High performance multifunction quiet inverter

VVVF Inverter

SAMCO-*vm05*

INSTRUCTION MANUAL

200 V systems

SBT-0.75K/1.5K to SBT 22K/30K for general industry, fan and pump

400 V systems

SHF-1.5K to SHF-55K for general industry
SPF-2.2K to SPF-75K for fan and pump

SANKEN ELECTRIC CO., LTD.

Thank you for purchasing the Sanken **SAMCO·VM05** general-purpose inverter. This inverter is designed to drive an induction motor at a variable speed. The inverter has a built-in microcomputer providing a wide range of functions and easy operability. To ensure many years of trouble-free operation and maintain optimum performance, be sure to read through this manual before using the product.

[For Safe Use]

■ Safety instructions are given in this manual and on the product to prevent physical injury to yourself or others, or damage to property.

Read the instructions thoroughly and use the product correctly.

■ After reading, keep this manual to hand for reference.

■ Critical safety instructions are marked "Danger" or "Caution" as follows:

◇ **Danger**   This symbol indicates a hazard that could lead to death or serious injury if the warning is ignored and the product is handled incorrectly.

⚠ **Caution**   This symbol indicates a hazard that could lead to injury or damage to property if the warning is ignored and the product is handled incorrectly.

* Even ignoring an instruction marked "Caution" can have serious consequences under some circumstances. Be sure to abide by all instructions, irrespective of the degree of danger.

―――――――――― Meanings of symbols ――――――――――

◇ This symbol indicates a potential danger.
The specific danger is indicated in the symbol. (This example indicates a general danger.)

⚠ This symbol indicates the need for caution.
The specific caution is indicated in the symbol. (This example indicates a general caution.)

🚫 This symbol indicates a prohibition.
The specific prohibited action is indicated in the symbol. (This example indicates a general prohibition.)

❗ This symbol indicates an action that must be performed.
The specific action is indicated in the symbol. (This example indicates a general requirement.)

Safety Notes

1. Mount the inverter on a strong metal panel or similar surface using the specified screws.

2. Ground the inverter and the motor using their ground terminals (⏚).

3. Install a circuit breaker (MCCB) of the appropriate capacity between the inverter and the power supply.

4. The inverter incorporates high-voltage circuitry that could cause an electric shock or other physical injury. Do not touch the inside of the inverter.

5. When carrying out maintenance or inspection, turn the power off and check with a circuit tester that there is no voltage between X and P on the terminal board after the CHARGE lamp goes out.

6. Some internal components in the inverter retain an electric change even when the inverter is not operating. Do not touch the terminal board.

7. When using a power supply with a frequency of 60 Hz or more, check the safety of the load, including the motor and so on.

8. Turn the power off when not using the inverter for a long time.

9. This inverter is made for domestic use. Please consult us before exporting this product.

Contents

1. Safety Notes

1.1 Notes on Installation

	⚠ **Caution**
🚫	■ Do not store or use the inverter under the environmental conditions described below. Failure to observe this warning may result in a fault, damage, or deterioration, which could lead to fire. 　• Very hot, cold, or humid locations 　• In direct sunlight 　• Near a heater or other heat source 　• In a location subject to vibration or physical shock 　• Near equipment that generates sparks 　• In a location subject to dust, corrosive or inflammable gases, salt, water droplets, or oil mist 　• Outdoors 　• Higher than 1000 meters above sea level 　• Other similar environments
❗	■ Mount the inverter on a metal surface or other non-flammable surface. Failure to observe this warning may result in a fire.
🚫	■ Do not hold the inverter by the front cover when carrying it. Failure to observe this warning may result in injury if the inverter is dropped.
❗	■ Install the inverter in a location that can bear its weight. Failure to observe this warning may result in injury if the inverter falls down.
🚫	■ Do not place flammable materials near the inverter. Failure to observe this warning may result in a fire.
🚫	■ Do not allow foreign objects into the inverter or attach to the cooling fans. Failure to observe this warning may result in a fire or an accident.
🚫	■ Do not operate an inverter which is damaged, lacking parts or dented. Failure to observe this warning may result in an electric shock, injury, fire or accident.

1.2 Notes on Wiring

	◇ **Danger**
❗	■ Wiring must be performed by qualified personnel. Failure to observe this warning may result in an electric shock or fire due to incorrect wiring.
❗	■ Turn off the power before carrying out wiring. Failure to observe this warning may result in an electric shock or fire.
⏚	■ Connect the ground cable. Failure to observe this warning may result in an electric shock or fire.
❗	■ Install the main part of the inverter before wiring. Failure to observe this warning may result in an electric shock or injury.

	⚠ **Caution**
❗	■ Do not connect AC power to an output terminal (U, V, or W). Failure to observe this warning may result in injury or fire.
❗	■ Check that the AC power supply voltage is equal to the rated voltage of the inverter. Failure to observe this warning may result in injury or fire.
❗	■ Do not connect a resistor directly to the DC terminals (P and X). Failure to observe this warning may result in a fire.
❗	■ The inverter, motor or wiring may cause noise. This may result in errors in peripheral devices. Failure to observe this warning may result in an accident.

1.3 Notes on Operation

	⟨!⟩ Danger
!	■ Attach the front cover before turning the power on. Do not remove the front cover when the power is on. Failure to observe this warning may result in an electric shock.
⊘	■ Do not touch any switches with wet hands. Failure to observe this warning may result in an electric shock.
⊘	■ Do not touch any inverter terminal when the inverter is energized even if the motor is not operating. Failure to observe this warning may result in an electric shock.
⊘	■ Do not get close to the machinery driven by the inverter after an alarm stop because it will restart suddenly if the retry function is selected. (Design the system to ensure physical safety at restart.) Failure to observe this warning may result in injury.
!	■ Provide a separate emergency stop switch. Failure to observe this warning may result in injury.
!	■ Turn off the operation signal before resetting an alarm, otherwise the operation signal will restart the machinery driven by the inverter suddenly. Failure to observe this warning may result in injury.

	⚠ Caution
!	■ Do not touch the radiator fins or DC reactor because they become very hot. Failure to observe this warning may result in burns.
!	■ It is easy to set the inverter drive speed from low to high, so be sure to confirm the operating range of the motor and machinery driven by the inverter before making such settings. Failure to observe this warning may result in injury.
!	■ Provide a retaining brake if necessary. Failure to observe this warning may result in injury.
!	■ Do not start or stop the inverter by turning the main circuit ON or OFF. Failure to observe this warning may result in problems with the inverter.

1.4 Notes on Maintenance and Inspection

	⟨!⟩ Danger
⊘	■ Maintenance, inspection, and replacement of parts must be carried out by a qualified engineer. [Take off any metal items (watch, bracelet, etc.) before working on the equipment.] [Use insulated tools.] Failure to observe this warning may result in an electric shock or injury.
!	■ Turn off the power for maintenance or inspection. After the CHARGE lamp goes out, check that the voltage between DC terminals P and X is less than 30 VDC. Failure to observe this warning may result in an electric shock.

1.5 Disposal

⚠ **Caution**	
❗	■ Dispose of this product as industrial wastes. Failure to observe this warning may result in an injury.

1.6 Others

◇ **Danger**	
🚫	■ Do not modify this product. Failure to observe this warning may result in an electric shock, injury, failure, damage or fire.
⚠	■ This product operates a three-phase induction motor. Do not use for single-phase motor or other purposes. Failure to observe this warning may result in a fire or accident.
⚠	■ Do not use this product for life-support equipment, or other purposes directly related to dangers to people. Failure to observe this warning may result in an accident.
❗	■ Install a safety device when this product is applied to facilities where the failure of this product may cause a serious accident or damage. Failure to observe this warning may result in an accident.

2. Checking the Product and Precautions on Use

2.1 Checking the Product

After unpacking the product, check the following:

(1) Check the model, capacity and other ratings on the inverter casing.
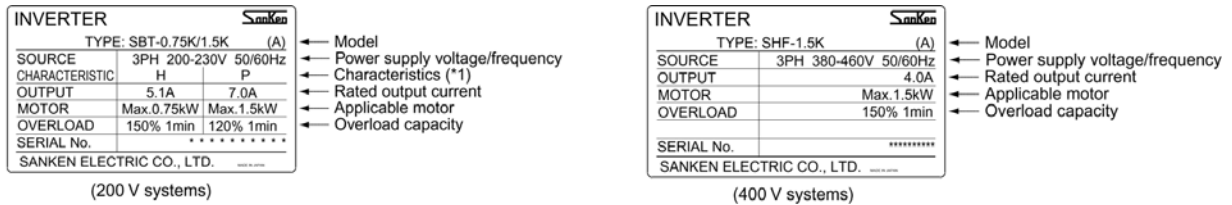
Figure 2.1 Inverter ratings

Table 2.1 Applicable motor/inverter models (200 V systems)

Applicable motor	Model	
	H characteristic (*1)	P characteristic (*1)
0.75kW	SBT-0.75K/1.5K	———
1.5kW	SBT-1.5K/2.2K	SBT-0.75K/1.5K
2.2kW	SBT-2.2K/3.7K	SBT-1.5K/2.2K
3.7kW	SBT-3.7K/5.5K	SBT-2.2K/3.7K
5.5kW	SBT-5.5K/7.5K	SBT-3.7K/5.5K
7.5kW	SBT-7.5K/11K	SBT-5.5K/7.5K
11kW	SBT-11K/15K	SBT-7.5K/11K
15kW	SBT-15K/18.5K	SBT-11K/15K
18.5kW	SBT-18.5K/22K	SBT-15K/18.5K
22kW	SBT-22K/30K	SBT-18.5K/22K
30kW	———	SBT-22K/30K

*1 H characteristic: Constant torque load (for general industry)
    P characteristic: Square-reduced torque load (for fan and pump)

Table 2.2 Applicable motor/inverter models (400 V systems)

Applicable motor	Model	
	SHF *2	SPF *3
1.5kW	SHF-1.5K	————
2.2kW	SHF-2.2K	SPF-2.2K
4kW	SHF-4.0K	SPF-4.0K
5.5kW	SHF-5.5K	SPF-5.5K
7.5kW	SHF-7.5K	SPF-7.5K
11kW	SHF-11K	SPF-11K
15kW	SHF-15K	SPF-15K
18.5kW	SHF-18.5K	SPF-18.5K
22kW	SHF-22K	SPF-22K
30kW	SHF-30K	SPF-30K
37kW	SHF-37K	SPF-37K
45kW	SHF-45K	SPF-45K
55kW	SHF-55K	SPF-55K
75kW	SHF-75K	SPF-75K

*2 SHF: Constant torque load (for general industry)
*3 SPF: Square-reduced torque load (for fan and pump)

(2) If the casing was dented or damaged during transportation or any other problem is found, contact the retailer.

2.2 Precautions on Use

1. Install the product in a location satisfying the standard environmental specifications (temperature, humidity, vibration, and dust).

2. Before starting up the product for the first time, carefully check the wiring.
   Make sure that the power cable (input) and motor cable (output) are connected correctly. Otherwise, the inverter will be damaged.

3. Since the ambient temperature of the installation location greatly affects the life of the inverter, it is recommended to keep the ambient temperature low.

4. When installing the product in an enclosure, check the enclosure size and ensure sufficient ventilation.

5. The capacitor and surge killer attached to the output side of the inverter for power-factor improvement may overheat or be damaged by output harmonic components of the inverter. Do not connect a capacitor or a surge killer to the inverter since surging it will set off overcurrent protection.
   Install the DC or AC reactor to the primary side of the inverter for power-factor improvement.

6. When implementing a megger test, follow the instructions given in 10.3, "Megger Test."

7. Use a high frequency earth leakage breaker when necessary.

8. Avoid inserting a magnetic contactor between the inverter and the motor.
   If the magnetic contactor is turned on and off while the inverter is operating, an excess current flows.

9. Select larger capacity since the operating characteristics of full electromagnetic-type MCCB changes with high harmonic current.

3. Installation

> ❗ ■ Read the safety notes before installation.
> Failure to observe these warnings may result in injury or fire.

3.1 Installation Location

(1) Do not install the inverter in direct sunlight or in a hot or humid location. Select a clean, dry location that is free of corrosive or inflammable gases, oil mist, or dust.

(2) Install the inverter in a location that is free from vibration.

Use the inverter under the environmental conditions described in Table 3.1.

Table 3.1 Operating environment

Ambient temperature	SBT	H characteristic	-10 to +50°C (Remove the top ventilation cover at +40°C or higher)
		P characteristic	-10 to +40°C (Remove the top ventilation cover of SBT-3.7K/5.5K or lower model at temperatures of +30°C or higher)
	SHF		-10 to +50°C (Remove the top ventilation cover at +40°C or higher)
	SPF		-10 to +40°C (Remove the top ventilation cover of SPF-5.5K or lower model at temperatures of +30°C or higher)
Ambient humidity			90%PH or less (with no condensation)
Operating environment			At 1000 m or lower altitude (No direct sunlight, corrosive or inflammable gases, oil mist or dust)
Location			Indoor

Store the inverter under the environmental conditions described in Table 3.2.

Table 3.2 Storage environment

Storage environment	-20 to +65°C This temperature is for short periods, such as during transportation. Ambient temperature must be +30°C or lower for more than 3 months of storage in consideration of the deterioration of the electrolytic capacitor. The product must be energized once a year for periods of 1 year or more.
Ambient humidity	90%PH or less (with no condensation)
Storage environment	No direct sunlight, corrosive or inflammable gases, oil mist, dust, steam, water droplet, vibration, or high salinity.

Table 3.3 Mounting screw

Series	Capacity	Mounting screw
SBT series	SBT-0.75K/1.5K to 3.7K/5.5K	M4
	SBT-5.5K/7.5K to 15K/18.5K	M5
	SBT-18.5K/22K to 22K/30K	M6
SHF series	SHF-1.5K to SHF-4.0K	M4
	SHF-5.5K to SHF-18.5K	M5
	SHF-22K	M6
	SHF-30K to SHF-55K	M8
SPF series	SPF-2.2K to SPF-5.5K	M4
	SPF-7.5K to SPF-22K	M5
	SPF-30K	M6
	SPF-37K to SPF-55K	M8

3.2 Installation Direction and Space

(1) This inverter is of the wall mounting type.

(2) Install the inverter vertically on a flat mounting surface.

(3) Since the inverter generates heat, provide adequate space for air circulation to cool the unit.

(4) When installing the inverter in an enclosure, provide a ventilation fan to keep the ambient temperature below 40°C.

(5) When installing the inverter in an enclosure, mounting the inverter so that the radiator fins are outside the enclosure will help to reduce the internal temperature of the enclosure.

(6) The inverter has an IP-20 housing, and may need to be mounted in an enclosure in certain environments.

> **❗** If the ambient temperature is likely to become 40°C or more with the H characteristic (constant torque load) or 30°C or more with the P characteristic (square-reduced torque load), remove the top ventilation cover of the unit.
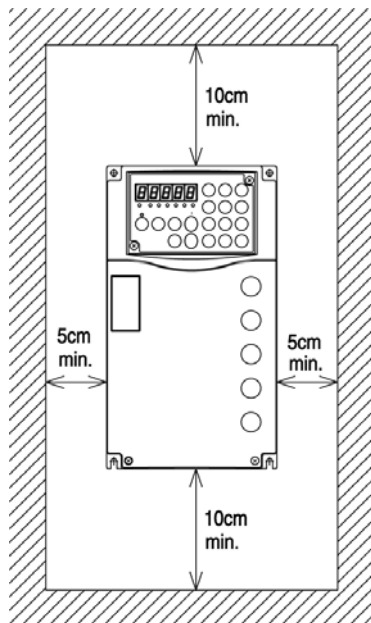
Figure 3.1 Space around the inverter   Figure 3.2 Installing the inverter with the radiator fins outside the enclosure
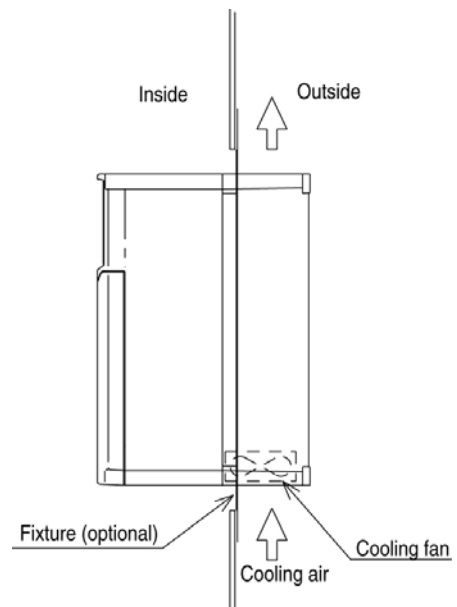
> When two or more inverters are housed in an enclosure, be sure to locate the ventilation fans properly to allow free air circulation. If the ventilation fans are mounted improperly, the ambient temperature will rise and reduce the cooling of the inverter.
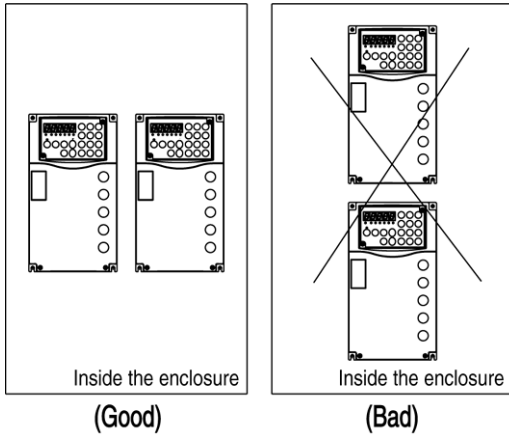
Figure 3.3 Housing in enclosure
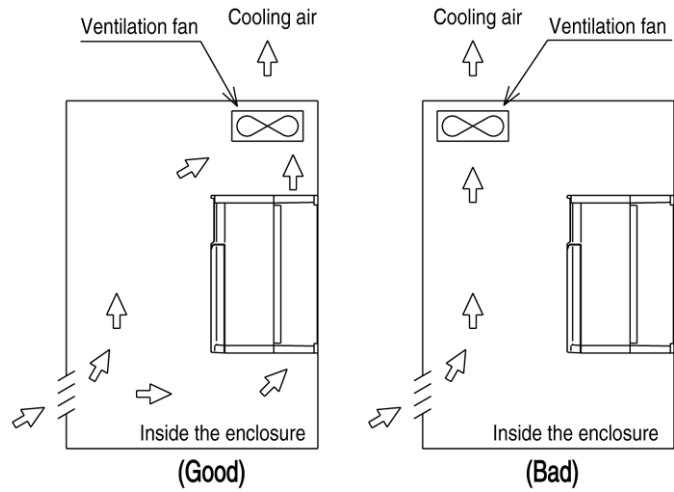
Figure 3.4 Ventilation fan position in enclosure

3.3   Removing and Attaching the Front Cover

3.3.1   Small-capacity model (200V type SBT-3.7K/5.5K or less, 400V type SHF-4.0K or less, 400V type SPF-5.5K or less)

(1) Removing the front cover
Loosen the screws at the bottom of the cover (Figure 3.5). Pull the cover toward you while pressing the sides of the casing (Figure 3.6).
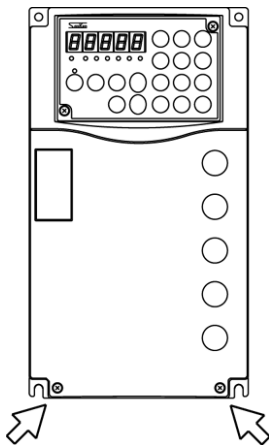
Figure 3.5
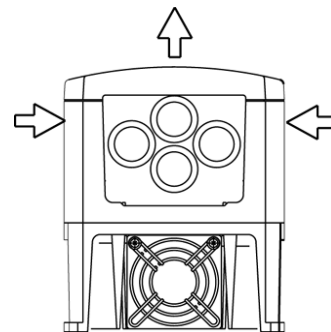
Figure 3.6

(2) Attaching the front cover
Hook the slots at the top of the front cover over the tabs on the casing and fit the cover onto the casing. Then tighten the screws at the bottom of the cover.

3.3.2 Middle- or large-capacity model (200V type SBT-5.5K/7.5K or more, 400V type SHF-5.5K or more, 400V type SPF-7.5K or more)

(1) Removing the front cover
Remove the two screws at the bottom of the cover. Lift the cover upward a little and remove the cover.

(2) Attaching the front cover
Hook the tabs on the front cover over the slots on the casing and close the cover. Then tighten the two screws at the bottom of the cover.

3.4 Removing and Attaching the Operation Panel

3.4.1 Small-capacity model (200V type SBT-3.7K/5.5K or less, 400V type SHF-4.0K or less, 400V type SPF-5.5K or less)

(1) Removing the operation panel
Remove the cover according to the instructions in part (1) of section 3.3.1 and disconnect the operation panel connection cable (Figure 3.7).
Loosen the upper right and lower left screws (Figure 3.8) and pull the operation panel toward you to remove it.
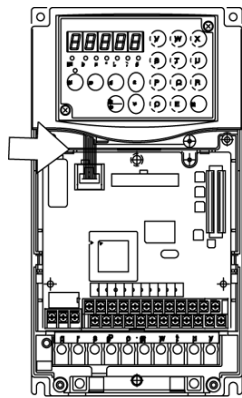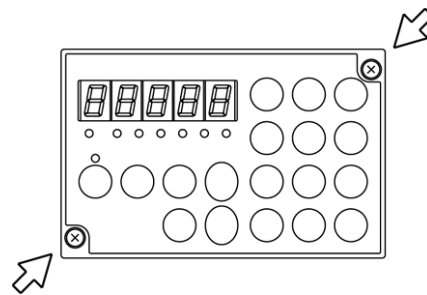
Figure 3.7   Figure 3.8

(2) Attaching the operation panel
Hold the operation panel in place, and tighten the upper right and lower left screws. Remove the cover of the inverter according to the instructions in part (1) of section 3.3.1 and connect the operation panel connection cable securely.
Then attach the cover according to the instructions in part (2) of section 3.3.1.

3.4.2 Middle- or large-capacity model (200V type SBT-5.5K/7.5K or more, 400V type SHF-5.5K or more, 400V type SPF-7.5K or more)

(1) Removing the operation panel
Remove the cover according to the instructions in part (1) of section 3.3.1 and disconnect the operation panel connection cable.
Loosen the upper right and lower left screws (Fig. 3.8) and remove the panel.

(2) Attaching the operation panel
Remove the cover of the inverter according to the instructions in part (1) of section 3.3.2. Hold the operation panel in place, and tighten the upper right and lower left screws. Then connect the operation panel connection cable securely.
Finally, attach the cover according to the instructions in part (2) of section 3.3.2.

4. Wiring

> ❗ ■ Read the safety notes before installation.
> Failure to observe these warnings may result in injury or fire.

4.1 Wiring Instructions

> ❗ ■ Wiring must be performed by qualified personnel.
> Failure to observe this warning may result in an electric shock or fire due to incorrect wiring.

Turn off the inverter power supply and check with a circuit tester that no voltage is present. Check also that the ⏢CHARGE⏢ lamp is not lit.

(1) Be sure to connect a circuit breaker (MCCB) between the power supply and the power input terminals (R, S, T). (Use a high-frequency earth leakage breaker when necessary.)
Connect a magnetic contactor (MC) between the MCCB and the power input terminals (R, S, T).
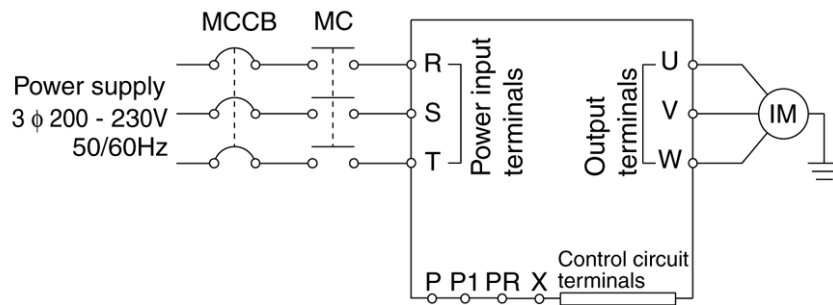
Figure 4.1 Basic wiring diagram of the inverter

> ⏚ ■ Connect the ground cable.
> Failure to observe this warning may result in an electric shock or fire.

(2) The phase order does not need to be considered when wiring the power input terminals (R, S, and T).

(3) Connect the motor to the output terminals (U, V, W) correctly.

The harmonic component leakage current increases by stray capacitance of wiring and causes adverse affects on the inverter itself and peripheral equipment when the length of wiring between inverter and motor is too long.
Wire the inverter and the motor within the length described in Table 4.1.

Table 4.1 Length of wiring between the inverter and the motor

Length of wiring between the inverter and the motor	50m	100m	200m
Carrier frequency (Specified by Cd051)	Cd051=130 or less	Cd051=090 or less	Cd051=040 or less

● Total length of wiring between the inverter and the motors must be within the length described in Table 4.1 when driving multiple motors.

- The surge voltage generated by the inverter element switching is superimposed and terminal voltage of the motor is impressed. The following measures should be considered to prevent deterioration of motor isolation especially for 400 V class motors when the length of wiring between the inverter and the motor is long.
  1) Use reinforced motor isolation.
  2) Length of wiring between the inverter and the motor should be as short as possible. (10 to 20 mor less)

(4) See Table 4.3 for details of the MCCB and MC capacitors and wire sizes.
    Use sleeved crimp terminals for the power and motor cables.

(5) Use shielded or twisted-pair wires for wiring to the control circuit terminals. Keep the wires well away from the main and high-voltage circuits (including 200 V relay sequence circuit).

(6) Use a micro-signal or twin contact relay for the control circuit terminal to prevent poor contact.

(7) Ground the ground terminal (⏚) securely.

Use the ground terminal of the inverter when grounding. (Do not use the case or the chassis.)
According to the electrical installation technical standards, connect to the grounding electrode applies either type D grounding for 200 V systems or type C grounding for 400 V systems.

Table 4.2 Types of grounding

Voltage	Types of grounding	Ground resistance
200 V systems	Type D grounding	100 Ω or less
400 V systems	Type C grounding	10 Ω or less

- Do not share the grounding wire with the welding machine or the power machinery.

- Use the grounding wire prescribed in the electrical installation technical standards, and wire this is as short as possible.

- Be careful not to loop the grounding wire when using multiple inverters.
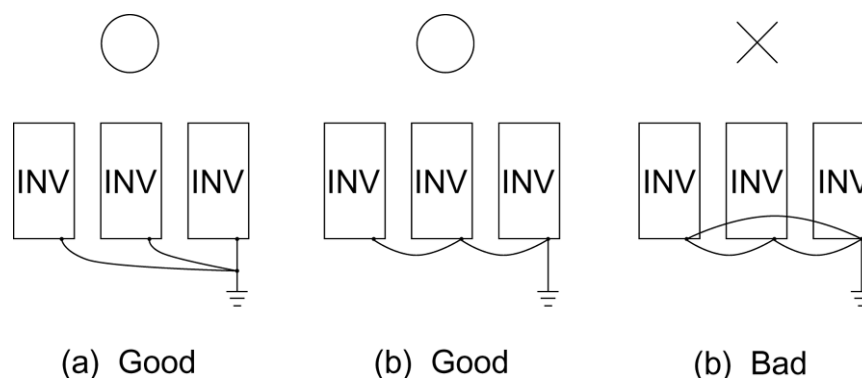
Figure 4.2 Grounding

Table 4.3 MCCB and MC capacitors and wire sizes

200V systems

Model	Load	Motor capacity	Circuit breaker (MCCB) [A]	MC Rated current [A]	MC Rated applied current [A]	Input wire	P/P1 wire	Output wire	Screw diameter	Maximum wire size [mm²]	Screw diameter (Control)	Maximum wire size [mm²] (Control)
SBT-0.75K/1.5K	H characteristic	0.75kW	10	11	20	1.25 (1.25)	1.25 (1.25)	1.25 (1.25)	M4	5.5	M3	1.25
	P characteristic	1.5kW	10	11	20	1.25 (1.25)	1.25 (1.25)	1.25 (1.25)				
SBT-1.5K/2.2K	H characteristic	1.5kW	15	11	20	1.25 (1.25)	1.25 (1.25)	1.25 (1.25)				
	P characteristic	2.2kW	15	11	20	1.25 (1.25)	1.25 (1.25)	1.25 (1.25)				
SBT-2.25K/3.7K	H characteristic	2.2kW	20	11	20	2.0 (1.25)	2.0 (1.25)	1.25 (1.25)				
	P characteristic	3.7kW	20	11	20	2.0 (1.25)	2.0 (1.25)	1.25 (1.25)				
SBT-3.7K/5.5K	H characteristic	3.7kW	30	18	25	3.5 (1.25)	3.5 (1.25)	2.0 (1.25)				
	P characteristic	5.5kW	30	18	25	3.5 (1.25)	3.5 (2.0)	2.0 (1.25)				
SBT-5.5K/7.5K	H characteristic	5.5kW	40	18	32	5.5 (2.0)	3.5 (2.0)	3.5 (2.0)	M6	22		
	P characteristic	7.5kW	50	26	50	5.5 (3.5)	5.5 (3.5)	3.5 (2.0)				
SBT-7.5K/11K	H characteristic	7.5kW	60	26	50	8 (3.5)	8 (3.5)	5.5 (2.0)				
	P characteristic	11kW	75	50	80	14 (8)	14 (5.5)	8 (3.5)				
SBT-11K/15K	H characteristic	11kW	75	50	80	14 (8)	14 (5.5)	8 (3.5)				
	P characteristic	15kW	100	65	100	22 (14)	14 (8)	14 (5.5)				
SBT-15K/18.5K	H characteristic	15kW	100	65	100	22 (14)	22 (8)	14 (5.5)				
	P characteristic	18.5kW	125	65	100	14 × 2 (14)	22 (14)	14 (8)				
SBT-18.5K/22K	H characteristic	18.5kW	125	80	135	38 (14)	22 (14)	22 (8)	M8	38		
	P characteristic	22kW	150	80	135	38 (22)	38 (14)	22 (14)				
SBT-22K/30K	H characteristic	22kW	150	80	135	38 (22)	38 (14)	22 (14)				
	P characteristic	30kW	175	152	200	22 × 2 (38)	22 × 2 (22)	38 (14)				

400V systems

Model	Circuit breaker (MCCB) [A]	MC Rated current [A]	MC Rated applied current [A]	Input wire	P/P1 wire	Output wire	Screw diameter	Maximum wire size [mm²]	Screw diameter (Control)	Maximum wire size [mm²] (Control)
SHF-1.5K	10	7	20	2.0(2.0)	2.0(2.0)	2.0(2.0)	M4	5.5	M3	1.25
SPF-2.2K	15	7	20	2.0(2.0)	2.0(2.0)	2.0(2.0)				
SHF-2.2K										
SPF-4.0K	20	7	20	2.0(2.0)	2.0(2.0)	2.0(2.0)				
SHF-4.0K										
SPF-5.5K	30	7	20	2.0(2.0)	2.0(2.0)	2.0(2.0)				
SHF-5.5K	30	17	32							
SPF-7.5K	30	17	32	3.5(2.0)	3.5(2.0)	3.5(2.0)				
SHF-7.5K	50									
SPF-11K	50	25	50	5.5	3.5	3.5(2.0)				
SHF-11K				8.0	5.5					
SPF-15K	60	32	60	14	5.5(3.5)	5.5(3.5)	M6	22		
SHF-15K										
SPF-18.5K	75	48	80	14(5.5)	8.0(5.5)	5.5(3.5)				
SHF-18.5K	100									
SPF-22K	100	48	80	22(14)	14(14)	8.0(5.5)				
SHF-22K		65	100							
SPF-30K	125	75	135	14×2 / 22(14)	22(14)	14(8)				
SHF-30K	150	75	135	38(14)	22(8)	14(5.5)	M8	38		
SPF-37K	150	75	135	22×2(22)	22(14)	22(8)				
SHF-37K	175	93	150	22×2(22)	22(14)	22(8)				
SPF-45K	200	150	200	22×2(38)	38(14)	22(14)				
SHF-45K	200	150	200	60(38)	38(14)	22(14)		60		
SPF-55K	225	150	200	38×2(38)	60(22)	38(14)				
SHF-55K	225	150	200	38×2(38)	60(22)	38(14)				

Note 1: The values for wires in the main circuit are for 600 V IV PVC-insulated wires (60ºC) when the inverter ambient temperature is 40ºC. The values in parentheses are for 600 V bridged-polyethylene insulated wires (90ºC).

Note 2: The maximum wire size indicates the maximum size of wire that can be used with the terminal board.

4.2 Terminal Connection Diagrams

(1) Main circuit connections

200V systems
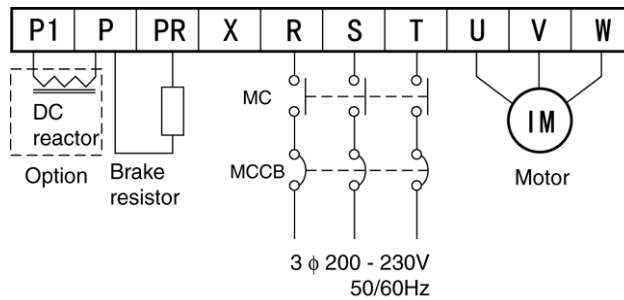
Figure 4.3.1 SBT-0.75K/1.5K - 3.7K/5.5K
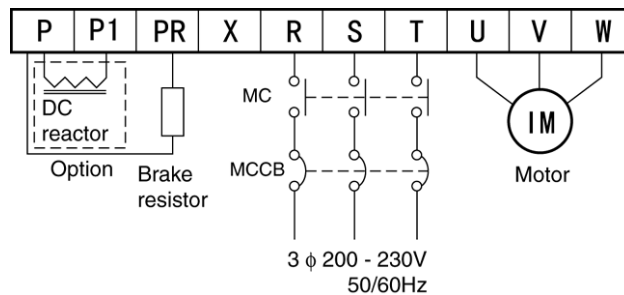
Figure 4.3.2 SBT-5.5K/7.5K - 7.5K/11K
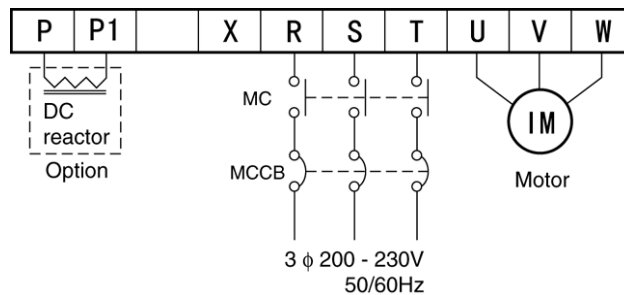
Figure 4.3.3 SBT-11K/15K
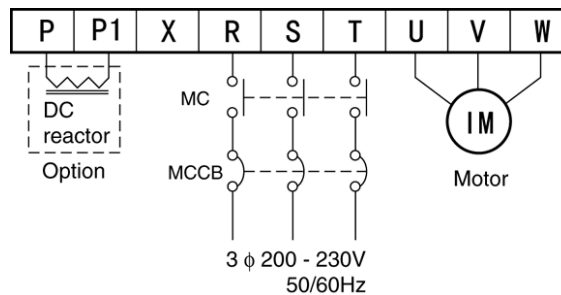
Figure 4.3.4 SBT-15K/18.5K
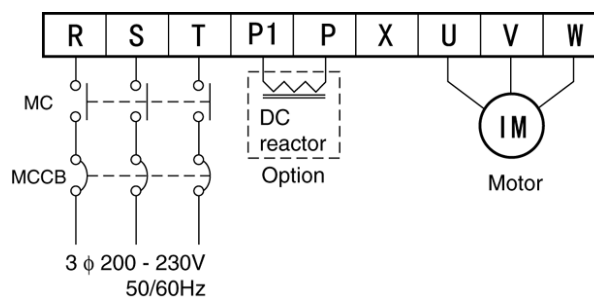
Figure 4.3.5 SBT-18.5K/22K - 22K/30K

400V systems
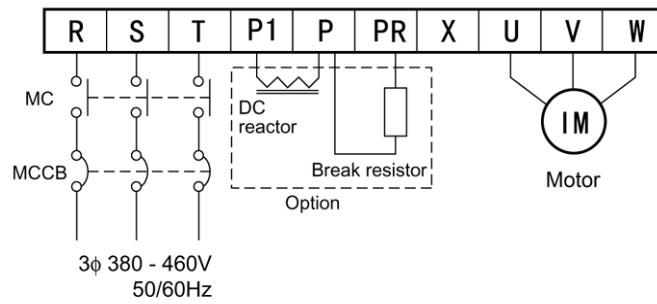
Figure 4.3.6 SHF-1.5K-4.0K   SPF-2.2K-5.5K
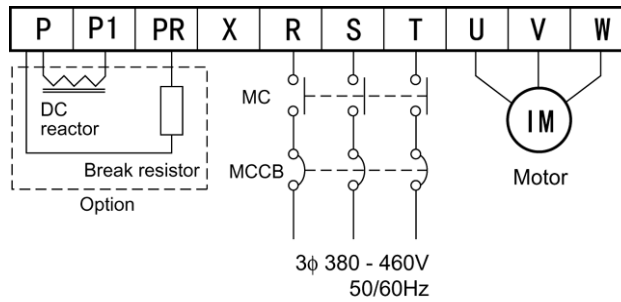
Figure 4.3.7 SHF-5.5K-15K   SPF-7.5K-18.5K
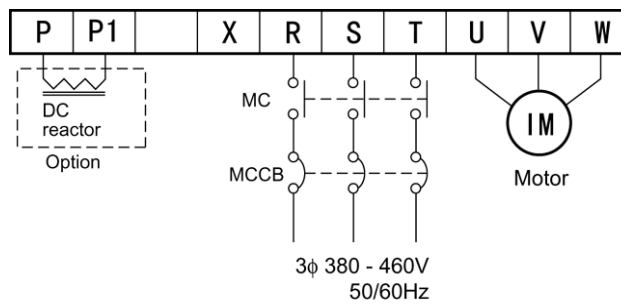
Figure 4.3.8 SHF-18.5K-22K   SPF-22K-30K
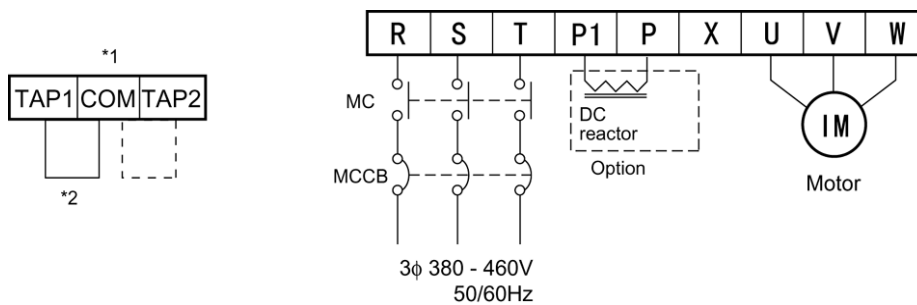
Figure 4.3.9 SHF-30K-55K SPF-37K-55K

*1 For SHF-37K to SHF-55K, SPF-45K and SPF-55K, a tap (TAP1 or TAP2) must be switched according to variable input ranges. Refer to the tap switching table.

Tap switching table

Variable input range	Tap position
380VAC -15%, +10%	TAP1 *2
380VAC -460VAC ±10%	TAP2 *3

*2 Factory preset
*3 Conditions for switching to TAP2
   Use TAP2 when the power supply voltage always exceeds 420V or the maximum voltage exceeds 430V.

Table 4.4 Main circuit terminals

Symbol	Terminal	Explanation
R, S, T	Power input terminals	Connected to a three-phase commercial power supply
U, V, W	Inverter output terminals	Connected to a three-phase induction motor
P, P1	DC reactor connection terminals	Connected to a DC reactor *1
P, PR	Brake resistor connection terminals	Connected to a brake resistor *2 (SBT-0.75K/1.5K - SBT-7.5K/11K, SHF-1.5K to SHF-15K, SPF-2.2K to SPF-18.5K)
P, X	DC link voltage connection terminals	P: DC positive terminal, X: DC negative terminal

*1 Remove the short-circuit bar between P1 and P before connecting to a DC reactor.

*2 The inverter incorporates an internal brake resistor. (SBT)
   Remove the connecting line of the internal brake resistor and insulate it with vinyl tape or other insulating material before using an external brake resistor.

Table 4.5 Example of external brake resistor

Model			External brake resistor	
SBT	SHF	SPF	Brake resistance	Capacity
SBT-0.75K/1.5K	—	—	120 Ω or more	150W *
SBT-1.5K/2.2K	—	—	60 Ω or more	300W *
SBT-2.2K/3.7K	—	—	60 Ω or more	300W *
SBT-3.7K/5.5K	—	—	40 Ω or more	400W *
SBT-5.5K/7.5K	—	—	20 Ω or more	800W *
SBT-7.5K/11K	—	—	20 Ω or more	800W *
—	SHF-1.5K	SPF-2.2K	320 Ω or more	200W *
—	SHF-2.2K	SPF-4.0K	160 Ω or more	400W *
—	SHF-4.0K	SPF-5.5K	120 Ω or more	600W *
—	SHF-5.5K	SPF-7.5K	80 Ω or more	800W *
—	SHF-7.5K	SPF-11K	60 Ω or more	1000W *
—	SHF-11K	SPF-15K	40 Ω or more	1500W *
—	SHF-15K	SPF-18.5K	40 Ω or more	1500W *

*   In this example, the maximum duty cycle of the brake resistor is assumed to be 10%.
    Set Cd049 (Duty Cycle of Brake Resistor) to less than 10% to protect the brake resistor.
    When setting the value 10 % or more, brake resistor capacity should be increased in proportion to the value described in Table 4.5.
    Example) When setting 20 %, the capacity should be doubled.

* Table 4.6 shows the list of brake circuit installed in each model.

Table 4.6 Brake circuit installation list

Model		Brake resistor	Drive device
200 V systems SBT	SBT-0.75K/1.5K	◯	◯
	SBT-1.5K/2.2K	◯	◯
	SBT-2.2K/3.7K	◯	◯
	SBT-3.7K/5.5K	◯	◯
	SBT-5.5K/7.5K	◯	◯
	SBT-7.5K/11K	◯	◯
	SBT-11K/15K	—	—
	SBT-15K/18.5K	—	—
	SBT-18.5K/22K	—	—
	SBT-22K/30K	—	—
400 V systems SHF	SHF-1.5K	—	◯
	SHF-2.2K	—	◯
	SHF-4.0K	—	◯
	SHF-5.5K	—	◯
	SHF-7.5K	—	◯
	SHF-11K	—	◯
	SHF-15K	—	◯
	SHF-18.5K to SHF-55K	—	—
400 V systems SPF	SPF-2.2K	—	◯
	SPF-4.0K	—	◯
	SPF-5.5K	—	◯
	SPF-7.5K	—	◯
	SPF-11K	—	◯
	SPF-15K	—	◯
	SPF-18.5K	—	◯
	SPF-22K to SPF-55K	—	—

◯ : Installed
— : Not installed

(2) Control circuit terminal connections
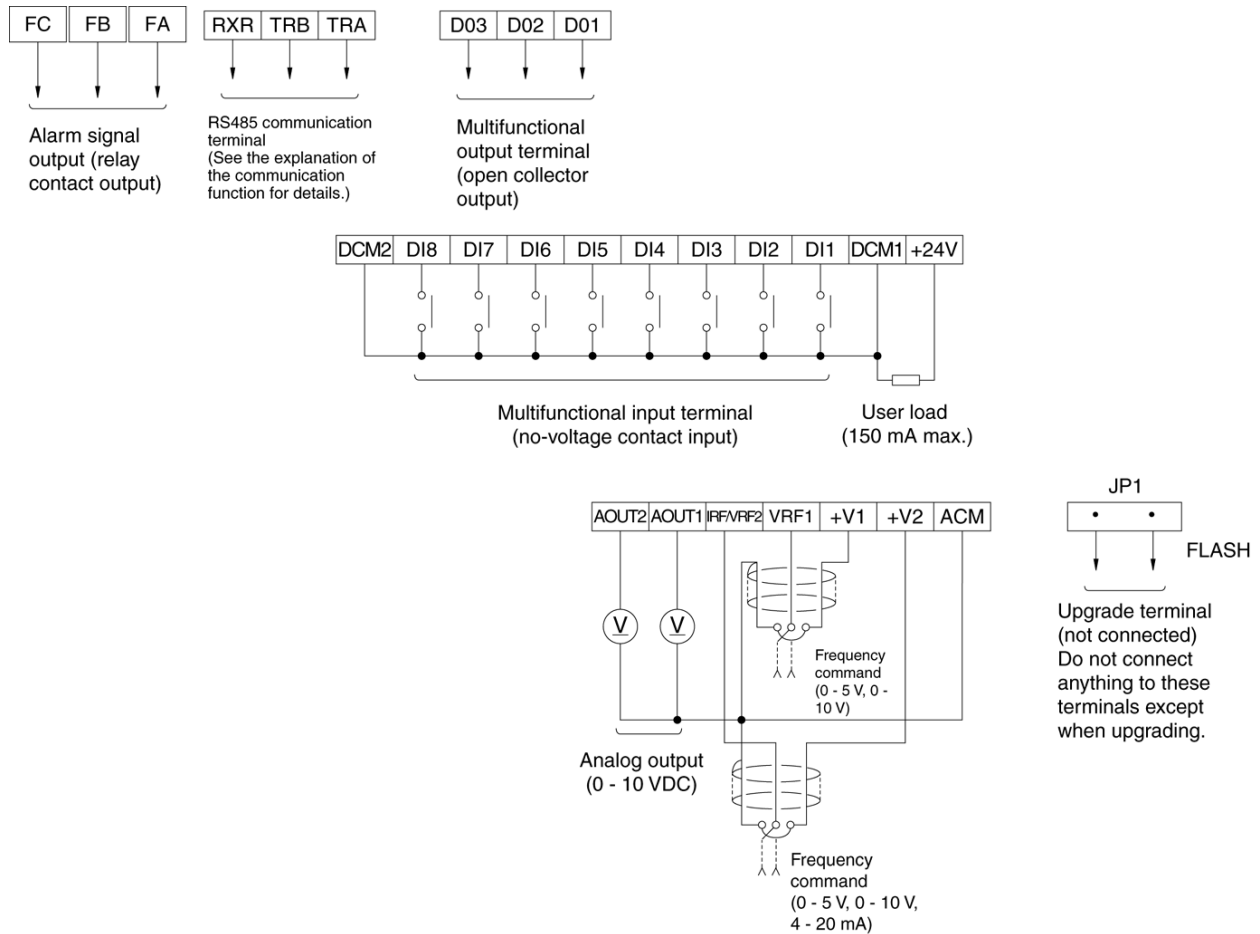
Figure 4.4 Control circuit connections

1) Frequency setting using variable resistor
- Use a 5 kΩ variable resistor with a rating of 0.3 Ω or more. (Function code Cd002 = 3 or 5)
- Use shielded wires. Connect the terminal end of the shielding to each common terminal and leave the other end open.
- The control circuit has analog input channels VRF1 and IRF/VRF2. A variable resistor can be connected to each of the two channels. When connecting a variable resistor using the internal power terminals of the inverter, connect the resistor to the following power terminals:

> VRF: Connect the variable resistor to the +V1 terminal.
> IRF/VRF2: Connect the variable resistor to the +V2 terminal.

Note: When using two variable resistors, do not connect them to the same terminal.

2) Multifunctional output (open collector output)
● The figure below shows an example of using multifunctional output terminals D01 to D03.
   * When using a relay, be sure to attach a surge killer (reverse-parallel connected diode).
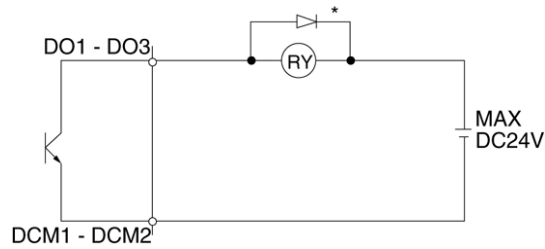
Figure 4.5 Example of using multifunctional output (open collector output)

Note: The maximum output current of the multifunctional output is 50 mA.

