO No.	Default COB-ID	Name	Re-map
2	0x280+Node ID	Status word (Default)	Yes
		vl control effort (r/min) (Default)	
		User-defined	Yes
		User-defined	Yes

Statusword: Display the status of state machine with DSP 402

vl control effort: Monitor output speed (r/min)

📖 For information about Statusword and vl control effort, refer to “9.2.10 [1] Operation according to CANopen's drive profile (DSP 402)”.

(3) Transmission PDO No.3

The format for reading the control codes mapped by the inverter function codes y29 to y32/o48 to o51 in advance. There are four types of mapped function codes.

PDO No.	Default COB-ID	Name	Re-map
3	0x380+Node ID	Reading function code 1 (function code data specified by y29/o48)	No
		Reading function code 2 (function code data specified by y30/o49)	
		Reading function code 3 (function code data specified by y31/o50)	
		Reading function code 4 (function code data specified by y32/o51)	

📖 For information on y29 to y32/o48 to o51, refer to “9.2.5 [2] Reception PDO (from master to inverter)”, “(4) How to set the inverter function codes y25 to y32/o40 to o43, o48 to o51 and Indexes 5E00, 5E01”.

📖 For information about data format of the mapped inverter function codes, refer to RS-485 Communication User's Manual, Chapter 5, “5.2 Data Format”.

Note After the setup of y29 to y 32/ o48 to o51, in order to reflect the settings in the inverter, restart the inverter or issue the ResetNode service to the inverter from the CANopen master.

Note The object indexes 5E01 sub 1 to 4 can map the inverter function codes. In this case, the mappings become effective immediately after the change. However, if the inverter is restarted or the ResetNode service is issued, the mappings with y29 to y 32/ o48 to o51 become effective.

Note The transmission timing of each transmission PDO can be changed. Refer to “9.2.5 [5] Communication parameters of transmission PDO”, “(3) Transmission type”. The factory default is “Transmit PDO upon data change and at the time specified by Event timer”.

[4] Communication parameters of reception PDO

(1) Communication parameters

Set the property of each reception PDO (RPDO). The Table 9.2.5-4 lists appropriate objects.

Table 9.2.5-4 Communication parameters of reception PDO and default values

Index	Sub	Name	Description
0x1400 RPDO No.1 0x1401 RPDO No.2 0x1402 RPDO No.3	1	COB-ID	Set CAN ID of each PDO and validity Default value: RPDO No.1: 0x200 + node ID RPDO No.2: 0x300 + node ID RPDO No.3: 0x400 + node ID
	2	Transmission type	Set the timing to reflect the received data in the operation (table 9.2.5-5) Default value: 255 (reflect it in the inverter immediately)

Note The value changed of the objects listed in the Table 9.2.5-4 is held even if inverter is turned OFF. Also, the setting can be initialized to default value by writing one into Index 3001 Restore defaults.

(2) COB-ID

Specify 11 bit CAN ID value for each PDO. The default changes according to the node ID.
(Example: If the node ID of inverter is one, RPDO No.2 COB-ID = 0x301). If the most significant bit (31th bit) is set to one, the RPDO will be invalid.

Note It is possible to change COB-ID only when the PDO is invalid.

Tip CAN ID is 11 bit. The bits 11 to 30 are fixed at zero. (Only the standard frame is supported.)

(3) Transmission type

In the reception PDO, set the timing to reflect the received PDO in the inverter. The TableTable 9.2.5-5 lists the setting.

Table 9.2.5-5 Transmission type setting of reception PDO

Transmission type	Name	Action
0	Acyclic Synchronous	Reflects the received PDO in the inverter after receiving a Sync signal
1-240	Cyclic Synchronous	Same as above
241-251	Reserved	---
252	Synchronous RTR only	No operation *
253	Asynchronous RTR only	No operation *
254	Asynchronous1	Reflects the received PDO immediately in the inverter
255	Asynchronous2	Same as above (default)

*: The CANopen communication of inverter does not support the CAN's remote frame.

[5] Communication parameters of transmission PDO

(1) Communication parameters

Set the property of each transmission PDO (TPDO). The Table 9.2.5-6 lists appropriate objects.

Table 9.2.5-6 Communication parameters of transmission PDO and default values

Index	Sub	Name	Description
0x1800 TPDO No.1 0x1801 TPDO No.2 0x1802 TPDO No.3	1	COB-ID	Set CAN ID of each PDO and validity Default value: TPDO No.1: 0x180 + node ID TPDO No.2: 0x280 + node ID TPDO No.3: 0x380 + node ID
	2	Transmission type	Specify the transmission timing (table 9.2.5-7) Default value: 255 (transmit data if the data changes)
	3	Inhibit time	Specify the minimum interval (unit: 0.1 ms) to next transmission. Default value: 100 (10.0 ms) *
	5	Event timer	Specify periodical transmission time (ms). Valid when the transmission type is 254/255 Default value: 0 (no operation) *

*: The resolution of timer setting value is 2 ms. If an odd value is specified, the value is moved forward. For example, if the timer is set to 119 ms, the value is assumed to be 120 ms.

Tip The value changed of the objects listed in the TableTable 9.2.5-6 is held even if inverter is turned OFF. Also, the setting can be initialized to default value by writing one into Index 3001 Restore defaults.

(2) COB-ID

Specify 11 bit CAN ID value for each PDO. The default changes according to the node ID. (Example: If the node ID of inverter is one, TPDO No.2 COB-ID = 0x281). If the most significant bit (31th bit) is set to one, the TPDO will be invalid.

Note It is possible to change COB-ID only when the PDO is invalid.

Tip CAN ID is 11 bit. The bits 11 to 30 are fixed at zero. (Only the standard frame is supported.)

(3) Transmission type

Set the transmission timing to the master for the transmission PDO. The TableTable 9.2.5-7 lists the setting.

Table 9.2.5-7 Transmission type setting of transmission PDO

Transmission type	Name	Action
0	Acyclic Synchronous	When the data is changed, transmits PDO immediately after receiving a Sync signal
1-240	Cyclic Synchronous	Transmits PDO every 1 to 240 times a sync signal is received. (Example: (if it is set to 10, transmits PDO every 10 times a sync signal is received)
241-251	Reserved	-
252	Synchronous RTR only	No operation *
253	Asynchronous RTR only	No operation *
254	Asynchronous1	Transmits PDO periodically at the time specified by Event timer
255	Asynchronous2	Transmit PDO upon data change and at the time specified by Event timer

*: The CANopen communication of inverter does not support the CAN's remote frame.

(4) Inhibit time

Set the minimum transmission interval (unit: 0.1 ms) for transmitting each PDO. All transmission types depend on this setting.

Note It is possible to change Inhibit time only when the PDO is invalid, that is, COB-ID's bit 31 is set to one.

Note If a smaller value is set for the Inhibit time, the data transmission frequency becomes higher, thereby increasing the CANopen communication traffic. As a result, the performance of the whole CANopen network may be degraded. Adjust the setting value according to the network configuration used, please.

(5) Event timer

Set the periodical transmission interval (unit: 1 ms) for transmission PDO. Valid when the transmission type is 254 or 255.

9.2.6 SDO protocol

[1] About SDO

The SDO (Service Data Object) protocol is used to set and adjust inverter. SDO enables to access all objects (parameters) inverter. The CANopen communication of inverter supports a single Server SDO.

📖 For information about how to transmit data in SDO, refer to the manual of the master or configuration tool.

📖 For information about the objects, refer to “9.2.8 Object list”.

[2] Response on SDO error

If the access in SDO has an error, this communication card returns an Abort code listed in Table 9.2.6-1.

Table 9.2.6-1 Abort codes on SDO access error

Abort codes	Description
0503 0000	Error on divided SDO transmission: Improper toggle bit
0504 0000	Response timeout error
0601 0000	Unsupported access to an object
0601 0001	Write only object is read
0601 0002	Read only object is written
0602 0000	Parameter not existent
0604 0041	Object cannot be mapped to the PDO.
0604 0042	The number and length of the objects to be mapped would exceed PDO length.
0606 0000	Writing while EEPROM is running of inverter
0607 0010	Different parameter's data type
0607 0012	Data type does not match, length of service parameter too high.
0607 0013	Data type does not match, length of service parameter too low.
0609 0011	Accessed to the object without subindex
0609 0030	The value written is out of range
0609 0031	Value of parameter written too high.
0609 0032	Value of parameter written too low.
0800 0021	Inverter function code write error (SO1, SO5, and SO6 are written by CANopen when the link to RS-485 communication port is valid)
0800 0022	Disabled to write inverter function code (running, writing, digital input terminal is ON)

9.2.7 Other services

(1) Network management (NMT)

Controls the DS 301 state machine. The Table 9.2.7-1 lists the behavior upon reception of each service.

Table 9.2.7-1 Behavior upon reception of NMT services

Services	Behavior on reception	Remarks
Start_Remote_Node	Enters into Operational state	PDO communication is valid only in Operational state.
Stop_Remote_Node	Enters into the Stop state.	Only the NMT service is available in the Stop state.
Enter_Pre-Operational	Enters into Pre-Operational state.	PDO communication is unavailable in the Pre-Operational state.
Reset_Communication		
Reset_Node	Same as the power restart	Reflects the node ID, y25 to y32/ o40 to o51 in the operation.

📖 For more information on NMT, refer to the master's user's manual or CANopen specifications DS 301 issued by CiA.

(2) Heartbeat and Node Guarding

A service for the disconnect detection. We recommend you to use either one.

📖 For information about Heartbeat and Node Guarding, refer to “9.2.11 Heartbeat and Node Guarding”.

⚠CAUTION

Important: Either Heartbeat or Node Guarding is recommended

The setting for detecting disconnection in the CANopen device is invalid by default. Unless the setting is enabled, the CANopen network including inverter can not detect a disconnection even if the disconnection occurs. We strongly recommend to enable the setting.

(3) Emergency (EMCY)

This service enables inverter to automatically transmit the alarm occurred in the inverter. The format of the transmission data is as follows:

COB-ID
0x80 + node ID

Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Error field (L byte)	(H byte)	Error register	0	0	0	0	0

Error field: Indicates the contents of alarm.

Error register: 1: alarm occurring, 0: no alarm. (same as Index 1001.)

📖 For more information on the alarm code, refer to “9.2.13 Alarm code list”.

9.2.8 Object list

This chapter describes the objects (parameters) supported by The CANopen communication of inverter. The objects are classified into three types of areas.

(1) Communication profile area

(Indexes: 1000 to 1FFF)

The objects common to all devices for the CANopen communication. This area is defined in the CANopen specifications DS 301.

(2) Manufacturer specific profile area (Indexes 2000 to 5FFF)

The objects only for our company. It is possible to access the inverter function codes, for example. Since they are dedicated objects, they are not compatible with CANopen devices provided by other manufacturer.

(3) Standard device profile area (Indexes 6000 to 9FFF)

The objects for controlling the inverter. This area is standardized in the CANopen specifications DSP 402 and is compatible with the devices provided by other companies.

[1] Objects in the communication profile area

Table 9.2.8-1 lists the objects in the communication profile area. In the access field, R represents read only, RW represents readable & writable. In the data hold field, O represents that the written data is held after the power OFF.

Table 9.2.8-1 Objects in the communication profile area

Index (Hex)	Sub	Name	Description	Data type	Data hold	Access
1000	-	Device type	Fixed at 0x10192	UNSIGNED32	-	R
1001	-	Error register	1: Error, 0: No error	UNSIGNED8	-	R
1003	-	Pre-defined error field		ARRAY	-	-
	0	Number of errors	Number of errors occurred 1: one error, 0: no error	UNSIGNED8	-	R
	1	Standard error field	Displays the code of the occurring error (For details, refer to the table 14.1)	UNSIGNED32	-	R
1005	-	COB-ID SYNC	COB-ID of the SYNC message Default value: 0x080	UNSIGNED32	Y	RW
1008	-	Manufacturer device name	Device name: Built-in CAN: “FRN-E2-COP” Option CAN: “OPC-E2-COP” (ASCII) fixed	STRING	-	R
1009	-	Manufacturer HW version	Hardware version: “SP0146” (ASCII) Control PCB No. for E2S	STRING	-	R
100A	-	Manufacturer SW version	Software version: “E2S1-” + code M25 (same as the inverter ROM Version)	STRING	-	R
100C	-	Guard time	Guarding reception cycle setting (ms) Default value: 0 (no operation)	UNSIGNED16	Y	RW
100D	-	Life time factor	Guarding time coefficient Default value: 0 (no operation)	UNSIGNED8	Y	RW
1014	-	COB-ID EMCY	COB-ID of the EMCY message Read value: 0x0080 + node ID	UNSIGNED32	-	R
1016	-	Consumer heartbeat time		ARRAY	-	-
	0	Number of entries	Number of configurations	UNSIGNED8	-	R
	1	Consumer heartbeat time	Upper word: Node ID to be monitored Lower word: Heartbeat monitoring cycle Default value: 0 (no operation)	UNSIGNED32	Y	RW
1017	-	Producer heartbeat time	Transmission cycle of Heartbeat message Default value: 0 (no operation)	UNSIGNED16	Y	RW
1018	-	Identity Object		RECORD	-	-
	0	Number of entries	Number of subindexes: 1	UNSIGNED8	-	R

Index (Hex)	Sub	Name	Description	Data type	Data hold	Access
	1	Vendor ID	0x0000025E (Fuji Electric Group)	UNSIGNED32	-	R
1200	-	Server SDO parameter		RECORD	-	-
	1	COB-ID C->S (rx)	0x600 + station No.	UNSIGNED32	-	R
	2	COB-ID S->C (tx)	0x580 + station No.	UNSIGNED32	-	R
1400	-	1st Receive PDO Communication Parameter		RECORD	-	-
	0	Number of entries	Number of subindexes: 2	UNSIGNED8	-	R
	1	COB-ID	COB-ID of RPDO No.1 Default value: 0x200 + node ID	UNSIGNED32	Y	RW *1
	2	Transmission type	Select the transmission type Default value: 255 (Change of state event) (refer to Tables 9.2.5-5, 9.2.5-6)	UNSIGNED8	Y	RW
1401	-	2nd Receive PDO Communication Parameter		RECORD	-	-
	0	Number of entries	Number of subindexes: 2	UNSIGNED8	-	R
	1	COB-ID	COB-ID of RPDO No.2 Default value: 0x300 + node ID	UNSIGNED32	Y	RW *1
	2	Transmission type	Select the transmission type Default value: 255 (Change of state event) (refer to Tables 9.2.5-5, 9.2.5-6)	UNSIGNED8	Y	RW
1402	-	3rd Receive PDO Communication Parameter		RECORD	-	-
	0	Number of entries	Number of subindexes: 2	UNSIGNED8	-	R
	1	COB-ID	COB-ID of RPDO No.3 Default value: 0x400 + node ID	UNSIGNED32	Y	RW *1
	2	Transmission type	Select the transmission type Default value: 255 (Change of state event) (refer to Tables 9.2.5-5, 9.2.5-6)	UNSIGNED8	Y	RW
1600	-	1st Receive PDO Mapping Parameter		RECORD	-	-
	0	Number of mapped objects	Number of mapped objects: 1 (up to 4)	UNSIGNED8	-	R
	1	PDO mapping entry1	0x60400010 (Controlword)	UNSIGNED32	-	R
	2	PDO mapping entry2	Default value: No mapping	UNSIGNED32	-	R
	3	PDO mapping entry3	Default value: No mapping	UNSIGNED32	-	R
	4	PDO mapping entry4	Default value: No mapping	UNSIGNED32	-	R
1601	-	2nd Receive PDO Mapping Parameter		RECORD	-	-
	0	Number of mapped objects	Number of mapped objects: 2 (up to 4)	UNSIGNED8	-	R
	1	PDO mapping entry1	0x60400010 (Controlword)	UNSIGNED32	-	R
	2	PDO mapping entry2	0x60420010 (vl target velocity)	UNSIGNED32	-	R
	3	PDO mapping entry3	Default value: No mapping	UNSIGNED32	-	R
	4	PDO mapping entry4	Default value: No mapping	UNSIGNED32	-	R
1602	-	3rd Receive PDO Mapping Parameter		RECORD	-	-
	0	Number of mapped objects	Number of mapped objects: 4	UNSIGNED8	-	R
	1	PDO mapping entry1	0x5F020110 (writing function code mapping 1)	UNSIGNED32	-	R
	2	PDO mapping entry2	0x5F020210 (writing function code mapping 2)	UNSIGNED32	-	R
	3	PDO mapping entry3	0x5F020310 (writing function code mapping 3)	UNSIGNED32	-	R
	4	PDO mapping entry4	0x5F020410 (writing function code mapping 4)	UNSIGNED32	-	R
1800	-	1st Transmit PDO Communication Parameter		RECORD	-	-
	0	Largest sub-index	Maximum sub-index No.: 5	UNSIGNED8	-	R
	1	COB-ID	COB-ID of TPDO No.1 Default value: 0x180 + node ID	UNSIGNED32	Y	RW *1
	2	Transmission type	Select the transmission type Default value: 255 (Change of state event) (refer to Tables 9.2.5-6, 9.2.5-7)	UNSIGNED8	Y	RW
	3	Inhibit time	Waiting time for transmission (unit: 0.1 ms) Default value: 100 (10.0 ms)	UNSIGNED16	Y	RW *2
	5	Event timer	Periodical transmission interval (unit: 1 ms) Transmission type Valid at the time of 254 or 255. Default value: 0 (not used)	UNSIGNED16	Y	RW

Index (Hex)	Sub	Name	Description	Data type	Data hold	Access
1801	-	2nd Transmit PDO Communication Parameter		RECORD	-	-
	0	Largest sub-index	Maximum sub-index No.: 5	UNSIGNED8	-	R
	1	COB-ID	COB-ID of TPDO No.2 Default value: 0x280 + node ID	UNSIGNED32	Y	RW *1
	2	Transmission type	Select the transmission type Default value: 255 (Change of state event) (refer to Tables 9.2.5-6, 9.2.5-7)	UNSIGNED8	Y	RW
	3	Inhibit time	Waiting time for transmission (unit: 0.1 ms) Default value: 100 (10.0 ms)	UNSIGNED16	Y	RW *2
	5	Event timer	Periodical transmission interval (unit: 1 ms) Transmission type Valid at the time of 254 or 255. Default value: 0 (not used)	UNSIGNED16	Y	RW
1802	-	3rd Transmit PDO Communication Parameter		RECORD	-	-
	0	Largest sub-index	Maximum sub-index No.: 5	UNSIGNED8	-	R
	1	COB-ID	COB-ID of TPDO No.3 Default value: 0x380 + node ID	UNSIGNED32	Y	RW *1
	2	Transmission type	Select the transmission type Default value: 255 (Change of state event) (refer to Tables 9.2.5-6, 9.2.5-7)	UNSIGNED8	Y	RW
	3	Inhibit time	Waiting time for transmission (unit: 0.1 ms) Default value: 100 (10.0 ms)	UNSIGNED16	Y	RW *2
	5	Event timer	Periodical transmission interval (unit: 1 ms) Transmission type Valid at the time of 254 or 255. Default value: 0 (not used)	UNSIGNED16	Y	RW
1A00	-	1st Transmit PDO Mapping Parameter		RECORD	-	-
	0	Number of mapped objects	Number of mapped objects: 1 (up to 4)	UNSIGNED8	-	R
	1	PDO mapping entry1	0x60410010 (Statusword)	UNSIGNED32	-	R
	2	PDO mapping entry2	Default value: No mapping	UNSIGNED8	-	R
	3	PDO mapping entry3	Default value: No mapping	UNSIGNED8	-	R
	4	PDO mapping entry4	Default value: No mapping	UNSIGNED32	-	R
1A01	-	2nd Transmit PDO Mapping Parameter		RECORD	-	-
	0	Number of mapped objects	Number of mapped objects: 2 (up to 4)	UNSIGNED8	-	R
	1	PDO mapping entry1	0x60410010 (Statusword)	UNSIGNED32	-	R
	2	PDO mapping entry2	0x60440010 (vl control effort)	UNSIGNED32	-	R
	3	PDO mapping entry3	Default value: No mapping	UNSIGNED8	-	R
	4	PDO mapping entry4	Default value: No mapping	UNSIGNED32	-	R
1A02	-	3rd Transmit PDO Mapping Parameter		RECORD	-	-
	0	Number of mapped objects	Number of mapped objects: 4	UNSIGNED8	-	R
	1	PDO mapping entry1	0x5F030110 (reading function code mapping 1)	UNSIGNED32	-	R
	2	PDO mapping entry2	0x5F030210 (reading function code mapping 2)	UNSIGNED32	-	R
	3	PDO mapping entry3	0x5F030310 (reading function code mapping 3)	UNSIGNED32	-	R
	4	PDO mapping entry4	0x5F030410 (reading function code mapping 4)	UNSIGNED32	-	R

*1: The change of COB-ID will be possible after writing one into the bit 31.

*2: The change of Inhibit timer is possible when the concerned PDO is invalid (COB-ID's bit 31 is one).

[2] Objects in the profile area specific to Fuji Electric

Table 9.2.8-2 lists the objects in the profile area specific to Fuji Electric. In the access field, R represents read only, RW represents readable & writable. In the data hold field, O represents that the written data is held after the power OFF.

Table 9.2.8-2 Objects in the profile area specific to Fuji Electric

Index (Hex)	Sub	Name	Description	Data type	Data hold	Access
2200	0	Bus state	CAN communication state 0: Normal 1: Bus off/error passive 2: Other error	UNSIGNED8	-	R
3000	0	Node state	CANopen communication state 0: CAN not connected 1: Initializing 2: Stopped 3: Pre-Operational 4: Operational	UNSIGNED8	-	R
3001	0	Restore defaults	If the data is changed from zero to one, the hold values in the Indexes 1000 to 1A02 are cleared to default values.	UNSIGNED8	-	RW *1
5E00 *2	-	Assignment of RPDO No.3		ARRAY	-	-
	0	Number of entries	Number of configurations: 4	UNSIGNED8	-	R
	1	Function code1	(writing function code mapping 1 for PDO No.3) Default value: Setting value of y25 / o40	UNSIGNED16	-	RW
	2	Function code2	(writing function code mapping 2 for PDO No.3) Default value: Setting value of y26 / o41	UNSIGNED16	-	RW
	3	Function code3	(writing function code mapping 3 for PDO No.3) Default value: Setting value of y27 / o42	UNSIGNED16	-	RW
	4	Function code4	(writing function code mapping 4 for PDO No.3) Default value: Setting value of y28 / o43	UNSIGNED16	-	RW
5E01 *2	-	Assignment of TPDO No.3		ARRAY	-	-
	0	Number of entries	Number of configurations: 4	UNSIGNED8	-	R
	1	Function code1	(reading function code mapping 1 for PDO No.3) Default value: Setting value of y29 / o48	UNSIGNED16	-	-
	2	Function code2	(reading function code mapping 2 for PDO No.3) Default value: Setting value of y30 / o49	UNSIGNED16	-	RW
	3	Function code3	(reading function code mapping 3 for PDO No.3) Default value: Setting value of y31 / o50	UNSIGNED16	-	RW
	4	Function code4	(reading function code mapping 4 for PDO No.3) Default value: Setting value of y32 / o51	UNSIGNED16	-	RW
5F02 to 5FFF *3	1 to 100	FRENIC's function code	Inverter function code access [How to specify function code] Index=5F□□, Sub=xx □□: type (table 9.2.5-3) xx: number **+ 1** Example: E01→ Index 5F*05*, Sub *02*	UNSIGNED16	Y *4	RW *1

*1: Writable only in Pre-Operational state.

*2: For information on how to specify the function code, refer to "9.2.5 [2] Reception PDO (from master to inverter)", "(4) How to set the inverter function codes y25 to y32/o40 to o43, o48 to o51 and Indexes 5E00, 5E01".

Tip: If the function code mapping is changed by the Indexes 5E00, 5E01, the change is reflected in the inverter immediately. If the inverter is restarted or the ResetNode service is received, the mapping with y25 to y32 / o40 to o43 and o48 to o51 becomes effective.

*3: For information on the function code type, refer to "9.2.5 [2] (4) How to set the inverter function codes y25 to y32/o40 to o43, o48 to o51 and Indexes 5E00, 5E01". For information about data format of the inverter function codes, refer to RS-485 Communication User's Manual, Chapter 5, "5.2 Data Format".

*4: The inverter function codes S01, S05, S06, S07, S12, S13, and S19 are cleared after the power OFF.

9.2.9 Standard device profile area

Table 9.2.9-1 lists the objects in the standard device profile area specific. In the access field, R represents read only, W represents write only, and RW represents readable & writable. In the data hold field, O represents that the written data is held after the power OFF.

Table 9.2.9-1 Objects in standard device profile area

Index (Hex)	Sub	Name	Description	Data type	Data hold	Access
603F	-	Error code	Alarm history (latest) (For details, refer to the Table 14.1)	UNSIGNED16	-	R
6040	-	Controlword	Operation control (DS 402 state machine control)	UNSIGNED16	-	RW
6041	-	Statusword	Status monitor (display the DS 402 state machine status)	UNSIGNED16	-	R
6042	-	vl target velocity	Speed command (r/min)	INTEGER16	-	RW
6043	-	vl velocity demand	Monitor the output speed (r/min)	INTEGER16	-	R
6044	-	vl control effort	ditto	INTEGER16	-	R
6046	-	vl velocity min max amount		ARRAY	-	-
	0	Number of entries	Number of subindexes: 2	UNSIGNED8	-	R
	1	vl velocity min amount	Lower limit speed (r/min) (corresponding to the inverter function code F16)	UNSIGNED32	Y	RW
	2	vl velocity max amount	Maximum speed (r/min) (corresponding to the inverter function codes F03/A01 *1)	UNSIGNED32	Y	RW
6048	-	vl velocity acceleration (Delta speed/Delta time sets the acceleration. It corresponds to the inverter function code S08)		RECORD	-	-
	0	Number of entries	Number of subindexes: 2	UNSIGNED8	-	R
	1	Delta speed	Speed increment (r/min) for Delta time	UNSIGNED32	Y [*2]	RW
	2	Delta time	Time (s)	UNSIGNED16	Y [*2]	RW
6049	-	vl velocity deceleration (Delta speed/Delta time sets the deceleration. It corresponds to the inverter function code S09)		RECORD	-	-
	0	Number of entries	Number of subindexes: 2	UNSIGNED8	-	R
	1	Delta speed	Delta time sets the deceleration (r/min)	UNSIGNED32	Y [*2]	RW
	2	Delta time	Time (s)	UNSIGNED16	Y [*2]	RW
604A	-	vl velocity quick stop (Delta speed/Delta time sets the deceleration. It corresponds to the inverter function code H56)		RECORD	-	-
	0	Number of entries	Number of subindexes: 2	UNSIGNED8	-	R
	1	Delta speed	Delta time sets the deceleration (r/min)	UNSIGNED32	Y [*2]	RW
	2	Delta time	Time (s)	UNSIGNED16	Y [*2]	RW
604B	-	vl set-point factor	Changes the resolution and range for the speed setting	ARRAY	-	-
	0	Highest sub-index supported	Number of subindexes: 2	INTEGER16	-	R
	1	vl set-point factor numerator	-32768 to +32767 (Except for 0; treated as “1” when the setting is made.)	INTEGER16	-	RW
	2	vl set-point		INTEGER16	-	RW
604D	-	vl pole number	Number of motor poles (corresponds to the inverter function codes P01/A15 *1)	UNSIGNED8	Y	RW
6060	-	Modes of operation	Select the DS 402's mode	INTEGER8	-	W
6061	-	Modes of operation display	Selected state of the DS 402's mode Always fixed at 2=Velocity mode	INTEGER8	-	R
6077	-	Torque actual value	Actual value of instantaneous torque	INTEGER16	-	R
6078	-	Current actual value	Actual value of output current	INTEGER16	-	R

*1: The corresponding inverter function code automatically changes according to the motor's selected state.

📖 For information about mode selection, refer to Chapter 5, “5.3.6 A codes”.

*2: If the power is turned OFF, the acceleration and deceleration slope values are held.

9.2.10 Inverter operation in CANopen communication

This chapter describes the inverter's operation by using the CANopen communication.

There are the following two ways to run the inverter:

1. Operation according to CANopen's drive profile (DSP 402)
2. Operation according to the inverter function code S06

[1] Operation according to CANopen's drive profile (DSP 402)

(1) Related object list

Index (Hex)	Sub	Name	Description	Data type	Access
6040	-	Controlword	Controls the state change of state machine	UNSIGNED16	RW
6041	-	Statusword	Displays the current state.	UNSIGNED16	R
6042	-	vl target velocity	Speed command (r/min)	INTEGER16	RW
6044	-	vl control effort	Monitor the output speed (r/min)	INTEGER16	R
604B	-	vl set-point factor	Modifies the resolution and specified range of the speed settings.	ARRAY	RW

Tip: As for the inverter's operation, PDO No.2 is useful which can send both Controlword and speed command at the same time.

(2) Description of related object

■ Controlword

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Fault reset	0	0	0	Enable operation	Quick stop	Enable voltage	Switch on

bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8
X4	X3	X2	X1	Reverse	0	0	Halt

bits 0 to 3 : Operates the state change of state machine. Refer to Figure 11.1.

bit 7 Fault reset : Resets the alarm by change from zero to one.

bit 8 Halt : 1= Fixes the inverter's output speed at 0 r/min.

bit 11 Reverse : Sets the rotation direction. 0= rotates forward, 1=rotates backward

bits 12 to 15 : Digital input terminal X1 to X4. 0=OFF, 1=ON

■ Statusword

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Warning	Switch on disabled	Quick stop	Voltage enabled	Fault	Operation enabled	Switched On	Ready to switch on

bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8
Direction of rotation	0	0	0	Internal limit active	Target reached	Remote	0

bits 0 to 2, 5, 6	:	Displays the state machine status. Refer to Figure 11.1.
bit 3 Fault	:	1= Tripping
bit 4 Voltage enabled	:	1= Main circuit ON
bit 7 Warning	:	Not used. Fixed at 0.
bit 9 Remote	:	1= Either speed or operation command is enabled through CANopen.
bit 10 Target reached	:	1= Reached to preset speed.
bit 11 Internal limit active	:	1= The torque, voltage, or current limit is limited.
bit 15 Direction of rotation	:	0= Normal rotation or stop, 1= Reverse rotation

■ vl target velocity

Issues a speed command on a r/min basis. Valid range: -32768 r/min to 32767 r/min

■ vl control effort

Displays the current output speed on a r/min basis. Output range: -32768 r/min to 32767 r/min

(3) State Machine

To run the inverter, operate the state machine (state transition diagram) defined with DSP 402. The state of the state machine is changed by Controlword (CTW in the figure) and the state is monitored by Statusword (STW in the figure). The Figure 9.2.10-1 shows the state machine and the Table 9.2.10-1 shows the commands to the inverter during each state transition.

Tip The inverter enters into running state by putting the state machine in the state 5 “Operation enabled” in the TableTable 9.2.10-1.

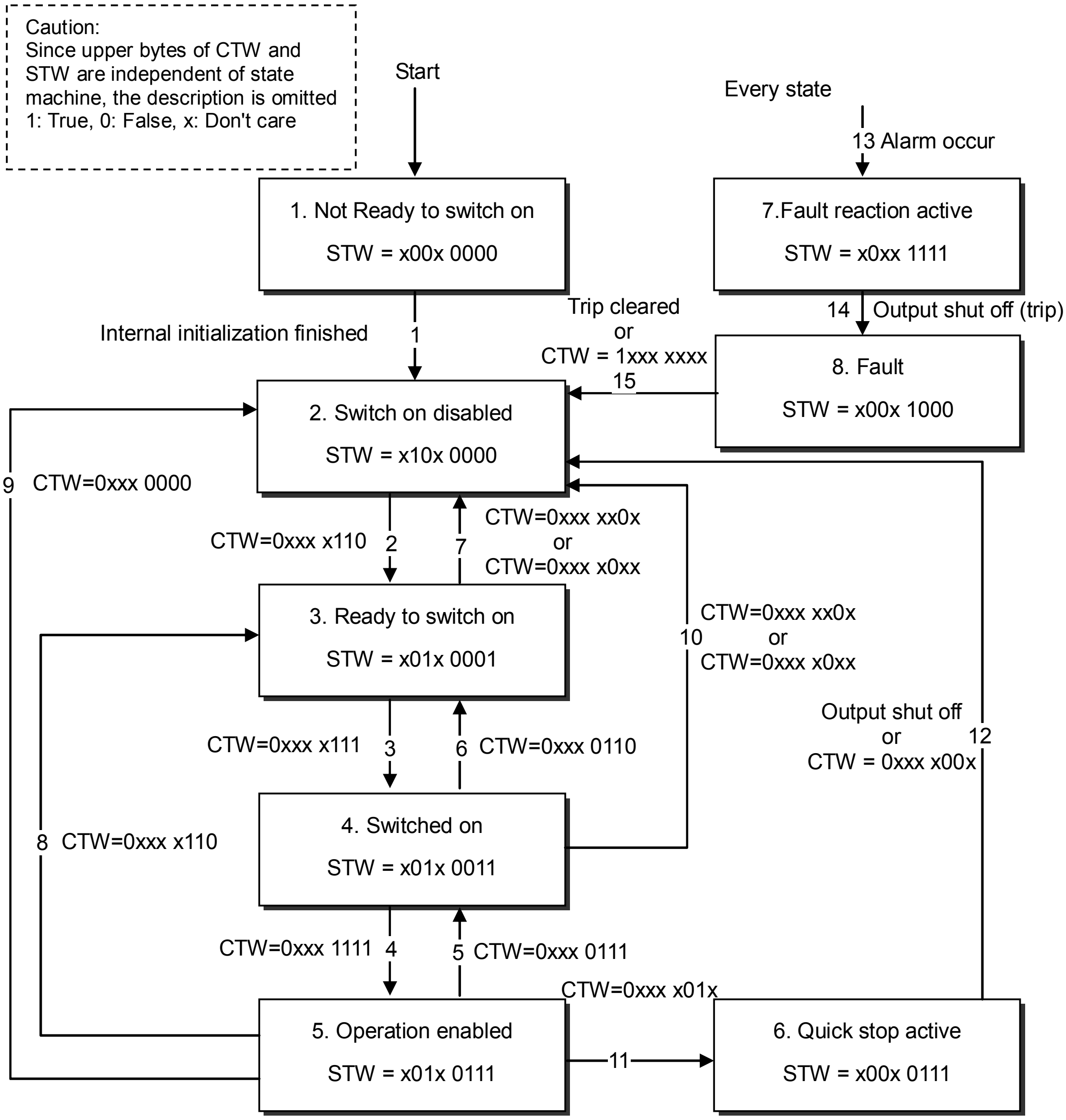


Figure 9.2.10-1 State machine

Table 9.2.10-1 Correspondence of the states of state machine and inverter

State No.	Name	State of inverter
1	Not Ready to switch on	Initializing the CANopen
2	Switch on disabled	Inverter's alarm cleared
3	Ready to switch on	Inverter output shut off
4	Switched on	Inverter stopped (running command OFF)
5	Operation enabled	Inverter running (running command ON)
6	Quick stop active	Inverter stopped urgently (for the time set in Index 604A)
7	Fault reaction active	Alarm detected
8	Fault	Inverter tripping

(4) Communication example

This section describes the communication example when running the inverter by controlling the DSP 402 state machine. In the description, PDO No.2 is used. Besides, the following conditions are assumed:

- Node ID of inverter (inverter function code y21 / o31 of this communication card) =1
- Transmission PDO Nos. 1 and 3 are invalid.
  That is, Index 1800 sub1=0x80000181, Index 1802 sub1=0x80000381
- Other CANopen's objects are set to default
- Inverter function code y98 =3

The format of PDO No.2 is as follows:

■ Reception PDO (from master to inverter)

COB-ID	Byte0	Byte1	Byte2	Byte3
0x301	Controlword (L byte)	(H byte)	vl_target_velocity (L byte)	(H byte)

■ Transmission PDO (from inverter to master)

COB-ID	Byte0	Byte1	Byte2	Byte3
0x281	Statusword (L byte)	(H byte)	vl_control_effort (L byte)	(H byte)

1) If Start_Remote_Node service is received, the inverter moves to Operational state to enable the PDO communication. At the same time as the state change, the transmission PDO No.2 responds as follows: The lower byte of Statusword (Byte0, 1) = 50 indicates that the state machine is in the state 2.

Transmission PDO (from inverter to master)

COB-ID	Byte0	Byte1	Byte2	Byte3
0x281	50	02	00	00

2) Here, change the state from 2 to 3. Transmit the data below to Controlword (Byte0, 1).

Reception PDO (from master to inverter)

COB-ID	Byte0	Byte1	Byte2	Byte3
0x301	06	00	00	00

As shown above, the transmission PDO responds as follows. The lower byte of Statusword (Byte0, 1) = 31 indicates that the state is 3.

Transmission PDO (from inverter to master)

COB-ID	Byte0	Byte1	Byte2	Byte3
0x281	31	02	00	00

3) Next, change the state from 3 to 4. Transmit the data below to Controlword (Byte0, 1).

Reception PDO (from master to inverter)

COB-ID	Byte0	Byte1	Byte2	Byte3
0x301	07	00	00	00

As shown above, the transmission PDO responds as follows. The lower byte of Statusword (Byte0, 1) = 33 indicates that the state is 4.

Transmission PDO (from inverter to master)

COB-ID	Byte0	Byte1	Byte2	Byte3
0x281	33	02	00	00

4) Issue the change of the state from 4 to 5 (normal rotation command) and a speed command. The speed command enters 1800 r/min (=0x0708) into vl_target_velocity (Byte2, 3).

Reception PDO (from master to inverter)	COB-ID	Byte0	Byte1	Byte2	Byte3
	0x301	0 F	00	08	07

Thus, the inverter enters into running state and starts to raise to 1800 r/min. The lower byte of Statusword (Byte0, 1) = 37 indicates that the state is 5. Also, since the value in the speed monitor vl_control_effort (Byte2, 3) changes during the acceleration, the inverter transmits the data below continuously until it reaches the speed.

Transmission PDO (from inverter to master)	COB-ID	Byte0	Byte1	Byte2	Byte3
	0x281	37	02	**	**

5) To stop the inverter, change the state from 5 to 4.

Reception PDO (from master to inverter)	COB-ID	Byte0	Byte1	Byte2	Byte3
	0x301	07	00	08	07

As shown above, the inverter is decelerated. The lower byte of Statusword (Byte0, 1) = 33 indicates that the state is 4. Also, since the value in the speed monitor vl_control_effort (Byte2, 3) changes during the acceleration, the inverter transmits the data below continuously until it stops.

Transmission PDO (from inverter to master)	COB-ID	Byte0	Byte1	Byte2	Byte3
	0x281	33	02	**	**

[2] Operation according to the inverter function code S06

Note Important: In order to enable the running command with S06, it is necessary to meet all conditions below:
- Both reception PDO Nos. 1 and 2 are invalid.
  That is, Index 1400 sub1=0x80000xxx, Index 1401 sub1=0x80000xxx
- The DSP 402 state machine is in the state 2.
- The inverter function code y98 = 2 or 3.

(1) Related object list

Index (Hex)	Sub	Name	Description	Data type	Access
5F02	07	Inverter function code S06	Running command (note)	UNSIGNED16	RW
5F03	0 F	Inverter function code M14	Running status monitor	UNSIGNED16	R
5F02	06	Inverter function code S05	Frequency command (unit: 0.01 Hz)	INTEGER16	RW
5F03	0A	Inverter function code M09	Output frequency monitor (unit: 0.01 Hz)	INTEGER16	R

Note The inverter operation with S06 does not follow the DSP 402 state machine. Therefore, Statusword does not indicates the inverter's status. Use M14.

Tip PDO No.3 is useful for the operation with S06. For information about PDO No.3, refer to “9.2.5 PDO Protocol”.

(2) Description of related object

■ Function code S06 only for the inverter communication

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
-	X5	X4	X3	X2	X1	REV	FWD

bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8
RST	XR	XF	0	0	0	0	0

bit 0 FWD: 1= normal rotation command

bit 1 REV: 1= reverse rotation command

bits 2 to 10, X1 to X5: Communication control input terminal (FRENIC-Ace supports X1 to X5)

bits 13, 14, XF, XR: Communication control input terminal, XF (FWD) terminal, XR (REV) terminal

bit 15 RST: Change value 0 to 1 for the bit to release the trip

■ Function code M14 only for the inverter communication

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
VL	TL	NUV	BRK	INT	EXT	REV	FWD

bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8
BUSY	0	0	RL	ALM	DEC	ACC	IL

bit 0 FWD: 1= normal rotating

bit 1 REV: 1= reverse rotating

bit 2 EXT: 1= DC braking or pre-exciting

bit 3 INT: 1= inverter shut off

bit 4 BRK: 1= braking

bit 5 NUV: 1= DC link established

bit 6 TL: 1= torque limiting

bit 7 VL: 1= voltage limiting

bit 8 IL: 1= current limiting

bit 9 ACC: 1= accelerating

bit 10 DEC: 1= decelerating

bit 11 ALM: 1= batch alarm

bit 12 RL: 1= valid communication

bit 15 BUSY: 1= function code writing

■ Function code S05 only for the inverter communication

Issue a frequency command on a 0.01 Hz basis. Setting range: -327.68 Hz to 327.67 Hz

■ Function code M09 only for the inverter communication

Displays the current output frequency on a 0.01 Hz basis. Output range: -327.68 Hz to 327.67 Hz

(3) Communication example

This section describes the communication example when running the inverter by using S06. In the description, PDO No.3 is used. Besides, the following conditions are assumed:

- Node ID of inverter (y21 o31 of this communication card) =1
- Mapping of PDO No.3

  y25 / o40=0206 (write function code 1=S06) y29 / o48=030E (read function code 1=M14)

  y26 / o41=0205 (write function code 2=S05) y30 / o49=0309 (read function code 2=M09)

  y27 / o42=0000 (write function code 3=none) y31 / o50=0000 (read function code 3=none)

  y28 / o43=0000 (write function code 4=none) y32 / o51=0000 (read function code 4=none)
- Reception PDO Nos. 1 and 2 are invalid.

  That is, Index 1400 sub1=0x80000201, Index 1401 sub1=0x80000301
- Transmission PDO Nos. 1 and 2 are invalid.

  That is, Index 1800 sub1=0x80000181, Index 1801 sub1=0x80000281
- Other CANopen's objects are set to default
- Inverter function code y98 =3

The format of PDO No.3 mapped above is as follows:

■ Reception PDO (from master to inverter)

COB-ID	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x401	S06 (L byte) (H byte)		S05 (L byte) (H byte)		Terminal command assigned Disable		Terminal command assigned Disable	

■ Transmission PDO (from inverter to master)

COB-ID	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x381	M14 (L byte) (H byte)		M09 (L byte) (H byte)		Terminal command assigned Disable		Terminal command assigned Disable	

1) If Start_Remote_Node service is received from, the inverter moves to Operational state (RUN LED lights up in green) to enable the PDO communication. At the same time as the state change, the transmission PDO No.3 responds as follows:

Transmission PDO (from inverter to master)	COB-ID	Byte0	Byte1	Byte2	Byte3	Bytes 4 to 7
	0x381	28	10	00	00	00000000

2) In this case, S06=1 (FWD=1) as a running command and S05=50.00 Hz (=0x1388) as a frequency command are transmitted.

Reception PDO (from master to inverter)	COB-ID	Byte0	Byte1	Byte2	Byte3	Bytes 4 to 7
	0x401	01	00	88	13	00000000

Thus, the inverter enters into a running state. The transmission PDO are as follows when the speed is reached:

Transmission PDO (from inverter to master)	COB-ID	Byte0	Byte1	Byte2	Byte3	Bytes 4 to 7
	0x381	21	10	88	13	00000000

3) To stop the inverter, transmit S06=0 (FWD=0).

Reception PDO (from master to inverter)	COB-ID	Byte0	Byte1	Byte2	Byte3	Bytes 4 to 7
	0x401	00	00	88	13	00000000

The FWD OFF command lets the inverter decelerate. After the stop, the transmission PDO responds as follows.

Transmission PDO (from inverter to master)	COB-ID	Byte0	Byte1	Byte2	Byte3	Bytes 4 to 7
	0x381	28	10	00	00	00000000

4) To run the inverter in reverse, transmit S06=2 (REV=1).

Reception PDO (from master to inverter)	COB-ID	Byte0	Byte1	Byte2	Byte3	Bytes 4 to 7
	0x401	02	00	88	13	00000000

Thus, the inverter enters into a reverse running state. The responses are as follows when the speed is reached:

Transmission PDO (from inverter to master)	COB-ID	Byte0	Byte1	Byte2	Byte3	Bytes 4 to 7
	0x381	22	10	88	13	000000 00

9.2.11 Heartbeat and Node Guarding

The Heartbeat and Node Guarding services are provided for detecting disconnection. We recommend you to use either one.

⚠CAUTION
Important: The use of either Heartbeat or Node Guarding is recommended The setting for detecting disconnection in the CANopen device is invalid by default. Unless the setting is enabled, the CANopen network including inverter can not detect a disconnection even if the disconnection occurs. We strongly recommend to enable the setting.

[1] Heartbeat

Heartbeat is to detect the disconnection in the CANopen network by monitoring the signals from the specified node.

For more information about detailed behavior of Heartbeat, refer to the CANopen specifications DS 301.

Note: Do not use both Heartbeat and Node Guarding at the same time. If they are used at the same time, the disconnection is not detected properly. To use Heartbeat, make Node Guarding invalid, that is, set Index 100C=0 and Index 100D=0 (refer to 9.2.11 [2]).

(1) Related object list

Index (Hex)	Sub	Name	Description	Data type	Access
1016	-	Consumer heartbeat time		ARRAY	-
	0	Number of entries	Number of configurations: 1	UNSIGNED8	R
	1	Consumer heartbeat time	Upper word: Node ID to be monitored Lower word: Heartbeat monitoring time Default value: 0 (no operation)	UNSIGNED32	RW
1017	-	Producer heartbeat time	Transmission cycle of Heartbeat message Default value: 0 (no operation)	UNSIGNED16	RW

(2) Consumer heartbeat time

Monitors whether the Heartbeat signals are received from the specified node ID (Heartbeat producer) at a preset interval. The format is as follows: If the Heartbeat signal can not be received over monitoring time, the disconnection is deemed to occur.

For information on the behavior upon the CANopen disconnection, refer to 9.2.12 “Behavior upon detection of CANopen network disconnection”.

Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0000		Node ID to be monitored		Heartbeat monitoring time (ms)			

(3) Producer Heartbeat time

Automatically transmits the Heartbeat signals continuously at the preset interval (on a 1 ms basis). Other node (Heartbeat consumer) monitors this Heartbeat signals.

[2] Node Guarding

Node Guarding is a scheme to detect disconnections by monitoring the guarding signals periodically sent from the master.

🕮 For more information about detailed behavior of Node Guarding, refer to the CANopen specifications DS 301.

Note: Do not use both Heartbeat and Node Guarding at the same time. If they are used at the same time, the disconnection is not detected properly. To use Node Guarding, make Heartbeat invalid, that is, set Index 1016=0 and Index 1017=0 (refer to 9.2.11 [1]).

(1) Related object list

Index (Hex)	Sub	Name	Description	Data type	Access
100C	-	Guard time	Guarding reception cycle setting (ms) Default value: 0 (no operation)	UNSIGNED16	RW
100D	-	Life time factor	Guarding time coefficient Default value: 0 (no operation)	UNSIGNED8	RW

(2) Guard time and Life time factor

Sets the receive interval of Guarding signals from the master. If the Guarding signal can not be received over preset receiving time, the disconnection is deemed to occur.

Set the receive interval in the equation below:

Guarding receive interval (ms) = Guard time (ms) × Life time factor

Example: Guard time=100ms, Life time factor =5:

Guarding receive interval (ms) = 100 ms × 5 = 500 ms

🕮 For information on the behavior upon the CANopen disconnection, refer to 9.2.12 “Behavior upon detection of CANopen network disconnection”.

9.2.12 Behavior upon detection of CANopen network disconnection

The inverter function codes y34 / o27 y35 / and o28 set up the behavior (Table 9.2.12-1) when the inverter detects the disconnection of the CANopen network.

Note that the inverter determines under the conditions below that a disconnection occurred:

- Consumer heartbeat or Node Guarding detect the disconnection.
- The bus-off occurs in CAN

📖 For more information about Heartbeat consumer or Node Guarding, refer to "9.2.11 Heartbeat and Node Guarding".

Table 9.2.12-1 Behavior setting upon detection of CANopen network disconnection (y34 / o27, y35 / o28)

y34 / o27	y35 / o28	Behavior upon disconnect detection	Remarks
0, 4 to 9	Invalid	Immediately coast to stop & trip, Er-5	
1	0.0 s to 60.0 s	After the lapse of the time specified by y35 / o28, coast to stop, Er-5.	
2	0.0 s to 60.0 s	If data is input within the time specified by y35 / o28, ignore the error. Time over and coast to stop, Er-5.	
3, 13 to 15	Invalid	Keep the current operation, ignoring the communication error. (Er-5.)	If a communication error is detected, LED indicates a communication error.
10	Invalid	Immediately decelerate to a stop. Er-5 after stop.	The forcible deceleration time depends on the inverter function code F08.
11	0.0 s to 60.0 s	After the lapse of the time specified by y35 / o28, decelerate to a stop, resulting in Er-5.	ditto
12	0.0 s to 60.0 s	If data is input within the time specified by y35 / o28, ignore the error. If the time is over, decelerate to a stop, resulting in Er-5.	Same as above

9.2.13 Alarm code list

There are following two ways to read alarm codes via CANopen when the inverter trips.

1. Read the alarm code defined in CANopen from Index 1003 sub1 Standard error field or Index 603F Error code

   For reference: When an alarm on occurs, EMCY message is automatically sent to the CANopen master (see 9.2.7) and the alarm code is written into Index 1003 sub1 Standard error field and Index 603F Error code. However, since the EMCY message is not held, the message can not be read afterward.

2. Use the inverter function codes M16, M17, M18, and M19 to read the alarm codes (latest, first, second, and third most recent alarm codes)

The TableTable 9.2.13-1 lists the alarm codes:

Table 9.2.13-1 Alarm code list

Alarm code		Content	Display	Alarm code		Content	Display
Error field	M16 to M19			Error field	M16 to M19		
0000	0 (00_H)	No alarm	– – –	7310	27 ($1B_H$)	Overspeed protection	OS
2310	1 (01_H)	Over current (accelerating)	OC1	7301	28 ($1C_H$)	PG disconnection	PG
2310	2 (02_H)	Over current (decelerating)	OC2	7300	29 ($1D_H$)	NTC thermistor disconnected	nrb
2310	3 (03_H)	Over current (constant rate)	OC3	5500	31 ($1F_H$)	Memory error	Er1
2120	5 (05_H)	Ground fault	EF	7520	32 (20_H)	Communication error for the keypad	Er2
3210	6 (06_H)	Overvoltage (accelerating)	OU1	5220	33 (21_H)	CPU error	Er3
3210	7 (07_H)	Overvoltage (decelerating)	OU2	7510	34 (22_H)	Communication card hardware error	Er4
3210	8 (08_H)	Overvoltage (constant rate or stopping)	OU3	8100	35 (23_H)	Option error	Er5
3220	10 ($0A_H$)	Undervoltage	LU	F004	36 (24_H)	Operation error	Er6
3130	11 ($0B_H$)	Open input phase	Lin	7200	37 (25_H)	Tuning error	Er7
5450	14 ($0E_H$)	Fuse disconnection	FUS	7510	38 (26_H)	RS-485 communication error (COM port 1)	Er8
5440	16 (10_H)	Charging circuit error	PbF	3300	46 ($0E_H$)	Open output phase	OPL
4210	17 (11_H)	Heat sink overheat	OH1	8400	47 ($2F_H$)	Speed mismatch (excessive speed deviation)	ErE
9000	18 (12_H)	Enable external alarm trip	OH2	3221	51 (33_H)	Data save error during undervoltage	ErF
4210	19 (13_H)	Inverter internal overheat	OH3	7510	53 (35_H)	RS-485 communication error (COM port 2)	ErP
4310	20 (14_H)	Motor protection (PTC/NTC thermistor)	OH4	8100	54 (36_H)	Hardware error	ErH
4210	22 (16_H)	Braking resistor overheat	dbH	8100	55 (37_H)	CAN communication error	Ert
4310	23 (17_H)	Overload of motor 1	OL1	7200	58 ($3A_H$)	PID feedback wire break	CoF
4310	24 (18_H)	Overload of motor 2	OL2	5400	59 ($3B_H$)	Braking transistor broken	dbA
4110	25 (19_H)	Inverter overload	OLU				
FF00	254 (FEH)	Mock alarm	Err				
8110	---	CAN overrun (Note)	– – –				
8120	---	CAN error passive (Note)	– – –				
8130	---	guarding error or hard beat error (CANopen communication disconnect detection) (Note)	– – –				
8140	---	Recovery from CAN bus-off (Note)	– – –				

Note: After this error occurred, the inverter generates *er5* according to the y34 / o27 setting.

9.2.14 Other points to note

Here, lists the points to note when using the CANopen communication:

(1) Avoid setting Transmission type 255 for the transmission PDO Nos. 2 and 3 at the same time (transmitted each time the data changes) and setting Inhibit time to zero. The CANopen communication traffic rises due to the frequency of the data change so that intended feature can not be met. Reduce either one of transmission frequency (set larger Inhibit time, use Sync signal, etc.)

(2) The resolution of the timer is 2 ms. Consequently, if odd timer value is set for the object whose timer can be set, the value is moved forward. For example, if the timer is set to 21 ms, the value is assumed to be 22 ms.

(3) To cancel the auto-tuning (writing data into the inverter function code P04 and A18) over the CANopen communication, write zero into each inverter function code.

(4) If the same object is mapped in the same RPDO, the information mapped later will be valid.

Example: If CTW is mapped in all elements of RPDO1, only the last data is valid.

6040	6040	6040	6040
Invalid	Invalid	Invalid	Valid

(5) Relationship between 6043 and 6044 in TPDO

- The simultaneity of numeric value is not guaranteed in order to poll internal data.
- Since 6043 is a request and 6044 is a feedback, in order to use the numeric value simply, it is recommended to map in order of 6043 and 6044.

9.2.15 Keypad LED operation monitor "3_40"

The status of CAN communication is displayed in the LED operation monitor item "3_40" in the keypad.

Display item	CANopen state	LED Display	Data
3_40	No-operation state (no operation is selected)	----	0
	"Stop" state	CStP	1
	"Pre-Operational" state	Crdy	2
	"Operational" state	CoPt	3

9.3 FRENIC loader overview

FRENIC Loader is a software tool that supports the operation of the inverter via an RS-485 communication.

This software allows you to edit, set, and manage the inverter function codes, monitor running data, and remotely operate the operation and stop, as well as monitor the running status and alarm history.

Note: With special order-made inverters, FRENIC Loader may not be able to display some function codes normally.

📖 For details, refer to the FRENIC Loader Instruction Manual.

9.3.1 Modes

Item		Modes	Remarks
Name		Inverter support loader (FRENIC loader)	
Supported inverter		FRENIC-MEGA/Multi/Eco/Mini	(Note 1)
Number of connected inverters		USB connection: 1 RS-485 connection: Up to 31	
Recommended cable		Cable (10BASE-T or more) compliant with EIA568 RJ-45 connector	For the RS-485 interface
Operating environment	CPU	Intel Pentium III 600 MHz or later	(Note 2)
	OS	Microsoft Windows XP (32 bit) Microsoft Vista (32 bit) Microsoft 7 (32 bit, 64 bit)	(Note 3)
	Memory	RAM area with 512 MB or more	1GB or more is recommended.
	Hard disk	20 MB or more of empty area	
	COM port	RS-232C (conversion to RS-485 communication is required to connect inverters) or USB	
	Monitor	800 x 600 or higher	XGA (1024×768) 32 bit Color or more monitor is recommended.
Transmission requirements	COM port	COM1 to COM255	PC COM ports assigned to Loader
	Transmission speed	USB connection: Between loader and keypad = fixed at 12 Mbps Between keypad and inverter = fixed at 19200 (bps) RS-485 connection: 38400, 19200, 9600, 4800, 2400 (bps)	19200 bps or more is recommended (Note 4)
	Character length	8 bit	Prefixed
	Stop bit length	1 bit	Prefixed
	Parity	Even	Prefixed
	No. of retries	None or 1 to 10	No. of retry times before detecting communication error
	Timeout setting	100 ms, 300 ms, 500 ms, 1.0 s to 1.5 s to 1.9 s, 2.0 to 9.0 s, 10.0 to 60.0 s	Set longer than the “Response interval time y09”

Note 1: The loader model is unavailable which does not support the protocol for loader commands (SX protocol).