3) Signal mode switching for emergency stop (multifunctional input ES terminal)
● The figure below shows an example of signal switching when the multifunctional input terminal is set for the emergency stop (ES) command.
● Select a signal using the function code (Cd070:ES input terminal function).

◆ Normally open signal

→ Cd070 = 1
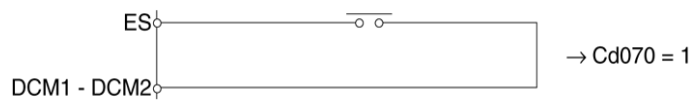
◆ Normally closed signal

→ Cd070 = 2
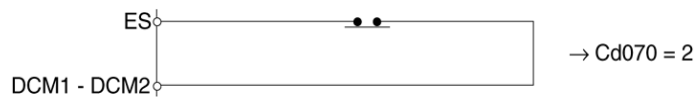
Figure 4.6 ES-terminal signal mode switching

(3) Operation panel cable connection
● When attaching the operation panel outside the unit, disconnect the standard cable and use a commercial shielded 8-pin straight modular cable of less than five meters length with RJ45-type connectors at both ends.

(4) Example of terminal connections (using control terminals)

- When using the control terminals of the inverter, follow the wiring diagram shown below. Use shielded wires as analog input wires and twisted-pair wires as wires to the frequency meter. (The settings of the function terminals are factory preset default values.)

- Operation can be performed using the main circuit wiring alone when operation is controlled from the operation panel. (There is no need to input external signals or frequency commands.)

- Provide MC circuit breakers (MCCBs) between the power supply and the input terminals of the inverter for protection.

- Provide magnetic contactors (MCs) between the MCCBs and the input terminals of the inverter as shown below to disconnect the power supply from the inverter and to prevent a fault from propagating when the protection function of the inverter operates or when a fault occurs. Locate the MCs as close to the inverter as possible.

Inverter samco-vm05

Note 1: Ground the inverter and the motor.
Note 2: The output terminals are multifunctional terminals that users assign individually with function codes Cd638 to Cd640.
Note 3: Terminal for upgrading. It should usually be kept open.
Note 4: Switch the function with function code Cd002. The terminal can be used as an input terminal for various feedback signals.
Note 5: The input terminals are multifunctional terminals that users assign individually with function codes Cd630 to Cd637.
Note 6: DCM1 and DCM2 are digital signal common terminals.
Note 7: The alarm signal output terminals are multifunctional terminals that users assign with function code Cd674.
Note 8: SBT-0.75K/1.75K to 7.5K/11K are equipped with a brake resistor as standard. Open the standard resistor when mounting an external brake resistor.

◎ Main circuit terminal
○ Control circuit input terminal
● Control circuit output terminal
□ Communications circuit terminal

Figure 4.7 Example of terminal connections

Table 4.7 Control circuit terminals

	Symbol	Terminal	Description
Input terminals	DCM1￼DCM2	Digital signal common terminals	● Common terminals for digital I/O signals and for +24 V power supply
	DI1￼DI2￼DI3￼DI4￼DI5￼DI6￼DI7￼DI8	Multifunctional input terminals (Function selection with Cd630 to Cd637)	● Signal input "on" by shorting with one of DCM1 to DCM2￼● Signal input "off" by disconnection from one of DCM1 to DCM2
	ACM	Analog signal common terminal	● Common terminal for analog signals
	+V1	Variable resistor connection terminal for frequency setting VRF1	● Use a 5 kΩ variable resistor with a rating of 0.3 W or more. (Function code Cd002 = 3 or 5)
	+V2	Variable resistor connection terminal for frequency setting VRF2	● Power cannot be supplied from this terminal. Connect only a variable resistor.
	VFR1	Analog voltage input terminal	● Input 0 to 10 VDC. When frequency setting is controlled by external input, the command frequency is proportional to the input signal voltage and the set gain frequency (Cd055) is applied when the input signal is 10 V. (When the setting of function code Cd002 specifies external control of VRF1.)￼● The input impedance is about 31 kΩ.￼● The input voltage range can be changed from 0 to 5 V using the corresponding function code.
	IRF/￼VRF2	Analog current/voltage input terminal (for current and voltage input)	● Current or voltage input (IRF or VRF2) can be selected using the corresponding function code￼● When frequency setting is selected, current input IRF or voltage input VRF can be selected using Cd002.￼● The code for selecting IRF or VRF2 depends on the function.￼● When VRF2 is selected, the hardware configuration is the same as VRF1.￼● When IRF is selected, input 4 to 20 mA DC. When frequency setting is controlled by external input, the command frequency is proportional to the input signal voltage and the set gain frequency (Cd063) is applied when the input signal is 20 mA. When IRF is selected, the input impedance is about 500 Ω.
Output terminals	+24V	+24 V power output	● +24 VDC power (maximum allowable output current: 150 mA)
	AOUT1￼AOUT2	Internal analog output terminal (2-channel output)	● Use the analog signal common terminal (ACM) as ground.￼● One monitor item is selected from Cd126 (AOUT1) and Cd128 (AOUT2), and indicated by an analog output.￼● The output signal voltage is from 0 to 10 VDC and the maximum allowable current is 15 mA. (Set the output coefficient because the output voltage decreases as the output current increases.)￼● The signal output can be varied from 0 to 20 times using function codes Cd127 (AOUT1) and Cd129 (AOUT2).
	DO1￼DO2￼DO3	Multifunctional output terminal (Function selection with Cd638 to Cd640)	● The open collector output is 24 VDC and 50 mA.￼● The signals turn on depending on the function selected.￼● Use DCM1 or DCM2 digital signal common terminals as ground.
	FA￼FB￼FC	Alarm signal output terminal and multifunctional contact output	● These terminals output contact signals indicating that the protective function has stopped the inverter.￼● Cd674: Multifunctional contact outputs according to the relay contact output setting.￼ Normal: FA-FC open, FB-FC closed￼ Abnormal: FA-FC closed, FB-FC open￼ Contact capacity: 250 VAC, 0.3 A
Communication terminals	TRA￼TRB	RS485 serial communication terminals (See the explanation of the serial communication function.)	● Send/receive terminals
	RXR		● Terminal resistor shorting terminal
	JP1	Upgrade jumper	● Do not connect anything to these terminals except when upgrading.

(5) Multifunctional input terminals

● The multifunctional input terminals allow the functions of the eight digital input channels to be specified freely by setting a value for the corresponding function code. A multiplexed terminal may have several functions.
When Cd630 = 11, for example, jog operation can be enabled simply by turning the DI1 terminal on. Signal inputs are turned on when the control terminals DI1 to DI8 are shorted to the terminals DCM1 to DCM2 and off when they are disconnected. (DCM1 to DCM2 are digital common terminals connected in the inverter.)

Table 4.8 Multifunctional input codes

Function code No.	Input terminal name	Data range	Initial value (symbol)
Cd630	DI1	0 to 99	1 (FR)
Cd631	DI2	0 to 99	2 (RR)
Cd632	DI3	0 to 99	3 (2DF)
Cd633	DI4	0 to 99	4 (3DF)
Cd634	DI5	0 to 99	5 (MBS)
Cd635	DI6	0 to 99	6 (ES)
Cd636	DI7	0 to 99	7 (RST)
Cd637	DI8	0 to 99	8 (AD2)

Table 4.9 Multifunctional input signals

Data No.	Symbol	Function	Data No.	Symbol	Function
0	—	Unused	35	PTR	Reset command for simple scheduled operation timer
1	FR	Forward run command	36	IF	IRF terminal signal priority command (*1)
2	RR	Reverse run command	37	5DF	Multi-speed (5th-8th speed) selection command
3	2DF	Multi-speed command 1	38	HD	Operation signal hold command
4	3DF	Multi-speed command 2	39	2P	2nd pressure switching command (option)
5	MBS	Free-run command	40	2PT	2nd pump switching time selection command (option)
6	ES	External emergency stop command command or down terminal	41	TCL	Regular pump timer reset command (option)
7	RST	Alarm reset command command or up terminal	42	Multiplexed terminal	2P+2PT
8	AD2	2nd or 4th acceleration/deceleration	43	CP	Command pulse blockingsignal (optional)
9	AD3	3rd or 4th acceleration/deceleration	44	CCL	Deviation counter clearing signal (optional)
10	JOG	Jog operation command	45	PC	P control signal (optional)
11	Multiplexed terminal	FR+JOG	46	PID	PID control switching signal
12	Multiplexed terminal	RR+JOG	47	PM1	External motor M1 selecting signal (option)
13	Multiplexed terminal	FR+AD2	48	PM2	External motor M2 selecting signal (option)
14	Multiplexed terminal	RR+AD2	49	PM3	External motor M3 selecting signal (option)
15	Multiplexed terminal	FR+AD3	50	PM4	External motor M4 selecting signal (option)
16	Multiplexed terminal	RR+AD3	51	PM5	External motor M5 selecting signal (option)
17	Multiplexed terminal	FR+2DF	52	PM6	External motor M6 selecting signal (option)
18	Multiplexed terminal	RR+2DF	53	PM7	External motor M7 selecting signal (option)
19	Multiplexed terminal	FR+3DF	54	Reserved	
20	Multiplexed terminal	RR+3DF	55	P0	Zero-speed command (optional)
21	Multiplexed terminal	FR+2DF+3DF	56	Multiplexed terminal	FR+CCL (optional)
22	Multiplexed terminal	RR+2DF+3DF	57	Multiplexed terminal	RR+CCL (optional)
23	Multiplexed terminal	FR+AD2+2DF	58 to 61	Reserved	
24	Multiplexed terminal	RR+AD2+2DF	62	Multiplexed terminal	FR+MBS
25	Multiplexed terminal	FR+AD2+3DF	63	Multiplexed terminal	FR+MBS
26	Multiplexed terminal	RR+AD2+3DF	64	Reserved	
27	Multiplexed terminal	FR+AD2+2DF+3DF	65	Multiplexed terminal	2DF+AD2
28	Multiplexed terminal	RR+AD2+2DF+3DF	66	Multiplexed terminal	2DF+AD3
29	Multiplexed terminal	FR+AD3+2DF	67	Multiplexed terminal	3DF+AD2
30	Multiplexed terminal	RR+AD3+2DF	68	Multiplexed terminal	3DF+AD3
31	Multiplexed terminal	FR+AD3+3DF	69	A × 10	Electric gear × 10 (optional)
32	Multiplexed terminal	RR+AD3+3DF	70	A × 100	Electric gear × 100 (optional)
33	Multiplexed terminal	FR+AD3+2DF+3DF	71 to 99	Reserved	
34	Multiplexed terminal	RR+AD3+2DF+3DF			

* When the IF terminal is on, an analog frequency command signal of 4 to 20 mA input to the IRF input terminal is used as the 1st speed frequency setting value, regardless of the setting of Cd002. In a sensor-based closed loop pump flow control system or similar system, it is easy to switch between manual setting from the operation panel in system adjustment mode, and automatic operation using 4 to 20 mA external analog command signal in ordinary mode.

(6) Multifunctional output terminals

● The multifunctional output terminals allow the functions of the three open-collector output channels to be specified freely by setting a value for the corresponding function code.

Table 4.10 Multifunctional output codes

Function code No.	Output terminal name	Data range	Initial value (symbol)
Cd638	DO1	0 to 99	1 (In operation 1)
Cd639	DO2	0 to 99	5 (Frequency matching)
Cd640	DO3	0 to 99	8 (Overload alarm level setting)

Table 4.11 Multifunctional output signals

Data No.	Function	Remarks
0	—	Unused terminal
1	In operation 1	On when the gate is on
2	Voltage low	
3	Operation cycle end signal	Simple scheduled operation
4	In operation 2	Off during DC braking and excitation
5	Frequency matching	1st speed frequency only
6	Frequency matching	1st to 8th speed frequencies
7	Frequency approach	
8	Overload alarm level setting signal	Value of Cd048 (Output only in constant operation.)
9	Electrothermal level signal	Output at 80% or more
10	Radiator heat prediction signal	
11	Auxiliary pump driving signal	Option
12	Regular pump switching signal	Option
13	Excitation and DC braking signal	
14	Lower frequency limit matching signal	
15	Upper frequency limit matching signal	
16	Servo on signal	Optional
17	Zero servo completion signale	Optional
18	FR signal	Multifunctional input terminal status output
19	RR signal	Multifunctional input terminal status output
20	2DF signal	Multifunctional input terminal status output
21	3DF signal	Multifunctional input terminal status output
22	AD2 signal	Multifunctional input terminal status output
23	AD3 signal	Multifunctional input terminal status output
24	JOG signal	Multifunctional input terminal status output
25	MBS signal	Multifunctional input terminal status output
26	ES signal	Multifunctional input terminal status output
27	RST signal	Multifunctional input terminal status output
28	Switching standby signal	Optional
29	Positioning completion signal	Optional
30	Brake resistor on signal	
31	Reserved	
32	Frequency counter output	Output frequency
33	Frequency counter output	Command frequency
34	Overload alarm level setting signal	Value of Cd048 (Output when in operation.)
35 to 99	Reserved	

5. Operation Panel

5.1 Section Names

7-segment display

Displays frequency, output current, speed of rotation, load factor, output voltage, pressure value, no units, settings, and alarms

Display mode indicators

Control indicator

Operation mode indicator

Drive key

Stop key

Numeric keys

Decimal point key

Enter key

Program key

Step keys

Display change/clear key
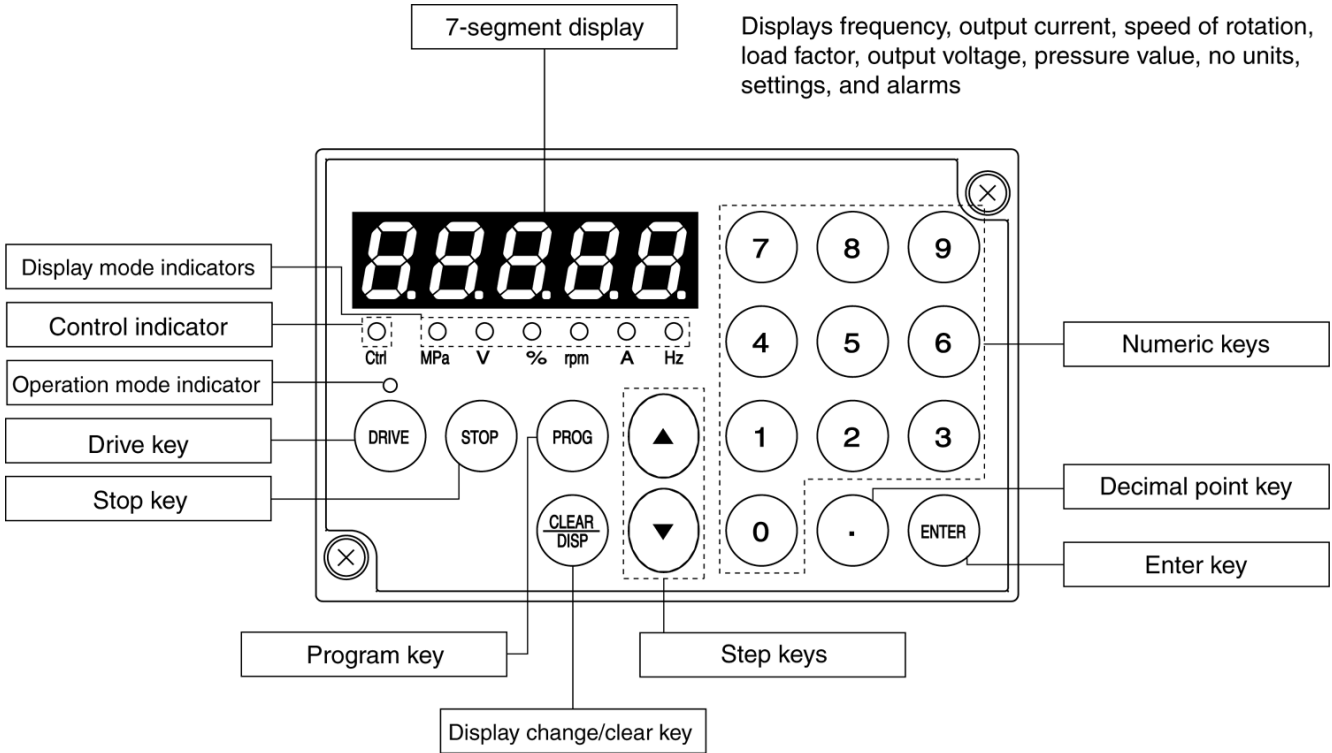
5.2 Operation Panel Keys

Classification	Key symbol	Description of function
Drive key	DRIVE	• Starts forward or reverse run. (The direction of rotation is switched by Cd130.)
Stop key	STOP	• Stops operation. • Resets the alarm in the alarm stop status.
Display change/ clear key	CLEAR DISP	• In Status Display mode, changes the display on the 7-segment display.
		• In Function Code Display mode, clears the input numeric data or makes the preceding (ENTER) key operation invalid.
Step keys	▲	• In Status Display mode, increments the frequency.
	▼	• In Status Display mode, decrements the frequency.
Program key	PROG	• Toggles the mode between Status Display and Function Code Display.
Enter key	ENTER	• Confirms numeric data indicated on the 7-segment display.
Numeric keys	0 1 2 3 4 5 6 7 8 9	• In Status Display mode, allows direct frequency setting.
Decimal point key	.	• Used to enter numeric data into the 7-segment display.

5.3 Display Modes

● The operation panel has two modes: Status Display mode and Function Code Display mode. These two modes can be toggled by pressing the (PROG) key.

Table 5.1 7-segment display modes

Display mode	Display contents
Status Display	Status of the inverter when operating and when stopped (frequency, output current, speed of rotation, load factor, output voltage, pressure value, and no units)
Function Code Display	Code number and data

● Press the (CLEAR DISP) key in Status Display mode to select frequency, output current, speed of rotation, load factor, output voltage, pressure value, and no units sequentially.

Table 5.2 7-segment display contents in Status Display mode

	Unit	7-segment display	
		Stopped	In operation
Frequency	Hz	Set frequency flashes	Output frequency lights
Output current	A	0 flashes	Output current lights
Speed of rotation	rpm	Synchronous speed of the set frequency flashes	Synchronous speed of the output frequency lights
Load factor	%	0 flashes	Load factor lights
Output voltage	V	0 flashes	Output voltage lights
Pressure value (optional)	MPa	PID feedback pressure value flashes	PID feedback pressure value lights
No units	—	Cd059-selected value flashes	Cd059-selected value lights

Note: The PID feedback pressure value is valid only when the water supply option is used in pressure mode.

● The operation mode indicator indicates whether the inverter is in operation or stopped.

Table 5.3 Operation mode displays

Operation status	Display
Stopped	●
In operation (forward run or reverse run)	○
DC braking Standby Deceleration to stop	◑

○ ...... Lit
● ...... Unlit
◑ ...... Flashing

● The control indicator is not lit during external operation and flashes during data setting.

Table 5.4 Operation mode displays

Operation command	Display
Not under external operation	○
Under external operation	●

○ ...... Lit
● ...... Unlit
◑ ...... Flashing

Operation panel status	Display
Setting data (Function Code Display mode) or frequency directly	◑

● The 7-segment display displays the version of the inverter software for several seconds after power-on. (Example of version display)

Software version: Ver. 1.00

Version

Inverter software (∗1)
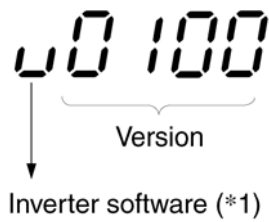
If communication cannot be established between the inverter and the operation panel for some reason at power-on, the 7-segment display displays the software version of the operation panel for several seconds. In this case, "P" is displayed at ∗1.

6. Operation

> ❗ ● Read the safety notes before installation.
>   Failure to observe these warnings may result in injury or fire.

6.1 Preliminary Checks

● Once the inverter has been installed and wired, check the following before power-on:

(1)   No miswiring, in particular, no power supply (input) connection to the U, V, or W terminal

(2)   No short circuits due to loose pieces of cut wire

(3)   No loose screws or terminals

(4)   No short circuit or ground fault on the output side or in the sequence circuit

6.2 Test Run

● When Cd001 (operation command selection) is set to 1 (operation through the operation panel), press the
(DRIVE) or (STOP) key to run or stop the inverter.
(The stop operation will work in any operation mode but the run operation will only work in Status Display mode.)

* Test run at 5 Hz (Flashing characters are shown as white on a black background.)

Operation	Display	Description
Power-on	**0.00** status.	All numerals on the 7-segment display remain flashing in the stop
Numeric keys or (▲)	**5.00**	Enter a numeric value. (Press the ENTER key to confirm an entry using the numeric keys.)
(DRIVE)	5.00	The 7-segment display stops flashing. Check the direction of rotation.
(STOP)	**5.00**	The 7-segment display changes to flashes to indicate the stop status.

6.3   Operation

At shipping, the inverter functions are set as shown in the function code list. To change the settings refer to Section 7.1, "Changing Settings".

6.3.1 Operation through the operation panel (Status Display mode)

(1)   Direct frequency setting

- The frequency can be set directly by specifying a numeric value from the operation panel. This is useful when changing the frequency significantly.

- The frequency can be set during run and stop operations when the frequency or speed of rotation is displayed in Status Display mode.

   * Changing the frequency from 5 to 50 Hz by direct setting

Operation	Display	Description
	5.00 or 5.00	Status Display mode (frequency display).
Numeric key (5)	5	Displays the rightmost input value.
Numeric key (0)	50	The display shifts to the left each time a key is pressed.
(ENTER)	50.00 or **50.00**	Stores the value as the new frequency and returns the display to the Status Display mode. If the inverter is in operation, the output frequency starts changing toward the new set value.

- To correct the numeric value, press the (CLEAR/DISP) key to return to the previous display.

- To stop the direct frequency setting (after using the numeric keys), press the (CLEAR/DISP) key rather than (ENTER) to return to the Status Display mode.

(2) Step setting

- Press the $(\blacktriangle)$ or $(\blacktriangledown)$ key to increment or decrement the displayed frequency to a target frequency. This is useful for fine adjustment of the set frequency.

- This works during run and stop operations when the frequency or speed of rotation is displayed in Status Display mode.

*Changing the frequency from 5 to 50 Hz by step setting

Operation	Display	Description
	5.00 or 5.00	Status Display mode (frequency/speed of rotation or no units display).
$(\blacktriangle)$ or $(\blacktriangledown)$	5.00 5.0 1 ↓ 49.00 50.00	Pressing the $(\blacktriangle)$ key or $(\blacktriangledown)$ key displays the current set frequency. While the $(\blacktriangle)$ key or $(\blacktriangledown)$ key is held down the value is incremented or decremented. When the $(\blacktriangle)$ key or $(\blacktriangledown)$ key is released, the displayed value is stored as the new frequency and the output frequency starts to change toward the new set value if the inverter is in operation.

6.3.2 Operation with external signals

(1) To run and stop the inverter using external signals, set function code Cd001 = 2.

(2) To set the frequency using an external variable resistor or with a current of 4 to 20 mA or a voltage of 0 to 10 V, set function code Cd002 to a value from 2 to 12.

(3) To use external signals, refer to the control circuit terminal connection diagram in Figure 4.4.

Note 1: The inverter does not operate when both the forward run (FR) and reverse run (RR) signals are input. Simultaneous input of the FR and RR signals during the operation of the inverter activates the "output frequency lock" function to lock the output frequency both during acceleration and deceleration.

Note 2: If the operation signal is turned off and a signal to drive the motor in the opposite direction from the present direction of rotation is input before the inverter stops, the inverter operates according to the value of Cd071 (motor control mode selection).

- Cd071 = 1 (V/f Control mode)
  The inverter operates according to the function code settings when starting and stopping. Consequently, the change in output frequency around 0 Hz may not follow a straight line, depending on settings such as the starting frequency. Since DC braking does not work when reversing the direction of rotation, set the DC braking start frequency low.

- Cd071 = 2 (Sensorless Vector Control mode)
  Braking excitation or starting excitation is not applied when switching the direction of rotation. This allows "forward and reverse run" in a continuous operation.

Forward run

Reverse run

Frequency

Starting frequency

Starting frequency

Time

<V/f Control mode>

Forward run

Reverse run

Frequency

Time

<Sensorless Vector Control mode>
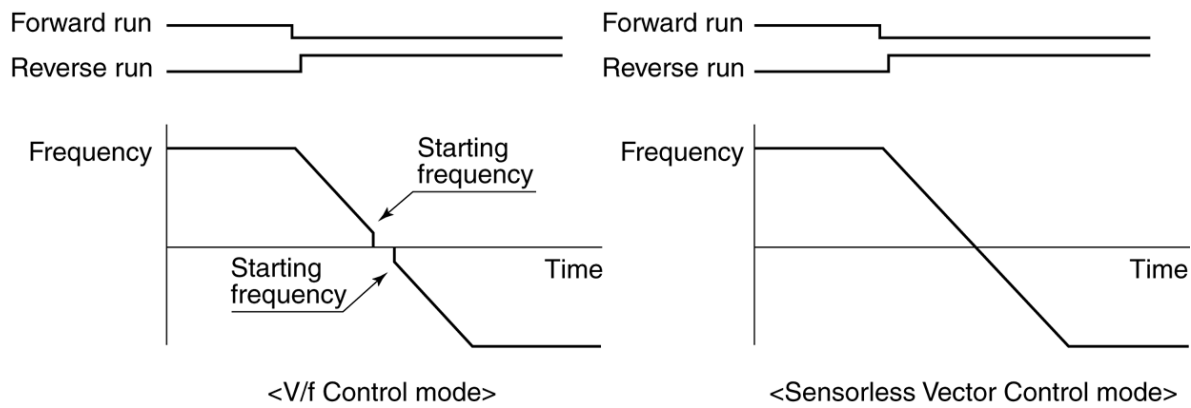
6.3.3 Jog operation

(1) Shorting the multifunctional terminal JOG to DCM 1 or 2 changes the inverter to Jog Operation mode.

(2) To use the jog operation, set Cd001 to 2 and short multifunctional terminal JOG to DCM 1 or 2. Then short multifunctional terminal FR or RR to DCM 1 or 2.
(The jog operation can only be controlled by external signals.)

Forward

Output frequency

Reverse

Short-circuit between JOG and DCM 1/2

Short-circuit between FR and DCM 1/2

Short-circuit between RR and DCM 1/2

Jog operation

Normal operation

Operation by external signals
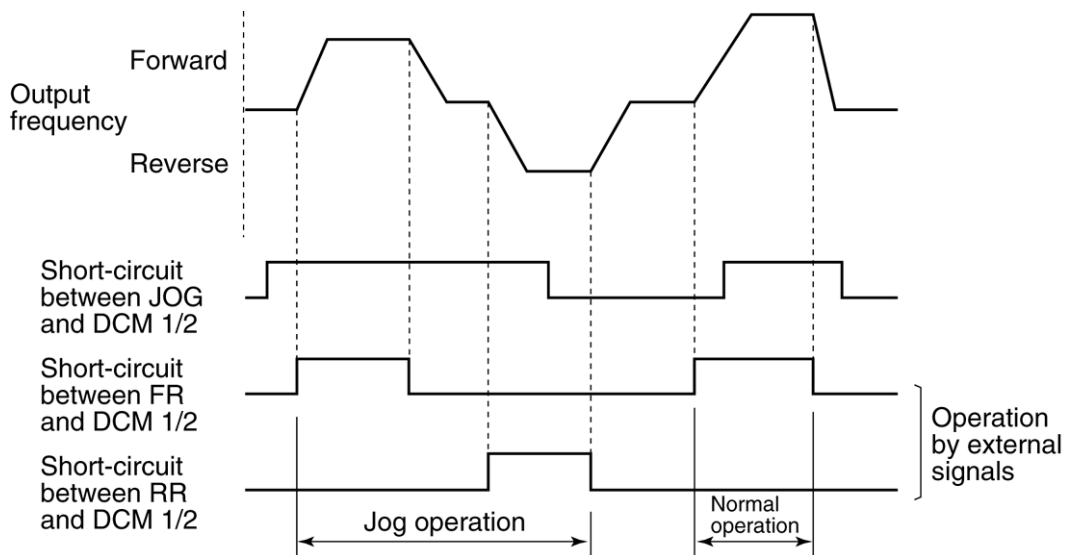
(3) The frequency can be set with Cd028 and the acceleration/deceleration time with Cd027.

(4) Inputting a JOG signal when the inverter is in operation does not change the mode to Jog mode. Be sure to input the JOG signal before or at the same time as starting operation. Even if the short circuit between JOG and DCM 1/2 is removed during jog operation, jog operation continues. (Turn the operation signal off to stop the inverter.)

(5) In Jog Operation mode, not Cd009 = 2 (flying start) but Cd009 = 1 (starting frequency) becomes valid. Other functions follow the function code settings.

6.3.4 Hold operation

(1) To use a push-button switch or other momentary contact to control operation, wire the circuit as shown in Figure 6.1 and set the appropriate function codes (codes related to the multifunctional input terminals and Cd001 = 2).
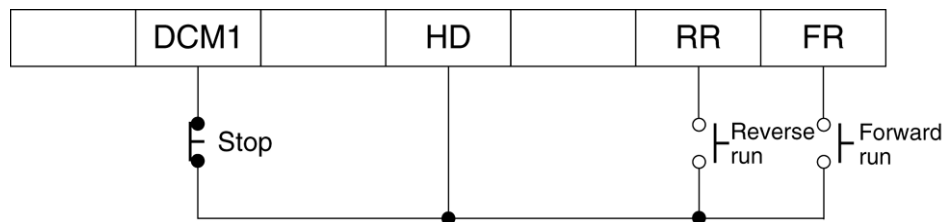
Figure 6.1 Operation signal hold circuit

(2) When the external signal terminals are used to operate and stop the inverter, and you do not want the motor to automatically restart after recovery from a power failure, use the above circuit and set CD046 to 0.

(3) When operating with the hold function, the inverter does not restart after recovery from the following conditions:

   1) Recovery from free run stop with MBS multifunctional input terminal

   2) Recovery from alarm stop with the auto alarm recovery function

   3) Recovery from a momentary power failure by the restart function

6.3.5 Notes on free run stop terminal (MBS)

The free run stop terminal is provided for systems in which mechanical braking is used to stop the motor. When setting the motor to the free run status using the terminal, be sure to turn any operation signal off. If the free run stop signal is released with an operation signal on, the inverter restarts according to the operating procedure and the function code settings. Therefore, depending on the free run speed of the motor, an unexpected overcurrent or overvoltage may occur and result in an alarm stop.

(If flying start is not set as the starting method and the free run stop signal is released when the motor is still rotating, for example, the inverter will restart from the starting frequency or after DC braking depending on the starting method.)

6.4 Reading Alarm Data

● The inverter drive keeps a record of up to five previous alarms. This data can be read using function code Cd098.

Operation	Display	Description
	50.00 or 50.00	Status Display mode
(PROG)	Cd	Function Code Display mode
Numeric keys (9) (8)	Cd 98	Specify Cd098
(ENTER)	0	Input wait status
(1)	1	Specify read (Enter 9 to clear the records.)
(ENTER)	×××××	Display the most recent alarm
(▲) or (▼)	××××× End	(▲) key to read older alarm data (▼) Key to read newer alarm data No record
(CLEAR DISP)	Cd 98	Function Code Display mode
(PROG)	**50.00** or 50.00	Status Display mode

6.5 Operational Error Displays

Table 6.1 Operational error displays

Display	Description
Er A	Frequency cannot be set from the operation panel.
Er b	The specified function code number is not defined.
Er C	The input value is beyond the input range. Motor constants are not registered for Cd053 (motor type).
Er E	No operations are permitted from the operation panel.
Er L	Function code data cannot be changed because the inverter is in operation.
Er n	Function code data cannot be changed because the operation panel is locked.
Er H	The input setting conflicts with the installed option board.
Er J	The input setting conflicts with the installed option board.
Er 5	The constants of the connected motor cannot be tuned automatically.
Er u	Function code data cannot be changed because the voltage is low (LuX).
Er d	The user's initialization data is not registered. Register the user's initialization data using Cd099 = 99.
Er o	Data cannot be transferred because the software version does not match. (Copy function) Or, data cannot be copied because the data transfer is from the remote operation panel (optional) to the inverter.
Er r	The memory contents cannot be transferred from the operation panel to the inverter. (Copy function)
Er t	Present function code data cannot be transferred to the operation panel. (Copy function) Data cannot be copied because the transfer is from the inverter to the remote operation panel (optional).
Er P	A password is necessary. Please contact the retailer.
Er 10	The inverter cannot communicate with the operation panel. Turn off the power and check the cable connections of the operation panel and the optional board. If an error code is displayed again, contact the retailer.
oFF L.	The inverter cannot communicate with the operation panel. Turn off the power and check the cable connections of the operation panel and the optional board. If an error code is displayed again, contact the retailer.

6.6 Conflict Error Displays

● Input data conflicts with the data of function code number XXX. Correct the input data or change the data of function code number XXX.

● Table 6.2 lists conflicting function codes and the corresponding error displays.

Table 6.2 Conflict error displays

Setting function code			Conflicting function codes		Error display
Code No.	Name	Set value	Check rule		
Cd001	Operation command selection	≠ 2	This value can be set when Cd071 ≠ 4.		Er071
Cd002	1st speed frequency setting	2,3,4 5,6	The following values can be set: 　(Cd120 set value) ≠ (Cd002 set value) -1 and 　(Cd085 set value) ≠ (Cd002 set value) -1 and 　(Cd086 set value) ≠ (Cd002 set value) -1		Er120 Er085 Er086
		7,8,9 10, 11 12	The following values can be set: 　(Cd120 set value) = 0 and 　(Cd085 set value) = 0 and 　(Cd086 set value) = 0		Er120 Er085 Er086
Cd007	Upper frequency limit	Any	This value shall not be lower than the Cd008 lower frequency limit.		Er008
			The vector control setting conditions are as follows: 　Setting range when Cd053 is two pole: Cd007 ≤ 60 Hz 　Setting range when Cd053 is four pole: Cd007 ≤ 130 Hz 　Setting range when Cd053 is six pole: Cd007 ≤ 200 Hz 　Setting range when Cd053 is eight pole: Cd007 ≤ 270 Hz 　Note: In P-characteristic V/f constant mode, the maximum output 　　　frequency for the upper frequency limit set by Cd007 is 　　　limited to 200 Hz in practice.		Er071
Cd008	Lower frequency limit	Any	This value shall not be higher than the Cd007 lower frequency limit.		Er007
Cd037	1st jump bottom frequency	Any	This value shall not be higher than the 1st jump top frequency of Cd038.		Er038
Cd038	1st jump top frequency	Any	This value shall not be lower than the 1st jump bottom frequency of Cd037.		Er037
Cd039	2nd jump bottom frequency	Any	This value shall not be higher than the 2nd jump top frequency of Cd040.		Er040
Cd040	2nd jump top frequency	Any	This value shall not be lower than the 2nd jump bottom frequency of Cd039.		Er039
Cd041	3rd jump bottom frequency	Any	This value shall not be higher than the 3rd jump top frequency of Cd042.		Er042
Cd042	3rd jump top frequency	Any	This value shall not be lower than the 3rd jump bottom frequency of Cd041.		Er041
Cd071	Motor control mode	not 3	This value can be set when Cd160 = 0.		Er160
			The vector control setting conditions for other than Cd071 = 12 are as follows: 　Setting range when Cd053 is two pole: Cd007 ≤ 60 Hz 　Setting range when Cd053 is four pole: Cd007 ≤ 130 Hz 　Setting range when Cd053 is six pole: Cd007 ≤ 200 Hz 　Setting range when Cd053 is eight pole: Cd007 ≤ 270 Hz 　Note: The operating range in each vector mode is 120 Hz or less.		Er007
			This value cannot be set when a motor not permitted by Cd053 is selected.		Er053
		4	This value can be set when Cd001 = 2.		Er001
		6	This value can be set when Cd101 = 0 or 3.		Er101
		7,8,9,10	This value can be set when Cd101 ≠ 2.		Er101
		11	This value can be set when Cd101 = 0 or 3.		Er101
		12	This value can be set when Cd101 ≠ 2.		Er101

Setting function code			Conflicting function codes		Error display
Code No.	Name	Set value	Check rule		
Cd085	Torque limiter analog (power running)	not 0	The following values can be set: (Cd085 set value) ≠ (Cd120 set value) and (Cd085 set value) ≠ (Cd002 set value) -1 and Cd002 ≠ 7, 8, 9, 10, 11, 12		Er120 Er002 Er002
Cd086	Torque limiter analog (regeneration)	not 0	The following values can be set: (Cd086 set value) ≠ (Cd120 set value) and (Cd086 set value) ≠ (Cd002 set value) -1 and Cd002 ≠ 7, 8, 9, 10, 11, 12		Er120 Er002 Er002
Cd101	Operation mode selection	1 2	This value can be set when Cd071 ≠ 6, 11. This value can be set when Cd071 < 6.		Er071 Er071
Cd120	Analog input switching	0 not 0	This value can be set when Cd175 ≠ 0. The following values can be set: (Cd120 set value) ≠ (Cd002 set value) -1 and "Cd002 ≠ (7, 8, 9, 10, 11, 12 and" (Cd120 set value) ≠ (Cd085 set value) and (Cd120 set value) ≠ (Cd086 set value)		Er175 Er002 Er002 Er085 Er086
Cd160	Feed pump control	not 0	This value can be set when Cd071 = 3.		Er071
Cd175	Pressure command	not 0	This value can be set when 120 ≠ 0.		Er120
Cd178	Upper pressure value limit	Any	Cd179: This value shall not be lower than the lower pressure value limit.		Er179
Cd179	Lower pressure value limit	Any	Cd178: This value shall not be higher than the higher pressure value limit.		Er178

Note: The two outputs of VRF1 and IRF/VRF2 are checked to see if they conflict. The same input type (e.g. Cd002 = 0 to 5 V, Cd120 = 0 to 5 V) cannot be set simultaneously for two functions.

Depending on the combination of function settings, however, a single input may be used for two functions (e.g. Cd002 = 0 to 5 V, Cd120 = 0 to 5 V). Allocate functions to the input terminals so that the two channels (VRF1 and IRF/VRF2) do not duplicate (conflict with) each other.

6.7 Other Displays

Table 6.3 Other displays

Display	Description
init	Flashes during the initialization of data
rEAdy	Displayed for a function code requiring confirmation
inity	Flashes during the initialization of user's data
dECid	Flashes when user's initialization data is confirmed
CoPy	Flashes during data transfer when copying
Find	Flashes when searching for a function code in user's data that is different from default data
2Ero	Displayed during zero-speed operation with vector option (position control mode)

6.8 Definition of Technical Terms
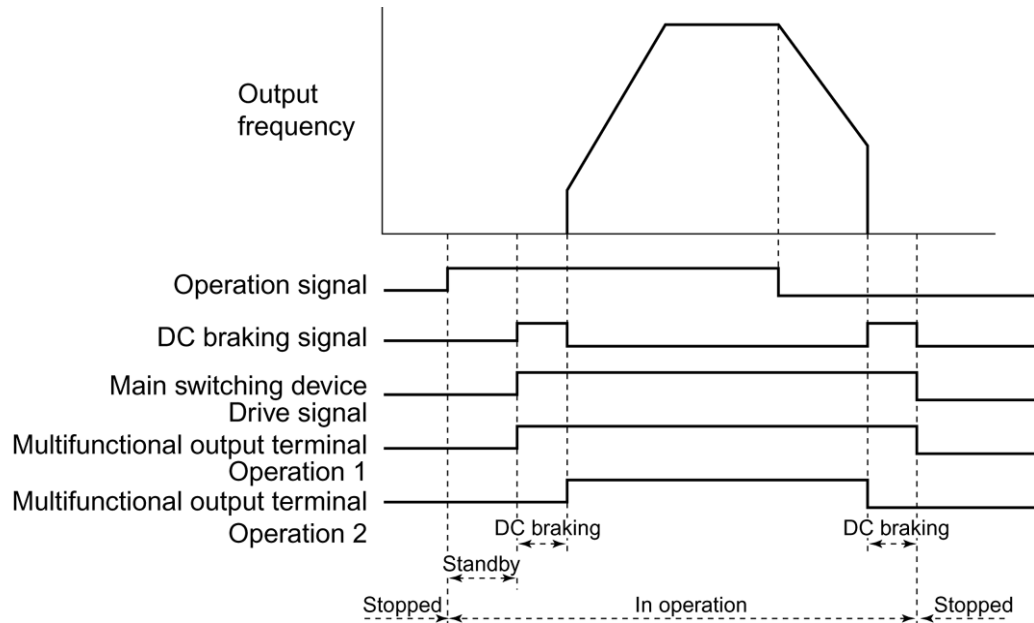
Terminology	Definition
Operation	General term describing both "forward run" and "reverse run" implying that the inverter is in operation
Operation signal	Signal requesting inverter operation, which is input by pressing the ⬭ key on the operation panel or using signals input through multifunctional control input terminals FR and RR
In operation (Operating)	Condition where the operation signal is being input or a drive signal is being output to the main switching device. In the stop status, the operation signal is off but the main switching device operates until DC braking, etc. is completed.
In constant operation	Condition when the inverter is in operation at the frequency setting value.
Stopped	Condition where the operation signal is not being input and the drive signal is not being output to the main switching device. Even when the operation signal input is on, the input to the multifunctional control input terminal MBS disables the drive signal output to the main switching device.
Standby	Condition where the operation signal is being input but there is no output for some reason, for example, while waiting for the start delay time to expire or when the set frequency is lower than the operation start frequency
DC braking	DC braking is applied when starting and stopping.
Frequency setting value or set frequency	Frequency set with Cd028 to Cd036 (Frequency value corresponding to an external signal when Cd002 = 2 to 16)
Output frequency or frequency output value	Actual inverter output frequency • V/f mode When the load is stable, the output frequency normally coincides with the frequency setting value. • Sensorless Vector mode Even when the load is stable, the output frequency does not coincide with the frequency setting value but keeps changing.
Command frequency	Frequency value used by the inverter. This frequency value is used as a command that determines the actual output frequency after controls, such as the acceleration/deceleration function and the current limiting function are applied to any change of the frequency setting value. The command frequency normally coincides with the set frequency at the end of acceleration/deceleration. • V/f mode If there is no feedback operation such as PID control mode, the command frequency equals the output frequency. • Sensorless Vector mode The command frequency and the output frequency may not match in this mode because the synchronous speed specified by the number of motor poles and the command frequency is used as the speed command.

7.   Setting Functions
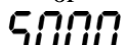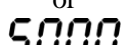
7.1   Changing Settings (Function Code Display Mode)

● The functions are set in Function Code Display mode. Press the (PROG) key to toggle the mode between Status Display and Function Code Display.

Status Display mode ◄──► Function Code Display mode

(PROG)

*   To set Cd008 = 15

Operation	Display	Description
	5000 or _5000_	Status Display mode
(PROG)	Cd	Function Code Display mode
Numeric key (8)	$Cd \quad 8$	Enter a function code number directly using the numeric keys.
(ENTER)	0.20	The data of the specified function code number is read and displayed, and the operation panel waits for numeric data input.
Numeric keys (1)(5)	15	Enter a numeric value using the numeric keys. Each time a numeral is entered, the display shifts to the left.
(ENTER)	$Cd \quad 8$	The input numeric value is stored as the new setting and the display returns to the Function Code Display mode. (To prevent errors, some function may request confirmation. → See the next page.)
(PROG)	**5000** or _5000_	The display returns to the Status Display mode.

● To correct numeric input, press the (CLEAR/DISP) key to return to the previous display.

● To cancel function code data input, press the (CLEAR/DISP) key to return to Function Code Display mode. (To cancel a change after pressing (ENTER) once, do not press (ENTER) again but press the (CLEAR/DISP) key twice to return to Function Code Display mode.)

● Copy function (Cd084)

This function transfers function code data from the inverter to the operation panel or to another inverter. This function is useful when setting the same function code data to multiple inverters. The same function code can be set to multiple inverters since after setting the function code data to one of the inverters, the function code data can be transferred to another inverter.

<Outline of function code>

   Cd084 = 1: Transfers the current function code data to the operation panel.
   Cd084 = 2: Transfers the memory contents from the operation panel to the inverter.
   For more details of function and operation, refer to description of function on Cd084.
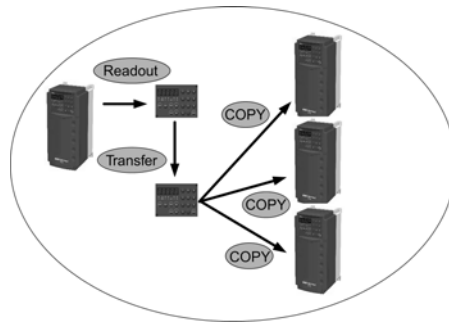
● Data initialization (Cd099)

The initial value of the inverter can be set by not only the factory presets but also the value determined by user (user's initial value). Data initialization can be selected from either the factory presets or user's initial value. By fixing the user's initial value as the initial value of the inverter, when the function code data is updated for some reason, this function can initialize the function code data to the user's initial value. The function code data can be reset with minimum steps.

<Outline of procedure>
1) Set the required function code.
2) Fix this value as the user's initial value with Cd099 = 99. (Confirmation message is displayed.)
3) Execute Cd099 = 3 to initialize the function code data to the user's initial value. Execute Cd099 = 1 to initialize to the factory presets. (Confirmation message is displayed.)

For more details of function and operation, refer to description of function on Cd099.
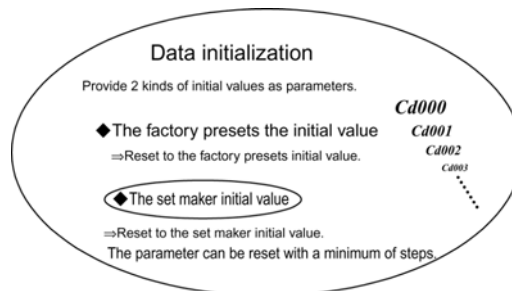
● Changed Code Display Function (Cd140)

This function compares the factory presets, user's initial value, and current function code data and displays the function codes for which data values are different.
This is useful when checking the difference between current function code data and the factory presets or user's initial value. The function code data can be confirmed easily when doing maintenance.

<Outline of procedure>
Cd140 = 1: Displays discrepancies between current function code data and the factory presets.
Cd140 = 2: Displays discrepancies between current function code data and the user's initial value.
For more details of function and operation, refer to description of function on Cd140.
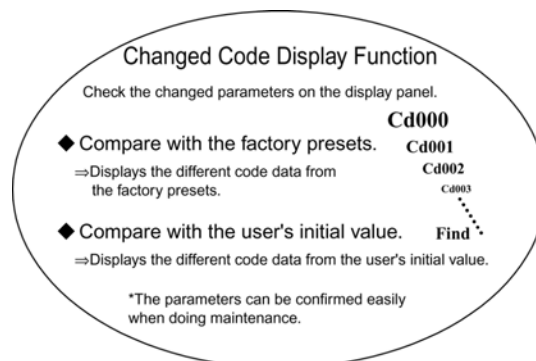
● For the following function code data, confirmation is required to avoid errors.
　　Where;
　　　Cd007 (Upper frequency limit):　120.00 or more
　　　Cd060 (Rating selection):　　　 1, 2
　　　Cd071 (Motor control mode):　　8, 9, 10, 11, 12
　　　Cd084 (Copy function):　　　　 1, 2
　　　Cd099 (Data initialization):　　 1, 2, 3, 99

* To set Cd099 = 1

Operation	Display	Description
	50.00 or *50.00*	Status Display mode
(PROG)	*Cd*	Function Code Display mode
Numeric keys (9)(9)	*Cd 99*	Enter a function code number directly using the numeric keys.
(ENTER)	*0*	The data of the specified function code number is read and displayed, and the operation panel waits for numeric data input.
Numeric key (1)	*1*	Enter a numeric value using the numeric keys.
(ENTER) *	*1* / *rEAdY*	The display toggles between the value and "ready" to indicate the confirmation mode.
(▲)	*Cd 99*	1 is entered as new data and Cd099 is set to 1 (data initialization). Note: **in it** ashes during initialization.
(PROG)	**50.00** or *50.00*	The display returns to the Status Display mode.