Note 2: Use a PC with as high a performance as possible, since some slow PCs may not properly refresh the operation monitoring and test-running windows.

Note 3: Only Microsoft Windows XP service pack 2 (SP2) or more is supported.

Note 4: To connect to the network where there is a FRENIC-Mini inverter, choose 19200 bps or below.

9.3.2 Connection

By connecting a number of inverters to one PC, you can control one inverter at a time or a number of inverters simultaneously. You can also simultaneously monitor a number of inverters on the multi monitor.

📖 For how to connect a PC to one or more inverters, refer to the RS-485 Communication User's Manual (MEH448).

9.3.3 Function overview

[1] Configuring inverter's function code

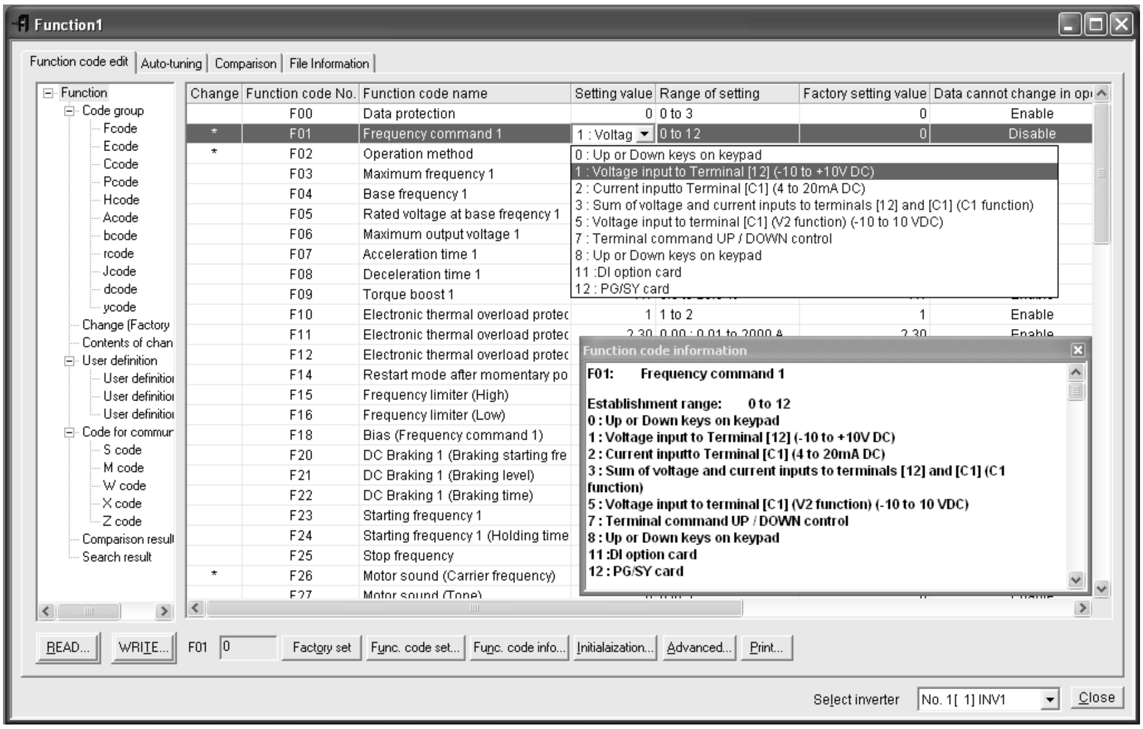
You can set, edit, and check the setting of the inverter’s function code data.

<u>List and Edit</u>

In List and edit, you can list and edit function codes with function code No., name, set value, set range, and factory default.
You can also list function codes by any of the following groups according to your needs:

- Function code group
- Function codes that have been modified from their factory defaults
- Result of comparison with the settings of the inverter
- Result of search by function code name
- User-specified function code set

etc.



Comparison

You can compare the function code data currently being edited with that saved in a file or stored in the inverter.

To perform a comparison and review the result displayed, click the Comparison tab and then click the Compared with inverter tab or click the Compared with file tab, and specify the file name.

The result of the comparison will be displayed also in the Comparison Result column of the list.

File information

Clicking the File information tab displays the property and comments for identifying the function code editing file.

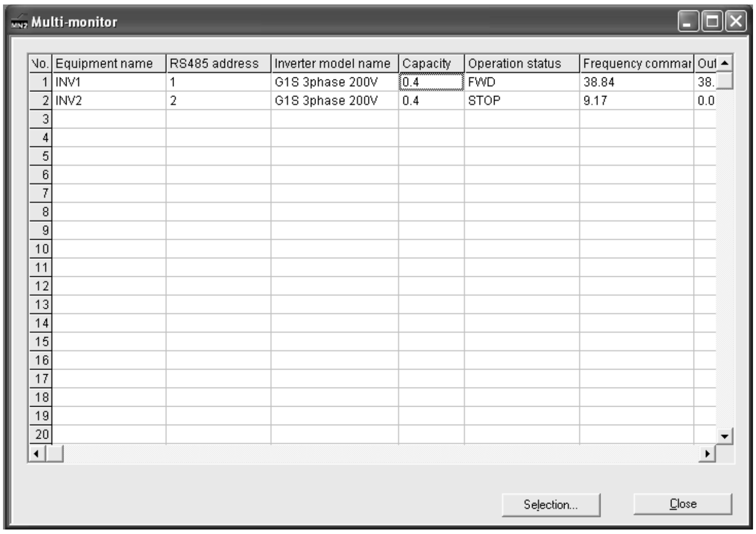
(1) Property
Shows file name, inverter model, inverter's capacity, date of readout, etc.

(2) Comment
Displays the comments you have entered. You can write any comments necessary for identifying the file.

[2] Multi-monitor

This feature lists the status of all the inverters that are marked "connected" in the configuration table.

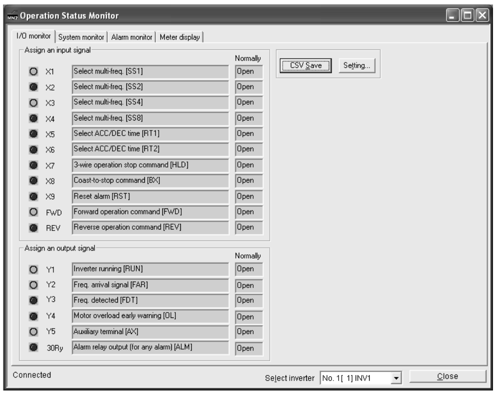
Multi-monitor
Allows you to monitor the status of more than one inverter in a list format.



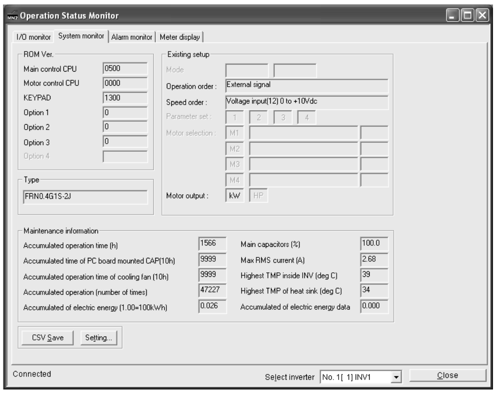
[3] Running status monitor

The running status monitor offers four monitor functions: I/O monitor, System monitor, Alarm monitor, and Meter display. You can choose an appropriate monitoring format according to the purpose and situation.

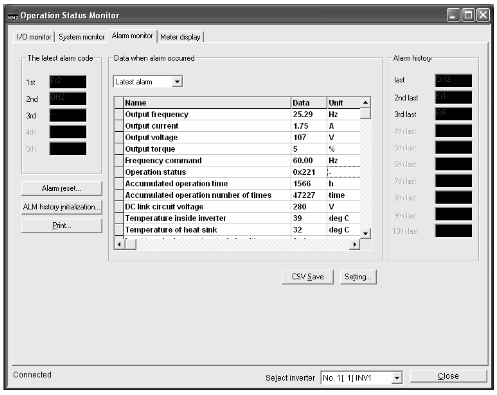
<u>I/O monitor</u>
Allows you to monitor the ON/OFF states of the digital input signals to the inverter and the transistor output signals.



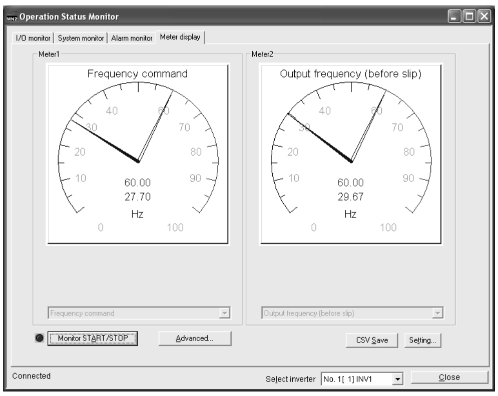
<u>System monitor</u>
The inverter's system information (version, type, maintenance information, etc.) can be confirmed.



<u>Alarm monitor</u>
The alarm monitor shows the alarm status of the selected inverter. In this window you can check the details of the alarm currently occurs and related information.



<u>Meter display</u>
Displays analog readouts of the selected inverter (such as output frequency) on analog meters. The example on the right displays the reference frequency and the output frequency.



[4] Test-running

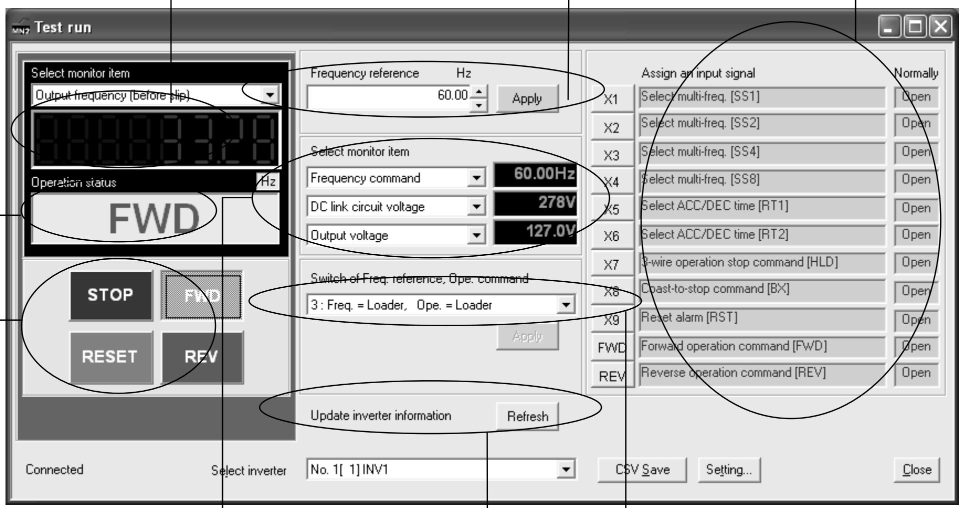
The Test-running feature allows you to test-run the motor in the forward or reverse direction while monitoring the running status of the selected inverter.

Operation status
Shows FWD, REV, STOP and alarm codes.

Select monitor item
Select what is to be displayed (e.g., output frequency or current) here using the pull-down menu.

Frequency command
(updated)
Transmits the frequency entered to the inverter

I/O terminal status
Shows the status of the programmable digital I/O terminals of the inverter.



Operation buttons
*

Select monitor item
Select the operation status information to be monitored in real-time.

Update with latest inverter information
(updated)
Click the Refresh button to refresh the contents of this window to show the latest inverter status.

Switch the frequency and running commands
(updated)
Select the frequency and run command sources and click Apply.

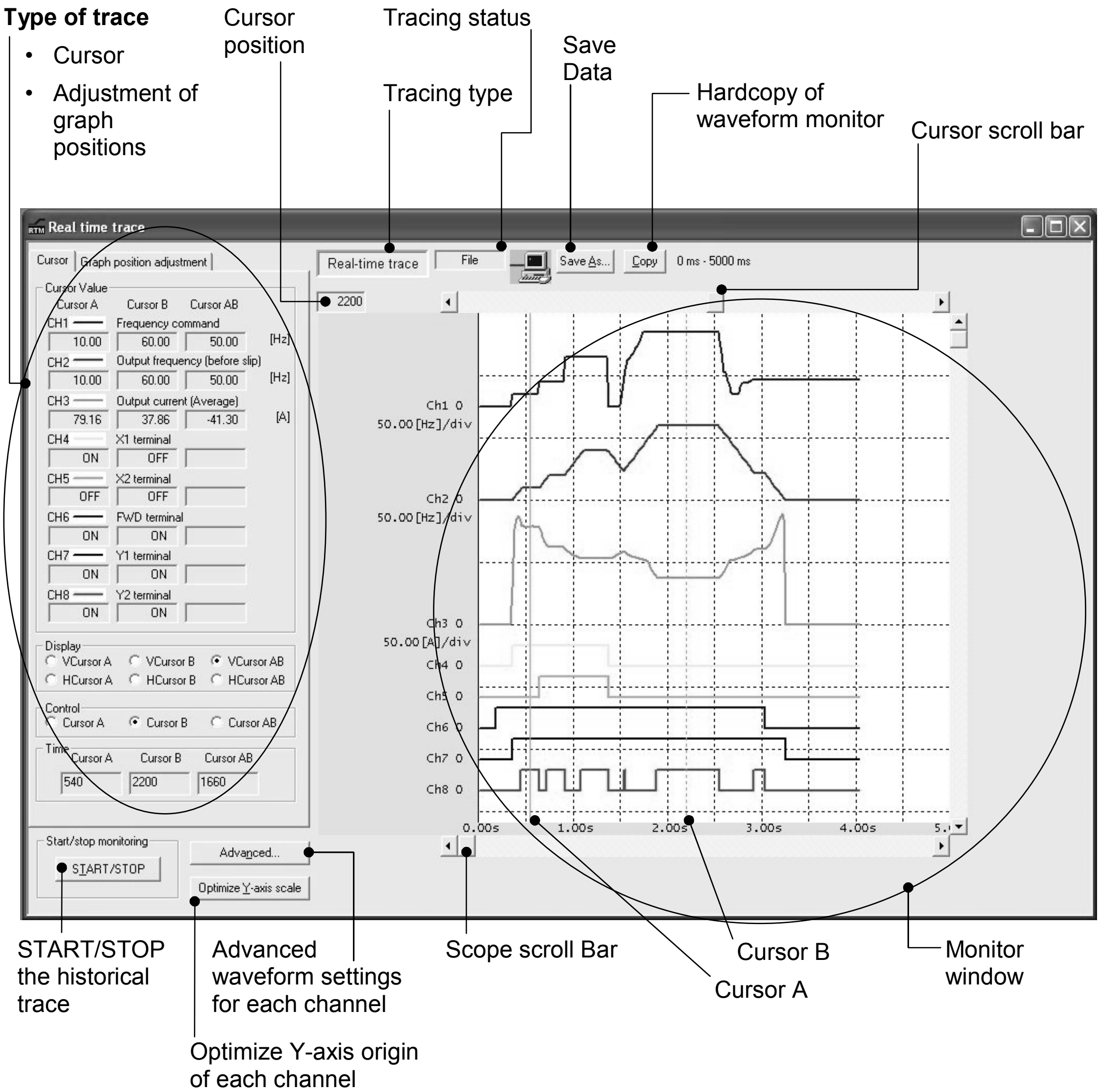
*: The table below lists the details of the operation buttons.

Button	Functionality
STOP	Stop the motor.
FWD	The motor runs in the normal rotation. (depressed state indicates running state.)
REV	The motor runs in the reverse rotation. (depressed state indicates running state.)
RESET	Reset all alarm information saved in the selected inverter.

[5] Real-time trace

When continuously observing the running state of inverters while the sampling time is fixed at 200 ms, up to 4 analog channels and up to 8 digital channels are available (up to 8 channels in total).

(Maximum waveform amount: 15360 sample/channel)



Note

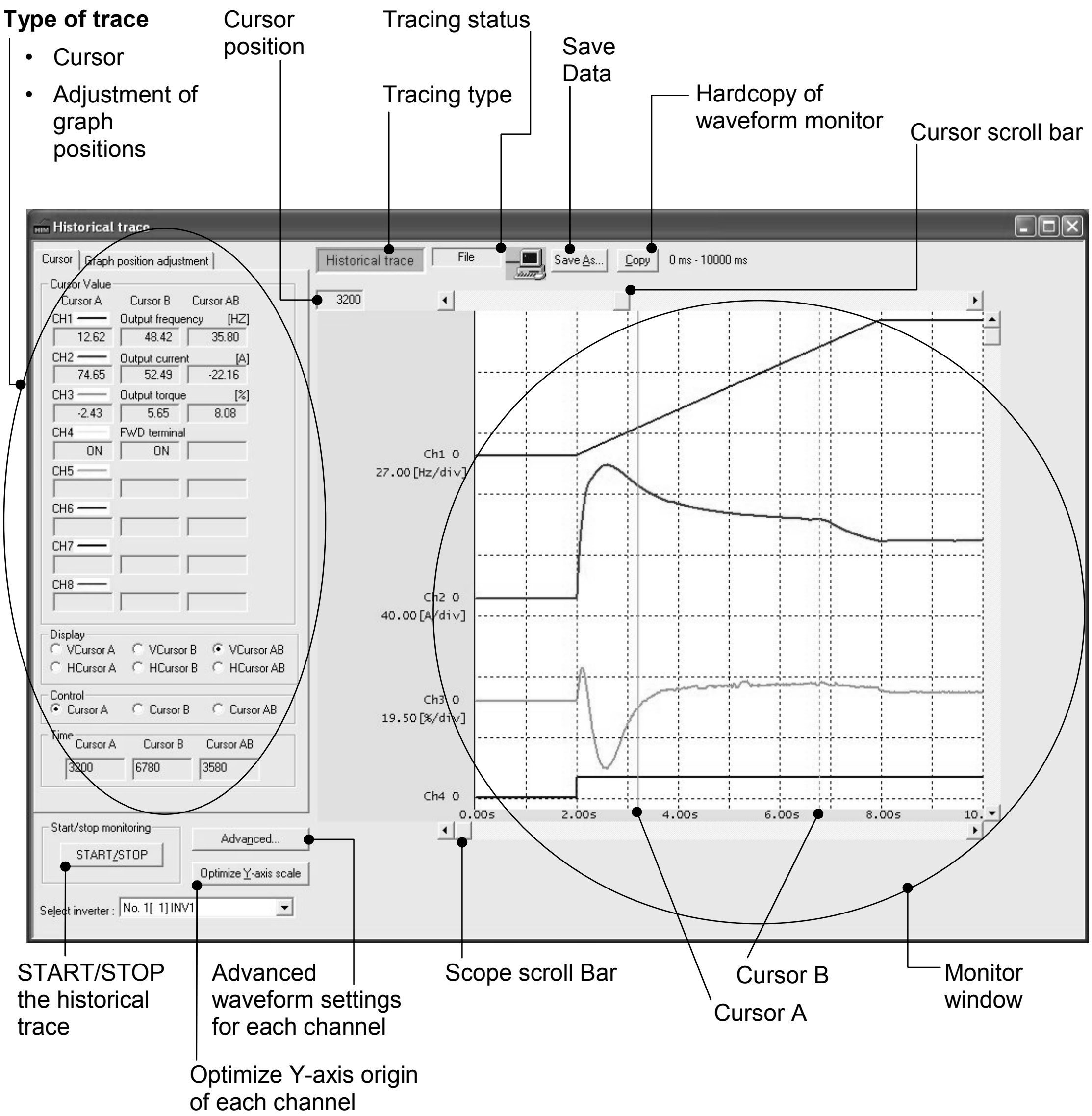
- The station No can not be changed while tracing waveforms real time.
- The detailed waveform can not be changed while tracing waveforms real time.
- Change the real time trace window to change the size of monitor window.
- The scrolling and cursor moving are unavailable in the waveform monitoring window while tracing waveforms real time.

[6] Historical trace

The sampling time can be selected between 1 ms to 200 ms. When observing the running state of inverters in much finer continuous waveforms than real-time trace, up to 4 analog channels and up to 8 digital channels are available (up to 8 channels in total).

- Number of pieces of saved data: 2 kbyte

(waveform capturing capability: Max. 500 sample/channel)



Note

- The station No can not be changed while tracing waveforms historically.
- The detailed waveform can not be changed while tracing waveforms historically.
- Change the historical trace window to change the size of monitor window.

Chapter 10

SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES

This chapter provides you with information about the inverter output torque characteristics, selection procedure, and equations for calculating capacities to help you select optimal motor and inverter models. It also helps you select braking resistors, inverter mode (ND, HD, HND, or HHD), and motor drive control.

Contents

Chapter 10 SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES

When selecting a general-purpose inverter, first select a motor and then inverter as follows:

(1) Key point for selecting a motor: Determine what kind of load machine is to be used, calculate its moment of inertia, and then select the appropriate motor capacity.

(2) Key point for selecting an inverter: Taking into account the operation requirements (e.g., acceleration time, deceleration time, and frequency in operation) of the load machine to be driven by the motor selected in (1) above, calculate the acceleration/deceleration/braking torque.

This section describes the selection procedure for (1) and (2) above. First, it explains the output torque characteristics obtained by using the motor driven by the inverter (FRENIC-Ace).

10.1 Motor Output Torque Characteristics

Figures 10.1-1 and 10.1-2 graph the output torque characteristics of motors at the rated output frequency individually for 50 Hz and 60 Hz base. The horizontal and vertical axes show the output frequency and output torque (%), respectively. Curves (a) through (f) depend on the running conditions.

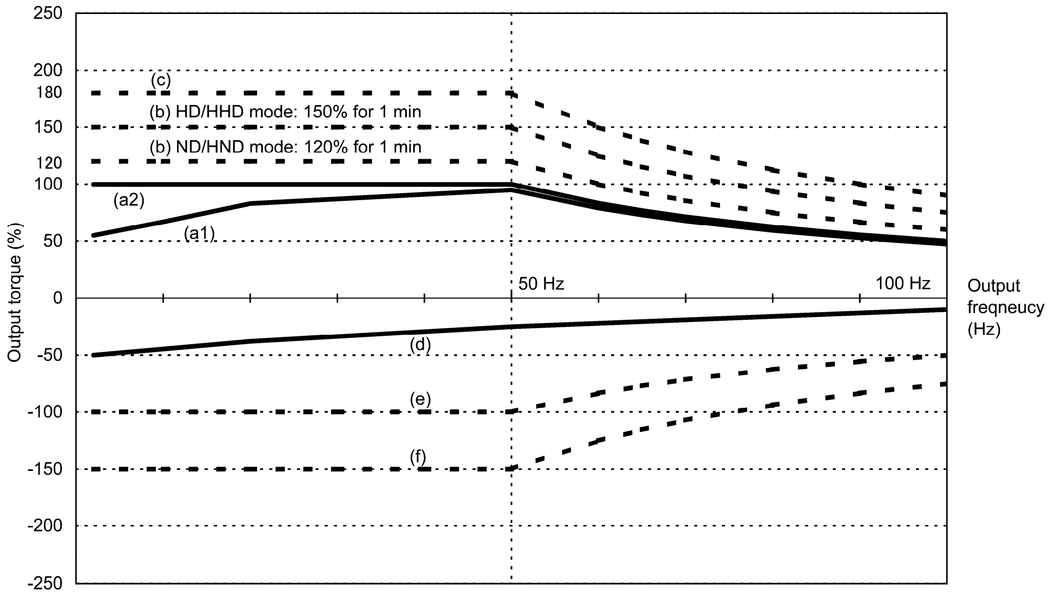


Figure 10.1-1 Output Torque Characteristics (Base frequency: 50 Hz)

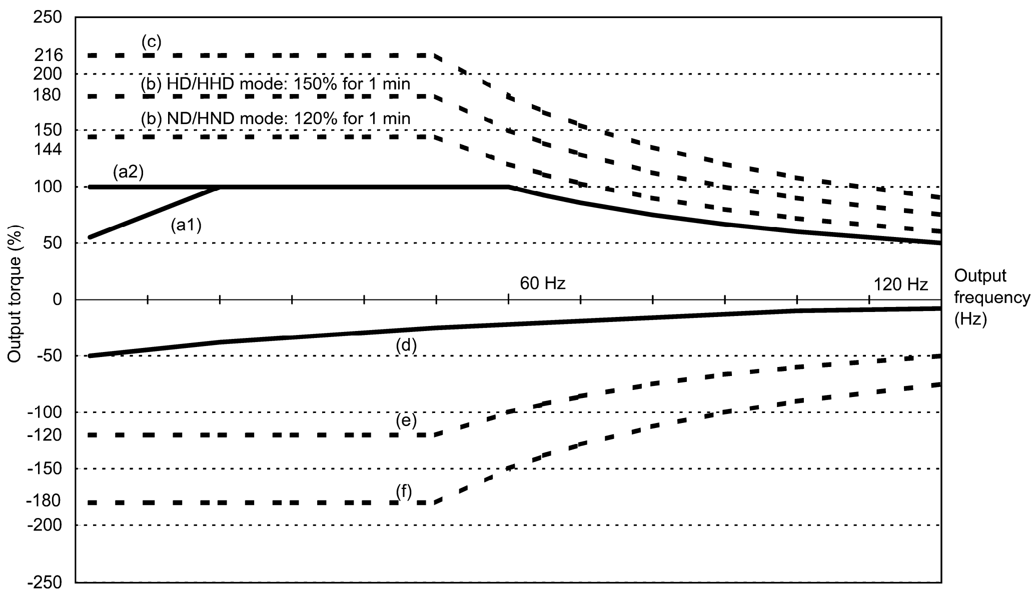


Figure 10.1-2 Output Torque Characteristics (Base frequency: 60 Hz)

(1) Continuous allowable driving torque

① Standard motor (Curve (a1) in Figures 10.1-1 and 10.1-2)

Curve (a1) shows the torque characteristic that can be obtained in the range of the inverter continuous rated current, where the standard motor's cooling characteristic is taken into consideration. When the motor runs at the base frequency of 60 Hz, 100 % output torque can be obtained; at 50 Hz, the output torque is somewhat lower than that in commercial power, and it further lowers at lower frequencies. The reduction of the output torque at 50 Hz is due to increased loss by inverter driving, and that at lower frequencies is mainly due to heat generation caused by the decreased ventilation performance of the motor cooling fan.

② Motor exclusively designed for vector control (Curve (a2) in Figures 10.1-1 and 10.1-2)

Curve (a2) shows the torque characteristic that can be obtained in the range of the inverter continuous rated current, where the motor exclusively designed for vector control is connected. In the motor exclusively designed for vector control, the attached forced-cooling fan reduces heat generation from the motor, so that the torque does not drop in the low-speed range, compared to the standard motor.

(2) Maximum driving torque in a short time (Curves (b) and (c) in Figures 10.1-1 and 10.1-2)

Curve (b) shows the torque characteristic that can be obtained in the range of the inverter overload capability in a short time (ND/HND mode: 120% for 1 minute, HD mode: 150% for 1 minute, HHD mode: 150% for 1 minute and 200% for 0.5 seconds) when torque-vector control is enabled. At that time, the motor cooling characteristics have little effect on the output torque.

Curve (c) shows an example of the torque characteristic when one class higher capacity inverter is used to increase the short-time maximum torque. In this case, the short-time torque is 20 to 30% greater than that when the standard capacity inverter is used.

(3) Starting torque (around the output frequency 0 Hz in Figures 10.1-1 and 10.1-2)

The maximum torque in a short time applies to the starting torque as it is.

(4) Braking torque (Curves (d), (e), and (f) in Figures 10.1-1 and 10.1-2)

In braking the motor, kinetic energy is converted to electrical energy and regenerated to the DC link bus capacitor (reservoir capacitor) of the inverter. Discharging this electrical energy to the braking resistor produces a large braking torque as shown in curve (e). If no braking resistor is provided, however, only the motor and inverter losses consume the regenerated braking energy so that the torque becomes smaller as shown in curve (d).

When an optional braking resistor is used, the braking torque is allowable only for a short time. Its time ratings are mainly determined by the braking resistor ratings. This manual and associated catalogs list the allowable values (kW) obtained from the average discharging loss and allowable values (kWs) obtained from the discharging capability that can be discharged at one time.

Note that the torque % value varies according to the inverter capacity.

Selecting an optimal brake unit enables a braking torque value to be selected comparatively freely in the range below the short-time maximum torque in the driving mode, as shown in curve (f).

📖 For braking-related values when the inverter and braking resistor are normally combined, refer to Chapter 11, Section 11.8 "Braking resistor (DBR) and braking unit."

10.2 Selection Procedure

Figure 10.2-1 shows the general selection procedure for optimal inverters. Items numbered (1) through (5) are described on the following pages.

You may easily select inverter capacity if there are no restrictions on acceleration and deceleration times. If "there are any restrictions on acceleration or deceleration time" or "acceleration and deceleration are frequent," then the selection procedure is more complex.

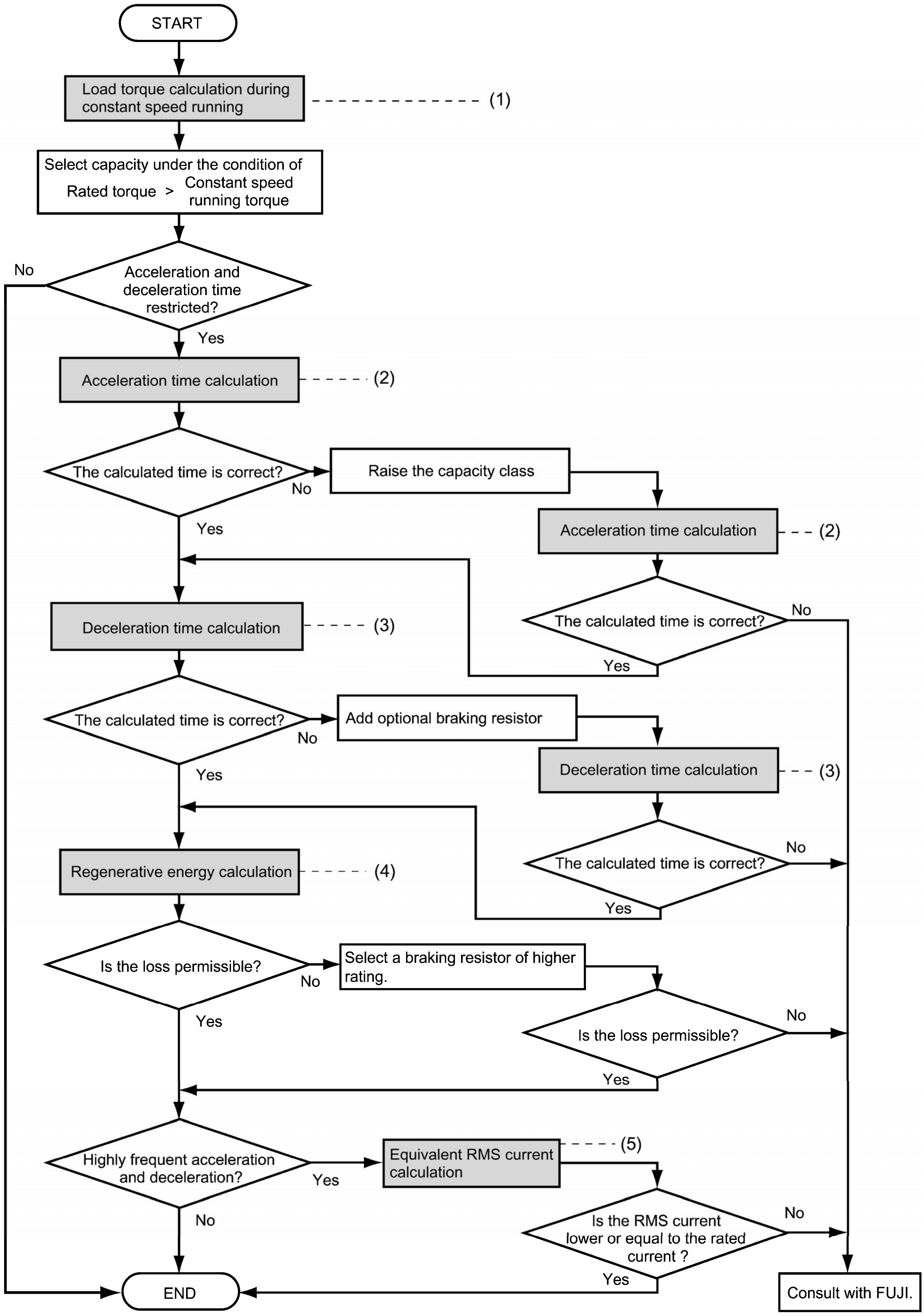


Figure 10.2-1 Selection Procedure

(1) Calculating the load torque during constant speed running (For detailed calculation, refer to Section 10.3.1.)

It is essential to calculate the load torque during constant speed running for all loads.

First calculate the load torque of the motor during constant speed running and then select a tentative capacity so that the continuous rated torque of the motor during constant speed running becomes higher than the load torque. To perform capacity selection efficiently, it is necessary to match the rated speeds (base speeds) of the motor and load. To do this, select an appropriate reduction-gear (mechanical transmission) ratio and the number of motor poles.

If the acceleration or deceleration time is not restricted, the tentative capacity can apply as a defined capacity.

(2) Calculating the acceleration time (For detailed calculation, refer to Section 10.3.2, [2].)

When there are some specified requirements for the acceleration time, calculate it according to the following procedure:

1) Calculate the **moment of inertia** for the load and motor
Calculate the moment of inertia for the load, referring to Section 10.3.2 "Acceleration and deceleration time calculation." For the moment of inertia for motors, refer to the related motor catalogs.

2) Calculate the **minimum acceleration torque** (See Figure 10.2-2.)
The acceleration torque is the difference between the motor short-time output torque (base frequency: 60 Hz) explained in Section 10.1 (2) "Maximum driving torque in a short time" and the load torque (τ_L / η_G) during constant speed running calculated in the above (1). Calculate the minimum acceleration torque for the whole range of speed.

3) Calculate the **acceleration time**
Assign the value calculated above to the equation (10.3.2-7) in Section 10.3.2 "Acceleration and deceleration time calculation" to calculate the acceleration time. If the calculated acceleration time is longer than the expected time, select the inverter and motor having one class larger capacity and calculate it again.

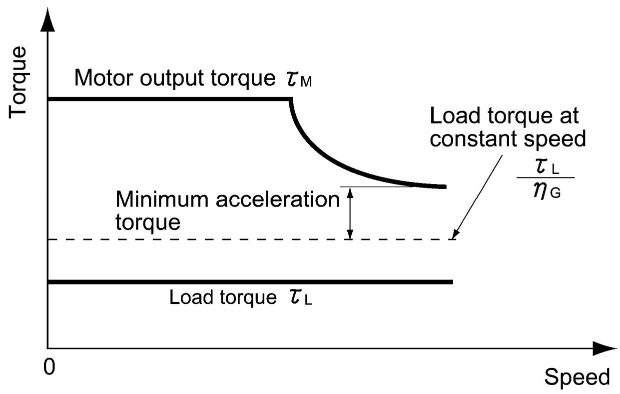


Figure 10.2-2 Example Study of Minimum Acceleration Torque

(3) Deceleration time (For detailed calculation, refer to Section 10.3.2, [3].)

To calculate the deceleration time, check the motor deceleration torque characteristics for the whole range of speed in the same way as for the acceleration time.

1) Calculate the **moment of inertia** for the load and motor
Same as for the acceleration time.

2) Calculate the **minimum deceleration torque** (See Figures 10.2-3 and 10.2-4.)
Same as for the deceleration time.

3) Calculate the **deceleration tim**e
Assign the value calculated above to the equation (10.3.2-8) to calculate the deceleration time in the same way as for the acceleration time. If the calculated deceleration time is longer than the requested time, select the inverter and motor having one class larger capacity and calculate it again.

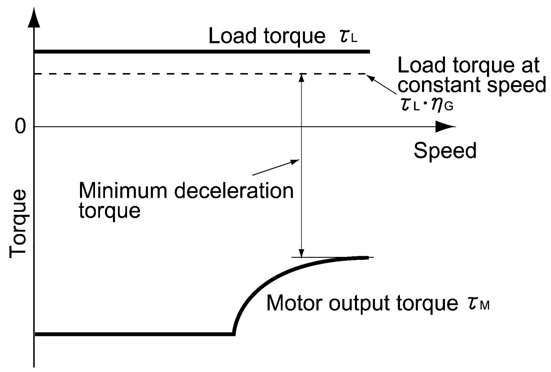


Figure 10.2-3 Example Study of Minimum Deceleration Torque (1)

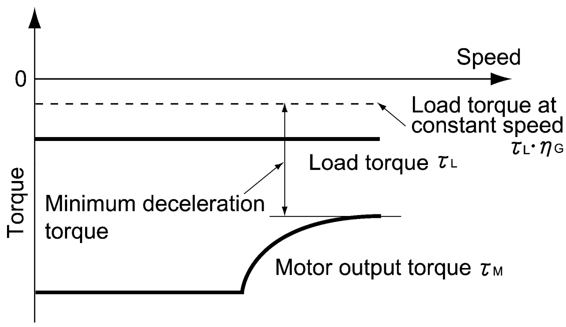


Figure 10.2-4 Example Study of Minimum Deceleration Torque (2)

(4) Braking resistor rating (For detailed calculation, refer to Section 10.3.3.)

Braking resistor rating is classified into two types according to the braking periodic duty cycle.

1) When the periodic duty cycle is 100 sec or less:
Calculate the average loss to determine rated values.

2) When the periodic duty cycle exceeds 100 sec:
The allowable braking energy depends on the maximum regenerative braking capacity. The allowable values are listed in Chapter 11, Section 11.8 "Braking resistor (DBR) and braking unit."

(5) Motor RMS current (For detailed calculation, refer to Section 10.3.4.)

In metal processing machines and materials handling machines requiring positioning control, highly frequent running for a short time is repeated. In this case, calculate the maximum equivalent RMS current value (effective value of current) not to exceed the allowable value (rated current) for the motor.

10.3 Equations for Selections

10.3.1 Load torque during constant speed running

[1] General equation

The frictional force acting on a horizontally moved load must be calculated. Calculation for driving a load along a straight line with the motor is shown below.

Where the force to move a load linearly at constant speed υ (m/s) is F (N) and the motor speed for driving this is N_M (r/min), the required motor output torque τ_M (N·m) is as follows:

$$\tau_M = \frac{60 \cdot \upsilon}{2\pi \cdot N_M} \cdot \frac{F}{\eta_G} \quad (N \cdot m) \qquad \text{(Equation 10.3.1-1)}$$

where, η_G is Reduction-gear efficiency.

When the inverter brakes the motor, efficiency works inversely, so the required motor torque should be calculated as follows:

$$\tau_M = \frac{60 \cdot \upsilon}{2\pi \cdot N_M} \cdot F \cdot \eta_G \quad (N \cdot m) \qquad \text{(Equation 10.3.1-2)}$$

$(60 \cdot \upsilon) / (2\pi \cdot N_M)$ in the above equation is an equivalent turning radius corresponding to speed υ (m/s) around the motor shaft.

The value F (N) in the above equations depends on the load type.

[2] Obtaining the required force F

■ Moving a load horizontally

A simplified mechanical configuration is assumed as shown in Figure 10.3.1-1. If the mass of the carrier table is W_0 (kg), the load is W (kg), and the friction coefficient of the ball screw is μ, then the friction force F (N) is expressed as follows, which is equal to a required force for driving the load:

$$F = (W_0 + W) \cdot g \cdot \mu \quad (N) \qquad \text{(Equation 10.3.1-3)}$$

where, g is the gravity acceleration ($\approx$ 9.8 (m/s^2)).

Then, the driving torque around the motor shaft is expressed as follows:

$$\tau_M = \frac{60 \cdot \upsilon}{2\pi \cdot N_M} \cdot \frac{(W_0 + W) \cdot g \cdot \mu}{\eta_G} \quad (N \cdot m) \qquad \text{(Equation 10.3.1-4)}$$

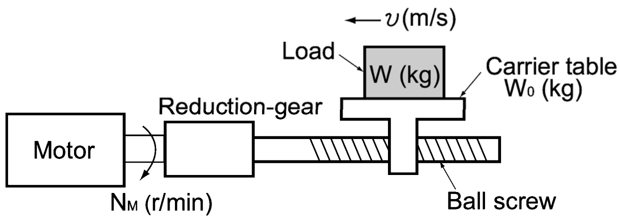


Figure 10.3.1-1 Moving a Load Horizontally

■ Vertical lift load

A simplified mechanical configuration is assumed as shown in Figure 10.3.1-2. If the mass of the cage is W_0 (kg), the load is W (kg), and the balance weight is W_B (kg), then the forces F (N) required for lifting the load up and down are expressed as follows:

$F = (W_0 + W \quad W_B) \cdot g$ (N) (For lifting up) (Equation 10.3.1-5)

$F = (W_0 \quad W \quad W_B) \cdot g$ (N) (For lifting down) (Equation 10.3.1-6)

Assuming the maximum load is W_{max}, the mass of the balance weight W_B (kg) is generally obtained with the expression $W_B = W_O + W_{max}/2$. Depending on the mass of load W (kg), the values of F (N) may be negative in both cases of lifting up and down, which means the lift is in braking mode. So, be careful in motor and inverter selection.

For calculation of the required output torque τ around the motor shaft, apply the expression (10.3.1-1) or (10.3.1-2) depending on the driving or braking mode of the lift, that is, apply the expression (10.3.1-1) if the value of F (N) is positive, and the (10.3.1-2) if negative.

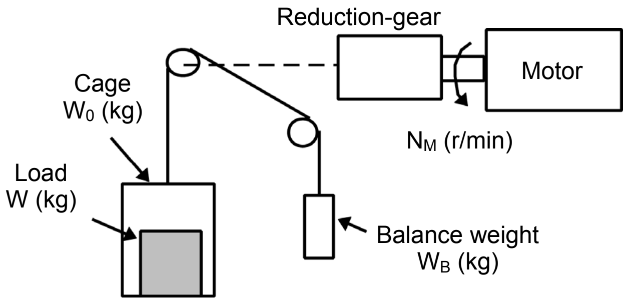


Figure 10.3.1-2 Vertical Lift Load

■ Inclined lift load

Although the mechanical configuration of an inclined lift load is similar to that of a vertical lift load, unignorable friction force in the inclined lift makes a difference; in an inclined lift load, there is a distinct difference between the expression to calculate the lift force F (N) for lifting up and that for lifting down.

If the incline angle is θ, and the friction coefficient is μ, as shown in Figure 10.3.1-3, the driving force F (N) is expressed as follows:

$F = ((W_0 + W)(\sin\theta + \mu \cdot \cos\theta) - W_B) \cdot g$ (N) (For lifting up) (Equation 10.3.1-7)

$F = ((W_B - (W_0 + W)(\sin\theta + \mu \cdot \cos\theta)) \cdot g$ (N) (For lifting down) (Equation 10.3.1-8)

The braking mode applies to both lifting up and down as in the vertical lift load. And the calculation of the required output torque τ around the motor shaft is the same as in the vertical lift load; apply the expression (10.3.1-1) if the value of F (N) is positive, and the (10.3.1-2) if negative.

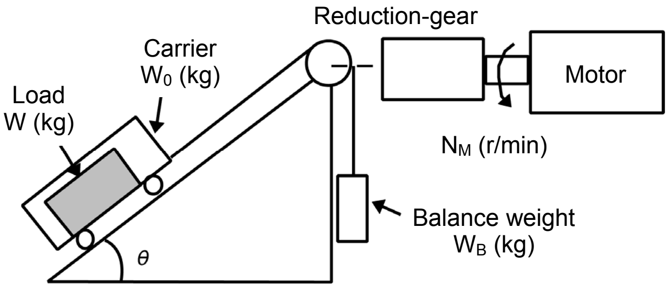


Figure 10.3.1-3 Inclined Lift Load

10.3.2 Acceleration and deceleration time calculation

When an object whose moment of inertia is J ($kg \cdot m^2$) rotates at the speed N (r/min), it has the following kinetic energy:

$$E = \frac{J}{2} \cdot \left(\frac{2\pi \cdot N}{60}\right)^2 \quad (J) \qquad \text{(Equation 10.3.2-1)}$$

To accelerate the above rotational object, the kinetic energy will be increased; to decelerate the object, the kinetic energy must be discharged. The torque required for acceleration and deceleration can be expressed as follows:

$$\tau = J \cdot \frac{2\pi}{60}\left(\frac{dN}{dt}\right) \quad (N \cdot m) \qquad \text{(Equation 10.3.2-2)}$$

This way, the mechanical moment of inertia is an important element in the acceleration and deceleration. First, calculation method of moment of inertia is described, then those for acceleration and deceleration time are explained.

[1] Calculation of moment of inertia

For an object that rotates around the shaft, virtually divide the object into small segments and square the distance from the shaft to each segment. Then, sum the squares of the distances and the masses of the segments to calculate the moment of inertia.

$$J = \Sigma(W_i \cdot r_i^2) \quad (kg \cdot m^2) \qquad \text{(Equation 10.3.2-3)}$$

The following describes equations to calculate moment of inertia having different shaped loads or load systems.

(1) Hollow cylinder and solid cylinder

The common shape of a rotating body is hollow cylinder. The moment of inertia J ($kg \cdot m^2$) around the hollow cylinder center axis can be calculated as follows, where the outer and inner diameters are D_1 and D_2 [m] and total mass is W [kg] in Figure 10.3.2-1.

$$J = \frac{W \cdot (D_1^2 + D_2^2)}{8} \quad (kg \cdot m^2) \qquad \text{(Equation 10.3.2-4)}$$

For a similar shape, a solid cylinder, calculate the moment of inertia as D_2 is 0.

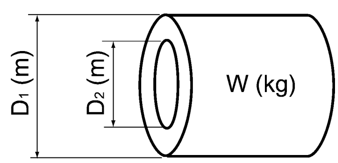
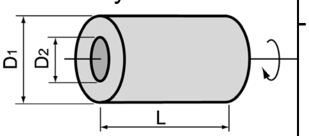
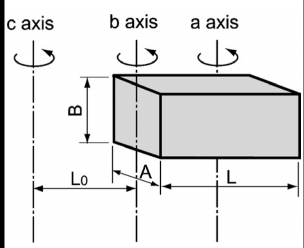
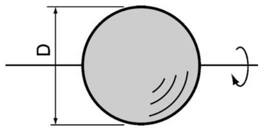
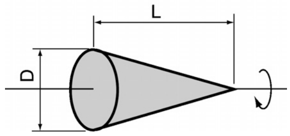
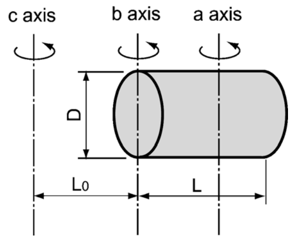
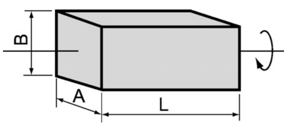
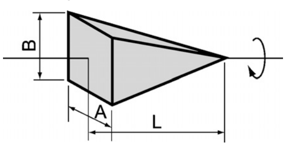
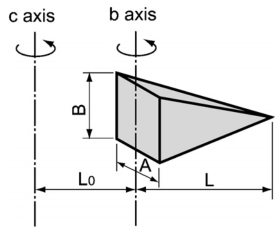
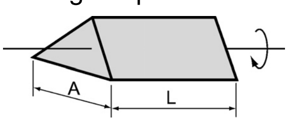
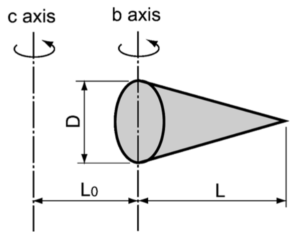
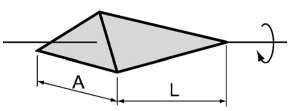


Figure 10.3.2-1 Hollow Cylinder

(2) For a general rotating body

Table 10.3-1 lists the calculation equations of moment of inertia of various rotating bodies including the above cylindrical rotating body.

Table 10.3-1 Moment of Inertia of Various Rotating Bodies

Shape	Mass: W (kg) / Moment of inertia: J ($kg \cdot m^2$)	Shape	Mass: W (kg) / Moment of inertia: J ($kg \cdot m^2$)
Hollow cylinder 	$W = \frac{\pi}{4} \cdot (D_1^2 \quad D_2^2) \cdot L \cdot \rho$ $J = \frac{1}{8} \cdot W \cdot (D_1^2 + D_2^2)$		$W = A \cdot B \cdot L \cdot \rho$ $J_a = \frac{1}{12} \cdot W \cdot (L^2 + A^2)$ $J_b = \frac{1}{12} \cdot W \cdot (L^2 + \frac{1}{4} \cdot A^2)$ $J_c \approx W \cdot (L_0^2 + L_0 \cdot L + \frac{1}{3} \cdot L^2)$
Sphere 	$W = \frac{\pi}{6} \cdot D^3 \cdot \rho$ $J = \frac{1}{10} \cdot W \cdot D^2$		
Cone 	$W = \frac{\pi}{12} \cdot D^2 \cdot L \cdot \rho$ $J = \frac{3}{40} \cdot W \cdot D^2$		$W = \frac{\pi}{4} \cdot D^2 \cdot L \cdot \rho$ $J_a = \frac{1}{12} \cdot W \cdot (L^2 + \frac{3}{4} \cdot D^2)$ $J_b = \frac{1}{3} \cdot W \cdot (L^2 + \frac{3}{16} \cdot D^2)$ $J_c \approx W \cdot (L_0^2 + L_0 \cdot L + \frac{1}{3} \cdot L^2)$
Rectangular prism 	$W = A \cdot B \cdot L \cdot \rho$ $J = \frac{1}{12} \cdot W \cdot (A^2 + B^2)$		
Square cone (Pyramid, rectangular base) 	$W = \frac{1}{3} \cdot A \cdot B \cdot L \cdot \rho$ $J = \frac{1}{20} \cdot W \cdot (A^2 + B^2)$		$W = \frac{1}{3} \cdot A \cdot B \cdot L \cdot \rho$ $J_b = \frac{1}{10} \cdot W \cdot (L^2 + \frac{1}{4} \cdot A^2)$ $J_c \approx W \cdot (L_0^2 + \frac{3}{2} \cdot L_0 \cdot L + \frac{3}{5} \cdot L^2)$
Triangular prism 	$W = \frac{\sqrt{3}}{4} \cdot A^2 \cdot L \cdot \rho$ $J = \frac{1}{3} \cdot W \cdot A^2$		$W = \frac{\pi}{12} \cdot D^2 \cdot L \cdot \rho$ $J_b = \frac{1}{10} \cdot W \cdot (L^2 + \frac{3}{8} \cdot D^2)$ $J_c \approx W \cdot (L_0^2 + \frac{3}{2} \cdot L_0 \cdot L + \frac{3}{5} \cdot L^2)$
Tetrahedron with an equilateral triangular base 	$W = \frac{\sqrt{3}}{12} \cdot A^2 \cdot L \cdot \rho$ $J = \frac{1}{5} \cdot W \cdot A^2$		
Main metal density (at 20°C) $\rho (kg/m^3)$	Iron: 7860, Copper: 8940, Aluminum: 2700		

(3) For a load running horizontally

Assume a carrier table driven by a motor as shown in Figure 10.3.1-1. If the table speed is υ (m/s) when the motor speed is N_M (r/min), then an equivalent distance from the shaft is equal to $60 \cdot \upsilon / (2\pi \cdot N_M)$ (m). The moment of inertia of the table and load to the shaft is calculated as follows:

$$J = \left(\frac{60 \cdot \upsilon}{2\pi \cdot N_M}\right)^2 \cdot (W_0 + W) \quad (kg \cdot m^2)$$ (Equation 10.3.2-5)

(4) For a vertical or inclined lift load

The moment of inertia J ($kg \cdot m^2$) of the loads connected with a rope as shown in Figures 10.3.1-2 and 10.3.1-3 is calculated with the following equation using the mass of all moving objects, although the motion directions of those loads are different.

$$J = \left(\frac{60 \cdot \upsilon}{2\pi \cdot N_M}\right)^2 \cdot (W_0 + W + W_B) \quad (kg \cdot m^2)$$ (Equation 10.3.2-6)

[2] Calculation of the acceleration time

Figure 10.3.2-2 shows a general load model. Assume that a motor drives a load via a reduction-gear with efficiency η_G. The time required to accelerate this load in stop state to a speed of N_M (r/min) is calculated with the following equation:

$$t_{ACC} = \frac{J_1 + J_2/\eta_G}{\tau_M \quad \tau_L/\eta_G} \cdot \frac{2\pi \cdot (N_M \quad 0)}{60} \quad (s)$$ (Equation 10.3.2-7)

where,

J_1: Motor shaft moment of inertia ($kg \cdot m^2$)
J_2: Load shaft moment of inertia converted to motor shaft ($kg \cdot m^2$)
τ_M: Minimum motor output torque in driving motor ($N \cdot m$)
τ_L: Maximum load torque converted to motor shaft ($N \cdot m$)
η_G: Reduction-gear efficiency.

As clarified in the above equation, the equivalent moment of inertia becomes ($J_1 + J_2/\eta_G$) by considering the reduction-gear efficiency.

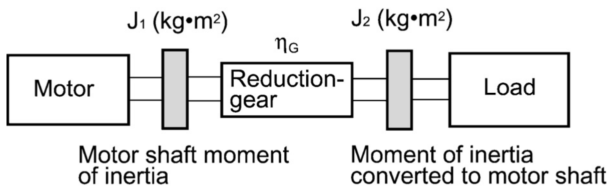


Figure 10.3.2-2 Load Model Including Reduction-gear

[3] Calculation of the deceleration time

In a load system shown in Figure 10.3.2-2, the time needed to stop the motor rotating at a speed of N_M (r/min) is calculated with the following equation:

$$t_{DEC} = \frac{J_1 + J_2 \cdot \eta_G}{\tau_M \quad \tau_L \cdot \eta_G} \cdot \frac{2\pi \cdot (0 \quad N_M)}{60} \quad \text{(s)} \qquad \text{(Equation 10.3.2-8)}$$

where,

J_1: Motor shaft moment of inertia ($kg \cdot m^2$)
J_2: Load shaft moment of inertia converted to motor shaft ($kg \cdot m^2$)
τ_M: Minimum motor output torque in braking (or decelerating) motor (N·m)
τ_L: Maximum load torque converted to motor shaft (N·m)
η_G: Reduction-gear efficiency

In the above equation, generally output torque τ_M is negative and load torque τ_L is positive. So, deceleration time becomes shorter.

Tip For lift applications, calculate the deceleration time using the negative value of τ_L (maximum load torque converted to motor shaft).

[4] Calculating non-linear acceleration/deceleration time

In applications requiring frequent acceleration/deceleration, the inverter can accelerate/decelerate the motor in the shortest time utilizing all torque margin. The inverter in a vector control mode can easily perform this type of operation.

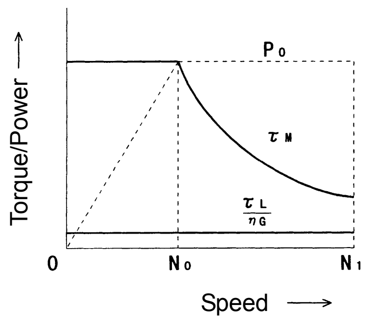


Figure 10.3.2-3 An Example of Driving Characteristics with a Constant Output Range

In this case, the acceleration/deceleration vs. speed curve will form a non-linear figure, and the acceleration/deceleration time cannot be calculated by a single expression.

Generally, the acceleration/deceleration time is obtained by calculating the acceleration/deceleration time of ΔN that is a difference of speed N broken into small parts, and then integrating it to obtain the total acceleration/deceleration time from start to end. Because the smaller ΔN provides higher accuracy, this numerical calculation needs an aid of a computer program.

The following is a guide for the numerical calculation method using a computer program.

Figure 10.3.2-3 illustrates an example of driving characteristics with a constant output range. In the figure, the range under N_0 is of constant torque characteristics, and the range between N_0 and N_1 is of a constant output with the non-linear acceleration/deceleration characteristics.

[4-1] Calculating non-linear acceleration time

The expression (10.3.2-9) gives an acceleration time Δt_{ACC} within a ΔN speed thread.

$$\Delta t_{ACC} = \frac{J_1 + J_2 / \eta_G}{\tau_M - \tau_L / \eta_G} \cdot \frac{2\pi \cdot \Delta N}{60} \quad \text{(s)} \qquad \text{(Equation 10.3.2-9)}$$

Before proceeding this calculation, obtain the motor shaft moment of inertia J_1, the load shaft moment of inertia converted to motor shaft J_2, maximum load torque converted to motor shaft τ_L, and the reduction-gear efficiency η_G. Apply the maximum motor output torque τ_M according to an actual speed thread ΔN as follows.

[τ_M in $N \le N_0$] Constant output torque range

$$\tau_M = \frac{60 \cdot P_O}{2\pi \cdot N_0} \ (\mathrm{N.m}) \qquad \text{(Equation 10.3.2-10)}$$

[τ_M in $N_0 \le N \le N_1$] Constant output power range
(The motor output torque is inversely proportional to the motor speed)

$$\tau_M = \frac{60 \cdot P_O}{2\pi \cdot N} \ (\mathrm{N.m}) \qquad \text{(Equation 10.3.2-11)}$$

If the result obtained by the above calculation does not satisfy the target value, select an inverter with one rank higher capacity.

[4-2] Calculating non-linear deceleration time

Use the following expression to obtain the non-linear deceleration time as well as for the acceleration time shown in [4-1].

$$\Delta t_{DEC} = \frac{J_1 + J_2 \cdot \eta_G}{\tau_M - \tau_L \cdot \eta_G} \cdot \frac{2\pi \cdot \Delta N}{60} \ (\mathrm{s}) \qquad \text{(Equation 10.3.2-12)}$$

In this expression, both τ_M, and ΔN are generally negative values so that the load torque τ_L serves to assist the deceleration operation. For a lift load, however, the load torque τ_L is a negative value in some modes. In this case, the τ_M, and τ_L will take polarity opposite to each other and the τ_L will serve to prevent the deceleration operation of the lift.

10.3.3 Heat energy calculation of braking resistor

If the inverter brakes the motor, the kinetic energy of mechanical load is converted to electric energy to be regenerated into the inverter circuit. This regenerative energy is often consumed in so-called braking resistors as heat. The following explains the braking resistor rating.

[1] Calculation of regenerative energy

In the inverter operation, one of the regenerative energy sources is the kinetic energy that is generated at the time an object is moved by an inertial force.

(1) Kinetic energy of a moving object

When an object with moment of inertia J ($kg\cdot m^2$) rotates at a speed N_2 (r/min), its kinetic energy is as follows:

$$E = \frac{J}{2} \cdot \left(\frac{2\pi \cdot N_2}{60}\right)^2 \quad (J = Ws)$$ (Equation 10.3.3-1)

$$\approx \frac{1}{182.4} \cdot J \cdot N_2^2 \quad (J)$$ (Equation 10.3.3-1')

When this object is decelerated to a speed N_1 (r/min), the output energy is as follows:

$$E = \frac{J}{2} \cdot \quad \left(\frac{2\pi \cdot N_2}{60}\right)^2 \quad \left(\frac{2\pi \cdot N_1}{60}\right)^2 \quad (J)$$ (Equation 10.3.3-2)

$$\approx \frac{1}{182.4} \cdot J \cdot (N_2^2 \quad N_1^2) \quad (J)$$ (Equation 10.3.3-2')

The energy regenerated to the inverter as shown in Figure 10.3.2-2 is calculated from the reduction-gear efficiency η_G and motor efficiency η_M as follows:

$$E \approx \frac{1}{182.4} \cdot \left(J_1 + J_2 \cdot \eta_G\right) \cdot \eta_M \cdot \left(N_2^2 \quad N_1^2\right) \quad (J)$$ (Equation 10.3.3-3)

(2) Potential energy of a lift

When an object whose mass is W (kg) falls from the height h_2 (m) to the height h_1 (m), the output energy is as follows:

$$E = W \cdot g \cdot (h_2 - h_1) \quad (J=Ws)$$ (Equation 10.3.3-4)

$$g \approx 9.8065 \ (m/s^2)$$

The energy regenerated to the inverter is calculated from the reduction-gear efficiency η_G and motor efficiency η_M as follows:

$$E = W \cdot g \cdot (h_2 - h_1) \cdot \eta_G \cdot \eta_M \quad (J)$$ (Equation 10.3.3-5)

10.3.4 Calculating the RMS rating of the motor

In case of the load which is repeatedly and very frequently driven by a motor, the motor current fluctuates largely and enters the short-time rating range of the motor repeatedly. Therefore, you have to review the allowable thermal rating of the motor. The heat value is assumed to be approximately proportional to the square of the motor current.

If an inverter drives a motor in duty cycles that are much shorter than the thermal time constant of the motor, calculate the "equivalent RMS current" as mentioned below, and select the motor so that this RMS current will not exceed the rated current of the motor.

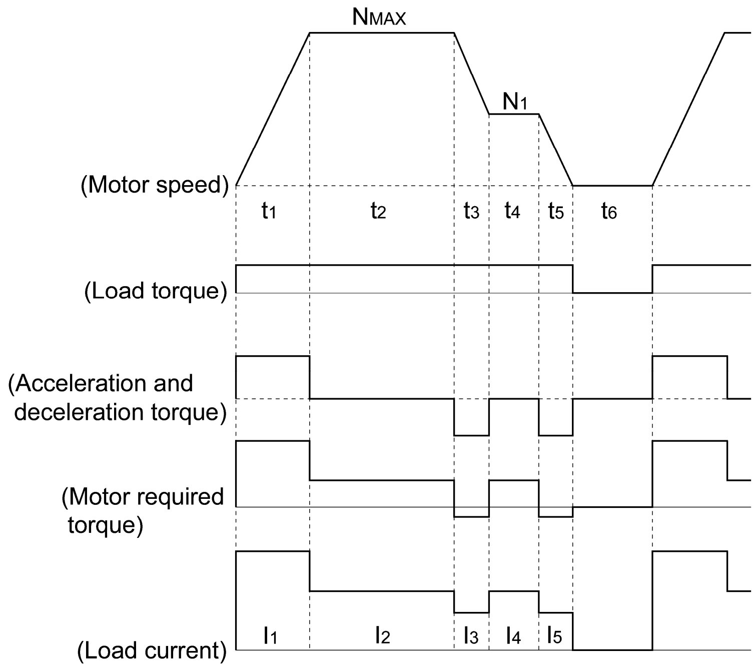


Figure 10.3.4-1 Sample of the Repetitive Operation

First, calculate the required torque of each part based on the speed pattern. Then using the torque-current curve of the motor, convert the torque to the motor current. The "equivalent RMS current, I_{eq}" can be finally calculated by the following equation:

$$I_{eq} = \sqrt{\frac{I_1^2 \cdot t_1 + I_2^2 \cdot t_2 + I_3^2 \cdot t_3 + I_4^2 \cdot t_4 + I_5^2 \cdot t_5}{t_1 + t_2 + t_3 + t_4 + t_5 + t_6}} \quad \text{(A)} \qquad \text{(Equation 10.3.4-1)}$$

The torque-current curve for the dedicated motor is not available for actual calculation. Therefore, calculate the motor current I from the load torque $\square_1$ using the following equation (10.3.4-2). Then, calculate the equivalent current I_{eq}:

$$I = \sqrt{\left(\frac{\tau_1}{100} \times I_{t100}\right)^2 + I_{m100}^2} \quad \text{(A)} \qquad \text{(Equation 10.3.4-2)}$$

Where, $\square_1$ is the load torque (%), I_{t100} is the torque current, and I_{m100} is exciting current.

10.4 Selecting an Inverter Drive Mode (ND/HD/HND/HHD)

10.4.1 Precaution in making the selection

The FRENIC-Ace is available in four different drive modes--ND and HD modes for general load and HND and HHD modes for heavy duty load, which allows users to switch the drive modes on site.

Select the inverter capacity appropriate to the user application, considering the motor capacity, overload characteristics, and ND/HD/HND/HHD mode, referring to Section 10.4.2 "Guideline for selecting inverter drive mode and capacity."

ND mode for general load
Apply to equipment where the inverter's load current in normal operations is less than the inverter rated current and the load current in overcurrent operation is less than 120% of the rated current for 1 minute. (Fan, pump, etc.)

HD mode for heavy duty load
Apply to equipment where the inverter's load current in normal operations is less than the inverter rated current and the load current in overcurrent operation is less than 150% of the rated current for 1 minute. (Wire drawing machine, etc.)

HND mode general load
Apply to equipment where the inverter's load current in normal operations is less than the inverter rated current and the load current in overcurrent operation is less than 120% of the rated current for 1 minute. This mode is for applications which require running the motor under low noise conditions or running the inverter with high responsibility. (Fan, pump, centrifugal machine, etc.)

HHD mode for heavy duty load
Apply to equipment where the inverter's load current in normal operations is less than the inverter rated current and the load current in overcurrent operation is less than 150% of the rated current for 1 minute and 200% for 0.5 second. This mode is for applications which require running the motor under low noise conditions or running the inverter with high responsibility. (Compact hoist, winding machine, etc.)

10.4.2 Guideline for selecting inverter drive mode and capacity

Table 10.4-1 lists the functional differences between ND, HD, HND, and HHD modes.

If the ND mode does not satisfy the requirements in your application in view of the overload capability and functionality, you need to select the inverter one or two ranks higher in capacity (HD/HND/HHD mode) than that of the motor rating.

To use the inverter under the ambient temperature or carrier frequency condition changed from the factory default, the output current rating requires derating due to the ambient temperature or carrier frequency. It is, therefore, necessary to select the inverter unit, referring to Figures 10.4.2-1 through 10.4.2-4.

Table 10.4-1 Functional Differences between ND, HD, HND, and HHD Modes

Function	ND mode	HD mode	HND mode	HHD mode
Application	General load	Heavy duty load	General load	Heavy duty load
Data for function code F80	"4" (Factory default)	"3"	"1"	"0"
Continuous current rating level (inverter rated current level)	100% (Operating temperature: 40°C) 80% (Operating temperature: 50°C) (See Figure 10.4.2-1.)		100% (Operating temperature: 50°C)	
Overload capability	120% for 1 min.	150% 1 min.	120% 1 min.	150% for 1 min. 200% for 0.5 s
Maximum frequency *1	Setting range: 25 to 120 Hz Upper limit: 120Hz	Setting range: 25 to 500 Hz Upper limit: 500 Hz		
DC braking (Braking level) *1	Setting range: 0 to 60% (Based on the rated current level of ND-mode inverter)	Setting range: 0 to 80% (Based on the rated current level of HD-mode inverter)	Setting range: 0 to 80% (Based on the rated current level of HND-mode inverter)	Setting range: 0 to 100% (Based on the rated current level of HHD-mode inverter)
Motor sound (Carrier frequency) *1	Setting range: 0.75 to 10 kHz (FRN0059E2S-4□) 0.75 to 6 kHz (FRN0072E2S-4□ to FRN0203E2S-4□)	Setting range: 0.75 to 16 kHz (FRN0059E2S-4□) 0.75 to 10 kHz (FRN0072E2S-4□ to FRN0168E2S-4□) 0.75 to 6 kHz (FRN0203E2S-4□)		Setting range: 0.75 to 16 kHz (FRN0059E2S-4□) to FRN0168E2S-4□ 0.75 to 10 kHz (FRN0203E2S-4□)
Current limiter (Level) *2	Initial value: 130%	Initial value: 160%	Initial value: 130%	Initial value: 160%
Current indication and output	Based on the rated current level of ND-mode inverter	Based on the rated current level of HD-mode inverter	Based on the rated current level of HND-mode inverter	Based on the rated current level of HHD-mode inverter

*1 In the ND/HD/HND mode, a setting value out of the range will be replaced with the upper limit of each mode.

*2 Mode switching with function code F80 initializes the current limiter level.

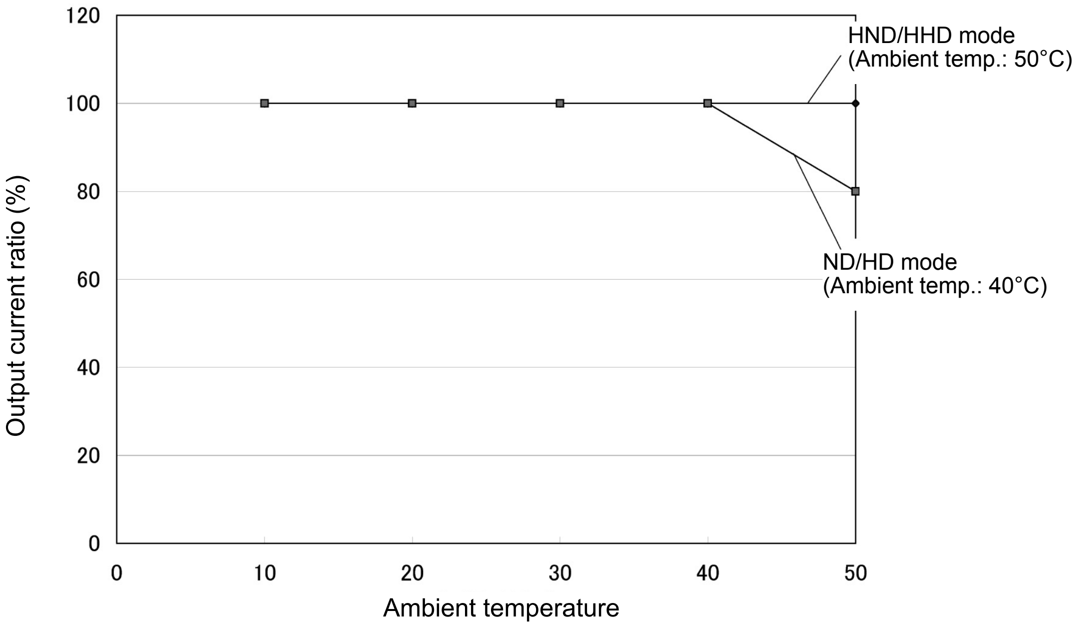


Figure 10.4.2-1 Derating of Output Current Due to Ambient Temperature

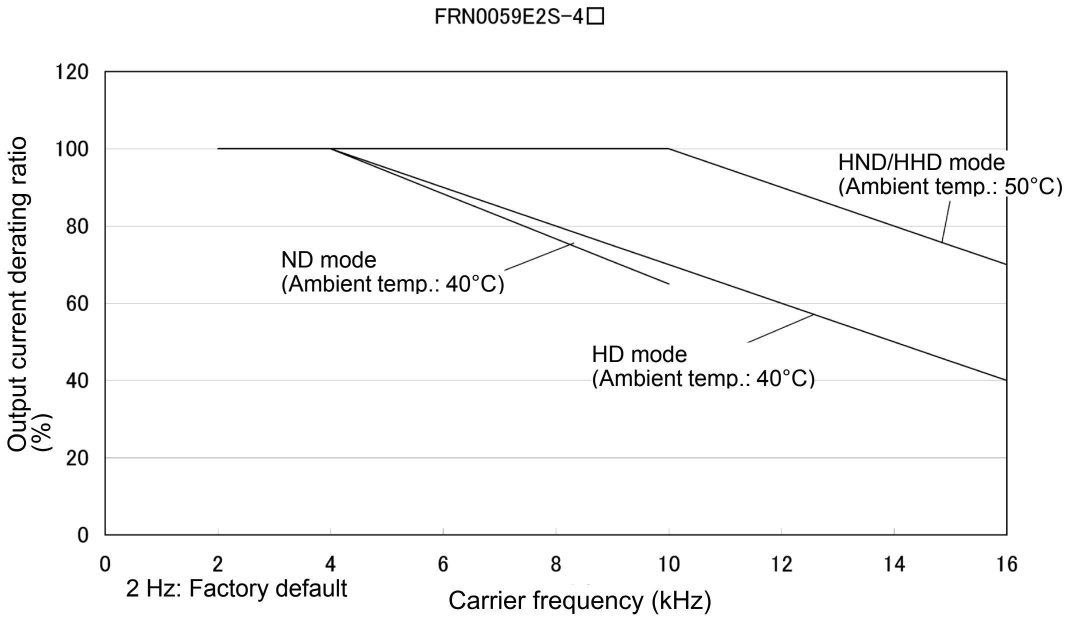


Figure 10.4.2-2 Derating of Output Current Due to Carrier Frequency (FRN0059E2S-4□)

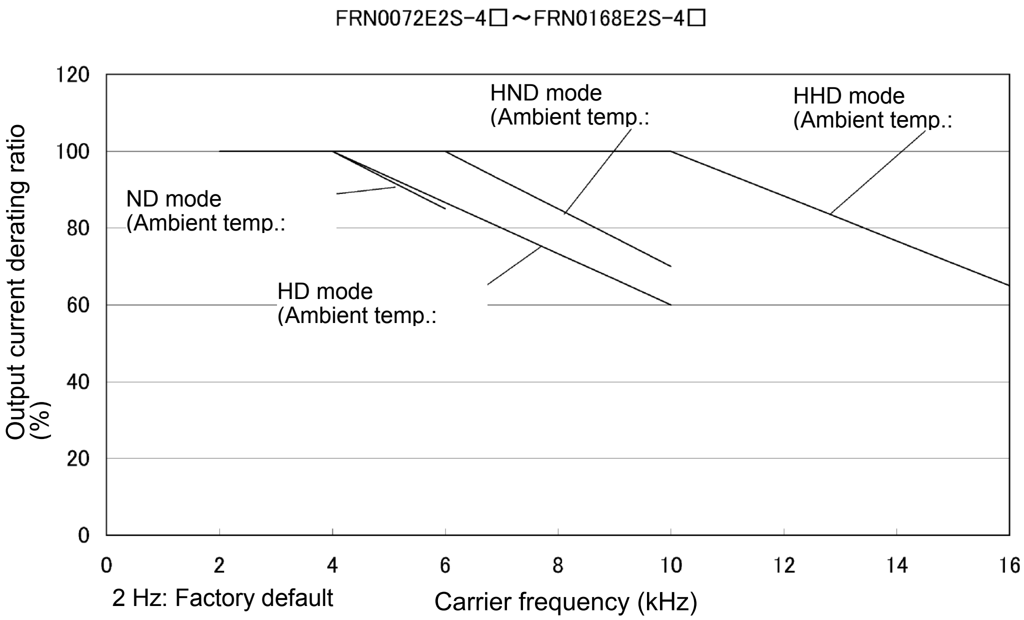


Figure 10.4.2-3 Derating of Output Current Due to Carrier Frequency
(FRN0072E2S-4□ to FRN0168E2S-4□)

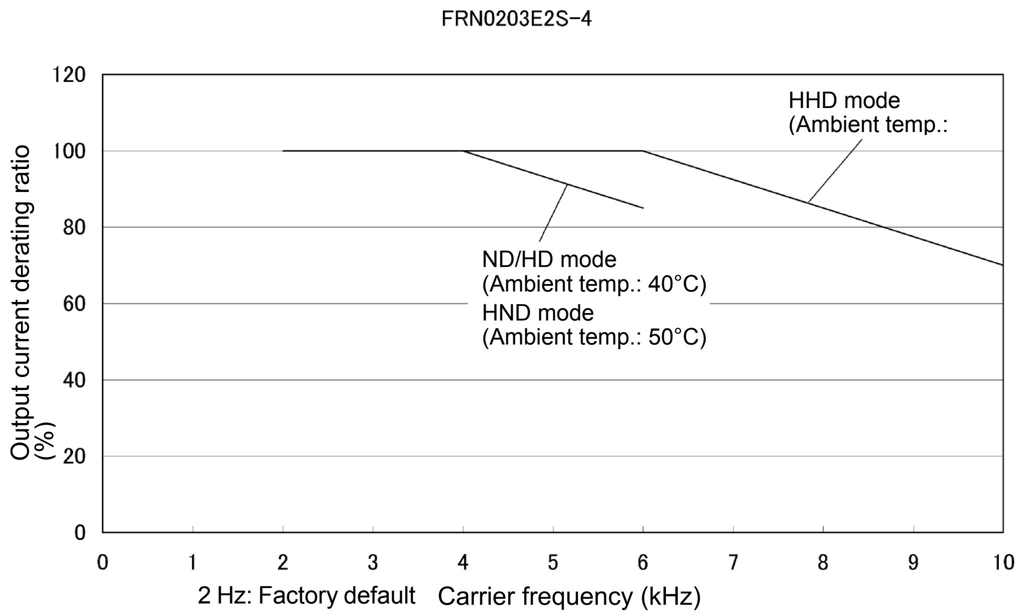


Figure 10.4.2-4 Derating of Output Current Due to Carrier Frequency (FRN0203E2S-4□)

10.5 Selecting a Motor Drive Control

10.5.1 Features of motor drive controls

The FRENIC-Ace supports the following motor drive controls.

This section shows their basic configurations and describes their features.

Drive control	Basic control	Speed feedback	Drive control class	Speed control	Other restrictions
V/f control with slip compensation inactive	V/f control	Disable	V/f	Frequency control	—
Vector control without speed sensor (Dynamic torque vector)				Frequency control with slip compensation	—
V/f control with slip compensation active					—

■ V/f control with slip compensation inactive

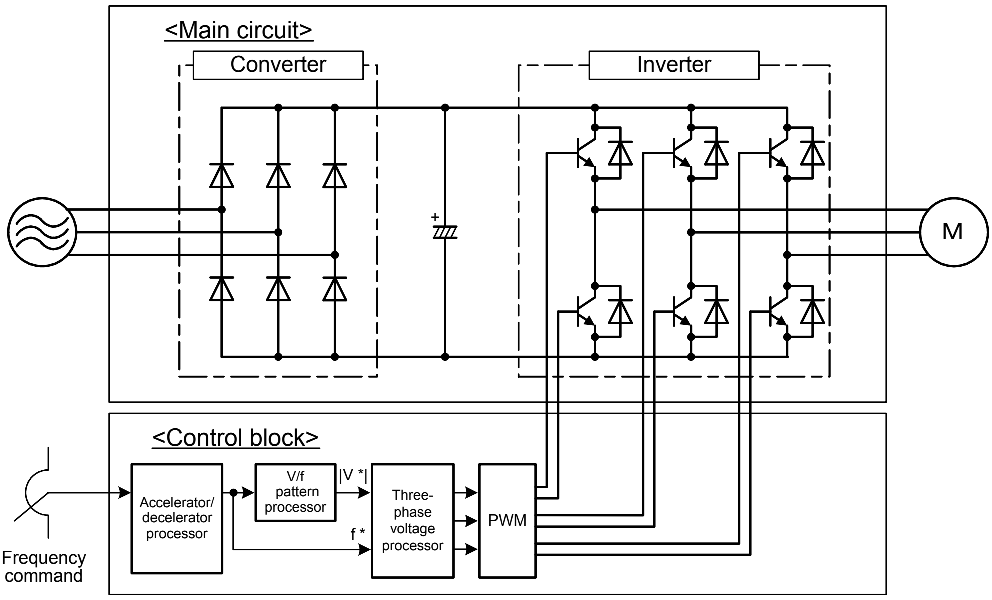


Figure 10.5.1-1 Schematic Block Diagram of V/f Control with Slip Compensation Inactive

As shown in the above configuration, the inverter does not receive any speed information feedback from the target machinery being controlled and it controls the load shaft speed only with a frequency command given by the frequency setting device (open-loop control). The inverter outputs the voltage/frequency following the V/f pattern processor's output to drive a motor. This control disables all automatically controlled features (such as the slip compensation), causing no unpredictable output fluctuation and enabling stable operation with constant output frequency.

This control is suitable for applications that do not need quick speed change such as variable torque load equipment, fans and pumps.

■ Dynamic torque vector control

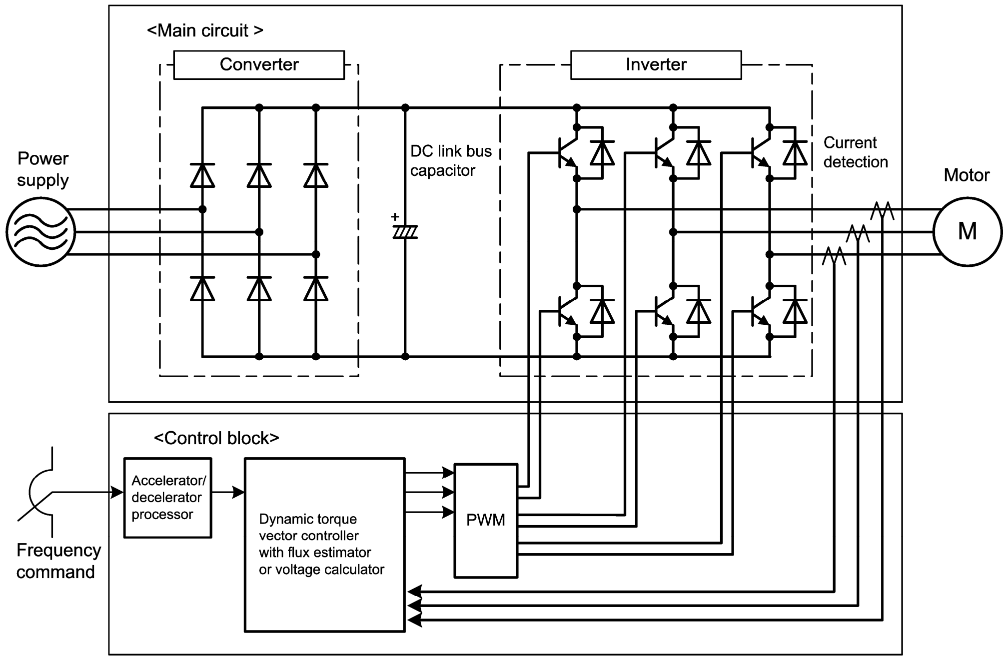


Figure 10.5.1-2 Schematic Block Diagram of Dynamic Torque Vector Control

The FRENIC-Ace features the dynamic torque vector controller with the flux estimator, which is always correcting the magnetic flux phase while monitoring the inverter output current as the feedback. This feature allows the inverter to always apply the drive power with an optimal voltage and current and consequently respond to quick load variation or speed change.
The feature also estimates the generated torque of the motor from the estimated flux data and output current to the motor to improve the motor efficiency for matching the current operation situation.

This control mode is effective for applications that need large torque in low speed range or that have quick load fluctuations. Selecting the dynamic torque vector control automatically enables the auto-torque boost and slip compensation.

■ V/f control with slip compensation active

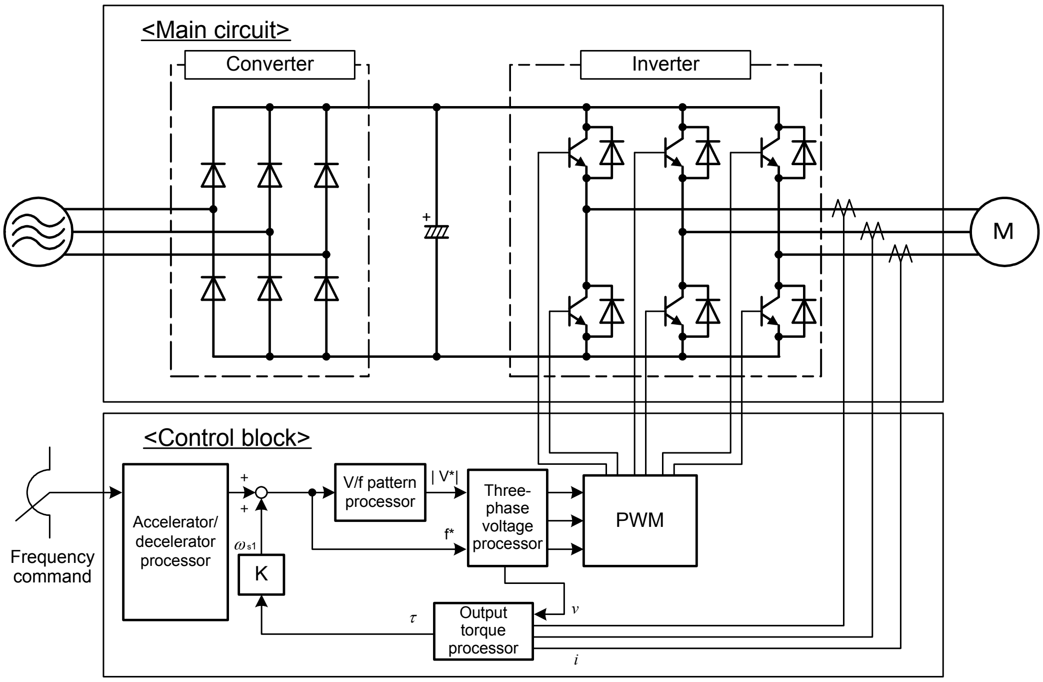


Figure 10.5.1-3 Schematic Block Diagram of
V/f Control with Slip Compensation Active

Applying any load to an induction motor causes a rotational slip due to the motor characteristics, decreasing the motor rotation. The inverter's slip compensation function first presumes the slip value of the motor based on the motor torque generated and raises the output frequency to compensate for the decrease in motor rotation. This prevents the motor from decreasing the rotation due to the slip.

That is, this function is effective for improving the motor speed control accuracy.

10.5.2 Selecting a Motor Drive Control by Purpose

Listed below is a general guide for selecting a motor drive control by purpose. Use this guide just for reference. In individual cases, selection should be made carefully after a technical consultation regarding the detailed specifications of your system.

Table 10.5-1 Motor Drive Control by Purpose

Drive control abbreviation: "V/f" (V/f control), "Torque vector" (Dynamic torque vector control)

Type of industry	Applications	Segment	Drive control: V/f	Drive control: Torque vector
Delivery equipment	Crane (Hoisting)	Compact hoist-type crane	N	Y
	(Traveling)	1 : 1	Y*	Y*
	(Traveling)	1 : N	Y	N
	(Traversing)		N	Y*
	Traveling dolly	Single motor	Y	Y
		Multiple motors	Y	Y
	Parking tower (Elevator type)	Less than 50 m/min	Y*	Y
		50 m/min or above (Zero speed not required)	Y*	Y*
	Parking tower (Circulation type)		Y*	Y
	Multistory warehouse (Stacker crane)	Without position compensation	Y	Y
	Variable speed escalator		Y*	Y
Plastic	Extruding machine	Low precision	N	Y
Metalworking	Wire drawing machine	Storage type	Y*	Y
	Drawbench		Y*	Y
	Press main engine driving	Standard type	Y	Y
		High-speed press	Y*	Y
Textile	Synthetic fiber spinning	Various rolls, gear pump	Y	Y
Others	Winder with dancer	Center drive (winding off)	Y*	Y
		Center drive (taking up)	Y*	Y
	(Cement) kiln		Y*	Y
	Centrifuge		Y*	Y
	Agitator		Y*	Y
	Crusher		Y*	Y

Y: Applicable (Examination required), Y*: Examination required, N: Not applicable

Chapter 11

SELECTING PERIPHERAL EQUIPMENT

This chapter describes how to use a range of peripheral equipment and options, FRENIC-Ace's configuration with them, and requirements and precautions for selecting wires and crimp terminals.

Contents

11.1. Configuring the FRENIC-Ace

This section lists the names and features of peripheral equipment and options for the FRENIC-Ace as well as a configuration example.

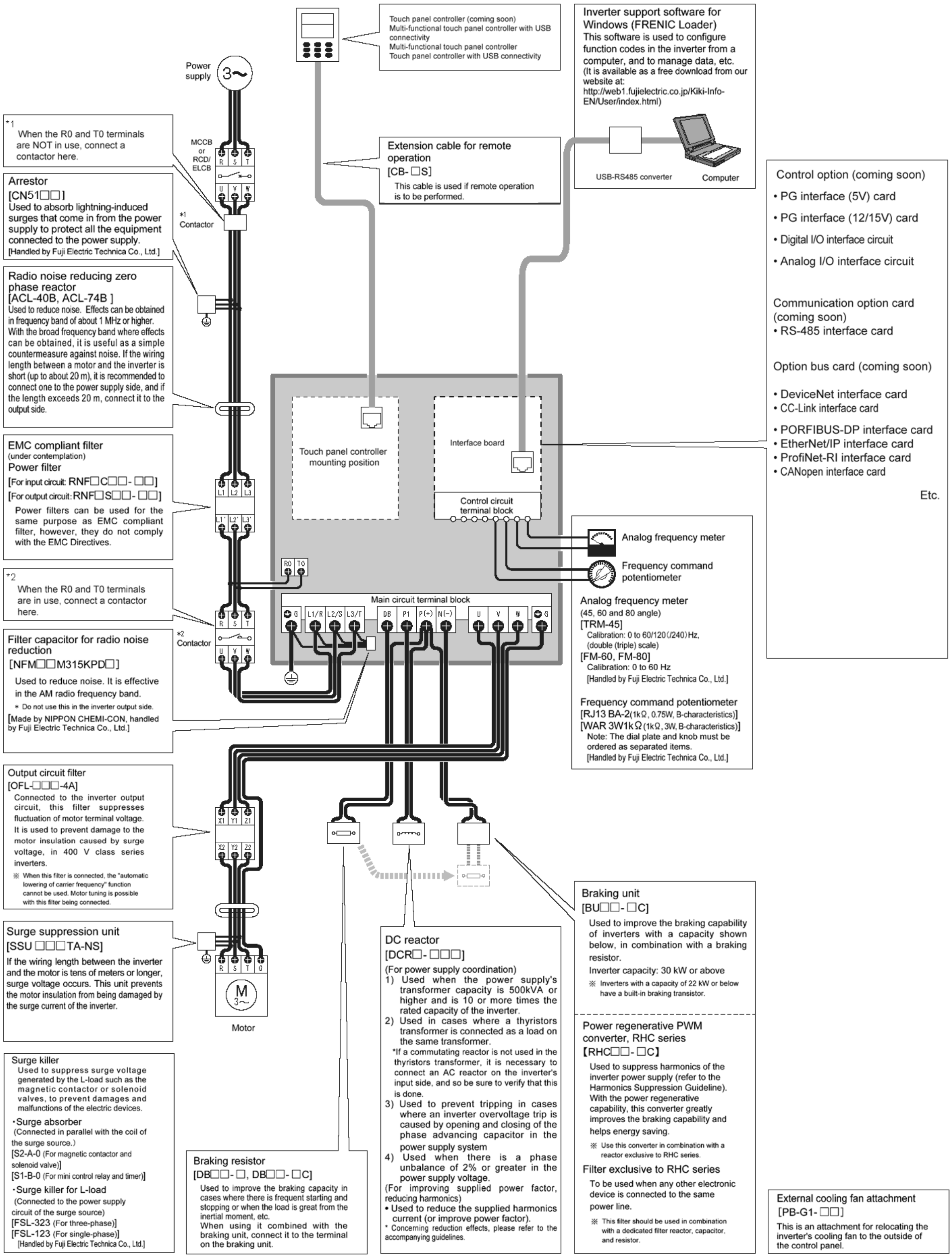


Figure 11.1-1 Quick Overview of Options

11.2. Currents Flowing across the Inverter Terminals

Table 11.2-1 summarizes average (effective) electric currents flowing across the terminals of each inverter model for ease of reference when selecting peripheral equipment and options for each inverter--including supplied power voltage and applicable motor rating.

Table 11.2-1 Currents Flowing across the Inverter Terminals

ND mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	50Hz, 400V			60Hz, 440V			Braking resistor circuit current (A)
			Input RMS current (A) DC reactors (DCRs)		DC link bus current (A)	Input RMS current (A) DC reactors (DCRs)		DC link bus current (A)	
			w/ DCR	w/o DCR		w/ DCR	w/o DCR		
Three-phase 400V	30	FRN0059E2S-4□	57	77.9	69.9	51.4	70.2	63	7.2
	37	FRN0072E2S-4□	68.5	94.3	83.9	61.8	85	75.7	7.7
	45	FRN0085E2S-4□	83.2	114	102	75	103	91.9	10.0
	55	FRN0105E2S-4□	102	140	125	91.9	126	113	12.0
	75	FRN0139E2S-4□	138	-	169	124	-	152	15.0
	90	FRN0168E2S-4□	164	-	201	148	-	181	19.0
	110	FRN0203E2S-4□	201	-	246	181	-	222	24.0

HD mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	50Hz, 400V			60Hz, 440V			Braking resistor circuit current (A)
			Input RMS current (A) DC reactors (DCRs)		DC link bus current (A)	Input RMS current (A) DC reactors (DCRs)		DC link bus current (A)	
			w/ DCR	w/o DCR		w/ DCR	w/o DCR		
Three-phase 400V	22	FRN0059E2S-4□	42.2	60.6	51.7	38	54.6	46.6	7.2
	30	FRN0072E2S-4□	57	77.9	69.9	51.4	70.2	63	7.7
	37	FRN0085E2S-4□	68.5	94.3	83.9	61.8	85	75.7	10.0
	45	FRN0105E2S-4□	83.2	114	102	75	103	91.9	12.0
	55	FRN0139E2S-4□	102	140	125	91.9	126	113	15.0
	75	FRN0168E2S-4□	138	-	169	124	-	152	19.0
	90	FRN0203E2S-4□	164	-	201	148	-	181	24.0

HND mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	50Hz, 400V			60Hz, 440V			Braking resistor circuit current (A)
			Input RMS current (A) DC reactors (DCRs)		DC link bus current (A)	Input RMS current (A) DC reactors (DCRs)		DC link bus current (A)	
			w/ DCR	w/o DCR		w/ DCR	w/o DCR		
Three-phase 400V	22	FRN0059E2S-4□	42.2	60.6	51.7	38	54.6	46.6	7.2
	30	FRN0072E2S-4□	57	77.9	69.9	51.4	70.2	63	7.7
	37	FRN0085E2S-4□	68.5	94.3	83.9	61.8	85	75.7	10.0
	45	FRN0105E2S-4□	83.2	114	102	75	103	91.9	12.0
	55	FRN0139E2S-4□	102	140	125	91.9	126	113	15.0
	75	FRN0168E2S-4□	138	-	169	124	-	152	19.0
	90	FRN0203E2S-4□	164	-	201	148	-	181	24.0

HHD mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	50Hz, 400V			60Hz, 440V			Braking resistor circuit current (A)
			Input RMS current (A)		DC link bus current (A)	Input RMS current (A)		DC link bus current (A)	
			DC reactors (DCRs)			DC reactors (DCRs)			
			w/ DCR	w/o DCR		w/ DCR	w/o DCR		
Three-phase 400V	18.5	FRN0059E2S-4□	35.5	52.3	43.5	32.0	47.1	39.2	7.2
	22	FRN0072E2S-4□	42.2	60.6	51.7	38.0	54.6	46.6	7.7
	30	FRN0085E2S-4□	57.0	77.9	69.9	51.4	70.2	63	10.0
	37	FRN0105E2S-4□	68.5	94.3	83.9	61.8	85	75.7	12.0
	45	FRN0139E2S-4□	83.2	114	102	75.0	103	91.9	15.0
	55	FRN0168E2S-4□	102	140	125	91.9	126	113	19.0
	75	FRN0203E2S-4□	138	-	169	124	-	152	24.0

- Inverter efficiency is calculated using values suitable for each inverter model. The input route mean square current is calculated based on a power supply capacity of 500 kVA (or 10 times as large as the inverter's capacity when the inverter's capacity exceeds 50 kVA), and a power supply reactance of 5%.
- The input RMS current listed in the above table will vary in inverse proportion to the power supply voltage, such as 480 VAC.
- The braking current is always constant, independent of braking resistor specifications, including standard and 10%ED models.

11.3. Molded case circuit breaker (MCCB), residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) and magnetic contactor (MC)

11.3.1. Function overview

■ MCCBs and RCDs/ELCBs*
* With overcurrent protection

Molded Case Circuit Breakers (MCCBs) are designed to protect the power circuits between the power supply and inverter's main circuit terminals ([L1/R], [L2/S] and [L3/T]) from overload or short-circuit, which in turn prevents secondary accidents caused by the broken inverter.

Residual-Current-Operated Protective Devices (RCDs)/Earth Leakage Circuit Breakers (ELCBs) function in the same way as MCCBs.

Built-in overcurrent/overload protective functions protect the inverter itself from failures related to its input/output lines.

■ Magnetic contactor

An MC can be used at both the power input and output sides of the inverter. At each side, the MC works as described below. Use it as necessary. When inserted in the output circuit of the inverter, the MC can also switch the motor drive power supply between the inverter output and commercial power lines.

<u>At the power supply side</u>

Insert an MC in the power supply side of the inverter in order to:

(1) Forcibly cut off the inverter from the power supply (generally, commercial/factory power lines) with the protective function built into the inverter, or with the external signal input.
(2) Stop the inverter operation in an emergency when the inverter cannot interpret the stop command due to internal/external circuit failures.
(3) Cut off the inverter from the power supply when the MCCB inserted in the power supply side cannot cut it off for maintenance or inspection purpose. For the purpose only, it is recommended that you use an MC capable of turning the MC ON/OFF manually.

Note: Avoid frequent ON/OFF operation of the magnetic contactor (MC) in the input (primary) circuit; otherwise, the inverter failure may result.
The frequency of the MC's ON/OFF should not be more than once per 30 minutes. To assure 10-year or longer service life of the inverter, it should not be more than once per hour.
If frequent start/stop of the motor is required, use FWD/REV terminal signals or the RUN/STOP keys on the inverter's keypad.

<u>At the output side</u>

Insert an MC in the power output side of the inverter in order to:

(1) Prevent externally turned-around current from being applied to the inverter power output terminals ([U], [V], and [W]) unexpectedly. An MC should be used, for example, when a circuit that switches the motor driving power supply between the inverter output and commercial power lines is connected to the inverter.

Tip: If a magnetic contactor (MC) is inserted in the inverter's output (secondary) circuit for switching the motor to a commercial power or for any other purposes, it should be switched on and off when both the inverter and motor are completely stopped. This prevents the contact point from getting rough due to a switching arc of the MC. The MC should not be equipped with any main circuit surge killer (Fuji SZ-ZM□, etc.).
Applying a commercial power to the inverter's output circuit breaks the inverter. To avoid it, interlock the MC on the motor's commercial power line with the one in the inverter output circuit so that they are not switched ON at the same time.

(2) Drive more than one motor selectively by a single inverter.
(3) Selectively cut off the motor whose thermal overload relay or equivalent devices have been activated.

Driving the motor using commercial power lines

MCs can also be used to switch the power supply of the motor driven by the inverter to a commercial power supply.

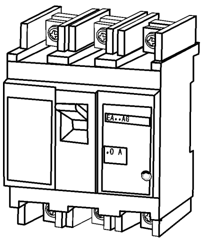
Select the MC so as to satisfy the rated currents listed in Table 11.2-1, which are the most critical RMS currents for using the inverter (Refer to Table 11.3-1). For switching the motor drive source between the inverter output and commercial power lines, use the MC of class AC3 specified by JIS C8325 in the commercial line side.

11.3.2. Connection example and criteria for selection of circuit breakers

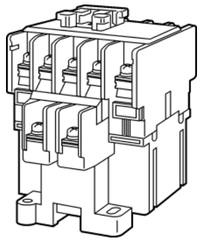
Figure 11.3-1 shows a connection example for MCCB or RCD/ELCB (with overcurrent protection) and MC in the inverter input circuit. Table 11.3-1 lists the rated current for the MCCB and corresponding inverter models. Table 11.3-2 lists the applicable grades of RCD/ELCB sensitivity.

⚠WARNING

Insert an MCCB or RCD/ELCB (with overcurrent protection) recommended for each inverter for its input circuits. Do not use an MCCB or RCD/ELCB of a higher rating than that recommended.
Doing so could result in a fire.



Molded case circuit breaker or residual-current-operated protective device/ earth leakage circuit breaker



Magnetic contactor

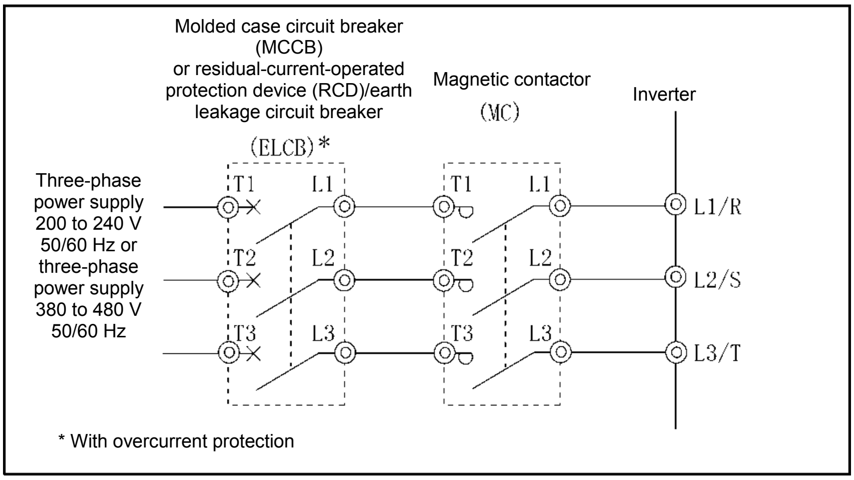


Figure 11.3-1 External Views of MCCB or RCD/ELCB and MC and Connection Example

Table 11.3-1 Rated Current of Molded Case Circuit Breaker (MCCB), Residual-Current-Operated Protective Device (RCD)/ Earth Leakage Circuit Breaker (ELCB) and Magnetic Contactor (MC)

ND mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	MCCB, RCD/ELCB rated current (A)		Magnetic contactor (MC)		
					Input circuit		Output circuit
			DC reactors (DCRs)		DC reactors (DCRs)		
			w/ DCR	w/o DCR	w/ DCR	w/o DCR	
Three-phase 400V	30	FRN0059E2S-4☐	75	125	SC-N2	SC-N3	SC-N2
	37	FRN0072E2S-4☐	100		SC-N2S	SC-N4	SC-N2S
	45	FRN0085E2S-4☐		150	SC-N3		SC-N3
	55	FRN0105E2S-4☐	125	200		SC-N5	SC-N4
	75	FRN0139E2S-4☐	175	-	SC-N4	-	SC-N5
	90	FRN0168E2S-4☐	200		SC-N7		SC-N7
	110	FRN0203E2S-4☐	250				SC-N8

HD mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	MCCB, RCD/ELCB rated current (A)		Magnetic contactor (MC)		
					Input circuit		Output circuit
			DC reactors (DCRs)		DC reactors (DCRs)		
			w/ DCR	w/o DCR	w/ DCR	w/o DCR	
Three-phase 400V	22	FRN0059E2S-4☐	50	100	SC-N1	SC-N2S	SC-N1
	30	FRN0072E2S-4☐	75	125	SC-N2	SC-N3	SC-N2
	37	FRN0085E2S-4☐	100		SC-N2S	SC-N4	SC-N2S
	45	FRN0105E2S-4☐		150	SC-N3		SC-N3
	55	FRN0139E2S-4☐	125	200		SC-N5	SC-N4
	75	FRN0168E2S-4☐	175	-	SC-N4	-	SC-N5
	90	FRN0203E2S-4☐	200		SC-N7		SC-N7

HND mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	MCCB, RCD/ELCB rated current (A)		Magnetic contactor (MC)		
					Input circuit		Output circuit
			DC reactors (DCRs)		DC reactors (DCRs)		
			w/ DCR	w/o DCR	w/ DCR	w/o DCR	
Three-phase 400V	22	FRN0059E2S-4☐	50	100	SC-N1	SC-N2S	SC-N1
	30	FRN0072E2S-4☐	75	125	SC-N2	SC-N3	SC-N2
	37	FRN0085E2S-4☐	100		SC-N2S	SC-N4	SC-N2S
	45	FRN0105E2S-4☐		150	SC-N3		SC-N3
	55	FRN0139E2S-4☐	125	200		SC-N5	SC-N4
	75	FRN0168E2S-4☐	175	-	SC-N4	-	SC-N5
	90	FRN0203E2S-4☐	200		SC-N7		SC-N7

- Install the MCCB or RCD/ELCB at the input side of the inverter. They cannot be installed at the output side of the inverter.
- The above table lists the rated current of MCCBs and RCD/ELCBs to be used in the power control panel with an internal temperature of lower than 50°C. The rated current is factored by a correction coefficient of 0.85 as the RCDs'/MCCBs' and ELCBs' original rated current is specified when using them in a surrounding temperature of 40°C or lower. Select an MCCB and/or RCD/ELCB suitable for the actual short-circuit breaking capacity needed for your power systems.
- For the selection of the MC type, it is assumed that HIV (allowable surrounding temperature: 75°C) wires for the power input/output of the inverter are used. If an MC type for another class of wires is selected, the wire size suitable for the terminal size of both the inverter and the MC type should be taken into account.
- Use ELCBs with overcurrent protection.
- To protect your power systems from secondary accidents caused by the broken inverter, use an MCCB and/or RCD/ELCB with the rated current listed in the above table. Do not use an MCCB or RCD/ELCB with a rating higher than that listed.

Table 11.3-1 Rated Current of Molded Case Circuit Breaker (MCCB), Residual-Current-Operated Protective Device (RCD)/ Earth Leakage Circuit Breaker (ELCB) and Magnetic Contactor (MC) (continued)

HHD mode

<table>
<tr><th rowspan="4">Power supply voltage</th><th rowspan="4">Nominal applied motor (kW)</th><th rowspan="4">Inverter type</th><th colspan="2" rowspan="2">MCCB, RCD/ELCB rated current (A)</th><th colspan="3">Magnetic contactor (MC)</th></tr>
<tr><th colspan="2">Input circuit</th><th rowspan="3">Output circuit</th></tr>
<tr><th colspan="2">DC reactors (DCRs)</th><th colspan="2">DC reactors (DCRs)</th></tr>
<tr><th>w/ DCR</th><th>w/o DCR</th><th>w/ DCR</th><th>w/o DCR</th></tr>
<tr><td rowspan="7">Three-phase 400V</td><td>18.5</td><td>FRN0059E2S-4□</td><td>40</td><td>75</td><td rowspan="2">SC-N1</td><td>SC-N2</td><td rowspan="2">SC-N1</td></tr>
<tr><td>22</td><td>FRN0072E2S-4□</td><td>50</td><td>100</td><td>SC-N2S</td></tr>
<tr><td>30</td><td>FRN0085E2S-4□</td><td>75</td><td rowspan="2">125</td><td>SC-N2</td><td>SC-N3</td><td>SC-N2</td></tr>
<tr><td>37</td><td>FRN0105E2S-4□</td><td rowspan="2">100</td><td>SC-N2S</td><td rowspan="2">SC-N4</td><td>SC-N2S</td></tr>
<tr><td>45</td><td>FRN0139E2S-4□</td><td>150</td><td rowspan="2">SC-N3</td><td>SC-N3</td></tr>
<tr><td>55</td><td>FRN0168E2S-4□</td><td>125</td><td>200</td><td>SC-N5</td><td>SC-N4</td></tr>
<tr><td>75</td><td>FRN0203E2S-4□</td><td>175</td><td>-</td><td>SC-N4</td><td>-</td><td>SC-N5</td></tr>
</table>

- Install the MCCB or RCD/ELCB at the input side of the inverter. They cannot be installed at the output side of the inverter.
- The above table lists the rated current of MCCBs and RCD/ELCBs to be used in the power control panel with an internal temperature of lower than 50°C. The rated current is factored by a correction coefficient of 0.85 as the RCDs'/MCCBs' and ELCBs' original rated current is specified when using them in a surrounding temperature of 40°C or lower. Select an MCCB and/or RCD/ELCB suitable for the actual short-circuit breaking capacity needed for your power systems.
- For the selection of the MC type, it is assumed that the 600 V HIV (allowable surrounding temperature: 75°C) wires for the power input/output of the inverter are used. If an MC type for another class of wires is selected, the wire size suitable for the terminal size of both the inverter and the MC type should be taken into account.
- Use ELCBs with overcurrent protection.
- To protect your power systems from secondary accidents caused by the broken inverter, use an MCCB and/or RCD/ELCB with the rated current listed in the above table. Do not use an MCCB or RCD/ELCB with a rating higher than that listed.

Table 11.3-2 lists the relationship between the rated leakage current sensitivity of RCDs/ELCBs (with overcurrent protection) and wiring length of the inverter output circuits. Note that the sensitivity levels listed in the table are estimated values based on the results obtained by the test setup in the Fuji laboratory where each inverter drives a single motor.

Table 11.3-2 Rated Current Sensitivity of Residual-Current-Operated Protective Device (RCD)/ Earth Leakage Circuit Breakers (ELCBs)

Power supply voltage	Nominal applied motor	Wiring length and current sensitivity					
		10m	30m	50m	100m	200m	300m
	0.1						
	0.2						
	0.4						
	0.75						
	1.5						
	2.2		30mA				
	3.7						
	5.5						
	7.5				100mA		
Three- phase 200V	11						
	15						
	18.5					200mA	
	22						
	30						
	37						
	45						
	55						
	75						500mA
	90						
	110						
	15						
	18.5						
	22	30mA					
	30		100mA				
	37				200mA		
Three- phase 400V	45						
	55					500mA	
	75						
	90						1000mA
	110						
	132						

- Values listed above were obtained using Fuji ELCB EG or SG series applied to the test setup.
- The rated current of applicable motor rating indicates values for Fuji standard motor (4 poles, 50 Hz and 200 V three-phase).
- The leakage current is calculated based on neutral grounding for 400 V class Y-connection power lines.
- Values listed above are calculated based on the static capacitance to the earth when the 600 V class of vinyl-insulated IV wires are used in a wiring through metal conduit pipes.
- Wiring length is the total length of wiring between the inverter and motor. If more than one motor is to be connected to a single inverter, the wiring length should be the total length of wiring between the inverter and motors.

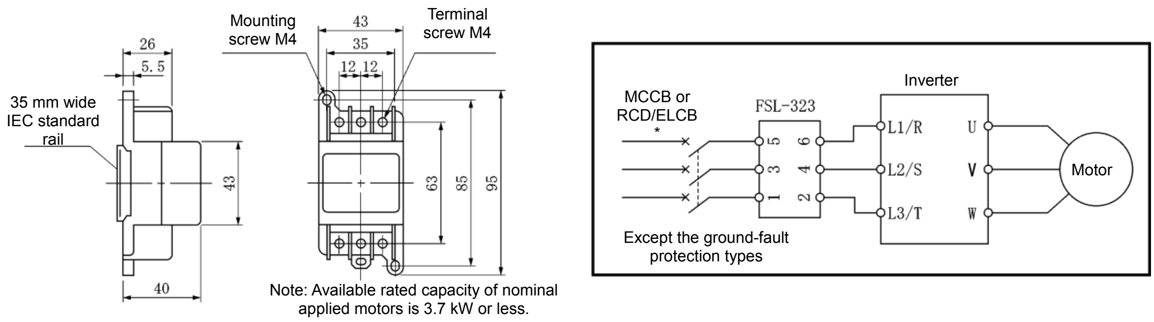
11.4. Surge killers for L-load

A surge killer absorbs surge voltage induced by L-load of an electro magnetic switch or solenoid valve. Use of a surge killer is effective in preventing the electronic equipment, including inverters, from damage or malfunctioning caused by such surges.

Install a surge killer near the power coil of the surge source. Connected to the inverter's power source side, as shown in Figure 11.4-1, a surge killer absorbs the surge voltage, preventing the electronic equipment, from damage or malfunctioning. (Available rated capacity of nominal applied motors is 3.7 kW or less.)

Refer to the catalog "Fuji Surge Killers/Absorbers (HS118: Japanese edition only)" for details. These products are available from Fuji Electric Technica Co., Ltd.

* Do not use the surge killer in the inverter secondary (output) line.



Available from Fuji Electric Technica Co., Ltd.

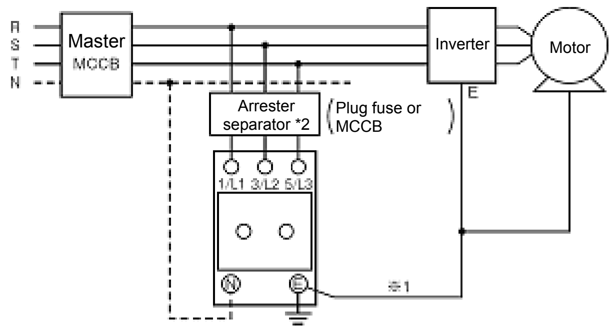
Figure 11.4-1 Dimensions of Surge Killer and Connection Example

11.5. Arresters

An arrester suppresses surge currents induced by lightning invaded from the power supply lines. Common use of the grounding wire that is used for electric equipment in the panel, with the arrester, is effective in preventing electronic equipment from damage or malfunctioning caused by such surges.