* If you notice a setting error while the display is toggling and want to cancel input, follow the steps below.

	1 / *rEAdY*	The display toggles between the value and "ready" to indicate the confirmation mode.
(CLEAR DISP)	*Cd 99*	The display returns to the Function Code Display mode.
(PROG)	**50.00** or *50.00*	The display returns to the Status Display mode.

● To change Cd053 = 42 2.2 to Cd053 = 62 1.5

Operation	Display	Description
	50.00	Status Display mode
(PROG)	Cd	Function Code Display mode
Numeric keys (5)(3)	Cd 53	Enter a function code number directly using the numeric keys.
(ENTER)	42 2.2	The data of the specified function code number is read, the number of motor poles at the leftmost digit flashes waiting for data input.
(▲)(▼)	62 2.2	Change the number of motor poles using the step keys.
(ENTER)	62 2.2	Press the ENTER key to enter the number of motor poles. The flashing cursor shifts to the rated voltage position and waits for data input.
(ENTER)	62 2.2	Press the ENTER key to enter the rated voltage. The flashing cursor shifts to the motor capacity position and waits for data input.
(▲)(▼)	62 1.5	Change the motor capacity using the step keys.
(ENTER)	Cd 53	The input numeric value is stored as the new setting and the display returns to the Function Code Display mode.
(PROG)	**50.00**	The display returns to the Status Display mode.

● Setting Cd054, Cd055, Cd062, Cd063, Cd068, Cd069, Cd176, and Cd177,
  *   To set Cd054 = -10

Operation	Display	Description
	50.00 or 50.00	Status Display mode
(PROG)	Cd	Function Code Display mode
Numeric keys (5)(4)	Cd 54	Enter a function code number directly using the numeric keys.
(ENTER)	P 0.0	The data of the specified function code number is read.
(▲)(▼)	- 0.0	Change the number of motor poles using the step keys.
Numeric keys (1)(0)	- 10	Change the data using the numeric keys.
(ENTER)	Cd 54	The input numeric value is stored as the new setting and the display returns to the Function Code Display mode.
(PROG)	**50.00** or 50.00	The display returns to the Status Display mode.

● Setting Cd140
  *   To display differences from the factory presets

Operation	Display	Description
	50.00	Status Display mode
(PROG)	Cd	Function Code Display mode
Numeric keys (1)(4)(0)	$Cd140$	Enter a function code number directly using the numeric keys.
(ENTER)	0	The data of the specified function code number is read.
Numeric key (1)	1	Change the data using the numeric keys.
(ENTER)	**Find**	Searching for code numbers of functions where user's settings differ from the factory presets ($Find$ flashes during the search.)
(▲) or (▼)	**CdXXX** **End**	(▲) Display the code number of the next function code whose settings have been changed. (▼) Display the code number of the previous function code whose settings have been changed.
(ENTER)	**CdXXX**	When the code number of a function code whose settings have been changed is displayed, press (ENTER) to display the function code data. Pressing (ENTER) toggles the display between the function code number and function code data.
(▲) or (▼)	**XXX.XX** **End**	(▲) Display the code number of the next function code whose settings have been changed. (▼) Display the code number of the previous function code whose settings have been changed.
(CLEAR DISP)	$Cd140$	The display returns to the Function Code Display mode.
(PROG)	**50.00**	The displays returns to the Status Display mode.

Note: The code number and code data of a function code whose settings have been changed flash.

7.2 Function Code List

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
000	Display selection	1: Frequency (Hz) 2: Output current 3: Speed of rotation (r/min) 4: Load factor 5: Output voltage 6: Pressure value 7: No units display	1	1	
001	Operation command selection	1: Operation panel 2: External terminal signal 3: Communication	1	1	
002	1st speed frequency setting	1: Operation panel 2: External analog VRF1 (0 - 5 V) 3: External analog VRF1 (0 - 10 V or variable resistor) 4: External analog VRF2 (0 - 5 V) 5: External analog VRF2 (0 - 10 V or variable resistor) 6: External analog IRF (4 - 20 mA) 7: External analog VRF1 + VRF2 8: External analog VRF1 - VRF2 9: External analog VRF2 - VRF1 10: External analog VRF1 + IRF 11: External analog VRF1 - IRF 12: External analog IRF - VRF1 13: Terminal board step 14: Communication 15: BINARY (option) 16: BCD (option)	1	1	
003	V/f pattern	1: Linear pattern 2: Square-law decreasing pattern (weak) 3: Square-law decreasing pattern (strong)	1	1	
004	Torque boost	0 - 20% (maximum voltage ratio)	0.1%	*1	

005	Base voltage	200 V system 0: No AVR
		                           30 - 240 V
		400 V system 0: No AVR
		                           30 - 460 V
			1 V	*1	

006	Base frequency	0.1 - 60 Hz	0.01 Hz	*1	
007	Upper frequency limit	30 - 600 Hz	0.01 Hz	60	
008	Lower frequency limit	0.05 - 200 Hz	0.01 Hz	0.05	
009	Starting method	1: Starting frequency 2: Flying start 3: Starting frequency after DC braking	1	1	
010	Starting frequency	0.05 - 200 Hz	0.01 Hz	1	
011	Operation start frequency	0 - 20 Hz	0.01 Hz	0	
012	Start delay time	0 - 5 sec.	0.1 s	0	
013	Braking method	1: Deceleration to stop 2: Deceleration to stop + DC braking 3: Free run stop	1	1	
014	DC braking start frequency	0.2 - 20 Hz	0.01 Hz	0.5	
015	DC braking time	0.1 - 10 sec.	0.1 s	2	
016	DC braking force	1 - 10	1	5	
017	Acceleration/deceleration curve	1: Linear 2: S-shaped	1	1	
018	Reference acceleration/ deceleration frequency	10 - 120 Hz	0.01 Hz	*1	
019	1st acceleration time	0 - 6500 sec.	0.1 s	*2	
020	2nd acceleration time	0 - 6500 sec.	0.1 s	*3	
021	3rd acceleration time	0 - 6500 sec.	0.1 s	*4	
022	4th acceleration time	0 - 6500 sec.	0.1 s	*5	
023	1st deceleration time	0 - 6500 sec.	0.1 s	*6	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
024	2nd deceleration time	0 - 6500 sec.	0.1 s	*7	
025	3rd deceleration time	0 - 6500 sec.	0.1 s	*8	
026	4th deceleration time	0 - 6500 sec.	0.1 s	*9	
027	Jog acceleration/deceleration time	0 - 20 sec.	0.1 s	0.1	
028	Jog frequency	0.1 - 60 Hz	0.01 Hz	5	
029	1st speed frequency	0 to 600 Hz	0.01 Hz	0	
030	2nd speed frequency	0 to 600 Hz	0.01 Hz	10	
031	3rd speed frequency	0 to 600 Hz	0.01 Hz	20	
032	4th speed frequency	0 to 600 Hz	0.01 Hz	30	
033	5th speed frequency	0 to 600 Hz	0.01 Hz	40	
034	6th speed frequency	0 to 600 Hz	0.01 Hz	50	
035	7th speed frequency	0 to 600 Hz	0.01 Hz	60	
036	8th speed frequency	0 to 600 Hz	0.01 Hz	0	
037	1st jump bottom frequency	0 to 600 Hz	0.01 Hz	0	
038	1st jump top frequency	0 to 600 Hz	0.01 Hz	0	
039	2nd jump bottom frequency	0 to 600 Hz	0.01 Hz	0	
040	2nd jump top frequency	0 to 600 Hz	0.01 Hz	0	
041	3rd jump bottom frequency	0 to 600 Hz	0.01 Hz	0	
042	3rd jump top frequency	0 to 600 Hz	0.01 Hz	0	
043	Output current limiting	H characteristic/SHF 0: No function 50 - 200%	1%	150	
		P characteristic/SPF 0: No function 50 - 150%	1%	120	
044	Electrothermal level setting	0: No function 20 - 105%	1%	100	

045	Output current limiting during constant power operation	0: No
		1: Yes V/F mode only
		  (Currently selected acceleration/deceleration time)
		2: Yes V/F mode only
		  (Acceleration/Deceleration time = Cd019,
		  Cd023: 1st acceleration/deceleration time)
		3: Yes V/F mode only
		  (Acceleration/Deceleration time = Cd020,
		  Cd024: 2nd acceleration/deceleration time)
		4: Yes V/F mode only
		  (Acceleration/Deceleration time = Cd021,
		  Cd025: 3rd acceleration/deceleration time)
		5: Yes V/F mode only
		  (Acceleration/Deceleration time = Cd022,
		  Cd026: 4th acceleration/deceleration time)
		6: Yes V/F mode and sensorless vector control
		  mode (Acceleration/Deceleration time = Cd019,
		  Cd023: 1st acceleration/deceleration time)
		7: Yes V/F mode and sensorless vector control
		  mode (Acceleration/Deceleration time = Cd020,
		  Cd024: 2nd acceleration/deceleration time)
		8: Yes V/F mode and sensorless vector control
		  mode (Acceleration/Deceleration time = Cd021,
		  Cd025: 3rd acceleration/deceleration time)
		9: Yes V/F mode and sensorless vector control
		  mode (Acceleration/Deceleration time = Cd022,
		  Cd026: 4th acceleration/deceleration time)
			1	0	

046	Restart after momentary power failure	0: Do not restart 1: Restart 2: Compensation for momentary power failure	1	0	
047	Auto alarm recovery	0: No auto alarm recovery function 1: Auto alarm recovery function	1	0	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
048	Overload alarm level setting	H characteristic/SHF 20 - 200%	1%	150	
		P characteristic/SPF 20 - 150%	1%	120	
049	Duty cycle of brake resistor	0: No brake resistor 2 - 25% ED 99: External brake unit	1% ED	*1	
050	Direction of rotation of motor Note: Cd130 for direction command from the operation panel	1: Forward and reverse run 2: Forward run only 3: Reverse run only	1	1	
051	Carrier frequency	0 - 130	1	*1	
052	Motor type	1: General-purpose motor 2: Motor designed specifically for inverter	1	1	

053	Motor poles, voltage, and capacity	XYZZZ
		     X: Number of motor poles
		     Y: Rated voltage
		     Z: Motor capacity
			–	*1	

054	Bias frequency (VRF1)	0 to ±600 Hz (frequency at 0 V)	0.1 Hz	P0	
055	Gain frequency (VRF1)	0 to ±600 Hz (frequency at 5 or 10 V)	0.1 Hz	P60	
056	Approach frequency	0 - 600 Hz	0.01 Hz	10	
057	Frequency matching range	0 - 10 Hz	0.01 Hz	0	
058	Multiple for no-units display	0.01 - 100 (multiple of the output frequency)	0.01	1	
059	Display selection	1: No units (multiple of CD058) 2: PID feedback frequency [Hz] 3: Command pressure [MPa] (option) 4: Set pressure [MPa] (option) 5: Command frequency [Hz] 6: Fin temperature [°C] 7: Detecting speed [rpm] (option) 8: Regular pump switching integrated time [H] (option) 9 - 10: Reserved 11: Detecting position [mm] (option) 12: DC voltage [V] 13: Output power [kW] (V/f mode only)	1	1	
060	Rating selection Note: This function is for SBT series only.	1: H characteristic (150% rating) 2: P characteristic (120% rating)	1	1	
061	Instability elimination	0 - 20	1	0	
062	Bias frequency (IRF/VRF2)	0 to ± 600 Hz (frequency at 0 or 4 mA)	0.1 Hz	P0	
063	Gain frequency (IRF/VRF2)	0 to ± 600 Hz (frequency at 5 V or 10 V or 20 mA)	0.1 Hz	P60	
064	Discharge resistor on signal output time	0.01 - 10 s	0.01 s	0.1	
065	Set frequency gain	0 - 100%	1	0	
066	V·f separate function selection	1: V·f comparison 2: Complete separation	1	1	
067	MBS terminal input mode	1: Level operation 2: Edge operation	1	1	
068	Internal analog output bias 1	0 - ±10.0 V	0.1 V	P0	
069	Internal analog output bias 2	0 - ±10.0 V	0.1 V	P0	
070	ES input terminal function	1: NO external thermal signal 2: NC external thermal signal	1	1	
071	Motor control mode selection	1: V/F control mode 2: Sensorless vector control mode 3: Internal PID control mode 4: Position control (optional) 5: Speed control (optional) 6: Simple energy-saving mode 7: Auto energy-saving mode 1 8: Auto energy-saving mode 2 9: Auto tuning mode 1 10: Auto tuning mode 2 11: V·f separate control 12: Switching between sensorless vector control and V/f control	1	1	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
072	Torque limiter (power running)	H characteristic/SHF: 5 - 200%	1%	100	
		P characteristic/SPF: 5 - 150%			
073	Torque limiter (regeneration)	5 - 100%	1%	*1	
074	Multiple for starting excitation current	1 - 10 (for applicable motor)	1	5	
075	Starting excitation time	0 - 10 (for no starting excitation)	0.1 s	*1	
076	Multiple for braking excitation current	1 - 10 (for applicable motor)	1	5	
077	Braking excitation time	0 - 10 (for no starting excitation)	0.1 s	1	
078	Motor current rating	Approx. 30 - 110% of inverter current rating	0.1 A	*1	
079	Motor frequency rating	1: 50 Hz 2: 60 Hz	1	*1	
080	Motor speed rating	0 to 2400 rpm	1 rpm	*1	
081	Motor isolation type	1: Type A 2: Type E 3: Type B 4: Type F 5: Type H	1	*1	
082	Speed adjustment gain	0.5 - 2	0.01	1	
083	External analog input filter time constant	1 - 500 (set value: 1 = 10 ms)	10 ms	10	
084	Copy function	1: Transfer the current code data to the operation panel 2: Transfer the operation panel memory to the inverter	1	0	
085	Torque limiter analog input function (power running)	0: Limit using Cd072 1: Limit using the signal on the VRF1 terminal (0 to 5 V) 2: Limit using the signal on the VRF1 terminal (0 to 10 V or variable resistor) 3: Limit using the signal on the VRF2 terminal (0 to 5 V) 4: Limit using the signal on the VRF2 terminal (0 to 10 V or variable resistor) 5: Limit using the signal on the IRF terminal (4 to 20 mA)	1	0	
086	Torque limiter analog input function (regeneration)	0: Limit using Cd073 1: Limit using the signal on the VRF1 terminal (0 to 5 V) 2: Limit using the signal on the VRF1 terminal (0 to 10 V or variable resistor) 3: Limit using the signal on the VRF2 terminal (0 to 5 V) 4: Limit using the signal on the VRF2 terminal (0 to 10 V or variable resistor) 5: Limit using the signal on the IRF terminal (4 to 20 mA)	1	0	
087	Function to switch between "OV" and "LV" alarms when stopped	0: OV enabled, LV disabled during stop 1: OV disabled, LV enabled during stop 2: OV disabled, LV disabled during stop 3: OV enabled, LV enabled during stop	1	0	
088	ASR proportional gain	0 - 7.8	0.01	*1	
089	ASR integral gain	0 - 106	0.01	*1	
090	Start of S-shaped acceleration	0 - 100%	1%	50	
091	End of S-shaped acceleration	0 - 100%	1%	50	
092	Gradient of middle of S-shaped acceleration	0 - 100%	1%	0	
093	Start of S-shaped deceleration	0 - 100%	1%	50	
094	End of S-shaped deceleration	0 - 100%	1%	50	
095	Gradient of middle of S-shaped deceleration	0 - 100%	1%	0	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
096	Function lock	0: Code data changeable (No lock function) 1: Code data unchangeable (except Cd096) 2: Code data unchangeable (except Cd096 and Cd028 to Cd036) 3: Code data unchangeable (except Cd096 or using communication function) 4: Code data unchangeable (except for Cd096, Cd175 or Cd182, pressure command.)	1	0	
097	Operation time display	Read only	1 hour	–	
098	Reading alarm data	0 1: Read start 9: Record erase	1	0	
099	Data initialization	0 1: Initialize factory presets 2: Invalid constant by auto tuning 3: Initialize user's data 99: Set user's initialization value	1	0	
100	Operation panel remote/local selection	0 1: Toggle function (optional)	1	0	
101	Operation mode selection	0: Normal operation 1: Simple scheduled operation 2: Disturbed operation	1	0	
102	Simple scheduled operation repetition	0: Continuous 1 - 250: Repetition count	1	1	
103	Operation timer T1	0 - 6500 s	0.1 s	10	
104	Operation timer T2	0 - 6500 s	0.1 s	10	
105	Operation timer T3	0 - 6500 s	0.1 s	10	
106	Operation timer T4	0 - 6500 s	0.1 s	10	
107	Operation timer T5	0 - 6500 s	0.1 s	10	
108	Operation timer T6	0 - 6500 s	0.1 s	10	
109	Operation timer T7	0 - 6500 s	0.1 s	10	
110	Operation stop timer T0	0 - 6500 s	0.1 s	10	
111	Midway stop deceleration time	1 - 4: Data of Cd023 - Cd026	1	1	
112	Midway start acceleration time	1 - 4: Data of Cd019 - Cd022	1	1	

113	Forward/reverse and acceleration/deceleration in T1	X Y
		  X ... 1: Forward run
		        2: Reverse run
		  Y ... 1 - 4: Acceleration/ deceleration time specified
			–	11	

114	Forward/reverse and acceleration/deceleration in T2		–	11	
115	Forward/reverse and acceleration/deceleration in T3		–	11	
116	Forward/reverse and acceleration/deceleration in T4		–	11	
117	Forward/reverse and acceleration/deceleration in T5		–	21	
118	Forward/reverse and acceleration/deceleration in T6		–	21	
119	Forward/reverse and acceleration/deceleration in T7		–	21	
120	Analog input switching (for PID, disturb, energy saving, and set frequency gain)	0: No analog input 1: External analog VRF1 (0 - 5 V) 2: External analog VRF1 (0 - 10 V or variable resistor) 3: External analog VRF2 (0 - 5 V) 4: External analog VRF2 (0 - 10 V or variable resistor) 5: External analog IRF (4 - 20 mA)	1	0	
121	Disturb modulation rate or simple energy saving rate	0 - 50%	1%	0	
122	PID control proportional gain	0 - 100	0.01	0.1	
123	PID control integral gain	0 - 100	0.01	0.1	
124	PID control differential gain	0 - 100	0.01	0	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
125	Feedback input filter time constant	1 - 500 (set value 1 = 10 ms)	10 ms	10	
126	Internal analog output function 1	0: No function 1: Set frequency 2: Output frequency 3: Output current 4: DC voltage 5: Fin temperature 6: Load factor (Electrothermal level integrated value) 7: Output of converted analog input value (VRF1 control circuit terminal input) 8: Output of converted analog input value (IRF/VRF2 control circuit terminal input) 9: Output voltage 10: Load factor (Percentage in terms of rated current) 11: Detected speed (option) 12: Output power (V/f mode only)	1	0	
127	Internal analog output coefficient 1	0 - 20X	by 0.01	1	
128	Internal analog output function 2	0: No function 1: Set frequency 2: Output frequency 3: Output current 4: DC voltage 5: Fin temperature 6: Load factor (Electrothermal level integrated value) 7: Output of converted analog input value (VRF1 control circuit terminal input) 8: Output of converted analog input value (IRF/VRF2 control circuit terminal input) 9: Output voltage 10: Load factor (Percentage in terms of rated current) 11: Detected speed (option) 12: Output power (V/f mode only)	1	0	
129	Internal analog output coefficient 2	0 - 20X	by 0.01	1	
130	Direction of rotation of motor (Operation panel)	1: Forward 2: Reverse	1	1	
131	Shortest operation time function	0 - 99.99	0.01 s	0	
132	Reserved				
133	Reserved				
134	Reserved				
135	Reserved				
136	Reserved				
137	Reserved				
138	Reserved				
139	Reserved				
140	Changed code display function	0 1: Display differences from factory preset 2: Display differences from user's initialization data	1	0	
141	Reserved				
142	Message checksum	0: No 1: Yes	1	1	
143	RS232C/RS485 switching	1: RS232C 2: RS485	1	1	
144	Pull-up/down function	0: No 1: Yes	1	0	
145	Reserved				

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
146	Communication function	0: No function 1: Serial communication function	1	0	
147	Inverter No.	1 - 32	1	1	
148	Communication speed	1: 1200bps 2: 2400bps 3: 4800bps 4: 9600bps 5: 19200bps	1	3	
149	Parity bit	0: None 1: Odd 2: Even	1	1	
150	Stop bit	1: 1 bit 2: 2 bits	1	1	
151	End bit	0:CR,LF 1:CR	1	0	
152	Reserved				
153	Reserved				
154	Reserved				
155	Reserved				
156	Reserved				
157	Reserved				
158	Reserved				
159	Reserved				
160	Feed pump control selection (Option)	0: No feed pump control 1-14: Feed pump mode	1	0	
161	Motor setting M1	0: M1 not used 1: M1 used (This setting is invalid for mode 1-8.)	1	1	
162	Motor setting M2	0: M2 not used 1: M2 used	1	0	
163	Motor setting M3	0: M3 not used 1: M3 used	1	0	
164	Motor setting M4	0: M4 not used 1: M4 used	1	0	
165	Motor setting M5	0: M5 not used 1: M5 used (This setting is invalid for mode 9-12.)	1	0	
166	Motor setting M6	0: M6 not used 1: M6 used (This setting is invalid for mode 9-12.)	1	0	
167	Motor setting M7	0: M7 not used 1: M7 used (This setting is invalid for mode 5-12.)	1	0	
168	Magnetic contactor switching time (Tmc)	0.10-2.00 s	0.01 s	1	
169	Maximum limiter duration time (Th)	0.1-10 min	0.1 min	5	
170	Minimum limiter duration time (Tl)	0.1-10 min	0.1 min	5	
171	Auxiliary pump switching ratio (K)	30-95%	1%	50	
172	Auxiliary pump return determining time (Tp)	0.1-10 min	0.1 min	5	
173	Full-voltage starting acceleration time (Ta)	0.1-20 s	0.1 s	5	
174	Full-voltage starting deceleration time (Td)	0.1-20 s	0.1 s	5	
175	Pressure command (Pref)	0-9.999MPa	0.001MPa	0	
176	Analog feedback bias pressure (Pb)	0-±9.999MPa	0.001MPa	P0	
177	Analog feedback gain pressure (Pg)	0-±9.999MPa	0.001MPa	P0	
178	Upper pressure value limit (Ph)	0.001-9.999MPa	0.001MPa	1	
179	Lower pressure value limit (Pl)	0-9.999MPa	0.001MPa	0	
180	Gradient of pressure acceleration /deceleration	0.001-9.999MPa	0.001MPa	0.1	
181	Motor switching allowable deviation	0-20%	0.1%	0	
182	2nd pressure command (Pref2)	0-9.999MPa	0.001MPa	0	
183	Maximum limiter duration time (Th2)	0.1-10 min	0.1 min	5	
184	Minimum limiter duration time (Tl2)	0.1-10 min	0.1 min	5	
185	Regular pump switching time (Tch)	0-720,999 h	1 h	0	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
186	Regular pump switching signal output time (Tchs)	0-120 s	1 s	120	
187	Motor switching function	0: Select by function code 1: Select by external signal	1	0	
191 192 193 194 195 196	Relay output function (RY3) Relay output function (RY4) Relay output function (RY5) Relay output function (RY6) Relay output function (RY7) Relay output function (RY8) Contact is on when operating (Option)	0: Output at alarm status 1: In operation 1 2: Low voltage 3: End of simple scheduled operation 4: In operation 2 5: Frequency matching (1st speed frequency) 6: Frequency matching (1st to 8th speed frequencies) 7: Frequency approach 8: Overload alarm level setting (Cd048 value. Output only in constant operation.) 9: Electrothermal level signal (Electrothermal 80%) 10: Fin heat prediction signal 11: Reserved 12: Reserved 13: Excitation and DC braking 14: Lower frequency limit matching 15: Upper frequency limit matching 16: Reserved 17: Reserved 18: FR signal 19: RR signal 20: 2DF signal 21: 3DF signal 22: AD2 signal 23: AD3 signal 24: JOG signal 25: MBS signal 26: ES signal 27: RST signal 28: Reserved 29: Reserved 30: Discharge resistor ON-signal 31 - 33: Reserved 34: Overload alarm signal (Cd048 value. Output when in operation.) 35 - 99: Reserved (*): Option	1	1 5 6 8 10 13	
197	Point to Point control position limiter	1 - 32767 mm	1 mm	32767	
198	Point to Point control smallest position unit	1: 1 mm 2: 0.1 mm 3: 0.01 mm	1	1	
199	Simple backlash calibration	0 - ±5000 pulses	1 pulse	P0	
600	Command pulse format	1: Forward and reverse pulse train 2: Coded pulse train 3: Two-phase pulse train	1	1	
601	Command pulse logic	1: Positive logic 2: Negative logic	1	1	
602	PG pulse output divisor	1: 1/1 2: 1/2 3: 1/4 4: 1/8 5: 1/16	1	1	
603	Deviation counter clear mode	1: Level operation (the counter is cleared when it is on.) 2: Edge operation (the counter is cleared when it is on.)	1	2	
604	PG pulse multiplication value	1: ×1 2: ×2 3: ×4	1	3	
605	PG switch	1: Compatible with line driver PG 2: Compatible with open collector PG	1	1	
606	Position control gain	0.1 - 50 rad/s	0.1 rad/s	1	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
607	Positioning complete width	0 - 32767 pulses	1 pulse	100	
608	Error level limit	0: No alarm function 1 - 1000 (set value 1=1000 pulses)	1000 pulses	100	
609	Position control acceleration /deceleration	0: Inactive 1: Active	1	1	
610	Number of pulses within 1 mm	0: Pulse is specified with Cd0611 1 - 32767 pulses	1 pulse	0	
611	Point to Point control position command	0: No control 0.01 - 32767 mm	0.01 - 1 mm	0	
612	Electric gear function selection	0: Inactive 1: Active	1	0	
613	Electric gear A data	1 - 100 (Setting accuracy: 1)	1	1	
614	Electric gear B data	1 - 100 (Setting accuracy: 1)	1	1	
615	Zero servo control function selection	0: No function 1: Zero servo switching at zero-speed 2: Zero servo switching at external terminal (PO)	1	0	
616	Zero-speed	1 - 3000 rpm	1 rpm	30	
617	Zero servo complete width	5 - 10000 pulses	1 pulse	10	
618	Number of PG pulses	500 - 2048 pulses	1 pulse	1000	
619	Observer gain setting ration	0 - 7.8	0.01	0	
620	Observer time constant	0 - 7.8	0.01	1	
630 631 632 633 634 635 636 637	Selection of input terminal DI1 Selection of input terminal DI2 Selection of input terminal DI3 Selection of input terminal DI4 Selection of input terminal DI5 Selection of input terminal DI6 Selection of input terminal DI7 Selection of input terminal DI8	0: Not used 1: FR 2: RR 3:2DF 4:3DF 5: MBS 6: ES 7: RST 8: AD2 9:AD3 10:JOG 11: FR+JOG 12: RR+JOG 13: FR+AD2 14: RR+AD2 15: FR+AD3 16: RR+AD3 17: FR+2DF 18: RR+2DF 19: FR+3DF 20: RR+3DF 21: FR+2DF+3DF 22: RR+2DF+3DF 23: FR+AD2+2DF 24: RR+AD2+2DF 25: FR+AD2+3DF 26: RR+AD2+3DF 27: FR+AD2+2DF+3DF 28: RR+AD2+2DF+3DF 29: FR+AD3+2DF 30: RR+AD3+2DF 31: FR+AD3+3DF 32: RR+AD3+3DF 33: FR+AD3+2DF+3DF 34: RR+AD3+2DF+3DF 35:PTR 36: IF 37: 5DF 38: HD 39:2P(*) 40:2PT(*) 41:TCL(*) 42:2P+2PT(*) 43:CP 44:CCL 45:PC 46:PID 47:PM1(*) 48:PM2(*) 49:PM3(*) 50:PM4(*) 51:PM5(*) 52:PM6(*) 53:PM7(*) 54: Reserved 55:P0 56:FR+CCL(*) 57:RR+CCL(*) 58-61: Reserved 62:FR+MBS 63:RR+MBS 64: Reserved 65:2DF+AD2 66:2DF+AD3 67:3DF+AD2 68:3DF+AD3 69:A×10 (*) 70:A×100 (*) 71-99: Reserved (*):Option	1	1 2 3 4 5 6 7 8	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting

638
639
640
	Selection of output terminal DO1
	Selection of output terminal DO2
	Selection of output terminal DO3
		0: Not used 1: In operation 1 2: Low voltage
		3: End of simple scheduled operation
		4: In operation 2
		5: Frequency matching (1st speed frequency)
		6: Frequency matching (1st to 8th speed
		   frequencies)
		7: Frequency approach
		8: Overload alarm level setting (Cd048 value.
		   Output only in constant operation.)
		9: Electrothermal level signal
		   (Electrothermal 80%)
		10: Fin heat prediction signal
		11: Auxiliary pump driving signal (*)
		12: Regular pump switching signal (*)
		13: Excitation and DC braking
		14: Lower frequency limit matching
		15: Upper frequency limit matching
		16: Servo on signal (option)
		17: Zero servo completion signal (option)
		18: FR signal 19: RR signal 20: 2DF signal
		21: 3DF signal 22: AD2 signal
		23: AD3 signal 24: JOG signal
		25: MBS signal 26: ES signal 27: RST signal
		28 : Switching standby signal (*)
		29: Positioning completion signal (option)
		30: Discharge resistor on signal
		31: Reserved
		32: Frequency counter output (Output frequency)
		33: Frequency counter output (Command
		   frequency)
		34: Overload alarm signal (Cd048 value.
		   Output when in operation.)
		35 - 99: Reserved (*): Option
			1	1
				5
				8	

641	Start standby time	0 - 120	0.1 s	0	
642	Start standby frequency	0.05 - 60	0.01 Hz	5	
670	Magnification of frequency counter output	1-10	by 1	1	
671	Cooling fan ON function Note: Supported only for cooling fan ON/OFF control model	0: Cooling fan ON/OFF control 1: Cooling fan ON normally	1	0	

672	Missing phase detection function	0: Missing input phase detection is invalid,
		   missing output phase detection is invalid.
		1: Missing input phase detection is valid,
		   missing output phase detection is invalid.
		2: Missing input phase detection is invalid,
		   missing output phase detection is valid.
		3: Missing input phase detection is valid,
		   missing output phase detection is valid.
			1	3	

673	Overvoltage stalling prevention function	0: Overvoltage stalling prevention function inactive. 1: Overvoltage stalling prevention function active.	1	1	

Code No. Cd	Function	Data	Setting resolution	Factory preset	User's setting
674	Relay contact output selection	0: Output at alarm status 1: In operation 1 2: Low voltage 3: End of simple scheduled operation 4: In operation 2 5: Frequency matching (1st speed frequency) 6: Frequency matching (1st to 8th speed frequencies) 7: Frequency approach 8: Overload alarm level setting (Cd048 value. Output only in constant operation.) 9: Electrothermal level signal (Electrothermal 80%) 10: Fin heat prediction signal 11: Auxiliary pump driving signal (*) 12: Regular pump switching signal (*) 13: Excitation and DC braking 14: Lower frequency limit matching 15: Upper frequency limit matching 16: Servo ON-signal (*) 17: Zero servo completion signal (*) 18: FR signal 19: RR signal 20: 2DF signal 21: 3DF signal 22: AD2 signal 23: AD3 signal 24: JOG signal 25: MBS signal 26: ES signal 27: RST signal 28: Switching standby signal (*) 29: Positioning completion signal (*) 30: Discharge resistor ON-signal 31 - 33: Reserved 34: Overload alarm signal (Cd048 value. Output when in operation.) 35 - 99: Reserved (*): Option	1	0	
675	Optional V/f pattern intermediate voltage 1	0-460V	1V	0	
676	Optional V/f pattern intermediate voltage 2	0-460V	1V	0	
677	Optional V/f pattern intermediate frequency 1	0.05-600Hz	0.01Hz	20	
678	Optional V/f pattern intermediate frequency 2	0.05-600Hz	0.01Hz	40	
679	Current output magnification (option)	0-20	by 0.01	1	

⬚ : The setting cannot be changed during operation.

*1 Typical constants for each model are entered.

*2 - *9 See the following table:

Type SBT	*2 Cd019	*3 Cd020	*4 Cd021	*5 Cd022	*6 Cd023	*7 Cd024	*8 Cd025	*9 Cd026
SBT-0.75K/1.5K - 7.5K/11K SHF-1.5K - SHF-7.5K SPF-2.2K - SHF-11K	5	10	15	20	5	10	15	20
SBT-11K/15K, 15K/18.5K SHF-11K, 15K SPF-15K, 18.5K	15	30	45	60	15	30	45	60
SBT-18.5K/22K, 22K/30K SHF-18.5K-SHF-55K SPF-22K-SPF-55K	30	60	90	120	30	60	90	120

7.3 Description of Functions

| **`Cd000`** | Display Function |

- This function switches the value displayed on the 7-segment display.
  - Cd000=1: Frequency (Hz)
  - Cd000=2: Output current (A)
  - Cd000=3: Speed of rotation (r/min)
  - Cd000=4: Load factor (%)
  - Cd000=5: Output voltage (V)
  - Cd000=6: Pressure value (MPa)
  - Cd000=7: No units display
- In the Stopped, Standby, and In Operation statuses, the display values and formats change as follows:

Cd000	Stopped	Standby/In Operation
1	The set frequency flashes.	The output frequency lights.
2	0 [A] flashes.	0 [A] lights.
3	$120 \times$ preset frequency/ no. of motor poles flashes.	$120 \times$ preset frequency/ no. of motor poles lights.
4	0 [%] flashes.	Output current/inverter rated current $\times 100$[%] lights.
5	0 [V] flashes.	The output voltage lights.
6	The PID feedback pressure value flashes.	The PID feedback pressure value lights.
7	The output display can be changed using Cd059.

- The value of Cd053 is used for the number of poles.

| **`Cd001`** | Operation Command Selection |

- This function is used to select whether to start or stop the inverter from the operation panel or through an external terminal.
  - Cd001=1: Operation from the operation panel
  - Cd001=2: Operation through an external terminal (However, the STOP key on the operation panel will work.)
  - Cd001=3: Operation using the communication function
- If Cd001=2 (external terminal), the input signals to control terminals FR and RR become valid.
  Inputs to other control terminals are always valid, regardless of the value of Cd001.
  Note: Even when the inverter is not operating, Cd001=1 cannot be changed if signals are being input to either FR or RR.

| **`Cd002`** | 1st Speed Frequency Setting |

- This function is used to select a method of frequency setting for 1st speed operation.
  - Cd002=1: Setting from the operation panel

- Cd002=2: Setting by analog signal input to the VRF1 terminal (0 to 5 V)
- Cd002=3: Setting by analog signal input to the VRF1 terminal (0 to 10 V or variable resistor)
- Cd002=4: Setting by analog signal input to the VRF2 terminal (0 to 5 V)
- Cd002=5: Setting by analog signal input to the VRF2 terminal (0 to 10 V or variable resistor)
- Cd002=6: Setting by analog signal input to the IRF terminal (4 to 20 mA)
- Cd002=7: Setting by the sum of analog signal inputs to the VRF1 and VRF2 terminals (VRF1+VRF2)
- Cd002=8: Setting by the difference in analog signal inputs to the VRF1 and VRF2 terminals (VRF1-VRF2)
- Cd002=9: Setting by the difference in analog signal inputs to the VRF2 and VRF1 terminals (VRF2-VRF1)
- Cd002=10: Setting by the sum of analog signal inputs to the VRF1 and IRF terminals (VRF1+IRF)
- Cd002=11: Setting by the difference in analog signal inputs to the VRF1 and IRF terminals (VRF1-IRF)
- Cd002=12: Setting by the difference in analog signal inputs to the IRF and VRF1 terminals (IRF-VRF1)
- Cd002=13: Setting using the step function of the terminal board
- Cd002=14: Setting using the communication function
- Cd002=15: BINARY (option)
- Cd002=16: BCD (option)

- Frequency analog input operation function
  - This function calculates the command frequency of the inverter from the two signals from the VRF1 and IRF/VRF2 (frequency command) analog input terminals of the control circuit. The inverter converts the input command on each terminal into a frequency by checking the bias and gain code. The results are added or subtracted according to the value of Cd002.
  - A negative result is always regarded as 0. The upper limit is determined from the upper frequency limit of Cd007.
- Cd002=13 The step function of the terminal board
  - The step function allows the set frequency to be increased or decreased in steps by input to the control terminals of the inverter.

This function is useful when it is difficult to input an analog frequency externally or set a frequency from the operation panel.

1) Related function codes and multifunctional input terminals

Function code	Multifunctional input terminal	
Cd002=13 (Step)	AD2	Up terminal
	AD3	Down terminal
	DCM1	Digital signal common terminal
	DCM2	Digital signal common terminal

- If step setting (Cd002=13) is selected for the first speed frequency, a frequency setting value can be entered only from external control input terminals AD2 and AD3 of the inverter.
  Note: The frequency cannot be changed from the operation panel.
- The AD2 terminal is used to increment the set frequency and the AD3 terminal to decrement the set frequency.
  Note: When Cd002=13 is selected, the AD2 and AD3 terminals set using Cd630 to Cd637 cannot be used for the 2nd, 3rd, or 4th acceleration/deceleration command.

2) Increasing or decreasing the set frequency
   - Increasing the set frequency
     Directly connect the AD2 terminal to the DCM1 or DCM2 terminal of the inverter. The set frequency increases gradually from the current value.
   - Decreasing the set frequency
     Directly connect the AD3 terminal to the DCM1 or DCM2 terminal of the inverter. The set frequency decreases gradually from the current value.
   - Frequency change steps
     When increasing or decreasing the set frequency, at first the second decimal place of the set frequency changes for about two seconds, next the first decimal place of the frequency changes for about two seconds, then the ones unit of the frequency changes.
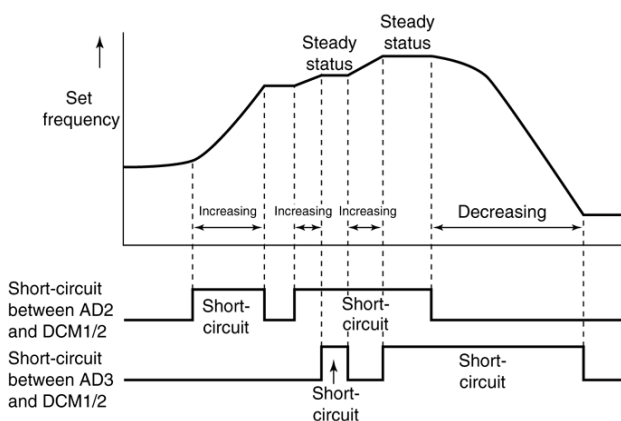
Note 1: The step function is used not only for setting the frequency for the first speed but also for setting the frequencies for multiple speeds.
For example, when you directly connect the 2DF terminal and the DCM1 terminal (to select the second speed) and select the step-up function while setting a frequency for the second speed, the set frequency for the second speed changes.
On the other hand, when a speed change is made during the step-up or down operation, the frequency for the preceding speed is set.

Note 2: The step function is disabled when the function lock (Cd096=1,3) is selected or at undervoltage.

Note 3: When the terminals AD2 and AD3 are both connected to either DCM1 or DCM2 or both left open, the set frequency remains unchanged.

Note 4: The new frequency set using the step function is reflected in the current multi-speed frequency code (Cd028 to Cd036).

● Other notes
Note 1: Even if Cd002=2 - 12, 15, 16 is selected during the multi-step speed operation (2nd thru 8th speeds) or jog operation, the frequency set by Cd028 or Cd030 - 036 becomes effective.

Note 2: Use a variable resistor of 5k Ω with a rating of 0.3W or more.

Note 3: When changing the frequency setting using a variable resistor, set the value of the gain frequency (Cd055) to about 10% higher than the actual desired frequency value.

Example: To set the frequency from 0-60 Hz using a variable resistor, set Cd055=66 Hz.

Cd003	V/f Pattern Selection

● The voltage and frequency responses are selectable from one linear and two square-law decreasing characteristics.
   Cd003=1: Linear V/f pattern (for constant torque load)
   Cd003=2: Square-law decreasing V/f weak (for reduced torque load)
   Cd003=3: Square-law decreasing V/f strong (for reduced torque load)
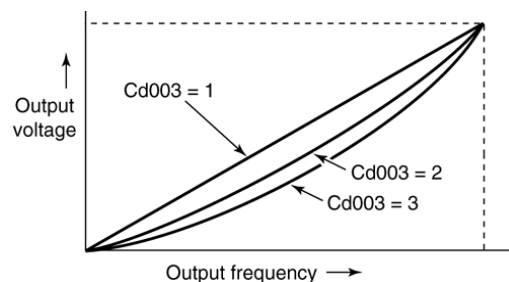
● Optional V/f pattern can be selected for linear V/f pattern. (This is effective when using special motors.) Refer to the related function code Cd675-Cd678. Optional V/f pattern has 2 intermediate points in the regular V/f pattern. V/f pattern is formed through these

2 points. Optional V/f pattern is described below.

● Optional V/f pattern is valid when either intermediate voltage 1 or intermediate voltage 2 (Cd675, Cd676) is not 0.
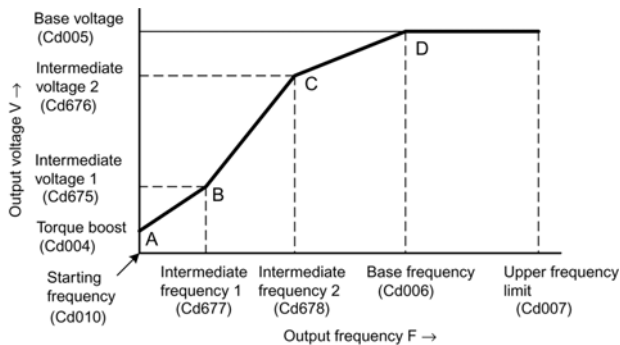
Note 1: Optional V/f pattern can only be valid for Cd003 = 1: linear V/f pattern.

Note 2: When the intermediate voltage 1 and 2 is not zero and lower than the voltage determined by Cd004: torque boost, the voltage will be limited by voltage command determined by torque boost.

Note 3: When the intermediate voltage 1 and 2 is higher than the voltage determined by Cd005: base voltage, the voltage will be limited by base voltage.

Note 4: When the intermediate frequency 1 and 2 is lower than Cd010: starting frequency, the frequency will be limited by starting frequency.

Note 5: When the intermediate frequency 1 and 2 is higher than Cd006: base frequency, the frequency will be limited by base frequency.

Note 6: Using optional V/f pattern, the inverter output command sometimes changes dramatically or becomes overexcited. Pay attention when changing the values setting during operation and the set values. (Change the value gradually and check the motor voltage.)

● When Cd003=2 or 3, the inverter can be operated more effectively with Cd045=1 (provides a function to limit the output current during constant power operation).

Note: When "Cd071=7" (Auto Energy-Saving Mode 1) is selected, the linear V/f pattern is set independently of the value of Cd003.

| Cd004 | Torque Boost |

● To compensate for torque deficiency of the motor in the low frequency range, the V/f pattern shown in the figure below is available.

Cd004 = 0 - 20% (in 0.1% step)
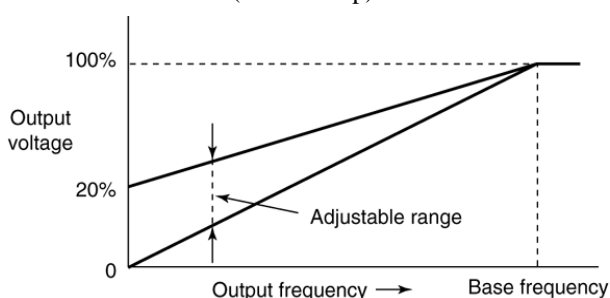
● An excessive increase will cause an excessive current, possibly activating the output current limiting function. To avoid this, confirm the output current before making this adjustment.

| Cd005 | Base Voltage |
| Cd006 | Base Frequency |

● These functions determine the V/f pattern including the base voltage and the base frequency appropriate to the characteristics of the motor in use.

Cd005=0: The base voltage is equal to the highest possible output voltage that is determined by the input voltage. No automatic output voltage control is available.

Cd005=30 - 460 (V):
Base voltage. Automatic output voltage control is performed. (30 - 240V for 200V system)

Cd006=0.1 - 600Hz: (in 0.01Hz step)
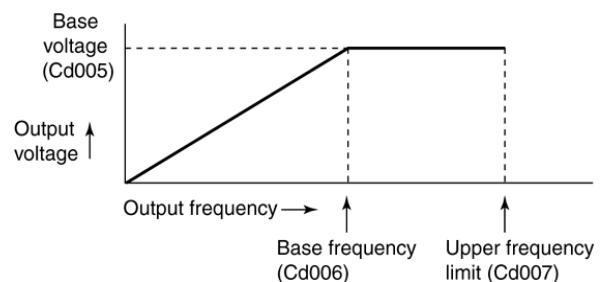
Note: General-purpose inverters do not output a voltage higher than the input voltage. Therefore, the range of automatic voltage control specified by the above functions depends on the highest possible input voltage. Cd005=230V may be set for a 200V system, for example, but 230V will not actually be output, though such a setting will serve to make the V/f pattern steeper.

| Cd007 | Upper Frequency Limit |
| Cd008 | Lower Frequency Limit |

● These functions specify the upper and lower frequency limits.

● Mistakes in using the operation panel or errors in external signals may cause an over frequency or a frequency setting that does not fall within the allowable rotation speed range of the motor. Cd007 and Cd008 provide protection against such errors.

Cd007=30 - 600Hz (in 0.01Hz step)
Cd008=0.05 - 200Hz (in 0.01Hz step)

● Although a frequency exceeding the upper limit can be specified, an output frequency higher than the upper limit is not actually output.

- Although a lower frequency than the lower limit can be specified, an output frequency lower than the lower limit is not actually output.
- The lower frequency limit must be greater than the starting frequency (Cd010) and the operation start frequency (Cd011).
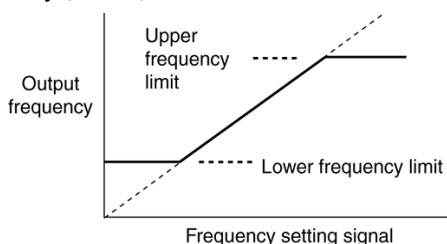
Note: In P-characteristic V/f constant mode, the maximum output frequency shall actually be limited to 200 Hz regardless of the upper frequency limit set by Cd007.

Cd009	Starting Method

- This function selects a starting method.
    - Cd009=1: Start using the starting frequency
    - Cd009=2: Flying start
    - Cd009=3: Start after DC braking using starting frequency
- The "flying start" is used to detect the rotation speed of a free-running motor and to turn on power to the motor with a frequency equivalent to the rotation speed. This function can reduce the starting shock to the motor. In this case, be sure to turn on the magnetic contactors (MCs) if any between the motor and the inverter before applying an operation signal.
- Start after DC braking using starting frequency: This is useful for starting a motor smoothly in cases such as when a fan is being blown by a back wind and spinning in the reverse direction. Applying the DC braking to the spinning motor helps reduce the starting shock to the motor. To set DC braking, refer to Cd014 - 016.
- Flying start is applied after auto alarm recovery and restart after a momentary power failure, irrespective of the setting of Cd009.
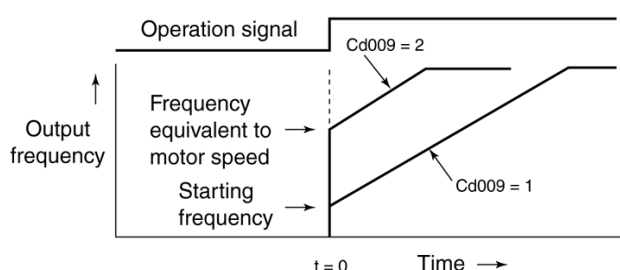
Note 1: The flying start function may not be effective when the capacity of the motor is much smaller than that of the inverter or when the free-running speed of the motor is very low.

Note 2: If the inverter starts a free-running motor with a low frequency, an excessive current may generate and trip the circuit breakers. This function detects not only the free running speed but also the direction of rotation of the motor to eliminate the starting shock to the motor. This function can start the motor in a predetermined rotation direction without any shock even when the motor is free-running in reverse, for example due to a back wind.
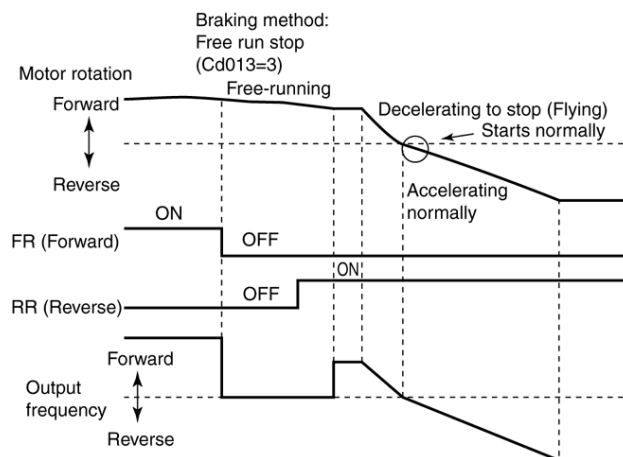
Cd010	Starting Frequency

- The inverter starts to operate with this frequency. If the set frequency is lower than starting frequency, the inverter does not start.
    - Cd010=0.05 - 20Hz (in 0.01Hz step)
    - Example 1: Cd010=20Hz and set frequency=50Hz: When operation signal is turned on, the inverter outputs 20Hz, and then goes up to 50Hz according to the specified acceleration curve.
    - Example 2: Cd010=20Hz and set frequency=15Hz When operation signal is turned on, the inverter remains in standby and does not output.
- Once the inverter starts, it continues to run even if a frequency lower than the starting frequency (but not lower than operation start frequency) is specified afterwards.
- When the stop signal is input, the inverter stops output as soon as the output frequency becomes lower than starting frequency (when DC braking function is not used).

Cd011	Operation Start Frequency

- This frequency value is used to determine whether the inverter can operate or not.
    - Cd011=0 - 20Hz (in 0.01Hz step)
- If the set frequency equals or exceeds the levels of the operation start frequency and the starting frequency, the inverter starts operating at the starting frequency.

If a frequency below the operation start frequency is set during operation, the inverter enters a standby state, and the output frequency drops to the starting frequency and then output stops. In this case, the operation mode indicator on the operation panel flashes, indicating the standby state.

This function is useful for starting or stopping the inverter using only an external frequency command.

Example: Cd011=20Hz, Cd002=3 for the frequency setting using a variable resistor.

By the adjusting the variable resistor, the output starts when the command frequency is 20Hz or higher. At a frequency lower than 20Hz, the output frequency goes down to the starting frequency, and output stops.

$Cd012$	Start Delay Time

- This function is used to set the time until the inverter starts operation after inputting an operation signal.
    Cd012=0 - 5 (sec.) (in 0.1 sec. step)
- This function is useful for setting the delay time with a sequence circuit for changeover between inverter/mains power, etc.
- When a switch between the motor and the inverter turns on at the same time as input of the operation signal, set Cd012 to approximately 0.5 sec.
- Flying start is used for auto alarm recovery.
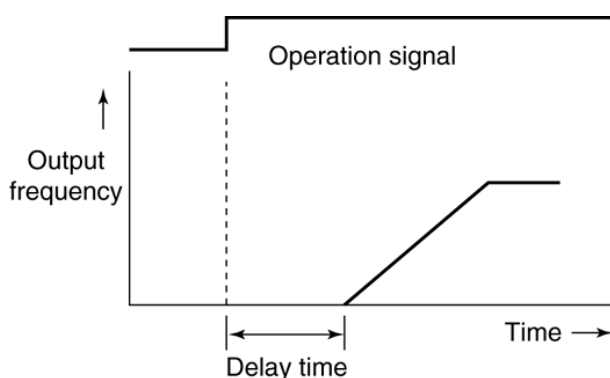
$Cd013$	Braking Method

- This function allows a stop mode to be selected when inputting a stop signal.

    Cd013=1: Deceleration & stop
        A normal stop mode in which the output frequency depends on the settings for the acceleration/deceleration mode (Cd017) and the deceleration time (Cd023-026).

    Cd013=2: Deceleration + DC braking to stop
        The output frequency decreases as with Cd013=1 until it becomes lower than DC

braking start frequency (Cd014), at which point the DC braking is applied to stop the motor quickly. The DC braking time and the DC braking force depend on Cd015 and Cd016.

    Cd013=3: Free run stop
        When input of the stop signal is input, all drive signals from the main switching device are turned off to allow the motor to run free.

$Cd014$	DC Braking Start Frequency
$Cd015$	DC Braking Time
$Cd016$	DC Braking Force

- The frequency at which DC braking is applied, the DC braking time and DC braking force can be specified using these function codes.
    Cd014=0.2 - 20Hz (in 0.01 Hz steps)
    Cd015=0.1 - 10 sec. (in 0.1 sec. steps)
    Cd016=1 - 10 (in steps of 1)
- When Cd013=2, the output frequency drops when a stop signal is input. When the frequency is less than that set by Cd014, DC braking starts.
- When Cd013=2, the starting frequency (Cd010) is invalid during braking. The output frequency decreases down to the frequency specified by Cd014, and DC braking is applied.
- DC braking at operation start:
    DC braking is applied after the operation signal is input and start-up conditions are met. After braking, the inverter starts with the starting frequency. The braking time and the braking force specified by function codes Cd015 and Cd016 apply in this case. For a description of DC braking operation at operation start, refer to Cd009.
- If the set frequency is less than the operation start frequency and the DC braking start frequency when the operation signal is input, operation is as follows, depending on the operation start frequency and the DC braking start frequency.
    (1) Operation start frequency > DC braking start frequency
        When the set frequency is lower than the operation start frequency, the output frequency is reduced to the DC braking start frequency, and DC braking is applied even if the set frequency is greater than the DC braking start frequency.
    (2) Operation start frequency < DC braking start frequency
        • Even if the set frequency is less than the DC

braking start frequency, operation continues if the set frequency is greater than the operation start frequency.

- • If the output frequency is greater than the DC braking start frequency when a set frequency lower than the operation start frequency is specified, the output frequency is reduced to the DC braking start frequency, and DC braking is applied as in (1).
- • If the output frequency is less than the DC braking start frequency when a set frequency lower than the operation start frequency is specified, DC braking is applied immediately.

● Pressing the stop key again during DC braking releases the DC braking.

● If an operation signal is input when DC braking is being applied during a stop operation, operation is restarted according to the usual operation procedures.

Note 1: Cd015 and Cd016 are only effective in the V/f mode (Cd071=1, 3, 4, 6, 7 and 11). In the Sensorless Vector Control Mode (Cd071=2, 5, 8, 9, 10 and 12), the settings of Cd074 - 077 correspond to the settings of Cd015 and Cd016.

Note 2: During DC braking, the motor may overheat because the self cooling effect of the motor's own rotation is ineffective. Therefore, it is recommended to set the DC braking force at a relatively low level to prevent the motor from overheating, or to attach a thermal relay to the motor.

Note 3: If increasing the DC braking force is not effective, it is assumed that a fault has occurred and the resulting overcurrent has actuated the current limiting function.
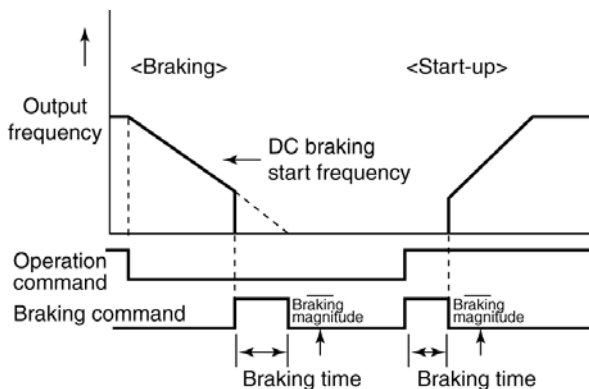

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[ Cd017 ]  Acceleration/Deceleration Curve
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● Linear and S-shaped acceleration/deceleration frequency curves can be selected.

Linear: Cd017 = 1   S-shaped: Cd017 = 2
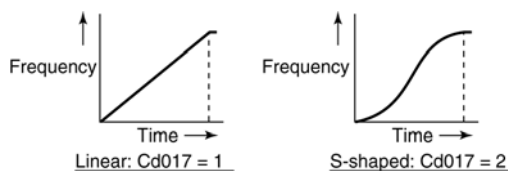
● The S-shaped acceleration/deceleration curve is effective in reducing shock when starting and stopping.
The shape of the S-shaped acceleration/deceleration curve can be changed using Cd090 - 095.

Note: Notes on the use of S-shaped acceleration/deceleration

(1) If the frequency setting is changed during S-shaped acceleration/deceleration, S-shaped acceleration/deceleration is started again for the new frequency setting. Therefore, the change in the actual output frequency is not a smooth curve, bending at the point at which the frequency was changed.

(2) When setting the frequency using external analog signals with Cd002=2 - 12, the analog signals are in fact constantly changing due to noise and ripple components. Therefore, in this case also, the change in the actual output frequency may not be a smooth curve for the reason described in (1). In this case, increasing the filter time constant for analog signals (Cd083) is effective in stabilizing the analog signal value.

(3) During S-shaped acceleration/deceleration, activating the frequency lock (simultaneously inputting a forward run signal and a reverse run signal under external terminal operation) stops any acceleration or deceleration and fixes the output frequency value. When the frequency lock is released, the remainder of the frequency change is applied by starting S-shaped acceleration/deceleration again.

Example) Frequency lock at 20 Hz during acceleration from 10 Hz to 50 Hz

During the frequency lock, the inverter operates at a fixed frequency of 20 Hz. When the lock is released, acceleration begins again from 20 Hz to 50 Hz.

(4) Changing the acceleration/deceleration time (Cd018-Cd026) during S-shaped acceleration/deceleration has no effect until the next acceleration/deceleration. Similarly, switching to another acceleration/deceleration pattern (such as the 2nd acceleration/deceleration) using an external control terminal during acceleration/deceleration has no effect until the next acceleration/deceleration.

(5) When the current limiting function is applied during S-shaped acceleration/deceleration, a linear acceleration/deceleration is used for the remainder of that acceleration/deceleration.

(6) Acceleration/deceleration when the current limiting function is used during constant power operation is conducted with the acceleration/deceleration mode specified by Cd017.

(7) "Forward and reverse run" (A function to temporarily disconnect the operation signal during forward run or reverse run in order to apply an operation signal for the opposite direction of rotation again before the motor stops. Only effective when Cd001=2): In the Sensorless Vector Control Mode (Cd071=2), "forward and reverse run" uses S-shaped acceleration/deceleration based on a reference frequency of 0Hz.

(8) Acceleration/deceleration during the JOG operation also uses S-shaped acceleration/deceleration.

Cd018	Reference Acceleration/Deceleration Frequency
Cd019	1st Acceleration Time
Cd020	2nd Acceleration Time
Cd021	3rd Acceleration Time
Cd022	4th Acceleration Time
Cd023	1st Deceleration Time
Cd024	2nd Deceleration Time
Cd025	3rd Deceleration Time
Cd026	4th Deceleration Time
Cd027	JOG Acceleration/Deceleration Time

● The acceleration/deceleration curve when the output frequency changes from the current value to a newly specified value is determined by specifying the acceleration time, deceleration time and the reference acceleration/deceleration frequency.

● Four different acceleration times and deceleration times can be selected to independently specify four different acceleration curves and deceleration curves. Cd027 specified the acceleration/deceleration curves during the jog operation.
   Cd018=10 - 120Hz (in 0.01Hz steps)
   Cd019 - 026=0 - 6500 sec. (in 0.1 sec. steps)
   Cd027=0 - 20 sec. (in 0.1 sec. steps)
   Example 1:   When Cd018=50Hz and Cd019=5 sec., 10Hz/sec. is selected for the acceleration curve.

● Even if the acceleration/deceleration time is set to 0 sec. in the V/f mode, the actual value is 0.1 sec.

● The 2nd thru 4th acceleration/deceleration times are selected by the combination of signals input to control input terminals AD2 and AD3.
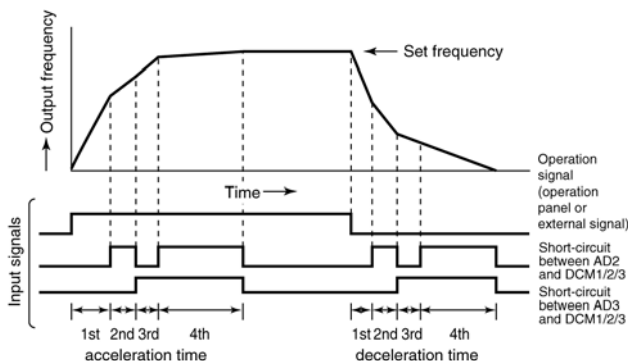
| Cd028 | JOG Frequency |

● The frequency during the jog operation can be specified using this function.

● Selection of the jog operation mode (control input terminals JOG-DCM1, JOG-DCM2 or JOG-DCM3 are shorted) allows the JOG frequency to be specified directly or in steps from the operation panel.
   Cd028=0.1 - 60Hz (in 0.01Hz steps)
Note: As long as the jog operation mode is selected, this mode takes precedence and cannot be changed to any other multi-speed frequency.

Cd029	1st Speed Frequency
Cd030	2nd Speed Frequency
Cd031	3rd Speed Frequency
Cd032	4th Speed Frequency
Cd033	5th Speed Frequency
Cd034	6th Speed Frequency
Cd035	7th Speed Frequency
Cd036	8th Speed Frequency

● This is function used to set frequencies during multi-step speed operation.
   Cd029 - 036= 0 - 600Hz (in 0.01Hz step)

● Multi-speed operation frequencies can be set for any one of the 1st through 8th speeds by a combination of three signals input to terminals 2DF, 3DF and 5DF. The inverter operates according to the multi-speed setting.

● During multi-speed operation, a new frequency can be set directly or in steps from the operation panel.
   Example 1:   Frequency setting using the operation panel when the 3rd frequency is selected: The new frequency specified directly or in steps from the operation panel is stored in Cd031.
   Example 2:   Speed is switched over to 5th speed while changing the set frequency during operation at the 3rd speed:
   1)   When the drive frequency is being changed in steps:
        The output frequency changes to the 5th speed, but the step setting procedure continues to change the specified frequency for the 3rd speed (Cd031).
   2)   When the frequency is being changed directly:
        Output frequency changes to the 5th speed but the newly specified frequency is applied to the 3rd frequency speed (Cd031).
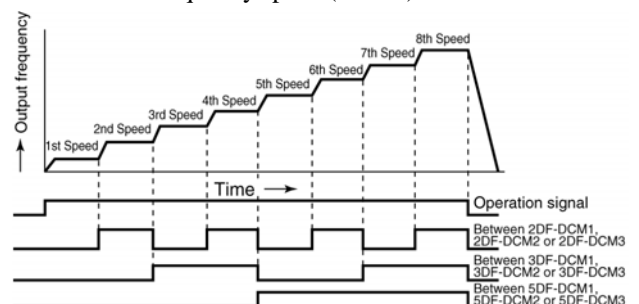
$Cd037$	1st Jump Bottom Frequency
$Cd038$	1st Jump Top Frequency
$Cd039$	2nd Jump Bottom Frequency
$Cd040$	2nd Jump Top Frequency
$Cd041$	3rd Jump Bottom Frequency
$Cd042$	3rd Jump Top Frequency

- Mechanical vibration can occur at the resonant frequency of some mechanical systems, and a beat derived from the power frequency can cause fluctuations in output voltage. This function is used to skip frequencies at which mechanical vibration or fluctuations in the output voltage occur.
- Three different frequencies to skip can be specified.
  Cd037 - 042=0 - 600Hz (in 0.01Hz steps)
- The frequency jumps between the top and bottom frequencies specified by Cd037 through Cd042. No jumps occur during acceleration or deceleration, however.
  Example 1: Cd037=48Hz and Cd038=52Hz
  1) If an output frequency of 51Hz is specified, the inverter continues to operate at 48Hz.
  2) When an output frequency of 53Hz is specified, normal acceleration skips 48-52Hz and reaches 53Hz at which the inverter continues to operate.
  Example 2: Cd037=39Hz, Cd038=43Hz, Cd039=41Hz and Cd040=46Hz
  Jump frequencies are combined, and a width of 39-46Hz is skipped.
- The 1st, 2nd and 3rd jump frequencies can be set independently, for example, 2nd jump > 1st jump > 3rd jump frequencies.
- It is impossible to set the top value lower than the bottom value of the jump frequency. Therefore, when setting the top value or the bottom value, set the values in the correct order so that the top and bottom values are not reversed. (Because in the initial settings both the top and bottom values are specified as 0, setting the bottom value first causes an error, prohibiting the setting.)
- When the upper frequency limit (Cd007) or the lower frequency limit (Cd008) is within the jump frequency range, the upper frequency limit changes to the bottom of the jump frequency, and the lower frequency limit changes to the top of the jump frequency.
- Setting a jump frequency range that includes both the upper frequency limit (Cd007) or highest frequency and the lower frequency limit (Cd008) is prohibited for safety reasons.

$Cd043$	Settings for Output Current Limiting Function

- The current at which the output current limiting function begins to work can be specified. This is useful for driving a motor with a small capacity compared with that of the inverter, or to make the best use of the inverter capacity to achieve the speediest acceleration.

	Code setting	Description
Constant torque load (H characteristic SHF)	Cd043=0	No function
	Cd043=50 - 200%	Sets the ratio of the rated current of the motor to / that of the inverter (in 1% steps).
Square-law torque load (P characteristic /SPF)	Cd043=0	No function
	Cd043=50 - 150%	Sets the ratio of the rated current of the motor to that of the inverter (in 1% steps).

- The output current limiting function is used to limit the inverter's output current to prevent overload during acceleration or during constant power operation. Using this function enables the inverter to temporarily operate in the ways described below:
  1) During acceleration/deceleration: Reduces the acceleration/deceleration gradient. This extends the time until the set frequency is reached. The extended time varies depending on the magnitude of this setting and the inertia of the load. Generally, accelerating/deceleration a load with a large inertia requires a considerable current, requiring a relatively high setting.
     Example 1: Cd043=200% (Constant torque load) Maximum use of the inverter capacity to minimize the acceleration/deceleration time.
     Example 2: Set current limit to the same value as the rated current of a motor with small capacity:
        Cd043=(rated motor current/rated inverter current) × 100%. However the drive frequency can only be specified within a range of 50 - 200% (for square-law torque load, 50 - 150%) of the rated current of the inverter.
  2) During constant power operation: When the inverter's output current reaches or exceeds this setting, the output frequency is automatically reduced. The output frequency is reduced with the acceleration/deceleration gradient specified by Cd045.
     Even during the acceleration/deceleration caused by the output current limiting function during the constant power operation, the output current

limiting function for acceleration/deceleration described in 1) functions.

Note: The current limiting function during constant power operation is generally useful for loads with a reduced torque such as fans and pumps. However, this function has an adverse effect on overloads during constant power operation with loads with normal and constant torque.
The factory preset, therefore, of Cd045 (setting to limit output current during constant power operation) suspends the output current limiting function during operation. It is recommended to set Cd045=1 for loads with a reduced torque (Refer also to Cd003, Cd060).

● The torque limiter functions in sensorless vector control mode obviate the need for the output current limiting function.

| Cd044 | Electrothermal Level Setting |

● The current at which the electrothermal protection begins to function (electrothermal level setting) is specified as a percentage relative to the rated inverter current.

    Cd044=0:   No electrothermal function. However, the thermal protection function prevents overheating of the inverter. This code is useful to drive multiple small motors using one inverter.

    Cd044=20 - 105% (in 1% step)

● When a motor with a small capacity is driven, Cd044 should be set to a small value (as above mentioned).

● For general-purpose motors, the function is usually set to operate earlier due to low cooling efficiency of the motor in the low speed range. Such current correction is not provided for motors designed specifically for use with an inverter (Refer to Cd052 for motor types).

● The electrothermal function is valid during DC braking.

Note: The electrothermal protection functions by monitoring the output current of the inverter to prevent the motor from overloading. It can only be used when one inverter is allocated to each motor. When many small capacity motors are driven with one inverter, each motor should be equipped with a thermal relay connected to the ES control signal terminal (external thermal function) to protect each motor.

Example 1: To drive a 2.2 kW motor using SBT-3.7K, set the function code as follows:
Cd044 = (rated current of 2.2 kW motor)/ (rated current of SBT-3.7K: 17.6 A) × 100%

Example 2: When set to Cd044=50%:
50% of the rated inverter current specified is equivalent to 100% of the load factor of the electrothermal function. Accordingly,

75% of the rated inverter current is equivalent to 150% of the load factor of the electrothermal function.
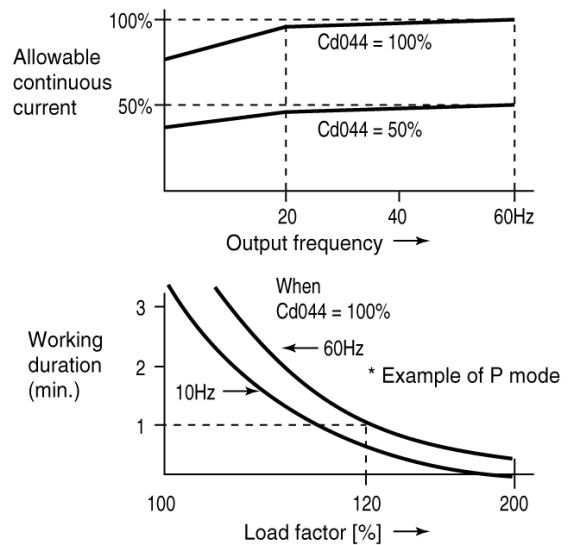
| Cd045 | Output Current Limiting During Constant Power Operation |

● Whether the inverter output limiting function (Cd043) operates can be specified using this function code.

● The motor control mode and the acceleration/deceleration time can be specified. The acceleration/deceleration time can be operated at the time specified with Cd019-Cd026. (The external signal input is not required.)

● For related functions, refer to Cd043 (Settings for Output Current Limiting Function).

    Cd045=0:   No protective function
    Cd045=1:   Use protective function V/F mode only (Currently selected acceleration/ deceleration time)
    Cd045=2:   Use protective function V/F mode only (Acceleration/Deceleration time = Cd019, Cd023: 1st acceleration/deceleration time)
    Cd045=3:   Use protective function V/F mode only (Acceleration/Deceleration time = Cd020, Cd024: 2nd acceleration/deceleration time)
    Cd045=4:   Use protective function V/F mode only (Acceleration/Deceleration time = Cd021, Cd025: 3rd acceleration/deceleration time)
    Cd045=5:   Use protective function V/F mode only (Acceleration/Deceleration time = Cd022, Cd026: 4th acceleration/deceleration time)
    Cd045=6:   Use protective function V/F mode and sensorless vector control mode (Acceleration/Deceleration time = Cd019,

Cd023: 1st acceleration/deceleration time)

Cd045=7: Use protective function V/F mode and sensorless vector control mode (Acceleration/Deceleration time = Cd020, Cd024: 2nd acceleration/deceleration time)

Cd045=8: Use protective function V/F mode and sensorless vector control mode (Acceleration/Deceleration time = Cd021, Cd025: 3rd acceleration/deceleration time)

Cd045=9: Use protective function V/F mode and sensorless vector control mode (Acceleration/Deceleration time = Cd022, Cd026: 4th acceleration/deceleration time)

Note: Output current limiting during constant power operation uses the same function code for 2nd - 4th acceleration/deceleration time.
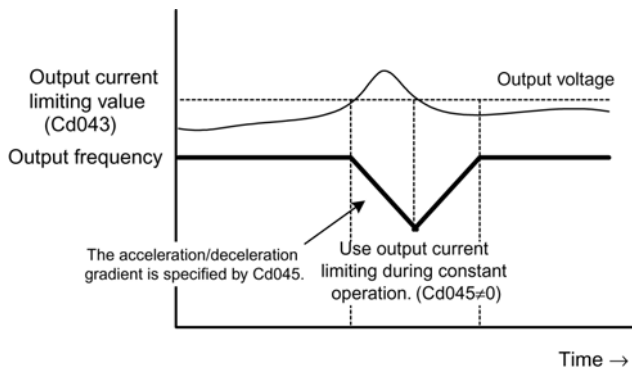
Cd046 Restart After Momentary Power Failure

● Whether the inverter resumes operation after it stops due to a momentary power failure can be specified using this function code. This function works properly only after a momentary power failure. If the duration of the power failure is longer, the control signal is lost, and the status is as shown in the following table.

Cd046	Momentary power failure			Long power failure		
	Operation panel	External control signals		Operation panel	External control signals	
		Operation signal	No operation signal		Operation signal	No operation signal
0: No restart	No restart	No restart	No restart	No restart	Restart	No restart
1: Restart	Restart	Restart	No restart	No restart	Restart	No restart
2. Restart	Restart	Restart	No restart	No restart	Restart	No restart

Note: The inverter starts in the flying start mode after a momentary power failure (or voltage drop).

● When "Cd046=2" (Restart) is selected, the Momentary Power Failure Compensation function is enabled to prolong the operation time of the inverter even in the event of a power failure.

The Momentary Power Failure Compensation function

detects a drop in the input voltage, and reduces the output frequency and voltage of the inverter before any alarms are tripped, and uses the regeneration energy from the motor to keep it operating for longer.

Note 1: While the Momentary Power Failure Compensation function is working, the output frequency of the inverter is reduced. Do not use the Momentary Power Failure Compensation function for loads for which a frequency reduction is not acceptable.

Note 2: When "Cd046=2" is selected, restart after a momentary power failure is the same as "Cd046=1."

Cd047 Auto Alarm Recovery

● This function code specifies whether the inverter automatically restarts after the protective function of the inverter is tripped due to overcurrent or overvoltage.

Cd047=0: No auto alarm recovery function
Cd047=1: Auto alarm recovery function

● The inverter restarts in the flying start mode. The alarm relay does not activate when the inverter is restarted.

● If three consecutive trips occur in 10 seconds, the alarm relay activates.

● When an alarm for which auto recovery is possible occurs during standby and then is released, the recovery method depends on the status at that time.

Standby: Continues in standby.

Conditions for operation are established: Starting frequency is invalid because flying start is used.

● When an alarm for which auto recovery is possible occurs during deceleration due to the stop signal and then is released, auto recovery is performed in the alarm stop status, but operation is not restarted.

● Auto recovery is possible with the following alarms:

oCH : Main switching device temperature abnormality
oCA : Overcurrent during acceleration
oCn : Overcurrent during constant power operation
oCd : Overcurrent during deceleration
ouA : Overvoltage during acceleration
oun : Overvoltage during constant power operation
oud : Overvoltage during deceleration
ouP : Brake resistor protection overvoltage

Cd048 Overload Alarm Level Setting

● This function code specifies the level of current at which an overload alarm is output to the control signal output terminal (can be set using Cd638-Cd640) before the inverter stops or the motor load is damaged.

	Code setting	Description
Constant torque load (H characteristic /SHF)	Cd048= 20 - 200%	Sets the ratio of the rated current of the motor to that of the inverter (in 1% steps).
Square-reduced torque load (P characteristic /SPF)	Cd048= 20 - 150%	Sets the ratio of the rated current of the motor to that of the inverter (in 1% steps).

- For related functions, refer to 4.2(6) multifunctional output terminals.
    Cd638-Cd640=8:   Output only in constant operation.
    Cd638-Cd640=34: Output when in operation.

`Cd049` Duty Cycle of Brake Resistor

- This function code specifies the duty cycle of the brake resistor. A setting within the allowable duty cycle should be selected.
    Cd049=0:   No brake resistor provided
    Cd049=2 - 25% ED (in steps of 1%ED)
    Cd049=99: External brake unit in use
- With Cd049=2 - 25, when it is judged that overcurrent has been flowing to the brake resistance for a long time, the function of the brake transistor is stopped temporarily to prevent the brake resistor from burning out.
    Note :   Set Cd049=99 for braking using an external circuit.

`Cd050` Direction of Rotation of Motor

- This function is useful to restrict the rotation of the motor to a fixed direction for safety reasons etc.
    Cd050=1:   Forward and reverse
    Cd050=2:   Forward only
    Cd050=3:   Reverse only
    Note 1: The direction of rotation of the motor that is actually "forward" or "reverse" depends on the construction of the motor and wiring between the inverter and the motor. Confirm which direction the motor actually runs when the "forward" or "reverse" run command is given to the inverter during a test run.
    Note 2: When the (DRIVE) key on the operation panel is pressed, the motor starts rotating in the direction set by Cd130.

`Cd051` Carrier Frequency

- This function sets the carrier frequency of the inverter. As the value of the Cd051 code increases, the carrier frequency goes higher. The maximum carrier frequency automatically varies according to the operating status and motor capacity.
    Cd051=0 - 130
    Note 1: When the carrier frequency is low, the carrier noise on the inverter increases, but the leak current

flowing to earth decreases.
    Note 2: Raise the carrier frequency to set the inverter output frequency high.

`Cd052` Motor Types

- The type of motor connected to the inverter is specified using this function code.
    Cd052=1:   General-purpose motor
    Cd052=2:   Motor designed specifically for inverter or variable speed motor
- For details of related functions, refer to Cd044 (electro-thermal level setting).

`Cd053` Poles, Voltage and Capacity of Motor

- The number of poles, voltage and capacity of the motor connected to the inverter are specified using this function code.
    Cd053= X Y ZZZ
                X: Number of poles
                Y: Rated voltage
                Z: Motor capacity
- Specify an appropriate value for each position using the operation panel keys (▲), (▼) and (ENTER).
- Acceptable settings and the corresponding display values are shown below.
    1)   Input one of four even numbers from 2 to 8 for the number of poles.

2	4	6	8

    2)   Input one of the following designation numbers for the rated voltage.

Designation No.	1	2	3	4	5	6	7	8
Corresponding voltage	200	220	230	380	400	415	440	460

(in [V])

    3)   Motor capacity: Motor capacity settings are listed below.

0.37	Δ0.4	0.55	0.75	Δ1.1	Δ1.5	Δ2.2
Δ3.0	Δ3.7	Δ4.0	Δ5.5	Δ7.5	11.0	15.0
18.5	22.0	30.0	37.0	45.0	55.0	75.0
90.0	110	132	160	200	220	250
280	315					

[Δ indicates a space]
(in [kW])

Example: Indication on the 7-segment display for a 220V, 2.2kW motor with four poles:

42 2.2

- 65 -

Example of key operation:

To change the rated voltage of the 220V, 2.2kW motor with four poles to 200V:
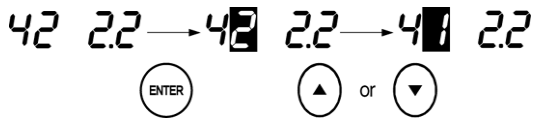
Note: In the V/f mode (Cd071=1), the value for the number of poles is indicated in place of the rotation speed. In the sensorless vector control mode (Cd071=2), the settings of the above function code (Cd053) provide the basis on which different parameters for controlling the inverter are determined. The above settings, therefore, must be specified properly for operation in the sensorless vector control mode. The settings shown below should generally be specified for the sensorless vector control mode. If motors with other specifications are planned to be used in the sensorless vector control mode, contact the supplier for details of how to set these values and other data.

Number of poles: 4 or 6
Rated voltage: 3 or less for a 200V type inverter
4 or more for a 400V type inverter
Motor capacity: If the motor does not have a capacity equal to or one level lower than the inverter, E_r C may be displayed.

Cd054	Bias Frequency (VRF1)
Cd055	Gain Frequency (VRF1)
Cd062	Bias Frequency (IRF/VRF2)
Cd063	Gain Frequency (IRF/VRF2)

● This function sets a frequency (bias frequency) corresponding to the minimum analog setting signal (0V or 4mA), and a frequency (gain frequency) corresponding to the maximum (5V or 10V and 20mA), used when the output frequency is controlled by analog signals.

Cd054, Cd062=0 to ±600Hz (in 0.1Hz step)
Cd055, Cd063=0 to ±600Hz (in 0.1Hz step)
"P×××" is displayed for plus, and "–×××", for minus.

Adjust input from the VRF1 terminal using Cd054 or Cd055.

Adjust input from the IRF/VRF2 terminal using Cd062 or Cd063.
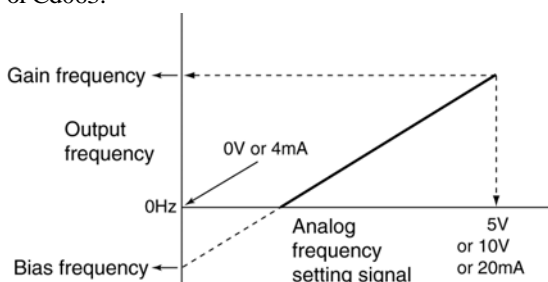
Setting example: Cd054=-10Hz,Cd055=90Hz,Cd002=3
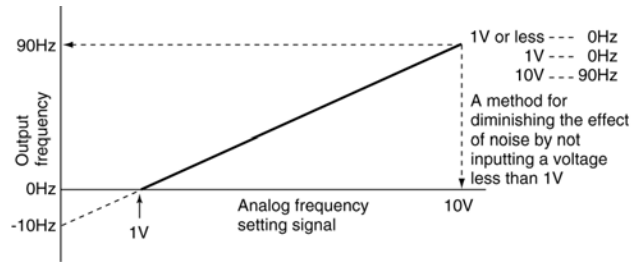
● By taking advantage of bias and gain frequencies, a common analog signal for frequency commands can be input to more than one inverter for proportional operation.

Example: Input 0 - 10V analog signals to two inverters, so that 1st and 2nd inverters deliver output frequencies with a ratio of 1:2 for the purpose of proportional operation.
Setting for the 1st inverter: Cd054=0Hz, Cd055=50Hz
Setting for the 2nd inverter: Cd054=0Hz, Cd055=100Hz
(The acceleration time should be adjusted as necessary.)

Note 1: In negative setting frequency range, the output frequency is 0Hz.
Note 2: For PID control with "Cd071=3," the bias and gain frequencies apply to the feedback signal.

| Cd056 | Approach Frequency |

● This function specifies the frequency at which a frequency approach signal is output.
Cd056=0 - 600Hz (in 0.01Hz steps)
● If the value of any of Cd638 to 640 is 7, the signal is output to terminals DO1 to DO3 when the output frequency exceeds the setting of Cd056.

| Cd057 | Frequency Matching Range |

● This function specifies the frequency range in which the frequency matching signal is output.
Cd057=0 - 10Hz (in 0.01Hz steps)
● If the value of any of Cd638 to 640 is 5, 6, 14 or 15, the frequency matching signal is output to terminals DO1 to DO3 when the output frequency is within the range specified by Cd057.

Note: When the frequency is specified using an analog signal, an appropriate setting should be specified using Cd057 to prevent chattering. When the sensorless vector control or PG option is active, the output frequency constantly fluctuates. Set Cd057 to several Hz.

Cd058 — Multiple for No-Units Display

- This function is used in the No-Units mode of the 7-segment display on the operation panel. It sets the multiple for the output frequency when Cd059=1 (No-units display)

  Cd058=0.01 - 100 (in 0.01 step)
- This function is useful for indicating values such as the line speed.

Cd059 — Display Selection

- This function is used to select output data displayed on the 7-segment display on the operation panel in No-Units Display mode.

  Cd059=1: No units (multiple of Cd058)
  Cd059=2: PID feedback frequency [Hz]
  Cd059=3: Command pressure [MPa] (option)
  Cd059=4: Set pressure [MPa] (option)
  Cd059=5: Command frequency [Hz]
  Cd059=6: Fin temperature [°C]
  Cd059=7: Detecting speed [rpm] (option)
  Cd059=8: Regular pump switching integrated time [H] (option)
  Cd059=9-10: Reserved
  Cd059=11: Detecting position [mm] (option)
  Cd059=12: DC voltage [V]
- In No-Units Display mode, the display on the 7-segment display can be changed with the step keys only when "No Units (Cd059=1)" is selected. If the value is changed using the step keys, the preset frequency also changes. The numeric keys cannot be used to change the display value on the 7-segment display.
- If a function code other than "No Units (Cd059=1)" is selected, the display on the 7-segment display cannot be changed using the step or numeric keys.

Cd060 — Rating Selection

- This function is used to switch ratings to the H (constant torque load) or P characteristic (square-reduced torque load).

  Cd060=1: H characteristic (constant torque load)
  Cd060=2: P characteristic (square-reduced torque load)
- If ratings are switched, the initial values of the selected ratings are used as the values of function codes whose ranges or initial values depend on the ratings.

  Note: This function is valid for SBT series only.

Cd061 — Instability Elimination

- When the inverter is used to drive a motor, the dead time to protect a switching device from a short circuit may make the current unstable. If the current becomes unstable, the motor may generate vibration or abnormal noises. In addition, the current value may become greater than when the current is stable. The instability elimination function is used to avoid this problem.

  Cd061=0 to 20 (in step of 1)

    The larger the value specified, the greater the compensation. Therefore, increase the value gradually to find the value at which instability is eliminated.

Cd064 — Discharge Resistor on Signal Output Time

- This function is used to output signals from a multi-functional output terminal for the time set with Cd064 when the internal discharge resistor for regenerated power discharge is turned on.

  Cd064=0.01 - 10 s
- Set Cd638, Cd389, or Cd640 to "30" for the multifunctional output terminal setting. The discharge resistor on signal is output from the terminal which is set to "30".
- During regenerated energy discharge, the discharge resistor switches on and off very quickly. The Discharge Resistor on Signal function facilitates the measurement of this high-speed on/off operation with a narrow pulse width by means of external equipment. The narrow pulse width of the on/off operation is expanded by the time set with Cd064 and output to a multifunctional output terminal.

  Example: When the Discharge Resistor on Signal Output Time Cd064=0.1 s.
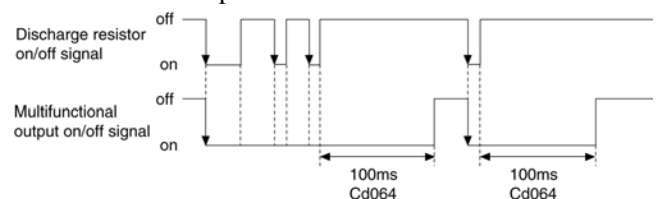
Cd065 — Set Frequency Gain Function

- This function multiplies a set frequency by a gain set using an external analog input terminal.

  Cd065=0-100% (in step of 1%)
- When several inverters are used for proportional operation, this function is useful for adjusting the command frequencies of the inverters from the master to the slave precisely.
- The external analog input terminal is selected with Cd120 "Analog Input Switching."

● The value set by Cd065 is multiplied by the given gain and added to or subtracted from the set frequency.

    Example: When the set frequency is 50 Hz, Cd065 is 50%, and the external analog input is 0 to 10V.

VRF1 or IRF/VRF2 input
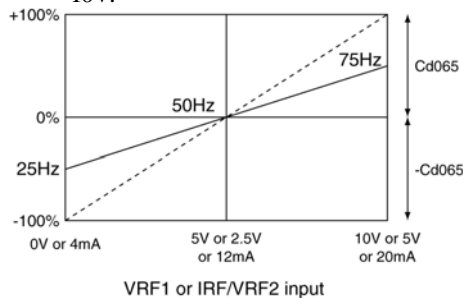
- 0V: $50\,\text{Hz} - (50\,\text{Hz} \times 50\%) = 25\,\text{Hz}$
- 5V: $50\,\text{Hz} - (50\,\text{Hz} \times 0\%) = 50\,\text{Hz}$
- 10V: $50\,\text{Hz} + (50\,\text{Hz} \times 50\%) = 75\,\text{Hz}$

Note: Since Cd120 is used, this function cannot be used together with the PID, energy saving, or disturbed operation functions that share the same function code Cd120. This function works when Cd065 is set to a value other than 0. To allow another function to use Cd120, set Cd065=0.

| Cd066 | V·f separate function selection |

● This function specifies the operation of Cd071=11 V·f separate control.

    Cd066=1: V·f comparison
    Cd066=2: Complete separation

| Cd067 | MBS Terminal Input Mode |

● This function is used to select the operation of the MBS input signal input to the multifunctional input terminal.

    Cd067=1: Level operation
    Cd067=2: Edge operation
                Edge operation will accept MBS input once between OFF and ON.

| Cd068 | Internal analog output bias 1 |
| Cd069 | Internal analog output bias 2 |

● This function specifies the bias to the analog output specified by the internal analog output function 1 and internal analog output function 2.

    Cd068, Cd069=0 - ±10.0 V (0.1 step)
    The following is displayed:
        Plus: Pxx.x
        Minus: -xx.x
    Cd068:   The bias for Cd126 internal analog output function 1.
    Cd069:   The bias for Cd128 internal analog output function 2.

Example: When internal analog output is set frequency, set frequency is output at 120 Hz 10 V.

a) Bias = 0 V   b) Bias = 5 V
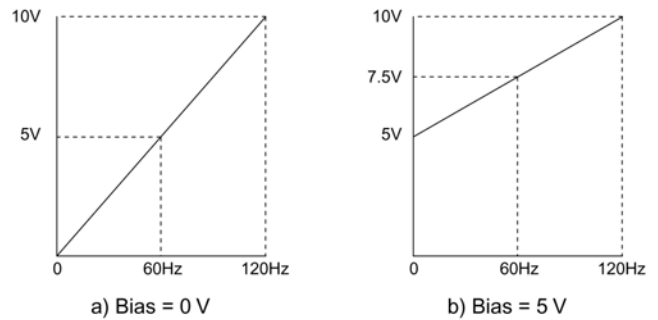
Note 1: When the analog output is in negative range by the bias, the output is 0 V.

Note 2: The analog output cannot be set higher than 10 V even if the bias setting is high.

| Cd070 | ES Input Terminal |

● The control input terminal ES can be switched between the following.

    Cd070=1: ES terminal (external thermal signal input terminal) is connected with an NO (normally open) contact.
    Cd070=2: ES terminal (external thermal signal input terminal) is connected with an NC (normally closed) contact.

| Cd071 | Motor Control Mode Selection |

● Function to select a motor control mode.

    Cd071=1: V/f mode
    Cd071=2: Sensorless vector control mode
    Cd071=3: Internal PID control mode (V/f mode base)
    Cd071=4: Position control (option)
    Cd071=5: Speed control (option)
    Cd071=6: Simple energy-saving control mode (V/f mode base)
    Cd071=7: Auto energy-saving control mode 1 (V/f mode base)
    Cd071=8: Auto energy-saving control mode 2 (sensorless vector control mode base)
    Cd071=9: Auto tuning mode 1
    Cd071=10: Auto tuning mode 2
    Cd071=11: Vf separate control
    Cd071=12: Switching between sensorless vector control and V/f control

● The V/f mode controls the motor with a specified V/f pattern.

● Sensorless vector control mode

    • The sensorless vector control mode is used for automatic constant speed control during constant power operation, irrespective of the load status. At

the same time, this control mode is able to generate a high torque in a low-frequency range to the motor.

• In the sensorless vector control mode, because the motor constant is used to control frequency and voltage and drive the motor, the control characteristic depends on the motor constant. For that reason, some motors may not deliver their best performance. When the motor characteristics cannot be determined, it is recommended to carry out auto tuning of the motor constant with the auto tuning mode in advance or to use the V/f mode, which does not depend on the motor constant.

• When external terminal board operation (Cd001=2) is specified, "forward/reverse run" can be conducted. When the operation is signal is temporarily cut off during forward or reverse operation but before the inverter stops, the opposite signal is input, then the inverter decelerates, and begins to accelerate again at 0 Hz. This allows an uninterrupted transition from forward to reverse rotation.

Note 1: When specifying the sensorless vector control mode, it is necessary to meet the following conditions.
  (1) One motor for one inverter.
  (2) The motor must be a Sanken designated 4-pole or 6-pole 3-phase conducting motor or a similar motor.
  (3) The motor drive capacity must be equal to that of the standard motor suitable for the inverter rating or one rank below.
  (4) The wiring length between the inverter and the motor shall be less than 30 m.
    If the wiring length exceeds 30 m, conduct auto tuning of the motor constant in advance using the auto tuning mode.

Note 2: Settings not failing under (2) and (3) in Note 1 cannot be specified for Cd053. Set the mode correctly in accordance with the above. When the setting of Cd053 and the connected motor rating do not match, the function and the control characteristic of the inverter cannot be guaranteed.

Note 3: When the sensorless vector control mode is specified, the following function codes are restricted:
  Cd004 - Cd008:
    Settings are invalid.
  Cd009=1, 3:
    Settings are invalid.
    Starting excitation is performed according to the setting of starting excitation time (Cd075), and operation starts from 1 Hz. However, the settings of the operation start frequency (Cd011) and the start delay time (Cd012) take precedence.
  Cd010:
    Settings are invalid.
  Cd013=1, 2:
    Deceleration is carried out according to the setting of the gradient of deceleration due to a

stop signal. When the output frequency reaches either the DC braking start frequency (Cd014) or the operation start frequency (Cd011), whichever is lower, braking excitation depending on the braking excitation time setting (Cd077) stops the inverter. The relationship between the output frequency and the settings of Cd011 and Cd014 is controlled similar way to the V/f mode.
  Cd015, 016:
    The function on DC braking changes to Cd074 - 077.
  Cd043, 045:
    The function on current limiting changes to Cd072, 073.

Note 4: Other notes
  (1) With the motor's rated speed of rotation as the synchronous speed, specify the frequency determined by the motor's poles and synchronous speed as the maximum value of the set frequency. Driving the motor with a frequency setting over this value causes the motor to overheat.
  (2) In constant power operation, because the motor's speed of rotation is controlled to keep it constant, the frequency that the inverter actually outputs constantly varies. In contrast to the case of the V/f mode, the set frequency and the output frequency do not necessarily coincide in constant power operation. Therefore, the output frequency may exceed the set frequency.
  (3) "Frequency approach" and "frequency matching" specified by Cd638, 639 and 640 determine when the output frequency reaches or matches the set frequency. Therefore, for the "frequency matching" function, set the frequency matching range (Cd057) to a few Hz because of the phenomenon described in (2).
  (4) All values output to the operation panel's 7-segment display are based on the command frequency. In the case of the frequency display mode, the command frequency is displayed. In the case of the rotation and no-units display mode, the command frequency multiplied by a designated value is displayed.
  (5) It is possible to set a frequency lower than 1Hz, but the inverter operates at 1Hz.

● Cd071=3 internal PID control mode
  • This function uses an analog signal (4mA to 20mA, 0V to 5V, 0V to 10V) from the external converter as a feedback signal to the inverter, compares it with the set frequency of the inverter to obtain the deviation, and P (proportional), I (integral), or D (differential) control is used to control the operation of the load to keep it to the specified value.
  • This function is valid in the V/f mode. Therefore, if the speed of rotation of the load is expected to drop due to fluctuation in the load, this function uses an analog feedback signal (e.g. from a speed sensor) to perform PID control in a closed loop. Thus the

steady operation of the motor (load) is assured despite fluctuations in the load.

1) Related function codes and control terminals of the inverter

Function code		Control terminal of the inverter	
Cd071=3	Internal PID Control Mode	VRF1	Voltage Feedback Input
Cd120= 1 - 5	Analog Input Switching	VRF2	Voltage Feedback Input
Cd122= 0.00 - 100.00	PID Control Proportional Gain	IRF	Current Feedback Input
Cd123= 0.00 - 100.00	PID Control Integral Gain	ACM	Analog Signal Common Terminal
Cd124= 0.00 - 100.00	PID Control Differential Gain		
Cd125= 1 - 500	Feedback Input Filter Time Constant		

2) Example of using the function
   • Figure 7.1 shows a basic example of using the PID control function. (This example assumes both command and feedback signals are analog signals.)