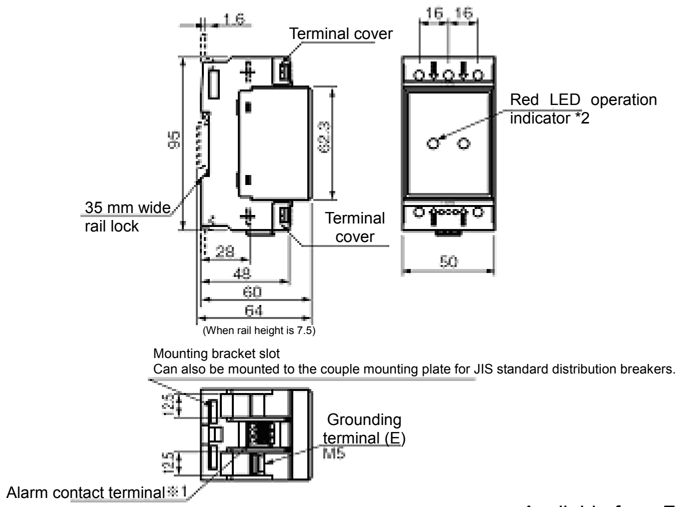
Applicable arrester models are CN5132 for three-phase 200V class series, and CN5134 for three-phase 400V class series. (CN523 series with 20 kA of discharging capability is also available.) Figure 11.5-1 shows their external dimensions and connection examples. Refer to the catalog "Fuji Surge Killers/Absorbers (HS165a: Japanese edition only)" for details. These products are available from Fuji Electric Technica Co., Ltd.

●Tree-phase (AC240/440V)



*1 Keep the wiring length as short as possible.
*2 The models with a built-in arrestor separator (CN5212-FK and CN5232-FK) are not required when the short-circuit current of the circuit is 250 VAC, 10kA or less.

(N-phase terminal is only for CN5234 and CN5234-K.)



*1 Available only on the CN5☐-K series.
*2 Two-pole models have only the left indicator.

Available from Fuji Electric Technica Co., Ltd.

Figure 11.5-1 Arrester Dimensions and Connection Examples

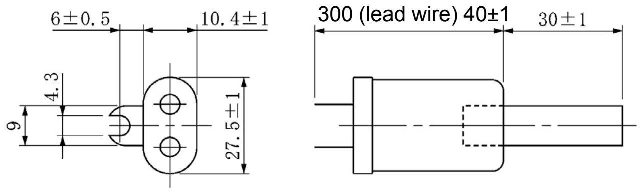
11.6. Surge absorbers

A surge absorber absorbs surges or noises generated by a magnetic contactor (MC) or solenoid valve in the power system to effectively protect electronic equipment in the panel from malfunctions or breakdown. Installed parallel to a coil of an MC, solenoid valve, or L load, a surge absorber absorbs a surge voltage.

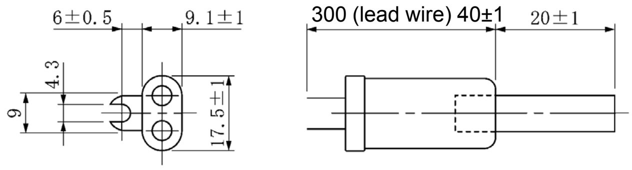
Applicable surge absorber models are the S2-A-O and S1-B-O. Figure 11.6-1 shows their external dimensions.

These products are available from Fuji Electric Technica Co., Ltd.

Type: S2-A-O (for magnetic contactor)



Type: S1-B-O (for mini-control relay or timer)



Available from Fuji Electric Technica Co., Ltd.

Figure 11.6-1 Surge Absorber Dimensions

11.7. Filtering capacitors suppressing AM radio band noises

These capacitors are effective to suppress AM radio band (less than 1 MHz) noises. Using them with Zero-phase reactors upgrades capability.

Applicable models are NFM25M315KPD1 for 200 V class series inverters and NFM60M315KPD for 400 V class. Use one of them no matter what the inverter capacity. Figure 11.7-1 shows their external dimensions. These products are available from Fuji Electric Technica Co., Ltd.

* Do not use the filtering capacitor in the inverter secondary (output) line.

NFM25M315KPD1 NFM60M315KPD

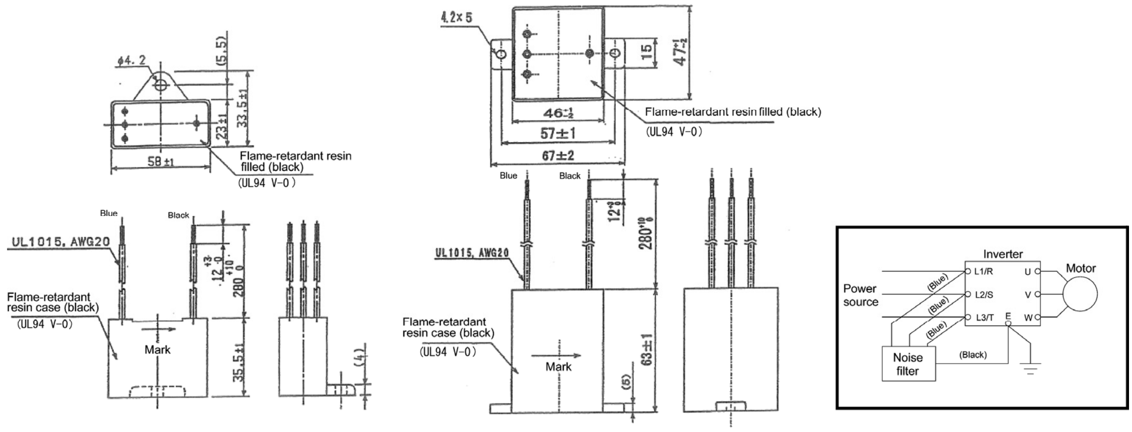


Figure 11.7-1 Filtering Capacitors Dimensions

11.8. Braking resistors (DBRs) and braking units

11.8.1. Selecting a Braking Resistor

[1] Selection procedure

Depending on the cyclic period, the following requirements must be satisfied.

(1) If the cyclic period is 100 s or less: [Requirement 1] and [Requirement 3]
(2) If the cyclic period exceeds 100 s: [Requirement 1] and [Requirement 2]

[Requirement 1] : The maximum braking torque should not exceed the values listed in the tables in 11.8.4 Specifications. To use the maximum braking torque exceeding the values in those tables, select the braking resistor whose capacity is one class larger.

[Requirement 2] : The discharge energy for a single braking action should not exceed the discharging capability (kWs) listed in the tables. For calculation details, refer to Chapter 10, "10.3.3 Braking resistor rating."

[Requirement 3] : The average loss that is calculated by dividing the discharge energy by the cyclic period must not exceed the average allowable loss (kW) listed in the tables in 11.8.4 Specifications.

[2] Notes on selection

The braking time T_1, cyclic period T_0, and duty cycle %ED are converted under deceleration braking conditions based on the rated torque as shown in Figure 11.8-1. However, it is not necessary to consider these values in the selection of braking resistor capacity.

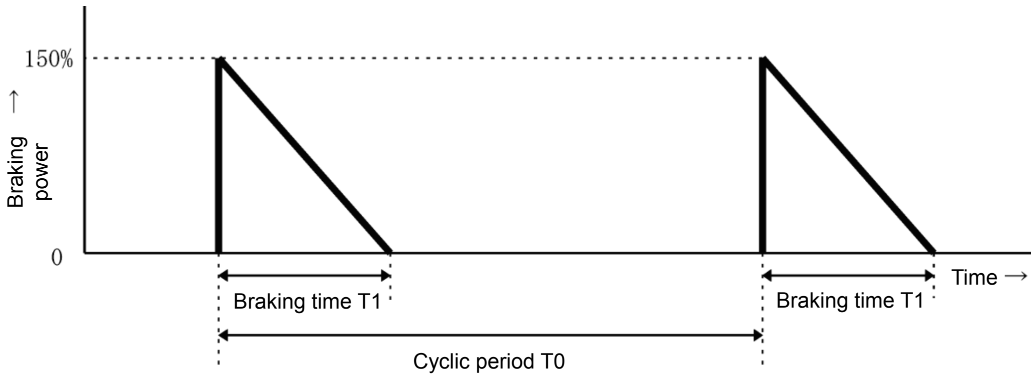


Figure 11.8-1 Duty Cycle

$$\text{Duty cycle (\%ED)} = \frac{T1}{T0} \times 100\ (\%)$$

11.8.2. Braking resistors (DBRs)

A braking resistor converts regenerative energy generated from deceleration of the motor to heat for consumption. Use of a braking resistor results in improved deceleration performance of the inverter.

[1] Standard model

The standard model of a braking resistor integrates a facility that detects the temperature on the heat sink of the resistor and outputs a digital ON/OFF signal if the temperature exceeds the specified level (as an overheating warning signal). To ensure that the signal is recognized at one of the digital input terminals of the FRENIC-Ace, assign the external alarm THR to any of terminals [X1] to [X5], [FWD] and [REV]. Connect the assigned terminals to terminals [1] and [2] of the braking resistor. Upon detection of the warning signal (preset detection level: 150°C), the inverter simultaneously transfers to Alarm mode, displays alarm OH2 on the LED monitor and shuts down its power output.

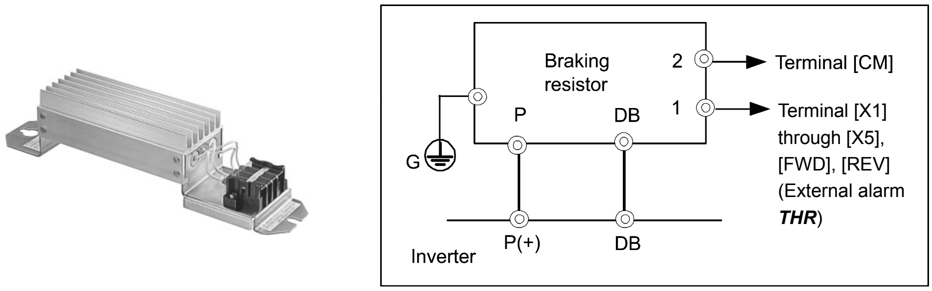


Figure 11.8-2 Braking Resistor (Standard Model) and Connection Example

[2] 10%ED model

The 10%ED braking resistor does not support overheating detection or warning output, so an electronic thermal overload relay needs to be set up using function codes F50 and F51 to protect the braking resistor from overheating.

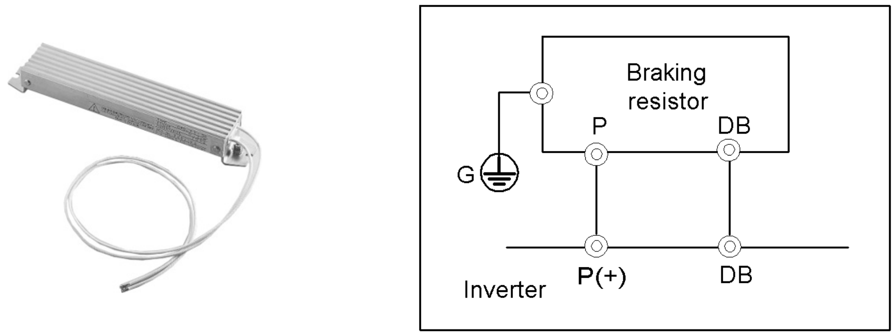


Figure 11.8-3 Braking Resistor (10%ED Model) and Connection Example

For the specifications and external dimensions of the braking units, refer to 11.8.4 Specifications and 11.8.5 External dimensions.

11.8.3. Braking units

Add a braking unit to the braking resistor to upgrade the braking capability of inverters with the following capacity.

FRN0072E2S-4☐ or the lower models of inverters have built-in IGBTs for the braking resistor.

Figure 11.8-4 Braking Unit

📖 For the specifications and external dimensions of the braking units, refer to 11.8.4 Specifications and 11.8.5 External dimensions.

11.8.4. Specifications

Table 11.8-1 Generated Loss in Braking Unit

Model	Generated loss (W)	Min. connection resistance (Ω)
BU37-4C	35	12
BU55-4C	40	7.5
BU90-4C	50	4.7
BU132-4C	60	3.0

*10%ED

Table 11.8-2 Braking Unit and Braking Resistor (Standard Model)

ND mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	Selecting Options					Maximum braking torque			Continuous braking (100% braking torque)		Repetitive braking (each cycle is 100 s or less)	
			Braking units		Braking resistor				50Hz	60Hz	Discharging capability	Braking time	Average allowable loss	Duty cycle
			Model	Q'ty	Model	Q'ty	Resistance (Ω)		(N·m)	(N·m)	(kWs)	(s)	(kW)	(%ED)
Three-phase 400V	30	FRN0059E2S-4☐	-		DB18.5-4	1	27	75	146	121	93	6	0.463	3
	37	FRN0072E2S-4☐			DB22-4	1	22		180	150	88	4.7	0.55	3
	45	FRN0085E2S-4☐	BU37-4C	1	DB37-4C	1	12		220	182	185	10	1.85	10
	55	FRN0105E2S-4☐	BU55-4C	1	DB45-4C	1	10		268	223	225	10	2.25	10
	75	FRN0139E2S-4☐			DB55-4C	1	7.5		365	303	275	10	2.75	10
	90	FRN0168E2S-4☐	BU90-4C	1	DB75-4C	1	6.5		437	364	375	10	3.75	10
	110	FRN0203E2S-4☐			DB110-4C	1	4.7		534	444	450	10	4.50	10

HD mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	Selecting Options					Maximum braking torque			Continuous braking (100% braking torque)		Repetitive braking (each cycle is 100 s or less)	
			Braking units		Braking resistor				50Hz	60Hz	Discharging capability	Braking time	Average allowable loss	Duty cycle
			Model	Q'ty	Model	Q'ty	Resistance (Ω)		(N·m)	(N·m)	(kWs)	(s)	(kW)	(%ED)
Three-phase 400V	22	FRN0059E2S-4☐	-		DB18.5-4	1	27	100	144	119	93	8	0.463	4
	30	FRN0072E2S-4☐			DB22-4	1	22		195	162	88	6	0.55	3.5
	37	FRN0085E2S-4☐	BU37-4C	1	DB37-4C	1	12		240	200	185	10	1.85	10
	45	FRN0105E2S-4☐	BU55-4C	1	DB45-4C	1	10		293	243	225	10	2.25	10
	55	FRN0139E2S-4☐			DB55-4C	1	7.5		357	298	275	10	2.75	10
	75	FRN0168E2S-4☐	BU90-4C	1	DB75-4C	1	6.5		487	405	375	10	3.75	10
	90	FRN0203E2S-4☐			DB110-4C	1	4.7		583	486	450	10	4.50	10

HND mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	Selecting Options					Maximum braking torque			Continuous braking (100% braking torque)		Repetitive braking (each cycle is 100 s or less)	
			Braking units		Braking resistor				50Hz	60Hz	Discharging capability	Braking time	Average allowable loss	Duty cycle
			Model	Q'ty	Model	Q'ty	Resistance (Ω)		(N·m)	(N·m)	(kWs)	(s)	(kW)	(%ED)
Three-phase 400V	22	FRN0059E2S-4☐	-		DB18.5-4	1	27	100	144	119	93	8	0.463	4
	30	FRN0072E2S-4☐			DB22-4	1	22		195	162	88	6	0.55	3.5
	37	FRN0085E2S-4☐	BU37-4C	1	DB30-4C	1	15	75	180	150	150	10	1.50	10
	45	FRN0105E2S-4☐			DB37-4C	1	12		219	182	185	10	1.85	10
	55	FRN0139E2S-4☐	BU55-4C	1	DB45-4C	1	10		269	223	225	10	2.25	10
	75	FRN0168E2S-4☐			DB55-4C	1	7.5		365	303	275	10	2.75	10
	90	FRN0203E2S-4☐	BU90-4C	1	DB75-4C	1	6.5		439	364	375	10	3.75	10

Table 11.8-3 Braking Unit and Braking Resistor (Standard Model)

HHD mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	Selecting Options: Braking units Model	Braking units Q'ty	Braking resistor Model	Braking resistor Q'ty	Braking resistor Resistance (Ω)	Maximum braking torque	Maximum braking torque 50Hz (N·m)	Maximum braking torque 60Hz (N·m)	Continuous braking (100% braking torque) Discharging capability (kWs)	Continuous braking Braking time (s)	Repetitive braking (each cycle is 100 s or less) Average allowable loss (kW)	Repetitive braking Duty cycle (%ED)
Three-phase 400V	18.5	FRN0059E2S-4☐	-		DB18.5-4	1	27	150	182	151	93	10	0.463	5
	22	FRN0072E2S-4☐			DB22-4	1	22		216	179	88	8	0.55	5
	30	FRN0085E2S-4☐	BU37-4C	1	DB30-4C	1	15	100	195	162	150	10	1.50	10
	37	FRN0105E2S-4☐			DB37-4C	1	12		240	200	185	10	1.85	10
	45	FRN0139E2S-4☐	BU55-4C	1	DB45-4C	1	10		292	243	225	10	2.25	10
	55	FRN0168E2S-4☐			DB55-4C	1	7.5		359	298	275	10	2.75	10
	75	FRN0203E2S-4☐	BU90-4C	1	DB75-4C	1	6.5		487	405	375	10	3.75	10

Table 11.8-4 Braking resistors (10% ED models)

ND mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	Selecting Options: Braking units Model	Braking units Q'ty	Braking resistor Model	Braking resistor Q'ty	Braking resistor Resistance (Ω)	Maximum braking torque	Maximum braking torque 50Hz (N·m)	Maximum braking torque 60Hz (N·m)	Continuous braking (100% braking torque) Discharging capability (kWs)	Continuous braking Braking time (s)	Repetitive braking (each cycle is 100 s or less) Average allowable loss (kW)	Repetitive braking Duty cycle (%ED)
Three-phase 400V	30	FRN0059E2S-4☐	-		DB22-4	1	22	75	146	121	93	6	0.925	6
	37	FRN0072E2S-4☐							180	150	110	6	1.1	6

HD mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	Selecting Options: Braking units Model	Braking units Q'ty	Braking resistor Model	Braking resistor Q'ty	Braking resistor Resistance (Ω)	Maximum braking torque	Maximum braking torque 50Hz (N·m)	Maximum braking torque 60Hz (N·m)	Continuous braking (100% braking torque) Discharging capability (kWs)	Continuous braking Braking time (s)	Repetitive braking (each cycle is 100 s or less) Average allowable loss (kW)	Repetitive braking Duty cycle (%ED)
Three-phase 400V	22	FRN0059E2S-4☐	-		DB22-4	1	22	100	144	119	93	7	0.925	7
	30	FRN0072E2S-4☐							195	162	110	7	1.1	7

HND mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	Selecting Options: Braking units Model	Braking units Q'ty	Braking resistor Model	Braking resistor Q'ty	Braking resistor Resistance (Ω)	Maximum braking torque	Maximum braking torque 50Hz (N·m)	Maximum braking torque 60Hz (N·m)	Continuous braking (100% braking torque) Discharging capability (kWs)	Continuous braking Braking time (s)	Repetitive braking (each cycle is 100 s or less) Average allowable loss (kW)	Repetitive braking Duty cycle (%ED)
Three-phase 400V	22	FRN0059E2S-4☐	-		DB22-4	1	22	100	144	119	93	7	0.925	7
	30	FRN0072E2S-4☐							195	162	110	7	1.1	7

HHD mode

Power supply voltage	Nominal applied motor (kW)	Inverter type	Selecting Options: Braking units Model	Braking units Q'ty	Braking resistor Model	Braking resistor Q'ty	Braking resistor Resistance (Ω)	Maximum braking torque	Maximum braking torque 50Hz (N·m)	Maximum braking torque 60Hz (N·m)	Continuous braking (100% braking torque) Discharging capability (kWs)	Continuous braking Braking time (s)	Repetitive braking (each cycle is 100 s or less) Average allowable loss (kW)	Repetitive braking Duty cycle (%ED)
Three-phase 400V	18.5	FRN0059E2S-4☐	-		DB22-4	1	22	150	182	151	92	10	0.925	10
	22	FRN0072E2S-4☐							216	179	110	10	1.1	10

* The 10%ED braking resistor does not support overheating detection or warning output, so an electronic thermal overload relay needs to be set up using function codes F50 and F51 to protect the braking resistor from overheating.

11.8.5. External dimensions

Braking resistors, standard models

Figure A Figure B Figure C

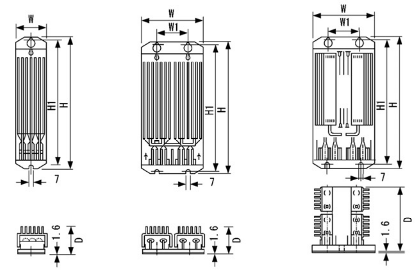


Figure D

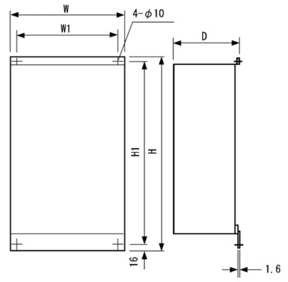
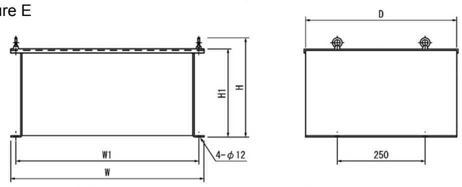


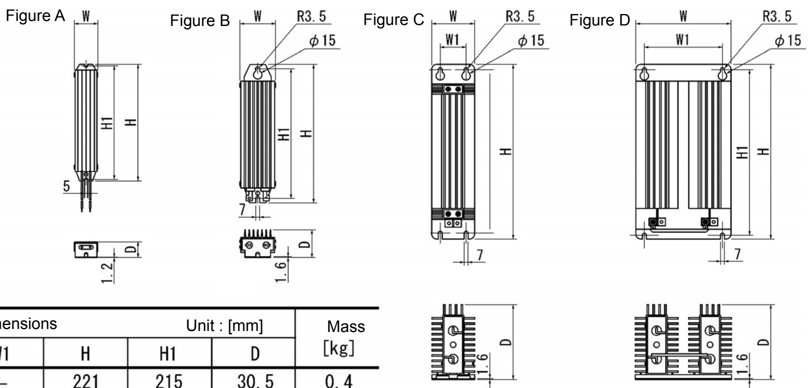
Figure E



Power supply voltage	Type	Figure	Dimensions (mm)					Mass
			W	W1	H	H1	D	[kg]
200 V class series	DB0.75-2	A	68	—	310	295	67	1.3
	DB2.2-2	A	80		345	332	94	2.0
	DB3.7-2	A	80		345	332	94	2.0
	DB5.5-2	B	146	90	450	430	67.5	4.5
	DB7.5-2	B	160	90	390	370	90	5.0
	DB11-2	C	142	74	430	415	160	6.9
	DB15-2	C	142	74	430	415	160	6.9
	DB18.5-2	C	142	74	510	495	160	8.7
	DB22-2	C	142	74	510	495	160	8.7
	DB30-2C	D	400	368	660	628	140	10
	DB37-2C	D					240	13
	DB45-2C	D						18
	DB55-2C		405		750	718		22
	DB75-2C	E	450	420	283	240	440	35
	DB110-2C		550	520				32
400 V class series	DB0.75-4	A	68	—	310	295	67	1.3
	DB2.2-4		68		470	455	67	2.0
	DB3.7-4		68		470	455	67	1.7
	DB5.5-4	B	146	74	470	455	67	4.5
	DB7.5-4		146	74	510	495	67	5.0
	DB11-4	C	142	74	430	415	160	6.9
	DB15-4	C	142	74	430	415	160	6.9
	DB18.5-4	C	142	74	510	495	160	8.7
	DB22-4	C	142	74	510	495	160	8.7
	DB30-4C	D	420	388	660	628	140	11
	DB37-4C	D					240	14
	DB45-4C	D						19
	DB55-4C		425		750	718		21
	DB75-4C	E	550	520	283	240	440	26
	DB110-4C							30
	DB132-4C		650	620				41
	DB160-4C		750	720				57
	DB200-4C							43
	DB220-4C*		600	570				74

* DB220-4C should be used in pairs. The dimension above is for one unit.

Braking resistors, 10% ED models



Type	Figure	Dimensions			Unit : [mm]		Mass
		W	W1	H	H1	D	[kg]
DB0.75-2C/4C	A	43	–	221	215	30.5	0.4
DB2.2-2C/4C	B	67	–	188	172	55	0.8
DB3.7-2C/4C	B	67	–	328	312	55	1.4
DB5.5-2C/4C	B	80	–	378	362	78	2.6
DB7.5-2C/4C	B	80	–	418	402	78	2.8
DB11-2C/4C	C	80	50	460	440	140	4.3
DB15-2C/4C	C	80	50	580	560	140	5.6
DB22-2C/4C	D	180	144	400	383	145	8.4

Braking units

Figure A

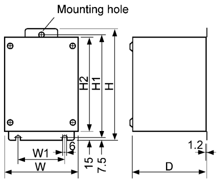
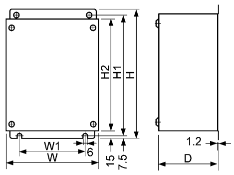


Figure B



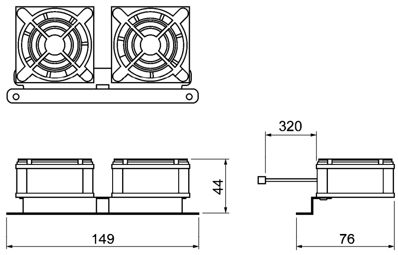
Power supply voltage	Type	Figure	Dimensions (mm)						Mass (kg)
			W	W1	H	H1	H2	D	
200 V class series	BU37-2C	A	150	100	240	225	210	160	4
	BU55-2C	B	230	130	240	225			6
	BU90-2C		250	150	370	355	340		9
400 V class series	BU37-4C	B	150	100	280	265	250	160	4
	BU55-4C		230	130					5.5
	BU90-4C								
	BU132-4C		250	150	370	355	340		9
	BU220-4C				450	435	420		13

Fan units for braking units

Using this option improves the duty cycle [%ED] from 10%ED to 30%ED.

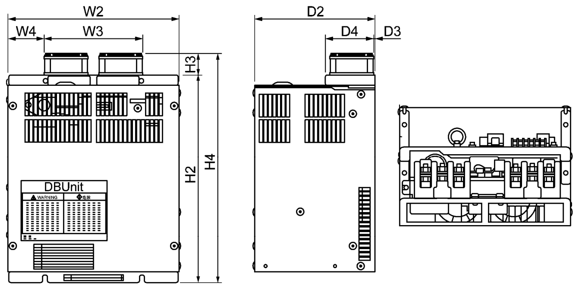
■ Fan unit

● BU-F



■ Braking unit + Fan unit

●BU37 to 220 - 2C/4C + BU-F



[Braking unit + Fan unit]

Power supply voltage	Type	Dimensions					Unit (mm)			
		W2	W3	W4	H2	H3	H4	D2	D3	D4
200 V class series	BU37-2C+BU-F	150	135	7.5	240	30	270	160	1.2	64
	BU55-2C+BU-F	230		47.5						
	BU90-2C+BU-F	250		57.5	370		400			
400 V class series	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			

11.9. Power regenerative PWM converters, RHC series

11.9.1. Overview

● Possible to reduce power supply facility capacity
Its power-factor control realizes the same phase current as the power-supply phase-voltage. The equipment, thus, can be operated with the power-factor of almost "1."
This makes it possible to reduce the power transformer capacity and downsize the other devices, compared with those required without the converter.

● Upgraded braking performance
Regenerated energy occurring at highly frequent accelerating and decelerating operation and elevating machine operation is entirely returned to power supply side.
Thus, energy saving during regenerative operation is possible.
As the current waveform is sinusoidal during regenerative operation, no troubles are caused to the power supply system.

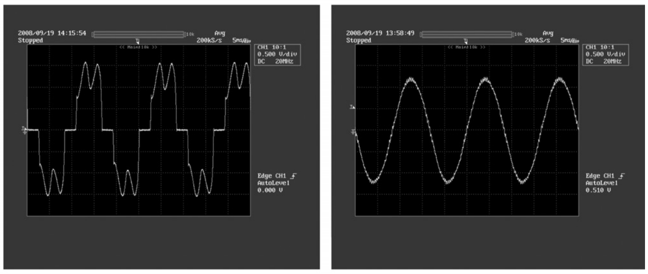
Rated continuous regeneration :	100%
Rated regeneration for 1 min	150% (CT use)
	120% (VT use)

● Enhanced maintenance/protective functions
Failure can be easily analyzed with the trace back function (option).
(1) The past 10 alarms can be displayed with the 7-segment LEDs.
This helps you analyze the alarm causes and take countermeasures.
(2) When momentary power failure occurs, the converter shuts out the gate to enable continuous operation after recovery.
(3) The converter can issue warning signals like overload, heat sink overheating, or the end of service life prior to converter tripping.

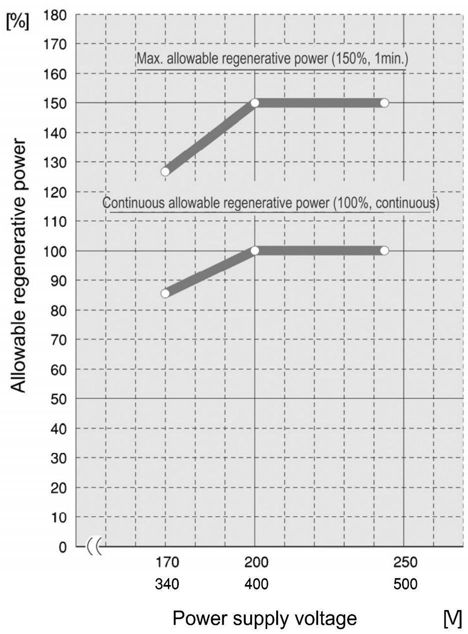
● Enhanced network support
The converter can be connected to MICREX-SX, F series and CC-Link master devices (using option).
The RS-485 interface is provided as standard.

Comparison of Input Current Waveforms

(With PWM converter) (Without PWM converter)



Allowable characteristics of the RHC unit



11.9.2. Specifications

[1] Standard specifications

■ 200 V class series

Item			Standard specifications										
Type RHC□□□-2C			200 V class series										
			7.5	11	15	18.5	22	30	37	45	55	75	90
CT mode		Applicable inverter capacity (kW)	7.5	11	15	18.5	22	30	37	45	55	75	90
CT mode	Output	Continuous capacity (kW)	8.8	13	18	22	26	36	44	53	65	88	103
CT mode	Output	Overload rating	150% of continuous rating for 1 minute										
CT mode	Output	Voltage 200 V	320 to 355 VDC (Variable with input power voltage) (*1)										
CT mode		Required power supply (kVA)	9.5	14	19	24	29	38	47	57	70	93	111
CT mode		Carrier frequency	15 kHz (typical)									10 kHz (typical)	
VT mode		Applicable inverter capacity (kW)	11	15	18.5	22	30	37	45	55	75	90	110
VT mode	Output	Continuous capacity (kW)	13	18	22	26	36	44	53	65	88	103	126
VT mode	Output	Overload rating	120% of continuous rating for 1 minute										
VT mode	Output	Voltage 200 V	320 to 355 VDC (Variable with input power voltage) (*1)										
VT mode		Required power supply (kVA)	14	19	24	29	38	47	57	70	93	111	136
VT mode		Carrier frequency	10 kHz (typical)									6 kHz (typical)	
Input power		Number of phases, voltage, frequency	Three-phase three lines, 200 to 220 V 50 Hz, 220 to 230 V 50 Hz (*2), 200 to 230 V 60 Hz										
Input power		Voltage/frequency fluctuation	Voltage: –15 to +10%, Frequency: ±5%, Voltage unbalance: 2% or less (*3)										

■ 400 V class series

Item			Standard specifications																				
Type RHC□□□-4C			400 V class series																				
			7.5	11	15	18.5	22	30	37	45	55	75	90	110	132	160	200	220	280	315	355	400	500	630
CT mode		Applicable inverter capacity (kW)	7.5	11	15	18.5	22	30	37	45	55	75	90	110	132	160	200	220	280	315	355	400	500	630
CT mode	Output	Continuous capacity (kW)	8.8	13	18	22	26	36	44	53	65	88	103	126	150	182	227	247	314	353	400	448	560	705
CT mode	Output	Overload rating	150% of continuous rating for 1 min																				
CT mode	Output	Voltage 200 V	640 to 710 V (Variable with input power voltage) (*1)																				
CT mode		Required power supply (kVA)	9.5	14	19	24	29	38	47	57	70	93	111	136	161	196	244	267	341	383	433	488	610	762
CT mode		Carrier frequency	15 kHz (typical)									10 kHz (typical)											6 kHz (typical)
VT mode		Applicable inverter capacity (kW)	11	15	18.5	22	30	37	45	55	75	90	110	132	160	200	220	280	315	355	400	500		
VT mode	Output	Continuous capacity (kW)	13	18	22	26	36	44	53	65	88	103	126	150	182	227	247	314	353	400	448	560		
VT mode	Output	Overload rating	120% of continuous rating for 1 min																				
VT mode	Output	Voltage 200 V	640 to 710 V (Variable with input power voltage) (*1)																				
VT mode		Required power supply (kVA)	14	19	24	29	38	47	57	70	93	111	136	161	196	244	267	341	383	433	488	610		
VT mode		Carrier frequency	10 kHz (typical)									6 kHz (typical)												
Input power		Number of phases, voltage, frequency	Three-phase three lines, 380 to 440 V 50 Hz, 380 to 460 V 60 Hz (*4)																				
Input power		Voltage/frequency fluctuation	Voltage: –15 to +10%, Frequency: ±5%, Voltage unbalance: 2% or less (*3)																				

(*1) When the power supply voltage is 200/400 V, 220/440 V, or 230/460 V, the output voltage is approximate 320/640 VDC, 343/686 VDC, 355/710 VDC, respectively.

(*2) The 220 to 230 V/50 Hz models are available on request.

(*3) Voltage unbalance (%) = (Max. voltage (V) - Min. voltage (V)) / Three-phase average voltage (V) x 67

(*4) When the power supply voltage is 380 to 398 V/50 Hz and 380 to 430 V/60 Hz, tap-switching is required in the converter.

[2] Common specifications

Item		Specifications
Control	Control method	AVR constant control with DC ACR minor
Control	Running/Stopping	Starts rectification when the converter is powered ON after connection. Starts boosting when it receives a run signal (terminals [RUN] and [CM] short-circuited or a run command via the communications link). After that, the converter is ready to run.
Control	Running status signal	Running, power running, regenerative operation, ready-to-run, alarm output (for any alarm), etc.
Control	CT/VT switching	Switching between CT and VT modes. CT: 150% of overload rating for 1 min VT: 120% of overload rating for 1 min
Control	Carrier frequency	Fixed to high carrier frequency
Control	Input power factor	0.99 or above
Control	Restart after momentary power failure	Shields the gate when the voltage level reaches the undervoltage level if a momentary power failure occurs, and the converter can automatically restart after the power recovers.
Control	Power limiting control	Controls the power not to exceed the preset limit value.
Indication	Alarm display (Protective functions)	AC fuse blown, AC overvoltage, AC undervoltage, AC overcurrent, AC input current error, input phase loss, synchronous power supply frequency error, DC fuse blown, DC overvoltage, DC undervoltage, charge circuit fault, heat sink overheat, external alarm, converter internal overheat, overload, memory error, keypad communications error, CPU error, network device error, operation procedure error, A/D converter error, optical network error, IPM error
Indication	Alarm history	Saves and displays the most recent 10 alarms. Saves and displays the detailed information of the trip cause for the previous alarm.
Indication	Monitor	Displays input power, input current in RMS, input voltage in RMS, DC link bus voltage and power supply frequency.
Indication	Load factor	Allows the user to measure the load factor with the keypad.
Indication	Language	Allows the user to specify or refer to function codes in any of the three languages--Japanese, English or Chinese.
Indication	Charging lamp	Lights when the DC link bus capacitor is charged.

11.9.3. Function specifications

■ Terminal functions

Classification	Symbol	Name	Functions
Main circuit	L1/R, L2/S, L3/T	Main circuit power inputs	Connects with the three-phase input power lines through a dedicated reactor.
	P(+), N(-)	Converter outputs	Connects with the power input terminals P(+) and N(-) on an inverter.
	ok	Grounding	Grounding terminal for the converter's chassis (or casing).
	R0, T0	Auxiliary power input for the control circuit	For a backup of the control circuit power supply, connect the power lines same as that of the main power input.
Voltage detection	R1, S1, T1	Synchronous power input for voltage detection	Voltage detection terminals for the internal control of the converter. Connect with the power supply side of the dedicated reactor or filter.
	R2, T2	Inputs for control monitoring	Detection terminal for AC fuse blown.
Input signal	[RUN]	Run command	Short-circuiting terminals [RUN] and [CM] runs the converter; opening them stops the converter.
	[RST]	Reset alarm command	When the converter stops due to an alarm, removing the alarm factor and short-circuiting the terminals [RST] and [CM] cancels the protective function, restarting the converter.
	[X1]	General-purpose transistor input	0: Enable external alarm trip ***THR*** 1: Cancel current limiter ***LMT-CCL*** 2: 73 answerback ***73ANS*** 3: Switch current limiter ***I-LIM*** 4: Option DI ***OPT-DI***
	[CM]	Digital input common	Common terminal for digital input signals.
	[PLC]	PLC signal power	Connects to PLC output signal power supply. (Rated voltage: 24 VDC (22 to 27 VDC)
Output signal	[30A/B/C]	Alarm relay output (for any alarm)	Outputs a signal when the protective function is activated to stop the converter. (Contact: [1C], Terminals [30A] and [30C] are closed: Signal ON) (Contact rating: 250 VAC, max. 50 mA)
	[Y1], [Y2], [Y3], [Y11] to [Y18]	General-purpose transistor output	0: Converter running ***RUN*** 1: Converter ready to run ***RDY*** 2: Power supply current limiting ***IL*** 3: Lifetime alarm ***LIFE*** 4: Heat sink overheat early warning ***PRE-OH*** 5: Overload early warning ***PRE-OL*** 6: Power running ***DRV*** 7: Regenerating ***REG*** 8: Current limiting early warning ***CUR*** 9: Restarting after momentary power failure ***U-RES*** 10: Synchronizing power supply frequency ***SY-HZ*** 11: Alarm content 1 ***AL1*** 12: Alarm content 2 ***AL2*** 13: Alarm content 4 ***AL4*** 14: Option DO ***OPT-DO*** * Mounting the OPC-VG7-DIOA option makes 8 points of DO extended functions available. (DI functions are not available.)
	[CME]	Digital output common	
	[Y5A/C]	Relay output	
	[A01], [A04], [A05]	General-purpose analog output	0: Input power ***PWR*** 1: Input current in RMS ***I-AC*** 2: Input voltage in RMS ***V-AC*** 3: DC link bus voltage ***V-DC*** 4: Power supply frequency ***FREQ*** 5: +10 V test ***P10*** 6: -10 V test ***N10*** * Mounting the OPC-VG7-AIO option makes 2 points of AO extended functions available. (AI functions are not available.)
	[M]	Analog output common	Common terminal for analog output signal.
	[73A], [73C]	Charging resistor input relay outputs	Control output for the input relay of the external charging resistor (73).

■ Communications specifications

Item		Specifications
General communication specifications		Monitoring the running information, running status and function code data, and controlling (selecting) the terminals [RUN], [RST] and [X1]. * Writing to function codes is not possible.
RS-485 (standard)		Communicating with a PC or PLC. (The converter supports the Fuji general-purpose inverter protocol and Modbus RTU protocol.)
T-Link (option)		Mounting the OPC-VG7-TL option enables communication with a T-Link module of MICREX-F or MICREX-SX via a T-Link network.
SX-bus (option)		Mounting the OPC-VG7-SX option enables communication with a MICREX-SX via an SX bus network.
CC-Link (option)		Mounting the OPC-VG7-CCL option enables communication with a CC-Link master.
Traceback (option)	Hardware	Mounting the OPC-RHC-TR option enables tracing back of the running status data of the converter. WPS-LD-TR software is required.
	Software	Installing the WPS-RHC-TR software enables collecting of traceback data on the PC.

■ Function settings

Function code	Name
F00	Data protection
F01	High frequency filter selection
F02	Restart mode after momentary power failure (Mode selection)
F03	Current rating switching
F04	LED monitor, item selection
F05	LCD monitor, item selection
F06	LCD monitor, language selection
F07	LCD monitor, contrast control
F08	Carrier frequency
E01	Terminal [X1] function
E02 to E13	Terminal [Y1], [Y2], [Y3,], [Y5], [Y11] to [Y18] function
E14	I/O function normal open/closed
E15	RHC overload early warning level
E16	Cooling fan ON/OFF control
E17	Under current limiting (Hysteresis width)
E18 to E20	A01, A04 and A05, function selection
E21 to E23	A01, A04 and A05, gain setting
E24 to E26	A01, A04 and A05, bias setting
E27	A01, A04 and A05, filter setting
S01	Operation method
S02, S03	Power supply current limiting (driving/braking)
H01	Station address
H02	Communications error processing
H03	Timer
H04	Baud rate
H05	Data length
H06	Parity bits
H07	Stop bits
H08	No-response error detection time
H09	Response interval
H10	Protocol selection
H11	TL transmission format
H12	Parallel system
H13	Number of slave stations in parallel system
H14	Clear alarm data
H15, H16	Power supply current limiter (driving 1/2)
H17, H18	Power supply current limiter (braking 1/2)
H19, H20	Current limiting early warning (level/timer)
M09	Power supply frequency
M10	Input power
M11	Input current in RMS
M12	Input voltage in RMS
M13	Run command
M14	Running status
M15	Output terminals [Y1] to [Y18]

■ Protective functions

Item	LED monitor displays:	Description	Remarks
AC fuse blown	ACF	Stops the converter output if the AC fuse (R-/T-phase only) is blown.	
AC overvoltage	AOU	Stops the converter output upon detection of an AC overvoltage condition.	
AC undervoltage	ALU	Stops the converter output upon detection of an AC undervoltage condition.	
AC overcurrent	AOC	Stops the converter output if the peak value of the input current exceeds the overcurrent level.	
AC input current error	ACE	Stops the converter output upon detection of the excessive deviation of the AC reactor from the AC input.	
Input phase loss	LPU	Stops the converter output upon detection of an input phase loss.	
Synchronous power frequency error	Fr-E	After the MC for charging circuit (73) is turned on, the converter checks the power frequency. If it detects a power frequency error, this function stops the converter output. An error during converter running (e.g., momentary power failure) triggers no alarm.	
DC fuse blown	dCF	Stops the converter output if the DC fuse (P side) is blown.	18.5 kW or above
DC overvoltage	dOU	Stops the converter output upon detection of a DC overvoltage condition. If a power failure continues for a long time and the control power source is shut down, this alarm is automatically reset.	200 V class series: 400 V ±3 V 400 V class series:800 V ±5 V
DC undervoltage	dLU	Stops the converter output upon detection of a DC undervoltage condition. If a power failure continues for a long time and the control power source is shut down, this alarm is automatically reset.	200 V class series: Stops at 185 V, restarts at 208 V. 400 V class series: Stops at 371 V, restarts at 417 V.
Charging circuit fault	PbF	Stops the converter output upon detection of a charging circuit fault, provided that the answerback signal from 73 is enabled.	Condition: ***73ANS*** (Answerback from 73) is assigned to terminal [X1].
Heat sink overheat	OH1	Stops the converter output upon detection of a heat sink overheat.	
External alarm	OH2	Stops the converter output upon receipt of an external signal ***THR***.	Condition: ***THR*** (Enable external alarm trip) is assigned to terminal [X1].
Converter internal overheat	OH3	Stops the converter output upon detection of an internal overheat of the converter.	
Converter overload	OLU	Stops the converter output with the inverse-time characteristics due to the input current.	Activate at 105%, 150% for 1 min
Memory error	Er-1	Stops the converter output if a data writing error or any other memory error occurs (when the checksums of the EEPROM and RAM do not match).	
Keypad communications error	Er-2	Displays "*er2* " upon detection of a wire break in initial communication with the keypad. This does not affect the converter operation.	
CPU error	Er-3	Activated if a CPU error occurs.	
Network device error	Er-4	Stops the converter output if a fatal error (including no power supply connection) occurs in the master unit in the network.	Applies to T-Link, SX-bus, and CC-Link devices.
Operation procedure error	Er-6	Stops the converter output upon detection of an error in the operation procedure.	
A/D converter error	Er-8	Stops the converter output upon detection of a failure in the A/D converter circuit.	
Optical network error	Er-b	Stops the converter output upon detection of an optical cable break or a fatal error in the optical option.	
IPM error	IPE	Activated when the IPM's self-diagnosis function works due to an overcurrent or overheat.	15 kW or below

■ Required structure and environment

Item		Required structure, environment and standards	Remarks
Structure	Structure	Mounting in a panel or mounting for external cooling	
	Enclosure	IP00	
	Cooling system	Forced air cooling	
	Installation	Vertical installation	
	Coating color	Munsell 5Y3/0.5, eggshell (Same color as our inverter FRENIC 5000VG7S series.)	
	Maintainability	Structure designed for easy parts replacement	
Environment	Site location	Shall be free from corrosive gases, flammable gases, dusts, and direct sunlight. Indoor use only.	
	Surrounding temperature	-10 to 50°C	
	Relative humidity	5 to 95% RH (No condensation)	
	Altitude	3,000 m max. (For use in an altitude between 1,001 m to 3,000 m, the output current should be derated.)	
	Vibration	2 to 9 Hz: Amplitude = 3 mm, 9 to 20 Hz: 9.8 m/s^2, 20 to 55 Hz: 2 m/s^2 (9 to 55 Hz: 2 m/s^2 for 90 kW or above), 55 to 200 Hz: 1 m/s^2	
	Storage temperature	-20 to 55°C	
	Storage humidity	5 to 95% RH	

11.9.4. Converter configuration

■ List of configurators

CT mode

Power supply	Nominal applied motor (kW)	PWM converter type	MC for charging circuit		MC for power supply		Charging box (*1)		Charging resistor		Fuse		Boosting reactor		Filtering resistor		Filtering reactor		Filtering capacitor		MC for filtering circuit	
			(73)	Q'ty	(52)	Q'ty	(CU)	Q'ty	(R0)	Q'ty	(F)	Q'ty	(Lr)	Q'ty	(Rf)	Q'ty	(Lf)	Q'ty	(Cf)	Q'ty	(6F)	Q'ty
200 V class series	7.5	RHC7.5-2C	SC-5-1	1			CU7.5-2C	1	(80W 7.5Ω)	(3)	(CR2LS-50/UL)	(2)	LR2-7.5C	1	GRZG80 0.42Ω	3	LFC2-7.5C	1	CF2-7.5C	1		
	11	RHC11-2C	SC-N1	1			CU11-2C	1	(HF5C5504)		(CR2LS-75/UL)	(2)	LR2-15C	1	GRZG150 0.2Ω	3	LFC2-15C	1	CF2-15C	1		
	15	RHC15-2C	SC-N2	1			CU15-2C	1			(CR2LS-100/UL)	(2)										
	18.5	RHC18.5-2C	SC-N3	1			CU18.5-2C	1	(GRZG120 2Ω)	(3)			LR2-22C	1	GRZG200 0.13Ω	3	LFC2-22C	1	CF2-22C	1		
	22	RHC22-2C					CU22-2C	1			(CR2L-150/UL)	(2)										
	30	RHC30-2C	SC-N4	1			CU30-2C	1			(CR2L-200/UL)	(2)	LR2-37C	1	GRZG400 0.1Ω	3	LFC2-37C	1	CF2-37C	1		
	37	RHC37-2C	SC-N5	1			CU45-2C	1			(CR2L-260/UL)	(2)										
	45	RHC45-2C	SC-N7	1									LR2-55C	1			LFC2-55C	1	CF2-55C	1		
	55	RHC55-2C	SC-N8	1			CU55-2C	1			(CR2L-400/UL)	(2)										
	75	RHC75-2C	SC-N11	1			CU75-2C	1					LR2-75C	1			LFC2-75C	1	CF2-75C	1		
	90	RHC90-2C					CU90-2C	1	(GRZG400 1Ω)	(3)	(A50P600-4)	(2)	LR2-110C	1	GRZG400 0.12Ω (2 pcs in parallel)	6	LFC2-110C	1	CF2-110C	1		
400 V class series	7.5	RHC7.5-4C	SC-05	1			CU7.5-4C	1	(TK50B 30Ω J)	(3)	(CR6L-30/UL)	(2)	LR4-7.5C	1	GRZG80 1.74Ω	3	LFC4-7.5C	1	CF4-7.5C	1		
	11	RHC11-4C	SC-4-0	1			CU15-4C	1	(HF5B0416)		(CR6L-50/UL)	(2)	LR4-15C	1	GRZG150 0.79Ω	3	LFC4-15C	1	CF4-15C	1		
	15	RHC15-4C	SC-5-1	1																		
	18.5	RHC18.5-4C	SC-N1	1			CU18.5-4C	1	(80W 7.5Ω)	(3)			LR4-22C	1	GRZG200 0.53Ω	3	LFC4-22C	1	CF4-22C	1		
	22	RHC22-4C					CU22-4C	1	(HF5C0416)		(CR6L-75/UL)	(2)										
	30	RHC30-4C	SC-N2	1			CU30-4C	1			(CR6L-100/UL)	(2)	LR4-37C	1	GRZG400 0.38Ω	3	LFC4-37C	1	CF4-37C	1		
	37	RHC37-4C	SC-N2S	1			CU45-4C	1			(CR6L-150/UL)	(2)										
	45	RHC45-4C	SC-N3	1									LR4-55C	1	GRZG400 0.26Ω	3	LFC4-55C	1	CF4-55C	1		
	55	RHC55-4C	SC-N4	1			CU55-4C	1			(CR6L-200/UL)	(2)										
	75	RHC75-4C	SC-N5	1			CU75-4C	1					LR4-75C	1	GRZG400 0.38Ω	3	LFC4-75C	1	CF4-75C	1		
	90	RHC90-4C	SC-N7	1			CU90-4C	1			(CR6L-300/UL)	(2)	LR4-110C	1	GRZG400 0.53Ω (2 pcs in parallel)	6	LFC4-110C	1	CF4-110C	1		
	110	RHC110-4C	SC-N8	1			CU110-4C	1	(GRZG120 2Ω)	(3)												
	132	RHC132-4C					CU132-4C	1			(A50P400-4)	(2)	LR4-160C	1	RF4-160C	1	LFC4-160C	1	CF4-160C	1		
	160	RHC160-4C	SC-N11	1			CU160-4C	1			(A50P600-4)	(2)										
	200	RHC200-4C	SC-N12	1			CU200-4C	1	(GRZG400 1Ω)	(3)			LR4-220C	1	RF4-220C	1	LFC4-220C	1	CF4-220C	1		
	220	RHC220-4C					CU220-4C	1			(A70QS800-4)	(2)										
	280	RHC280-4C	SC-N3	1	SC-N14	1			GRZG400 1Ω (2 pcs in parallel)	6	A70QS800-4	2	LR4-280C	1	RF4-280C	1	LFC4-280C	1	CF4-280C	1	SC-N4	1
	315	RHC315-4C									A70P1600-4TA	2	LR4-315C	1	RF4-315C	1	LFC4-315C	1	CF4-315C	1		
	355	RHC355-4C											LR4-355C	1	RF4-355C	1	LFC4-355C	1	CF4-355C	1		
	400	RHC400-4C			SC-N16	1							LR4-400C	1	RF4-400C	1	LFC4-400C	1	CF4-400C	1		
	500	RHC500-4C			SC-N11	3							LR4-500C	1	RF4-500C	1	LFC4-500C	1	CF4-500C	1(*2)		
	630	RHC630-4C			SC-N12	3					A70P2000-4	2	LR4-630C	1	RF4-630C	1	LFC4-630C	1	CF4-630C	1(*2)	SC-N7	1

VT mode

Power supply	Nominal applied motor (kW)	PWM converter type	MC for charging circuit		MC for power supply		Charging box (*1)		Charging resistor		Fuse		Boosting reactor		Filtering resistor		Filtering reactor		Filtering capacitor		MC for filtering circuit	
			(73)	Q'ty	(52)	Q'ty	(CU)	Q'ty	(R0)	Q'ty	(F)	Q'ty	(Lr)	Q'ty	(Rf)	Q'ty	(Lf)	Q'ty	(Cf)	Q'ty	(6F)	Q'ty
200 V class series	11	RHC7.5-2C	SC-N1	1			CU7.5-2C	1	(80W 7.5Ω)	(3)	(CR2LS-50/UL)	(2)	LR2-15C	1	GRZG150 0.2Ω	3	LFC2-15C	1	CF2-15C	1		
	15	RHC11-2C	SC-N2	1			CU11-2C	1	(HF5C5504)		(CR2LS-75/UL)	(2)										
	18.5	RHC15-2C	SC-N3	1			CU15-2C	1			(CR2LS-100/UL)	(2)	LR2-22C	1	GRZG200 0.13Ω	3	LFC2-22C	1	CF2-22C	1		
	22	RHC18.5-2C					CU18.5-2C	1	(GRZG120 2Ω)	(3)												
	30	RHC22-2C	SC-N4	1			CU22-2C	1			(CR2L-150/UL)	(2)	LR2-37C	1	GRZG400 0.1Ω	3	LFC2-37C	1	CF2-37C	1		
	37	RHC30-2C	SC-N5	1			CU30-2C	1			(CR2L-200/UL)	(2)										
	45	RHC37-2C	SC-N7	1			CU45-2C	1			(CR2L-260/UL)	(2)	LR2-55C	1			LFC2-55C	1	CF2-55C	1		
	55	RHC45-2C	SC-N8	1																		
	75	RHC55-2C	SC-N11	1			CU55-2C	1			(CR2L-400/UL)	(2)	LR2-75C	1			LFC2-75C	1	CF2-75C	1		
	90	RHC75-2C					CU75-2C	1					LR2-110C	1	GRZG400 0.12Ω (2 pcs in parallel)	6	LFC2-110C	1	CF2-110C	1		
	110	RHC90-2C	SC-N12	1			CU90-2C	1	(GRZG400 1Ω)	(3)	(A50P600-4)	(2)										
400 V class series	11	RHC7.5-4C	SC-4-0	1			CU7.5-4C	1	(TK50B 30Ω J)	(3)	(CR6L-30/UL)	(2)	LR4-15C	1	GRZG150 0.79Ω	3	LFC4-15C	1	CF4-15C	1		
	15	RHC11-4C	SC-5-1	1			CU15-4C	1	(HF5B0416)		(CR6L-50/UL)	(2)										
	18.5	RHC15-4C	SC-N1	1									LR4-22C	1	GRZG200 0.53Ω	3	LFC4-22C	1	CF4-22C	1		
	22	RHC18.5-4C					CU18.5-4C	1	(80W 7.5Ω)	(3)												
	30	RHC22-4C	SC-N2	1			CU22-4C	1	(HF5C5504)		(CR6L-75/UL)	(2)	LR4-37C	1	GRZG400 0.38Ω	3	LFC4-37C	1	CF4-37C	1		
	37	RHC30-4C	SC-N2S	1			CU30-4C	1			(CR6L-100/UL)	(2)										
	45	RHC37-4C	SC-N3	1			CU45-4C	1			(CR6L-150/UL)	(2)	LR4-55C	1	GRZG400 0.26Ω	3	LFC4-55C	1	CF4-55C	1		
	55	RHC45-4C	SC-N4	1																		
	75	RHC55-4C	SC-N5	1			CU55-4C	1			(CR6L-200/UL)	(2)	LR4-75C	1	GRZG400 0.38Ω	3	LFC4-75C	1	CF4-75C	1		
	90	RHC75-4C	SC-N7	1			CU75-4C	1					LR4-110C	1	GRZG400 0.53Ω (2 pcs in parallel)	6	LFC4-110C	1	CF4-110C	1		
	110	RHC90-4C	SC-N8	1			CU90-4C	1			(CR6L-300/UL)	(2)										
	132	RHC110-4C					CU110-4C	1	(GRZG120 2Ω)	(3)			LR4-160C	1	RF4-160C	1	LFC4-160C	1	CF4-160C	1		
	160	RHC132-4C	SC-N11	1			CU132-4C	1			(A50P400-4)	(2)										
	200	RHC160-4C	SC-N12	1			CU160-4C	1			(A50P600-4)	(2)	LR4-220C	1	RF4-220C	1	LFC4-220C	1	CF4-220C	1		
	220	RHC200-4C					CU200-4C	1	(GRZG400 1Ω)	(3)												
	280	RHC220-4C	SC-N14	1			CU220-4C	1			(A70QS800-4)	(2)	LR4-280C	1	RF4-280C	1	LFC4-280C	1	CF4-280C	1		
	315	RHC280-4C	SC-N3	1	SC-N14	1			GRZG400 1Ω (2 pcs in parallel)	6	A70QS800-4	2	LR4-315C	1	RF4-315C	1	LFC4-315C	1	CF4-315C	1	SC-N4	1
	355	RHC315-4C									A70P1600-4TA	2	LR4-355C	1	RF4-355C	1	LFC4-355C	1	CF4-355C	1		
	400	RHC355-4C			SC-N16	1							LR4-400C	1	RF4-400C	1	LFC4-400C	1	CF4-400C	1		
	500	RHC400-4C			SC-N11	3							LR4-500C	1	RF4-500C	1	LFC4-500C	1	CF4-500C	1(*2)		

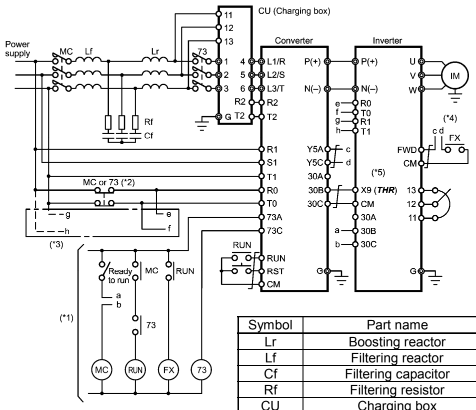
(*1) The charging box (CU) contains a combination of a charging resistor (R0) and a fuse (F). If no CU is used, it is necessary to prepare the charging resistor (R0) and fuse (F) at your end.