   IRF/VRF2 terminal:
      Inputs a feedback signal in the form of a current signal (4mA to 20mA (specified by "Cd120=5")).

   VRF1 terminal:
      Inputs a set frequency in the form of a voltage signal (0V to 10V (specified by "Cd002=3")) as a feedback signal.

   The set frequency and the feedback signal can be combined in different ways as long as the VRF1 analog input (voltage input) and the IRF analog input (current input) of the inverter do not conflict. (Only positive analog values can be entered.)

      Set frequency → Cd002 (Inputs a set value in the specified mode.)
      Feedback signal → Cd120 (Inputs a signal to the VRF1 or IRF/VRF2 terminal.)
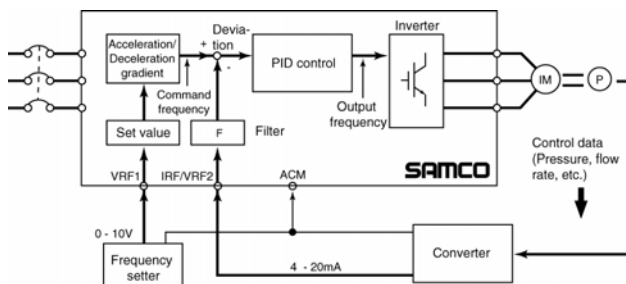
Figure 7.1

3) Filter function
   • When the feedback signal is likely to contain noise, adjust the time constant of the feedback input filter (Cd125). "F" in Figure 7.1 indicates a filter.
   • The time constant (Cd125) is represented in the format "N × 10msec" (N = 1 to 500). (The time constant is in the range 10msec to 5000msec.) When "Cd125=1" is set, the filter function is invalidated as the sampling cycle is 10msec.

   Note: A greater filter time constant may delay the control response and reduce the controllability.

4) Entering a set value (converting the feedback to a frequency)
   • The set value is entered in the form of a frequency from the operation panel or the external analog input. Figure 7.2 shows how a set value (frequency) is determined for the pressure converter in Figure 7.1.

   (1) Read the Y-axis value (Is) of a point on the P-I line at which the vertical line passing through X = Pset intersects.

   (2) Read the X-axis value (Fset) of a point on the F-I line at which the horizontal line passing through Y = Is intersects. The Fset value is the set frequency.

   (3) Enter this frequency value from the operation panel or the external analog input.
      The F-I characteristic line is the gain frequency set by "Cd055" at 20mA, 5V, and 10V (the maximum feedback input set by "Cd120").

   Note 1: Set the gain of the feedback input in the form of a frequency for the maximum analog input value with "Cd055" or "Cd063".

   Note 2: When the starting frequency is greater than the feedback input frequency, the command frequency is increased from the feedback input frequency.

Figure 7.2

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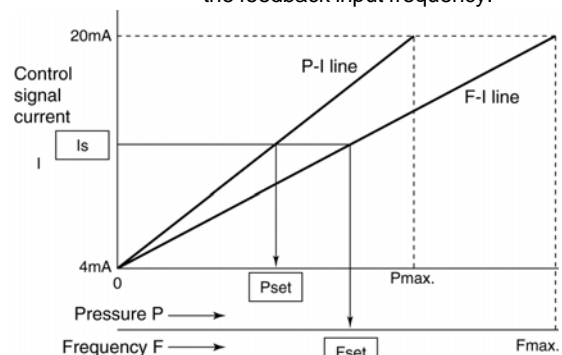
5) Setting a PID gain
   • Adjust the PID gain by referring to the block diagram in Figure 7.3.
   The sampling cycle (software processing cycle) for PID control is 10msec.

Command value + Deviation F_e → Output frequency F_o
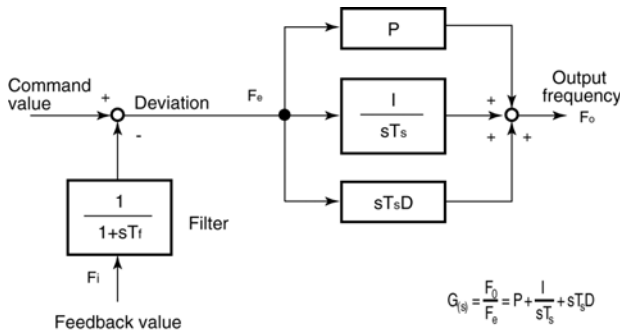
$$G_{(s)} = \frac{F_0}{F_e} = P + \frac{I}{sT_s} + sT_sD$$

P: Proportional gain (Cd122)
I: Integral gain (Cd123)
D: Differential gain (Cd124)
Ts: Sampling cycle=10ms
Tf: Filter time constant (Cd125)
S: Laplacean operator

Figure 7.3

Note 1: If only the P gain is set (without the I gain), a steady deviation is output.
Note 2: An excessive D gain will make the output frequency change rapidly. Use it only if required.

6) Example of PID control
   • An actual PID control example is shown in Figure 7.4. When the Inverter ON command is entered and acceleration starts, the inverter starts PID control. The command frequency is accelerated to the set frequency gradually in the currently applicable acceleration time. The PID operation uses the deviation between the command frequency and the feedback frequency to change the output frequency so as to make the feedback value follow the command value. This PID control is performed also in the constant power operation and during deceleration.
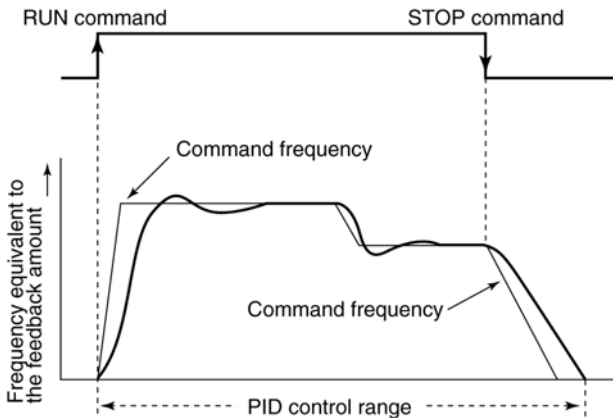
Figure 7.4

7) Recommended code settings

Step1
Range of target setting values
A MPa/rpm to B MPa/rpm
A: Minimum target setting value
B: Maximum target setting value
Check: Is the ratio of A to B 1:200 or less?
Yes

Step2
Feedback level to target setting value
C V/A to D V/A
C: Detection value when feedback value is A
D: Detection value when feedback value is B
Check: Are C and D 0V to 5V (0V to 10V or 4mA to 20mA)?

Code setting
Voltage feedback:
Cd120 = 1 or 3 if D<5V
Cd120 = 2 or 4 if D≥5V
Current feedback:
Cd120 = 3
Yes

Step3
Feedback gain
E MPa/rpm to F MPa/rpm
E: Control amount during 0V (4mA) feedback
F: Control amount during 5V (10V or 20mA) feedback

Relationship between control amount and FB value
Can also be calculated from:
$Y(V) = (C-D)/(A-B) \times X(MPa) + (AD-BC)/(A-B)$

Step4
(Load) Motor drive frequency
G Hz to H Hz
G: Minimum drive frequency
H: Maximum drive frequency
Check: Are G and H within 0.05Hz to 600Hz?

Code setting
Set:
Cd008 (Lower frequency limit) = G
Cd007 (Upper frequency limit) = H
Yes

Step5
Bias and gain frequency setting
I Hz = 0(zero)
J Hz = Frequency conversion value of the sensor max.
I: Bias frequency
J: Gain frequency

Code setting
Set:
Cd054 (bias) = I
Cd055 (gain) = J

Step6
Acceleration/deceleration time setting
Set in accordance with the recommended values in Figure 7.5.
Fan, pump: Must be equal to or less than the factory preset. Power of 22kW or greater must not exceed 30 sec.
Example: SBT 1.5kW → Cd019, 023 = 5 sec. or less

Code setting
Set Cd019 and Cd023

Note: Acceleration operation using PID control differs from regular operation because the acceleration/deceleration gradient of the command value is not consistent with the acceleration/deceleration gradient of the output frequency. Set the acceleration/deceleration time lower than the factory preset in order to be able to suitably adjust PID gain.

Step7
PI gain adjustment

1. Test operation is performed with the default settings. Are characteristics satisfied? Yes
No

Slow response	There is a ripple:	Resonance occurs	Overcurrent occurs during acceleration
Acceleration/deceleration is slow: Increase gain (double). Load response is slow during constant power operation: Increase P gain (double).	Lower P gain or increase filter time constant (Cd125) (double).	Increase P gain (double) or lower I gain (by 1/2).	Lower I gain (by 1/2).
		Refer to Figure 7.6	Refer to Figure 7.7

Adjustment completed

Note: Please contact a sales office if each step results in a "No."
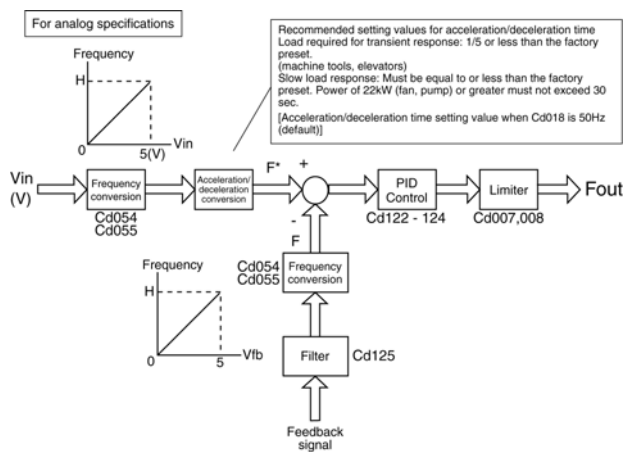
Figure 7.5
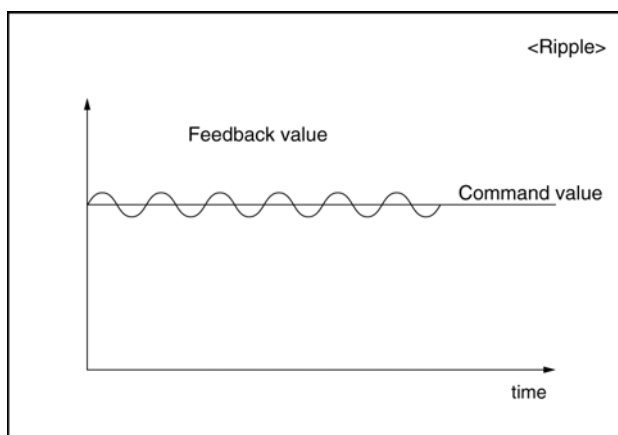
Figure 7.6
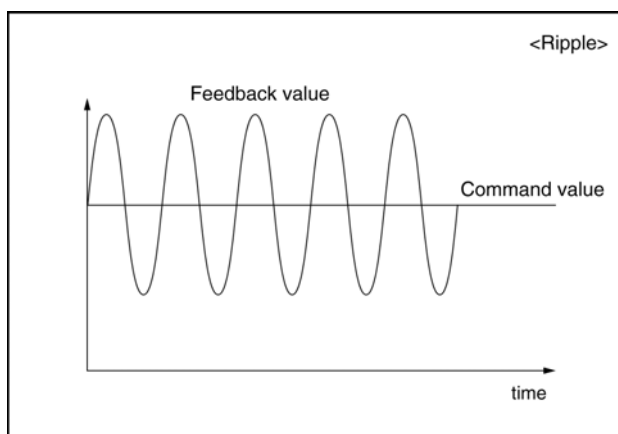
Figure 7.7

8) PID control switching signal
- PID control can be enabled or disabled using an external signal (PID) if one of the function codes Cd630 to Cd637 for multifunctional input terminal selection is set to the following:
  46: PID control switching signal (PID)
- If multifunctional input terminal PID goes on

when the inverter is not operating, not feedback PID control but ordinary V/f constant control is activated even though internal PID control is specified.

- This function is useful when you need to switch easily between PID control mode and ordinary operation mode (V/f constant mode).
  Note 1: This switching is valid only when the inverter is not operating. Inputting the PID control signal only switches to the V/f mode when the inverter is stopped.
  Note 2: This function is invalid for PID operations in modes other than the frequency setting mode. (For example, this function is invalid when the water supply option is used in the pressure setting mode.)

9) Notes
- Do not enter a negative feedback value because the feedback input has no polarity.
- The Jump Frequency functions Cd037 to Cd042 are disabled.
- The flying start function is available during PID control.
- The multi-speed function is available during PID control. (PID control is performed according to the selected set frequency.)
- The frequency value displayed on the operation panel during PID control indicates the output frequency of the inverter.
- Set Cd122 to Cd124 to "0" when either the P, I, or D operations respectively are not required.
- Connect the feedback signal correctly to the selected control input terminal (VRF1 or IRF/VRF2) of the inverter (according to the setting of Cd120).
- When a line break in the feedback system is detected or no feedback is input during PID control operation, the inverter alarm-stops with "$CAL\ 1$" displayed on the 7-segment display.
- The Output Current Limiting function (Cd043) accelerates or decelerates the command frequency before PID operation. Therefore, the output current may not be limited for some PID gain values. Set the gain values carefully.
- The output frequency is limited between the upper frequency limit and the lower frequency limit during steady operation (as in the normal operation).
- When an upper frequency limit (Cd007) below the output frequency is set during the PID control operation, the output frequency is immediately limited to the upper frequency limit. In an extreme case, a steep deceleration may result in an alarm-stop. Be careful when changing the upper frequency limit.

- Cd071=6 Simple Energy-Saving function
  - This function saves energy by reducing only the voltage command by a specified amount in the steady operation a preset time after the acceleration is completed in the V/f mode.

- Generally, the power to loads (such as fans and pumps) can be reduced by reducing the output voltage of the inverter during V/f constant control (to reduce the current input to the motor). This function enables manual setting of the voltage-frequency relationship to satisfy the load torque characteristics.
  1) Related function codes
     Function code
     Cd071=6 Simple Energy-Saving Control Mode
     Cd103=0.0 - 6500.0 sec. Operation Timer T1
     Cd121=0 - 50%   Simple Energy-Saving Rate
  2) Operation in the Simple Energy-Saving Control Mode
     - When the RUN command is input to the inverter, the inverter begins ordinary acceleration until the operation becomes steady. If the Simple Energy-Saving Control mode (Cd071=6) is selected, the Simple Energy-Saving function starts a specified time (determined by the operation timer Cd103) after the operation becomes steady. This function reduces the output voltage of the inverter by a rate set by Cd121. For example, when the output voltage of the inverter (before the Simple Energy-Saving Control mode is set) is approx. 200V and the value set by Cd121 is 50%, this function reduces the output voltage gradually down to 100V. The energy-saving rate (Cd121) can also be changed while the inverter is in operation. Select a value suitable for the characteristics of the load.
     - Once the Simple Energy-Saving function starts, this function performs V/f control on the subsequent output voltage at a preset voltage reduction rate even when the command frequency is changed. However, when a STOP command is entered, this function gradually increases the output voltage towards the original output voltage. When it reaches the original output voltage, the inverter starts deceleration.
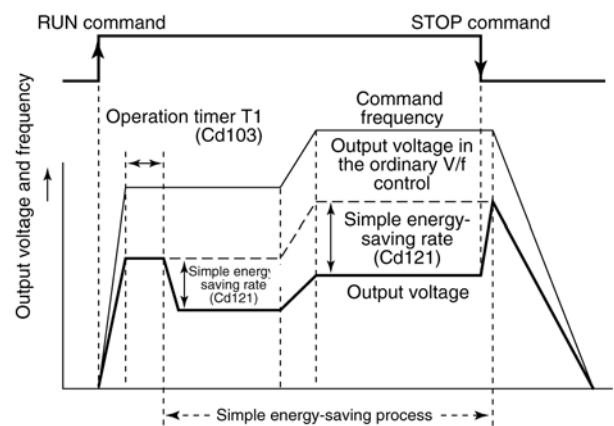
  3) Output reducing/restoring time
     - The Simple Energy-Saving function reduces the voltage very slowly so as not to apply a steep torque change to the load (about 10 seconds for the maximum output voltage).
       Example 1:   When the energy saving control is used at an energy-saving rate of 50% while the inverter (having a maximum output voltage of 440V) is outputting 200V to run the load, the output voltage is reduced down to 100V in about 2.3 seconds.
     - When the STOP command is entered, the original output voltage is restored in about 1 second to prevent reduction of the braking force due to insufficient load torque.
       Example 2:   In Example 1, the original output voltage is restored in about 0.23 second after the STOP command is entered. When it reaches the original output voltage, the inverter starts deceleration.
  4) Notes:
     - The Simple Energy-Saving function reduces only the output voltage of the inverter for energy saving. For some kinds of loads, this voltage reduction may cause a drop in the speed of rotation. Therefore, to perform energy-saving without reducing the speed of rotation of the load, it is recommended to combine the PID control function and Auto Energy-Saving Control Mode 1 or 2.
     - Do not use this function for loads where energy-saving cannot be expected to be achieved by reducing the output voltage of the inverter.
     - When operation is started by the Flying Start function, the Auto Alarm Recovery function, or the Restart after Momentary Power Failure function, the Simple Energy-Saving function is restarted from the beginning. (The flying-start operation is enabled.)
     - When the inverter is stopped during Simple Energy-Saving, deceleration is carried out after the output

voltage has returned to the original voltage value. Therefore, the time period between applying the STOP command and the actual stop of the load varies according to this time period. Consider this time period when performing sequence control.

● Cd071=7 Auto Energy-Saving Control Mode 1 (V/f mode base)

• This energy-saving mode is based on the V/f mode and saves energy by supplying the most efficient voltage to the required load torque.

• While the Simple Energy-Saving function requires manual adjustment of the optimum voltage value, the Auto Energy-Saving function automatically calculates the voltage values that are most efficient for the changing load, and thus provides stable energy saving.

• To perform energy-saving during motor speed control or feedback control, provide sensors in the system and use them together with the PID control function. (Set Cd120=1 to 5 for details of the PID control function.)

1) Related function code
   Function code
   Cd071=7 Auto Energy-Saving Control Mode 1

2) Operation in Auto Energy-Saving Control Mode 1

• The Auto Energy-Saving Control Mode 1 function is enabled when "Cd071=7" is set. No adjustment using the other function codes is required.

• Auto Energy-Saving Control Mode 1 starts after the inverter is started in Auto Energy-Saving Control Mode 1 and the operation of the load becomes steady. During energy-saving, the function calculates the output voltage of the inverter for the most efficient operation of the load and changes the voltage gradually.

• As this function is always active during energy saving, the same energy-saving effect can also be obtained when the torque of the load is changing gradually. When the set frequency or the load torque changes rapidly, the inverter recovers from the energy-saving operation and makes up for the insufficient torque.
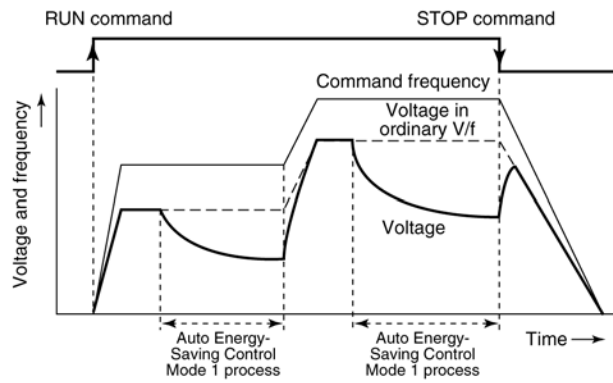
3) Notes

• This function controls only the output voltage of the inverter for energy saving. For some kinds of loads, this voltage reduction may cause a drop in the speed of rotation. Therefore, to perform energy-saving without reducing the speed of rotation of the load, it is recommended to combine the PID control function and Auto Energy-Saving Control Mode 1. The PID function is enabled by setting Cd120 to a value between 1 and 5. Set Cd120=1 to 5 for the PID control function.

• The time required to reduce or increase the voltage to the most efficient voltage value depends on the load status at that time.

• When the set frequency is changed, when the STOP command is entered, or when the load changes rapidly, the load torque becomes insufficient and the driving ability reduces. To counter this, the function restores the output voltage to the original voltage in a few milliseconds.

• Unlike the Simple Energy-Saving function, the Auto Energy-Saving function starts to decelerate immediately when the STOP command is entered. The time between the input of the STOP command and the stopping of the load is the same as that for the ordinary stop operation. When the inverter is too slow to absorb the regeneration energy, the protective function works and the time becomes longer.

• This energy-saving function is effective for light loads of reduced torque such as fans and pumps, but may not be effective for heavy loads of constant torque.

• When operation is started using the Flying Start function, the Auto Alarm Recovery function, or the Restart after Momentary Power Failure function, the Auto Energy-Saving Control Mode 1 function is restarted from the beginning. (The flying-start operation is enabled.)

• The energy-saving operation is carried out while the load torque is constant and steady (in the frequency matching status). Therefore, when the set frequency changes (e.g. by input of an analog frequency), a greater frequency matching range (Cd057) must be set to continue the energy-saving operation even for a gradual change in the set frequency.

• The V/f pattern of the Auto Energy-Saving Control Mode 1 function is linear.

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● Cd071=8 Auto Energy-Saving Control Mode 2
   • This energy-saving mode is based on the Sensorless Vector Control mode and saves energy by increasing the motor efficiency for an arbitrary load torque.
   • While the Simple Energy-Saving function requires manual adjustment of the optimum voltage value, the Auto Energy-Saving function automatically reduces the motor loss in the steady status and performs more efficient operation of a selected load torque. A stable energy-saving effect is obtained even when the load changes.
   • The Auto Energy-Saving Control Mode 2 function is basically the same as the Auto Energy-Saving Control Mode 1 function except for the control mode in which it is used (V/f mode or Sensorless vector control mode). The Auto Energy-Saving Control Mode 2 function compensates for the rotation speed of the motor while performing the energy-saving operation.
     1) Related function code
        Function code
        Cd071=8 Auto Energy-Saving Control Mode 2
        Note: When setting "Cd071=8", the setting must be confirmed to prevent overwriting of data with the wrong value. (See 7.1 for details of setting and reconfirmation.)
     2) Operation in Auto Energy-Saving Control Mode 2
        • The Auto Energy-Saving Control Mode 2 function is enabled when "Cd071=8" is set. No adjustment using other function codes is required.
        • Auto Energy-Saving Control Mode 2 starts after the inverter is started in Auto Energy-Saving Control Mode 2 and the operation of the load becomes steady.
        • As this function is always active during energy saving, the same energy-saving effect can be obtained when the torque of the load is changing gradually. When the set frequency or the load torque changes rapidly, the inverter recovers from the energy-saving operation and makes up for the insufficient torque.
     3) Notes
        • The time required before the operation becomes steady at the most efficient point varies according to the load status. In some cases, it may take some ten minutes.
        • When the set frequency is changed, when the STOP command is entered, or when the load changes rapidly, the load torque becomes insufficient and the driving ability reduces. To

counter this, the function restores the output voltage to the original voltage in a few milliseconds.
        • Unlike the simple energy-saving function, the Auto Energy-Saving function starts to decelerate immediately when the STOP command is entered. The time between the input of the STOP command and the stopping of the load is the same as that for the ordinary stop operation. When the inverter is too slow to absorb the regeneration energy or when the torque is limited by the torque limiter, the protective function works and the time becomes longer.
        • The Auto Energy-Saving Control Mode 2 function is based on the Sensorless Vector Control mode. Refer to "Cd071" (Motor Control Mode Selection) before using this function.
        • When operation is started using the Flying Start function, the Auto Alarm Recovery function, or the Restart after Momentary Power Failure function, the Auto Energy-Saving Control Mode 2 function is restarted from the beginning. (The flying start operation is enabled.)
        • The energy-saving operation is carried out while the load torque is constant and steady (in the frequency matching status). Therefore, when the set frequency changes (e.g. by input of an analog frequency), a greater frequency matching range (Cd057) must be set to continue the energy-saving operation even for a gradual change in the set frequency. "Cd057" is also related to the frequency matching settings (Cd638-640) of multifunctional terminal output.
● Cd071=9, 10 (Auto tuning function)
   • The auto tuning function automatically measures the constant of the connected motor and this measurement is used for the inverter. This function is used when using the sensorless vector control operation with a motor for which the motor constant has not been accurately determined or when using the sensorless vector control operation in a condition where the distance between the inverter and the motor is over 30 m.
   • There are two modes in the auto tuning function;
     Auto tuning mode 1 (Cd071=9):
        Mode to measure the motor constant without rotating the motor. Used when the auto tuning mode 2 cannot be used.
     Auto tuning mode 2 (Cd071=10):
        Mode to measure the motor constant by rotating the motor.

● Auto tuning method: ─────────

(1) Set Cd053, 078 - 081 to the correct values.

(2) Set Cd071 (Cd071=9, 10).

(3) Input the operation signal to start auto tuning. During auto tuning, the operation panel indicates that the inverter is in operation. When auto tuning terminates, the operation panel indicates that the inverter is stopped. Auto tuning mode 2 rotates the motor up to the rated frequency (Cd079) in a direction in accordance with the operation signal.

(4) An auto-tuning failure is indicated by "Er 5" on the operation panel.
During auto tuning, confirm the operation panel display. If "Er 5" is displayed, reconfirm the settings and conduct auto tuning again.

(5) The auto tuning mode can be forcibly terminated using the stop signal.

Note: Notes on auto tuning mode function

(1) In auto tuning mode 2, disconnect any load from the motor shaft. If the load cannot be disconnected (ex. one piece brake motor), auto tuning mode 2 will not work correctly.

(2) If the settings of Cd053, and 078-081 are incorrect, auto tuning will not work correctly.

(3) Auto tuning must be conducted in a state where the motor temperature is normal. When the motor is overheated because of other test operations auto tuning will not work correctly.

(4) The auto tuning mode function follows the usual operation procedure. Therefore, some settings of function codes may cause the inverter to not operate. In such a case, confirm whether contradictory settings have been applied to the function code data setting, as in the case of normal operation.

(5) Do not auto-tune a motor whose capacity is much smaller than the capacity of the inverter. If done, the motor may be damaged. The capacity of the motor to be auto-tuned should be no more than two ranks below the inverter.

Example) Frequency setting is lower than operation start frequency: No operation. The frequency setting is invalid during the auto tuning mode function, though the frequency setting is valid as the operation start condition.

Example) Frequency setting is higher than the upper frequency limit, or is smaller than the lower frequency limit: No operation.

(6) During operation with auto tuning mode 2;
If an operation signal is input again during deceleration, operation restarts at the frequency set by Cd079. Therefore, do not input an operation command until auto tuning has completely finished.

(7) If an alarm or momentary power failure occurs during auto tuning, conduct auto tuning again.

(8) During operation with auto tuning mode 2;
If the motor enters the free run status due to a multifunctional terminal input MBS control signal (related to Cd630-637) and then the signal is turned off so as to resume auto tuning, auto tuning will not work correctly.

(9) Acceleration/deceleration time with auto tuning mode 2 operates with the factory presets for the 1st acceleration/deceleration speed.

(10) If the fixed-shaft tuning is not satisfactory, it must be performed again.

● Cd071=11 V·f separate function

• This function allows the output frequency and voltage of the inverter to be set independently.

• The control mode is V/f.

• Cd066: This function is used to select complete separation type or V·f comparison type.

1) Related function code and inverter control terminal

Function code		Inverter control terminal	
Cd071=11	V·f separate function	VRf1	Voltage command input terminal
Cd066=1 or 2	=1:V·f comparison type	+V1	Variable resistor connection terminal
	=2:Complete separation type	ACM	Analog signal common terminal

• V·f separate function becomes valid when Cd071=11 is set.

• Cd066 is used to select one of two functions: complete separation type or V·f comparison type.

2) Frequency and voltage command input method.

• The frequency command can be set from the operation panel or using an external signal according to 1st Speed Frequency Setting (Cd002).

Note: Setting the frequency command to VRF1 external analog (Cd002=2, 3, 7, 8, 9, 10, 11, 12) conflicts with the inverter output voltage command when the V·f separate function is active. Avoid duplicate setting of the VRF1 terminal function.

• The output voltage command can be entered either by applying 0 to 10 VDC directly between the external control terminals VRF1 and ACM of the inverter, or by applying a voltage from the +V1 internal power supply of the inverter to the VRF1 terminal through an external variable resistor. Attach the external variable resistor correctly by referring to "Control Circuit Terminal Connections." (Ratings of external variable resistor: Value= 5kΩ max. Capacity=0.3 W min.)

3) Gain of output voltage command
3)-1 V·f comparison type
(Cd071=11 and Cd066=1)

- With the ordinary V/f pattern, the voltage command Vin corresponding to the present frequency is multiplied by the given gain using the input value (0 to 10 V) of the inverter external control terminal VRF1 to give an output voltage command to the inverter. While the relationship between the frequency command and voltage command remains proportional, the ratio changes depending on the VRF1 input value. The relationship between the VRF1 voltage input and the gain coefficient is as follows:

Gain coefficient

VRF1=0V input $\rightarrow$

$$Vout = Vin - (Vin \times 100\%) = 0\,(V)$$

VRF1=5V input $\rightarrow$

$$Vout = Vin + (Vin \times 0\%) = Vin\,(V)$$

VRF1=10V input $\rightarrow$

$$Vout = Vin + (Vin \times 100\%) = 2Vin\,(V)$$

Vin=Current voltage command

Vout=Voltage command after processing

Note: Set the output voltage with Cd005 "Base Voltage." If the voltage command is too large at the maximum variable resistor value, adjust it by setting a smaller value with Cd005.
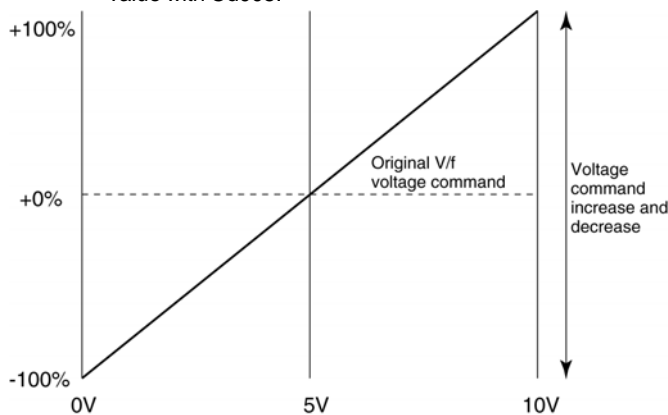
3)-2 Complete separation type
(Cd071=11 and Cd066=2)

- With the base voltage (Cd005) of the ordinary V/f pattern as the maximum value, this voltage command is multiplied by the given gain using the input value (0 to 10 V) of the inverter external control terminal VRF1 to give an output voltage command to the inverter. The frequency command and voltage command become independent of each other. The relationship between the VRF1 voltage input and gain coefficient is as follows:

Gain coefficient (primary function)

VRF1=0V input $\rightarrow$

Output voltage=Base voltage $\times$ 0

VRF1=5V input $\rightarrow$

Output voltage=Base voltage $\times$ 0.5

VRF1=10V input $\rightarrow$

Output voltage=Base voltage $\times$ 1.0
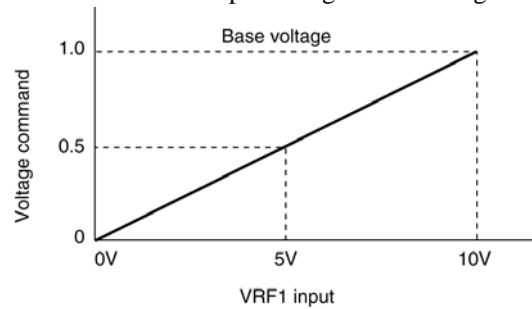
Notes:
- This function is invalid during DC braking.
- The AVR function is enabled depending on the base voltage (Cd005 data).
- The Instability Elimination function (Cd061) is enabled if specified but frequency and voltage commands may make the function ineffective.
- The bias and gain settings of VRF1 voltage coefficient are invalid.
- Frequency and voltage commands are independent of each other. If an excessively large voltage command is issued for an output frequency, the motor may be over-excited and an overcurrent may trip the inverter. Set the frequency and voltage commands with great care (especially for acceleration and deceleration).

● Cd071=12 Sensorless vector and V/f control switching operation

- When the inverter is not operating, this function sets sensorless vector control or V/f control for the next operation depending on the value of the target frequency. The reference frequency for mode switching is 60 Hz when the motor has two poles or 120 Hz in other cases.
- The control mode can be switched easily, simply by changing the target frequency.

Example: When the sensorless vector and V/f control switching operation (Cd071=12) is selected (Four-pole motor)
- If the inverter is not operating and the target frequency is higher than 120 Hz, V/f control mode is set.
- If the inverter is not operating and the target frequency is equal to or lower than 120 Hz, sensorless vector control mode is set.

Note: If the frequency is changed when the inverter is operating in sensorless vector control mode, the maximum frequency is 60 Hz for a two-pole motor or 120 Hz for other motors.

`Cd072` Torque Limiter (Power Running)

`Cd073` Torque Limiter (Regeneration)

- These functions limit the torque delivered by the motor in sensorless vector control mode.
  Settings for the torque limiter can be set independently for both power running and regeneration operations. The above functions work in a similar manner to the output current limiting function (Cd043) in the V/f mode. However, the motor torque can be limited directly in sensorless vector control mode.

  Note: When the torque limiter value is too small, it may not be possible to accelerate some loads, or the load deceleration characteristic may deteriorate.

Code setting		Description
Constant torque load (H characteristic/SHF)	Cd072= 5 - 200%	Set the ratio of the generated torque to the rated torque of the motor (in 1% steps).
Square-law torque load (P characteristic/SPF)	Cd072= 5 - 150%	
	Cd073= 5 - 150%	

Set the rated torque of a general purpose motor as 100% of the rating of the inverter.

`Cd074` Multiple for Starting Excitation Current

- The starting excitation current in sensorless vector control mode is specified using this function code. This function works in a similar manner to DC braking force in the V/f mode.
  Cd074=1 - 10 (in steps of 1)
  If the multiple for the excitation current is too high, this may result in a stop due to overcurrent.
  If the set multiple for the excitation current does not have any effect upon the braking force, it is possible that the current limiting function has operated due to the occurrence of an overcurrent.

`Cd075` Starting Excitation Time

- This is similar to the DC braking time in the V/f mode at start-up. Set the time for which the excitation current is applied (current setting for Cd074).
  Cd075=0 - 10.0 sec. (in 0.1 sec. steps)
  With Cd075=0, there is no braking function at start-up.
- In the event of auto alarm recovery and restart after momentary power failure, flying start is used instead of start excitation.

  Note: This setting is dependant on the settings of the number of motor poles, voltage and capacity (Cd053). Therefore, changing Cd053 automatically applies the standard value for the settings of Cd053 to Cd075.

`Cd076` Multiple for Braking Excitation Current

- The excitation current for braking in sensorless vector control mode is set by this function code. This is similar to the DC braking force for stopping in the V/f mode.
  Cd076=1 - 10 (in steps of 1)
  If the multiple for the excitation current is too high, this may result in a stop due to an overcurrent.
  If the set multiple for the excitation current does not have any effect upon the braking force, it is possible that the current limiting function has operated due to the occurrence of an overcurrent.

`Cd077` Braking Excitation Time

- This is similar to the DC braking time for stopping in the V/f mode. Set the time for which the excitation current is applied (current setting for Cd076).
  Cd077=0 - 10.0 sec. (in 0.1 sec. steps)
  With Cd077=0, there is no braking function available for stopping.

`Cd078` Motor Current Rating

`Cd079` Motor Frequency Rating

`Cd080` Motor Speed Rating

`Cd081` Motor Isolation Type

- The rated current, frequency, speed of rotation and isolation type of the motor to be connected are specified.
  Usually, use the motor's rated values. Incorrect settings reduce the effectiveness of auto tuning and the control characteristic in the sensorless vector control mode.
  Cd078= Approx. 30 - 110% of inverter rated current (0.1 A steps)
  Cd079= 1: 50 Hz
      2: 60 Hz
  Cd080= 0 - 24000 r/min. (1 r/min steps)
  Cd081= 1: Type A
      2: Type E
      3: Type B
      4: Type F
      5: Type H

  Note: This setting is dependant on the settings of the number of motor poles, voltage and capacity (Cd053). Therefore, changing Cd053 automatically applies the standard values for the setting of Cd053 to Cd078 - 081.

  Note: These settings are not used in the V/f mode.

`Cd082` Speed Adjustment Gain

- Function code to adjust the speed control accuracy

when using the sensorless vector control mode (Cd071=2).

Cd082=0.50 - 2.00 (0.01 step)

Large speed decrease during load operation: Set to less than 1.

Large speed increase during load operation: Set to over 1.

Note: To adjust this setting, gradually adjust the value in steps of 0.1 while conducting test operation.

| Cd083 | External Analog Input Filter Time Constant |

- This function sets a filter time constant for reading external analog signals.

  If noise is detected in external analog signals, adjust the external analog filter time constant (Cd083).

  Set the time constant to $N \times 10$ ms ($N = 1$ to 500). The setting range is 10 to 5000 ms.

  Note: Signals are usually filtered simultaneously at the VRF1 and IRF/VRF2 terminals. To use PID control feedback, set the filter time constant for the feedback value with Cd125. In PID control mode, analog commands and feedback values can be filtered independently.

| Cd084 | Copy |

- This function transfers function code data from the inverter to the operation panel or to another inverter.

  Cd084=1:   Transfers the current function code data to the operation panel.

  Cd084=2:   Transfers the memory contents from the operation panel to the inverter.

- Transfer the current function code data first to the operation panel, then to another inverter.

  During copying, "CoPY" keeps flashing on the 7-segment display.

- After data transfer to the destination inverter, power the inverter off and on to reset it.

  (Procedure) Copying data to another inverter

  1.   Transfer the current function code data to the operation panel with Cd084=1.

  2.   During data transfer, "CoPY" keeps flashing on the 7-segment display.

       Wait until "CoPY" disappears.

  3.   Power off the inverter, remove the operation panel, and mount the panel on the destination inverter.

       Before mounting the panel, power off the destination inverter as well.

  4.   Power on the destination inverter.

  5.   Transfer the data from the operation panel to the destination inverter with Cd084=2.

  6.   During data transfer, "CoPY" keeps flashing on the 7-segment display.

       Wait until "CoPY" disappears.

  7.   After data transfer to the destination inverter, power the inverter off and on to reset it.

- This function does not copy Cd053, Cd078, Cd084, Cd097, Cd098, Cd099, Cd100, or Cd140 or other function codes or data that enable optional functions. Some data may not be copied between inverters of different capacities or rated voltages. (Example: Cd005)

  Note 1: The copy function is controlled using the software version numbers, and may not work if the software versions are not compatible. In addition, there may be cases where alarms and other functions do not behave as expected when settings are copied from one inverter that has additional functions to another inverter that does not have these functions due to a difference in software. Be sure to confirm that all required functions are available before copying settings to an inverter. We recommend that you install a software upgrade if the software versions of the inverters are significantly different. For details of upgrades, please contact the retailer.

  Note 2: If an error occurs during data transfer to the operation panel, do not transfer data back to the same or to another inverter.

  Note 3: The display flashes to indicate that the copy function is in operation. When the display is flashing, do not remove or mount the operation panel or turn the power on or off.

  Note 4: When the copy function is in operation, the operation panel keys are disabled.

  Note 5: This code cannot be written using the communication function. "Undefined" is returned in response to a write attempt.

  Note 6: The copy function is not available on the remote operation panel (optional).

| Cd085 | Torque Limiter Analog Input (Power Running) |

- This function varies the torque limiter (power running) according to analog commands that are input to the VRF and IRF control terminals.

  Cd085=0:   Limit using Cd072

  Cd085=1:   Limit using the signal on the VRF1 terminal (0V to 5V)

  Cd085=2:   Limit using the signal on the VRF1 terminal (0V to 10V or variable resistor)

  Cd085=3:   Limit using the signal on the VRF2 terminal (0V to 5V)

  Cd085=4:   Limit using the signal on the VRF2 terminal (0V to 10V or variable resistor)

  Cd085=5:   Limit using the signal on the IRF terminal (4mA to 20mA)

- With a setting of Cd085=0, the torque limiter (power running) value is set by Cd072.

- With a setting of Cd085=1or 3, the torque limiter (power running) value is determined by the level (0V

to 5V) of a signal input to the VRF1 or VRF2 terminal.

- With a setting of Cd085=2 or 4, the torque limiter (power running) value is determined by the level (0V to 10V) of a signal input to the VRF1 or VRF2 terminal.

- With a setting of Cd085=5, the torque limiter (power running) value is determined by the level (4mA to 20mA) of a signal input to the IRF terminal.

Control circuit terminal VRF1 and VRF2/IRF input value
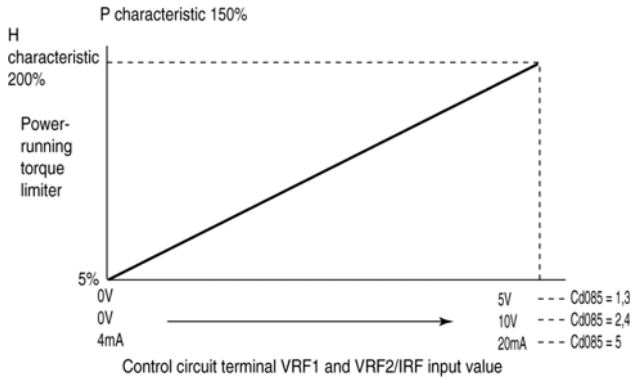
Note 1: The power-running torque limiter varies in the range of 5% to 200% of the value that is input to the control terminal (for H characteristic) or in the range of 5% to 150% of the value that is input to the control terminal (for P characteristic)

Note 2: This function is valid only in the Sensorless Vector Control mode.

Cd086 Torque Limiter Analog Input (Regeneration)

- This function allows the torque limiter (regeneration) to be controlled by analog commands that are input to the VRF and IRF control terminals.

  Cd086=0:   Limit using Cd073
  Cd086=1,3: Limit using the signal on the VRF1 or VRF2 terminal (0V to 5V)
  Cd086=2,4: Limit using the signal on the VRF1 or VRF2 terminal (0V to 10V)
  Cd086=5:   Limit using the signal on the IRF terminal (4mA to 20mA)

- With a setting of Cd086=0, the torque limiter (regeneration) value is set by Cd073.

- With a setting of Cd086=1 or 3, the torque limiter (regeneration) value is determined by the level (0V to 5V) of a signal input to the VRF terminal.

- With a setting of Cd086=2 or 4, the torque limiter (regeneration) value is determined by the level (0V to 10V) of a signal input to the VRF terminal.

- With a setting of Cd086=5, the torque limiter (regeneration) value is determined by the level (4mA to 20mA) of a signal input to the IRF terminal.

Control circuit terminal VRF1 and VRF2/IRF input value
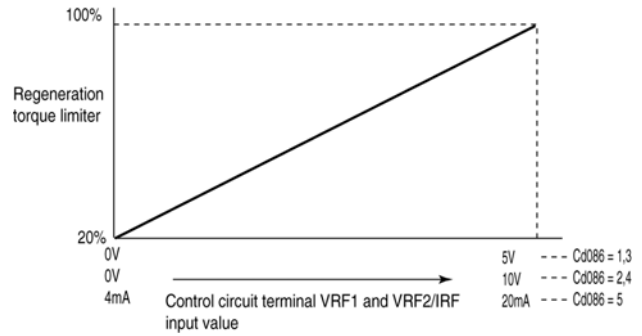
Note 1: The regeneration torque limiter varies in the range of 5% to 100% of the value that is input to the control terminals.

Note 2: This function is valid only in the Sensorless Vector Control mode.

Cd087 Function to Switch "ou" and "Lu" Alarms When Stopped

- This function selects which alarm function "OV" (Overvoltage) or "LV" (Undervoltage) of the inverter is selected.

  Cd087=0:   "OV" valid and "LV" invalid when stopped
  Cd087=1:   "OV" invalid and "LV" valid when stopped
  Cd087=2:   "OV" invalid and "LV" invalid when stopped
  Cd087=3:   "OV" valid and "LV" valid when stopped

Note 1: Even when the selected alarm function ("OV" or "LV") is invalidated by this function, the protection function is enabled. The Alarm Display (on the operation panel), Alarm Relay Output, and Alarm Log functions are disabled.

Note 2: This function is effective when the "OV" or "LV" Alarm Display or Alarm Relay Output function is not available (because of an error in an external sequence).

Cd088 ASR Proportional Gain
Cd089 ASR Integral Gain

- These codes respectively control the ASR proportional and integral gains in the Sensorless Vector Control mode and with the vector control option. Typical values have been factory-set as defaults for these codes. When these gains must be adjusted, change these codes.

  Cd088 = 0.00 to 7.80
  Cd089 = 0.00 to 106.00

`Cd090`	Start of S-shaped Acceleration
`Cd091`	End of S-shaped Acceleration
`Cd092`	Gradient of Middle of S-shaped Acceleration
`Cd093`	Start of S-shaped Deceleration
`Cd094`	End of S-shaped Deceleration
`Cd095`	Gradient of S-shaped Deceleration

- Function codes to alter the shape of acceleration/
  deceleration curve when specifying S-shaped accel-
  eration/deceleration (Cd017=2) in the acceleration/
  deceleration mode. The shape of the S-shaped
  acceleration/deceleration curve can be set indepen-
  dently for both acceleration and deceleration. Also,
  the curvature of the start and end of the curve, and the
  gradient of the middle portion can be set individually.
  Cd090 - 092 are the settings for acceleration, and
  Cd093 - 095 are for deceleration. The method of
  setting is described below. As the same method
  applies to both acceleration and deceleration, only the
  method of setting acceleration is described here.

    Cd090=0 - 100% (1% step): Specifies the curvature of
        the start portion of the acceleration.
        With 0, the start portion is a linear
        acceleration, and with 100, the curvature
        is maximum.
    Cd091=0 - 100% (1% step): Specifies the curvature of
        the end portion of the acceleration. With
        0, the end portion is a linear acceleration,
        and with 100, the curvature is maximum.
    Cd092=0 - 100% (1% step): Specifies the gradient of
        the middle portion of the acceleration.
        With 0, the portion is the gradient set in
        Cd018 - 022, and with 100, the gradient is
        twice the gradient set in Cd018 - 022.

- When the settings are changed during S-shaped
  acceleration or deceleration, the new settings are valid
  from the next acceleration/deceleration.
- In the case of the S-shaped acceleration/deceleration
  mode, the time until the frequency is reached varies
  depending on the settings of Cd090 - 095. The time is
  calculated as follows:

$$Ts = \frac{T}{2} \times \frac{200}{100 + \text{gradient of middle of S-shaped curve}} + \left(\frac{\text{Curvature of start of S-shaped curve} + \text{Curvature of end of S-shaped curve}}{200} \right)$$

    Ts: Time to reach the target frequency in the S-shaped
        acceleration/deceleration mode (in seconds)
    T: Time to reach the target frequency in the linear
        acceleration/deceleration mode with the settings of
        Cd018-026 (in seconds)

Curvature of start of S-shaped curve:
    Setting of Cd090 or Cd093 (%)
Curvature of end of S-shaped curve:
    Setting of Cd091 or Cd094 (%)
Gradient of middle of S-shaped curve:
    Setting of Cd092 or Cd095 (%)
(Calculation example) Acceleration from 20 Hz to 50 Hz
at the 1st acceleration/deceleration
    Cd018=50(Hz):
        Acceleration/deceleration standard time setting
    Cd019=5 (in seconds):
        Acceleration time setting
    Cd090=50(%):
        S-shaped curve with medium-curvature start
    Cd091=50(%):
        S-shaped curve with medium-curvature end
    Cd092=0(%):
        Gradient of the middle portion is the same as
        that for linear acceleration

(1) $T = \dfrac{5 \text{ sec.}}{50 \text{Hz}} \times (50\text{Hz} - 20\text{Hz}) = 3 \text{ sec.}$

(2) $Ts = \dfrac{3 \text{ sec.}}{2} \times \left(\dfrac{200}{100 + 0} + \dfrac{50 + 50}{200} \right) = 3.75 \text{ sec.}$

- The following are examples of the S-shaped curve with
  different combinations of settings. The standard
  acceleration/deceleration time and the acceleration/
  deceleration time settings are the same in all examples.
    Cd018=50(Hz)
    Cd019=5 (in seconds)
    Cd023=5 (in seconds)
  Example 1) Cd090=100, Cd091=100, Cd092=100,
            Cd093=100, Cd094=100, Cd095=100
    • The time taken to reach the set frequency is
      the same as that for linear acceleration.
      However, since the gradient of the middle
      portion is twice as that of the linear accelera-
      tion/deceleration mode, the current limiting
      function may operate depending on the
      magnitude of the load inertia.
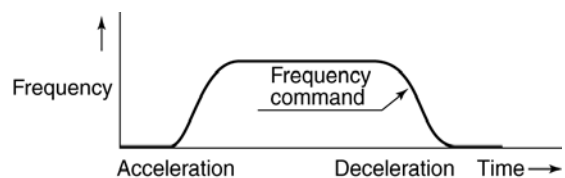
Example 2) Cd090=100, Cd091=100, Cd092=0,
            Cd093=100, Cd094=100, Cd095=0
The curvature of the acceleration/deceleration's start
portion and end portion is maximum. The gradient of
the acceleration/deceleration's middle portion is the
same as that of the linear acceleration/deceleration
mode.

Frequency ↑

Frequency command

Acceleration   Deceleration   Time →
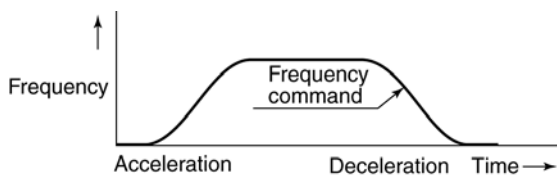
Example 3) Cd090=0, Cd091=0, Cd092=0, Cd093=0, Cd094=0, Cd095=0

Consequently, the same acceleration as that of the linear acceleration/deceleration mode.

Frequency ↑

Frequency command

Acceleration   Deceleration   Time →
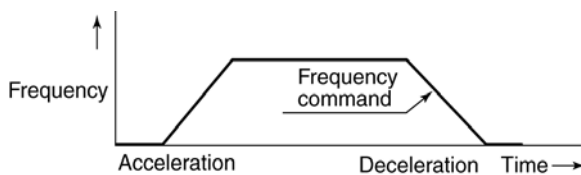
Example 4) Cd090=0, Cd091=100, Cd092=0, Cd093=0, Cd094=100, Cd095=0

Effective for acceleration/deceleration of a square-reduced torque load, such as a fan.

Frequency ↑

Frequency command

Acceleration   Deceleration   Time →
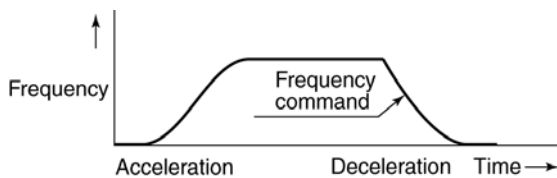
| Cd096 | Function Lock |

- To prevent an operation error, the operation panel can be locked.
  - Cd096=0: Code data can be changed.
  - Cd096=1: No code data can be changed except Cd096 (it is also impossible to change the setting of the frequency).
  - Cd096=2: No code data can be changed except Cd096 and Cd028 - Cd036) (it is also impossible to change the setting of the frequency).
  - Cd096=3: No code data can be changed except Cd096 and data changes using the communication function
  - Cd096=4: Code data unchangeable (except for Cd096, Cd175 or Cd182, pressure command.)

| Cd097 | Operation Time Display |

- This function displays the total operation time (in hours) of the inverter. (Read-only)

| Cd098 | Reading Alarm Data |

- This function allows you to read the last five alarms stored in the memory in chronological sequence.

Cd098=1: Start reading data

Use the ▲ and ▼ keys to read the last five alarms issued. Every time the ▲ or ▼ key is pressed the next or previous alarm is displayed.

Cd098=9: Data in the alarm memory is cleared.

| Cd099 | Data Initialization |

- This function initializes function code data to the factory presets or user's initialization data.
  - Cd099=1: Initializes to factory presets.
  - Cd099=2: Erases motor constants measured by auto tuning.
  - Cd099=3: Initializes to user's initialization data.
  - Cd099=99: Sets a user's initialization value.
- Cd097 and Cd098 are not initialized.

(Procedure 1) Setting a user's initialization value
1. Set the required function code.
2. Identify this value as the user's initialization value with Cd099=99.
3. The confirmation message "rEAdY" and the set value start flashing. Press the ▲ key to confirm the value.
4. "dEC id" keeps flashing while the user's initialization value is being stored. Wait until "dEC id" disappears.
5. Once "dEC id" has disappeared, the function code data can be initialized to the user's initialization data with Cd099=3.

(Procedure 2) Initializing to the user's initialization data
1. Execute Cd099=3 to initialize the function code data to the user's initialization data determined with Cd099=99.
2. The confirmation message "rEAdY" and the set value start flashing. Press the ▲ key to confirm the value.
3. "in itY" keeps flashing while the function code data is being initialized to the user's initialization data. Wait until "in itY" disappears.
4. "in itY" disappears when initialization is complete.

Note 1: If Cd099=3 (Initialization to User's Initialization Data) is executed with no user's initialization data determined, "Er d" is displayed.

Note 2: "dEC id" and "in itY" are not displayed for serial communication function.

$\boxed{Cd100}$	Operation Panel Remote/Local Selection

● This function is used to set the remote operation panel (optional) to remote mode.

Setting Cd100=1 changes the panel to local mode.

This function is valid only when the remote operation panel is mounted.

● The Stop key is valid in both modes. The display contents are also identical.

Note: The copy function is not available on the remote operation panel (optional).

$\boxed{Cd101}$	Operation Mode Selection

● This function selects an operation mode.

　　Cd101=0:　Ordinary operation

　　Cd101=1:　Simple scheduled operation

　　Cd101=2:　Disturbed operation

● Cd101=1　Simple scheduled operation function

　• This function automatically executes an operating pattern (including direction of rotation, set frequency, operation time, acceleration/deceleration time, etc.) that has been set by function codes in advance. This function is effective for automatic operation according to a preset operation sequence.

　• Up to 8 operation patterns (including the operation-stop timer pattern) can be specified. It is also possible to repeat a cycle of these eight patterns a preset number of times. When power to the system is cut off, these operation patterns are stored in non-volatile memory so that the operation may be continued from the succeeding pattern when power is recovered.

　　1) Related function codes and control terminals of the inverter

Function code			
Cd002=1 - 9	1st Speed Frequency Setting	Cd106=0.0 - 6500.0 sec.	Operation Timer T4
Cd029=0 - 600Hz	1st Speed Frequency	Cd107=0.0 - 6500.0 sec.	Operation Timer T5
Cd030=0 - 600Hz	2nd Speed Frequency	Cd108=0.0 - 6500.0 sec.	Operation Timer T6
Cd031=0 - 600Hz	3rd Speed Frequency	Cd109=0.0 - 6500.0 sec.	Operation Timer T7
Cd032=0 - 600Hz	4th Speed Frequency	Cd110=0.0 - 6500.0 sec.	Operation Stop Timer T0
Cd033=0 - 600Hz	5th Speed Frequency	Cd111=1 - 4	Midway Stop Deceleration Time
Cd034=0 - 600Hz	6th Speed Frequency	Cd112=1 - 4	Midway Start Acceleration Time
Cd035=0 - 600Hz	7th Speed Frequency	Cd113=××	Forward/Reverse Deceleration in T1 Pattern
Cd638 - 640=3	End of Simple Scheduled Operation Cycle	Cd114=××	Forward/Reverse Acceleration/Deceleration in T2 Pattern
Cd630 - 637=35	Reset of Simple Scheduled Operation Timer	Cd115=××	Forward/Reverse Acceleration/Deceleration in T3 Pattern
Cd101=1	Simple Scheduled Operation	Cd116=××	Forward/Reverse Acceleration/Deceleration in T4 Pattern
Cd102= 0 - 250 times	Number of Repetitions of Simple Scheduled Operation	Cd117=××	Forward/Reverse Acceleration/Deceleration in T5 Pattern
Cd103=0.0 - 6500.0 sec.	Operation Timer T1	Cd118=××	Forward/Reverse Acceleration/Deceleration in T6 Pattern
Cd104=0.0 - 6500.0 sec.	Operation Timer T2	Cd119=××	Forward/Reverse Acceleration/Deceleration in T7 Pattern
Cd105=0.0 - 6500.0 sec.	Operation Timer T3		

Control terminal of the inverter			
*1	Cycle End Function	DCM1	Digital Signal Common Terminal
PTR*2	Timer Reset Function	DCM2	Digital Signal Common Terminal

*1 Set using Cd638 - 640.

*2 Set using Cd630 -639.

　2) Starting a simple scheduled operation

　• Set "Cd101=1" (Simple Scheduled Operation). The Simple Scheduled Operation function is enabled in V/f and Sensorless Vector Control modes.

　• Only the forward run command is valid as an operation command on the operation panel, external control circuit terminals, etc. Always enter the forward run command regardless of the direction of rotation.

　• The direction of rotation and an acceleration/deceleration time can be set for each of the timers T1 to T7.

　Setting method

　• Enter a 2-digit value indicating the direction of rotation and the acceleration/deceleration time for each code (T1 to T7).

　Example:　Setting of "Reverse" and "3rd Acceleration/Deceleration Time" for the T1 operation timer

Cd113 = 2 3

Specification of acceleration/deceleration time

1: 1st acceleration/deceleration time (Cd019 and Cd023)

2: 2nd acceleration/deceleration time (Cd020 and Cd024)

3: 3rd acceleration/deceleration time (Cd021 and Cd025)

4: 4th acceleration/deceleration time (Cd022 and Cd026)

Specification of direction of rotation

1: forward

2: reverse

Note 1: The jog operation is performed normally before a simple scheduled operation starts. (The forward or reverse run is enabled.)

The jog operation is also performed normally when simple scheduled operation stops.

Note 2: Methods and conditions for starting and braking in simple scheduled operation are the same as those for ordinary operation unless otherwise specified.

Note 3: When the direction of rotation of the motor is fixed by the Cd050 code (Fix direction of rotation of motor), the inverter waits for the next operation

timer while the operation timer for the opposite direction of rotation specified by T1 to T7 is on.

Note 4: As the acceleration/deceleration time for a simple scheduled operation is specified for respective operation timers, changing acceleration/deceleration times using the AD2 and AD3 multifunctional input terminals is disabled. (Set AD2 and AD3 in Cd630 to 637) However, when the AD3 terminal is selected by "Cd630 - 637=38" (Operation Signal Hold), the function is enabled.

3) Timer operations in simple scheduled operations

- When the forward run command is entered, a simple scheduled operation of a specified direction of rotation and a specified acceleration/deceleration time starts. At the same time, the operation timers T1 to T7 and T0 start counting in sequence. When the first operation timer counts up, the next timer starts counting. This is repeated in the order T1, T2, T3,...,T7, and T0. An operation timer whose set time is 0.0 seconds is skipped.

Timer setting

Operation timer T1: Cd103=0.0-6500.0 seconds

Operation timer T2: Cd104=0.0-6500.0 seconds

Operation timer T3: Cd105=0.0-6500.0 seconds

Operation timer T4: Cd106=0.0-6500.0 seconds

Operation timer T5: Cd107=0.0-6500.0 seconds

Operation timer T6: Cd108=0.0-6500.0 seconds

Operation timer T7: Cd109=0.0-6500.0 seconds

Set a desired time for each operation timer.

Note: When you set a timer value for an operation timer that is in operation (counting), the setting is valid in the next and later operation cycles. When you set a timer value for the operation timer that is to be in operation next, the setting is valid for the operation timer.

- Operation Stop Timer T0 (Cd110)

The Simple Scheduled Operation function uses the operation stop timer T0 (Cd110) in addition to the operation timers T1 to T7. This timer is used to stop the current operation cycle (one cycle of operation timers T1 to T7) and start the next operation cycle (the next cycle of operation timers T1 to T7) after a preset time period.

Cd110 = 0.0 to 6500.0 seconds

Note 1: You cannot specify a frequency value for the period defined by operation stop timer T0. While the operation stop timer is in operation, the inverter always decelerates to stop the motor.

Note 2: This deceleration-to-stop time is specified by "Cd111 =1 to 4" (Midway Stop Deceleration Time).

Note 3: If the inverter is still decelerating to stop the motor even when the operation stop timer T0 has finished counting, the next operation cycle waits until the inverter stops completely. Therefore, it is recommended to set a timer period longer than the time taken to decelerate and stop at the end of operation timer T7.

Note 4: The braking operation is the same as that in the ordinary operation. (DC braking, braking excitation, and free-run stop functions are available.)

Note 5: When the operation stop timer is not required, specify "Cd110=0.0." Operation timer T1 starts immediately after operation timer T7 when the operation timer T7 has finished counting. The inverter runs the motor without a break.
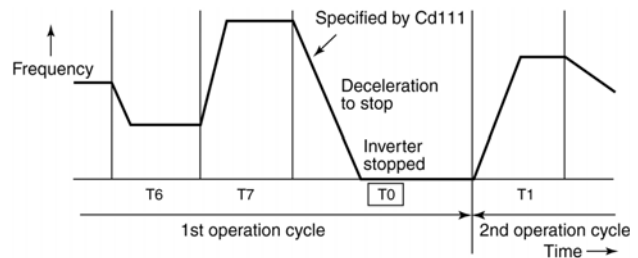
4) Setting a frequency value for each timer

- Use the standard function codes for multi-speed frequencies (1st to 7th speed frequencies) to set frequencies for operation timers. When "Cd002" (1st Speed Frequency Setting) is 1, 13, or 14, the 1st speed frequency specified by CD029 is used as the frequency value. If any other value is specified, the value of the specified function is the set frequency. In other words, an analog frequency or binary or BCD value can be specified for operation timer T1.

Setting methods

Operation timer T1: Specify Cd002 = 1 to 16.
When Cd002 = 1, 3, or 14 → 1st speed frequency (Cd029)
When Cd002 = 2 to 12 → Analog frequency input (on VRF1 and IRF/VRF2 terminals)
When Cd002 = 15 or 16 → Digital frequency input (An optional PC board is required.)

Operation timer T2: Determined by the value of Cd030 (= 0 to 600Hz).

Operation timer T3: Determined by the value of Cd031 (= 0 to 600Hz).

Operation timer T4: Determined by the value of Cd032 (= 0 to 600Hz).
Operation timer T5: Determined by the value of Cd033 (= 0 to 600Hz).
Operation timer T6: Determined by the value of Cd034 (= 0 to 600Hz).
Operation timer T7: Determined by the value of Cd035 (= 0 to 600Hz).

Note 1: When the set frequency value is changed by a multi-speed frequency code (Cd029 to Cd035), using the step keys on the operation panel, or by the terminal board step function while an operation timer (T1 to T7) is in operation, the set frequency of the operation timer that is in operation is changed. The new frequency is reflected in the Multi-Speed Frequency function code.

Example: When you change the set frequency value by pressing the operation panel key while the operation timer T2 is in operation, this function increases or decreases the frequency to the new frequency value. The new frequency value is set in "Cd030."

Note 2: In the simple scheduled operation, changing speeds using the control circuit input terminals is disabled because speeds are respectively set by operation timers (Set by Cd630 to 637). However, when the 2DF and 3DF are selected by a function other than the 2nd Speed and 3rd Speed functions (Cd066 = 2 and Cd067 = 2), the function is enabled.

5) Simple Scheduled Operation Cycle End signal
   • If the control terminal output function is set to End of Simple Scheduled Operation Cycle (one of Cd638 to 640 is set to 3), when the inverter stops in operation cycle T0 or when DC braking or braking excitation is carried out, the open collector output between the control circuit output terminals and DCM1,2,3 turns on for about 200msec. Use this Cycle End signal to turn off the external operation command at the end of one cycle or for synchronization with the peripheral units of the inverter.
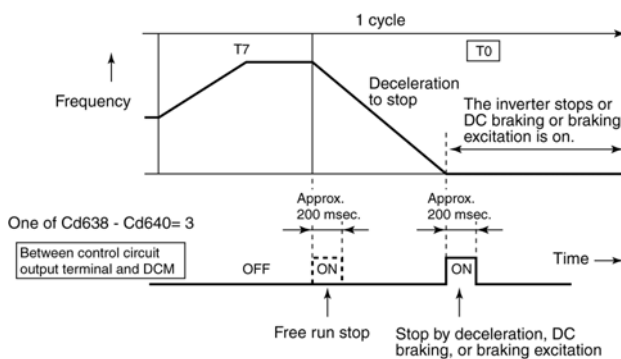
Note 1: The Simple Scheduled Operation Cycle End signal is output each time the operation stop timer T0 works.

To suppress this cycle end signal, avoid setting "Cd062 - Cd640=3" or set 0.0 for "Cd110" (T0 Operation Stop).

Note 2: If the inverter stops or DC braking or braking excitation starts while the operation timer for the end of all operation cycles is in operation, the Simple Scheduled Operation Cycle End signal turns on independently of the status of the operation timer.

6) Simple scheduled operation and code settings
   • An example of a simple scheduled operation determined by function codes is shown below.
   Operation timers T0 (Cd103) to T7 (Cd110):   0 to 6500.0 seconds
   Multi-speed Frequency Setting "1st Speed" (Cd029) to "7th Speed" (Cd035):   0 to 400 Hz
   Forward/Reverse, Acceleration/Deceleration: Cd113 to Cd119
   Number of repetitions (Cd102):   0 to 250 (0 for infinite)
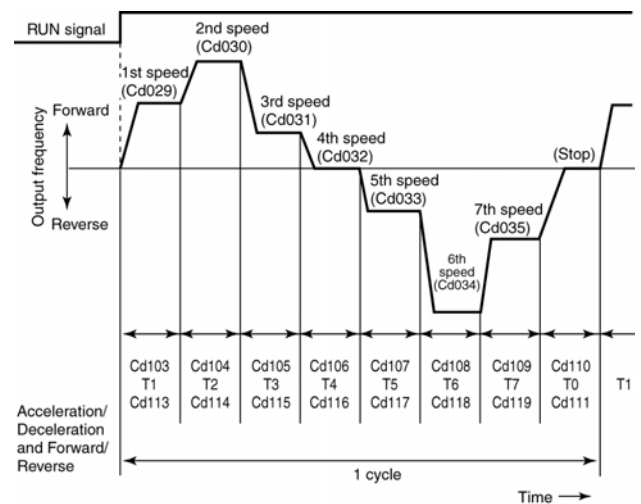
7) Midway stopping or starting a simple scheduled operation
   • If you have to stop the inverter while a simple scheduled operation is in progress, you can set the deceleration time to stop the motor independently of the setting of the operation timer.
   • When a STOP command (or alarm) is entered to the inverter while an operation timer (T1 to T6) is in operation, the inverter decelerates to stop the motor or stops the motor without braking (free run stop) and the simple scheduled operation stops midway. The deceleration-to-stop time is determined by the setting of "Cd111" (Midway Stop Deceleration Time). The value of Cd111 can be in the range of Cd023 (1st Deceleration Time) to Cd026 (4th Deceleration Time).

Setting method

Select a midway-stop deceleration time using the "Cd111" code as follows:

Cd111=1: Selects the 1st deceleration time (Cd023).

Cd111=2: Selects the 2nd deceleration time (Cd024).

Cd111=3: Selects the 3rd deceleration time (Cd025).

Cd111=4: Selects the 4th deceleration time (Cd026).

Note: When the STOP (or Free-Run) command is input to the inverter, the value of the current operation timer is immediately held until operation is restarted. When the RUN command is entered again and the original set frequency is reached, the operation timer starts again.

• If the operation starting condition is satisfied while stopped due to a midway stop, the inverter accelerates (increases) the frequency towards the set frequency of the operation timer and starts the operation from midway. The acceleration time is determined according to the setting of "Cd112" (Midway Start Acceleration Time)

The Cd112 value can be in the range of Cd019 (1st Acceleration Time) to Cd022 (4th Acceleration Time). When the frequency reaches the set frequency, the held operation timer starts again.

Setting method

Select a midway start acceleration time using the "Cd112" code.

Cd112=1: Selects the 1st acceleration time (Cd019).

Cd112=2: Selects the 2nd acceleration time (Cd020).

Cd112=3: Selects the 3rd acceleration time (Cd021).

Cd112=4: Selects the 4th acceleration time (Cd022).

Reference:

When the operation is stopped midway, the Midway Stop function stores the preceding status of the operation timers even when the power to the system is shut off. Therefore, you can start from the aborted operation even on the next day.
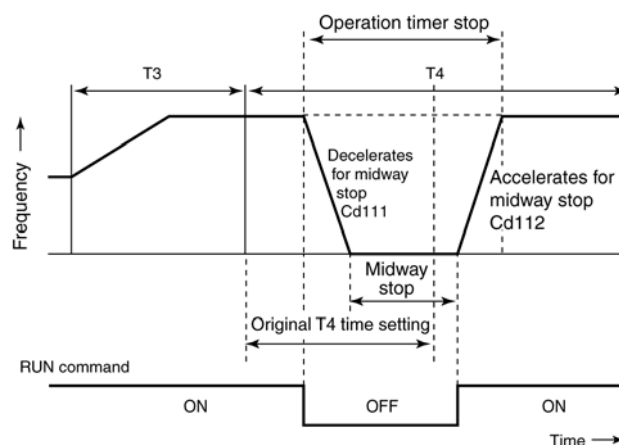
8) Function to reset the simple scheduled operation timer when held by the Midway Stop function

• When the simple scheduled operation is stopped midway, the simple scheduled operation timer that is in operation is held. Therefore, when conditions for restarting operation are satisfied, the inverter accelerates (increases) the frequency towards the set frequency of this operation timer and starts operation from the point at which the operation stopped. If it is not necessary to hold the operation timer, you can reset the operation timer from the control terminals of the inverter.

• This Timer Reset function resets all simple scheduled operation timers. Therefore, the next operation starts with the first of operation timers T1 to T7.

Setting and resetting

• Set the multifunctional input terminal to function as the simple scheduled operation timer reset. (Set one of Cd630 - Cd637 to 35.)

• If the inverter stops midway through the operation of an operation timer, connect the control circuit terminals to the DCM1 or DCM2 for at least 100 msec to reset the simple scheduled operation timers.

• Be sure to reset the simple scheduled operation timers before the next RUN command is entered after the inverter has stopped completely. Timer resetting is not possible while the inverter is in operation, in the standby status, or while accelerating after restarting.
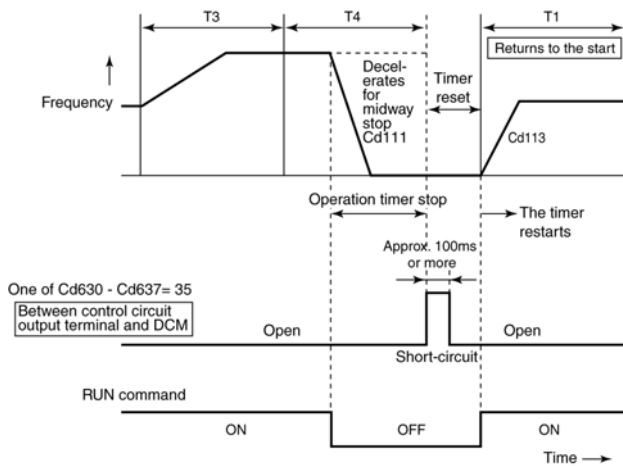
Note: If the timer reset is continuously input, the operation timers will be reset again at the next midway stop. Therefore, input the reset signal only when it is required.

● Cd101=2 (Disturbed Operation Function)
  • This function repeatedly changes between two set frequencies in a preset acceleration/deceleration time. This function is useful in systems where the frequency must be varied, for example to match the difference in diameter of each end of a bobbin in a bobbin winding system.
  • With this function, you can modulate the set frequency freely by external analog commands. Therefore, you can adjust the frequency value according to the status of the load.
  1) Related function codes and control terminals of the inverter

Function code			
Cd019=0.0 - 6500.0 sec.	1st acceleration time	Cd036=0 - 600Hz	8th speed frequency
Cd020=0.0 - 6500.0 sec.	2nd acceleration time	Cd055=0 - ±600Hz	Gain frequency
Cd023=0.0 - 6500.0 sec.	1st deceleration time	Cd101=2	Disturbed operation
Cd024=0.0 - 6500.0 sec.	2nd deceleration time	Cd120=1 - 5	Analog input switching
Cd029=0 - 600Hz	1st speed frequency	Cd121=0 - 50%	Disturb modulation rate
Cd030=0 - 600Hz	2nd speed frequency		

Inverter control terminal			
VRF1	Voltage signal modulation input	VRF2	Voltage signal modulation input
IRF	Current signal modulation input	ACM	Analog signal common terminal

  2) Basic disturbed operation
    • Set Cd101=2 (Disturbed Operation Function). Disturbed operation can be used in either motor control mode (V/f mode or Sensorless Vector Control mode).
    • There are two frequency setting values: 1st speed frequency (Cd029) and 2nd speed frequency (Cd030).
    • When the RUN command is entered, the inverter repeatedly changes from the 1st speed frequency to the 2nd speed frequency and

back to the 1st speed frequency, and so on. When the output frequency reaches either of the set frequencies, it is increased or decreased (ΔF) so that the set frequency is only attained momentarily for the minimum acceleration/deceleration time. This is to prevent problems such as uneven bobbin winding. When the output frequency reaches the 1st speed frequency, this function subtracts the 8th speed frequency (Cd036) from the 1st speed frequency. When the output frequency reaches the 2nd speed frequency, this function adds the 8th speed frequency to the 2nd speed frequency.
  New set frequency when the output frequency reaches the 1st speed frequency:
      1st speed frequency - 8th speed frequency (ΔF)
  New set frequency when the output frequency reaches the 2nd speed frequency:
      2nd speed frequency + 8th speed frequency (ΔF)
  • In disturbed operation, the acceleration/deceleration times are used as follows:
  The 1st acceleration/deceleration time is used to vary the frequency at the start (from the input of the RUN command to reaching the 1st speed frequency) and at the end of operation (from the input of the stop command until the inverter comes to a stop). The 2nd acceleration/deceleration time is used to vary the frequency at other times.
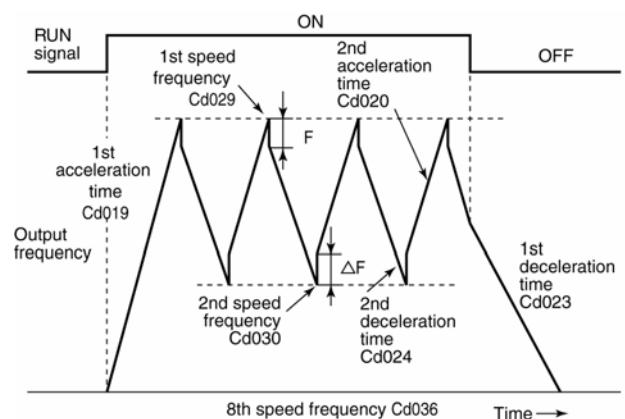
*1. ΔF is added to the value of Cd030 or subtracted from the value of Cd029.
*2. The period of "ΔF" is the maximum acceleration/deceleration time.

Note 1: The 1st speed frequency in disturbed operation is fixed to the value of Cd029. Therefore, you cannot set the 1st speed frequency using the external analog or digital input function (optional) or the terminal board step function. To set the 1st speed frequency, specify Cd002 = 1 or 14.
Note 2: Jog operation before the disturbed operation works

normally.

Note 3: In the Disturbed Operation mode, the acceleration/deceleration times for the 1st and 2nd speed frequencies are fixed. Therefore, changing acceleration/deceleration times using the AD2 and AD3 control terminals is disabled (except when the control circuit input terminal is selected by "Cd630-Cd637=38" (Operation Signal Hold)).

Note 4: In the Disturbed Operation mode, only the 1st and 2nd speeds are used. Therefore, changing speeds using the 2DF and 3DF control terminals is disabled.

Note 5: When the Flying Start, Auto Alarm Recovery, or Restart after Momentary Power Failure function is used, the inverter increases or decreases the output frequency towards the 1st speed frequency to restart.

3) Modulation (Frequency Change) function in disturbed operation

• The 1st and 2nd speed frequencies that are set can be changed (modulated) by an external analog command in disturbed operation. When "Cd120" (Analog Input Switching) is not "0," the speed frequencies can be changed by the analog input corresponding to the setting of Cd120. The gain (frequency) of the maximum analog command is set by "Cd055" or "Cd063" (Gain Frequency Setting). Further, as only positive analog inputs are used and the frequency setting value can be increased or decreased, the offset of the disturb modulation can be adjusted by "Cd121" (Disturb Modulation Rate).

Setting and changing

• Specify the value that you want to change using "Cd120" (Analog Input Switching).

  Cd120=0: Not changed
  Cd120=1: Input (0V to 5V) between VRF1 and ACM terminals
  Cd120=2: Input (0V to 10V) between VRF1 and ACM terminals
  Cd120=3: Input (0V to 5V) between VRF2 and ACM terminals
  Cd120=4: Input (0V to 10V) between VRF2 and ACM terminals
  Cd120=5: Input (4mA to 20mA) between IRF and ACM terminals

• Set the maximum analog input value using "Cd055" or "Cd063" (Gain Frequency Setting).

  Cd055 = 0 to ±600Hz

The gain frequency indicates the value by which the set frequency is changed when the analog command specified by Cd120 is at its maximum value. In other words, it is the gain

of the analog input. When a gain frequency is determined, the modulation function converts the entered analog signal into a modulation frequency, and adds it to the two set frequencies (1st and 2nd speed frequencies) for the disturbed operation. With this, new modulated frequencies are generated. However, the function codes of the 1st and 2nd speed frequencies remain unchanged. Negative gain frequency can be also set. In this case the modulation frequency has a negative value, and has a negative gradient relative to an increase in the analog command input. The negative modulation frequency represents "subtraction" in the disturbed operation.

Example 1: Cd120=2 and Cd055=+50Hz (VRF1 used)
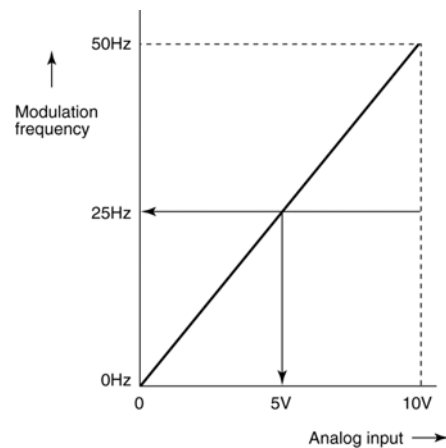
Example 2: Cd120=5 and Cd055=-30Hz (VRF1 used)
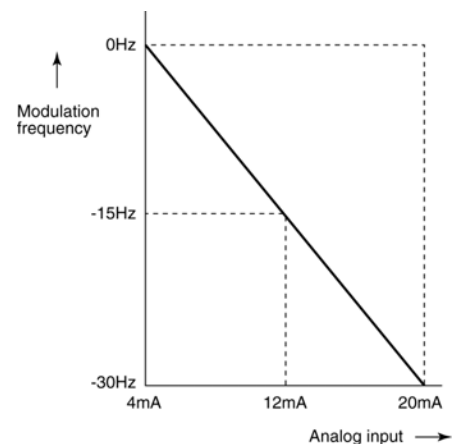
• Offset of the modulation frequency
After the modulation frequency has been adjusted by the analog input, the result is added to the two set frequencies (1st and 2nd speed frequencies) for the disturbed operation. However, as shown in Examples 1 and 2, modulation is achieved either by addition or subtraction alone according to the

polarity of the gain frequency (Cd055 or Cd063). If you want to modulate the original set frequencies (1st and 2nd speed frequencies) up and down, specify an offset value using the disturb modulation rate (Cd121).

The offset should be

Cd121 = 0% to 50%.

In this case, the rate indicates where the 0Hz point of the modulated frequency is relative to the modulated analog input. This specification changes the gain of the analog modulation input and the modulation frequency, but the range of the modulation frequency is fixed to the value set by the Gain Frequency setting (Cd055 or Cd063).

Example 1: Cd120=2 and Cd055=+50Hz, Cd121=50% (VRF1 used)
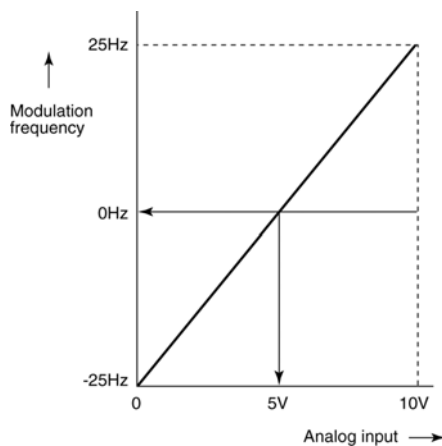
Example 2: Cd120=3 and Cd055=30Hz, Cd121=25% (VRF1 used.)

* In case of modulation rate Cd121=50%
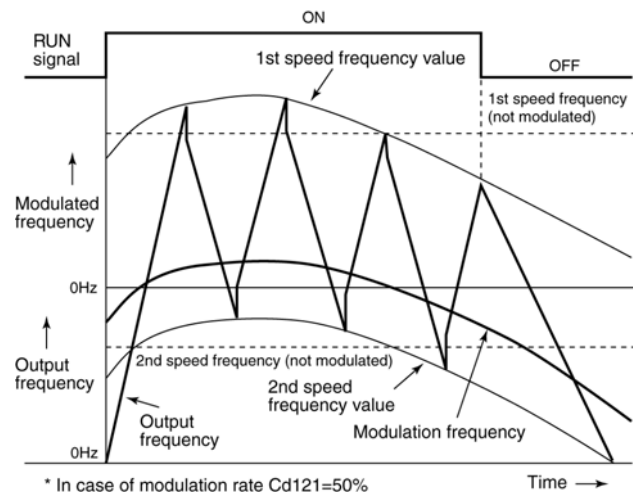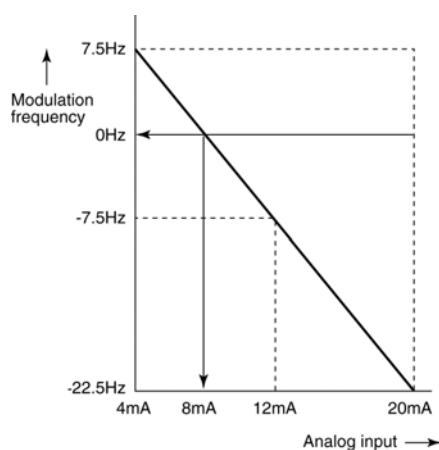
Note 1: When both the disturbed operation and the Internal PID Control mode (Cd071=3) are selected at the same time, the modulation function is disabled because the modulation input and the feedback input conflict with each other.

Note 2: The Bias Frequency setting function (Cd054) does not affect the modulation input in the modulation of the disturbed operation.

$Cd126$	Internal Analog Output Function 1
$Cd128$	Internal Analog Output Function 2
$Cd127$	Internal Analog Output Coefficient 1
$Cd129$	Internal Analog Output Coefficient 2

● These functions output various internal statuses of the inverter between analog output terminals AOUT1/2 and analog signal common terminal ACM of the control circuit in an analog form (0 to 10 V).

Cd126: AOUT1
Cd128: AOUT2

Cd126,128=0: No function
Cd126,128=1: Set frequency
Cd126,128=2: Output frequency
Cd126,128=3: Output current
Cd126,128=4: DC voltage
Cd126,128=5: Fin temperature
Cd126,128=6: Load factor (Electrothermal level integrated value)
Cd126,128=7: Output of converted analog input value (VRF1 control circuit terminal input)
Cd126,128=8: Output of converted analog input value (IRF/VRF2 control circuit terminal input)
Cd126,128=9: Output voltage
Cd126,128=10: Load factor (Percentage in terms of rated current)
Cd126,128=11: Detected speed (Option)
Cd126,128=12: Output power (V/f mode only)

- Output signals can be increased or decreased by the internal analog output coefficients Cd127 and Cd129. If the output signal from the AOUT1 or AOUT2 terminal is not of an adequate level, the signal level can be adjusted by setting the internal analog output coefficient.

  Cd127: Coefficient for Cd126 (Internal Analog Output Function 1)

  Cd129: Coefficient for Cd128 (Internal Analog Output Function 2)

  Note: If the coefficients of Cd127 and Cd129 are smaller than 1, the output signals are decreased.

- The analog signals that can be output from the AOUT1 and AOUT2 terminals and the actual values are converted as follows:

Cd126/128 setting	Output signal	Conversion method
0	No function (no output)	
1	Set frequency	120 Hz=10 V
2	Output frequency	120 Hz=10 V
3	Output current	*1
4	DC voltage	500 V=5 V
5	Fin temperature	100°C=8 V
6	Load factor (Electrothermal level integrated value)	100%=5 V
7	Analog input (VRF1 control circuit terminal)	5 V=5 V at 0 to 5 V input 10 V=10 V at 0 to 10 V input
8	Analog input (IRF/VRF2 control circuit terminal)	20 mA=10 V or 5 V=5 V at 0 to 5 V input 10 V=10 V at 0 to 10 V input
9	Output voltage	500 V=10 V
10	Load factor (Percentage in terms of rated current)	100%=5 V
11	Detected speed (optional)	1800 rpm=5 V
12	Output power (V/f mode only)	10kW=10 V

  Note: Maximum allowable current = 15 mA (The converted values are output voltages under no load. Since the output voltage decreases as the output current increases, set the output coefficient accordingly.)

*1

SBT	SHF	SPF	
0.75K/1.5K	1.5K-4.0K	2.2K-5.5K	20A=10V
1.5K/2.2K-3.7K/5.5K	5.5K-11K	7.5K-15K	50A=10V
5.5K/7.5K-11K/15K	15K-22K	18.5K-30K	100A=10V
15K/18.5K-22K/30K			250A=10V

Cd130 Direction of Rotation of Motor (Operation Panel)

- This function is used to assign the direction of rotation to the (DRIVE) key on the operation panel.

Cd130=1: Forward run

Cd130=2: Reverse run

Note: The direction of rotation of the motor is fixed by Cd050.

Cd131 Shortest Operation Time Function

- Even when a brief operation signal is input via an external control terminal, this function holds the operation command for the time set by Cd131.

  Cd131 = 0.00 to 99.99 (in step of 0.01 s)

- During operation using signals input to the external control terminal, the function defines the minimum ON period for multifunctional input terminal FR or RR. In other words, the function starts counting when the input signal turns on, and the signal is assumed to remain on for the duration of the count even if the physical signal to the multifunctional input terminal FR or RR goes off.

  After the time set by Cd131, the inverter operates again according to the current status of multifunctional input terminal FR or RR.
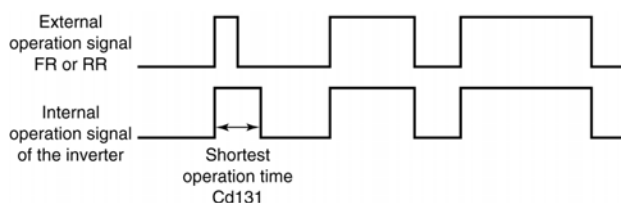
  Note 1: If the time setting of Cd131 is changed while the shortest operation time function is counting the time, the new value will be valid from the next time.

  Note 2: If an external operation signal for motor rotation in the opposite direction is input when the shortest operation time function is counting the time, the shortest operation time does not apply to that operation command.

Cd140 Changed Code Display Function

- This function compares the factory presets, user's initialization data, and current function code data and displays the function codes for which data values are different.

  Cd140=1: Displays discrepancies from the factory presets.

  Cd140=2: Displays discrepancies from the user's initialization data.

- This function does not display the function codes Cd084, Cd097, Cd098, Cd099, Cd100, or Cd140 even if they have been changed.

Operating procedure

  1. Execute Cd140=1 to compare the current function code data with the factory presets to find function codes that have been changed.

2. "F ind" keeps flashing while the function is searching the data for codes that have been changed.

   Wait until "F ind" disappears.

3. The numbers of the function codes that have been changed are displayed flashing.

   For details of the operating procedure, see 7.1, "Changing Settings"

Note 1: If Cd140=2 is executed with no user's initialization data determined by Cd099=99, "Er d" is displayed.

Note 2: Even when not changed intentionally by the user, a function code whose initialization value differs depending on the motor and inverter ratings may be changed from its initialization value if related codes are changed.

$\mathsf{Cd641}$	Start Standby Time
$\mathsf{Cd642}$	Start Standby Frequency

● This function is used to make the frequency increase halt temporarily until the rotation speed increases enough and restart the frequency increase with the output frequency standby function. This allows smooth acceleration when the inertia of the load is high.

   Cd641=0.0 - 120.0 s: Start standby time
   Cd642=0.05 - 60.00 Hz: Start standby frequency

● When a value other than 0 is set with Cd641, the inverter locks the frequency for the time set with Cd641 (output frequency standby) after accelerating to the frequency set with Cd642.

Note 1: When the acceleration/deceleration curve is S-shaped (Cd017=2), this function is invalid.

Note 2: If the set standby frequency is higher than the starting frequency, the inverter stands by at the starting frequency.

Note 3: The target frequency is lower than the standby frequency, the standby operation is not performed.

Note 4: The standby operation is not performed during deceleration.
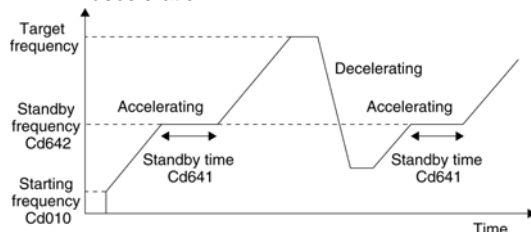
$\mathsf{Cd670}$	Magnification of frequency counter output

● This function specifies the output magnification when the output frequency and command frequency of the inverter are counter output to the control signal output terminals.

   Cd670=1 - 10 (1 step)

Example 1: Cd670=1 outputs the frequency to the control signal output terminals at 1 time the output frequency and command frequency of the inverter. When the inverter output frequency is 60 Hz, the frequency counter output is 60 Hz.

Example 2: Cd670=10 outputs the frequency to the control signal output terminals at 10 times the output frequency and command frequency of the inverter. When the inverter output frequency is 60 Hz, the frequency counter output is 600 Hz.

● Refer to 4.2 (6) "Multifunctional output terminals" as related function.

   Cd638-Cd640=32: Frequency counter output (Output frequency)
   Cd638-Cd640=33: Frequency counter output (Command frequency)

Note 1: The output range of the frequency counter output is 1-1500 Hz. When the calculated result of the frequency counter output using magnification of frequency counter output is lower than 1 Hz, the frequency counter output is limited to 1 Hz. Also, if the result is higher than 1500 Hz, the frequency counter output is limited to 1500 Hz. The control signal output terminals are set to OFF when the inverter is stopped.

Note 2: The output frequency is the actual inverter output frequency. When in the sensorless vector control mode, the output frequency is different from the frequency setting and keeps changing depending on the load condition. When the constant frequency counter output is required even in constant operation of sensorless vector control mode, set Cd638-Cd640=33 (command frequency).

Note 3: The waveform of frequency counter output is delayed by the size of the connected peripheral devices' impedance. This causes an imbalance of the duty cycle. To reduce the imbalance of the duty cycle, adjust the connected peripheral devices' impedance. The open collector output should be 50 mA, 2 kΩ or less.

$\mathsf{Cd671}$	Cooling fan on function

● This function is valid only for SHF and SPF series.

● Specify the operation of the cooling fan that cools radiator fins of the inverter. ON/OFF controls are performed automatically by fin temperature and inverter driver conditions when ON/OFF controls are selected.

   Cd671=0: Cooling fan ON/OFF control
   Cd671=1: Cooling fan ON normally

Note: When replace the fan, test the operation of the fan using Cd671=1: Cooling fan ON normally mode.

`Cd672` Missing phase detection function

- This function specifies whether missing phase detection function is ON or OFF.

  Cd672=0: Missing input phase detection is invalid, missing output phase detection is invalid.

  Cd672=1: Missing input phase detection is valid, missing output phase detection is invalid.

  Cd672=2: Missing input phase detection is invalid, missing output phase detection is valid.

  Cd672=3: Missing input phase detection is valid, missing output phase detection is valid.

  Note 1: The missing input/output phase detection function is valid in factory presets. Set the missing phase detection function invalid when a malfunction is likely to occur because of peripheral devices or noises.

  Note 2: Alarm display for the missing input phase detected is "LuX."

  Note 3: Alarm display for the missing output phase detected is "oPEn."

`Cd673` Overvoltage stalling prevention function

- To prevent an over-voltage trip when in regeneration during deceleration of the motor, use this overvoltage stalling prevention function to control gradient of deceleration.

  Cd673=0: Overvoltage stalling prevention function inactive.

  Cd673=1: Overvoltage stalling prevention function active.

  Note: This function is effective when deceleration is completed within the specified deceleration time. Since the DC voltage of the inverter is rising, mount a sufficient number of discharge units.

`Cd674` Relay contact output selection

- Select functions for outputting relay contacts for output terminals (FA, FB, FC).

  Cd674=

  0: Output at alarm status

  1: In operation 1

  2: Low voltage

  3: End of simple scheduled operation

  4: In operation 2

  5: Frequency matching (1st speed frequency)

  6: Frequency matching (1st to 8th speed frequencies)

  7: Frequency approach

  8: Overload alarm level setting

  (Cd048 value. Output only in constant operation.)

  9: Electrothermal level signal (Electrothermal 80%)

  10: Fin heat prediction signal

  11: Auxiliary pump driving signal (Option)

  12: Regular pump switching signal (Option)

  13: Excitation and DC braking

  14: Lower frequency limit matching

  15: Upper frequency limit matching

  16: Servo ON-signal (Option)

  17: Zero servo completion signal (Option)

  18: FR signal 19: RR signal

  20: 2DF signal 21: 3DF signal

  22: AD2 signal 23: AD3 signal

  24: JOG signal 25: MBS signal

  26: ES signal 27: RST signal

  28: Switching standby signal (Option)

  29: Positioning completion signal (Option)

  30: Discharge resistor ON-signal

  31: Reserved 32: Reserved 33: Reserved

  34: Overload alarm signal (Cd048 value. Output when in operation.)

  35 - 99: Reserved

Note 1: Cd674=30: Discharge resistor ON-signal operates at high speed. Set Cd064: Discharge resistors ON-signal output time 0.2 seconds or more so that the relay can correspond fully.

Note 2: ON: FA and FC is conducted. OFF: FB and FC is conducted.

`Cd675` Optional V/f pattern intermediate voltage 1
`Cd676` Optional V/f pattern intermediate voltage 2
`Cd677` Optional V/f pattern intermediate frequency 1
`Cd678` Optional V/f pattern intermediate frequency 2

- Optional V/f pattern can be specified when Cd003 = 1, linear V/f pattern is selected for V/f pattern selection.
- Refer to Cd003: V/f pattern as related functions.

  Cd675=0-460 V (1 V step): Optional V/f pattern intermediate voltage 1

  Cd676=0-460 V (1 V step): Optional V/f pattern intermediate voltage 2

  Cd677=0.05-600 Hz (0.01 Hz step): Optional V/f pattern intermediate frequency 1

  Cd678=0.05-600 Hz (0.01 Hz step): Optional V/f pattern intermediate frequency 2

Note: Patterns whose voltage slope is negative cannot be set.
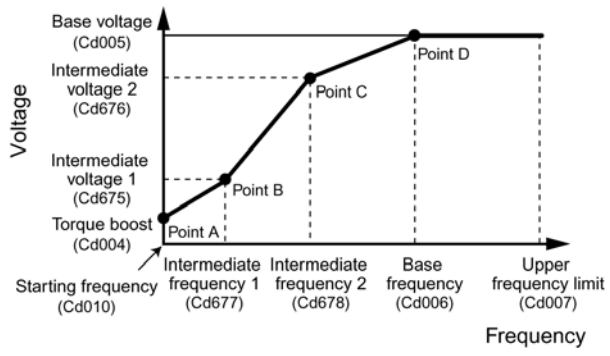
7.4　Serial Communication Function

7.4.1　Outline

● The serial communication function is an interface function that controls the inverter using serial signals from a computer. This function controls inverter start/stop, frequency setting, operation status monitoring, and function code reading and setting.