(*2) The filtering capacitor consists of two pieces of capacitors. For an order of quantity "1," two pieces of capacitors are to be delivered.

■ Basic connection diagrams

- RHC7.5-2C to RHC90-2C (Applicable inverters: Three-phase 200 V class series, 7.5 to 90 kW)
- RHC7.5-4C to RHC220-4C (Applicable inverters: Three-phase 400 V class series, 7.5 to 220 kW)

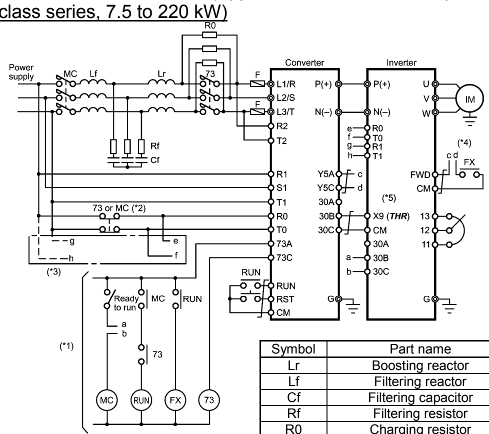
*When a charging box is connected



Symbol	Part name
Lr	Boosting reactor
Lf	Filtering reactor
Cf	Filtering capacitor
Rf	Filtering resistor
CU	Charging box
73	Magnetic contactor for charging circuit

(*1) For the 400 V class power supply, connect a stepdown transformer to limit the voltage of the sequence circuit to 220 V or below.
(*2) Be sure to connect the auxiliary power input terminals R0 and T0 of the PWM converter to the main power input lines via B contacts of magnetic contactors of the charging circuit (73 or MC).
If 73 uses SC-05, SC-4-0, or SC-5-1, connect an auxiliary contact unit to the MC's B contact or 73.
(*3) Be sure to connect the auxiliary power input terminals R0 and T0 of the inverter to the main power input lines via B contacts of magnetic contactors of the charging circuit (73 or MC). For 200 V class series of inverters with a capacity of 37 kW or above and 400 V class series with 75 kW or above, connect the fan power input terminals R1 and T1 of the inverter to the main power input lines without going through the MC's B contacts or 73.
(*4) Construct a sequence in which a run command is given to the inverter after the PWM converter becomes ready to run.
(*5) Assign the external alarm ***THR*** to any of terminals [X1] to [X9] on the inverter.

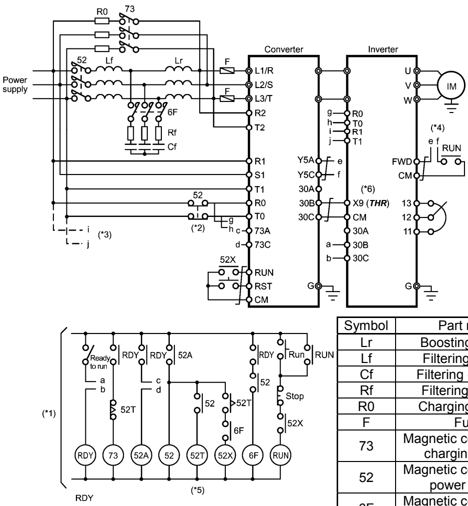
- RHC7.5-2C to RHC90-2C (Applicable inverters: Three-phase 200 V class series, 7.5 to 90 kW)
- RHC7.5-4C to RHC220-4C (Applicable inverters: Three-phase 400 V class series, 7.5 to 220 kW)



Symbol	Part name
Lr	Boosting reactor
Lf	Filtering reactor
Cf	Filtering capacitor
Rf	Filtering resistor
R0	Charging resistor
F	Fuse
73	Magnetic contactor for charging circuit

(*1) For the 400 V class power supply, connect a stepdown transformer to limit the voltage of the sequence circuit to 220 V or below.
(*2) Be sure to connect the auxiliary power input terminals R0 and T0 of the PWM converter to the main power input lines via B contacts of magnetic contactors of the charging circuit (73 or MC).
If 73 uses SC-05, SC-4-0, or SC-5-1, connect an auxiliary contact unit to the MC's B contact or 73.
(*3) Be sure to connect the auxiliary power input terminals R0 and T0 of the inverter to the main power input lines via B contacts of magnetic contactors of the charging circuit (73 or MC). For 200 V class series of inverters with a capacity of 37 kW or above and 400 V class series with 75 kW or above, connect the fan power input terminals R1 and T1 of the inverter to the main power input lines without going through the MC's B contacts or 73.
(*4) Construct a sequence in which a run command is given to the inverter after the PWM converter becomes ready to run.
(*5) Assign the external alarm ***THR*** to any of terminals [X1] to [X9] on the inverter.

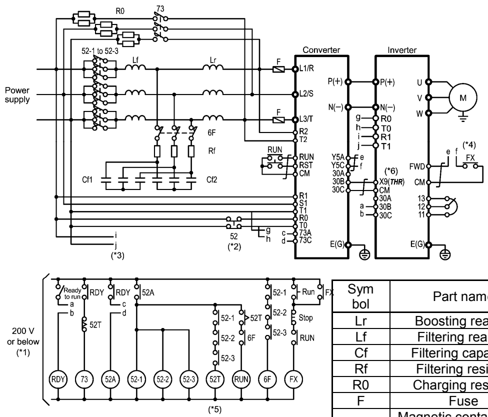
- RHC280-4C to RHC400-4C (Applicable inverters: Three-phase 400 V, 280 to 400 kW)



Symbol	Part name
Lr	Boosting reactor
Lf	Filtering reactor
Cf	Filtering capacitor
Rf	Filtering resistor
R0	Charging resistor
F	Fuse
73	Magnetic contactor for charging circuit
52	Magnetic contactor for power supply
6F	Magnetic contactor for filtering circuit

(*1) Connect a stepdown transformer to limit the voltage of the sequence circuit to 220 V or below.
(*2) Be sure to connect the auxiliary power input terminals R0 and T0 of the PWM converter and the inverter to the main power input lines via B contacts of magnetic contactors of the power supply circuit (52).
(*3) Connect the fan power input terminals R1 and T1 of the inverter to the main power input lines without going through the B contacts of 52, since the inverter's AC fans are supplied with power from these terminals.
(*4) Construct a sequence in which a run command is given to the inverter after the PWM converter becomes ready to run.
(*5) Set the timer 52T at 1 sec.
(*6) Assign the external alarm ***THR*** to any of terminals [X1] to [X9] on the inverter.

- RHC400-4C in VT mode (Applicable inverters: Three-phase 400 V, 400 kW)
- RHC500-4C and RHC630-4C (Applicable inverters: Three-phase 400 V, 500 and 630 kW)



Symbol	Part name
Lr	Boosting reactor
Lf	Filtering reactor
Cf	Filtering capacitor
Rf	Filtering resistor
R0	Charging resistor
F	Fuse
73	Magnetic contactor for charging circuit
52	Magnetic contactor for power supply
6F	Magnetic contactor for filtering circuit

(*1) Connect a stepdown transformer to limit the voltage of the sequence circuit to 220 V or below.
(*2) Be sure to connect the auxiliary power input terminals R0 and T0 of the PWM converter and the inverter to the main power input lines via B contacts of magnetic contactors of the power supply circuit (52).
(*3) Connect the fan power input terminals R1 and T1 of the inverter to the main power input lines without going through the B contacts of 73 or 52, since the inverter's AC fans are supplied with power from these terminals.
(*4) Construct a sequence in which a run command is given to the inverter after the PWM converter becomes ready to run.
(*5) Set the timer 52T at 1 sec.
(*6) Assign the external alarm ***THR*** to any of terminals [X1] to [X9] on the inverter.
(*7) Wiring for terminals L1/R, L2/S, L3/T, R2, T2, R1, S1, and T1 should match with the phase sequence.

11.9.5. External dimensions

PWM converter

Fig. A

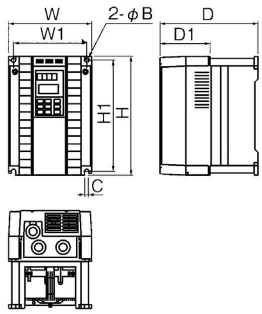


Fig. B

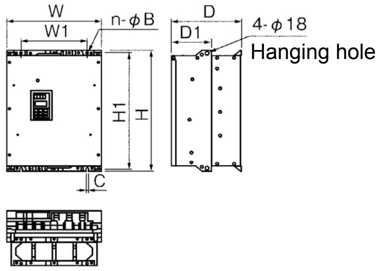


Fig. C

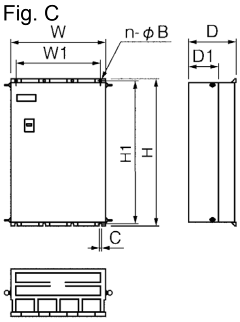
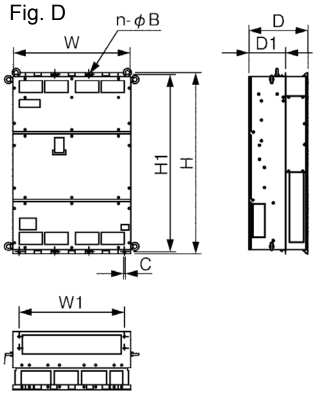


Fig. D



PWM converter type		Figure	Dimensions (mm)									Mass (kg)
			W	W1	H	H1	D	D1	n	B	C	
	RHC7.5-2C	A	250	226	380	358	245	125	2	10	10	12.5
	RHC11-2C											
	RHC15-2C											
	RHC18.5-2C	B	340	240	480	460	255	145	2	10	10	24
	RHC22-2C											
200V class series	RHC30-2C	B	340	240	550	530	255	145	2	10	10	29
	RHC37-2C	B	375	275	615	595	270	145	2	10	10	36
	RHC45-2C	B	375	275	740	720	270	145	2	10	10	42
	RHC55-2C	B	375	275	740	720	270	145	2	10	10	44
	RHC75-2C	C	530	430	750	720	285	145	2	15	15	70
	RHC90-2C	C	680	580	880	850	360	220	3	15	15	115
	RHC7.5-4C	A	250	226	380	358	245	125	2	10	10	12.5
	RHC11-4C											
	RHC15-4C											
	RHC18.5-4C	B	340	240	480	460	255	145	2	10	10	24
	RHC22-4C											
	RHC30-4C	B	340	240	550	530	255	145	2	10	10	29
	RHC37-4C	B	375	275	550	530	270	145	2	10	10	34
	RHC45-4C	B	375	275	675	655	270	145	2	10	10	38
	RHC55-4C	B	375	275	675	655	270	145	2	10	10	39
	RHC75-4C	B	375	275	740	720	270	145	2	10	10	48
	RHC90-4C	C	530	430	740	710	315	175	2	15	15	70
400V class series	RHC110-4C											
	RHC132-4C	C	530	430	1000	970	360	220	2	15	15	100
	RHC160-4C											
	RHC200-4C	C	680	580	1000	970	360	220	3	15	15	140
	RHC220-4C											
	RHC280-4C	C	680	580	1400	1370	450	285	3	15	15	320
	RHC315-4C											
	RHC355-4C	C	880	780	1400	1370	450	285	4	15	15	410
	RHC400-4C											
	RHC500-4C	D	999	900	1550	1520	500	313.2	4	15	15	525
	RHC630-4C											

< Boosting reactor >

Figure A

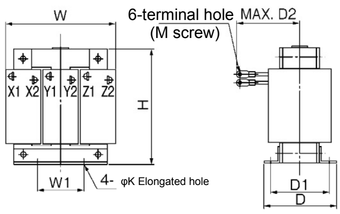


Figure B

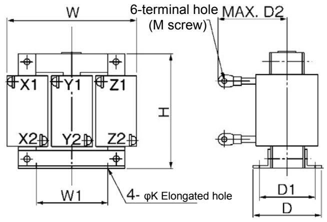


Figure C

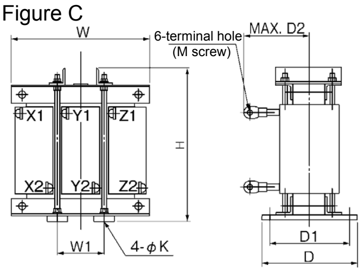
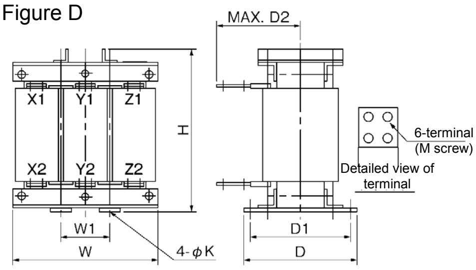


Figure D



Boosting reactor type		Figure	Dimensions (mm)								Mass (kg)
			W	W1	H	D	D1	D2	K	M	
200V class series	LR2-7.5C	A	180	75	205	105	85	95	7	M5	12
	LR2-15C	B	195	75	215	131	110	130	7	M8	18
	LR2-22C	C	240	80	340	215	180	145	10	M8	33
	LR2-37C	C	285	95	420	240	205	150	12	M10	50
	LR2-55C	C	285	95	420	250	215	160	12	M12	58
	LR2-75C	C	330	110	440	255	220	165	12	M12	70
	LR2-110C	C	345	115	500	280	245	185	12	M12	100
400V class series	LR4-7.5C	B	180	75	205	105	85	90	7	M4	12
	LR4-15C	A	195	75	215	131	110	120	7	M5	18
	LR4-22C	C	240	80	340	215	180	120	10	M6	33
	LR4-37C	C	285	95	405	240	205	130	12	M8	50
	LR4-55C	C	285	95	415	250	215	145	12	M10	58
	LR4-75C	C	330	110	440	255	220	150	12	M10	70
	LR4-110C	C	345	115	490	280	245	170	12	M12	100
	LR4-160C	C	380	125	550	300	260	185	15	M12	140
	LR4-220C	C	450	150	620	330	290	230	15	M12	200
	LR4-280C	C	480	160	740	330	290	240	15	M16	250
	LR4-315C	C	480	160	760	340	300	250	15	M16	270
	LR4-355C	C	480	160	830	355	315	255	15	M16	310
	LR4-400C	C	480	160	890	380	330	260	19	M16	340
	LR4-500C	C	525	175	960	410	360	290	19	M16	420
	LR4-630C	D	600	200	64	440	390	290	19	4×M12	450

< Filtering reactor >

Figure A

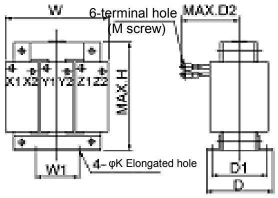


Figure B

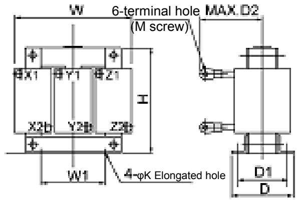


Figure C

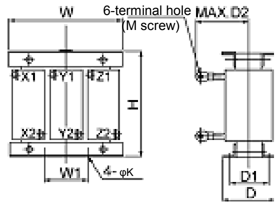


Figure D

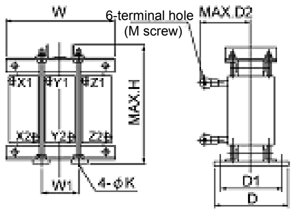
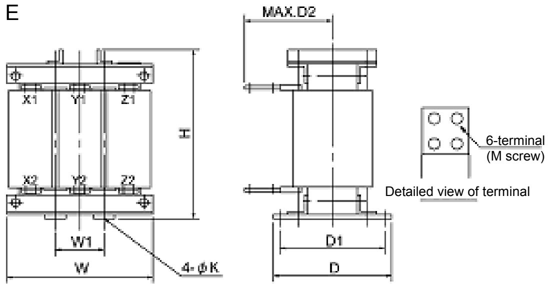


Figure E



Filtering reactor type		Figure	Dimensions (mm)								Mass (kg)
			W	W1	H	D	D1	D2	K	M	
200V class series	LFC2-7.5C	B	125	40	100	85	67	85	6	M5	2.2
	LFC2-15C	B	125	40	100	93	75	90	6	M8	2.5
	LFC2-22C	B	125	40	100	93	75	105	6	M8	3.0
	LFC2-37C	B	150	60	115	103	85	125	6	M10	5.0
	LFC2-55C	B	175	60	145	110	90	140	6	M12	8.0
	LFC2-75C	B	195	80	200	120	100	150	7	M12	13
	LFC2-110C	C	255	85	230	118	95	165	7	M12	20
400V class series	LFC4-7.5C	A	125	40	100	85	67	75	6	M4	2.2
	LFC4-15C	A	125	40	100	93	75	90	6	M5	2.5
	LFC4-22C	A	125	40	100	93	75	95	6	M6	3.0
	LFC4-37C	B	150	60	115	108	90	110	6	M8	5.0
	LFC4-55C	B	175	60	145	110	90	120	6	M10	8.0
	LFC4-75C	B	195	80	200	113	93	130	7	M10	12
	LFC4-110C	C	255	85	220	113	90	145	7	M12	19
	LFC4-160C	C	255	85	245	137	110	150	7	M12	22
	LFC4-220C	D	300	100	320	210	180	170	10	M12	35
	LFC4-280C	D	330	110	320	230	195	195	12	M16	43
	LFC4-315C	D	315	105	365	230	195	200	12	M16	48
	LFC4-355C	D	315	105	395	235	200	210	12	M16	53
	LFC4-400C	D	345	115	420	235	200	235	12	M16	60
	LFC4-500C	D	345	115	480	240	205	240	12	M16	72
	LFC4-630C	E	435	145	550	295	255	205	15	4×M12	175

< Filtering capacitor >

Fig. A

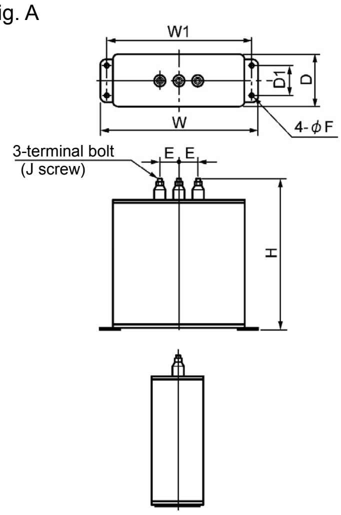
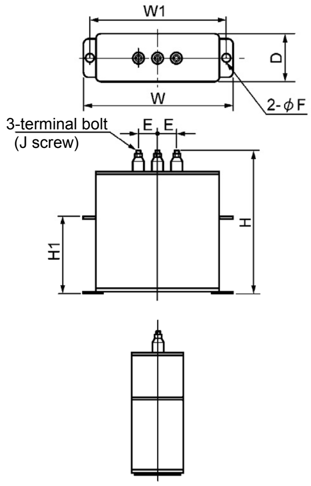


Fig. B



Filtering capacitor type		Figure	Dimensions (mm)									Mass (kg)
			W	W1	H	H1	D	D1	E	F	J	
200V class series	CF2-7.5C	A	165	150	185	-	70	40	30	7	M5	1.9
	CF2-15C	A	205	190	245	-	70	40	30	7	M5	3.5
	CF2-22C	A	280	265	215	-	90	55	30	7	M5	5.5
	CF2-37C	A	280	265	235	-	90	55	30	7	M5	6.0
	CF2-55C	A	280	265	340	-	90	55	80	7	M6	8.5
	CF2-75C	A	280	265	235	-	90	55	30	7	M5	6.0
	CF2-110C	A	280	265	340	-	90	55	80	7	M8	8.5
400V class series	CF4-7.5C	A	165	150	135	-	70	40	30	7	M5	1.3
	CF4-15C	A	165	150	215	-	70	40	30	7	M5	2.3
	CF4-22C	A	205	190	185	-	70	40	30	7	M5	2.5
	CF4-37C	A	205	190	205	-	70	40	30	7	M5	2.9
	CF4-55C	A	205	190	245	-	70	40	30	7	M5	3.5
	CF4-75C	A	205	190	205	-	70	40	30	7	M5	2.9
	CF4-110C	A	205	190	245	-	70	40	30	7	M5	3.5
	CF4-160C	A	280	265	260	-	90	55	80	7	M6	6.0
	CF4-220C	B	435	400	310	125	100	-	80	15x20 Elongated hole	M12	13.0
	CF4-280C	B	435	400	350	165	100	-	80	15x20 Elongated hole	M12	15.0
	CF4-315C	B	435	400	460	275	100	-	80	15x20 Elongated hole	M12	20.0
	CF4-355C	B	435	400	520	335	100	-	80	15x20 Elongated hole	M12	23.0
	CF4-400C	B	435	400	610	425	100	-	80	15x20 Elongated hole	M12	27.0
	CF4-500C	B	435	400	310	125	100	-	80	15x20 Elongated hole	M12	13.0
	CF4-630C	B	435	400	460	275	100	-	80	15x20 Elongated hole	M12	20.0

< Filtering resistor >

Fig. A

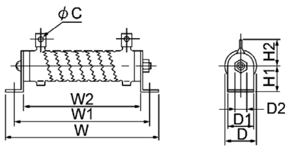


Fig. B

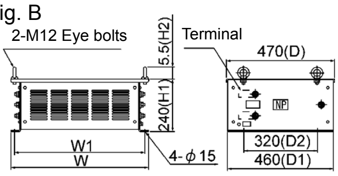
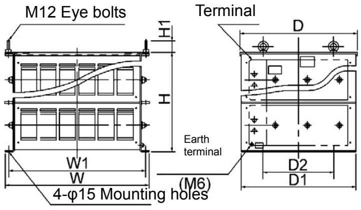


Fig. C



Filtering resistor type		Figure	Dimensions (mm)									Mass (kg)
			W	W1	W2	H1	H2	D	D1	D2	C	
200V class series	GRZG80 0.42Ω	A	167	148	115	22	32	33	26	6	5.5	0.19
	GRZG150 0.2Ω	A	247	228	195	22	40	33	26	6	8.2	0.19
	GRZG200 0.13Ω	A	306	287	254	22	40	33	26	6	8.2	0.35
	GRZG400 0.1Ω	A	411	385	330	40	46	47	40	9.5	8.2	0.85
	GRZG400 0.12Ω	A	411	385	330	40	46	47	40	9.5	8.2	0.85
400V class series	GRZG80 1.74Ω	A	167	148	115	22	32	33	26	6	5.5	0.19
	GRZG150 0.79Ω	A	247	228	195	22	32	33	26	6	5.5	0.3
	GRZG200 0.53Ω	A	306	287	254	22	32	33	26	6	5.5	0.35
	GRZG400 0.38Ω	A	411	385	330	40	46	47	40	9.5	8.2	0.85
	GRZG400 0.26Ω	A	411	385	330	40	46	47	40	9.5	8.2	0.85
	GRZG400 0.53Ω	A	411	385	330	40	46	47	40	9.5	8.2	0.85
	RF4-160C	B	400	370	-	240	55	470	460	320	-	22
	RF4-220C											25
	RF4-280C	C	655	625	-	240	55	470	460	320	-	31
	RF4-315C											35
	RF4-355C											36
	RF4-400C											38
	RF4-500C											41
	RF4-630C	C	655	625	-	440	55	530	520	320	-	70

< Charging box >

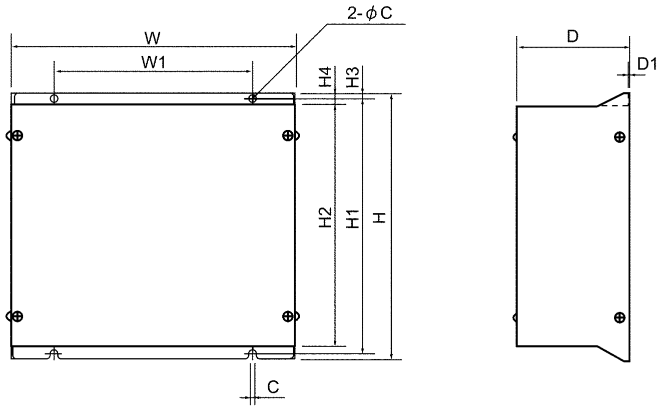
The charging box contains a combination of a charging resistor and a fuse, which is essential in the configuration of the RHC-C series of PWM converters. Using this charging box eases mounting and wiring jobs.

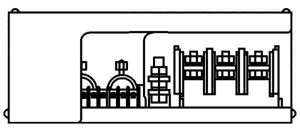
■ Capacity range

200 V class series: 7.5 to 90 kW in 10 types,

400 V class series: 7.5 to 220 kW in 14 types, Total 24 types

As for 400 V class series with a capacity of 280 to 400 kW, the charging resistor and the fuse are separately provided as before.





Fuse type		Dimensions (mm)										Mounting bolt	Mass (kg)
		W	W1	H	H1	H2	H3	4	D	D1	C		
200V class series	CU7.5-2C	270	170	300	285	270	7.5	15	100	2.4	6	M5	6
	CU11-2C												
	CU15-2C												
	CU18.5-2C												
	CU22-2C												
	CU30-2C	300	200	310	295	280	7.5	15	110	2.4	6	M5	7
	CU45-2C	330	230	310	295	280	7.5	15	130	2.4	6	M5	8
	CU55-2C												
	CU75-2C	430	330	560	536	510	12	25	150	3.2	10	M8	17
	CU90-2C												20
400V class series	CU7.5-4C	270	170	300	285	270	7.5	15	100	2.4	6	M5	5.5
	CU15-4C												
	CU18.5-4C												6
	CU22-4C												
	CU30-4C	300	200	310	295	280	7.5	15	110	2.4	6	M5	7
	CU45-4C												
	CU55-4C												
	CU75-4C	330	230	310	295	280	7.5	15	130	2.4	6	M5	8
	CU90-4C												
	CU110-4C												
	CU132-4C	430	330	560	536	510	12	25	150	3.2	10	M8	18
	CU160-4C												
	CU200-4C												20
	CU220-4C												

< Charging resistor >

Fig.A

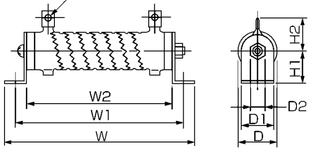


Fig.B

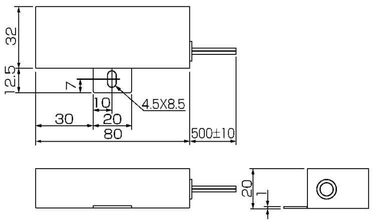
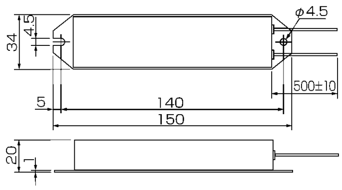


Fig.C



Charging resistor type	Figure	Dimensions (mm)									Mass (kg)
		W	W1	W2	H1	H2	D	D1	D2	C	
GRZG120 2Ω	A	217	198	165	22	32	33	22	6	5.5	0.25
GRZG400 1Ω	A	411	385	330	40	39	47	40	9.5	5.5	0.85
TK50B 30ΩJ (HF5B0416)	B	-	-	-	-	-	-	-	-	-	0.15
80W 7.5Ω (HF5C5504)	C	-	-	-	-	-	-	-	-	-	0.19

< Fuse >

Fig.A

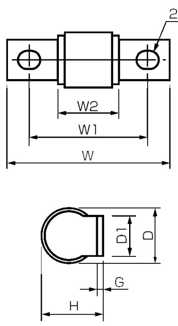


Fig.B

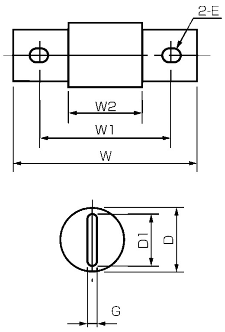
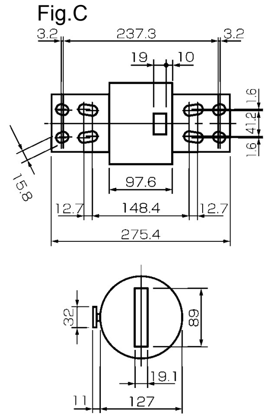
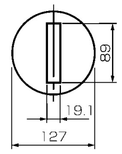


Fig.C



Side view of the A70P1600-4TA



Side view of the A70P2000-4

Fuse type		Figure	Dimensions (mm)								Mass (kg)
			W	W1	W2	H	D	D1	G	E	
200V class series	CR2LS-50/UL	A	56	42	26	18.5	17.5	12	2	6.5x8.5	0.03
	CR2LS-75/UL										
	CR2LS-100/UL										
	CR2L-150/UL	A	80	58	29.5	30.5	27	20	3	9x11	0.10
	CR2L-200/UL	A	85	60	30	33.5	30	25	3.2	11x13	0.13
	CR2L-260/UL										
	CR2L-400/UL	A	95	70	31	42	37	30	4	11x13	0.22
	A50P600-4	B	113.5	81.75	56.4	-	50.8	38.1	6.4	10.3x18.2	0.60
400V class series	CR6L-30/UL	A	76	62	47	18.5	17.5	12	2	6.5x8.5	0.04
	CR6L-50/UL										
	CR6L-75/UL	A	95	70	40	34	30	25	3.2	11x13	0.15
	CR6L-100/UL										
	CR6L-150/UL										
	CR6L-200/UL	A	107	82	43	42	37	30	4	11x13	0.25
	CR6L-300/UL										
	A50P400-4	B	110	78.6	53.1	-	38.1	25.4	6.4	10.3x18.4	0.30
	A50P600-4	B	113.5	81.75	56.4	-	50.8	38.1	6.4	10.3x18.2	0.60
	A70QS800-4	B	180.2	129.4	72.2	-	63.5	50.8	9.5	13.5x18.3	1.1
	A70P1600-4T	C	-	-	-	-	-	-	-	-	8.0
	A70P2000-4	C	-	-	-	-	-	-	-	-	8.0

■ Generated loss

In CT mode

PWM converter		Boosting reactor		Filtering reactor		Filtering resistor		
Type	Generated loss (W)	Type	Generated loss (W)	Type	Generated loss (W)	Type	Qty.	Generated loss (W)
RHC7.5-2C	400	LR2-7.5C	95	LFC2-7.5C	10	GRZG80 0.42Ω	3	16
RHC11-2C	500	LR2-15C	150	LFC2-15C	19	GRZG150 0.2Ω	3	48
RHC15-2C	650							
RHC18.5-2C	700	LR2-22C	230	LFC2-22C	26	GRZG200 0.13Ω	3	68
RHC22-2C	800							
RHC30-2C	1000	LR2-37C	330	LFC2-37C	32	GRZG400 0.1Ω	3	107
RHC37-2C	1350							
RHC45-2C	1500	LR2-55C	450	LFC2-55C	43			240
RHC55-2C	1750							
RHC75-2C	2050	LR2-75C	520	LFC2-75C	74			137
RHC90-2C	2450	LR2-110C	720	LR2-110C	115	GRZG400 0.12Ω Two in parallel	6	374
RHC7.5-4C	400	LR4-7.5C	90	LFC4-7.5C	9	GRZG80 1.74Ω	3	15
RHC11-4C	500	LR4-15C	160	LFC4-15C	20	GRZG150 0.79Ω	3	48
RHC15-4C	600							
RHC18.5-4C	650	LR4-22C	230	LFC4-22C	22	GRZG200 0.53Ω	3	70
RHC22-4C	900							
RHC30-4C	1200	LR4-37C	350	LFC4-37C	36	GRZG400 0.38Ω	3	86
RHC37-4C	1550							
RHC45-4C	1800	LR4-55C	490	LFC4-55C	43	GRZG400 0.26Ω	3	130
RHC55-4C	2050							
RHC75-4C	2150	LR4-75C	520	LFC4-75C	78	GRZG400 0.38Ω	3	112
RHC90-4C	2600	LR4-110C	710	LFC4-110C	90	GRZG400 0.53Ω Two in parallel	6	405
RHC110-4C	3050							
RHC132-4C	3500	LR4-160C	1000	LFC4-160C	160	RF4-160C	1	568
RHC160-4C	4150							
RHC200-4C	5100	LR4-220C	1240	LFC4-220C	200	RF4-220C	1	751
RHC220-4C	5600							
RHC280-4C	7100	LR4-280C	1430	LFC4-280C	220	RF4-280C	1	1027
RHC315-4C	8000	LR4-315C	1660	LFC4-315C	260	RF4-315C	1	1154
RHC355-4C	8900	LR4-355C	1910	LFC4-355C	300	RF4-355C	1	1286
RHC400-4C	10100	LR4-400C	2160	LFC4-400C	350	RF4-400C	1	1454

In VT mode

PWM converter		Boosting reactor		Filtering reactor		Filtering resistor		
Type	Generated loss (W)	Type	Generated loss (W)	Type	Generated loss (W)	Type	Qty.	Generated loss (W)
RHC7.5-2C	450	LR2-15C	150	LFC2-15C	19	GRZG150 0.2Ω	3	48
RHC11-2C	550							
RHC15-2C	650	LR2-22C	230	LFC2-22C	26	GRZG200 0.13Ω	3	68
RHC18.5-2C	750							
RHC22-2C	850	LR2-37C	330	LFC2-37C	32	GRZG400 0.1Ω	3	107
RHC30-2C	1200							
RHC37-2C	1500	LR2-55C	450	LFC2-55C	43			240
RHC45-2C	1600							
RHC55-2C	2100	LR2-75C	520	LFC2-75C	74			137
RHC75-2C	2300	LR2-110C	720	LFC2-110C	115	GRZG400 0.12Ω Two in parallel	6	374
RHC90-2C	2650							
RHC7.5-4C	400	LR4-15C	160	LFC4-15C	20	GRZG150 0.79Ω	3	48
RHC11-4C	500							
RHC15-4C	600	LR4-22C	230	LFC4-22C	22	GRZG200 0.53Ω	3	70
RHC18.5-4C	600							
RHC22-4C	950	LR4-37C	350	LFC4-37C	36	GRZG400 0.38Ω	3	86
RHC30-4C	1200							
RHC37-4C	1450	LR4-55C	490	LFC4-55C	43	GRZG400 0.26Ω	3	130
RHC45-4C	1750							
RHC55-4C	2250	LR4-75C	520	LFC4-75C	78	GRZG400 0.38Ω	3	112
RHC75-4C	1950	LR4-110C	710	LFC4-110C	90	GRZG400 0.53Ω Two in parallel	6	405
RHC90-4C	2400							
RHC110-4C	2900	LR4-160C	1000	LFC4-160C	160	RF4-160C	1	568
RHC132-4C	3250							
RHC160-4C	4100	LR4-220C	1240	LFC4-220C	200	LFC4-220C	1	751
RHC200-4C	4400							
RHC220-4C	5600	LR4-280C	1430	LFC4-280C	220	LFC4-280C	1	1027
RHC280-4C	6250	LR4-315C	1660	LFC4-315C	260	LFC4-315C	1	1154
RHC315-4C	7000	LR4-355C	1910	LFC4-355C	300	LFC4-355C	1	1286
RHC355-4C	8050	LR4-400C	2160	LFC4-400C	350	LFC4-400C	1	1454
RHC400-4C	8950	LR4-500C	2470	LFC4-500C	450	LFC4-500C	1	1821

Note: Generated losses listed in the above tables are approximate values that are calculated according to the following conditions:

- The power supply is three-phase 200 V/400 V 50 Hz with 0% interphase voltage unbalance ratio.
- The power supply capacity uses the larger of either 500 kVA or 10 times the rated capacity of the inverter.
- The motor is a 4-pole standard model at full load (100%).

11.10. DC reactors (DCRs)

A DCR is mainly used for power supply matching and for input power factor correction (for reducing harmonic components).

■ For power supply matching

- Use a DCR when the capacity of a power supply transformer exceeds 500 kVA and is 10 times or more the rated inverter capacity. In this case, the percent reactance of the power supply decreases, and harmonic components and their peak value increase. These factors may break rectifiers or capacitors in the converter section of inverter, or decrease the capacitance of the capacitor (which can shorten the inverter's service life).
- Also use a DCR when there are thyristor-driven loads or when phase-advancing capacitors are being turned ON/OFF.
- Use a DCR when the interphase voltage unbalance ratio of the inverter power supply exceeds 2%.

$$\text{Interphase voltage unbalance (\%)} = \frac{\text{Max. voltage (V)} \quad \text{Min. voltage (V)}}{\text{Three - phase average voltage (V)}} \times 67$$

■ For input power factor correction (for suppressing harmonics)

Generally a capacitor is used to improve the power factor of the load, however, it cannot be used in a system that includes an inverter. Using a DCR increases the reactance of inverter's power supply so as to decrease harmonic components on the power supply lines and improve the power factor of inverter. Using a DCR improves the input power factor to approximately 86% to 95%.

Note
- At the time of shipping, a jumper bar is connected across terminals P1 and P (+) on the terminal block. Remove the jumper bar when connecting a DCR.
- If a DCR is not going to be used, do not remove the jumper bar.

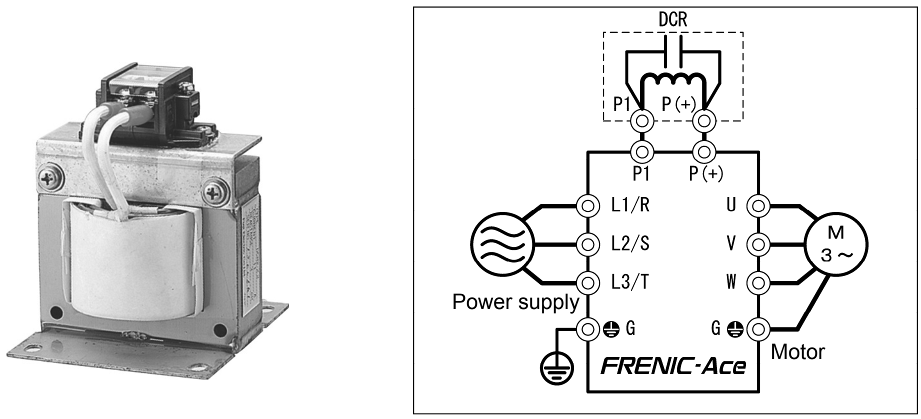


Figure 11.10-1 External View of a DC Reactor (DCR) and Connection Example

Table 11.10-1 DC Reactors (DCRs)

Power supply voltage	Nominal applied motor (kW)	DC reactor type	Rated current (A)	Inductance (mH)	Generated loss (W)
Three-phase 400V	18.5	DCR4-18.5	41	1.4	29
	22	DCR4-22A	49	1.2	35
	30	DCR4-30B	71	0.86	35
	37	DCR4-37B/ DCR4-37C	88/ 88	0.70/ 0.483	40/ 63
	45	DCR4-45B/ DCR4-45C	107/ 107	0.58/ 0.4	44/ 69
	55	DCR4-55B/ DCR4-55C	131/ 131	0.47/ 0.324	55/ 78
	75	DCR4-75C	178	0.23	97
	90	DCR4-90C	214	0.2	111
	110	DCR4-110C	261	0.166	122

Note: Generated losses listed in the above tables are approximate values that are calculated according to the following conditions:

- The power supply is three-phase 400 V 50 Hz with 0% interphase voltage unbalance ratio.
- The power supply capacity uses the larger of either 500 kVA or 10 times the rated capacity of the inverter.
- The motor is a 4-pole standard model at full load (100%).
- An AC reactor (ACR) is not connected.

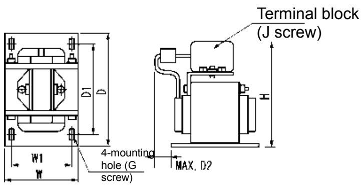


Fig.A

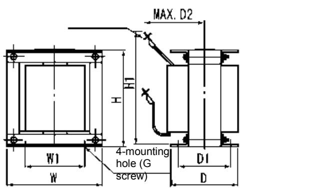


Fig.B

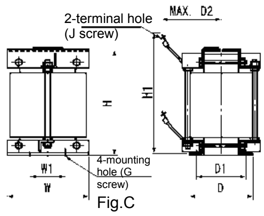
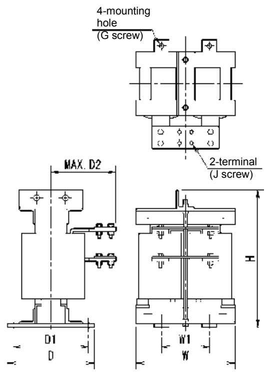


Fig.C



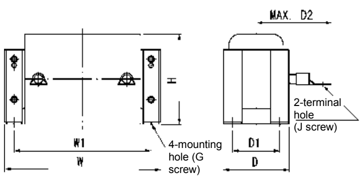


Fig.D

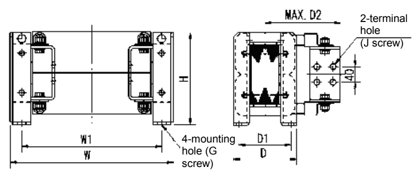


Fig.E

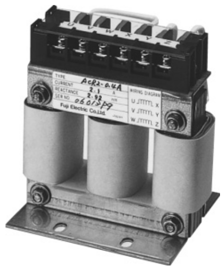
Fig.F

Table 11.10-2 DC Reactors (DCRs) External Dimensions

Power supply voltage	DC reactor type	Figure	Dimensions (mm)									Mass (kg)
			W	W1	D	D1	D2	H	H1	Mounting hole	Terminal hole	
Three-phase 400V	DCR4-18.5	A	146	124	120	96	25	171	-	M6 (7×11)	M6	7.2
	DCR4-22A	A	146	124	120	96	25	171	-	M6 (7×11)	M6	7.2
	DCR4-30B	B	152	90	157	115	100	130	190	M6 (φ8)	M8	13
	DCR4-37B	B	171	110	150	110	100	150	200	M6 (φ8)	M8	15
	DCR4-37C	D	210	185	101	81	105	125	-	M6 (7×13	M8	7.4
	DCR4-45B	B	171	110	165	125	110	150	210	M6 (φ8)	M8	18
	DCR4-45C	D	210	185	106	86	120	125	-	M6 (7×13)	M8	8.4
	DCR4-55B	B	171	110	170	130	110	150	210	M6 (φ8)	M8	20
	DCR4-55	D	255	225	96	76	120	145	-	M6 (7×13)	M10	11
	DCR4-75C	D	255	225	106	86	125	145	-	M6 (7×13)	M10	13
	DCR4-90C	D	255	225	116	96	140	145	-	M6 (7×13)	M12	15
	DCR4-110C	D	300	265	116	90	175	155	-	M8 (10×18)	M12	19

11.11. AC reactors (ACRs)

Use an ACR when the converter part of the inverter should supply very stable DC power, for example, in DC link bus operation (shared PN operation). Generally, ACRs are used for correction of voltage waveform and power factor or for power supply matching, but not for suppressing harmonic components in the power lines. For suppressing harmonic components, use a DCR.



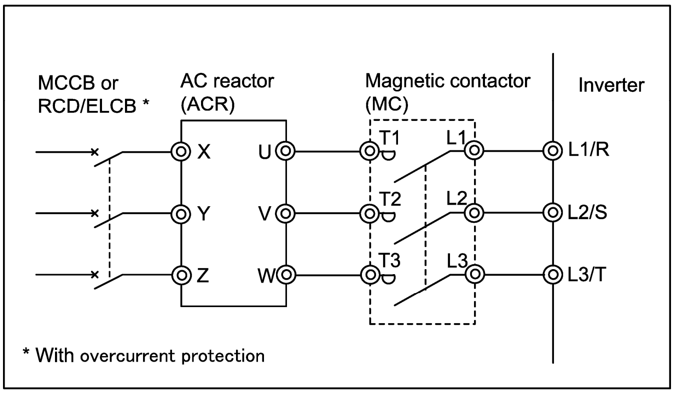


Figure 11.11-1 External View of AC Reactor (ACR) and Connection Example

Table 11.11-1 AC Reactor (ACR)

Power supply voltage	Nominal applied motor (kW)	DC reactor type	Rated current (A)	Reactance (mΩ/phase)		Coil resistance (mΩ)	Generated loss (W)
				50Hz	60Hz		
Three-phase 400V	18.5	ACR4-18.5A	39	114	137	-	57
	22	ACR4-22A	45	95.8	115	-	62
	30	ACR4-37	100	41.7	50	2.73	38.9
	37	ACR4-37	100	41.7	50	2.73	55.7
	45	ACR4-55	135	30.8	37	1.61	50.2
	55	ACR4-55	135	30.8	37	1.61	70.7
	75	ACR4-75 *	160	25.8	31	1.16	65.3
	90	ACR4-110	250	16.7	20	0.523	42.2
	110	ACR4-110	250	16.7	20	0.523	60.3

* Cool this reactor using a fan with 3 m/s or more WV (Wind Velocity).

Note: Generated losses listed in the above table are approximate values that are calculated according to the following conditions:

- The power supply is three-phase 400 V 50 Hz with 0% interphase voltage unbalance ratio.
- The power supply capacity uses the larger of either 500 kVA or 10 times the rated capacity of the inverter.
- The motor is a 4-pole standard model at full load (100%).

Fig.D

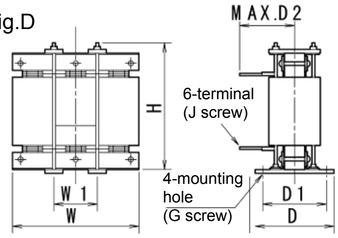


Fig.E

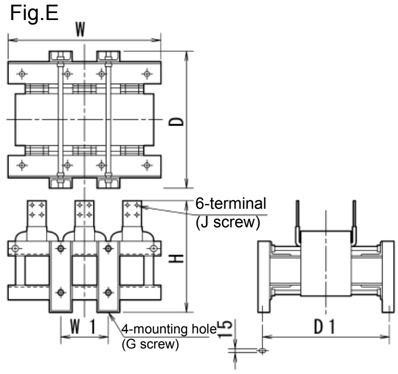
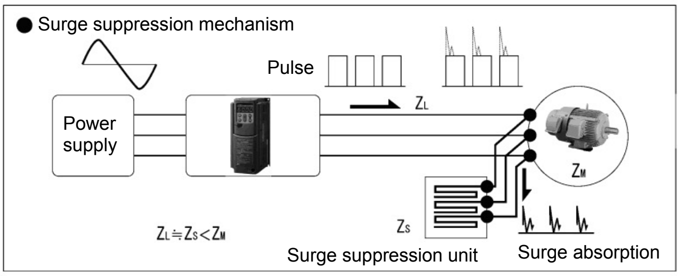


Table 11.11-2 AC Reactors (ACRs) External Dimensions

Power supply voltage	DC reactor type	Figure	Dimensions (mm)								Mass (kg)
			W	W1	D	D1	D2	G	H	Terminal hole	
Three-phase 400V	ACR4-18.5A	D	180	60	110	85	106	M6 (7×11)	137	M6	5.7
	ACR4-22A		180	60	110	85	106	M6 (7×11)	137	M6	5.9
	ACR4-37		190	60	120	90	172	M6 (7×11)	190	M8	12
	ACR4-55	E	190	60	120	90	200	M6 (7×11)	190	M10	14
	ACR4-75		190	60	126	90	157	M6 (7×10)	190	M10	16
	ACR4-110		250	100	136	105	202	M8 (9.5×18)	245	M12	24

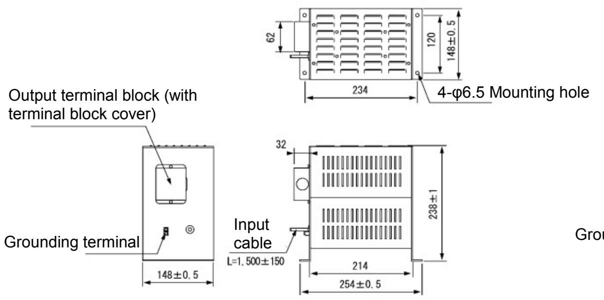
11.12. Surge suppression unit (SSU)

If the drive wire for the motor is long, an extremely low surge voltage (micro surge) occurs at the wire end connected to the motor. Surge voltage causes motor degradation, insulation breakdown, or increased noises. The surge suppression unit (SSU) suppresses the surge voltage. It features the connectivity for all inverter capacities and easy wiring work.

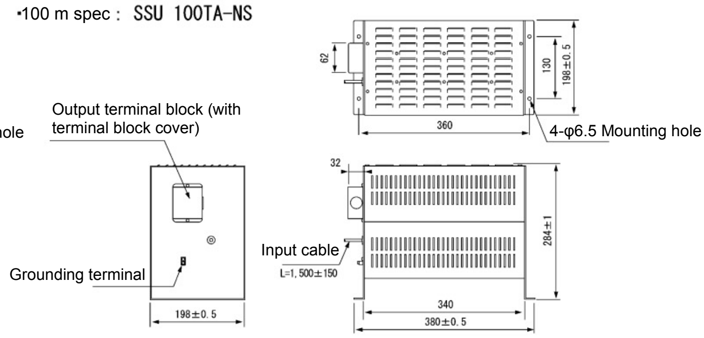


■ Dimensions

• 50 m spec : SSU 50TA-NS

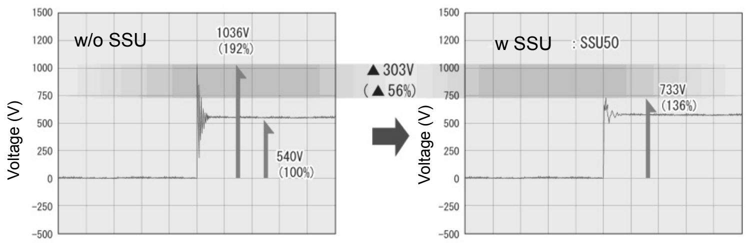


•100 m spec : SSU 100TA-NS

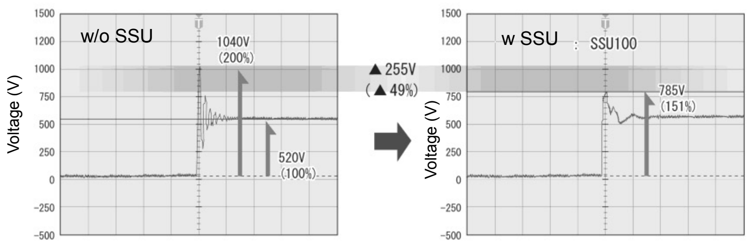


■ Effects of surge suppression units (voltage waveform between motors)

- Motor/inverter capacity: 3.7 kW
- Running status: No-load
- Wiring length: 50 m
- Power supply voltage: Three-phase 400 V



- Motor/inverter capacity: 75 kW
- Running status: No-load
- Wiring length: 100 m
- Power supply voltage: Three-phase 400 V



■ Basic specifications

Item	Specifications	
Type	SSU 50TA-NS	SSU 100TA-NS
Applicable wiring length	Up to 50m	Up to100m
Power supply voltage	200 V and 400 V classes; PWM converter is applicable.	
Inverter capacity	Up to 75 kW (90 kW or larger requires customized service.)	
Output frequency	～400Hz	
Carrier frequency	～15kHz (Cannot be used at 16 kHz.)	
Enclosure	IP20	
Installation environment	Ambient temperature: -20 to +40°C, relative humidity: 85% RH or below, vibration: 0.7 G or less, Installation: horizontally	
Dielectric strength voltage	AC2500V、1min	

11.13. Output circuit filters (OFLs)

Insert an OFL in the inverter power output circuit to:

- Suppress the surge voltage at motor terminal
  This protects the motor from insulation damage caused by the application of high voltage surge currents from the 400 V class series of inverters.
- Suppress leakage current from the output lines
  This reduces the leakage current from long power feed lines. (The maximum wiring length must be 400 m.)
- Minimize radiation and induction noise from the output lines
  An OFL effectively suppresses noise from long lines such as wiring at plants.

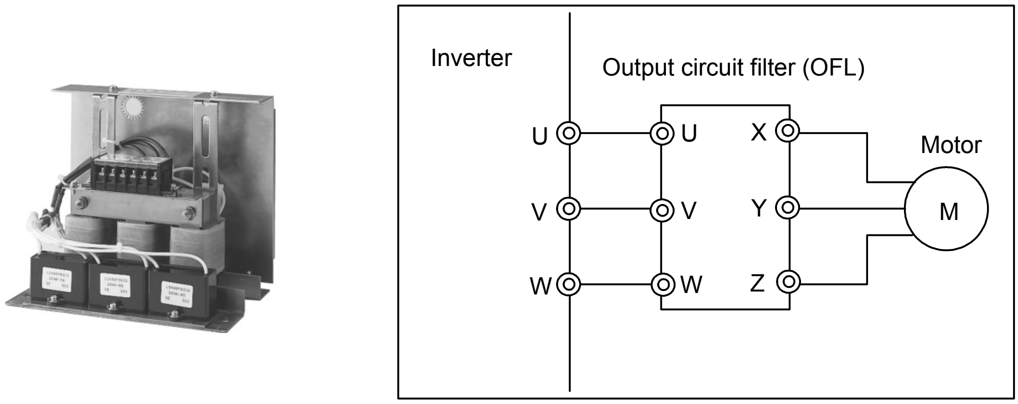


Figure 11.13-1 External View of Output Circuit Filter (OFL) and Connection Example

Table 11.13-1 Output Circuit Filter (OFL)

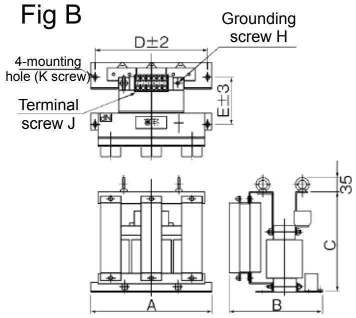
OFL-□□□-4A

Power supply voltage	Nominal applied motor (kW)	Filter type	Rated current (A)	Generated loss (kW)
Three-phase 400V	18.5	OFL-22-4A	45	350
	22			
	30	OFL-30-4A	60	570
	37	OFL-37-4A	75	610
	45	OFL-45-4A	91	810
	55	OFL-55-4A	112	910
	75	OFL-75-4A	150	1200
	90	OFL-90-4A	176	1360
	110	OFL-110-4A	210	1410

OFL-□□□-4A

■Filter (for 22 kW or below)

Fig B



■ Filter (for 30 kW or above) : Reactor

Fig C

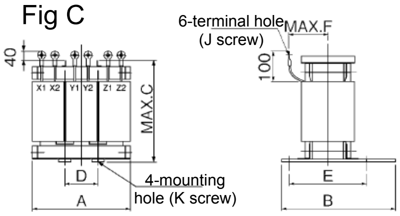
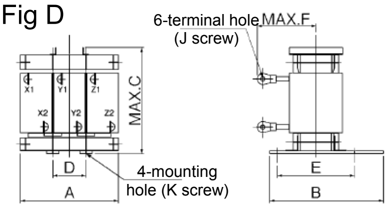
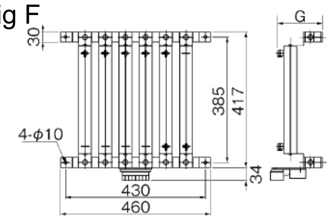


Fig D



■ Filter (for 30 kW or above) :
Resistor/Capacitor

Fig F



For filters OFL-30-4A and greater, a reactor, resistor, and capacitor should be installed separately. (Those parts are not included in the mass of a filter. If ordered with the filter type, the filter is shipped in combination with a reactor, resistor, and capacitor.)

Table 11.13-2 Output Circuit Filter (OFL) Dimensions

Filter type	Filter type	Dimensions (mm)											Mass (kg)
		Figure	A	B	C	D	E	F	G	Grounding screw	Terminal screw	Mounting screw	
Three-phase 400V	OFL-22-4A	B	330	300	330	300	170	-	-	M6	M6	M8	45
	OFL-30-4A	C/F	210	175	210	70	140	90	160	-	M5	M6	12
	OFL-37-4A		220	190	220	75	150	95	160	-	M5	M6	15
	OFL-45-4A	D/F	220	195	265	70	155	140	160	-	M6	M8	17
	OFL-55-4A		260	200	275	85	160	150	160	-	M6	M8	22
	OFL-75-4A		260	210	290	85	170	150	233	-	M8	M10	25
	OFL-90-4A		260	210	290	85	170	155	233	-	M8	M10	28
	OFL-110-4A		300	230	330	100	190	170	233	-	M8	M10	38

* The OFL-***-4A models have no restrictions on carrier frequency.

11.14. Zero-phase reactors for reducing radio noise (ACLs)

An ACL is used to reduce radio frequency noise emitted by the inverter.

An ACL suppresses the outflow of high frequency harmonics caused by switching operation for the power supply lines inside the inverter. Pass the power supply lines together through the ACL.

If wiring length between the inverter and motor is less than 20 m, insert an ACL to the power supply lines; if it is more than 20 m, insert it to the power output lines of the inverter.

Wire size is determined depending upon the ACL size (I.D.) and installation requirements.

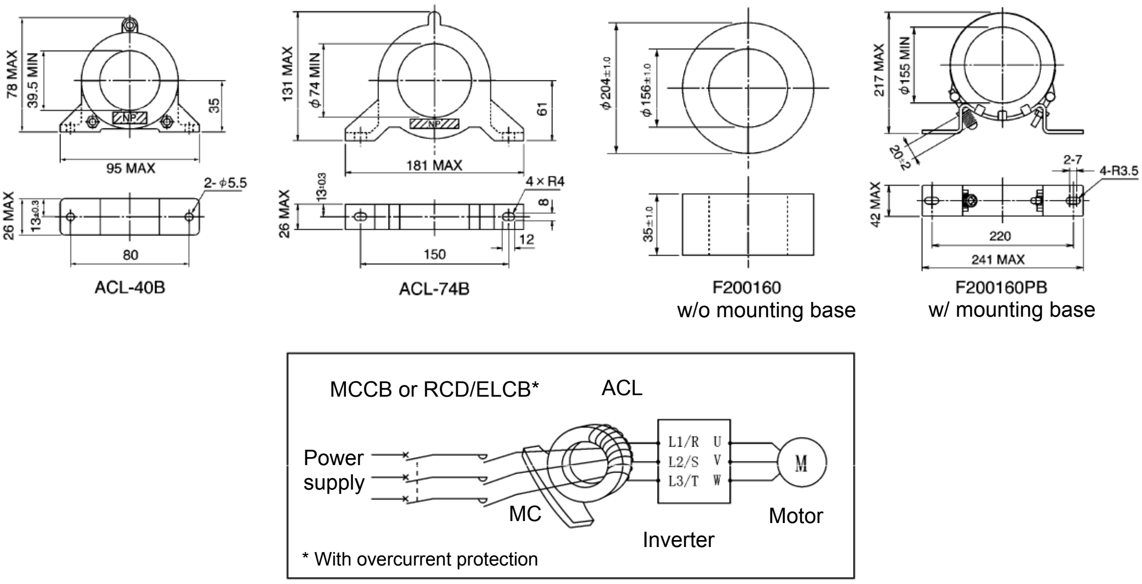


Figure 11.14-1 Dimensions of Zero-phase Reactor for Reducing Radio Noise (ACL) and Connection Example

Table 11.14-1 Zero-phase Reactors for Reducing Radio Noise (ACL)

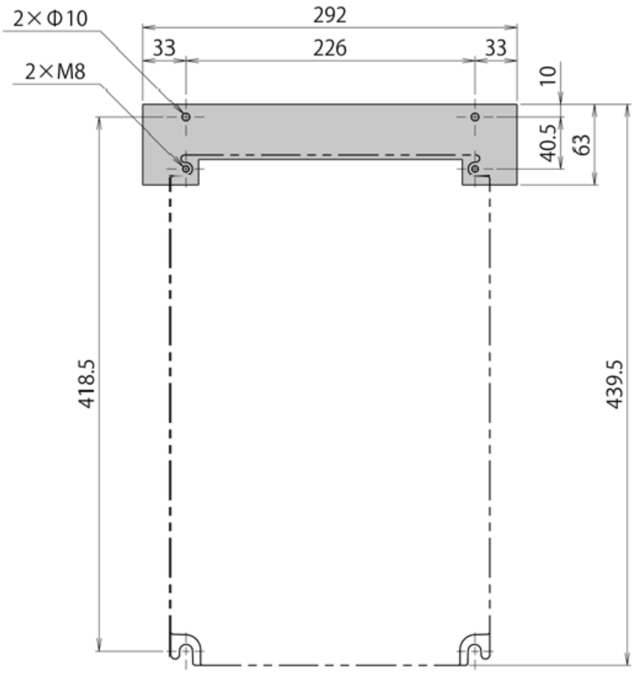
Zero-phase reactor type	Installation requirements		Wire size (mm^2)
	Qty.	Number of turns	
ACL-40B	1	4	2.0, 3.5, 5.5
	2	2	8, 14
ACL-74B	1	4	8, 14
	2	2	22, 38, 60, 5.5×2, 8×2, 14×2, 22×2
	4	1	100, 150, 200, 250, 325, 38×2, 60×2, 100×2, 150×2
F200160, F200160PB	4	1	200×2, 250×2, 325×2, 325×3

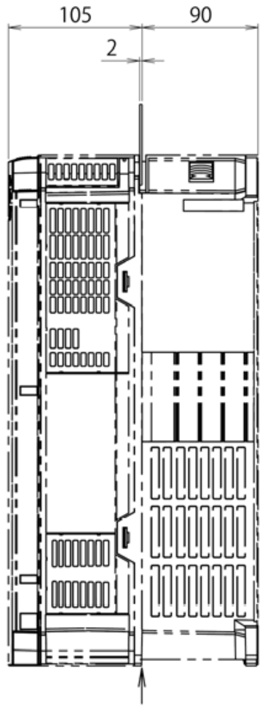
The selected wires are for use with 3-phase input/output lines (3 wires).

Note: Use the insulated wire of 75°C, 600 V, HIV-insulated.

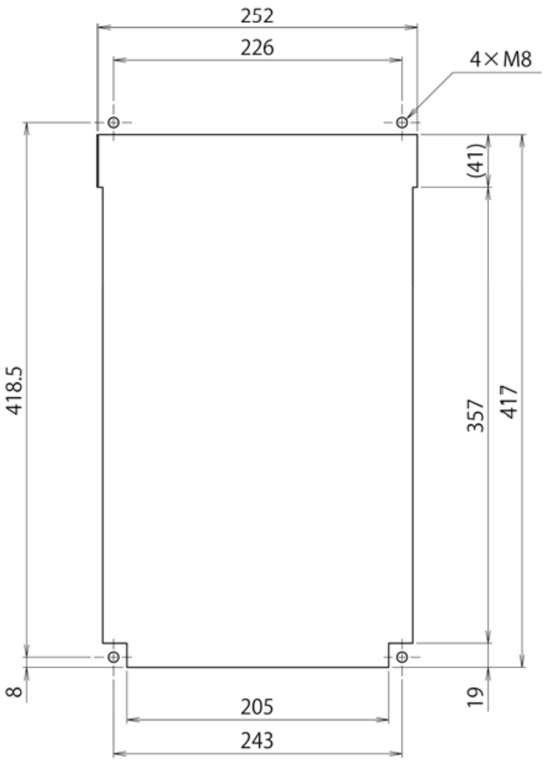
11.15. External cooling fan attachments

An external cooling fan attachment for the FRENIC-Ace has the cooling fin outside the panel, which enhances cooling efficiency while making the panel small. It can discharge from the panel approximately 70% of the inverter's generated loss.





Panel mounting surface



Panel processing diagram

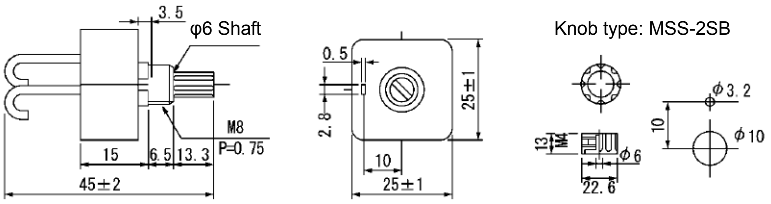
Option type	Applicable inverter type
PB-F1-30	FRN0059E2S-4# ・ FRN0072E2S-4#

11.16. External frequency command potentiometer

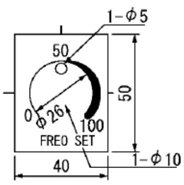
An external frequency command potentiometer may be used to set the drive frequency. Connect the potentiometer to control signal terminals [11] through [13] of the inverter as shown in Figure 11.16-1

Type: RJ-13 (BA-2 B-characteristics, 1 kΩ)

Panel hole size

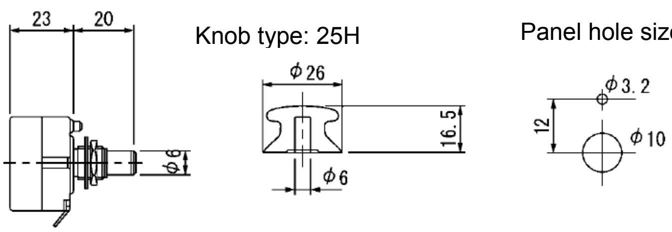


Dial plate type: YS549810-0

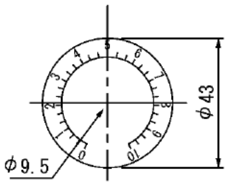


Note: The dial plate and knob must be ordered separately. Available from Fuji Electric Technica Co., Ltd.

Type : WAR3W-1kΩ (3W B-characteristics)



Dial plate type: 40P



Note: The dial plate and knob must be ordered separately. Available from Fuji Electric Technica Co., Ltd.

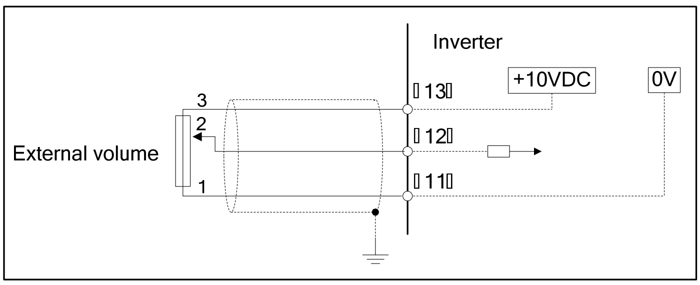


Figure 11.16-1 External Frequency Command Potentiometer Dimensions and Connection Example

11.17. Extension cable for remote operation

The extension cable connects the inverter with the keypad (standard or multi-function) or USB−RS-485 converter to enable remote operation of the inverter. The cable is a straight type with RJ-45 jacks and its length is selectable from 5, 3, and 1 m.

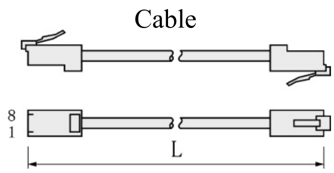


Table 11.17-1 Extension Cable Length for Remote Operation

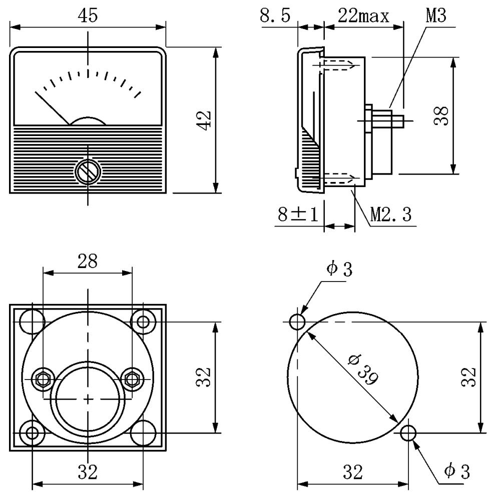
Type	Length (m)
CB-5S	5
CB-3S	3
CB-1S	1

11.18. Frequency meters

Connect a frequency meter to analog signal output terminals [FM], [FM2] (for China only) and [11] of the inverter to measure the frequency component selected by function code F31. Figure 11.8-1 shows the dimensions of the frequency meter and a connection example.

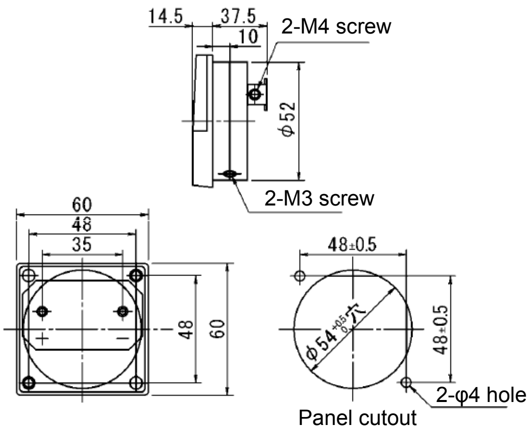
Type : TRM-45 (DC10V, 1mA)

This model has two types of calibration: "0 to 60/120 Hz" and "60/120/240 Hz."

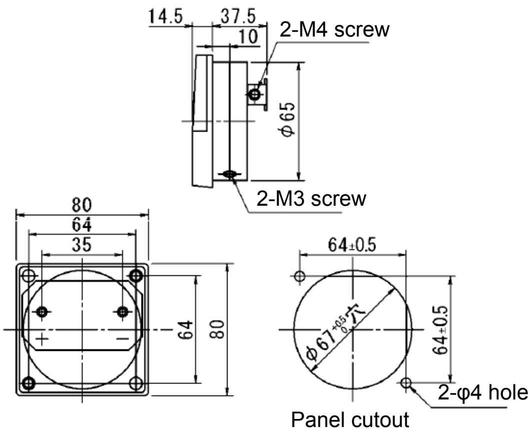


Available from Fuji Electric Technica Co., Ltd.

Type : FMN-60 (10VDC, 1mA)



Type : FMN-80 (10VDC, 1mA)



Available from Fuji Electric Technica Co., Ltd.

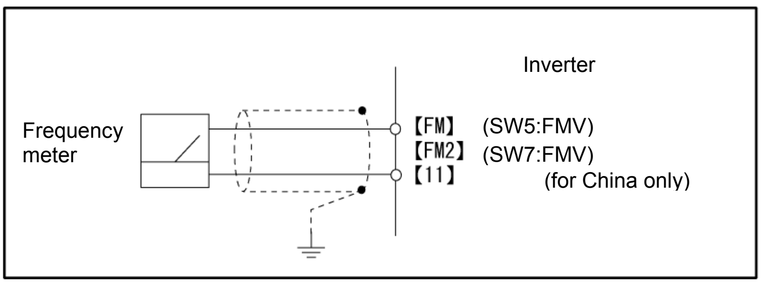


Figure 11.18-1 Frequency Meter Dimensions and Connection Example

Chapter 12

SPECIFICATIONS

This chapter describes the output ratings, input power, basic functions and other specifications of the FRENIC-Ace standard model.

Contents

Chapter 12 SPECIFICATIONS

12.1 Standard Model

12.1.1 ND-mode inverters for general load

• Three-phase 400 V class series

Item		Specifications						
Type (FRN_ _ _ _E2S-4☐)		0059	0072	0085	0105	0139	0168	0203
Nominal applied motor (kW) (Output rating) ***1**		30	37	45	55	75	90	110
Output ratings	Rated capacity (kVA) ***2**	45	55	65	80	106	128	155
	Rated voltage (V) ***3**	Three-phase 380 to 480 V (with AVR function)						
	Rated current (A) ***4**	59	72	85	105	139	168	203
	Overload capability	120%-1 min						
Input power	Voltage, frequency	Three-phase 380 to 480 V, 50/60 Hz						Three-phase 380 to 440 V, 50 Hz Three-phase 380 to 480 V, 60 Hz ***5**
	Allowable voltage/frequency	Voltage: +10 to -15% (Interphase voltage unbalance: 2% or less) ***6**, Frequency: +5 to -5%						
	Rated input current ***7** (w/o DCR) (A)	77.9	94.3	114	140	–	–	–
	(with DCR) (A)	57.0	68.5	83.2	102	138	164	201
	Required capacity (with DCR) (kVA) ***8**	39	47	58	71	96	114	139
Braking	Torque (%) ***9**	12%		5% to 9%				
	DC braking	Braking starting frequency: 0.1 to 60.0 Hz, Braking time: 0.0 to 30.0 s, Braking level: 0 to 60%						
	Braking transistor	Built-in as standard		Separately mounted option				
	Braking resistor	Separately mounted option						
DC reactor (DCR) ***6**		Separately mounted option				Bundled as standard ***10**		
Applicable safety standards		IEC/EN61800-5-1: 2007						
Enclosure (IEC60529)		IP20, UL open type		IP00, UL open type				
Cooling method		Fan cooling						
Weight / Mass (kg)		9.5	10	25	26	30	33	40

*1 Fuji 4-pole standard motor

*2 Rated capacity is calculated assuming the rated output voltage as 440 V.

*3 Output voltage cannot exceed the power supply voltage.

*4 Setting the carrier frequency (F26) to 4 kHz or above requires current derating.
If the ambient temperature is 40°C (104°F) or above, derating of 2%/°C (2%/1.8°F) relative to the rated current given in this manual is required. For details, refer to Figure 10.4.2-1 in Chapter 10, Section 10.4.2 "Guideline for selecting inverter drive mode and capacity."

*5 Inverters of FRN0203E2S-4☐ or above (400 V class series) are equipped with a power switching connector. Use the connector depending upon the applied voltage. For details, refer to Chapter 2, Section 2.2.7 "Switching connectors."

*6 $$\text{Voltage unbalance (\%)} = \frac{\text{Max. voltage (V)} - \text{Min. voltage (V)}}{\text{Three - phase average voltage (V)}} \times 67 \text{ (IEC 61800 - 3)}$$

If the unbalance ratio is 2% to 3%, use an optional AC reactor (ACR).

*7 This specification is an estimate to be applied when the power supply capacity is 500 kVA (Inverter capacity x 10 when the capacity exceeds 50 kVA) and the power supply with %X = 5% is connected. For applied motors of 75 kW or above, a DC reactor (DCR) should be used.

*8 This specification applies when a DC reactor (DCR) is used.

*9 Average braking torque for the motor running alone. (It varies with the efficiency of the motor.)

*10 Separately mounted option for the FRN_ _ _ _ E2S-4C (destined for China).

Note: A box (☐) in the above table replaces C, A, E, or U depending on the shipping destination.

12.1.2 HD-mode inverters for heavy duty load

• Three-phase 400 V class series

	Item	Specifications						
Type (FRN_ _ _ _E2S-4□)		0059	0072	0085	0105	0139	0168	0203
Nominal applied motor (kW) (Output rating) *1		22	30	37	45	55	75	90
Output ratings	Rated capacity (kVA) *2	34	46	57	69	85	114	134
	Rated voltage (V) *3	Three-phase 380 to 480 V (with AVR function)						
	Rated current (A) *4	45	60	75	91	112	150	176
	Overload capability	150%-1min						
Input power	Voltage, frequency	Three-phase 380 to 480 V, 50/60 Hz						Three-phase 380 to 440 V, 50 Hz Three-phase 380 to 480 V, 60 Hz ***5**
	Allowable voltage/frequency	Voltage: +10 to -15% (Interphase voltage unbalance: 2% or less) ***6**, Frequency: +5 to -5%						
	Rated input current *7 (w/o DCR) (A)	60.6	77.9	94.3	114	140	–	–
	(with DCR) (A)	42.2	57.0	68.5	83.2	102	138	164
	Required capacity (with DCR) (kVA) *8	29	39	47	58	71	96	114
Braking	Torque (%) *9	15%		7 to 12%				
	DC braking	Braking starting frequency: 0.1 to 60.0 Hz, Braking time: 0.0 to 30.0 s, Braking level: 0 to 80%						
	Braking transistor	Built-in		Separately mounted option				
	Braking resistor	Separately mounted option						
DC reactor (DCR) *6		Separately mounted option					Bundled as standard ***10**	
Applicable safety standards		IEC/EN61800-5-1: 2007						
Enclosure (IEC60529)		IP20, UL open type		IP00, UL open type				
Cooling method		Fan cooling						
Weight / Mass (kg)		9.5	10	25	26	30	33	40

*1 Fuji 4-pole standard motor

*2 Rated capacity is calculated assuming the rated output voltage as 440 V.

*3 Output voltage cannot exceed the power supply voltage.

*4 Setting the carrier frequency (F26) to 4 kHz or above requires current derating.
If the ambient temperature is 40°C (104°F) or above, derating of 2%/°C (2%/1.8°F) relative to the rated current given in this manual is required. For details, refer to Figure 10.4.2-1 in Chapter 10, Section 10.4.2 "Guideline for selecting inverter drive mode and capacity."

*5 Inverters of FRN0203E2S-4□ or above (400 V class series) are equipped with a power switching connector. Use the connector depending upon the applied voltage. For details, refer to Chapter 2, Section 2.2.7 "Switching connectors."

*6 $$\text{Voltage unbalance (\%)} = \frac{\text{Max. voltage (V)} - \text{Min. voltage (V)}}{\text{Three - phase average voltage (V)}} \times 67 \text{ (IEC 61800 - 3)}$$

If the unbalance ratio is 2% to 3%, use an optional AC reactor (ACR).

*7 This specification is an estimate to be applied when the power supply capacity is 500 kVA (Inverter capacity x 10 when the capacity exceeds 50 kVA) and the power supply with %X = 5% is connected. For applied motors of 75 kW or above, a DC reactor (DCR) should be used.

*8 This specification applies when a DC reactor (DCR) is used.

*9 Average braking torque for the motor running alone. (It varies with the efficiency of the motor.)

*10 Separately mounted option for the FRN_ _ _ _ E2S-4C (destined for China).

Note: A box (□) in the above table replaces C, A, E, or U depending on the shipping destination.

12.1.3 HND-mode inverters for general load

• Three-phase 400 V class series

Item		Specifications						
Type (FRN_ _ _ _E2S-4☐)		0059	0072	0085	0105	0139	0168	0203
Nominal applied motor (kW) (Output rating) ***1**		22	30	37	45	55	75	90
Output ratings	Rated capacity (kVA) ***2**	34	46	57	69	85	114	134
	Rated voltage (V) ***3**	Three-phase 380 to 480 V (with AVR function)						
	Rated current (A) ***4**	45	60	75	91	112	150	176
	Overload capability	120%-1min						
Input power	Voltage, frequency	Three-phase 380 to 480 V, 50/60 Hz						Three-phase 380 to 440 V, 50 Hz Three-phase 380 to 480 V, 60 Hz ***5**
	Allowable voltage/frequency	Voltage: +10 to -15% (Interphase voltage unbalance: 2% or less) ***6**, Frequency: +5 to -5%						
	Rated input current ***7** (w/o DCR) (A)	60.6	77.9	94.3	114	140	–	–
	(with DCR) (A)	42.2	57.0	68.5	83.2	102	138	164
	Required capacity (with DCR) (kVA) ***8**	29	39	47	58	71	96	114
Braking	Torque (%) ***9**	15%		7 to 12%				
	DC braking	Braking starting frequency: 0.1 to 60.0 Hz, Braking time: 0.0 to 30.0 s, Braking level: 0 to 80%						
	Braking transistor	Built-in as standard		Separately mounted option				
	Braking resistor	Separately mounted option						
DC reactor (DCR) ***6**		Separately mounted option					Bundled as standard ***10**	
Applicable safety standards		IEC/EN61800-5-1: 2007						
Enclosure (IEC60529)		IP20, UL open type		IP00, UL open type				
Cooling method		Fan cooling						
Weight / Mass (kg)		9.5	10	25	26	30	33	40

*1 Fuji 4-pole standard motor

*2 Rated capacity is calculated assuming the rated output voltage as 440 V.

*3 Output voltage cannot exceed the power supply voltage.

*4 Setting the carrier frequency (F26) to the following value or above requires current derating.
FRN0059E2S-4☐: 10 kHz, FRN0072E2S-4☐ to FRN0168E2S-4☐: 6 kHz, FRN0203E2S-4☐: 4 kHz

*5 Inverters of FRN0203E2S-4☐ or above (400 V class series) are equipped with a power switching connector. Use the connector depending upon the applied voltage. For details, refer to Chapter 2, Section 2.2.7 "Switching connectors."

*6 $$\text{Voltage unbalance (\%)} = \frac{\text{Max. voltage (V)} - \text{Min. voltage (V)}}{\text{Three-phase average voltage (V)}} \times 67 \text{ (IEC 61800 - 3)}$$

If the unbalance ratio is 2% to 3%, use an optional AC reactor (ACR).

*7 This specification is an estimate to be applied when the power supply capacity is 500 kVA (Inverter capacity x 10 when the capacity exceeds 50 kVA) and the power supply with %X = 5% is connected. For applied motors of 75 kW or above, a DC reactor (DCR) should be used.

*8 This specification applies when a DC reactor (DCR) is used.

*9 Average braking torque for the motor running alone. (It varies with the efficiency of the motor.)

*10 Separately mounted option for the FRN_ _ _ _ E2S-4C (destined for China).

Note: A box (☐) in the above table replaces C, A, E, or U depending on the shipping destination.

12.1.4 HHD-mode inverters for heavy duty load

- **Three-phase 400 V class series**

Item		Specifications						
Type (FRN_ _ _ _E2S-4□)		0059	0072	0085	0105	0139	0168	0203
Nominal applied motor (kW) (Output rating) *1		18.5	22	30	37	45	55	75
Output ratings	Rated capacity (kVA) *2	30	34	46	57	69	85	114
	Rated voltage (V) *3	Three-phase 380 to 480 V (with AVR function)						
	Rated current (A) *4	39	45	60	75	91	112	150
	Overload capability	150%-1min, 200%-0.5s						
Input power	Voltage, frequency	Three-phase 380 to 480 V, 50/60 Hz						Three-phase 380 to 440 V, 50 Hz Three-phase 380 to 480 V, 60 Hz *5
	Allowable voltage/frequency	Voltage: +10 to -15% (Interphase voltage unbalance: 2% or less) *6, Frequency: +5 to -5%						
	Rated input current *7 (w/o DCR) (A)	52.3	60.6	77.9	94.3	114	140	–
	(with DCR) (A)	35.5	42.2	57.0	68.5	83.2	102	138
	Required capacity (with DCR) (kVA) *8	25	29	39	47	58	71	96
Braking	Torque (%) *9	20%		10 to 15%				
	DC braking	Braking starting frequency: 0.1 to 60.0 Hz, Braking time: 0.0 to 30.0 s, Braking level: 0 to 100%						
	Braking transistor	Built-in as standard		Separately mounted option				
	Braking resistor	Separately mounted option						
DC reactor (DCR) *6		Separately mounted option						Bundled as standard *10
Applicable safety standards		IEC/EN61800-5-1: 2007						
Enclosure (IEC60529)		IP20, UL open type		IP00, UL open type				
Cooling method		Fan cooling						
Weight / Mass (kg)		9.5	10	25	26	30	33	40

*1 Fuji 4-pole standard motor

*2 Rated capacity is calculated assuming the rated output voltage as 440 V.

*3 Output voltage cannot exceed the power supply voltage.

*4 Setting the carrier frequency (F26) to the following value or above requires current derating.
FRN0059E2S-4□ to FRN0168E2S-4□: 10 kHz, FRN0203E2S-4□: 6 kHz

*5 Inverters of FRN0203E2S-4□ or above (400 V class series) are equipped with a power switching connector. Use the connector depending upon the applied voltage. For details, refer to Chapter 2, Section 2.2.7 "Switching connectors."

*6 $$\text{Voltage unbalance (\%)} = \frac{\text{Max. voltage (V)} - \text{Min. voltage (V)}}{\text{Three - phase average voltage (V)}} \times 67 \text{ (IEC 61800 - 3)}$$

If the unbalance ratio is 2% to 3%, use an optional AC reactor (ACR).

*7 This specification is an estimate to be applied when the power supply capacity is 500 kVA (Inverter capacity x 10 when the capacity exceeds 50 kVA) and the power supply with %X = 5% is connected. For applied motors of 75 kW or above, a DC reactor (DCR) should be used.

*8 This specification applies when a DC reactor (DCR) is used.

*9 Average braking torque for the motor running alone. (It varies with the efficiency of the motor.)

*10 Separately mounted option for the FRN_ _ _ _ E2S-4C (destined for China).

Note: A box (□) in the above table replaces C, A, E, or U depending on the shipping destination.

12.2 Common Specifications

Item			Explanation	Remarks
Output	Setting range	Maximum frequency	HHD/HND/HD mode: 25 to 500 Hz variable (under V/f control) ND mode: 25 to 120 Hz (under any drive control)	
Output	Setting range	Base frequency	25 to 500 Hz variable (in conjunction with the maximum frequency)	
Output	Setting range	Starting frequency	0.1 to 60.0 Hz variable	
Output	Setting range	Carrier frequency	FRN0059E2S-4☐: • 0.75 to 16 kHz variable (HHD/HND/HD mode) • 0.75 to 10 kHz variable (ND mode) FRN0072/0085/0105/0139/0168E2S-4☐: • 0.75 to 16 kHz variable (HHD mode) • 0.75 to 10 kHz variable (HND/HD mode) • 0.75 to 6 kHz variable (ND mode) FRN0203E2S-4☐: • 0.75 to 10 kHz variable (HHD mode) • 0.75 to 6 kHz variable (HND/HD/ND mode) **Note:** The carrier frequency may automatically lower depending upon the ambient temperature or the output current to protect the inverter. (The automatic lowering function can be disabled.)	
Output	Output frequency accuracy (Stability)		• Analog setting:±0.2% of maximum frequency (at 25±10°C) • Keypad setting: ±0.01% of maximum frequency (at -10 to +50°C)	
Output	Frequency setting resolution		• Analog setting:0.05% of maximum frequency • Keypad setting: 0.01 Hz (99.99 Hz or less), 0.1 Hz (100.0 to 500 Hz) • Link setting: 0.05% of maximum frequency or 0.01 Hz (fixed)	
Control	Control method		• V/f control • Vector control without speed sensor (Dynamic torque vector) • V/f control, with slip compensation	
Control	Voltage/frequency characteristics		• Possible to set 160 to 500 V at base frequency and at maximum output frequency.	
Control	Voltage/frequency characteristics		• The AVR control can be turned ON or OFF.	
Control	Voltage/frequency characteristics		• Non-linear V/f setting (3 points): Free voltage (0 to 500 V) and frequency (0 to 500 Hz) can be set.	
Control	Torque boost		• Auto torque boost (For constant torque load) • Manual torque boost: Torque boost value can be set between 0.0 and 20.0% • Select application load with the function code. (Variable torque load or constant torque load)	
Control	Starting torque		• 200% or higher, reference frequency 0.5 Hz (HHD-mode inverters of FRN0072E2S-4☐ or below) 150% or higher, reference frequency 0.5 Hz (HHD-mode inverters of FRN0085E2S-4☐ or above) • 120% or higher, reference frequency 0.5 Hz (HND mode) • 150% or higher, reference frequency 0.5 Hz (HD/ND mode) Base frequency 50 Hz, with slip compensation and auto torque boost active	
Control	Start/stop operation		Keypad: Start and stop with RUN and STOP keys (Standard keypad) Start and stop with FWD / REV and STOP keys (Optional multi-function keypad)	
Control	Start/stop operation		External signals (digital inputs): Forward (Reverse) rotation, stop command (capable of 3-wire operation), coast-to-stop command, external alarm, alarm reset, etc.	
Control	Start/stop operation		Link operation: Operation through RS-485 (built-in as standard), CANopen (built-in as standard) or field bus (option) communications link	
Control	Start/stop operation		Switching run command: Remote/local switching, link switching	

Item		Explanation	Remarks
Control	Frequency setting	Keypad: Using ∧ and ∨ keys	
		External potentiometer: Using external frequency command potentiometer. (External resistor of 1 to 5 kΩ 1/2 W)	
		Analog input: 0 to ±10 VDC (±5 VDC)/ 0 to ±100% (terminal [12]), 0 to +10 VDC (+5 VDC)/ 0 to +100% (terminal [12]) 4 to 20 mADC/ 0 to +100% (terminal [C1] (C1 function)) 4 to 20 mADC/ 0 to ±100% (terminal [C1] (C1 function)) 0 to 20 mADC/ 0 to +100% (terminal [C1] (C1 function)) 0 to 20 mADC/ 0 to ±100% (terminal [C1] (C1 function)) 0 to +10 VDC (+5 VDC)/ 0 to +100% (terminal [C1] (V2 function)), 0 to +10 VDC (+5 VDC)/ 0 to ±100% (terminal [C1] (V2 function))	
	Frequency setting	UP/DOWN operation: Frequency can be increased or decreased while the digital input signal is ON.	
		Multistep frequency: Selectable from 16 different frequencies (step 0 to 15)	
		Pattern operation: The inverter runs automatically according to the previously specified run time, rotation direction, acceleration/deceleration time and reference frequency. Up to 7 stages can be specified.	
		Link operation: Operation through RS-485 (built-in as standard), CANopen (built-in as standard) or field bus (option) communications link	
		Frequency setting: Two types of frequency settings can be switched with an external signal (digital input). Remote/local switching, link switching	
		Auxiliary frequency setting: Inputs at terminal [12], [C1] (C1 function) or [C1] (V2 function) can be added to the main setting as auxiliary frequency settings.	
		Operation at a specified ratio: The ratio can be set by analog input signal. 0 to 10 VDC/0 (4) to 20 mA/0 to 200% (variable)	
		Inverse operation: Switchable from "0 to +10 VDC/0 to 100%" to "+10 to 0 VDC/0 to 100%" by external command (terminals [12] and [C1] (V2 function) Switchable from "0 to -10 VDC/0 to -100%" to "-10 to 0 VDC/0 to -100%" by external command (terminal [12]) Switchable from "4 to +20 mA DC/0 to 100%" to "20 to 4 mA DC/0 to 100%" by external command (terminal [C1] (C1 function)) Switchable from "0 to +20 mA DC/0 to 100%" to "20 to 0 mA DC/0 to 100%" by external command (terminal [C1] (C1 function))	
		Pulse train input (standard): Pulse input = Terminal [X5], Rotational direction = general terminal Complementary output: Max. 100 kHz, Open collector output: Max. 30 kHz	
	Acceleration/ deceleration time	Setting range: Between 0.00 and 6000 s	
		Switching: The four types of acceleration/deceleration time can be set or selected individually (switchable during operation).	
		Acceleration/deceleration pattern: Linear acceleration/deceleration, S-curve acceleration/deceleration (weak, arbitrary (with function code)), curvilinear acceleration/deceleration	
		Deceleration mode (coast-to-stop): Shutoff of the run command lets the motor coast to a stop.	
		Acceleration/deceleration time exclusive to jogging (0.00 to 6000 s)	
		Forcible stop deceleration time: Deceleration stop by the forcible stop ***STOP***. During forced stop operation, S-curve acceleration/deceleration is disabled.	
	Frequency limiter (Upper limit and lower limit frequencies)	• Specifies the upper and lower limits in Hz. • "Continue to run" or "Decelerate to a stop" selectable when the reference frequency drops below the lower limit.	
	Frequency/PID command bias	• Bias of reference frequency and PID command can be independently set (setting range: 0 to ±100%).	

Item		Explanation	Remarks
	Analog input	• Gain: Setting range from 0 to 200% • Offset: Setting range from -5.0 to +5.0% • Filter: Setting range from 0.00 s to 5.00 s • Polarity selection (±/+)	
	Jump frequency	• Three operation points and their common jump width (0 to 30.0 Hz) can be set.	
	Timer operation	The inverter drives the motor for the run time specified from the keypad and stops its output. (Single-cycle operation)	
	Jogging operation	• Operation with (RUN) key (standard keypad), (FWD) or (REV) key (multi-function keypad), or digital input signal ***FWD*** or ***REV*** (Exclusive acceleration/deceleration time setting, exclusive frequency setting)	
	Auto-restart after momentary power failure	• Trip immediately: Trip immediately at the time of power failure. • Trip after a recovery from power failure: Coast to a stop at the time of power failure and trip when the power is recovered. • Trip after decelerate-to-stop: Deceleration stop at power failure, and trip after stoppage • Continue to run: Operation is continued using the load inertia energy. • Start at the frequency selected before momentary power failure: Coast-to-stop at power failure and start after power recovery at the frequency selected before momentary stop. • Start at starting frequency: Coast-to-stop at power failure and start at the starting frequency after power recovery. • Start at the frequency searched at the time of power recovery: Coast-to-stop at power failure, search for the idling motor speed, and restart the motor.	
Control	Hardware current limiter	Limits the current by hardware to prevent an overcurrent trip from being caused by fast load variation or momentary power failure, which cannot be covered by the software current limiter. This limiter can be canceled.	
	Operation by commercial power supply	With commercial power selection commands (***SW50***, ***SW60***), the inverter outputs 50/60 Hz.	
	Slip compensation	• Compensates for decrease in speed according to the load • Possible to set constants at the response of slip compensation.	
	Droop control	• Decreases the speed according to the load torque.	
	Torque limit	Controls the output torque to suppress it below the preset specified limit value. • Switchable between 1st and 2nd torque limit values	
	Software current limiter	Automatically reduces the frequency so that the output current becomes lower than the preset operation level.	
	Overload stop	If the detected torque or current exceeds the preset value, the inverter decelerates the motor to a stop or causes the motor to coast to a stop.	
	PID control	• PID processor for process control/dancer control • Normal operation/inverse operation • PID command: Keypad, analog input (from terminals [12], [C1] (C1 function) and [C1] (V2 function)), multistep frequency (3 steps), RS-485 communication • PID feedback value: Analog input (from terminals [12], [C1] (C1 function) and [C1] (V2 function)) • Alarm output (absolute value alarm, deviation alarm) • Slow flowrate stop function (Pressurized operation is possible before the slow flowrate stop.) • Anti-reset wind-up function • PID output limiter • Integration reset/hold	
	Auto search for idling motor speed	The inverter automatically searches for the idling motor speed to be harmonized and starts to drive it without stopping it.(Motor parameters need tuning: Offline tuning	
	Automatic deceleration	• If the DC link bus voltage or calculated torque exceeds the automatic deceleration level during deceleration, the inverter automatically prolongs the deceleration time to avoid overvoltage trip. (It is possible to select forcible deceleration actuated when the deceleration time becomes three times longer.) • If the calculated torque exceeds automatic deceleration level during constant speed operation, the inverter avoids overvoltage trip by increasing the frequency.	
	Deceleration characteristic (improved braking capacity)	The motor loss is increased during deceleration to reduce the regenerative energy in the inverter to avoid overvoltage trip.	

Item		Explanation	Remarks
	Auto energy saving operation	Controls the output voltage to minimize the total sum of the motor loss and inverter loss.	
	Overload prevention control	If the surrounding temperature or IGBT joint temperature increases due to overload, the inverter lowers the output frequency to avoid overload.	
	Offline tuning	Tunes the motor while the motor is stopped or running, for setting up motor parameters.	
	Online tuning	Controls the motor speed variation caused by the motor temperature rise during running.	
	Cooling fan ON/OFF control	• Detects inverter internal temperature and stops cooling fan when the temperature is low. • Possible to output a fan control signal to an external device.	
	1st to 2nd motor settings	• Switchable between two motors It is possible to set the base frequency, rated current, torque boost, and electronic thermal slip compensation as the data for 1st and 2nd motors.	
	Universal DI	Transfers the status of an external digital signal connected with the general-purpose digital input terminal to the host controller.	
	Universal DO	Outputs a digital command signal sent from the host controller to the general-purpose digital output terminal.	
	Universal AO	Outputs an analog command signal sent from the host controller to the analog output terminal.	
	DC braking	Applies DC current to the motor at the operation start time or at the time of inverter stop to generate braking torque.	
Control	Mechanical brake control	• Possible to output mechanical brake control signals with the brake ON/OFF timing adjusted by the output current, torque command, output frequency and timer. • Mechanical brake application check input.	
	Rotation direction control	Select either of reverse or forward rotation prevention.	
	Customizable logic interface	Possible to select or connect digital logic circuits or analog operation circuits with digital/analog I/O signals, configure a simple relay sequence, and operate it freely. • Logic circuits: (Digital) AND, OR, XOR, flip-flop, detection of rising and falling edges, various counters. (Analog) Addition, subtraction, multiplication, division, limiters, absolute values, sign inversion addition, comparison, maximum value selection, minimum value selection, average values, scale conversion. • Multifunction time: On-delay timer, off-delay timer, pulse train output, etc. Setting range: 0.0 to 600 s • Input/output signals: Terminal input/output, inverter control functions • Others: Available in 100 steps configured with 2 input and 1 output per step.	
	Functions for wiredrawing machines, hoists, and spinning frames	Customizable logic function enables dedicated functions for each application. (Available soon)	
Display	Indicators	Detachable, 7-segment, 4-digit LED, 7 push-buttons (PRG/RESET, FUNC/DATA, UP, DOWN, RUN, STOP, and SHIFT), and 6 LED indicators (KEYPAD CONTROL, Hz, A, kW, X10, and RUN)	
	Running/stopping	Speed monitor (reference frequency, output frequency, motor speed, load shaft speed, line speed, and speed indication with percent), output current (A), output voltage (V), calculated torque (%), input power (kW), PID command value, PID feedback amount, PID output, timer values for timer operation (s), load factor (%), and motor output (kW) • Analog input monitor, input watt-hour, constant feeding rate time (min.), and remaining time for timer operation (s) can be displayed.	

Item		Explanation	Remarks
	Maintenance monitor	DC link bus voltage, maximum effective current, input watt-hour, input watt-hour data, temperature (inverter internal temperature, maximum inverter internal temperature, heat sink temperature, maximum heat sink temperature), capacitance of the DC link bus capacitor, service life of DC ink but capacitor (elapsed time/remaining time), cumulative run times (inverter power-ON time, electrolytic capacitors on printed circuit boards, cooling fans, individual motors), light-alarm contents (last four alarms), RS-485 error contents and number of error times, CANopen error contents, option error contents and number of error times, ROM version (inverter, keypad, and option)	
	I/O check	Displays the I/O signal states of control circuit terminals using the segment ON/OFF of the 7-segment LED monitor or hexadecimal format. (digital and analog signals)	
	Trip	Displays the cause of a trip by codes.	
	Light-alarm	Shows the light-alarm display L-AL.	
	During running or at the time of a trip	• Trip history: Saves and displays the cause of the last four trips (with a code). • Saves and displays the detailed running status data of the last four trips.	

When the protective function is activated so that the LED monitor shows alarm codes, refer to Chapter 6 "Troubleshooting."

For the usage environment and storage environment, refer to Chapter 1, Section 1.3 "Precautions for Using Inverters."

Chapter 13

EXTERNAL DIMENSIONS

This chapter gives external dimensions of the inverter.

Contents

Chapter 13 EXTERNAL DIMENSIONS

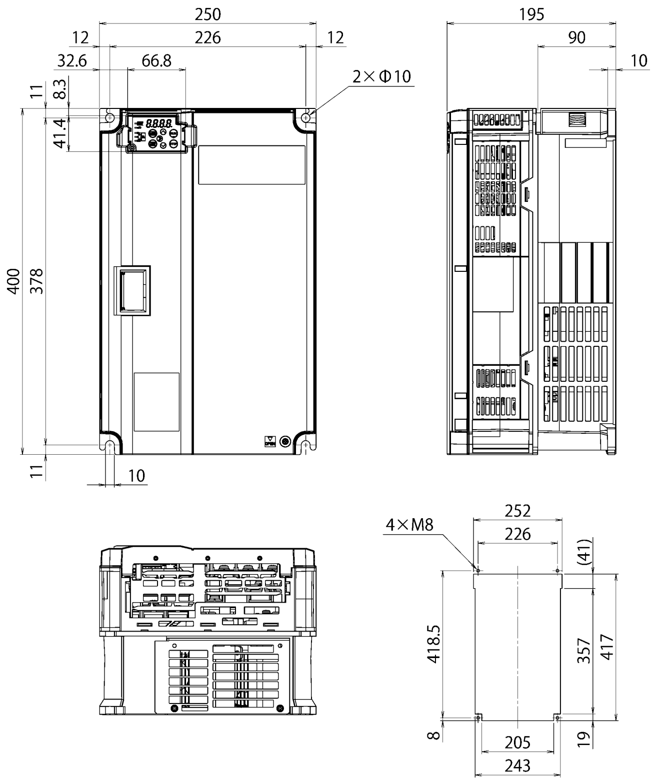
13.1 Standard Model

The drawings below show external dimensions of the FRENIC-Ace series of inverters according to the inverter capacity. (400 V class series)

* A figure given in the lower right-hand corner of each set of drawings shows the dimension of panel cutting required for external cooling. To employ external cooling for inverters FRN0059E2S-4☐ and FRN0072E2S-4☐, the optional mounting adapter for external cooling is necessary. For the external dimensions of the mounting adapter, refer to Chapter 11, Section 11.15.

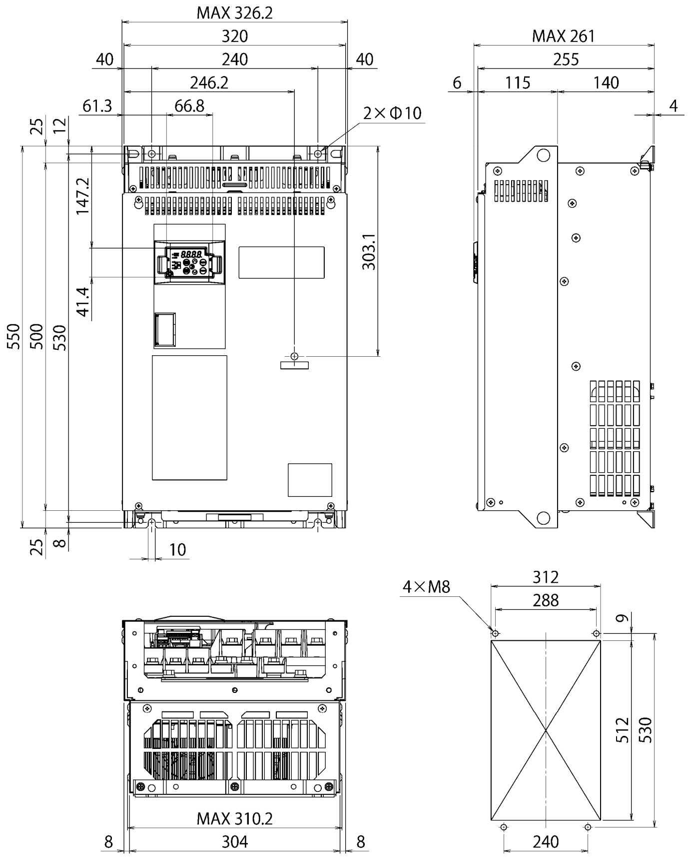
(Unit: mm)

■ FRN0059E2S-4☐, FRN0072E2S-4☐

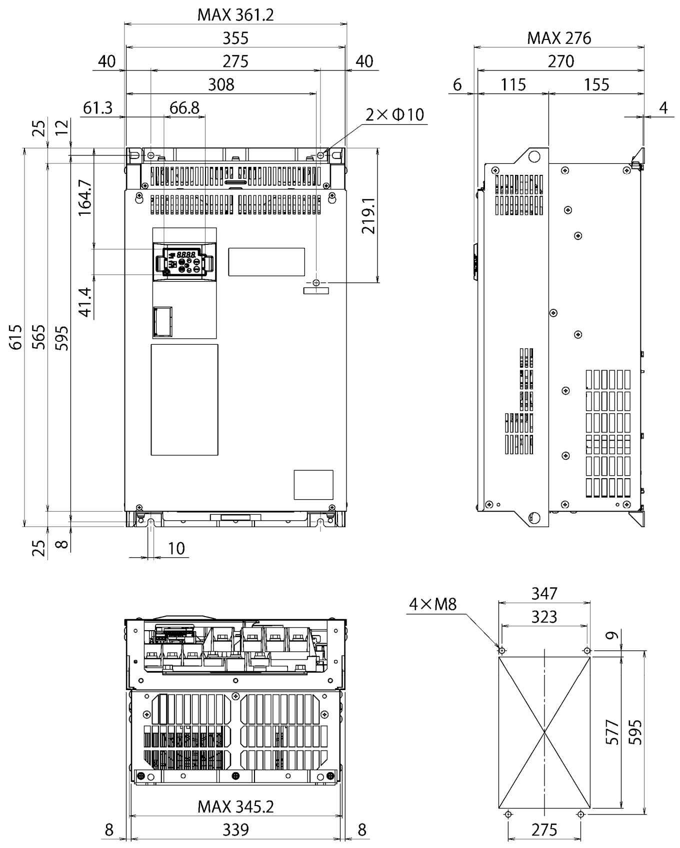


(Unit: mm)

■ FRN0085E2S-4□， FRN0105E2S-4□

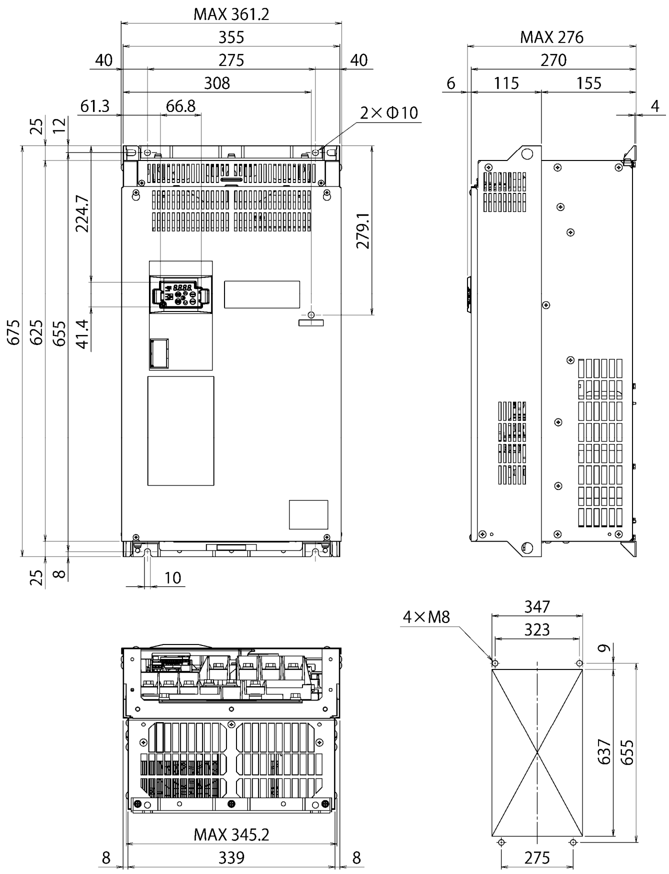


■ FRN0139E2S-4□

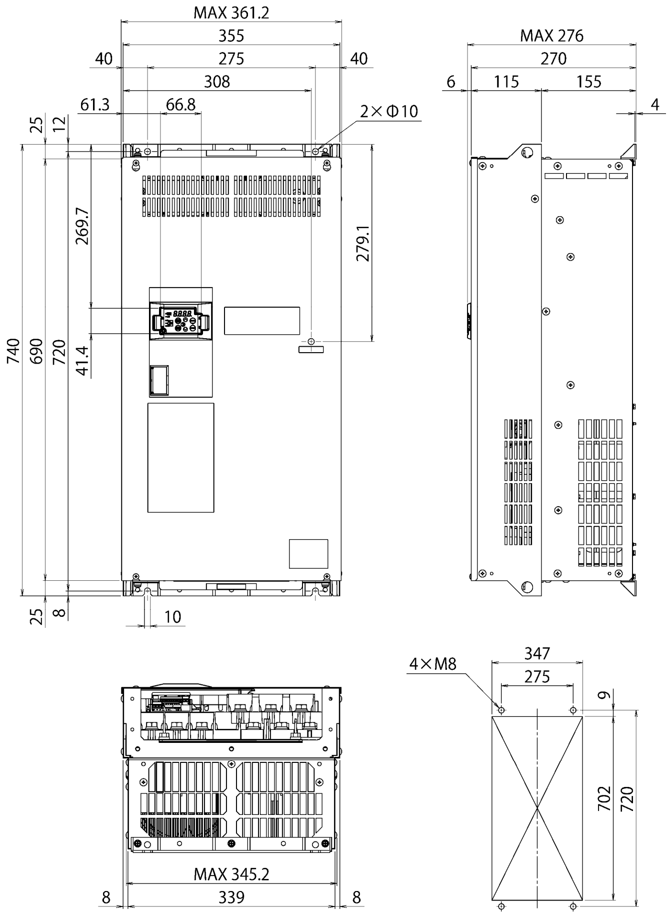


(Unit: mm)

■ FRN0168E2S-4□

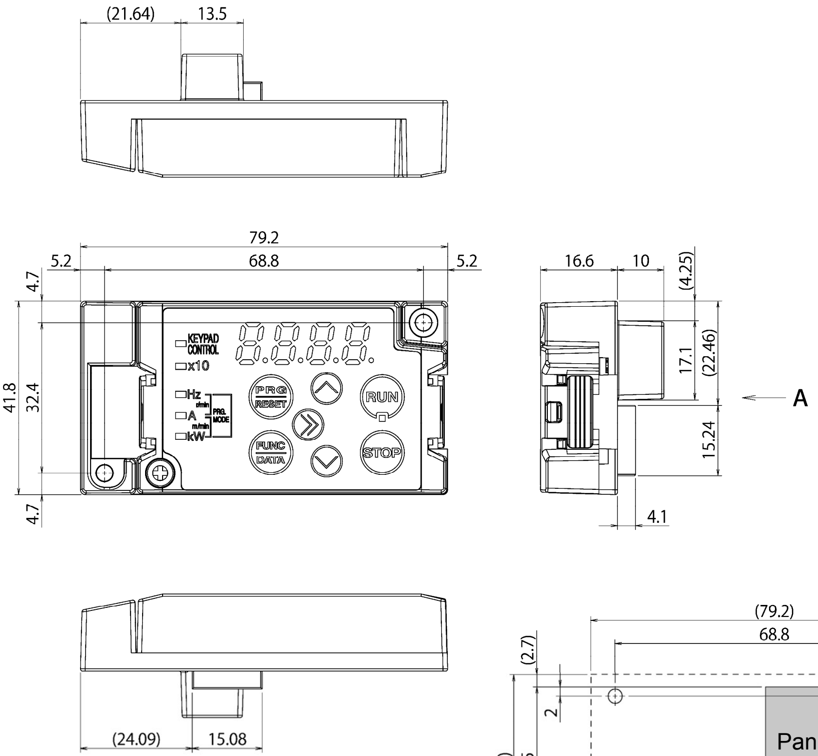


■ FRN0203E2S-4□

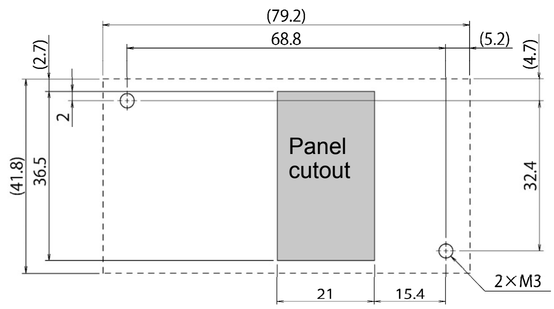


13.2 Keypad

(Unit: mm)



When operating the keypad at remote location or mounting it in a panel (Keypad rear cover attached)



Dimensions of panel cutting (viewed from arrow "A")

APPENDICES

Contents

Appendix A Advantageous Use of Inverters (Notes on electrical noise)

Excerpt from technical material of
the Japan Electrical Manufacturers' Association (JEMA) (April 1994)

A.1 Effect of inverters on other devices

Inverters have been and are rapidly expanding its application fields. This paper describes the effect that inverters have on electronic devices already installed or on devices installed in the same system as inverters, as well as introducing noise prevention measures. (Refer to Section A.3 [3], "Noise prevention examples" for details.)

[1] Effect on AM radios

Phenomena — If an inverter operates, AM radios may pick up noise radiated from the inverter. (An inverter has almost no effect on FM radios or television sets.)

Probable cause — The noise radiated from the inverter may be received by a radio.

Measure — Inserting a noise filter on the power supply side of the inverter is effective.

[2] Effect on telephones

Phenomena — If an inverter operates, nearby telephones may pick up noise radiated from the inverter in conversation so that it may be difficult to hear.