● The inverter has an RS232C and an RS485 communication interface. The RS232C interface allows an ordinary computer with an RS232C interface to be connected directly for easy setting of inverter function codes. The RS485 interface enables a computer to control up to 32 inverters.

7.4.2　Terminal functions and wiring

(1)　Terminal functions

　　1)　RS485 communication interface (Control circuit terminal TB10)
　　　　(1-to-N connection)

Terminal symbol	Terminal name	Function
TRA	Send-receive data terminal (+)	Use the positive signal terminal (+) to connect a computer via the RS485 interface.
TRB	Send-receive data terminal (–)	Use the negative signal terminal (-) to connect a computer via the RS485 interface.
RXR	Terminating terminal	When connecting several inverters to a computer via the RS485 interface, connect the TRB and RXR terminals of the last inverter together.
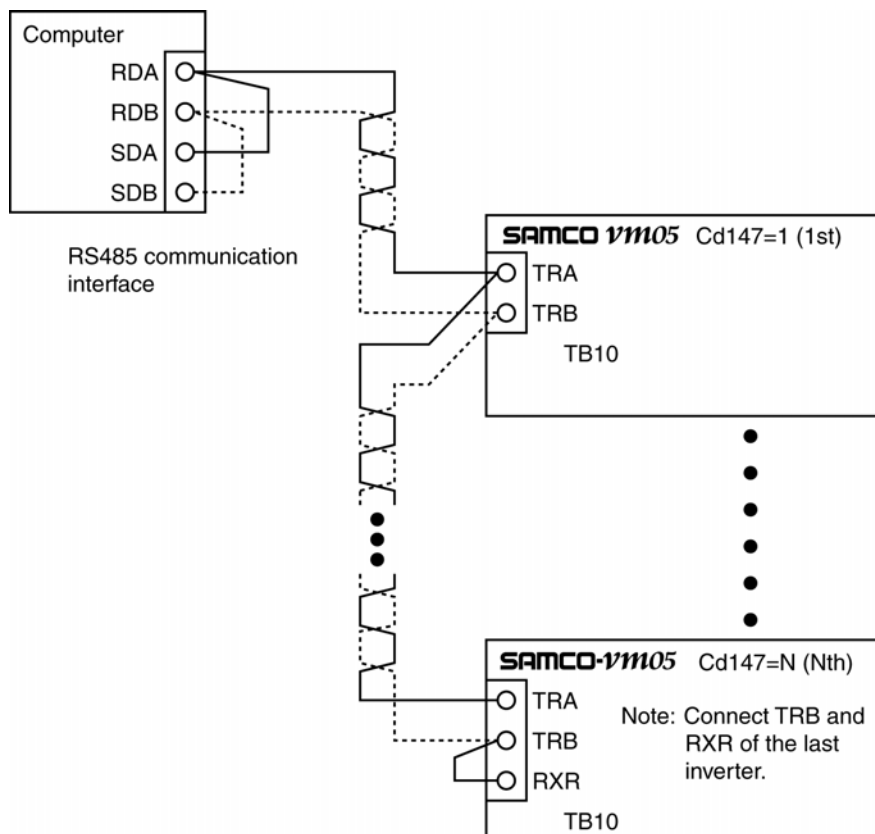
2) RS232C communication interface (Serial port on the control board)
(1-to-1 connection)
Connect the serial port of the inverter control board and the serial port of the personal computer using a commercial serial cross cable of 5 meters or less with 9-pin female D-subconnectors as follows:
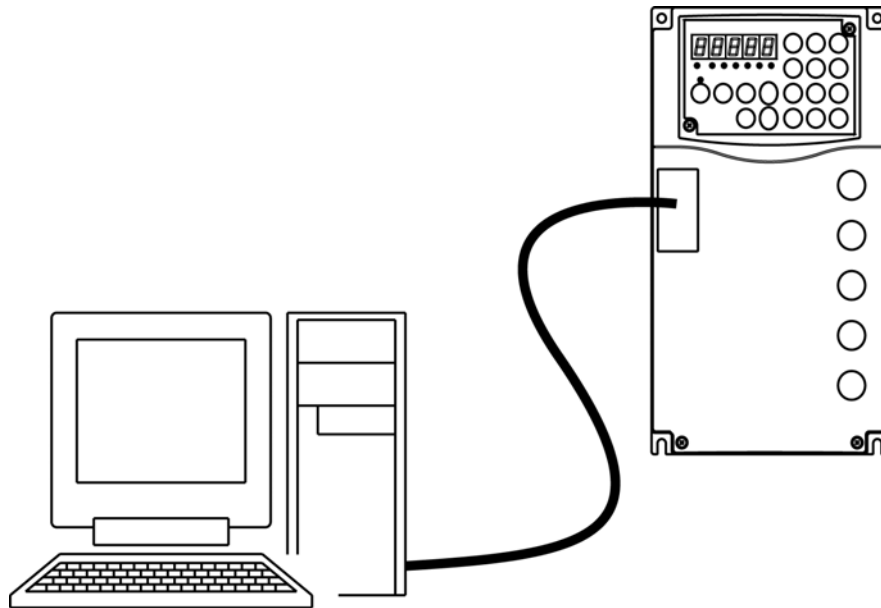
7.4.3   Inverter operation and function code setting by serial communication

(1) Enabling or disabling serial communication

Cd146 setting	Operator	Serial communication						Description
		Function code		Operation		Frequency		
		Reference	Set	Start	Stop	Display	Set	
0	Enabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Serial communication cannot be used.
1	Enabled	Enabled	Enabled	Enabled *1	Enabled	Enabled	Enabled *2	Operation panel can be used at the same time.

*1 Set Cd001=3 for operation by serial communication.
*2 Set Cd002=14 for frequency setting by serial communication.

(2)　Setting function codes related to the computer and serial communication

Code	Description
Cd142	Message checksum 　　Select whether to add a checksum to a communication message. 　　　0: No 　　　1: Yes (Factory preset)
Cd143	RS232C/485 　　Select a communication protocol. 　　　1: RS232C (Factory preset) 　　　2: RS485
Cd144	Pull-up/down 　　Select pull-up/down for the RS485 communication circuit. 　　　0: No (Factory preset) 　　　1: Yes
Cd146	Communication function 　　Select a communication function 　　　0: No function (Factory preset) 　　　1: Serial communication function
Cd147	Inverter number 　　Set a value from 1 to 32. Be careful not to set the same number as another inverter. (Factory preset) 　　Notes: 1.　If the same number is set, the function may not work normally. 　　　　　　2.　The inverters need not be numbered sequentially. A missing number is acceptable.
Cd148	Communication speed 　　1: 1200 bps 　　2: 2400 bps 　　3: 4800 bps (Factory preset) 　　4: 9600 bps 　　5: 19200 bps
Cd149	Parity bit 　　0: None 　　1: Odd (Factory preset) 　　2: Even
Cd150	Stop bit 　　1: 1 bit (Factory preset) 　　2: 2 bits
Cd151	End bit 　　0: CR, LF (Factory preset) 　　1: CR

Notes:
1. Do not set or change a communication-related function code during communication. Communication may not work normally if a function code is set or changed during communication.
2. Set the output of the RS485 communication interface to high impedance when not used for data transmission. To prevent unstable output or malfunctioning, the computer may have a fail-safe circuit that keeps the RS485 communication interface circuit at low impedance by pulling output signals up or down.
   If your computer does not have this fail-safe circuit built-in, set the pull-up/down function code (Cd144=1).

RS485 interface circuit
in the computer

RS485 receiving circuit   RS485 transmitting circuit

Pull-down resistor   Pull-up resistor

GND

+

RS485 transmission line

Terminating
resistor
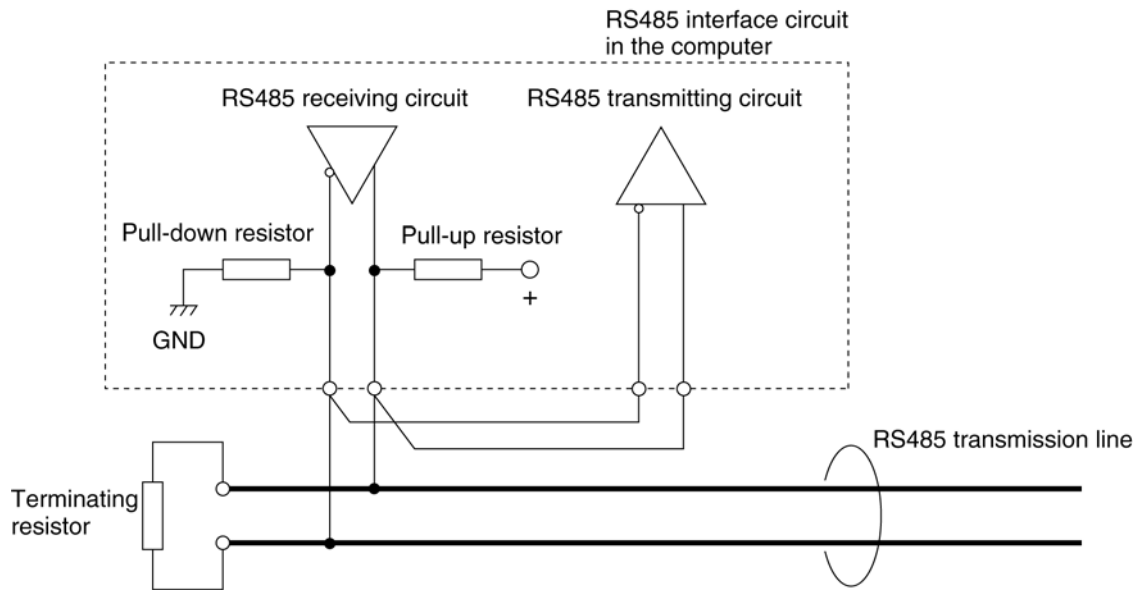
7.4.4 Serial communication functions

(1) Command list

Command type	Command	Processing	Remarks
Data read	A	Alarm contents	
	B	Function code data	
	C	Output frequency	
	D	Output current	
	E	DC link voltage	
	F	Fin temperature	
	G	Load factor	
	H	Operation status 1	
	I	Operation status 2	
	J	Terminal control board input status	
	K	Output voltage	
	L	VRF1 control circuit terminal input	
	M	IRF/VRF2 control circuit terminal input	
Data write	N	Function code data	
	O	Frequency setting	
Start/stop/reset	P	Forward run	Setting permitted when Cd001=3
	Q	Reverse run	Setting permitted when Cd001=3
	R	Stop	
	S	Alarm reset	
Automatic alarm	X	Automatic alarm permitted	
	Y	Automatic alarm prohibited	
	Z	Automatic alarm	
Batch operation	a	Select inverters for batch control	
	b	Specify direction of rotation for batch inverter control	
	c	Release batch inverter control	
	d	Batch start	Setting permitted when Cd001=3
	e	Batch stop	
Error	?	Error response	

(2) Frequency Setting command

- The Frequency Setting (O) command provides a function for setting the frequency from a computer, equivalent to directly setting the frequency from the operation panel. The set frequency is written into an appropriate frequency-related function code (Cd028 to Cd036) depending on the status of signal input into the control circuit terminals (2DF, 3DF, and JOG) at that time.

   Example: If control circuit terminals 2DF and DCM1 are connected when the inverter has received command O, the set frequency is written to function code Cd030 as the 2nd speed frequency.

   Note: Set Cd002=14 before setting a frequency using command O or writing data to a frequency-related function code (Cd028 to Cd036) using the Function Code Data Write (N) command.

(3) Batch operation function

● The batch operation function allows selected inverters or all inverters connected through a communication line to be started and stopped simultaneously from a computer.

1) Batch operation of selected inverters
① Select inverters for batch operation using command a.
② Specify the direction of rotation using command b.
③ Transmit command d with "inverter number 33" to simultaneously start the inverters selected using command a. The inverters return no response to command d.
④ Transmit command e with "inverter number 33" to simultaneously stop the inverters selected using command a. The inverters return no response to command e.

2) Batch operation of all connected inverters
① Specify the direction of rotation using command b.
② Transmit Command d with "inverter number 34" to simultaneously start all the connected inverters. The inverters return no response to command d.
③ Transmit command e with "inverter number 34" to simultaneously stop all the connected inverters. The inverters return no response to command e.

3) Release of batch operation
① Transmit command c with "inverter number 35" to release the inverters selected using command a from batch control.

Notes:
During batch operation, keep in mind the following:
1) Inverters return no response to command c, d, or e.
2) If command c, d, or e sent from a computer is not received normally for some reason, the connected inverter cannot execute the command. Therefore, the computer should transmit an Operation Status 1 (H) command to each inverter to see that the inverter is now executing the received command correctly.
3) For the meanings of inverter numbers 33, 34, and 35, see "(1) Message formats" in 7.4.5. Different numbers from 1 to 32 are given to inverters connected using a communication line to identify them as message destinations. "33" to "35" are special inverter numbers indicating that the messages are addressed to all inverters connected for batch operation.

(4) Automatic alarm function

- If an alarm occurs, the automatic alarm function automatically issues an Automatic Alarm (Z) command to notify the computer of the alarm. This function enables the computer to detect an inverter alarm immediately.

- An inverter can issue command Z automatically only if an Automatic Alarm Permitted (X) command is received from the computer. However, if the Automatic Alarm Prohibited (Y) command is received after command X, the inverter cannot issue command Z.
  Note: If automatic alarm is enabled, the inverter automatically issues an Automatic Alarm command in the event of an alarm. Consequently, message collision may occur on a communication line. The causes of message collision and preventive actions are as follows:
  (1) If the computer transmits a command to an inverter and another inverter in which an alarm has occurred issues command Z simultaneously
  ① The computer detects the message collision. Transmit the messages again.
  ② If the computer cannot detect the message collision, the messages cannot be conveyed to their destination incorrectly. Therefore, a normal response from the destination cannot be expected.
  (2) If an alarm occurs simultaneously in several inverters permitted to issue command Z
  ① Since a message collision destroys the messages, the computer receives an abnormal message. Discard the abnormal message received by the computer.
  ② An inverter has a function to detect the collision of a transmitted message. If a message collision is detected, the inverter automatically transmits the message again.
  Reference: If simultaneous message transmissions from several inverters cause a message collision, the inverters transmit the messages in ascending order of inverter number set by Cd147.

- An alarm permitted inverter automatically issues command Z about every two seconds in case of an error. This automatic transmission stops if an Alarm Read (A) command is received. If command Z is received, the computer must transmit command A immediately to the inverter issuing command Z.
  Note: If command A is received, the inverter issuing command Z stops automatic alarm transmission. Command Z cannot be issued again even if the cause of the alarm has not yet been solved (ex. the fin temperature is high and the fin overheat protection function has activated) or the alarm status has not been reset.

(5) Reading alarm data (Cd098)

- By using function code Cd098, the last five alarms can be read in chronological order. The procedure for reading the alarms is as follows:
  ① Write 1 to Cd098 using command N.
  ② Transmit a Function Code Data Read (B) command to Cd098. The alarm numbers of past alarms if any are read. See list of alarm codes for details of the alarm numbers.
  ③ Transmit command B to Cd098. Once all the stored alarm numbers have been returned, "ΔENDΔ" is returned.
  Δ represents a blank space code (20H).
  Note: Execute step ② immediately after step ①. If a command other than B is transmitted after ①, the alarms can no longer be read by ②.

7.4.5 Programming

(1) Message formats

● Messages have the following two formats:
① ASCII format: Consisting of character codes only
② Binary format: Consisting of an inverter number and data in hexadecimal
   Since a binary-format message is shorter than an ASCII-format message, the communication time for one message is shorter. This format is available only for the Frequency Setting (O), Forward Run (P), Reverse Run (Q), Stop (R), and Alarm Reset (S) commands.

If the message check function is disabled (Cd142=0), "SUM" is not necessary for messages in the ASCII or binary format.

1) Message from computer to inverter (ASCII format)

	Item	Name	Description
①	HD	Start code	Message transmission start code (*: ASCII code 2AH)
②③	IN	Inverter number	Destination inverter number (Data length: 2 bytes fixed) This data is set by function code Cd147. Example: Inverter number 20 ② → "2", ③ → "0",
④	OP	Command code	Inverter command code

⑤	OP	Data	Example: Function code data read/write contents
			1) Function code number section (Data length: 3 bytes fixed)
			   Example: Code number Cd031
			      (1) → "0" (2) → "3" (3) → "1"
			2) Function code data section (Data length: 5 bytes fixed)
			   Example: Code data 123
			      (4) → "0" (5) → "0" (6) →"1"
			      (7) → "2" (8) → "3"
			
			• The data length and format are determined for each command. For details, see Details of message formats.

⑥	SUM	Checksum	Obtain the two's complement of the lowest byte of the binary sum of data ① to ⑤. Change bit 7 to 0 and bit 6 to 1. (See Reference.)
⑦⑧ or ⑦	EM	End code	Determine the end code from the data transfer end code and function code Cd151. ASCII codes 0DH (CR) and 0AH (LF) or 0DH (CR)

Reference: Setting inverter number 1 to 50.0 Hz using function code Cd029 as an example of checksum calculation

	Item	Item data	ASCII code
①	Start code	*	(1) 2AH .... "*"
② ③	Inverter number	01	(2) 30H .... "0" (3) 31H .... "1"
④	Command code	N	(4) 4EH .... "N"
⑤	Data	Function code number Cd029	(5) 30H .... "0" (6) 32H .... "2" (7) 39H .... "9"
		Function code data 50.00Hz (†)	(8) 30H .... "0" (9) 35H .... "5" (10) 30H .... "0" (11) 30H .... "0" (12) 30H .... "0"
Sum of ASCII codes (1) to (12)			269H Lower byte: 69H
Two's complement of the lower byte of the sum			97H
⑥	Change bit 7 to 0 and bit 6 to 1.		97H=10010111B → 01010111B=57H Checksum: 57H

†: Frequency data consists of a 3-digit integer part and a 2-digit decimal part.

2) Message from inverter to computer (ASCII format)

	Item	Name	Description
①	HD	Start code	Message transmission start code (*: ASCII code 2AH)
②③	IN	Inverter number	Destination inverter number (Data length: 2 bytes fixed) This data is set by function code Cd147. Example: Inverter number 20　②→ "2", ③→ "0",
④	OP	Command code	Same as command code from computer "?" for error response
⑤	DT	Data	Example: Function code data read contents 1) Normally read data is 5 bytes long (fixed). Example: Data 123 (1) → "0"　(2) → "0"　(3) → "1" (4) → "2"　(5) → "3" Example: Normal termination code if no data is read (1) → "e"　(2) → "F"　(3) → "F" (4) → "F"　(5) → "0" 2) As an error response, an error code or interference code of 5 bytes long (fixed) is returned. ⑤Data area • The data length and format are determined for each command. For details, see Details of message formats.
⑥	SUM	Checksum	Obtain the two's complement of the lowest byte of the binary sum of data ① to ⑤. Change bit 7 to 0 and bit 6 to 1.
⑦⑧ or ⑦	EM	End code	Determine the end code from the data transfer end code and function code Cd151. ASCII codes 0DH (CR) and 0AH (LF) or 0DH (CR)

The following messages are used for commands N and B for signed function codes:

<Command N>　　Example 1:　When setting +50 Hz with Cd054

The write data (DT) is 0 0 5 0 0 or + 0 5 0 0 .

　　　　　　　　Example 2:　When setting -50 Hz with Cd054

The write data (DT) is − 0 5 0 0 .

<Command B>　　Example 3:　When +50 Hz is set with Cd054

The read data (DT) is 0 0 5 0 0 .

　　　　　　　　Example 4:　When -50 Hz is set with Cd054

The read data (DT) is − 0 5 0 0 .

3) Message from computer to inverter (Binary format)
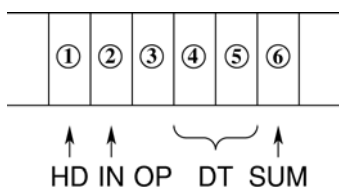
HD IN OP DT SUM

Item		Name	Description
①	HD	Start code	Message transmission start code ("@": ASCII code 40H)
②	IN	Inverter number	Destination inverter number Example: 14H for Inverter number 20
③	OP	Command code	Inverter command code

④ ⑤	DT	Setting data	Send data to inverter
			  Example: Data 123
			    ④ → 00H ⑤ → 78H "1"
			＊This is added only to a command code when there is applicable setting data.

⑥	SUM	Checksum	Add the two's complement of the lower byte of the binary sum of data ① to ⑤. (See Reference.)

Reference: Setting Inverter number 1 to 50.0 Hz as an example of checksum calculation
  ① Start code = 40H: "@"
  ② Inverter number = 01H:
  ③ Command code = 4FH: "O"
  ④ Data (upper byte) = 13H: 50.00 Hz → 5000D → 1388H
  ⑤ Data (lower byte) = 88H:
  ⑥ Sum of ① to ⑤ = 12BH: 40H + 01H + 4FH + 13H + 88H = 12BH
  ⑥ Lower byte of 12BH = 2BH:
  ⑥ Two's complement of 2BH = D5H: Checksum

4) Message from inverter to computer (Binary format)
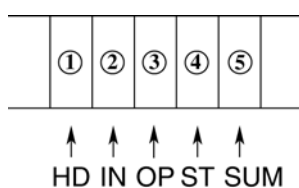
HD IN OP ST SUM

Item		Name	Description
①	HD	Start code	Message transmission start code ("@": ASCII code 40H)
②	IN	Inverter number	Destination inverter number Example: Inverter number 20 ② → "2", ③ → "0"
③	OP	Command code	Same as command code from computer "?" for error response
④	ST	Command status code	Define this code for each command. See Details of message formats-Binary format for details.
⑥	SUM	Checksum	Add the two's complement of the lower byte of the binary sum of data ① to ④.

(2)   Details of message formats

1)   ASCII-format message

OP-CD	Example of communication data (inverter number 1)	
	Transmission from computer to inverter	Transmission from inverter to computer
A	• Reading the alarm number `* 0 1 A SUM EM`	• External thermal alarm (18) `* 0 1 A 0 0 0 1 8 SUM EM` • The response is 0 if no alarm is detected. • See list of alarm codes for details of the alarm numbers.
B	• Reading the function code data (*1) • Cd007 "Upper frequency limit" `* 0 1 B 0 0 7 SUM EM`	• Cd007: 60 [Hz] `* 0 1 B 0 6 0 0 0 SUM EM` • The read data is a fixed floating-point value of the same format as the display on the operation panel of the inverter. • If a read error occurs, "eXXXX" is returned as an error code. See list of alarm codes for details of the error codes. • See "Note" for the read data format of Cd053 (Number of poles, voltage, and capacity of motor).
C	• Reading the output frequency `* 0 1 C SUM EM`	• Output frequency: 50 [Hz] `* 0 1 C 0 5 0 0 0 SUM EM` • The frequency data is multiplied by 100.
D	• Reading the output current `* 0 1 D SUM EM`	• Output current: 12 [A] `* 0 1 D 0 0 1 2 0 SUM EM` • The current data is multiplied by 10.
E	• Reading the DC voltage `* 0 1 E SUM EM`	• DC voltage: 150 [V] `* 0 1 E 0 1 5 0 0 SUM EM` • The voltage data is multiplied by 10.
F	• Reading the fin temperature `* 0 1 F SUM EM`	• Fin temperature: 50 [°C] `* 0 1 F 0 0 0 5 0 SUM EM` • The fin temperature data is multiplied by 1.
G	• Reading the load factor `* 0 1 G SUM EM`	• Load factor: 40 [%] `* 0 1 G 0 0 0 4 0 SUM EM` • The load factor data is multiplied by 1.
H	• Reading Operation Status 1 `* 0 1 H SUM EM`	• The operation status is returned as bit data. `* 0 1 H 0 0 0 0 X SUM EM` • The data has a one-byte format. • See Operation Status 1 data for the bit correspondence of data X.

*1:   Do not read using a code number not listed in the function code table, otherwise the data returned by the inverter is undefined.

OP-CD	Example of communication data (inverter number 1)	
	Transmission from computer to inverter	Transmission from inverter to computer
I	• Reading Operation Status 2 `* 0 1 I SUM EM`	• The operation status is returned as bit data. `* 0 1 I 0 X X X X SUM EM` • The data has a four-byte format. • See Operation Status 2 data for the bit correspondence of data X.
J	• Reading the input status of the control terminal board `* 0 1 J SUM EM`	• The terminal status is returned as bit data. `* 0 1 J 0 X X X X SUM EM` • The data has a four-byte format. • See Control Terminal Board Input Status data for the bit correspondence of data X.
K	• Reading the output voltage `* 0 1 K SUM EM`	• Output voltage: 100 [V] `* 0 1 K 0 1 0 0 SUM EM` • The voltage data is multiplied by 10.
L	• VRF1 control terminal input value `* 0 1 L SUM EM`	• The VRF1 control terminal input value is returned. `* 0 1 L 0 1 0 2 3 SUM EM` • Up to 1023 (10 bits) are returned for the maximum input (10 V).
M	• IRF/VRF2 control terminal input value `* 0 1 M SUM EM`	• The IRF/VRF2 control terminal input value is returned. `* 0 1 M 0 1 0 2 3 SUM EM` • Up to 1023 (10 bits) are returned for the maximum input (10 V or 20 mA). Note: Switch between IRF and VRF2 with Cd002.

N	• Writing the function code data
	• Writing 50 Hz to Cd008 "Lower frequency limit"
	
	`* 0 1 N 0 0 8 0 5 0 0 0 SUM EM`
	
	• Set the frequency data multiplied by 100.
		• Normal write
		
		`* 0 1 N e F F F 0 SUM EM`
		
		• Interference error (Example: Interference with Cd007)
		
		`* 0 1 N e 0 0 0 7 SUM EM`
		
		Interference code number
		
		• Setting error (Example: Locked)
		
		`* 0 1 N e F F F 5 SUM EM`
		
		Error code
		
		• See Chapter _ for details of the error codes.
		• See "Note" for the write data format of Cd053 (Number of poles, voltage, and capacity of motor).

O	• Setting the output frequency • Setting the output frequency to 55 Hz `* 0 1 O 0 5 5 0 0 SUM EM` • Set the frequency data multiplied by 100.	• Same as for code data write `* 0 1 O e F F F 0 SUM EM` Error code (Example: 0 Hz) • "eFFFA" is returned if the frequency setting is not permitted.

OP-CD	Example of communication data (inverter number 1)	
	Transmission from computer to inverter	Transmission from inverter to computer
P	• Forward run command `*` `0` `1` `P` `SUM` `EM`	• Transmission from inverter to computer `*` `0` `1` `OP` `ST` `SUM` `EM` Command execution status 　0: Normal 　1: Operation control is not permitted 　2: No operation in alarm status
Q	• Reverse run command `*` `0` `1` `Q` `SUM` `EM`	
R	• Stop command `*` `0` `1` `R` `SUM` `EM`	
S	• Alarm Reset command `*` `0` `1` `S` `SUM` `EM`	`*` `0` `1` `S` `SUM` `EM`
X	• Automatic Alarm Permitted command `*` `0` `1` `X` `SUM` `EM`	`*` `0` `1` `X` `SUM` `EM`
Y	• Automatic Alarm Prohibited command `*` `0` `1` `Y` `SUM` `EM`	`*` `0` `1` `Y` `SUM` `EM`
Z	• Command A is returned if an automatic alarm is received.	• Automatic alarm `*` `0` `1` `Z` `SUM` `EM`
a	• Selecting inverters for batch operation • Selecting inverter number 1 `*` `0` `1` `a` `SUM` `EM`	`*` `0` `1` `a` `ST` `SUM` `EM` Command execution status 　0: Normal 　1: Operation control is not permitted 　2: No operation in alarm status Command repetition
b	• Selecting the direction of rotation of batch-operation inverters • Selecting forward run for inverter number 1 `*` `0` `1` `b` `0` `SUM` `EM` ↑ Direction of rotation (Forward: 0, Reverse: 1)	
c	• Releasing batch operation `*` `3` `5` `c` `SUM` `EM` • Sent with inverter number 35.	• No response is returned. • The command is ignored if operation control is not permitted.

| OP-CD | Example of communication data (inverter number 1) | |
	Transmission from computer to inverter	Transmission from inverter to computer

d	• Batch Start command
	• The selected inverters are started simultaneously.
	
	`*` `3` `3` `d` `SUM` `EM`
	
	• Sent with inverter number 33.
	
	• Batch Start command
	• The selected inverters are started simultaneously.
	
	`*` `3` `4` `d` `SUM` `EM`
	
	• Sent with inverter number 34.
		• No response is returned.
		• The command is ignored if operation control is not permitted.

e	• Batch Start command
	• The selected inverters are started simultaneously.
	
	`*` `3` `3` `d` `SUM` `EM`
	
	• Sent with inverter number 33.
	
	• Batch Start command
	• The selected inverters are started simultaneously.
	
	`*` `3` `4` `d` `SUM` `EM`
	
	• Sent with inverter number 34.	

Note: Read/write data formats of Cd053 (Number of poles, voltage, and capacity of motor)

The Cd053 data format has a 5-digit format.

$$\underline{X}\ \underline{Y}\ \underline{ZZZ}$$
Ⓐ Ⓑ Ⓒ

Ⓐ Number of poles data

Example: 4 poles → 4

Ⓑ Rated voltage data

Set the rated voltage using the corresponding setting number as follows:

Rated voltage	200	220	230	380	400	415	440	460
Setting No.	1	2	3	4	5	6	7	8

Example: 380 V → 4

Ⓒ Rated capacity

Set the rated capacity of the motor using the corresponding setting number as follows:

Rated voltage	0.37	0.40	0.55	0.75	1.1	1.5	2.2	3.0
Setting No.	1	2	3	4	5	6	7	8
Rated voltage	3.7	4.0	5.5	7.5	11.0	15.0	18.5	22.0
Setting No.	9	10	11	12	13	14	15	16
Rated voltage	30.0	37.0	45.0	55.0	75.0	90.0	110	132
Setting No.	17	18	19	20	21	22	23	24
Rated voltage	160	200	220	250	280	315		
Setting No.	25	26	27	28	29	30		

Example: Writing 4.0 kW → 010 or _10

　　　　Reading 4.0 kW → _10

　　　　Where, "_" is ASCII code 5FH

2)　Binary format

　　Note: A binary-format message can be transmitted for the following commands only.

OP-CD	Example of communication data (inverter number 1)	
	Transmission from computer to inverter	Transmission from inverter to computer
O	• Setting the output frequency • Setting the output frequency to 55 Hz 　"@"　01H　"O"　15H　7CH　SUM • Set the frequency data by a multiple of 100.	"@"　01H　"O"　ST　SUM • "ST" returns the contents of the error code.
P	• Forward run command 　"@"　01H　"P"　SUM	"@"　01H　"P"　ST　SUM Command execution status 0: Normal termination 1: Abnormal termination or operation control not permitted Command repetition
Q	• Reverse run command 　"@"　01H　"Q"　SUM	
R	• Stop command 　"@"　01H　"R"　SUM	
S	• Alarm Reset command 　"@"　01H　"S"　SUM	"@"　01H　"S"　SUM

(3) Inverter operation and control terminal board input status data

● Data read by the Operation Status 1 (H), Operation Status 2 (I), and Control Terminal Board Input Status (J) commands is as follows:

1) Operation Status 1
Operation Status 1 data is returned in one byte.

```
0 1 X X X X X X
```

bit3 - 0

Bit position	3	2	1	0	
Stage 1	0	0	0	0	Current number of stages in multi-speed operation
Stage 2	0	0	0	1	
Stage 3	0	0	1	0	
Stage 4	0	0	1	1	
Stage 5	0	1	0	0	
Stage 6	0	1	0	1	
Stage 7	0	1	1	0	
Stage 8	0	1	1	1	
JOG	1	0	0	0	Jog operation
Analog	1	0	0	1	Operation by external analog frequency command
Option	3	2	1	0	Operation by frequency command from the digital input board (optional)

0: No warning
1: Warning

0: No alarm
1: Alarm

2) Operation Status 2
Operation Status 2 data is returned in four bytes.
• Byte 1

```
0 1 0 0
```

V slowing down
During DC braking
During braking excitation
During starting excitation

• Byte 2

```
0 1 0 0
```

Decelerating to stop
Raising frequency
Lowering frequency
Matching frequency

• Byte 3

```
| 0 | 1 | 0 | 0 |   |   |   |   |
```
— Matching deceleration
— Reverse run (See Note)
— Gate ON
— Frequency locked

• Byte 4

```
| 0 | 1 | 0 | 0 | 0 | 0 | 0 |   |
```
— Standby
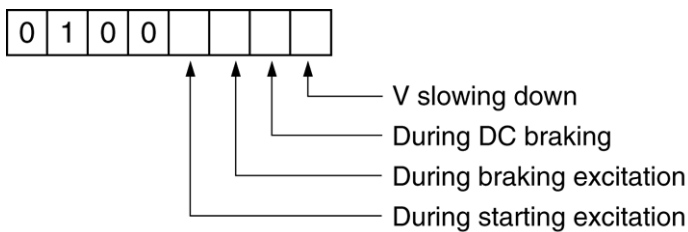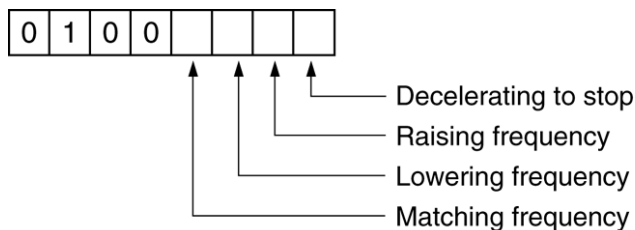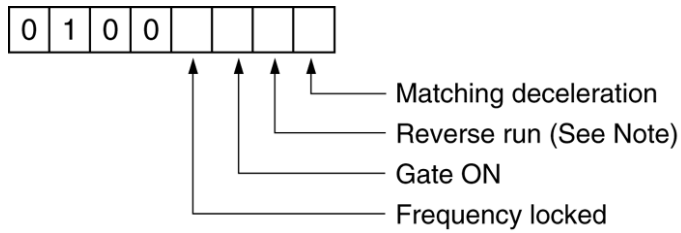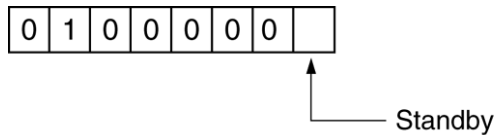
Note: The Reverse Run bit remains 1 even when the inverter stops after reverse run. If it is necessary to confirm forward or reverse run, also check the Gate ON bit status.

3) Control Terminal Board Input Status
   Input status data is returned in four bytes.
   • Byte 1

```
| 0 | 1 | 0 | 0 |   |   |   |   |
```
— DI1
— DI2
— DI3
— DI4

   • Byte 2

```
| 0 | 1 | 0 | 0 |   |   |   |   |
```
— DI5
— DI6
— DI7
— DI8

   • Byte 3

```
| 0 | 1 | 0 | 0 |   |   |   |   |
```
— Spare
— Spare
— Spare
— Spare

   • Byte 4

```
| 0 | 1 | 0 | 0 |   |   |   |   |
```
— Spare
— Spare
— Spare
— Spare
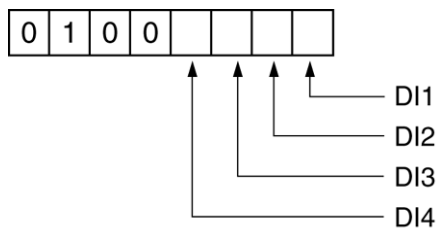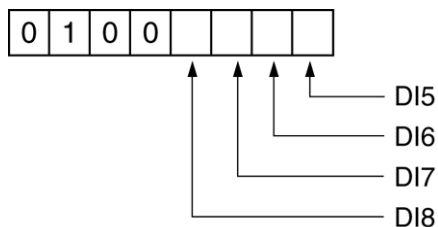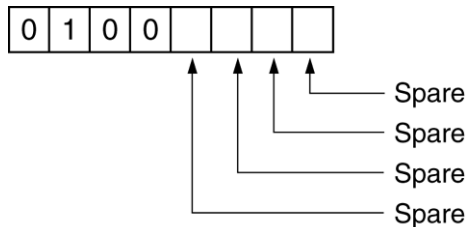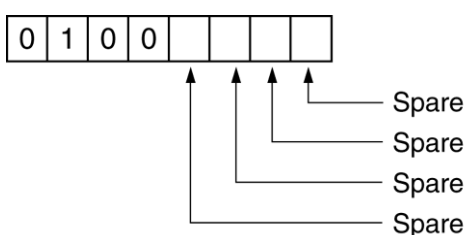
(4)　Function code setting error codes

ASCII	BIN	Meaning
"e0xxx"		Setting value conflicts with function code number XXX
"eFFF0"	F0H	Normal termination of function code setting
"eFFF1"	F1H	Function code value is out of range, user's initial value is not determined, or motor constant is not registered (Cd053)
"eFFF2"	F2H	Function code setting conflicts with mounted optional board
"eFFF3"	F3H	Function code setting conflicts with mounted options
"eFFF4"	F4H	Unable to change function code during inverter operation
"eFFF5"	F5H	Unable to change function code with operation function locked
"eFFF9"	F9H	Unable to change function code during LV
"eFFFA"	FAH	Frequency setting is not permitted: Check the value of Cd002.
"eFFFB"	FBH	Inverter control microcomputer busy: Send the message again.
"eFFFC"	FCH	Reserved
"eFFFE"	FEH	Access to undefined code

ASCII: ASCII-format message communication

BIN: Binary-format message communication

(5)　Inverter alarm codes

Alarm No.	Alarm code	Meaning	Alarm No.	Alarm code	Meaning
01	AL5	CPU abnormality	20	OCPA	Momentary overload during acceleration
02	AL1	Memory abnormality	21	OCPN	Momentary overload during constant power operation
03	AL2	System abnormality	22	OCPD	Momentary overload during deceleration
04	OCH	IPM thermal alarm	23	ACER	Overload prevention alarm during acceleration
05	OCA	Overcurrent during acceleration	24	CNER	Overload prevention alarm during constant power operation
06	OCN	Overcurrent during constant power operation	25	DCER	Overload prevention alarm during deceleration
07	OCD	Overcurrent during deceleration	26	AL3	System abnormality
08	OVA	Overvoltage during acceleration	27	AL4	System abnormality
09	OVN	Overvoltage during constant power operation	28	AL9	System abnormality
10	OVD	Overvoltage during deceleration	29	AL10	System abnormality
11	OVP	Brake resistor protection overvoltage	30	GAL1	Disconnection of feedback signal cable
12	LVA	Undervoltage during acceleration	31	---	Reserved
13	LVN	Undervoltage during constant power operation	32	---	Reserved
14	LVD	Undervoltage during deceleration	33	---	Reserved
15	OLA	Overload during acceleration	34	---	Reserved
16	OLN	Overload during constant power operation	35	---	Reserved
17	OLD	Overload during deceleration	36	PONG	Power supply abnormality
18	ES	External thermal alarm	37	OPEN	Missing output phase
19	OH	Fin temperature abnormality			

(6) Communication error processing by the inverter

● If an error is found in a message from the master computer, the inverter executes the following processing:

1) ASCII-format message

① Parity error, SUM error, or undefined command code
The inverter returns an error message with the command code ? and a one-byte communication error code for DT.
Example: Inverter number 1

*	0	1	?	DT	SUM	EM

② DT data too long or short, or data cannot be interpreted
The same error processing as (1) is executed if a message where the data is too long or short is defined for a code, or the received message data cannot be interpreted.

③ Timeout
The receive status is terminated forcibly if the entire message cannot be received within 150 ms after its start code. The inverter returns communication error code "d."

④ Start code not detected
If data is being received without a correct start code, the above error is reported after a correct start code is detected.

⑤ Communication error code list
p: Parity error
s: SUM error
u: Operation code not defined
d: Data too long or short, or data cannot be interpreted

⑥ Other errors
The timeout processing applies to other errors related to message reception from a computer. The computer returns no response.

2) Binary-format message
If an error is detected in a received message, the inverter returns an error message to the computer with OP set to ? and ST set to 1 (Binary).

① Error detection
Parity error, SUM error, undefined command code, or message data too short (receive timeout)
Example: Binary format

@	IN	?	ST	SUM

(7) Message transmission and reception between inverter and computer

1) Basics

① The serial communication protocol is based on a procedure for an inverter to respond to a computer command. Whenever a command is received from a computer, the inverter returns a response. If the computer sends more commands to the inverter without waiting for a response from the inverter, the inverter may not work normally.

② Due to an inverter or communication line fault, however, the computer may not be able to receive a response from the inverter. To prevent the response wait status from locking the communication protocol, the computer should use a receive timeout of two seconds or longer.

③ The following commands are exceptions:
   a) Command Z: The inverter automatically issues this command to notify the computer of an alarm, whether or not a command is received from the computer.
   b) Commands c, d, and e: The inverter can return no responses to these batch control commands.

④ When sending commands c, d, and e with no response from the inverter, the computer should insert an interval of about 10 ms between commands.

2) Message transmission and receive timings on the RS485 communication interface
The inverter uses an RS485 communication interface with a half-duplex communication line system. Therefore, the computer should use the timing described below when sending messages to prevent a collision between computer-sent and inverter-sent messages.
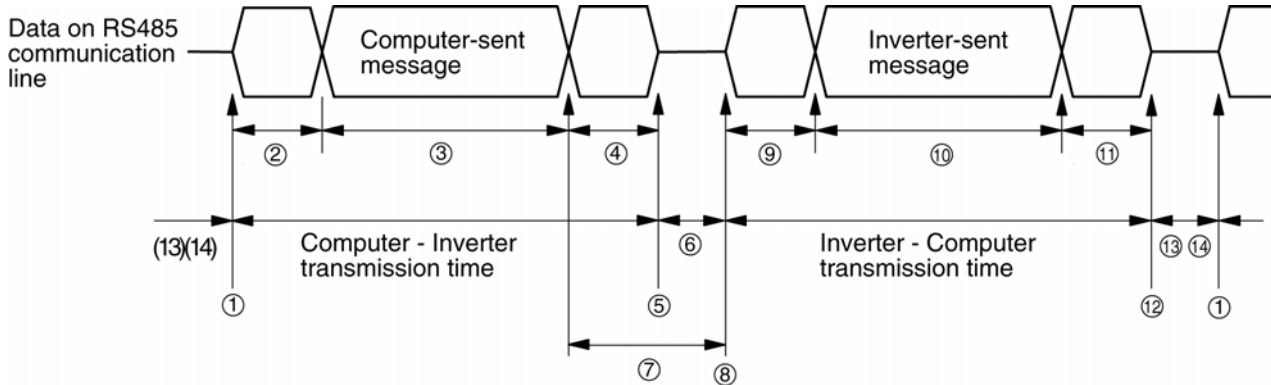
① The computer enables the RS485 communication line for message transmission.
② The RS485 communication line is enabled but the computer has not started message transmission yet. Start message transmission as soon as possible after the computer has enabled the communication line.
③ The computer is transmitting a message. The transmission should be completed within 150 ms.
④ The computer has completed message transmission but the communication line is not disabled yet. Communication line should be disabled within about 5 ms after completing the transmission.
⑤ The computer disables the RS485 communication line.
⑥ The computer has not started message transmission yet. The RS485 communication line is disabled.
⑦ The inverter has completed message reception from the master computer but is not transmitting a message yet.
⑧ The inverter enables the RS485 communication line for message transmission.
⑨ The RS485 communication line is enabled but the inverter has not started message transmission yet. The inverter starts transmission about 100 μs to 50 ms after enabling the communication line.
⑩ The inverter is transmitting a message.
⑪ The inverter has completed message transmission but the communication line is not disabled yet. The inverter should disable the communication line within about 100 μs after completing the transmission.
⑫ The inverter disables the RS485 communication line.
⑬ Neither the computer nor the inverter is transmitting. Both the computer and the inverter keep the RS-458 communication line disabled while there is no communication.
⑭ Before transmitting the next command to the same inverter, insert an interval of about 10 ms.

3) Message transmission and receive timings on the RS232C communication interface
The inverter uses an RS232C communication interface with a full-duplex communication line system. However, since the communication program in the inverter does not support full-duplex communication, messages should be transmitted and received using the same timing as the RS485 communication interface.

(8) Sample program

Example 1)　　N$_{88}$-Basic

```
100  '**********************************************************
110  '*Sample program for reading the output frequency (BASIC Program Language)        *
120  '*             Author: SANKEN Electric Co., Ltd.                                  *
130  '*                                                                                *
140  '**********************************************************
150  '
160  OPEN  '' COM1:'' AS #1                'Open the serial communication line
170  '
180  TX$='' *01C''                         'Set data to be sent to the inverter
190  TXLEN=LEN(TX$)                        'Acquire the send data length (excluding checksum and end code)
200  '
210  SUM=0                                 'Calculate the transmission checksum
220  FOR I=1 TO TXLEN
230  SUM=SUM+ASC(MID$ (TX$, I, 1))
240  NEXT I
250  SUM=((0-SUM) AND 127) OR 64
260  '
270  TX$=TX$+CHR$(SUM)+CHR$(13)+CHR$(10) 'Add a checksum and end code (CR+LF) to send data
280  '
290  PRINT #1, TX$                         'Transmit data to the inverter
300  '
310  LINE INPUT #1, RX$                    'Data received from the inverter
320  '
330  RXLEN=LEN (RX$)                       'Acquire the receive data length (excluding end code)
340  '
350  SUM=0                                 'Calculate the received checksum
360  FOR I=1 TO RXLEN-1
370  SUM=SUM+ASC(MID$ (RX$, I, 1))
380  NEXT I
390  SUM=((0-SUM) AND 127) OR 64
400  '
410  IF MID$ (RX$, RXLEN, 1)=CHR$ (SUM) THEN PRINT ''OK!'' ELSE PRINT ''NG!''
     'Check the received checksum
420  '
430  'CLOSE #1                             'Close the serial communication line
440  END                                  'Exit the program
```

Example 2)　　Visual Basic

```
'**********************************************************
'*Sample program for reading the output frequency (Visual Basic 6.0)        *
'*(Example of receiving data from Comm event)                               *
'**********************************************************
```
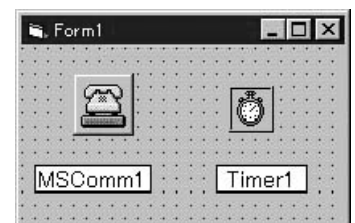

'Create a new project.

'Select [Project] then [Components] from Visual Basic Toolbar. Check "Microsoft CommControl 6.0" in [Component].

'Place the object "MSComm1" in the form.