Probable cause — A high-frequency leakage current radiated from the inverter and motors enters shielded telephone cables, causing noise.

Measure — It is effective to commonly connect the grounding terminals of the motors and return the common grounding line to the grounding terminal of the inverter.

[3] Effect on proximity switches

Phenomena — If an inverter operates, proximity switches (capacitance-type) may malfunction.

Probable cause — The capacitance-type proximity switches may provide inferior noise immunity.

Measure — It is effective to connect a filter to the input terminals of the inverter or change the power supply treatment of the proximity switches. The proximity switches can be replaced with superior noise immunity types such as magnetic types.

[4] Effect on pressure sensors

Phenomena — If an inverter operates, pressure sensors may malfunction.

Probable cause — Noise may penetrate through a grounding wire into the signal line.

Measure — It is effective to install a noise filter on the power supply side of the inverter or to change the wiring.

[5] Effect on position detectors (pulse encoders)

Phenomena — If an inverter operates, pulse encoders may produce erroneous pulses that shift the stop position of a machine.

Probable cause — Erroneous pulses are liable to occur when the signal lines of the PG and power lines are bundled together.

Measure — The influence of induction noise and radiation noise can be reduced by separating the PG signal lines and power lines. Providing noise filters at the input and output terminals is also an effective measure.

APPENDICES

A.2 Noise

This section gives a summary of noises generated in inverters and their effects on devices subject to noise.

[1] Inverter noise

Figure A.1 shows an outline of the inverter configuration. The inverter converts AC to DC (rectification) in a converter unit, and converts DC to AC (inversion) with 3-phase variable voltage and variable frequency. The conversion (inversion) is performed by PWM implemented by switching six transistors (IGBT: Insulated Gate Bipolar Transistor, etc), and is used for variable speed motor control.

Switching noise is generated by high-speed on/off switching of the six transistors. Noise current (i) is emitted and at each high-speed on/off switching, the noise current flows through stray capacitance (C) of the inverter, cable and motor to the ground. The amount of the noise current is expressed as follows:

$$i = C \cdot dv/dt$$

It is related to the stray capacitance (C) and dv/dt (switching speed of the transistors). Further, this noise current is related to the carrier frequency since the noise current flows each time the transistors are switched on or off.

In addition to the main circuit of the inverter, the DC-to-DC switching power regulator (DC/DC converter), which is the power source for the control circuit of the inverter, may be a noise source in the same principles as stated above.

The frequency band of this noise is less than approximately 30 to 40 MHz. Therefore, the noise will affect devices such as AM radios using low frequency band, but will not virtually affect FM radios and television sets using higher frequency than this frequency band.

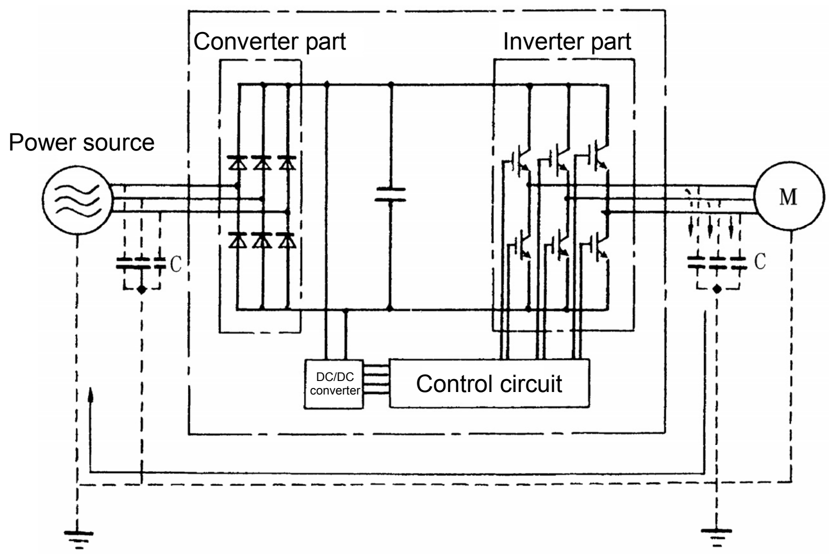


Figure A.1 Outline of Inverter Configuration

[2] Types of noise

Noise generated in an inverter is propagated through the main circuit wiring to the power supply and the motor so as to affect a wide range of applications from the power supply transformer to the motor. The various propagation routes are shown in Figure A.2. According to those routes, noises are roughly classified into three types--conduction noise, induction noise, and radiation noise.

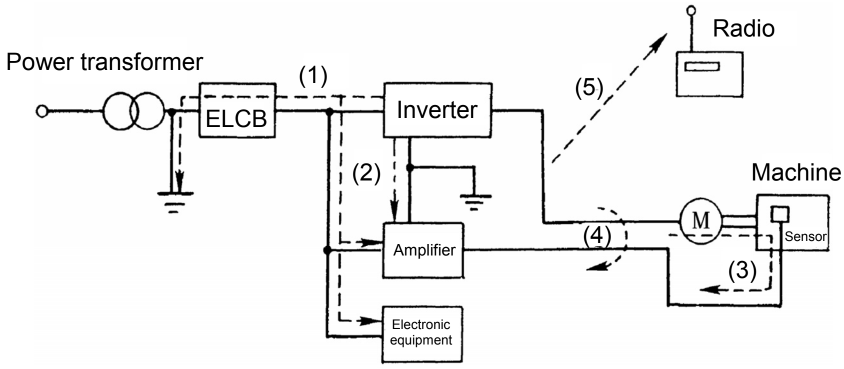


Figure A.2 Noise Propagation Routes

(1) Conduction noise

The noise that has occurred in the inverter and propagates through a conductor to influence peripheral equipment is called a conduction noise. Some conduction noises will propagate through the main circuit (1). If the ground wires are connected to a common ground, conduction noise will propagate through route (2). As shown in route (3), some conduction noises will propagate through signal lines or shielded wires.

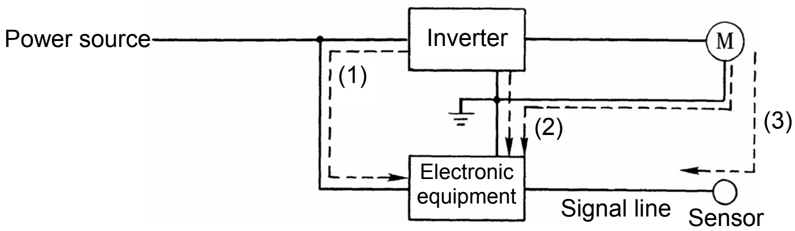


Figure A.3 Conduction Noise

(2) Induction noise

When wires or signal lines of peripheral devices are brought close to the wires on the input and output sides of the inverter through which noise current is flowing, noise will be induced into those wires and signal lines of the devices by electromagnetic induction (Figure A.4) or electrostatic induction (Figure A.5). This is called "induction noise" (4).

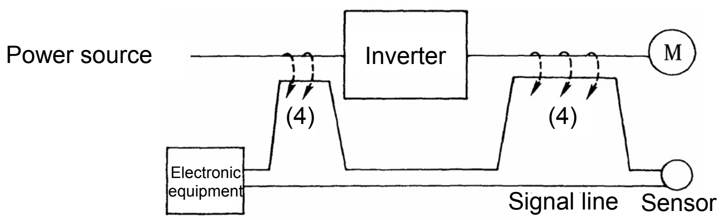


Figure A.4 Electromagnetic Induced Noise

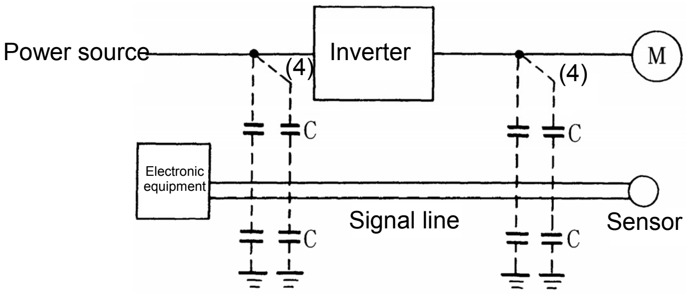


Figure A.5 Electrostatic Induced Noise

(3) Radiation noise

Noise generated in an inverter may be radiated through the air from wires (that act as antennas) at the input and output sides of the inverter so as to affect peripheral devices. This noise is called "radiation noise" as shown below as (5). Not only wires but motor frames or control system panels containing inverters may also act as antennas.

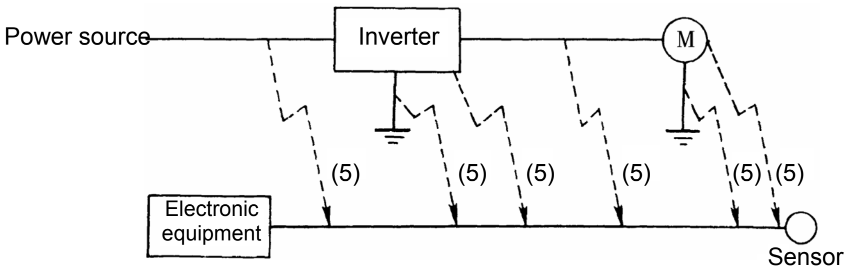


Figure A.6 Radiation Noise

A.3 Measure

The more noise prevention is strengthened, the more effective. However, with the use of appropriate measures, noise problems may be resolved easily. It is necessary to implement economical noise prevention according to the noise level and the equipment conditions.

[1] Noise prevention prior to installation

Before installing an inverter in your control panel or installing an inverter panel, you need to consider noise prevention. Once noise problems occur, it will cost additional materials and time for solving them.

Noise prevention prior to installation includes:

(1) Separate the main circuit from the control circuit.
(2) Accommodate the main circuit wiring in a metal pipe (conduit pipe).
(3) Use shielded wire or twisted shielded wire in the control circuit.
(4) Perform reliable grounding work and wiring.

These noise prevention measures can avoid most noise problems.

[2] Implementation of noise prevention measures

There are two types of noise prevention measures--one for noise propagation routes and the other for noise receiving sides (that are affected by noise).

The basic measures for lessening the effect of noise at the receiving side include: Separating the main circuit wiring from the control circuit wiring, avoiding noise effect.

Measures on the noise-affected side are:
(1) Lower the noise level for example by installing a noise filter.
(2) Suppress the noise level for example by using a metal wiring pipe or metal control panel.
(3) Block the noise propagation route for example by using an insulation transformer for power source.

Table A.1 lists the noise prevention measures, their goals, and propagation routes.

Table A.1 Noise Prevention Measures

Noise prevention method		Goal of noise prevention measures				Conduction route		
		Make it more difficult to receive noise	Cutoff noise conduction	Confine noise	Reduce noise level	Conduction noise	Induction noise	Radiation noise
Wiring and installation	Separate main circuit from control circuit	○					○	
	Minimize wiring distance	○			○		○	○
	Avoid parallel and bundled wiring	○					○	
	Use appropriate grounding	○			○	○	○	
	Use shielded wire and twisted shielded wire	○					○	○
	Use shielded cable in main circuit			○			○	○
	Use metal conduit pipe			○			○	○
Control panel	Appropriate arrangement of devices in panel	○					○	○
	Metal control panel			○			○	○
Anti-noise devices	Line filter	○			○	○		○
	Insulation transformer		○			○		○
Measures taken on noise-affected side	Use a passive capacitor for control circuit	○					○	○
	Use ferrite core for control circuit	○			○		○	○
	Line filter	○		○		○		
Other	Separate power supply systems		○			○		
	Lower the carrier frequency				△	○	○	○

In the table, a column marked with ○ shows a measure expected to produce an effect and a column marked with △ shows a measure expected to produce an effect depending on the conditions. A vacant column shows an ineffective measure.

APPENDICES

What follows is noise prevention measures for the inverter drive configuration.

(1) Wiring and grounding

As shown in Figure A.7, separate the main circuit wiring from control circuit wiring as far as possible regardless of being located inside or outside the system control panel containing an inverter. Use shielded wires and twisted shielded wires that will block out extraneous noises, and minimize the wiring distance. Also avoid bundled wiring of the main circuit and control circuit or parallel wiring.

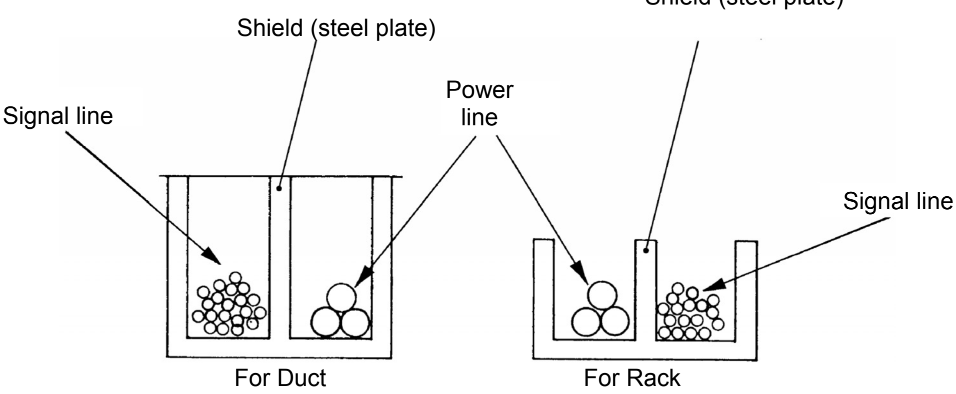


Figure A.7 Separate Wiring

For the main circuit wiring, use a metal conduit pipe and connect its wires to the ground to prevent noise propagation (refer to Figure A.8).

The shield (braided wire) of a shielded wire should be securely connected to the base (common) side of the signal line at only one point to avoid the loop formation resulting from a multi-point connection (refer to Figure A.9).

The grounding is effective not only to reduce the risk of electrical shocks due to leakage current, but also to block noise penetration and radiation. Corresponding to the main circuit voltage, the grounding work should be Class D (300 VAC or less, grounding resistance: 100Ω or less) and Class C (300 to 600 VAC, grounding resistance: 10Ωor less). Each ground wire is to be provided with its own ground or separately wired to a grounding point.

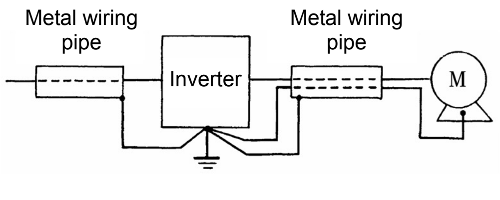


Figure A.8 Grounding of Metal Conduit Pipe

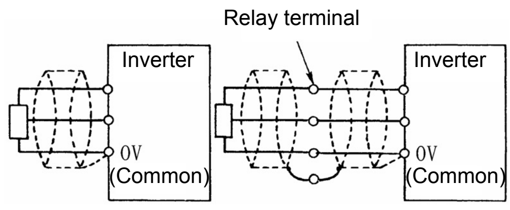


Figure A.9 Treatment of Braided Wire of Shielded Wire

(2) Control panel

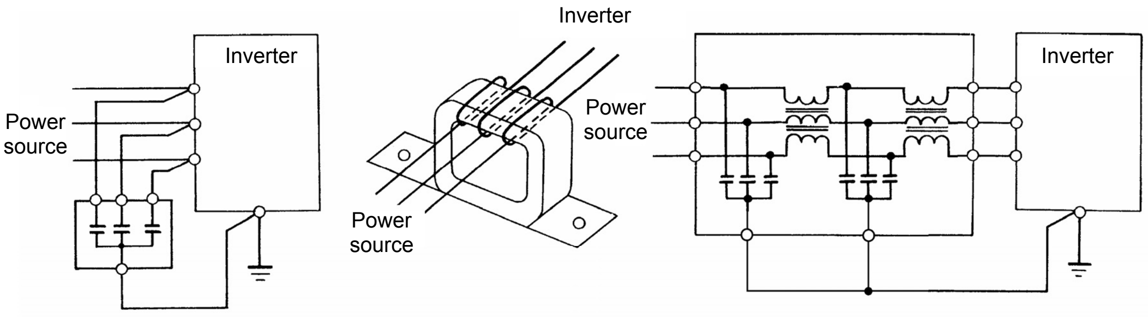
The system control panel containing an inverter is generally made of metal, which can shield noise radiated from the inverter itself.

When installing other electronic devices such as a programmable logic controller in the same control panel, be careful with the layout of each device. If necessary, arrange shield plates between the inverter and peripheral devices.

(3) Anti-noise devices

To reduce the noise propagated through the electrical circuits and the noise radiated from the main circuit wiring to the air, a line filter and power supply transformer should be used (refer to Figure A.10).

Line filters are classified into simple-type filters including capacitive filters to be connected in parallel to a power line and inductive filters to be connected in series to a power line and authentic filters (LC filters) to address radio noise restrictions. They are used selectively used to meet the target noise reduction effect. Power transformers include generally used insulation transformers, shield transformers and noise-cut transformers, which have different effects to block propagation of noise.



(a) Capacitive filter (b) Inductive filter (zero-phase reactor) (c) LC filter

Figure A.10 Various Filters and their Connection

(4) Noise prevention measures at the receiving side

It is important to strengthen the noise immunity of those electronic devices installed in the same control panel as the inverter or located near an inverter. Line filters and shielded or twisted shielded wires are used to block the penetration of noise in the signal lines of these devices. The following treatments are also implemented.

1) Lower the circuit impedance by connecting capacitors or resistors to the input and output terminals of the signal circuit in parallel.
2) Increase the circuit impedance for noise by inserting choke coils in series in the signal circuit or passing signal lines through ferrite core beads. It is also effective to widen the signal base lines (0 V line) or grounding lines.

(5) Other

The level of generating/propagating noise will change with the carrier frequency of the inverter. The higher the carrier frequency, the higher the noise level.

In an inverter whose carrier frequency can be changed, lowering the carrier frequency can reduce the generation of electrical noise and result in a good balance with the audible noise of the motor under driving conditions.

APPENDICES

[3] Noise prevention examples

Table A.2 lists examples of the measures to prevent noise generated by a running inverter.

Table A.2 Examples of Noise Prevention Measures

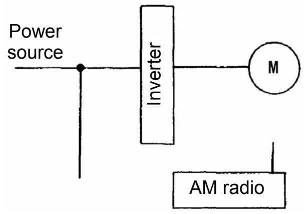
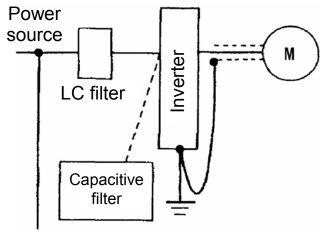
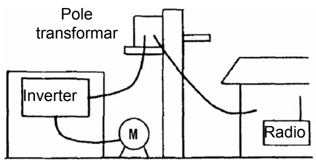
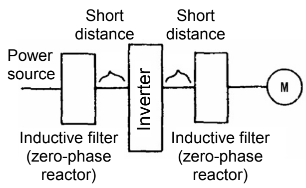
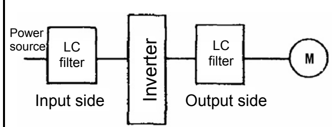
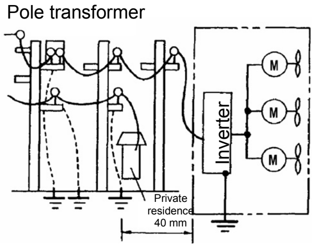
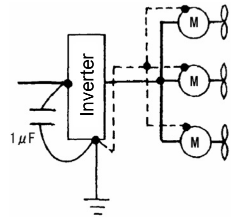
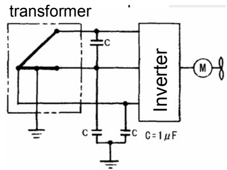
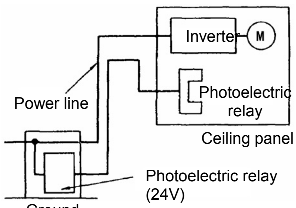
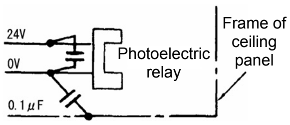
No.	Target device	Phenomena	Measure	Notes
1	AM radio	Noise enters the AM radio broadcast (500-1500kHz) when the inverter is operated.  <Possible cause> Radiation noise from the power source and output wiring of inverted was received by the AM radio.	1) Install an LC filter at the power supply side of the inverter. (In some cases, a capacitive filter may be used as a simple method.) 2) Install a metal conduit wiring between the motor and inverter.  (Note) Minimize the distance between the LC filter and the inverter (within 1m).	1) The radiation noise of the wiring can be reduced. 2) Reduce the conduction noise to the power source or apply shielded wiring. Note: Sufficient improvement may not be expected in narrow regions such as between mountains.
2	AM radio	Noise enters the AM radio broadcast (500 to 1500kHz) when the inverter is operated.  <Possible cause> Radiation noise from the power line of inverter's power source was received by the AM radio.	1) Install inductive filters at the input and output sides of the inverter.  The number of turns of the zero-phase reactor (or ferrite ring) should be as large as possible. Minimize the distance between the inverter and the inductive filter (within 1 m). 2) When further improvement is necessary, install LC filters.  	1) The radiation noise of the wiring can be reduced.

Table A.2 Examples of Noise Prevention Measures (Continued)

No.	Target device	Phenomena	Measure	Notes
3	Telephone (in a common private residence at a distance of 40 m)	When driving a ventilation fan with an inverter, noise enters a telephone in a private residence at a distance of 40 m.  <Possible cause> Harmonic leak current of the inverter and motor flows into the shielded groung of the telephone cable on the way back via the ground of the pole transformer to cause noise by electrostatic induction.	1) Connect the ground terminals of the motors in a common connection. Return to the inverter panel, and insert a 1 μF capacitor between the input terminal of the inverter and ground.  	1) The effect of the inductive filter and LC filter may not be expected because of sound frequency component. 2) In the case of a V-connection power supply transformer in a 200V system, it is necessary to connect capacitors as shown in the following figure, because of different potentials to ground. 
4	Photo-electric relay	A photoelectric relay malfunctioned when the inverter runs the motor. [The inverter and motor are installed in the same place (for overhead traveling)]  <Possible cause> Input power line of the inverter and wiring of the photoelectric relay run parallel for 30 to 40 m with a spacing of about 25 mm, which invites induction noise. Due to conditions of the installation, these lines cannot be separated.	1) As a temporary measure, Insert a 0.1 μF capacitor between the 0 V terminal of the power supply circuit in the detection unit of the overhead photoelectric relay and a frame of the overhead panel.  2) As a permanent measure, move the 24 V power supply from the ground to the overhead unit so that signals are sent to the ground side with relay contacts in the ceiling part.	1) Separate the wiring (30 cm or more). 2) When separation is impossible, signals can be received and sent with dry contacts etc. 3) Do not wire low-current signal lines and power lines in parallel.

APPENDICES

Table A.2 Examples of Noise Prevention Measures (Continued)

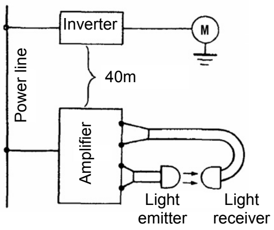
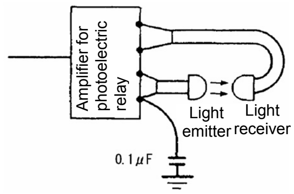
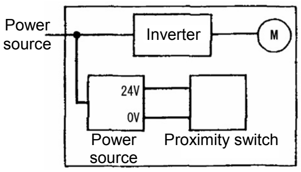
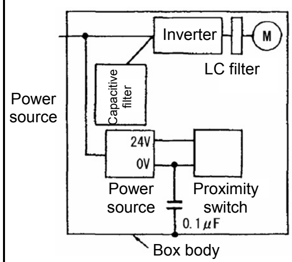
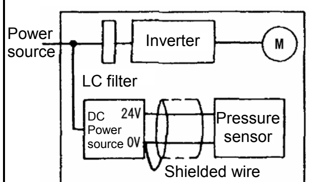
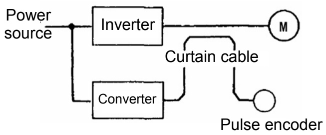
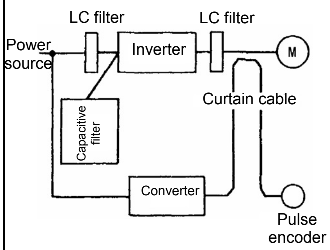
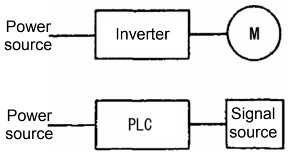
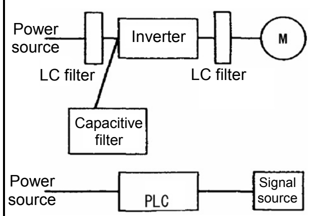
No.	Target device	Phenomena	Measure	Notes
5	Photo-electric relay	A photoelectric relay malfunctioned when the inverter was operated.  <Possible cause> While the inverter is sufficently away from the photoelectric relay, the power source is connected in common. Comnduction noise has enteted from the power source line.	1) Insert a 0.1 μF capacitor between the output common terminal of the amplifier of the photoelectric relay and the frame. 	1) If a low-current circuit at the malfunctioning side is observed, the measures may be simple and economical.
6	Proximity switch (capacitance type)	A proximity switch malfunctioned.  <Possible cause> The electrostatic capacitive proximity switch has a low noise immunity, and is vulnerable to circuit conduction noise and radiation noise.	1) Install an LC filter at the output side of the inverter. 2) Install a capacitive filter at the input side of the inverter. 3) Ground the 0 V (common) line of the DC power supply of the proximity switch through a capacitor to the box body of the machine. 	1) Noise generated in the inverter can be reduced. 2) The switch is superseded by a proximity switch of superior noise immunity (such as a magnetic type).
7	Pressure sensor	Power source	1) Install an LC filter on the input side of the inverter. 2) Connect the shield of the shielded wire of the pressure sensor to the 0 V line (common) of the pressure sensor, changing the original connection. 	1) The shielded parts of shield wires for sensor signals are connected to a common point in the system. 2) Conduction noise from the inverter can be reduced.

Table A.2 Examples of Noise Prevention Measures (Continued)

No.	Target device	Phenomena	Measure	Notes
8	Position detector (pulse encoder)	Erroneous-pulse outputs from a pulse converter caused a shift in the stop position of a crane.  <Possible cause> The motor power line and the signel line for the encoder are wired together in a bundle. This produces induction noise to cause output of error pulses.	1) Install an LC filter and a capacitive filter at the input side of the inverter. 2) Install an LC filter at the output side of the inverter. 	1) This is an example of a measure where the power line and signal line cannot be separated. 2) Induction noise and radiation noise at the output side of the inverter can be reduced.
9	Programmable logic controller (PLC)	The PLC program sometimes malfunctions.  <Possible cause> Power sources of the inveter and PLC are in the same system so that noise enters PLC via the power source.	1) Install a capacitive filter and an LC filter on the input side of the inverter. 2) Install an LC filter on the output side of the inverter. 3) Lower the carrier frequency of the inverter. 	1) Total conduction noise and induction noise in the electric line can be reduced.

APPENDICES

Appendix B Japanese Guideline for Suppressing Harmonics by Customers Receiving High Voltage or Special High Voltage (General-purpose inverter)

Agency of Natural Resource and Energy of Japan published the following two guidelines for suppressing harmonic noise in September 30, 1994.

(1) "Guideline to reduce harmonic emissions caused by electrical and electronic equipment for household and general use"
(2) "Guideline of harmonics reduction for consumers with high or ultra-high voltage power receiving facilities"

Assuming that electronic devices generating high harmonics will be increasing, these guidelines are to establish regulations for preventing high frequency noise interference on devices sharing the power source. These guidelines should be applied to all devices that are used on the commercial power lines and generate harmonic current. This section gives a description limited to general-purpose inverters.

B.1 Application to general-purpose inverters

[1] Guideline for suppressing harmonics in home electric and general-purpose appliances

Our three-phase, 200 V class series inverters of 3.7 kW or less (FRENIC-MEGA series) were the products of which were restricted by the "Guideline for Suppressing Harmonics in Home Electric and General-purpose Appliances" (established in September 1994 and revised in October 1999) issued by the Ministry of Economy, Trade and Industry. The above restriction, however, was lifted when the Guideline was revised in January 2004. Since then, the inverter makers have individually imposed voluntary restrictions on the harmonics of their products. We, as before, recommend that you connect a reactor (for suppressing harmonics) to your inverter.

[2] Guideline for suppressing harmonics by customers receiving high voltage or special high voltage

Unlike other guidelines, this guideline is not applied to the equipment itself such as a general-purpose inverter, but is applied to each large-scale electric power consumer for total amount of harmonics. Regulation is applied to each power consumer rather than direct regulation of harmonic current generating equipment such as the "general-purpose inverter". Calculation of the amount of generated harmonic current is necessary on individual equipment.

(1) Scope of regulation

In principle, the guideline applies to the customers that meet the following two conditions:

- The customer receives high voltage or special high voltage.
- The "equivalent capacity" of the converter load exceeds the standard value for the receiving voltage (50 kVA at a receiving voltage of 6.6 kV).

Appendix B.2 [1] "Calculation of equivalent capacity (Pi)" gives you some supplemental information with regard to estimation for the equivalent capacity of an inverter according to the guideline.

(2) Regulation

The level (calculated value) of the harmonic current that flows from the customer's receiving point out to the system is subjected to the regulation. The regulation value is proportional to the contract demand. The regulation values specified in the guideline are shown in Table B.1.

Appendix B.2 gives you some supplemental information with regard to estimation for the equivalent capacity of the inverter for compliance to "Japanese guideline for suppressing harmonics by customers receiving high voltage or special high voltage."

Table B.1 Upper Limits of Harmonic Outflow Current per kW of Contract Demand (mA/kW)

Receiving voltage	5th	7th	11th	13th	17th	19th	23rd	Over 25th
6.6kV	3.5	2.5	1.6	1.3	1.0	0.90	0.76	0.70
22kV	1.8	1.3	0.82	0.69	0.53	0.47	0.39	0.36

(3) When the regulation applied

The guideline has been applied.

As the application, the estimation for "Voltage distortion factor" required as the indispensable conditions when entering into the consumer's contract of electric power is already expired.

B.2 Compliance to the harmonic suppression for customers receiving high voltage or special high voltage

When calculating the required matters related to inverters according to the guideline, follow the terms listed below. The following descriptions are based on "Technical document for suppressing harmonics" (JEAG 9702-1995) published by the Japan Electrical Manufacturer's Association (JEMA).

[1] Calculation of equivalent capacity (Pi)

The equivalent capacity (Pi) may be calculated using the equation of (input rated capacity) x (conversion factor). However, catalogs of conventional inverters do not contain input rated capacities, so a description of the input rated capacity is shown below:

(1) "Inverter rated capacity" corresponding to "Pi"

- In the guideline, the conversion factor of a 6-pulse converter is used as reference conversion factor 1. It is, therefore, necessary to express the rated input capacity of inverters in a value including harmonic component current equivalent to conversion factor 1.
- In particular, calculate the input fundamental current I_1 from the kW rating and efficiency of the motor and the efficiency of the inverter as loads and then calculate:

  Input rated capacity=$\sqrt{3}$ × (power voltage) × I_1 × 1.0228/1000 (kVA).
  Then, calculate the input rated capacity as shown below: where 1.0228 is the 6-pulse converter's value of (effective current)/ (fundamental current).
- When a general-purpose motor or inverter motor is used, the appropriate value shown in Table B.2 can be used. Select a value based on the kW rating of the motor used, irrespective of the inverter type.

Note: The input rated capacity shown above is for the dedicated use in the equation to calculate capacity of the inverters, following the guideline. Note that the capacity cannot be applied to the reference for selection of the equipment or wires to be used in the inverter input circuits.

For selection of capacity for the peripheral equipment, refer to the catalogs or technical documents issued from their manufacturers.

APPENDICES

Table B.2 "Input Rated Capacities" of General-purpose Inverters Determined by the Applicable Motor Ratings

Applicable motor rating (kW)		0.4	0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5
Pi (kVA)	200V	0.57	0.97	1.95	2.81	4.61	6.77	9.07	13.1	17.6	21.8
	400V	0.57	0.97	1.95	2.81	4.61	6.77	9.07	13.1	17.6	21.8

Applicable motor rating (kW)		22	30	37	45	55	75	90	110	132	160
Pi (kVA)	200V	25.9	34.7	42.8	52.1	63.7	87.2	104	127		
	400V	25.9	34.7	42.8	52.1	63.7	87.2	104	127	153	183

Applicable motor rating (kW)		200	220	250	280	315	355	400	450	500	630
Pi (kVA)	200V										
	400V	229	252	286	319	359	405	456	512	570	718

(2) Values of "Ki (conversion factor)"
Depending on whether an optional ACR (AC reactor) or DCR (DC reactor) is used, apply the appropriate conversion factor specified in the appendix to the guideline. The values of the conversion factor are listed in Table B.3.

Table B.3 "Conversion Factors Ki" for General-purpose Inverters Determined by Reactors

Circuit category	Circuit type		Conversion factor Ki	Main applications
3	Three-phase bridge (Capacitor smoothing)	w/o a reactor	K31=3.4	• General-purpose inverter
		w/- a reactor (ACR)	K32=1.8	• Elevator
		w/- a reactor (DCR)	K33=1.8	• Cold air refrigerating machine
		w/- reactors (ACR and DCR)	K34=1.4	• Other equipment in general

Note Some models are equipped with a reactor as a standard accessory.

[2] Calculation of Harmonic Current

(1) Value of "input fundamental current"

- When you calculate the amount of harmonics according to Table 2 in Appendix of the Guideline, you have to previously know the input fundamental current.
- Apply the appropriate value shown in Table B.4 based on the kW rating of the motor, irrespective of the inverter type or whether a reactor is used.

Note If the input voltage is different, calculate the input fundamental current in inverse proportion to the voltage.

Table B.4 "Input Fundamental Currents" of General-purpose Inverters Determined by the Applicable Motor Ratings

Applicable motor rating (kW)		0.4	0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5
Input fundamental current (A)	200V	1.62	2.74	5.50	7.92	13.0	19.1	25.6	36.9	49.8	61.4
	400V	0.81	1.37	2.75	3.96	6.50	9.55	12.8	18.5	24.9	30.7
6.6 kV converted value (mA)		49	83	167	240	394	579	776	1121	1509	1860

Applicable motor rating (kW)		22	30	37	45	55	75	90	110	132	160
Input fundamental current (A)	200V	73.1	98.0	121	147	180	245	293	357		
	400V	36.6	49.0	60.4	73.5	89.9	123	147	179	216	258
6.6 kV converted value (mA)		2220	2970	73.5	4450	5450	7450	8910	10850	13090	15640

Applicable motor rating (kW)		200	220	250	280	315	355	400	450	500	630
Input fundamental current (A)	200V										
	400V	323	355	403	450	506	571	643	723	804	1013
6.6 kV converted value (mA)		19580	21500	24400	27300	30700	34600	39000	43800	48700	61400

(2) Calculation of harmonic current

Usually, calculate the harmonic current according to the Sub-table 3 "Three-phase bridge rectifier with the smoothing capacitor" in Table 2 of the Guideline's Appendix. Table B.5 lists the contents of the Sub-table 3.

Table B.5 Generated Harmonic Current (%), 3-phase Bridge Rectifier (Capacitor Smoothing)

Degree	5th	7th	11th	13th	17th	19th	23rd	25th
w/o a reactor	65	41	8.5	7.7	4.3	3.1	2.6	1.8
w/- a reactor (ACR)	38	14.5	7.4	3.4	3.2	1.9	1.7	1.3
w/- a reactor (DCR)	30	13	8.4	5.0	4.7	3.2	3.0	2.2
w/- reactors (ACR and DCR)	28	9.1	7.2	4.1	3.2	2.4	1.6	1.4

- ACR: 3%
- DCR: Accumulated energy equal to 0.08 to 0.15 ms (100% load conversion)
- Smoothing capacitor: Accumulated energy equal to 15 to 30 ms (100% load conversion)
- Load: 100%

$$\text{nth harmonic current (A)} = \text{Fundamental current (A)} \times \frac{\text{Generated nth harmonic current (\%)}}{100}$$

Calculate the harmonic current of each degree using the following equation:

(3) Maximum availability factor

- For a load for elevators, which provides intermittent operation, or a load with a sufficient designed motor rating, reduce the current by multiplying the equation by the "maximum availability factor" of the load.
- According to the Appendix to Guideline, “Maximum availability factor of equipment refers to the ratio of the maximum capacity of the operating equipment to the total capacity of the harmonic generation equipment. Capacity of the operating equipment shall be an average value over 30 minutes.”
- In general, the maximum availability factor is calculated according to this definition, but the standard values shown in Table B.6 are recommended for inverters for building equipment.

Table B.6 Availability Factors of Inverters, etc. for Building Equipment (Standard Values)

Equipment type	Inverter capacity category	Single inverter availability
Air conditioning system	200 kW or less	0.55
	Over 200 kW	0.60
Sanitary pump	-	0.30
Elevator	-	0.25
Refrigerator, freezer	50 kW or less	0.60
UPS (6-pulse)	200kVA	0.60

<u>Correction coefficient according to contract demand level</u>

Since the total availability factor decreases if the scale of a building increases, calculating reduced harmonics with the correction coefficient β defined in Table B.7 is permitted.

Table B.7 Correction Coefficient according to the Building Scale

Contract demand (kW)	Correction coefficient β
300	1.00
500	0.90
1,000	0.85
2,000	0.80

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Note: If the contract demand is between two specified values listed in Table B.7, calculate the value by interpolation.

Note: The correction coefficient β is to be determined as a matter of consultation between the customer and electric power company for the customers receiving the electric power over 2000 kW or from the special high voltage lines.

(4) Degree of harmonics to be calculated

The higher the degree of harmonics, the lower the current flows. This is the property of harmonics generated by inverters so that the inverters are covered by "The case not causing a special hazard" of the term 3.(3) in the above Appendix for the 9th or higher degrees of the harmonics.

Therefore, "It is sufficient that the 5th and 7th harmonic currents should be calculated."

[3] Examples of calculation

(1) Equivalent capacity

Example of loads		Input capacity and No. of inverters	Conversion factor	Equivalent capacity
[Example (1)]	400V, 3.7kW,10 units w/- AC/DC reactor	4.61 kVA × 10 units	K32=1.4	4.61×10×1.4= 64.54 kVA
[Example (2)]	400V, 1.5kW, 15 units w/- AC reactor	2.93 kVA × 15 units	K34=1.8	2.93×15×1.8= 79.11 kVA
		Refer to Table B.2.	Refer to Table B.3.	

(2) Harmonic current every degrees

Example 1: 400V, 3.7kW, 10 units (w/- AC reactor), maximum availability factor: 0.55

6.6kV side fundamental current (mA)	Harmonic current onto 6.6 kV lines (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%)	23th (1.7%)	25th (1.3%)
	823.5	314.2						
Refer to Tables B.4 and B.6.	Refer to Table B.5.							

Example 2: 400V, 3.7kW, 15 units (w/- AC/DC reactor), maximum availability factor: 0.55

6.6kV side fundamental current (mA)	Harmonic current onto 6.6 kV lines (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%)	23th (1.6%)	25th (1.4%)
	910.1	295.8						
Refer to Tables B.4 and B.6.	Refer to Table B.5.							

Appendix C Effect on Insulation of General-purpose Motors Driven with 400 V Class Inverters

Excerpt from technical material of
the Japan Electrical Manufacturers' Association (JEMA) (March 1995)

Preface

When an inverter drives a motor, surge voltages generated by switching the inverter elements are superimposed on the inverter output voltage and applied to the motor terminals. If the surge voltages are too high they may have an effect on the motor insulation and some cases have resulted in damage.

For preventing such cases this document describes the generating mechanism of the surge voltages and countermeasures against them.

Refer to A.2 [1] "Inverter noise" for details of the principle of inverter operation.

C.1 Generating mechanism of surge voltages

As the inverter rectifies a commercial power source voltage and smoothes into a DC voltage, the magnitude E of the DC voltage becomes about $\sqrt{2}$ times that of the source voltage (about 620 V in case of an input voltage of 440 VAC). The peak value of the output voltage is usually close to this DC voltage value.

But, as there exists inductance (L) and stray capacitance (C) in wiring between the inverter and the motor, the voltage variation due to switching the inverter elements causes a surge voltage originating in LC resonance and results in the addition of high voltage to the motor terminals. (Refer to Figure C.1)

This voltage sometimes reaches up to about twice that of the inverter DC voltage (620 V x 2 = approximately 1,200 V) depending on a switching speed of the inverter elements and wiring conditions.

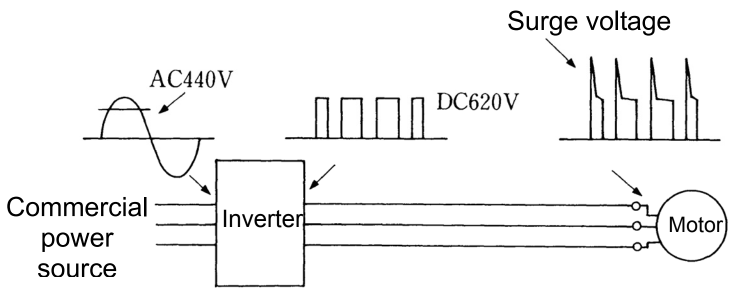

Figure C.1 Voltage Waveform of Individual Portions

A measured example in Figure C.2 illustrates the relation of a peak value of the motor terminal voltage with a wiring length between the inverter and the motor.

From this it can be confirmed that the peak value of the motor terminal voltage ascends as the wiring length increases and becomes saturated at about twice the inverter DC voltage.

The shorter a pulse rise time becomes, the higher the motor terminal voltage rises even in the case of a short wiring length.

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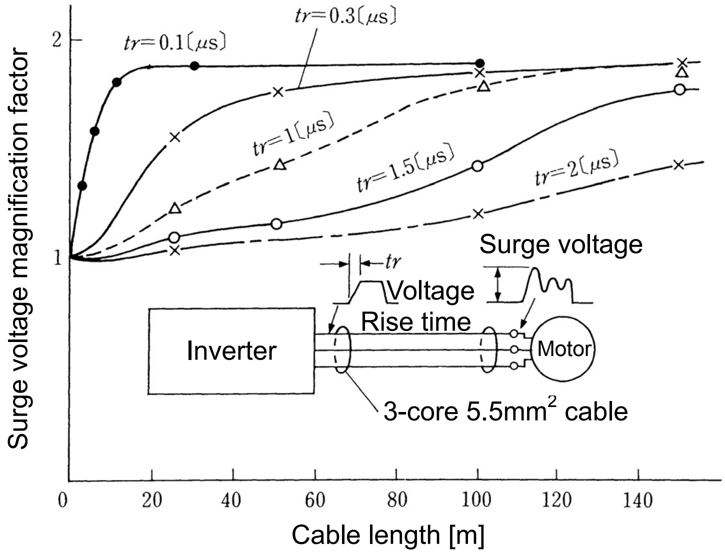


For IGBT,
tr is equivalent to 0.1 to 0.3 μs.
For the bipolar transistor,
tr is equivalent to 0.3 to1 μs.
In case an output reactor or a filter is inserted,
tr is equivalent to 1μs or more.
Surge voltage magnification factor:
Magnification factor for DC voltage E

Excerpt from Journal of IEEJ, No. 7, vol. 107, 1987

Figure C.2 Measured Example of Wiring Length and Peak Value of Motor Terminal Voltage

C.2 Effect of surge voltages

The surge voltages originating in LC resonance of wiring may be applied to the motor terminals and depending on their magnitude sometimes cause damage to the motor insulation.

When the motor is driven with a 200 V class inverter, the dielectric strength of the insulation is no problem since the peak value at the motor terminal voltage increases twice due to the surge voltages (the DC voltage is only about 300 V).

But in case of a 400 V class inverter, the DC voltage is approximately 600 V and depending on the wiring length, the surge voltages may greatly increase and sometimes result in damage to the insulation.

C.3 Countermeasures against surge voltages

When driving a motor with a 400 V class inverter, the following are countermeasures against damage to the motor insulation by the surge voltages.

[1] Using a surge suppressor unit, SSU (Patent pending)

The surge suppressor unit (SSU) is a newly structured unit using circuits based on the impedance-matching theory of a transmission line. Just connecting the SSU to the surge suppressor cable of the existing equipment can greatly reduce the surge voltage that results in a motor dielectric breakdown.

For 50 m of wiring length: SSU 50TA-NS   For 100 m of wiring length: SSU 100TA-NS

[2] Suppressing surge voltages

There are two ways for suppressing the surge voltages, one is to reduce the voltage rise time and another is to reduce the voltage peak value.

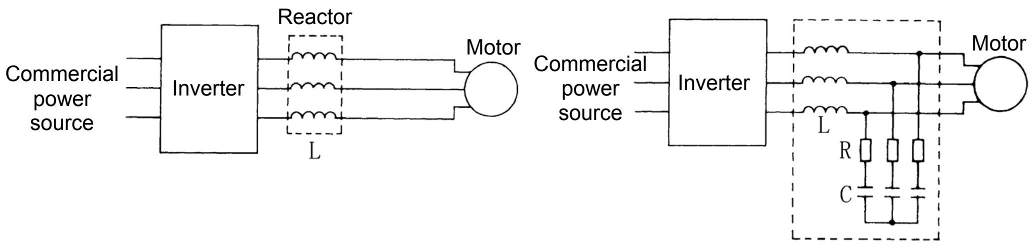
(1) Output reactor

If wiring length is relatively short, the surge voltages can be suppressed by reducing the voltage rise time (dv/dt) with the installation of an AC reactor on the output side of the inverter. (Refer to Figure C.3 (1).)

However, if the wiring length becomes long, suppressing the peak voltage due to surge voltage may be difficult.

(2) Output filter

Installing a filter on the output side of the inverter allows a peak value of the motor terminal voltage to be reduced. (Refer to Figure C.3 (2).)



(1) Output reactor (2) Output filter

Figure C.3 Method to Suppress Surge Voltage

Tip: If the wiring length between the inverter and the motor is comparatively long, the crest value of the surge voltage can be suppressed by connecting a surge suppressor unit (SSU) to the motor terminal. For details, refer to Chapter 11, "11.9.8 Surge supplrssion unit (SSU)".

[3] Using motors with enhanced insulation

Enhanced insulation of a motor winding allows its surge withstanding to be improved.

C.4 Regarding existing equipment

[1] In case of a motor being driven with 400 V class inverter

A survey over the last five years on motor insulation damage due to the surge voltages originating from switching of inverter elements shows that the damage incidence is 0.013% under the surge voltage condition of over 1,100 V and most of the damage occurs several months after commissioning the inverter. Therefore there seems to be little probability of occurrence of motor insulation damage after a lapse of several months of commissioning.

[2] In case of an existing motor driven using a newly installed 400 V class inverter

We recommend suppressing the surge voltages with the ways shown in Section C.3.

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Appendix D Inverter Generating Loss

The table below lists the inverter generating loss.

Unit: W

Power system	Inverter type	Carrier frequency (Functional code:F26)					
		ND mode	HD mode	HND mode		HHD mode	
		Factory shipment value	Factory shipment value	Factory shipment value	Maximum set value	Factory shipment value	Maximum set value
3-phase 400V	FRN0059E2S-4□	710	510	510	870	440	770
	FRN0072E2S-4□	900	750	710	1000	510	900
	FRN0085E2S-4□	1200	1000	1000	1250	800	1150
	FRN0105E2S-4□	1350	1200	1200	1550	1000	1450
	FRN0139E2S-4□	1700	1300	1300	1700	1100	1600
	FRN0168E2S-4□	2000	1850	1850	2300	1350	1950
	FRN0203E2S-4□	2250	1950	1950	2250	1600	2150

Note 1: The maximum set value (max. carrier) differs depending on specification. For details please refer to Chapter 5 FUNCTION CODE F26.

Note 2: When NH/HD specification units are operated at maximum carrier, reduce output to 60% of rated current. At that setting, generated losses will be at same level as the factory shipment value.

Appendix E Conversion from SI Units

All expressions given in Chapter 3, "SELECTING OPTIMAL MOTOR AND INVERTER CAPACITIES" are based on SI units (The International System of Units). This section explains how to convert expressions to other units.

[1] Conversion of units

(1) Force

- 1[kgf]≈9.8[N]
- 1[N] ≈0.102[kgf]

(2) Torque

- 1[kgf•m] ≈9.8[N•m]
- 1[N•m] ≈0.102[kgf•m]

(3) Power (energy)

- 1[kgf•m] ≈9.8[N•m]=9.8[J]=9.8[W•s]

(4) Power

- 1[kgf•m/s] ≈9.8[N•m/s]=9.8[J/s]= 9.8[W]
- 1[N•m/s] ≈1[J/s]=1[W] ≈0.102[kgf•m/s]

(5) Rotation speed

- 1[min^{-1}]= $\frac{2\pi}{60}$[rad/s] ≈0.1047[rad/s]
- 1[rad/s]= $\frac{60}{2\pi}$[min^{-1}] ≈9.549[min^{-1}]

(6) Inertia constant

J[kg•m^2] :moment of inertia
GD^2[kg•m^2] :flywheel effect

- GD^2=4J
- $J = \frac{GD^2}{4}$

(7) Pressure, stress

- 1[mmAq] ≈9.8[Pa] ≈9.8[N/m^2]
- 1[Pa] ≈1[N/m^2] ≈0.102[mmAq]
- 1[bar] ≈100000[Pa] ≈1.02[kg•cm^2]
- 1[kg•cm^2] ≈98000[Pa] ≈980[mbar]
- 1 barometric pressure
  =1013[mbar]=760[mmHg]
  =101300[Pa] ≈1.033[kg/cm^2]

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[2] Calculation formula

(1) Torque, power, rotation speed

- $P[W] \approx \frac{2\pi}{60} \bullet N[min^{-1}] \bullet \tau[N \bullet m]$
- $P[W] \approx 1.026 \bullet N[min^{-1}] \bullet T[kgf \bullet m]$
- $\tau[N \bullet m] \approx 9.55 \bullet \frac{P[W]}{N[min^{-1}]}$
- $T[kgf \bullet m] \approx 0.974 \bullet \frac{P[W]}{N[min^{-1}]}$

(2) Kinetic energy

- $E[J] \approx \frac{1}{182.4} \bullet J[kg \bullet m^2] \bullet N^2[(min^{-1})^2]$
- $E[J] \approx \frac{1}{730} \bullet GD^2[kg \bullet m^2] \bullet N^2[(min^{-1})^2]$

(3) Linear motion load torque

[Driving mode]

- $\tau[N \bullet m] \approx 0.159 \frac{V[m/min]}{N_M[min^{-1}] \bullet \eta_G} \bullet F[N]$
- $T[kgf \bullet m] \approx 0.159 \frac{V[m/min]}{N_M[min^{-1}] \bullet \eta_G} \bullet F[kgf]$

[Braking mode]

- $\tau[N \bullet m] \approx 0.159 \frac{V[m/min]}{N_M[min^{-1}]/\eta_G} \bullet F[N]$
- $T[kgf \bullet m] \approx 0.159 \frac{V[m/min]}{N_M[min^{-1}]/\eta_G} \bullet F[kgf]$

(4) Acceleration torque

[Driving mode]

- $\tau[N \bullet m] \approx \frac{J[kg \bullet m^2]}{9.55} \bullet \frac{\triangle N[min^{-1}]}{\triangle t[s] \bullet \eta_G}$
- $T[kgf \bullet m] \approx \frac{GD^2[kg \bullet m^2]}{375} \bullet \frac{\triangle N[min^{-1}]}{\triangle t[s] \bullet \eta_G}$

[Braking mode]

- $\tau[N \bullet m] \approx \frac{J[kg \bullet m^2]}{9.55} \bullet \frac{\triangle N[min^{-1}] \bullet \eta_G}{\triangle t[s]}$
- $T[kgf \bullet m] \approx \frac{GD^2[kg \bullet m^2]}{375} \bullet \frac{\triangle N[min^{-1}] \bullet \eta_G}{\triangle t[s]}$

(5) Acceleration time

- $t_{ACC}[s] \approx \frac{J_1+J_2/\eta_G[kg \bullet m^2]}{\tau_M-\tau_L/\eta_G[N \bullet m]} \bullet \frac{\triangle N[min^{-1}]}{9.55}$
- $t_{ACC}[s] \approx \frac{GD_1^2+GD_2^2/\eta_G[kg \bullet m^2]}{T_M-T_L/\eta_G[kgf \bullet m]} \bullet \frac{\triangle N[min^{-1}]}{375}$

(6) Deceleration time

- $t_{DEC}[s] \approx \frac{J_1+J_2 \bullet \eta_G[kg \bullet m^2]}{\tau_M-\tau_L \bullet \eta_G[N \bullet m]} \bullet \frac{\triangle N[min^{-1}]}{9.55}$
- $t_{DEC}[s] \approx \frac{GD_1^2+GD_2^2 \bullet \eta_G[kg \bullet m^2]}{T_M-T_L \bullet \eta_G\ [kgf \bullet m]} \bullet \frac{\triangle N[min^{-1}]}{375}$

Appendix F Allowable Current of Insulated Wires

The tables below list the allowable current of IV wires, HIV wires, and 600 V cross-linked polyethylene insulated wires.

■ IV wire (Maximum allowable temperature: 60°C)

Table F.1 (a) Allowable Current of Insulated Wires

Wire size	Allowable current Reference value (30°C or less)	Wiring in free air					Wiring in wire duct (up to three wires in the same duct)			
		35 °C	40 °C	45 °C	50 °C	55 °C	35 °C	40 °C	45 °C	50 °C
(mm^2)		(Io×0.91)	(Io×0.82)	(Io×0.71)	(Io×0.58)	(Io×0.40)	(Io×0.63)	(Io×0.57)	(Io×0.49)	(Io×0.40)
	Io (A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
2.0	27	24	22	19	15	11	17	15	13	10
3.5	37	33	30	26	21	15	23	21	18	14
5.5	49	44	40	34	28	20	30	27	24	19
8.0	61	55	50	43	35	25	38	34	29	24
14	88	80	72	62	51	36	55	50	43	35
22	115	104	94	81	66	47	72	65	56	46
38	162	147	132	115	93	66	102	92	79	64
60	217	197	177	154	125	88	136	123	106	86
100	298	271	244	211	172	122	187	169	146	119
150	395	359	323	280	229	161	248	225	193	158
200	469	426	384	332	272	192	295	267	229	187
250	556	505	455	394	322	227	350	316	272	222
325	650	591	533	461	377	266	409	370	318	260
400	745	677	610	528	432	305	469	424	365	298
500	842	766	690	597	488	345	530	479	412	336
2 x 100	497	452	407	352	288	203	313	283	243	198
2 x 150	658	598	539	467	381	269	414	375	322	263
2 x 200	782	711	641	555	453	320	492	445	383	312
2 x 250	927	843	760	658	537	380	584	528	454	370
2 x 325	1083	985	888	768	628	444	682	617	530	433
2 x 400	1242	1130	1018	881	720	509	782	707	608	496
2 x 500	1403	1276	1150	996	813	575	883	799	687	561

■ HIV wire (Maximum allowable temperature: 75°C)

Table F.1 (b) Allowable Current of Insulated Wires

Wire size	Allowable current Reference value (30°C or less)	Wiring in free air					Wiring in wire duct (up to three wires in the same duct)			
		35 °C	40 °C	45 °C	50 °C	55 °C	35 °C	40 °C	45 °C	50 °C
(mm^2)		(Io×0.91)	(Io×0.82)	(Io×0.71)	(Io×0.58)	(Io×0.40)	(Io×0.63)	(Io×0.57)	(Io×0.49)	(Io×0.40)
	Io (A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
2.0	32	31	29	27	24	22	21	20	18	17
3.5	45	42	39	37	33	30	29	27	25	23
5.5	59	56	52	49	44	40	39	36	34	30
8.0	74	70	65	61	55	50	48	45	42	38
14	107	101	95	88	80	72	70	66	61	55
22	140	132	124	115	104	94	92	86	80	72
38	197	186	174	162	147	132	129	121	113	102
60	264	249	234	217	197	177	173	162	151	136
100	363	342	321	298	271	244	238	223	208	187
150	481	454	426	395	359	323	316	296	276	248
200	572	539	506	469	426	384	375	351	328	295
250	678	639	600	556	505	455	444	417	389	350
325	793	747	702	650	591	533	520	487	455	409
400	908	856	804	745	677	610	596	558	521	469
500	1027	968	909	842	766	690	673	631	589	530
2 x 100	606	571	536	497	452	407	397	372	347	313
2 x 150	802	756	710	658	598	539	526	493	460	414
2 x 200	954	899	844	782	711	641	625	586	547	492
2 x 250	1130	1066	1001	927	843	760	741	695	648	584
2 x 325	1321	1245	1169	1083	985	888	866	812	758	682
2 x 400	1515	1428	1341	1242	1130	1018	993	931	869	782
2 x 500	1711	1613	1515	1403	1276	1150	1122	1052	982	883

■ 600V crosslinkable polyethylene insulated wire (Maximum allowable tempertaure: 90°C)

Table F.1 (c) Allowable Current of Insulated Wires

Wire size (mm²)	Allowable current Reference value (30°C or less) Io (A)	Wiring in free air					Wiring in wire duct (up to three wires in the same duct)			
		35 °C (Io×0.91) (A)	40 °C (Io×0.82) (A)	45 °C (Io×0.71) (A)	50 °C (Io×0.58) (A)	55 °C (Io×0.40) (A)	35 °C (Io×0.63) (A)	40 °C (Io×0.57) (A)	45 °C (Io×0.49) (A)	50 °C (Io×0.40) (A)
2.0	38	36	34	32	31	29	25	24	22	21
3.5	52	49	47	45	42	39	34	33	31	29
5.5	69	66	63	59	56	52	46	44	41	39
8.0	86	82	78	74	70	65	57	54	51	48
14	124	118	113	107	101	95	82	79	74	70
22	162	155	148	140	132	124	108	103	97	92
38	228	218	208	197	186	174	152	145	137	129
60	305	292	279	264	249	234	203	195	184	173
100	420	402	384	363	342	321	280	268	253	238
150	556	533	509	481	454	426	371	355	335	316
200	661	633	605	572	539	506	440	422	398	375
250	783	750	717	678	639	600	522	500	472	444
325	916	877	838	793	747	702	611	585	552	520
400	1050	1005	961	908	856	804	700	670	633	596
500	1187	1136	1086	1027	968	909	791	757	715	673
2 x 100	700	670	641	606	571	536	467	447	422	397
2 x 150	927	888	848	802	756	710	618	592	559	526
2 x 200	1102	1055	1008	954	899	844	735	703	664	625
2 x 250	1307	1251	1195	1130	1066	1001	871	834	787	741
2 x 325	1527	1462	1397	1321	1245	1169	1018	974	920	866
2 x 400	1751	1676	1602	1515	1428	1341	1167	1117	1055	993
2 x 500	1978	1894	1809	1711	1613	1515	1318	1262	1192	1122

Appendix G Index by Functional Code Purpose

G.1 Performing the minimum setting required for simple operation

To perform simple operation under a constant torque load and V/f control, setting of the following functional codes is mandatory. These are functional codes displayed via quick setup.

Application/Purpose	Functional code	Functional code name	
Select the frequency setting input method.	F01	Frequency command 1	
Select the operation/stop method.	F02	Operation method	
Set the maximum value of motor rotations (output frequency).	F03	Maximum frequency 1	
Limit the set frequency.	F16	Frequency limiter (lower limit)	
Input the motor nameplate value for correct operation of the motor.	F04 F05 F06	Base frequency 1 Base frequency voltage 1 Maximum output voltage 1	
Set the acceleration/deceleration time.	F07 F08	Acceleration time 1 Deceleration time 1	
Adjust the insufficient torque at low speed with torque boost.	F09	Torque boost 1	
Protect the motor.	F10 F11	Electronic thermal switch 1 (for motor protection) (Characteristics selection) (Operation level)	
Set the restart from instantaneous power failure.	F14	(Selection of restart from instantaneous power failure)	
Reduce the noise from the motor.	F26	Motor operation noise (Carrier frequency)	
Cancel the menu restrictions to allow use of various check functions on the keypad.	E52	Keypad menu selection	
Set the motor constant.	P02 P03 P04 P99	Motor 1 (Capacity) (Rated current) (Auto tuning) Motor 1 selection	

G.2 Setting the frequency

[1] Frequency setting on the keypad

Application/Purpose	Functional code	Functional code name	
Set the frequency on the keypad.	F01 E64	Frequency setting 1 Storage of digitally set frequency	

[2] Analog-based frequency setting

Application/Purpose	Functional code	Functional code name	
Externally set the frequency via analog voltage/current. (Terminal [12] , [C1] (C1 function), [C1] (V2 function))	F01	Frequency command 1	

Application/Purpose	Functional code	Functional code name	
Give the bias/gain such as 1-5V to the analog frequency setting and set the analog input and frequency setting to an arbitrary relation.	F18 C50	Bias (Frequency command 1) Bias (for Frequency setting 1) (Bias reference point)	
	C55 C56 C61 C62 C67 C68	Analog input adjustment (Terminal [12]) Bias (Terminal [12]) (Bias reference point) (Terminal [C1] (C1 function)) Bias (Terminal [C1] (C1 function)) (Bias reference point) (Terminal [C1] (V2 function)) Bias (Terminal [C1] (V2 function)) (Bias reference point)	
	C32 C34 C37 C39 C42 C44	Analog input adjustment (Terminal [12]) (Gain) (Terminal [12]) (Gain reference point) (Terminal [C1] (C1 function) (Gain) (Terminal [C1] (C1 function)) (Gain reference point) (Terminal [C1] (V2 function)) (Gain) (Terminal [C1] (V2 function)) (Gain reference point)	
Use Terminal [12] at both polarities (such as ±10V), or minus polarity (such as -10V). At Terminal [12] , provide an offset for zero point via the bias function and use 0 to +10V as -100% to +100% or the like.	C35	Analog input adjustment (Terminal [12]) (Polarity selection)	
At Terminal [C1] (V2 function), provide an offset for zero point via the bias function and use 0 to +10V as -100% to +100% or the like.	C45	(Terminal [C1] (V2 function)) (Polarity selection)	
Use Terminal [C1] (C1 function) within the range of 0 to 20 mA. At Terminal [C1] (C1 function), provide an offset for zero point via the bias function and use 4 to 20 mA/0 to 20 mA as -100% to +100% or the like.	C40	Terminal [C1] (C1 function) range selection	
Cancel the offset of the equipment from which an analog input is to be outputted.	C31 C36 C41	Analog input adjustment (Terminal [12]) (Offset) (Terminal [C1] (C1 function)) (Offset) (Terminal [C1] (V2 function)) (Offset)	

Application/Purpose	Functional code	Functional code name	
Remove the noise of the analog input with a filter.	C33 C38 C43	Analog input adjustment (Terminal [12]) (Filter) (Terminal [C1] (C1 function)) (Filter) (Terminal [C1] (V2 function)) (Filter)	
Synchronize the operation pattern of analog frequency setting with switchover of forward/reverse operation (air conditioning) .	C53 E01-E05	Forward/Reverse operation selection (Frequency setting 1) Terminal [X1] - [X5] "IVS"	
Detect a fault or wire break in an external frequency setting unit and output a warning and continue operation.	E65 E20-E21	Command loss detection (operation continuation frequency) Terminal [Y1] - [Y2] "REF OFF"	

[3] Other frequency setting

Application/Purpose		Functional code	Functional code name	
UP/DOWN	Make frequency setting via UP command (speed increase) or DOWN command (speed decrease).	F01 E01-E05	Frequency setting 1 Terminal [X1] - [X5] "UP" "DOWN"	
	Reset the initial value of UP/DOWN command at the start of operation (start from 0Hz).	H61	UP/DOWN control (Initial frequency setting)	
Multi-stage frequency	Store multiple frequencies and switch between frequencies with the multi-stage frequency slection signal.	F01 E01-E05 C05-C19	Frequency setting 1 Terminal [X1] - [X5] "SS1, 2, 4, 8" Multi-stage frequency 1-15	
Pulse train input	Make frequency setting with pulse train. Receive pulses from PG of another motor and perform ratio operation.	F01 d59 d61 d62 d63 E01-E05	Frequency command 1 Command (pulse train input) (Pulse input system) (Filter time constant) (Pulse correction coefficient 1) (Pulse correction coefficient 2) Terminal [X1] - [X5] (Only Terminal [X5] is valid."PIN") (Terminals except Terminal [X5] are valid. "SIGN")	
Distant/Local switchover	Switchover of frequency sething method; Switch between the frequency command via analog current (4-20mA) command from the distant electricity room and analog voltage (0-10V) command from the local operation unit.	F01 C30 E01-E05	Frequency setting 1 Frequency setting 2 Terminal [X1] - [X5] "Hz2/Hz1"	
Auxiliary frequency setting	Give the correction setting (auxiliary frequency setting) to the main setting of preset frequency via analog input and add the same to the main setting.	E61 E62 E63	Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection)	
Ratio setting	Give ratio setting via analog input and multiply the frequency command with the ratio to perform override.	E61 E62 E63	Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection)	
Digital input interface card (option)	Make frequency setting via binary codes (8, 12, bits). (For details, refer to the optional Instruction Manual.)	F01	Frequency command 1	

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G.3 Inputting operation command

Application/Purpose		Functional code	Functional code name	
Keypad	Perform operation and stop by using keypad keys.	F02 E98 E99 E20-E21	Operation/Manipulation Terminal [FWD] (Function selection) Terminal [REV] (Function selection) Terminal [Y1] - [Y2] "KP"	
External signal	Use the ‘FWD’ or ‘REV’ command assigned to Terminals [FWD] and [REV] to perform operation and stop (2-wire operation).	F02 E98 E99	Operation/Manipulation Terminal [FWD] (Function selection) Terminal [REV] (Function selection)	
	Use the ’FWD’ ’REV’ or ’HOLD’ command assigned to Terminal [FWD], [REV] or any one of [X1] - [X5] to perform operation and stop (3-wire operation).	F02 E98 E99 E01-E05	Operation/Manipulation Terminal [FWD] (Function selection) Terminal [REV] (Function selection) Terminal [X1] - [X5] "HLD"	

G.4 Starting/Stopping

Application/Purpose		Functional code	Functional code name	
Starting frequency (Freq.)	Perform smooth startup.	F23 F24	Start frequency 1 Start frequency 1 (Continuation time)	
Restart from free-run	Restart a free-running motor in a shockless way.	H09 H49 H46 E01-E05	Start characteristics (Restart-from-free-run mode) (Restart-from-free-run wait time 1) (Restart-from-free-run wait time 2) Terminal [X1] - [X5] ’STM’	
Stop method	Smoothly stop the system.	F25 F39	Stop frequecy Stop frequecy (Continuation time)	
	Provide a sufficient torque at low speed before stop.			
DC Braking 1	Prevent jerky stop operation of the motor by DC braking.	F20 F21 F22 H95	DC braking 1 (Start frequerncy) (Operation level) (Time) (Characteristics selection)	
	Perform DC braking via external command.	E01-E05	Terminal [X1] - [X5] "DCBRK"	
Force to stop	Use forced stop for safety.	H56 E01-E05	Forced stop deceleration time Terminal [X1] - [X5] "STOP"	
Free-run stop	Use free-run stop for safety.	E01-E05	Terminal [X1] - [X5] (Function selection) "BX"	

G.5 Setting acceleration/deceleration (time/method/pattern)

Application/Purpose		Functional code	Functional code name	
Acceleration/ Deceleration time	Perform acceleration/deceleration in the specified acceleration/deceleration time.	F07 F08	Acceleration time 1 Deceleration time 1	
Acceleration/Deceleration time switchover	Switch over the acceleration/deceleration time.	E01-E05 E10 E11 E12 E13 E14 E15	Terminal [X1] - [X5] "RT1" "RT2" Acceleration time 2 Deceleration time 2 Acceleration time 3 Deceleration time 3 Acceleration time 4 Deceleration time 4	

Application/Purpose		Functional code	Functional code name	
Coast-to-stop	Place the motor in free-run operation to minimize variations in the deceleration torque when operation command is OFF.	H11	Deceleration mode	
	Cause the motor to run free to prevent conflict with the mechanical brake.			
S-curve	Give an S curve to the acceleration/deceleration pattern and perform shockless acceleration/deceleration operation.	H07 H57 H58 H59 H60	Curve acceleration/deceleration 1st S curve range at acceleration (start) 2nd S curve range at acceleration (end) 1st S curve range at deceleration (start)) 2nd S curve range at deceleration (end)	
Curvilinear	Set the curve acceleration/deceleration pattern and perform acceleration/deceleration pattern at the maximum capability of the inverter.	H07	Curvilinear	
Torque-restricted acceleration/ deceleration pattern	Use torque-restricted acceleration/deceleration pattern and perform acceleration/deceleration pattern at the maximum capability or arbitrary capacity of the inverter.	F40 F41 E16 E17 H73 H76 E01-E05 E20-E21	Torque restriction value1 (Driving) Torque restriction value 1 (Braking) Torque restriction value 2 (Driving) Torque restriction value 2 (Braking) Torque restriction (Operating condition selection) Torque restriction (Braking) (Increase frequency limiter) Terminal [X1] - [X5] "TL2/TL1" Terminal [Y1] [Y2] "IOL" "'IOL2"	

G.6 Adjusting operation performance

Application/Purpose		Functional code	Functional code name	
V/f setting	Select the V/f setting to suit the load facility.	F37	Load selection/automatic torque boost/automatic energy-saving operation 1	
	Select an arbitrary V/f setting to suit the load facility.	H50 H51 H52 H53 H65 H66	Polygonal line V/f 1 (Frequency) (Voltage) Polygonal line V/f 2 (Frequency) (Voltage) Polygonal line V/f 3 (Frequency) (Voltage)	
Torque boost	Provide the torque at a low speed.	F09	Torque boost 1	
	Provide the torque at a low speed and prevent over-excitation.	F37	Load selection/automatic torque boost/ automatic energy-saving operation 1	
Jump frequency	Operate while avoiding resonance with load.	C01-C04	Jump frequency 1-4	
Magnetize current vibration damping gain	Stabilize the motor current.	H80	Output current fluctuation damping gain for motor 1	

Application/Purpose		Functional code	Functional code name	
Motor sound	Reduce the noise from the motor.	F26 F27	Motor operation noise (Carrier frequency) (Tone)	

G.7 Controlling the motor

[1] Selecting the motor control system

Application/Purpose		Functional code	Functional code name	
Control system	Select the motor control system to suit the machine characteristics (such as V/f and torque vector).	F42	Drive control selection 1	
Slip compensation	Upgrade the motor speed accuracy. (Compensate for the drop of motor speed or slip due to load.)	H68	Slip compensation 1 (Operating condition selection)	

[2] Setting the motor constant

Application/Purpose	Functional code	Functional code name	
Use the Fuji general-purpose motor (Type 8 series, 4P, 50Hz base).	P99 P02 H03	Motor 1 selection Motor 1 (Capacity) Data initialization	
Set the motor constant referring to the motor nameplate.	P99 F04 F05 F06 F03 P01 P02 P03	Motor 1 selection Base frequency 1 Base frequency voltage 1 Maximum output voltage 1 Maximum output frequency 1 Motor 1 (No. of poles) (Capacity) (Rated current)	
Perform motor constant tuning (offline tuning).	P04	Motor 1 (Auto tuning)	

Application/Purpose	Functional code	Functional code name	
Set the motor constant from tuning or test report. (For test report, conversion is necessary.)	 P06 P07 P08 P09 P10 P11 P12 P13	Motor 1 (No-load current) (%R1) (%X) (Slip compensation gain (driving)) (Slip compensation response time) (Slip compensation gain (braking)) (Rated slip) (Iron loss coefficient)	
Identify the motor constant corresponding to the change in the motor temperature (online tuning) to reduce variations in the motor speed.	P05	Motor 1 (Online tuning)	

G.8 Setting input/output terminals

Application/Purpose		Functional code	Functional code name	
Assignment of input terminal functions	Assign functions to digital input terminals and control the inverter.	E01-E05	Terminal [X1] - [X5] (Function selection)	
Assignment of general-purpose output terminals	Output the operating state of the inverter/motor to the transistor output or contact output.	E20-E21	Terminal [Y1] - [Y2] (Function selection)	
Input/Output signal	Perform logical inversion of general-purpose input/output.	E01-E05 E20-E21	Terminal [X1] - [X5] (Function selection) Terminal [Y1] - [Y2] (Function selection)	

G.9 Performing motor output

Application/Purpose		Functional code	Functional code name	
Analog output	As output for the meter, output various information from Terminals [FM] and [FM2] via analog voltage or analog current. (Terminal [FM2] is mounted only on C (for China).	F29 SW5 F30 F31 F32 SW7 F34 F35	Terminal [FM] (Operation selection) <Switch to select voltage/current/pulse output of Terminal [FM] > Terminal [FM] (Output gain) Terminal [FM] (Function selection) Terminal [FM2] (Operation selection) <Switch to select voltage/current output of Terminal [FM2]) Terminal [FM2] (Output gain) Terminal [FM2] (Function selection)	
Pulse output	As output for the meter, output various information from Terminal Terminal [FM] via pulse signal.	F29 SW5 F33 F31	Terminal [FM] (Pulse output) Terminal [FM] (Operation selection) <Switch to select voltage/current/pulse output of Terminal [FM])> Terminal [FM] (Pulse rate) Terminal [FM] (Function selection)	

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G.10 Continuing the operation

Application/Purpose		Functional code	Functional code name	
Auto-reset	Enable the retry operation that automatically generates a reset signal despite an alarm and attempts restart.	H04 H05 E20-E21	Retry (Count) (Wait time) Terminal [Y1] - [Y2] "TRY"	
Restart from instantaneous power failure	Continue the operation despite instantaneous power failure.	F14 H13 H14 H15 H16 H92 H93 E20-E21 E01-E05	Restart from instantaneous power failure (Operation selection) (Wait time) (Frequency drop ratio) (Operation continuation level) (Instantaneous power failure allowable time) Operation continuation (P) Operation continuation (I) Terminal [Y1] - [Y2] "LU" Terminal [X1] - [X5] "IL"	
	Restart from the frequency at the time of instantaneous power failure despite instantaneous power failure.			
	Restart from the start frequency despite instantaneous power failure.			
	Search for the speed of the free-running motor and restart the free-running motor in a shockless way at restart from instantaneous power failure.	H09 H46 d67	Start characteristics (Restart-from-free-run mode) (Restart-from-free-run wait time 2) (Restart-from-free-run mode)	
Regeneration avoidance control (Trip avoidance)	Prevent trips due to overvoltage protection in a system without DB resistor.	H69 H76 E20-E21	Regeneration avoidance control (Operation selection) Torque restriction (Braking) (Increase frequency limiter) Terminal [Y1] - [Y2] "IOL" "IOL2"	
Brakeing capability enhancement		H71	Deceleration characteristics	
Overload avpidance control	Lower the frequency to reduce the load before the inverter trips due to overload (overheating of cooling fin or inverter overload).	H70 E20-E21	Overload avoidance control Terminal [Y1] - [Y2] "OLP"	
Reference loss detected	Detect a fault or wire break in an external frequency setting unit and perform alarm output and continuation of operation.	E65 E20-E21	Command loss detection (Operation continuation frequency) Terminal [Y1] - [Y2] "REF OFF"	
Light alarm	Continue operation despite a specific alarm.	H81 H82 E20-E21	Light alarm selection 1 Light alarm selection 2 Terminal [Y1] - [Y2] "L-ALM"	

G.11 Detecting/Outputting the inverter state signal

Application/Purpose		Functional code	Functional code name	
Frequency level detection	Detect the level of the motor operation speed.	 E31 E32 E36 E54 E20-E21	Frequency detection (Operation level) (Hysteresis width) Frequency detection 2 (Operation level) Frequency detection 3 (Operation level) Terminal [Y1] - [Y2] "FDT" "FDT2" "FDT3"	
Frequency equivalence signal	Determine whether the motor speed has reached the target set value.	E30 E20-E21	Frequency reaching detection width (Detection width) Terminal [Y1] - [Y2] "FAR" "FAR3"	

Application/Purpose		Functional code	Functional code name	
Torque detection	Detect the torque to check whether the preset torque is outputted and whether an excessive torque is not outputted.	E78 E79 E20-E21	Torque detection 1 (Operation level) (Timer time) Terminal [Y1] - [Y2] "B/D" "TD1"	
Low torque output	Detect a low torque (no load state) to detect belt break in the drive system.	E80 E81 E20-E21	Torque detection 2/Low torque detection (Operation level) (Timer time) Terminal [Y1] - [Y2] "B/D" "U-TL" "TD2"	
Current detected	Detect the current to check whether the current is flowing in the specified amount or more, and whether an excessive current is not flowing.	E34 E35 E55 E56 E20-E21	Overload forecast/Current detection (Operation level) (Timer time) Current detection 3 (Operation level) (Timer time) Terminal [Y1] - [Y2] "ID" "ID3" "OL"	
Low current detection	Detect a low torque (no load state) to detect belt break in the drive system.	E37 E38 E20-E21	Current detection 2/ Low current detection (Operation level) (Timer time) Terminal [Y1] - [Y2] "ID2" "ITL" "IDL"	
Undervoltage	Output the undervoltage state.	E20-E21	Terminal [Y1] - [Y2] "LU"	

G.12 Performing various operations

Application/Purpose		Functional code	Functional code name	
JOG operation	Perform JOG operation using keypad keys. Perform JOG operation via a signal to Terminals [FWD] and [REV] . Enable ’JOG’ via communications.	C20 H54 H55 E01-E05 d99 *4	JOG frequency Acceleration time (JOG operation) Deceleration time (JOG operation) Terminal [X1] - [X5] "JOG" Extended function 1	
Energy-saving operation	Perform energy-saving operation.	F37 H67	Load selection/automatic torque boost/automatic energy-saving operation 1 Automatic energy-saving operation (Mode selection)	
	Perform energy management.	E51 E01-E05	Integral power data display coefficient Terminal [X1] - [X5] "SW50" "SW60"	
Motor-switched operation	Switch over two motors via one inverter.	A42 E01-E05 E20-E21	Motor/Parameter switchover 2 (Operation selection) Terminal [X1] - [X5] "M2" Terminal [Y1] - [Y2] "SWM1, 2"	

Application/Purpose		Functional code	Functional code name	
Brake signal	Use a brake signal effective for elevating transfer machine, etc.	J68 J69 J70 J71 J72 J95 J96 E20-E21	Brake signal (Release current) (Release frequency/speed) (Release timer) (Input frequency/speed) (Input timer) (Release torque) (Speed selection) Terminal [Y1] - [Y2] "BRKS"	
Control parameter switchover	Operate with parameters to suit the varying conditions (such as inertia) of the mechanical system. (Change parameters via gear switchover.)	A42 E01-E05 E20-E21 d25	Motor/Parameter switchover 2 (Operation selection) Terminal [X1] - [X5] "M2" Terminal [Y1] - [Y2] "SWM1, 2" ASR switchover time	

G.13 Performing control to suit each application

[1] Droop operation

Application/Purpose	Functional code	Functional code name	
Use the droop control function to strike a load balance.	H28 E01-E05	Droop control Terminal [X1] - [X5] "DROOP"	

[2] PID control for process control

Application/Purpose		Functional code	Functional code name	
Perform process control related to pressure, flow rate and temperature.		J01	PID control (Operation selection)	
Reverse operation	Switch over the operation on PID output via air conditioning.	J01 E01-E05	PID control (Operation selection) Terminal [X1] - [X5] "IVS"	
PID command	Perform setting of PID command on the keypad.	J02	PID control (Remote command)	
	Perform setting of PID command via analog input.	J02 E61 E62 E63	PID control (Remote command) Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection)	
		C55 C56 C61 C62 C67 C68	Analog input adjustment (Terminal [12]) Bias (Terminal [12]) (Bias reference point) (Terminal [12]) Bias (Terminal [12]) (Bias reference point) (Terminal [12]) Bias (Terminal [12]) (Bias reference point)	
		C32 C34 C37 C39 C42 C44	Analog input adjustment (Terminal [12]) (Gain) (Terminal [12]) (Gain reference point) (Terminal [C1] (C1 function)) (Gain) (Terminal [C1] (C1 function)) (Gain reference point) (Terminal [C1] (V2 function)) (Gain) (Terminal [C1] (V2 function)) (Gain reference point)	
		C31 C36 C41	Analog input adjustment (Terminal [12]) (Offset) (Terminal [C1] (C1 function)) (Offset) (Terminal [C1] (V2 function)) (Offset)	
		C33 C38 C43	Analog input adjustment (Terminal [12]) (Filter) (Terminal [C1] (C1 function)) (Filter) (Terminal [C1] (V2 function)) (Filter)	
		C35	Analog input adjustment (Terminal [12]) (Polarity selection)	
	Perform setting of PID command via UP command and DOWN command.	J02 E01-E05 H61	PID control (Remote command) Terminal [X1] - [X5] "UP" "DOWN" UP/DOWN control initial value selection	
	Perform setting of PID command via communications.	J02	PID control (Remote command)	

Application/Purpose		Functional code	Functional code name	
	Store multiple PID commands and switch between PID commands via the multi-stage frequency signal.	J02 E01-E05 J136 J137 J138	PID control (Remote command) Terminal [X1] - [X5] "PID-SS1" "PID-SS2" PID multi-stage command 1 PID multi-stage command 2 PID multi-stage command 3	
PID feedback	Perform setting of PID feedback via analog input.	E61 E62 E63	Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection)	
		C32 C34 C37 C39 C42 C44	Analog input adjustment (Terminal [12]) (Gain) (Terminal [12]) (Gain reference point) (Terminal [C1] (C1 function)) (Gain) (Terminal [C1] (C1 function)) (Gain reference point) (Terminal [C1] (V2 function)) (Gain) (Terminal [C1] (V2 function)) (Gain reference point)	
PID feedback	Perform setting of PID feedback via analog input.	C31 C36 C41	Analog input adjustment (Terminal [12]) (Offset) (Terminal [C1] (C1 function)) (Offset) (Terminal [C1] (V2 function)) (Offset)	
		C33 C38 C43	Analog input adjustment (Terminal [12]) (Filter) (Terminal [C1] (C1 function)) (Filter) (Terminal [C1] (V2 function)) (Filter)	
PID adjustment	Perform optiumum setting of the PID adjusting unit.	J03 J04 J05 J06	PID control P (Gain) I (Integral time) D (Derivative time) (Feedback filter)	
Anti-reset windup	Reduce the overshoot.	J10	PID control (Anti-reset windup)	
Warning output	Output a PID control error (deviation warning, absolute value warning, etc.) as a warning.	J11 J12 J13 E20-E21	PID control (Warning output selection) (Upper limit warning (AH)) (Lower limit warning (AL)) Terminal [Y1] - [Y2] "PID-ALM"	
	PID feedback wire break	H91 E20-E21	PID feedback wire break detection Terminal [Y] - [Y2] "C1OFF"	

Application/Purpose		Functional code	Functional code name	
Small water amount stop function	Use the small water amount stop function to save energy of pump.	J15 J16 J17 E20-E21	PID control (Small water amount stop operation frequency level) (Small water amount stop elapsed time) (Start frequency) Terminal [Y1] - [Y2] "PID-STP"	
Output limiter	Limit the operation of PID control with a limiter.	J18 J19	PID control (PID output limiter upper limit) (PID output limiter lower limit)	
PID control	Externally perform PID control, such as holding/resetting the PID adjusting unit and canceling the PID control.	E01-E05	Terminal [X1] - [X5] "PID-HLD" "Hz/PID" "PID-RST"	
Output of PID control under way	Output that PID control is under way.	E20-E21	Terminal [Y1] - [Y2] "PID-CTL"	
Process display	Display the control amount on the keypad in terms of the physical amount of the process.	J105 J106 J107	PID control (Display unit) PID control (Maximum measure) PID control (Minimum measure)	

[3] PID control for dancer control

Application/Purpose		Functional code	Functional code name	
Perform speed control such as dancer control.		J01 J62	PID control (Operation selection) (PID control block diagram selection)	
PID command	Perform setting of PID control on the keypad.	J02 J57	PID control (Remote command) (Dancer reference position)	
	Perform setting of PID command via analog input.	J02 E61 E62 E63	PID control (Remote command) Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection)	
		C55 C56 C61 C62 C67 C68	Analog input adjustment (Terminal [12]) Bias (Terminal [12]) (Bias reference point) (Terminal [C1] (C1 function) Bias (Terminal [C1] (C1 function) (Bias reference point) (Terminal [C1] (V2 function)) Bias (Terminal [C1] (V2 function)) (Bias reference point)	
		C32 C34 C37 C39 C42 C44	Analog input adjustment (Terminal [12]) (Gain) (Terminal [12]) (Gain reference point) (Terminal [C1] (C1 function)) (Gain) (Terminal [C1] (C1 function)) (Gain reference point) (Terminal [C1] (V2 function)) (Gain) (Terminal [C1] (V2 function)) (Gain reference point)	
		C31 C36 C41	Analog input adjustment (Terminal [12]) (Offset) (Terminal [C1] (C1 function)) (Offset) (Terminal [C1] (V2 function)) (Offset)	
		C33 C38 C43	Analog input adjustment (Terminal [12]) (Filter) (Terminal [C1] (C1 function)) (Filter) (Terminal [C1] (V2 function)) (Filter)	
		C35	Analog input adjustment (Terminal [12]) (Polarity selection)	
PID command	Perform setting of PID command via UP command and DOWN command.	J02 E01-E05 H61	PID control (Remote command) Terminal [X1] - [X5] "UP" "DOWN" UP/DOWN control initial value selection	
	Perform setting of PID command via communications.	J02	PID control (Remote command)	

Application/Purpose		Functional code	Functional code name	
	Store multiple PID commands and switch between PID commands via the multi-stage frequency signal.	J02 E01-E05 J136 J137 J138	PID control (Remote command) Terminal [X1] - [X5] "PID-SS1" "PID-SS2" PID multi-stage command 1 PID multi-stage command 2 PID multi-stage command 3	
PID feedback	Perform setting of PID feedback via analog input.	E61 E62 E63	Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection)	
		C32 C34 C37 C39 C42 C44	Analog input adjustment (Terminal [12]) (Gain) (Terminal [12]) (Gain reference point) (Terminal [C1] (C1 function)) (Gain) (Terminal [C1] (C1 function)) (Gain reference point) (Terminal [C1] (V2 function)) (Gain) (Terminal [C1] (V2 function)) (Gain reference point)	
PID feedback	Perform setting of PID feedback via analog input.	C31 C36 C41	Analog input adjustment (Terminal [12]) (Offset) (Terminal [C1] (C1 function)) (Offset) (Terminal [C1] (V2 function)) (Offset)	
		C33 C38 C43	Analog input adjustment (Terminal [12]) (Filter) (Terminal [C1] (C1 function)) (Filter) (Terminal [C1] (V2 function)) (Filter)	
PID adjustment	Perform optiumum setting of the PID adjusting unit.	J03 J04 J05 J06	PID control P (Gain) I (Integral time) D (Derivative time) (Feedback filter)	
	Perform control using a different constant of the PID adjusting unit in case the dance position is close to the target position.	J58 J59 J60 J61	PID control (Dancer reference position detection width) P (Gain) 2 I (Integral time) 2 D (Derivative time) 2	
Anti-reset windup	Reduce the overshoot.	J10	PID control (Anti-reset windup)	

Application/Purpose		Functional code	Functional code name	
Warning output	Output a PID control error (deviation warning, absolute value warning, etc.) as a warning.	J11 J12 J13 E20-E21	PID control (Warning output selection) (Upper limit warning (AH)) (Lower limit warning (AL)) Terminal [Y1] - [Y2] "PID-ALM"	
	PID feedback wire break	H91 E20-E21	PID feedback wire break detection) Terminal [Y1] - [Y2] "C1OFF"	
Output limiter	Limit the operation of PID control with a limiter.	J18 J19	PID control (PID output limiter upper limit) (PID output limiter lower limit)	
PID control	Externally perform PID control, such as holding/resetting the PID adjusting unit and canceling the PID control.	E01-E05	Terminal [X1] - [X5] "PID-HLD" "Hz/PID" "PID-RST"	
Output of PID control under way	Output that PID control is under way.	E20-E21	Terminal [Y1] - [Y2] "PID-CTL"	
Process display	Display the control amount in terms of the physical amount of the process.	J105 J106 J107	PID control (Display unit) PID control (Maximum measure) PID control (Minimum measure)	

G.14 Using convenient functions on the keypad

Application/Purpose	Functional code	Functional code name	
Prevent functional code data from being inadvertently overwritten.	F00 E01-E05	Data protection Terminal [X1] - [X5] "WE-KP"	
Reset functional code data to the initial value.	H03	Data Initializing	
Reset the motor constant. (Initialize the constant.)			
Cancel the menu restrictions to allow use of various check functions on the keypad.	E52	Touch penel menu selection	
Suppress variations in the display on the keypad.	E42	LED Display Filter	
Specify the display details on the keypad (LED monitor).	E43 E48	LED monitor (Display selection) LED monitor details (Speed monitor selection)	
Display the output frequency even while the inverter operation is stopped.	E44	LED monitor (Display during stop)	
Input the extenal analog sensor signal and display data in terms of the physical amount of the sensor.	E61 E62 E63	Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection)	
	C58 C59 C60 C64 C65 C66 C70 C71 C72	Terminal [12] Display unit Terminal [12] Maximum measure Terminal [12] Minimum measure Terminal [C1] (C1 function) Display unit Terminal [C1] (C1 function) Maximum measure Terminal [C1] (C1 function) Minimum measure Terminal [C1] (V2 function) Display unit Terminal [C1] (V2 function) Maximum measure Terminal [C1] (V2 function) Minimum measure	
Display the load rotation speed and line speed.	E50	Coefficient for Speed Indication	
Display the integral power amount (kWh) multiplied by a coefficient.	E51	Integral power data display coefficient	
Display the PID command value and feedback value in terms of the physical amount.	J105 J106 J107	PID control (Display unit) PID control (Maximum measure) PID control (Minimum measure)	

G.15 Controlling via communications

Application/Purpose	Functional code	Functional code name	
Set conditions for communications.	 y01 y02 y03 y04 y05 y06 y07 y08 y09 y10 SW2	RS-485 setting 1 (Station address)) (Operation selection upon error) (Timer time) (Transmission speed) (Data length selection) (Parity bit selection) (Stop bit selection) (Communication drop detection time) (Response interval time) (Protocol selection) <RS-485 communications terminator resistorselector switch (RS-485 communication port 1)>	

APPENDICES

Application/Purpose	Functional code	Functional code name	
Set conditions for communications.	y11 y12 y13 y14 y15 y16 y17 y18 y19 y20 SW6	RS-485 setting 2 (Station address)) (Operation selection upon error) (Timer time) (Transmission speed) (Data length selection) (Parity bit selection) (Stop bit selection) (Communication drop detection time) (Response interval time) (Protocol selection) <RS-485 communications terminator resistor selector switch (RS-485 communication port 2)>	
Set conditions for communications (Built-in CAN communications). (CAN is not mounted on C (for China).)	y21 y22 y23 y24 y25 y26 y27 y28 y29 y30 y31 y32 y33 y34 y35	Built-in CAN setting (Station address) Built-in CAN setting (Transmission error (Operation selection)) Built-in CAN setting (Transmission speed) Built-in CAN setting (Transmission error (Timer time)) Built-in CAN setting Write functional code allocation 1 Built-in CAN setting Write functional code allocation 2 Built-in CAN setting Write functional code allocation 3 Built-in CAN setting Write functional code allocation 4 Built-in CAN setting Write functional code allocation 5 Built-in CAN setting Write functional code allocation 6 Built-in CAN setting Write functional code allocation 7 Built-in CAN setting Write functional code allocation 8 Built-in CAN setting (Operation selection) Built-in CAN setting (Transmission error (Operation selection)) Built-in CAN setting (Transmission error (Timer time))	
Set the command paths of operation command and frequency command.	H30 y98 y99	Link function (Operation selection) Bus fon (Operation selection) Support link function (Operation selection)	
Frequently change the functional code during communications.	y97	Communication data storage system selection	
Switch the operation command or frequency command on the communicating side.	E01-E05	Terminal [X1] - [X5] "LE"	
Use the input/output signal for the inverter as general-purpose DI/DO.	E01-E05	Terminal [X1] - [X5] "U-DI”	
	E20-E21	Terminal [Y1] - [Y2] "U-DO"	

G.16 Using customized logic

Application/Purpose	Functional code	Functional code name	
Enable the sequence built by a customized logic.	U00	Customized logic (Operation selection)	
Form a logic circuit for the digital input/output seignal and analog input/output signal, arbitrarily process the signal and build a relay sequence in the inverter.	U01-U70	Customized logic: Step 1-14 (Operation setting)	
	U71-U77	Customized logic output signal 1-7 (Output selection)	
	U81-U87	Customized logic output signal 1-7 (Function selection)	
	U91	Customized logic timer monitor (Step selection)	
		Conversion factor	
	U92-U107 U121-U124	Functional code switchover setting	
	E01-E05	Terminal [X1] - [X5] (Function selection)	
	E20-E27	Terminal [Y1] - Terminal [30A/B/C] (Ry output) (Function selection)	
	E98, E99	Terminal [FWD] [REV] (Function selection)	

G.17 Using protective functions

[1] Protecting the machine (Limit functions)

Application/Purpose	Functional code	Functional code name	
Limit the frequency to protect the machine.	F15 F16 H63	Frequency limiter (Upper limit) (Lower limit) Lower limiter (Operation selection)	
	F03	Maximum Frequency 1	
	H64	Lower limiter (Minimum frequency during restricted operation)	
Limit the motor rotating direction to protect the machine.	H08	Rotational direction limitation	
Limit the load by restricting the current to protect the machine.	F43 F44 E20-E21	Current restriction (Operation selection) (Operation level) Terminal [Y1] - [Y2] "IOL" "IOL2"	
Limit the load by restricting the torque to protect the machine.	F40 F41 E16 E17 E61 E62 E63 H74 H76 E01-E05 E20-E21	Torque restriction value 1-1 Torque restriction value 1-2 Torque restriction value 2-1 Torque restriction value 2-1 Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection) Torque restriction (Target of control) (Braking) (Increase frequency limiter) Terminal [X1] - [X5] "TL2/TL1" Terminal [Y1] - [Y2] "IOL" "IOL2"	
Limit the overspeed level via speed restriction to protect the machine.	E61 E62 E63	Terminal [12] (Extended function selection) Terminal [C1] (C1 function) (Extended function selection) Terminal [C1] (V2 function) (Extended function selection)	

[2] Protecting the motor

Application/Purpose		Functional code	Functional code name	
Electronic thermal overload protection for braking resistor	Protect the motor from high temperature via electronic thermal cutoff function of the inverter.	F10 F11 F12	Electronic thermal switch 1 (for motor protection) (Characteristics selection) (Operation level) (Thermal time constant)	
OL1 function	Output a warning before the motor trips via the electronic thermal cutoff function.	F10 F12 E34 E20-E21	Electronic thermal switch 1 (for motor protection) (Characteristics selection) (Thermal time constant) Overload forecast/Current detection (Timer time) Terminal [Y1] - [Y2] "OL"	

Application/Purpose		Functional code	Functional code name	
Motor overheat	Perform thermal protection of the motor via the PTC thermistor built into the motor.	H26 H27 SW3 SW4	Thermistor (for motor) (Operation selection) (Operation level) <Function selecctor switch for Terminal [C1] >	
Thermistor detection	Detect that the PTC thermistor built into the motor has operated and output a warning.	H26 H27 SW3 E20-E21	Thermistor (for motor) (Operation selection) (Operation level) <Function selecctor switch for Terminal [C1] > Terminal [Y1] - [Y2] "THM"	

[3] Other protective/safety functions

Application/Purpose		Functional code	Functional code name	
Tripping upon instantaneous power failure (No restart)	Immediately shut down (trip) the inverter upon instantaneous power failure. The inverter immediately start free running but does not trip upon instantaneous power failure. It trips when power is recovered. The inverter is immediately decelerated to stop upon instantaneous power failure. It trips when the frequency has dropped to zero.	F14 H15 H92 H93 E20-E21 E01-E05	Restart from instantaneous power failure (Operation selection) (Operation continuation level) Operation continuation (P) Operation continuation (I) Terminal [Y1] - [Y2] "LU" "IPF" Terminal [X1] - [X5] "IL"	
External alarm	Immediately interrupts the inverter output upn error in the peripheral equipment.	E01-E05	Terminal [X1] - [X5] "THR"	
Protective/ Maintenance function	Enables/Disables: • Carrier frequency automatic reducing function • Input phase loss/Output phase loss • Main circuit capacitor service life decision • DC fan lock detection • Error in braking transistor	H98	Protective/Maintenance function (Operation selection)	
Braking resistor	Protect the inverter with electronic thermal by using an external braking resistor.	F50 F51 F52	Electronic thermal switch (for protection of braking resistor) (Discharge immunity) (Average allowable losss) (Braking resistance value)	
Braking transistor	Detect error in the braking transistor and protect the inverter.	E20-E21	Terminal [Y1] - [Y2] "DBAL"	
Communication error	Detect communication errors.	y02 y03 y08	RS-485 setting 1 (Operation selection upon error) (Timer time) (Communication drop detection time)	
		y12 y13 y18	RS-485 setting 2 (Operation selection upon error) (Timer time) (Communication drop detection time)	
PID feedback wire break	Shuts down the system in the event of wire break of PID feedback (Current input [C1]).	H91	PID feedback wire break	

Application/Purpose		Functional code	Functional code name	
Force to stop	Use forced stop for safety.	H56 E01-E05	Forced stop deceleration time Terminal [X1] - [X5] "STOP"	
Free-run stop	Use free-run stop for safety.	E01-E05	Terminal [X1] - [X5] (Function selection) "BX"	
STOP key priority	Enable STOP key at any time for safety.	H96	STOP key priority /Start check fuction	
Start check function	Check for an operation command upon mode change for safety to prevent sudden operation of the motor.	H96	STOP key priority /Start check fuction	
Cooling fin overheat forecast	Output a warning before the inverter trips due to overload (overheat of cooling fin).	E20-E21	Terminal [Y1] - [Y2] "OH"	
Cancellation of current restriction	Cancel current restriction in case a nonconformity arises when the motor-generated torque temporarily drops due to current restriction.	H12	Instantaneous current restriction (Operation selection)	
Alarm	Erase the alarm history.	H97	Alarm data clear	
	Generate a simulated fault.	H45	Mock alarm	

G.18 Performing maintenance

[1] Maintenance of inverter

Application/Purpose		Functional code	Functional code name	
Main circuit capacitor service life	Tailor the operating conditions for main circuit capacitor service life mesurement to the use conditions of the user.	H42 H47	Main circuit capacitor measurement value Main circuit capacitor initial value	
Service life decision	In case the control power auxiliary input is provided and the main circuit capaitor service life measurement is incorrect, disable the main circuit capaitor service life decision.	H98	Protective/Maintenance function (Operation selection)	
Cooling fan ON/OFF control	Extend the service life of the inverter cooling fan and reduce the fan noise when stopped.	H06 E20-E21	Cooling fan ON-OFF control Terminal [Y1] - [Y2] "FAN" "LIFE"	

[2] Maintenance of machine

Application/Purpose		Functional code	Functional code name	
Cumulative motor operation time	Check the cumulative operation time of the motor.	H94	Cumulative motor operation time 1	
	Count the cumulative motor operation time even while the motor is driven from a commercial power source.	E01-E05	Terminal [X1] - [X5] "CRUN-M1, M2, M3, M4"	
Start count	In a facility where start torque is applied to the drive belt for each start sequence to degrade the belt, check the start count to determine the service life of the belt.	H44	Start count 1	
Maintenance timer	Notify the maintenance period based on the cumulative motor operation time.	H78 E20-E21	Maintenance set time (M1) Terminal [Y1] - [Y2] "MNT"	
	Notify the maintenance period based on the start count.	H79 E20-E21	Maintenance set start count (M1) Terminal [Y1] - [Y2] "MNT"	
Remote/Local switchover	Disconnect the inverter from the system and perform maintenance of the inverter while keeping it operated by a command from the keypad.	E01-E05 E20-E21	Terminal [X1] - [X5] "LOC" Terminal [Y1] - [Y2] "RMT"	

APPENDICES

Appendix H CONFORMITY WITH STANDARDS

H.1 Compliance with European Standards (CE)

The CE marking on Fuji products indicates that they comply with the essential requirements of the Electromagnetic Compatibility (EMC) Directive 2004/108/EC, Low Voltage Directive 2006/95/EC, and Machinery Directive 2006/42/EC which are issued by the Council of the European Communities.

Table H.1-2 1 Conformity with Standards

	Standards	
EMC Directives	IEC/EN61800-3 Immunity Emission IEC/EN61326-3-1	: 2004/ A 1 : 2012 : Second environment (Industrial) : Category C2 : 2008
Low Voltage Directive	IEC/EN61800-5-1	: 2007

H.1.1 Compliance with EMC standards

The CE marking on inverters does not ensure that the entire equipment including our CE-marked products is compliant with the EMC Directive. Therefore, CE marking for the equipment shall be the responsibility of the equipment manufacturer. For this reason, Fuji's CE mark is indicated under the condition that the product shall be used within equipment meeting all requirements for the relevant Directives. Instrumentation of such equipment shall be the responsibility of the equipment manufacturer.

Generally, machinery or equipment includes not only our products but other devices as well. Manufacturers, therefore, shall design the whole system to be compliant with the relevant Directives.

■ List of EMC-compliant filters

To satisfy the requirements noted above, use inverters in combination with an external filter (option) dedicated to Fuji inverters. In either case, mount inverters in accordance with the installation procedure given below. To ensure the compliance, it is recommended that inverters be mounted in a metal panel.

Table H.1-2 2 EMC-compliant filter

Power supply voltage	Inverter type	Specification	Filter type
Three-phase 400V	FRN0059E2S-4□	ND	FS21312-78-07
		HD	FS5536-72-07 (EFL-22G11-4)
		HND	FS5536-72-07 (EFL-22G11-4)
		HHD	FS5536-72-07 (EFL-22G11-4)
	FRN0072E2S-4□	ND	-
		HD	FS21312-78-07
		HND	FS21312-78-07
		HHD	FS5536-72-07 (EFL-22G11-4)
	FRN0085E2S-4□	ND	FS5536-180-40
		HD	FS5536-100-35
		HND	FS5536-100-35
		HHD	FS5536-100-35
	FRN0105E2S-4□	ND	FS5536-180-40
		HD	FS5536-180-40
		HND	FS5536-180-40
		HHD	FS5536-100-35
	FRN0139E2S-4□	ND	FS5536-180-40
		HD	FS5536-180-40
		HND	FS5536-180-40
		HHD	FS5536-180-40
	FRN0168E2S-4□	ND	FS5536-180-40
		HD	FS5536-180-40
		HND	FS5536-180-40
		HHD	FS5536-180-40
	FRN0203E2S-4□	ND	FS5536-250-99-1
		HD	FS5536-180-40
		HND	FS5536-180-40
		HHD	FS5536-180-40

■ Recommended installation procedure

To make the machinery or equipment fully compliant with the EMC Directive, have certified technicians wire the motor and inverter in strict accordance with the procedure described below.

When an EMC-compliant filter (option) is externally used

1) Mount the inverter and the filter on a grounded panel or metal plate. Use shielded wires for the motor cable and route the cable as short as possible. Firmly clamp the shields to the metal plate to ground them. Further, connect the shielding layers electrically to the grounding terminal of the motor.
2) For connection to inverter's control terminals and for connection of the RS-485 communication signal cable, use shielded wires. As with the motor, clamp the shields firmly to a grounded panel.
3) If noise from the inverter exceeds the permissible level, enclose the inverter and its peripherals within a metal panel as shown in Figure Appendix C Effect on Insulation of General-purpose Motors Driven with 400 V Class Inverters

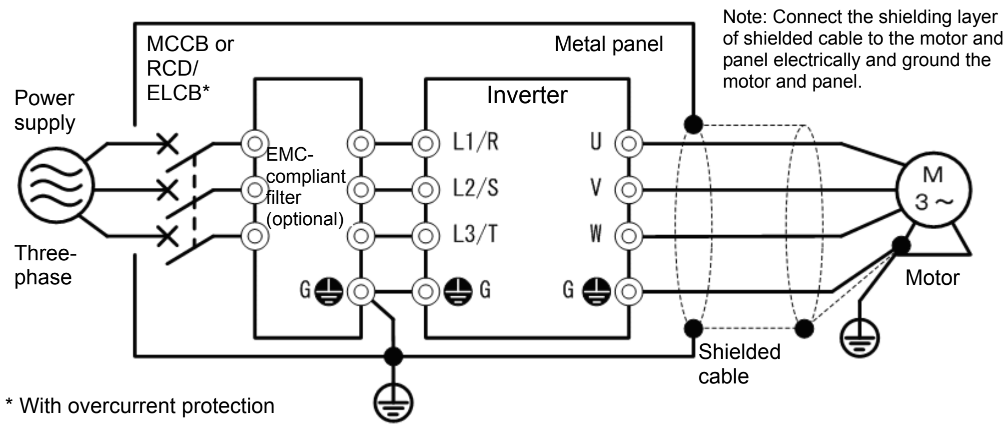


Figure H.1- 1 Mounting an EMC-compliant Filter (option) in a Metal Panel

APPENDICES

H.1.2 Compliance with the low voltage directive in the EU

General-purpose inverters are regulated by the Low Voltage Directive in the EU. Fuji Electric states that all our inverters with CE marking are compliant with the Low Voltage Directive.

■ **Note**

If installed according to the guidelines given below, inverters marked with CE are considered as compliant with the Low Voltage Directive 2006/95/EC.

Compliance with European Standards

Adjustable speed electrical power drive systems.

Part 5-1: Safety requirements. Electrical, thermal and energy. IEC/EN61800-5-1 : 2007

⚠ ⚠WARNING

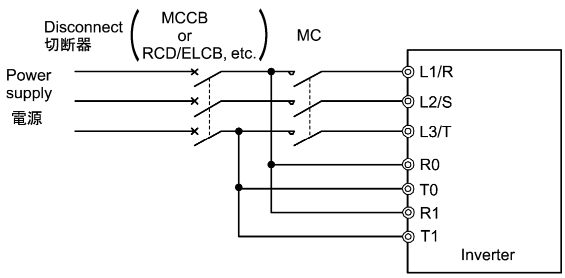
1. The ground terminal ⏚G should always be connected to the ground. Do not use only a residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB)* as the sole method of electric shock protection. Be sure to use ground wires whose size is greater than power supply lines.

   *With overcurrent protection.

2. To prevent the risk of hazardous accidents that could be caused by damage of the inverter, install the specified fuses in the supply side (primary side) according to the following tables.

   • - Breaking capacity: Min. 10 kA - Rated voltage: Min. 500 V

Power supply voltage	Nominal applied motor (kW)	Inverter type	HD/MD/LD mode	Fuse rating (A)
Three-phase 400V	30	FRN0059E2S-4□	ND	160(IEC60269-4)
	22		HD	160(IEC60269-4)
	22		HND	160(IEC60269-4)
	18.5		HHD	160(IEC60269-4)
	37	FRN0072E2S-4□	ND	160(IEC60269-4)
	30		HD	160(IEC60269-4)
	30		HND	160(IEC60269-4)
	22		HHD	160(IEC60269-4)
	45	FRN0085E2S-4□	ND	250(IEC60269-4)
	37		HD	250(IEC60269-4)
	37		HND	250(IEC60269-4)
	30		HHD	250(IEC60269-4)
	55	FRN0105E2S-4□	ND	315(IEC60269-4)
	45		HD	315(IEC60269-4)
	45		HND	315(IEC60269-4)
	37		HHD	315(IEC60269-4)
	75	FRN0139E2S-4□	ND	315(IEC60269-4)
	55		HD	315(IEC60269-4)
	55		HND	315(IEC60269-4)
	45		HHD	315(IEC60269-4)
	90	FRN0168E2S-4□	ND	350(IEC60269-4)
	75		HD	350(IEC60269-4)
	75		HND	350(IEC60269-4)
	55		HHD	350(IEC60269-4)
	110	FRN0203E2S-4□	ND	350(IEC60269-4)
	90		HD	350(IEC60269-4)
	90		HND	350(IEC60269-4)
	75		HHD	350(IEC60269-4)



Conformity to the Low Voltage Directive in the EU (Continued)

⚠WARNING ⚠

3. When used with the inverter, a molded case circuit breaker (MCCB), residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) or magnetic contactor (MC) should conform to the EN or IEC standards.
4. When you use a residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) for protection from electric shock in direct or indirect contact power lines or nodes, be sure to install type B of RCD/ELCB on the input (primary) of the inverter.

<table>
<tr><th rowspan="2">Power supply voltage</th><th rowspan="2">Nominal applied motor (kW)</th><th rowspan="2">Inverter type</th><th rowspan="2">ND/HD/ HND mode</th><th colspan="2">MCCB or RCD/ELCB *1 Rated current</th></tr>
<tr><th>W/DCR</th><th>W/o DCR</th></tr>
<tr><td rowspan="28">Three-phase 400 V</td><td>30</td><td rowspan="4">FRN0059E2S-4□</td><td>ND</td><td>75</td><td>125</td></tr>
<tr><td>22</td><td>HD</td><td rowspan="2">50</td><td rowspan="2">100</td></tr>
<tr><td>22</td><td>HND</td></tr>
<tr><td>18.5</td><td>HHD</td><td>40</td><td>75</td></tr>
<tr><td>37</td><td rowspan="4">FRN0072E2S-4□</td><td>ND</td><td>100</td><td rowspan="3">125</td></tr>
<tr><td>30</td><td>HD</td><td rowspan="2">75</td></tr>
<tr><td>30</td><td>HND</td></tr>
<tr><td>22</td><td>HHD</td><td>50</td><td>100</td></tr>
<tr><td>45</td><td rowspan="4">FRN0085E2S-4□</td><td>ND</td><td rowspan="3">100</td><td>150</td></tr>
<tr><td>37</td><td>HD</td><td rowspan="3">125</td></tr>
<tr><td>37</td><td>HND</td></tr>
<tr><td>30</td><td>HHD</td><td>75</td></tr>
<tr><td>55</td><td rowspan="4">FRN0105E2S-4□</td><td>ND</td><td>125</td><td>200</td></tr>
<tr><td>45</td><td>HD</td><td rowspan="3">100</td><td rowspan="2">150</td></tr>
<tr><td>45</td><td>HND</td></tr>
<tr><td>37</td><td>HHD</td><td>125</td></tr>
<tr><td>75</td><td rowspan="4">FRN0139E2S-4□</td><td>ND</td><td>175</td><td>—</td></tr>
<tr><td>55</td><td>HD</td><td rowspan="2">125</td><td rowspan="2">200</td></tr>
<tr><td>55</td><td>HND</td></tr>
<tr><td>45</td><td>HHD</td><td>100</td><td>150</td></tr>
<tr><td>90</td><td rowspan="4">FRN0168E2S-4□</td><td>ND</td><td>200</td><td rowspan="3">—</td></tr>
<tr><td>75</td><td>HD</td><td rowspan="2">175</td></tr>
<tr><td>75</td><td>HND</td></tr>
<tr><td>55</td><td>HHD</td><td>125</td><td>200</td></tr>
<tr><td>110</td><td rowspan="4">FRN0203E2S-4□</td><td>ND</td><td>250</td><td rowspan="4">—</td></tr>
<tr><td>90</td><td>HD</td><td rowspan="2">200</td></tr>
<tr><td>90</td><td>HND</td></tr>
<tr><td>75</td><td>HHD</td><td>175</td></tr>
</table>

*1 The frame size and model of the MCCB or RCD/ELCB (with overcurrent protection) will vary, depending on the power transformer capacity. Refer to the related technical documentation for details.

5. The inverter should be used in an environment that does not exceed Pollution Degree 2 requirements. If the environment conforms to Pollution Degree 3 or 4, install the inverter in an enclosure of IP54 or higher.
6. Install the inverter, AC or DC reactor, input or output filter in an enclosure with minimum degree of protection of IP2X (Top surface of enclosure shall be minimum IP4X when it can be easily accessed), to prevent human body from touching directly to live parts of these equipment.
7. Do not connect any copper wire directly to grounding terminals. Use crimp terminals with tin or equivalent plating to connect them.
8. When you use an inverter at an altitude of more than 2000 m, you should apply basic insulation for the control circuits of the inverter. The inverter cannot be used at altitudes of more than 3000 m.
9. Use wires lsiterd in Chapter 2 2.2.5 [1] Screw Specifications and Recommended Wire Size (Main Circuit Terminals).

APPENDICES

High Performance Inverter

FRENIC-Ace

User's Manual

First Edition, February 2013

Fuji Electric Co., Ltd.

The purpose of this User's manual is to provide accurate information in handling, setting up and operating of the FRENIC-Ace series of inverters. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

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