'Place the timer "Timer1" object in the form.

```
      Dim i As Integer
      Option Explicit
Private Sub Form_Load()                    '[Transmit data.]
      Dim Tx As String, TxLen As Integer, Sum As Integer

      MSComm1.CommPort=1                   'Select communication port 1
      MSComm1.Settings="4800,o,8,1"        'Specify 4800bps, odd number, data: 8 bits, stop: 1 bite
      MSComm1.RTHrshild=1                  'Comm Event is generated when receiving 1 character
      MSComm1.InputLen=0                   'Read all input buffer data
      MSComm1.PortOpen=True                'Open communication port
      Timer1.Interval=1000                 'Interval for receive time out (m sec.)

      Tx="*01C"                            'Set data to be sent to the inverter
      TxLen=Len( Tx )                      'Acquire the send data length (excluding checksum and end code)
      Sum=0
      For i=1 To TxLen
          Sum=Sum+Acs(Mid(Tx, i, 1))
      Next i
      Sum=((0-Sum)And 127) Or 64

      Tx=Tx+Chr(Sum)+vbCrLf                'Add a checksum and end code (CR+LF) to send data

      Timer1.Enable=True                   'Enable receive time out error detecting timer
      MSComm1.Output=Tx                    'Transmit data to the inverter

End Sub

Private Sub MSComm1_OnComm()              '[Receive data with Comm event receive]
      Dim Rx As String, RxLen As Integer,Sum As Integer
      Dim Msg As String
      If MSComm1.CommEvent<>comEvReceive Then Exit Sub   'Confirm that the data is Comm event

      Do
          Rx=Rx+MSComm1.Input              'Receive data from the inverter
          DoEvents
      Loop Until Right(Rx,2)=(Chr(13)& Chr(10))          'Detect end code

      Timer1.Enabled=False                 'Cancel time out error detecting timer

      RxLen=Len(Rx)-2                      'Acquire the receive data length (excluding end code)

      Sum=0                                'Calculate the received checksum
      For i=1 To RxLen-1
          Sum=Sum+Acs(Mid(Rx, i, 1))
      Next i
      Sum=((0-Sum)And 127) Or 64
      If Mid(Rx, RxLen, 1)=Chr(Sum) Then   'Check the checksum
          Mag=Left(Rx, RxLen)              'Received data (including checksum, excluding end code)
      Else
          Msg="Check Sum NG"               'Display checksum error
      End If

      MSBox "Received Data="& Msg          'Display received data

      MSComm1.PortOpen=False               'Close communication port
   End
End Sub

Private Sub Timer1_Timer()                'Receive time out processing
      MsBox "Communication Timeout"
      End
```

```
        End Sub
```
'When the output frequency of the inverter is 20 Hz
'This program displays "*01C02999@" in the message box
'   *: Header 01: Number of the inverter 02000: 20.00 Hz
'   @: Check Sum
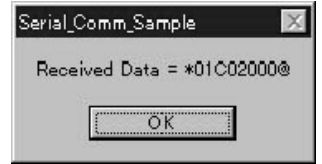
(9)   Character code list

Upper 4 bits →

Lower 4 bits ↓	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0		D_E		0	@	P	`	p				－	タ	ミ		╳
1	S_H	D_1	!	1	A	Q	a	q			。	ア	チ	ム		円
2	S_X	D_2	"	2	B	R	b	r			「	イ	ツ	メ		年
3	E_X	D_3	#	3	C	S	c	s			」	ウ	テ	モ		月
4	E_T	D_4	$	4	D	T	d	t			、	エ	ト	ヤ		日
5	E_Q	N_K	%	5	E	U	e	u			・	オ	ナ	ユ		時
6	A_K	S_N	&	6	F	V	f	v			ヲ	カ	ニ	ヨ		分
7	B_L	E_B	'	7	G	W	g	w			ア	キ	ヌ	ラ		秒
8	B_S	C_N	(	8	H	X	h	x			イ	ク	ネ	リ	♠	
9	H_T	E_M	)	9	I	Y	i	y			ウ	ケ	ノ	ル	♥	
A	L_F	S_B	*	:	J	Z	j	z			エ	コ	ハ	レ	♦	
B	H_M	E_C	+	;	K	[	k	{			オ	サ	ヒ	ロ	♣	
C	C_L	→	,	<	L	¥	l	¦			ヤ	シ	フ	ワ	●	
D	C_R	←	-	=	M	]	m	}			ユ	ス	ヘ	ン	○	
E	S_O	↑	.	>	N	^	n	~			ヨ	セ	ホ	゛		
F	S_I	↓	/	?	O	_	o				ツ	ソ	マ	゜		

8.   Protection Functions

8.1   Warning Status

● This warning status alerts you that the protection function of the inverter has been activated. However, the inverter keeps on running. If the inverter runs for a long time in this status, the inverter may enter the alarm status and stop running.
(See Table 8.1 for warning list)

● In the Status Display mode, details of the warning and the status indication alternate on the 7-segment display when a warning has occurred. When the Status Display mode is not selected, the alternating display appears on the 7-segment display if the warning is still active after the Status Display mode is resumed.

● All keys are valid during the warning status because the inverter continues to operate.

Table 8.1 List of warnings

Warning display	Warning	Description
5u	Protection against overvoltage has been activated	Deceleration time too short
5C	Current limiting during acceleration/deceleration	Acceleration (deceleration) time too short
5Cn	Current limiting during constant power operation	Load too heavy Output frequency too high
oL	Overload warning	Load too heavy Inverter will stop unless an action is taken
tH	Overheating of radiator fins	Temperature of the radiator fins is rising. Check the ambient temperature and operation of the cooling fan. The warning is issued at a temperature 10°C below the abnormal radiator fin temperature (oH) (The abnormal radiator fin temperature differs depending upon the output frequency, output current and other factors)
dboH	Overheating of brake resistor	Brake resistor capacity too low. (%ED is small) Brake resistor stops to prevent heat damage.
oPtEr	Option error	Two mounted option boards are conflicting with each other.
FbEr	PID pressure feedback disconnection	PID pressure feedback is abnormal. Check the feedback value and the feedback signal.

8.2 Alarm Status

● The alarm status occurs when the protection function stops the inverter (See Table 8.3 for alarm list).

● During alarm status, all values on the 7-sement display (Hz, A, rpm, %, V, MPa) flash indicating the alarm status.

● When the Status Display mode selected, details of the alarm are indicated on the 7-segment display. If the Status Display mode is not selected, details of the alarm are indicated on the 7-segment display if the alarm status continues after the Status Display mode is resumed. Details of the alarm cannot be deleted.

Table 8.2 Key functions during alarm status

Key operation	Functions
(STOP)	Alarm reset key. The alarm can be cleared if the cause of the alarm has been removed. (AL1, AL2, AL3, AL4, AL9 and AL10 cannot be cleared using the stop key.)
(PROG)	The display can be switched to the Function Code Display mode, even during alarm status. Using Cd098, data for the last 5 alarms at maximum can be read. This is useful for investigating the possible causes of the alarm.
(ENTER) (CLEAR DISP) Numeric keys (▲) (▼) Decimal point keys	Keys valid in the Function Code Display mode
(DRIVE)	During alarm status, this key does nothing.

Table 8.3 List of alarms

Alarm display	Description	Check points	Actions
AL 1*2	Memory abnormality	Turn off the power so the CHARGE lamp turns off, turn the power on again and check the alarm.	Contact your supplier.
AL 2*1	System abnormality	Excessive external electrical noise? Are signal and power lines separated far enough?	Attach absorber and noise filter. Separate signal lines from power lines.
AL 3*1	System abnormality		
AL 4*2	System abnormality	Abrupt capacitor discharge? Turn off the power so the CHARGE lamp turns off, turn the power on again and check the alarm.	Reconfirm the modified code data. Turn the power on and off several times. If the alarm cannot be cancelled, reset the system using Cd099=1 and then turn the power off and on again. All the function data is initialized to the factory presets.
AL 5*2	System abnormality	Excessive external electrical noise? Are signal and power lines separated far enough?	Attach absorber and noise filter. Separate signal lines from power lines.
AL 9*2	System abnormality		
AL 10	System abnormality	Turn off the power so the CHARGE lamp turns off, turn the power on again and check the alarm.	Contact your supplier.
ACEr	Overload prevention alarm during acceleration	Current limit value: Setting for Cd043 too low?	Increase the set value. Increase acceleration and deceleration time.
CnEr	Overload prevention alarm during constant power operation		
dCEr	Overload prevention alarm during deceleration		
ES	External thermal alarm	Motor overheated?	Reduce the load.
oH	Fin temperature abnormality	Fan stopped? Ambient temperature too high?	Check fan operation. Increase the ventilation.
LuA	Undervoltage during acceleration	Does power supply satisfy conditions? Has the voltage dropped? Any phase failure?	Examine/improve power supply conditions.
Lun	Undervoltage during constant power operation		
Lud	Undervoltage during deceleration		
oCH	Main switching device temperature abnormality	Fan stopped? Ambient temperature too high?	Check fan operation. Increase the ventilation.
oCA*3	Overcurrent during acceleration	Abrupt acceleration/deceleration rate?	Increase acceleration and deceleration time.
oCn*3	Overcurrent during constant power operation	Output short-circuited or ground fault? Main switching device abnormality?	Correct the short-circuit or ground fault. Contact your supplier.
oCd*3	Overcurrent during deceleration		
oCPA	Momentary overload during acceleration	Excessive acceleration rate? Current limit value: Setting for Cd043 too high?	Increase the acceleration time. Decrease the set value.

Alarm display	Description	Check points	Actions
oCPn	Momentary overload during constant power operation	Abrupt change (increase) in load? Current limit value: Setting for Cd043 too high?	Eliminate the abrupt change in load. Decrease the set value.
oCPd	Momentary overload during deceleration	Excessive deceleration rate with a large GD^2? Current limit value: Setting for Cd043 too high?	Increase the deceleration time. Decrease the set value.
oLA	Overload during acceleration	Motor operated with an excessive load? Electrothermal level set properly? GD^2 of the load excessive?	Reduce the load. Increase the capacity of the inverter and motor.
oLn	Overload during constant power operation		
oLd	Overload during deceleration		
ouA	Overvoltage during acceleration	Did start-up occur during free run?	Flying start.
oun	Overvoltage during constant power operation	Is motor being turned by other force?	Redesign the system so that the motor is not driven by external force. Use a brake resistor with a large capacity.
oud	Overvoltage during deceleration	Excessive deceleration?	Increase the deceleration time (so that GD^2 of the load is met).
ouP	Brake resistor protection overvoltage	Braking frequency too high?	Reduce the braking frequency. Increase the brake resistor capacity.
oPEn	Missing output phase (This is not detected with ultra low frequency such as a few Hz)	Check whether any of the output cables of the inverter has a missing phase.	Connect the output cables securely to the inverter.
CAL 1	Disconnection of feedback signal cable detected during PID control of Cd071=3.	Feedback signal cable disconnected? Feedback signal correct? Cd055: gain frequency correct?	Connect the feedback cables securely. Set Cd055:gain frequency properly.
PonG [2]	Power supply abnormality	+24 V power supply output from the control circuit overloaded or shorted?	Check the +24V power supply for overload.

*1 Since all function data is initialized to the factory presets, settings will need to be input again.

*2 If alarm is displayed again after turning the power on again, contact the retailer.

*3 Even through a protective function against short-circuiting of the main switching device is installed, repeated short-circuiting may cause deterioration of devices and lead to damage to the inverter. After removing the cause of the problem, check safety before restarting operation.

Note: If the display on the operation panel goes out for some reason, turn off power to the inverter to check the wiring, and turn the power on after CHARGE lamp has gone out. (for example, after accidentally short-circuiting 24V power supply)

8.3 Protection Operations
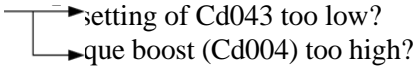
Table 8.4 List of protection operations

Protection functions	Description	Indication
Overcurrent limiting (Anti-breakdown)	When the current exceeds the value set by Cd043, the frequency curves are adjusted to limit the increase in current. Acceleration: After the output current reaches the setting for Cd043 during acceleration, the frequency increases at a slower rate for a while to accelerate the motor within the current limit, preventing breakdown from occurring. Constant power operation: When the output current reaches the setting for Cd043 due to an overload during constant power operation, the frequency is reduced to keep the output current below the setting. When the overload is removed, the frequency returns to its previous setting.	SC SCn
Overload prevention	When the energy regenerated during deceleration of the motor exceeds the dissipation capacity of the brake resistor, raising the DC voltage of the inverter, the drive frequency stops decreasing and actually increases as necessary to prevent an over-voltage trip. After the regenerated energy decreases, deceleration is continued at a slower rate.	Su
Overcurrent shutdown	When a current exceeding the allowable current range of the inverter is input, the protection circuit activates and stops the inverter.	oCA oCn oCd
Overvoltage shutdown	When the inverter-DC link voltage exceeds the specified voltage due to excessive regenerated energy, a protection circuit is activated to stop the inverter.	ouA oun oud
Protection against undervoltage (momentary power failure)	When the DC voltage falls below the specified value due to an abnormal power supply voltage, the inverter stops operating.	LuA Lun Lud
Overload shutdown (motor electrothermal protector)	Overloading and overheating of the motor during low speed operation are detected by the electrothermal protector to stop the inverter. Different values can be specified to trip electrothermal protector depending on the type, rated current, etc. of the motor.	oLA oLn oLd
Overload shutdown (inverter thermal protector)	The inverter stops operating when a current greater than the current rating of the inverter flows for one second or longer.	$oCPA$ $oCPn$ $oCPd$
Protection against radiator fin overheat	Warning (tH) is issued at a temperature 10°C below the abnormal radiator fin temperature (oH) when the ambient temperature rises sharply or the cooling fan stops. If it continues to rise further and exceeds the abnormal radiator fin temperature (oH), the protection function stops the motor drive. (The abnormal radiator fin temperature (oH) differs depending upon the output frequency and output current.) This function also stops the drive when the main switching device (power module) is overheating. This function is released when the temperature decreases to more than 10°C below the abnormal radiator fin temperature (oH).	tH oH oCH

Table 8.4 List of protection operations

Protection functions	Description	Indication
Brake resistor over-heating protection	As the regenerative energy of the motor increases, and the allowable brake resistor value (%ED) is exceeded, the brake resistor becomes temporarily unusable due to overheating protection. By letting the brake resistor cool down, it becomes usable again.	*dboH*
Overload prevention alarm	The inverter stops operating if the motor is unable to accelerate or decelerate because the motor load is excessive or the setting of Cd043 (output current limiting function) is too low.	*ACEr* *dCEr* *CnEr*
External thermal protection	An external thermal protector can be attached to a motor. By inputting this signal to the ES control signal terminal, the inverter can be set to stop when the thermal protector is activated.	*ES*
CPU abnormality	If excessive external electrical noise or other disturbances lead to a malfunction of the CPU, connection failure of an option board, or internal memory abnormality, the inverter stops operating.	*AL 1* | *AL 10*

9. Troubleshooting

Problem		Check Points
Motor does not rotate	Main circuit	• Voltages at terminals R, S, T normal? • Is the motor wired correctly?
	Load	• Load too heavy? • Motor locked?
	Operation panel	• Starting frequency setting too high (Cd010)? • Operation start frequency setting too high (Cd011)? • Is operation command selected for control by external signal (Cd001=2)? • Upper frequency limit set too low (Cd007)? • Check if no setting is specified for the direction of rotation of motor (Cd050)?
	Input signal	• Are operation signals (FR, RR) being input? • Make sure that signals FR and RR are not being input at the same time. • Make sure that free run stop signal (MBS) is not being input. • Make sure that the analog signal for frequency setting is not zero.
Rotation direction different from what it should be		• Wrong wiring of output terminals U, V and W? • Is the wiring for forward and reverse run mixed up?
Rotation speed does not increase		• Maker sure that the upper frequency limit function (Cd007) is not activated. • Make sure that output current limiting ⌐→ setting of Cd043 too low? function is not activated. ⌐→ que boost (Cd004) too high? • Load too heavy?
Rotation is not constant		• Load fluctuating? • Frequency setting (analog) signal fluctuating? • Are the capacity and no. of poles appropriate for the inverter capacity specified for use in the sensorless vector control mode?
Acceleration/ deceleration is not constant		• Acceleration/deceleration time too short? • Make sure that output current limiting function is not activated. • Load too heavy?
Motor heating up		• Wrong setting for V/f pattern? • Torque boost too high?
Rotation speed changes abnormally during operation		• Is the load fluctuating? • Make sure that output current limiting function is not activated. ——→ Is setting of Cd043 too low?

10. Maintenance and Inspection

> 🚫   ■ This product must only be serviced by a qualified engineer.
>   Failure to observe these warnings may result in injury or fire.

Careful checking and maintenance are essential to ensure that the **SAMCO-VM05** general-purpose inverter operates correctly with a long service life.

10.1 Precautions on Checking and Maintenance

- This product must only be serviced by a qualified engineer.

- Capacitors retain a high voltage charge for a while after the power is turned off. Make sure that the CHARGE lamp on the PCB goes out before working on this product. Then check using a circuit tester to see that the voltage across terminals X and P is lower than 30 VDC.

10.2 Basic Inspection Items

- The motor works as expected;

- The cooling system is free from any problems (such as abnormal heating);

- There is no abnormality at the location of installation; and

- There is no abnormal vibration or noise.

Inspection must be carried out following the periodic inspection list described in Table 10.1.

Table 10.1 Periodic inspection list

Inspection item		Inspection details	Method and measuring instrument	Criteria
General	Ambient environment	· Ambient temperature, relative humidity · Confirm operating environment	· Visual inspection: Use measuring instrument. · Use thermometer and hygrometer.	· Satisfy standard specifications.
	Power supply voltage	· Power supply voltage of the inverter is normal.	· Measure interphase voltage of R, S, T power input terminals. · Use tester and multimeter.	· Satisfy standard specifications of input.
	Appearance and structural parts	· There is no abnormal vibration or or noise. · There is no loosening of bolts. · There is no deformations or breakage. · There is no adhesion of dust or dirt.	· Tighten bolts. · Visual inspection	· There is no abnormality.
Main circuit	General	· Megger check · There is no deformations or dirt. · There is no adhesion of dust or dirt.	· Tighten bolts. · Visual inspection	· There is no abnormality.
	Connection conductors and wires.	· There is no distortion or dirt on conductors · There is no discoloration because of overheating.	· Visual inspection	· There is no abnormality.
	Main module	· Check resistance between terminals.	· Disconnect the main wiring of the inverter and measure each terminal with tester (1 range) · Use analog tester.	Refer to Table 10.2 Main circuit power module checklist.
	Terminalboard	· There is no burning or breakage.	· Visual inspection	· There is no abnormality.
	Main electrolytic capacitor	· There is no liquid leaks. · There is no loosening of safety valves. · Measure electrical capacitance.	· Visual inspection · Measure with capacity meter	· There is no abnormality. · More than 85% of rated capacity.
	Relay magnetic contactor	· There is no chatter during operation. · There is no rough surface on the contact. · There is no abnormal noise when the switch is ON.	· Visual and hearing inspection	· There is no abnormality.

Inspection item		Inspection details	Method and measuring instrument	Criteria
Main circuit	Resistor	· Check if there is no disconnection. · There is no odors or cracks because of overheating.	· Odor and visual inspection · Remove one-side and check with tester. · Use tester and multimeter.	· There is no abnormality. · Less than ±10% of indicated resistance value.
	Transformer	· There is no abnormal beat sound or odor.	· Odor, visual and hearing inspection	· There is no abnormality.
Control circuit display	Connector	· There is no loosening of connectors. · There is no cracks, breakage or deformation.	· Visual inspection	· There is no abnormality.
	Capacitor	· There is no liquid leaks, breakage or deformation.	· Visual inspection	· There is no abnormality.
	Board	· There is no discoloration or dirt.	· Visual inspection	· There is no abnormality.
	Display	· There is no break in the LCD lamp of operation panel · There is no abnormality in key operation.	· Visual inspection	· Check that the lamp lights up. · Check key operations.
Cooling system	Fan	· There is no abnormal vibrations or noise. · There is no "OH" alarm status. · There is no loosening of bolts, wiring or connectors.	· Visual and hearing inspection · Tighten bolts, wiring and connectors.	· There is no abnormality.
	Ventilation flue	· There is no blockage in cooling fan inlet and outlet or contaminationor adhesion of foreign objects.	· Visual inspection	· There is no abnormality.
	Fin	· There is no abnormal heating.	· Tactile inspection. Check the temperature. · Use the thermometer.	· There is no abnormality.
Motor	General	· There is no abnormal vibration or noise.	· Visual and hearing inspection	· There is no abnormality.
	Insulation resistance	· Megger check	· Disconnect the inverter output wiring U, V, and W. · Use megger tester.	· More than 5 M Ω.

Table 10.2 Main circuit power module checklist

Input/Output	Terminals		Measured value
	Tester +	Tester -	
Input (R, S, T)	P	R, S, T	Conducted
	R, S, T	P	Not conducted
	X	R, S, T	Not conducted
	R, S, T	X	Conducted
Output (U, V, W)	P	U, V, W	Conducted
	U, V, W	P	Not conducted
	X	U, V, W	Not conducted
	U, V, W	X	Conducted

10.3 Megger Test

● When performing a megger test on the motor and the sequential circuit, be careful not to apply the test voltage to the inverter.

● For the inverter itself, perform the megger test only on the main circuit as shown below. Do not conduct a megger test on the control circuit.

Megger test
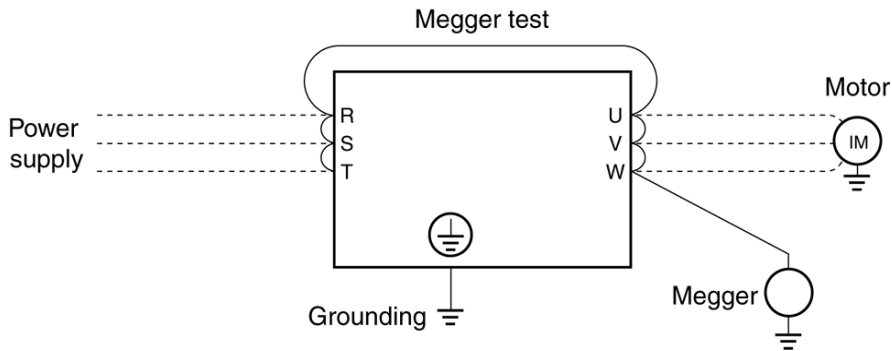
⊘ Use a circuit tester (high resistance range) for continuity testing of the control circuit. Do not use a megger or buzzer.

10.4 Part Replacement

● The bearings of the cooling fan usually have a service life of between 10,000-35,000 hours. In a system that is continually operated, therefore, the bearings must be replaced every 2nd or 3rd year together with the cooling fan. Run the fan using the Cd097 function. If any abnormal vibration or sound is detected during inspection, replace the fan.

❶ Turn OFF the power for parts replacement. Check that the rotation of the fan is stopped. Failure to observe this warning may result in an electric shock or injury.

Step 1: Remove the screws that secure the fan. (Figure 10.1, 10.2 In some models, remove the fan cover first.)

Step 2: Remove the fan connector. (Figure 10.3-10.5 The location of the connector differs according to the model.)

Step 3: Change the fan to the maintenance fan and insert the fan connector.

Step 4: Attach the fan.

Note 1: Use the maintenance fan.
Note 2: Attach the fan so that the direction of the fan blast (FLOW) corresponds to the direction of blast shown below.
Note 3: Remember to attach the finger guard or the fan cover.

Figure 10.1
Removing the fan (small-capacity models)

Figure 10.2
Fan cover (55K class)

Direction of flow
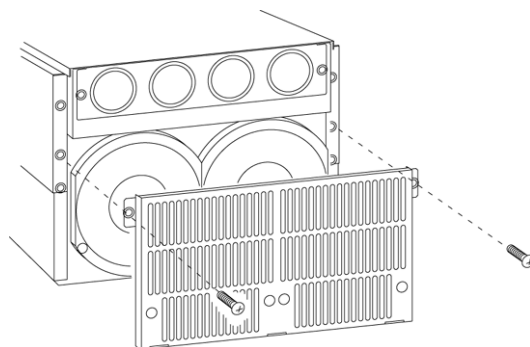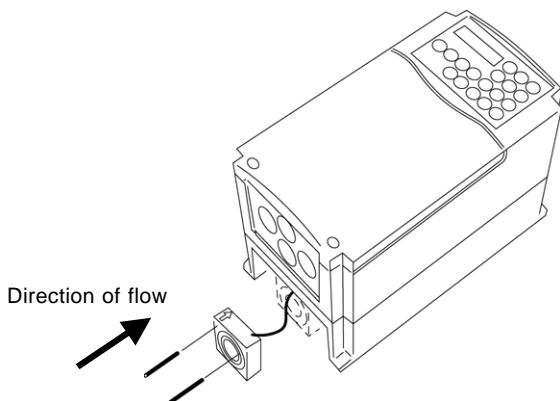
Figure 10.3
Connector position (small-capacity models)
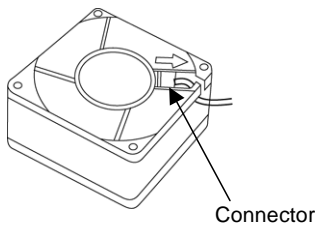
Connector

Figure 10.4
Connector position (7.5K class)

Connector

Direction of flow
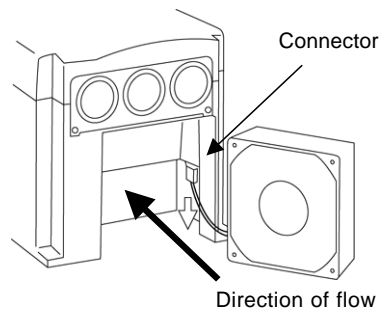
Figure 10.5
Connector position (55K class)

Connector

Direction of flow
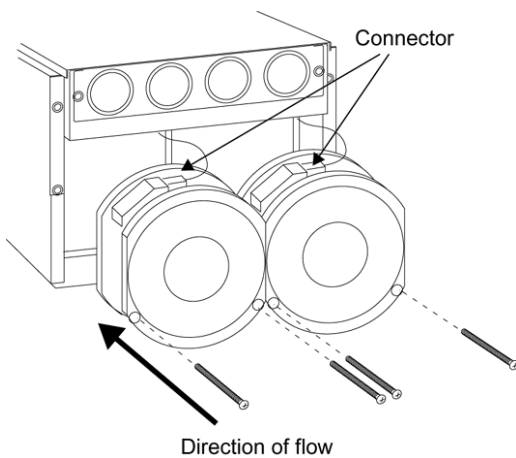
● Smoothing Capacitors
   Aluminum electrolytic capacitors for smoothing deteriorate over time. Although the service life varies greatly depending on the ambient temperature, load and length of use, they should be replaced approximetely every 5th year or so when used under normal ambient conditions.
   The inverter must receive transmitted electricity at least once a year when the inverter is stored and not energized. The capacitors must be inspected at least once a year, and once in 6 months when they are near the end of their lifetime.
   (Inspection details)
     1) Check that there is no liquid leaking.
     2) Check that there is no loosening of safety valves.
     3) Check that there is no deformation of or cracks in the cases.
     4) Check that the measured result of electrical capacitance is not less than 85 % of rated capacity.

10.5 Electrical Measurement of Main Circuit

- Since the voltages and currents of the main inverter circuit at the input (power supply) and output (motor) contain harmonic components, measured values may differ depending on the meter used. When using a commercial frequency meter, select one of the types listed in the table below.

- The power factor cannot be measured with a commercial power-factor meter that measures the phase difference between voltage and current. Measure the voltage, current, and power separately at the input and output and calculate the power factor using the following formula:

$$\text{Power factor } [\%] = \frac{\text{Power [kW]}}{\sqrt{3} \times \text{Voltage [V]} \times \text{Current [A]}} \times 100$$
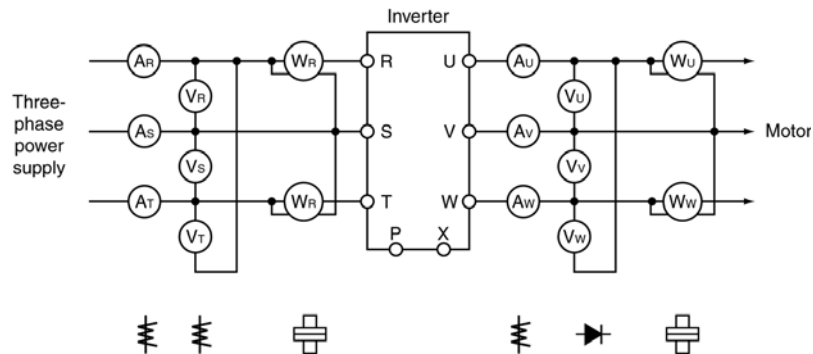
Table 10.3 Main circuit measuring instruments

Symbol	Measuring points	Measuring instruments
≩	Power supply voltage	Moving-iron type AC voltmeter
≩	Power supply current	Moving-iron type AC ammeter
串	Power supply power	Electrodynamic single-phase power meter or digital power meter
	Power supply power factor	Digital power meter (Can be calculated with the measured power supply voltage, current and power.)
►ᛁ	Output voltage	Rectifier type AC voltmeter or digital power meter
≩	Output current	Moving-iron type AC ammeter or digital power meter
串	Output power	Electrodynamic single-phase power meter or digital power meter
	Output power factor	Digital power meter (Can be calculated with the measured output voltage, current and power.)

11. Specifications

11.1 Standard Specifications

200V system: SBT

	Model	SBT-0.75K/1.5K		SBT-1.5K/2.2K		SBT-2.2K/3.7K		SBT-3.7K/5.5K		SBT-5.5K/7.5K		SBT-7.5K/11K		SBT-11K/15K		SBT-15K/18.5K		SBT-18.5K/22K		SBT-22K/30K	
	Load (*1)	H	P	H	P	H	P	H	P	H	P	H	P	H	P	H	P	H	P	H	P
Output	Applicable motor capacity	0.75kW	1.5kW	1.5kW	2.2kW	2.2kW	3.7kW	3.7kW	5.5kW	5.5kW	7.5kW	7.5kW	11kW	11kW	15kW	15kW	18.5kW	18.5kW	22kW	22kW	30kW
	Rated capacity (*2)	1.9kVA	2.7kVA	3.0kVA	3.7kVA	4.3kVA	5.8kVA	6.7kVA	8.5kVA	9.1kVA	11.4kVA	12.6kVA	16.8kVA	17.5kVA	21.7kVA	22.9kVA	25.9kVA	28.6kVA	31.2kVA	33.5kVA	41.9kVA
	Rated current	5.1A	7.0A	8.0A	9.6A	11.2A	15.1A	17.6A	22.3A	24A	30A	33A	44A	46A	57A	60A	68A	75A	82A	88A	110A
	Overload current (*3)	7.6A	8.4A	12.0A	11.5A	16.8A	18.1A	26.4A	26.7A	36A	36A	49.5A	52.8A	69A	68.4A	90A	81.6A	112.5A	98.4A	132A	132A
	Rated output voltage	200 V at 50 or 60 Hz, 220 V at 60 Hz																			
Input	Rated voltage and frequency	3-phase, 200 to 230 V at 50 or 60 Hz																			
	Allowable fluctuation	Voltage: ±10% Frequency: ±5% Voltage imbalance: 3% max																			
	Power supply impedance	1% or more (Use the optional reactor if less than 1%)																			
	Protective structure	Totally enclosed (IP20)																			
	Cooling method	Natural cooling		Forced air cooling																	
	Weight	3 kg		4 kg		4 kg		4.5 kg		8 kg		8 kg		10 kg		12 kg		15 kg		18 kg	
Control functions	Control method	V/f control or sensorless vector control																			
	High-frequency carrier	Sine wave PWM (carrier frequency: 1 to 14 kHz) (*4)																			
	Output frequency range — H characteristic	0.05 to 600 Hz (starting frequency: 0.05 to 20 Hz variable) (*5)																			
	Output frequency range — P characteristic	0.05 to 200 Hz (starting frequency: 0.05 to 20 Hz variable) (*5)																			
	Frequency setting resolution — Digital setting	0.01 Hz (0.05 to 600 Hz)																			
	Frequency setting resolution — Analog setting	0.1% (10 bits for 0 to 10 V, 4 to 20 mA), 0.2% (9 bits for 0 to 5 V) for maximum output frequency																			
	Frequency accuracy — Digital setting	±0.01% of the output frequency (at -10 to +40°C)																			
	Frequency accuracy — Analog setting	±0.2% of the maximum output frequency (at 25 ±10°C) (*6)																			
	DC braking	Starting frequency (0.2 to 20 Hz), operation time (0.1 to 10 s), braking force (1 to 10 steps)																			
	Additional functions	Restart after momentary power failure, flying start, multi-speed operation, frequency jump, auto alarm recovery, PID control operation, simple scheduled operation, energy-saving operation, torque limiter (for sensorless vector control only)																			
Operational functions	Start/stop setting	Operation panel, serial communication (RS485, RS232C), control circuit terminals																			
	Frequency command setting — Digital setting	Operation panel, serial communication (RS485, RS232C), step setting from terminal board																			
	Frequency command setting — Analog setting	2 channels, 0 to 5 V, 0 to 10 V, 4 to 20 mA, variable resistor (5 kΩ, 0.3 W or more)																			
	Input signals	Frequency command, forward run command, reverse run command, acceleration/deceleration time setting, free-run stop/alarm reset, emergency stop, jogging selection, step frequency setting, operation signal hold, torque limiter (sensorless vector control only) [Digital input; 8 channels (arbitrary allocation)] [Analog input; 1 channel for voltage, 1 channel for current and voltage]																			
	Output signals — Contact output	Alarm batch and multifunctional contact output (1C contact, 250 VAC, 0.3 A)																			
	Output signals — Monitor signal	Operating, frequency matching, overload alarm, undervoltage, overvoltage, frequency approach [Open-collector output: 3 channels (arbitrary allocation), Analog output: 2 channels]																			
	LED display	Frequency, output current, synchronous rotation, load factor, output voltage, pressure, line speed (no units), operating, alarm																			
	Serial communication I/F	RS485, RS232C																			
	Function extension	Software upgrade by RS232C serial communication supported																			
	External power supply output	24 VDC, 150 mA (control terminal)																			
	Protection functions	Current limiting, overcurrent shutoff, motor overload, external thermal alarm, undervoltage, overvoltage, momentary power failure, fin overheat, missing phase																			
	Warning functions	Overvoltage prevention, current limiting during acceleration/deceleration, brake resistor overheat, overload, overheating of radiator fins																			
Environment	Ambient temperature — H characteristic	-10 to +50°C (Remove the top ventilation cover at +40°C or higher)																			
	Ambient temperature — P characteristic	-10 to +40°C (Remove the top ventilation cover of the SBT-3.7K/5.5K or a lower model at temperatures of +30°C or higher)																			
	Storage temperature	-20 to +65°C (*7)																			
	Ambient humidity	90%RH or less (with no condensation)																			
	Operating environment	Indoor at 1,000 m or lower altitude (No direct sunlight, corrosive or inflammable gases, oil mist, or dust)																			

*1 H characteristic (H): Constant torque load (for general industry)

  P characteristic (P): Square-law decreasing torque load (for fan and pump)

*2 Rated capacity at the output voltage of 220 V

*3 One minute every 10 minutes

*4 The maximum carrier frequency varies with the rated characteristics and the operating status.

*5 The frequency setting range for sensorless vector control is 1 to 130 Hz for a four-pole motor (depends on the number of poles).

*6 The maximum output frequency is at 5 V, 10 V, and 20 mA.

*7 This temperature is for short periods, such as during transportation.

*   The SBT-7.5K/11K and lower models are equipped with discharge resistors as standard.

400V system: SHF

Model		SHF-1.5K	SHF-2.2K	SHF-4.0K	SHF-5.5K	SHF-7.5K	SHF-11K	SHF-15K	SHF-18.5K	SHF-22K
Output	Applicable motor capacity	1.5kW	2.2kW	4.0kW	5.5kW	7.5kW	11kW	15kW	18.5kW	22kW
	Rated capacity (*1)	2.8kVA	4.2kVA	6.2kVA	8.7kVA	11.8kVA	17.3kVA	22.2kVA	26.3kVA	31.9kVA
	Rated current (*2)	4A	6A	9A	12.6A	17A	25A	32A	38A	46A
	Overload current rating	150% 1 min								
	Rated output voltage	3-phase, 380 V at 50 Hz, 400 V at 50 Hz, 460 V at 60 Hz								
Input	Rated voltage and frequency	3-phase, 380 to 460 V at 50 or 60 Hz								
	Allowable fluctuation	Voltage: −15%, +10% Frequency: ±5% Voltage imbalance: 3% max								
	Power supply impedance	1% or more (Use the optional reactor if less than 1%)								
	Protective structure	Totally enclosed (IP20)								
	Cooling method	Forced air cooling								
	Weight	4 kg	4 kg	4.5 kg	6.5 kg	6.5 kg	7 kg	10 kg	12 kg	15 kg
Control functions	Control method	V/f control or sensorless vector control								
	High-frequency carrier	Sine wave PWM (carrier frequency: 1 to 14 kHz) (*3)								
	Output frequency range	0.05 to 600 Hz (starting frequency: 0.05 to 20 Hz variable) (*4)								
	Frequency setting resolution — Digital setting	0.01 Hz (0.05 to 600 Hz)								
	Frequency setting resolution — Analog setting	0.1% (10 bits for 0 to 10 V, 4 to 20 mA), 0.2% (9 bits for 0 to 5 V) for maximum output frequency								
	Frequency accuracy — Digital setting	±0.01% of the output frequency (at -10 to +40°C)								
	Frequency accuracy — Analog setting	±0.2% of the maximum output frequency (at 25 ±10°C) (*5)								
	DC braking	Starting frequency (0.2 to 20 Hz), operation time (0.1 to 10 s), braking force (1 to 10 steps)								
	Additional functions	Restart after momentary power failure, flying start, multi-speed operation, frequency jump, auto alarm recovery, PID control operation, simple scheduled operation, energy-saving operation, torque limiter (for sensorless vector control only)								
Operational functions	Start/stop setting	Operation panel, serial communication (RS485, RS232C), control circuit terminals								
	Frequency command setting — Digital setting	Operation panel, serial communication (RS485, RS232C), step setting from terminal board								
	Frequency command setting — Analog setting	2 channels, 0 to 5 V, 0 to 10 V, 4 to 20 mA, variable resistor (5 kΩ, 0.3 W or more)								
	Input signals	Frequency command, forward run command, reverse run command, acceleration/deceleration time setting, free-run stop/alarm reset, emergency stop, jogging selection, step frequency setting, operation signal hold, torque limiter (sensorless vector control only) [Digital input; 8 channels (arbitrary allocation)] [Analog input; 1 channel for voltage, 1 channel for current and voltage]								
	Output signals — Contact output	Alarm batch and multifunctional contact output (1C contact, 250 VAC, 0.3 A)								
	Output signals — Monitor signal	Operating, frequency matching, overload alarm, undervoltage, overvoltage, frequency approach [Open-collector output: 3 channels (arbitrary allocation), Analog output: 2 channels]								
	LED display	Frequency, output current, synchronous rotation, load factor, output voltage, pressure, line speed (no units), operating, alarm								
	Serial communication I/F	RS485, RS232C								
	Function extension	Software upgrade by RS232C serial communication supported								
	External power supply output	24 VDC, 150 mA (control terminal)								
	Protection functions	Current limiting, overcurrent shutoff, motor overload, external thermal alarm, undervoltage, overvoltage, momentary power failure, fin overheat, missing phase								
	Warning functions	Overvoltage prevention, current limiting during acceleration/deceleration, brake resistor overheat, overload, overheating of radiator fins								
Environment	Ambient temperature	-10 to +50°C (Remove the top ventilation cover at +40°C or higher)								
	Storage temperature	-20 to +65°C (*6)								
	Ambient humidity	90%RH or less (with no condensation)								
	Operating environment	Indoor at 1,000 m or lower altitude (No direct sunlight, corrosive or inflammable gases, oil mist, or dust)								

*1 Rated capacity at the output voltage of 400 V

*2 Rated current should be reduced according to outout power when input voltage is 400 VAC or higher.

*3 The maximum carrier frequency varies depending on the capacity of the inverter and the operating status.

*4 The frequency setting range for sensorless vector control is 1 to 130 Hz for a four-pole motor (depends on the number of poles).

*5 The maximum output frequency is at 5 V, 10 V, and 20 mA.

*6 This temperature is for short periods, such as during transportation.

400V system: SHF

Model		SHF-30K	SHF-37K	SHF-45K	SHF-55K
Output	Applicable motor capacity	30kW	37kW	45kW	55kW
	Rated capacity (*1)	42.3kVA	51.3kVA	62.4kVA	76.2kVA
	Rated current (*2)	61A	74A	90A	110A
	Overload current rating	150% 1 min			
	Rated output voltage	3-phase, 380 V at 50 Hz, 400 V at 50 Hz, 460 V at 60 Hz			
Input	Rated voltage and frequency	3-phase, 380 to 460 V at 50 or 60 Hz (*7)			
	Allowable fluctuation	Voltage: −15%, +10% Frequency: ±5% Voltage imbalance: 3% max (*7)			
	Power supply impedance	1% or more (Use the optional reactor if less than 1%)			
	Protective structure	Totally enclosed (IP20)			
	Cooling method	Forced air cooling			
	Weight	20 kg	25 kg	32 kg	33 kg
Control functions	Control method	V/f control or sensorless vector control			
	High-frequency carrier	Sine wave PWM (carrier frequency: 1 to 14 kHz) (*3)			
	Output frequency range	0.05 to 600 Hz (starting frequency: 0.05 to 20 Hz variable) (*4)			
	Frequency setting resolution — Digital setting	0.01 Hz (0.05 to 600 Hz)			
	Frequency setting resolution — Analog setting	0.1% (10 bits for 0 to 10 V, 4 to 20 mA), 0.2% (9 bits for 0 to 5 V) for maximum output frequency			
	Frequency accuracy — Digital setting	±0.01% of the output frequency (at -10 to +40°C)			
	Frequency accuracy — Analog setting	±0.2% of the maximum output frequency (at 25 ±10°C) (*5)			
	DC braking	Starting frequency (0.2 to 20 Hz), operation time (0.1 to 10 s), braking force (1 to 10 steps)			
	Additional functions	Restart after momentary power failure, flying start, multi-speed operation, frequency jump, auto alarm recovery, PID control operation, simple scheduled operation, energy-saving operation, torque limiter (for sensorless vector control only)			
Operational functions	Start/stop setting	Operation panel, serial communication (RS485, RS232C), control circuit terminals			
	Frequency command setting — Digital setting	Operation panel, serial communication (RS485, RS232C), step setting from terminal board			
	Frequency command setting — Analog setting	2 channels, 0 to 5 V, 0 to 10 V, 4 to 20 mA, variable resistor (5 kΩ, 0.3 W or more)			
	Input signals	Frequency command, forward run command, reverse run command, acceleration/deceleration time setting, free-run stop/alarm reset, emergency stop, jogging selection, step frequency setting, operation signal hold, torque limiter (sensorless vector control only) [Digital input; 8 channels (arbitrary allocation)] [Analog input; 1 channel for voltage, 1 channel for current and voltage]			
	Output signals — Contact output	Alarm batch and multifunctional contact output (1C contact, 250 VAC, 0.3 A)			
	Output signals — Monitor signal	Operating, frequency matching, overload alarm, undervoltage, overvoltage, frequency approach [Open-collector output: 3 channels (arbitrary allocation), Analog output: 2 channels]			
	LED display	Frequency, output current, synchronous rotation, load factor, output voltage, pressure, line speed (no units), operating, alarm			
	Serial communication I/F	RS485, RS232C			
	Function extension	Software upgrade by RS232C serial communication supported			
	External power supply output	24 VDC, 150 mA (control terminal)			
	Protection functions	Current limiting, overcurrent shutoff, motor overload, external thermal alarm, undervoltage, overvoltage, momentary power failure, fin overheat, missing phase			
	Warning functions	Overvoltage prevention, current limiting during acceleration/deceleration, brake resistor overheat, overload, overheating of radiator fins			
Environment	Ambient temperature	-10 to +50°C (Remove the top ventilation cover at +40°C or higher)			
	Storage temperature	-20 to +65°C (*6)			
	Ambient humidity	90%RH or less (with no condensation)			
	Operating environment	Indoor at 1,000 m or lower altitude (No direct sunlight, corrosive or inflammable gases, oil mist, or dust)			

*1 Rated capacity at the output voltage of 400 V

*2 Rated current should be reduced according to outout power when input voltage is 400 VAC or higher.

*3 The maximum carrier frequency varies depending on the capacity of the inverter and the operating status.

*4 The frequency setting range for sensorless vector control is 1 to 130 Hz for a four-pole motor (depends on the number of poles).

*5 The maximum output frequency is at 5 V, 10 V, and 20 mA.

*6 This temperature is for short periods, such as during transportation.

*7 For SHF-37K to SHF-55K, a tap (TAP1 or TAP2) must be switched according to variable input ranges. Refer to section 4.2 Terminal Connection Diagrams for details.

	Model	SPF-2.2K	SPF-4.0K	SPF-5.5K	SPF-7.5K	SPF-11K	SPF-15K	SPF-18.5K	SPF-22K	SPF-30K
Output	Applicable motor capacity	2.2kW	4.0kW	5.5kW	7.5kW	11kW	15kW	18.5kW	22kW	30kW
	Rated capacity (*1)	3.8kVA	6.2kVA	8.7kVA	11.4kVA	16.6kVA	22.2kVA	26.3kVA	31.2kVA	40.9kVA
	Rated current (*2)	5.5A	8.9A	12.6A	16.4A	24A	32A	38A	45A	59A
	Overload current rating	120% 1 min								
	Rated output voltage	3-phase, 380 V at 50 Hz, 400 V at 50 Hz, 460 V at 60 Hz								
Input	Rated voltage and frequency	3-phase, 380 to 460 V at 50 or 60 Hz								
	Allowable fluctuation	Voltage: −15%, +10% Frequency: ±5% Voltage imbalance: 3% max								
	Power supply impedance	1% or more (Use the optional reactor if less than 1%)								
	Protective structure	Totally enclosed (IP20)								
	Cooling method	Forced air cooling								
	Weight	4 kg	4 kg	4.5 kg	6.5 kg	6.5 kg	7 kg	10 kg	12 kg	15 kg
Control functions	Control method	V/f control or sensorless vector control								
	High-frequency carrier	Sine wave PWM (carrier frequency: 1 to 14 kHz) (*3)								
	Output frequency range	0.05 to 200 Hz (starting frequency: 0.05 to 20 Hz variable) (*4)								
	Frequency setting resolution — Digital setting	0.01 Hz (0.05 to 200 Hz)								
	Frequency setting resolution — Analog setting	0.1% (10 bits for 0 to 10 V, 4 to 20 mA), 0.2% (9 bits for 0 to 5 V) for maximum output frequency								
	Frequency accuracy — Digital setting	±0.01% of the output frequency (at -10 to +40°C)								
	Frequency accuracy — Analog setting	±0.2% of the maximum output frequency (at 25 ±10°C) (*5)								
	DC braking	Starting frequency (0.2 to 20 Hz), operation time (0.1 to 10 s), braking force (1 to 10 steps)								
	Additional functions	Restart after momentary power failure, flying start, multi-speed operation, frequency jump, auto alarm recovery, PID control operation, simple scheduled operation, energy-saving operation, torque limiter (for sensorless vector control only)								
Operational functions	Start/stop setting	Operation panel, serial communication (RS485, RS232C), control circuit terminals								
	Frequency command setting — Digital setting	Operation panel, serial communication (RS485, RS232C), step setting from terminal board								
	Frequency command setting — Analog setting	2 channels, 0 to 5 V, 0 to 10 V, 4 to 20 mA, variable resistor (5 kΩ, 0.3 W or more)								
	Input signals	Frequency command, forward run command, reverse run command, acceleration/deceleration time setting, free-run stop/alarm reset, emergency stop, jogging selection, step frequency setting, operation signal hold, torque limiter (sensorless vector control only) [Digital input; 8 channels (arbitrary allocation)] [Analog input; 1 channel for voltage, 1 channel for current and voltage]								
	Output signals — Contact output	Alarm batch and multifunctional contact output (1C contact, 250 VAC, 0.3 A)								
	Output signals — Monitor signal	Operating, frequency matching, overload alarm, undervoltage, overvoltage, frequency approach [Open-collector output: 3 channels (arbitrary allocation), Analog output: 2 channels]								
	LED display	Frequency, output current, synchronous rotation, load factor, output voltage, pressure, line speed (no units), operating, alarm								
	Serial communication I/F	RS485, RS232C								
	Function extension	Software upgrade by RS232C serial communication supported								
	External power supply output	24 VDC, 150 mA (control terminal)								
	Protection functions	Current limiting, overcurrent shutoff, motor overload, external thermal alarm, undervoltage, overvoltage, momentary power failure, fin overheat, missing phase								
	Warning functions	Overvoltage prevention, current limiting during acceleration/deceleration, brake resistor overheat, overload, overheating of radiator fins								
Environment	Ambient temperature	-10 to +40°C (Remove the top ventilation cover of the SPF-5.5K or a lower model at temperatures of +30°C or higher)								
	Storage temperature	-20 to +65°C (*6)								
	Ambient humidity	90%RH or less (with no condensation)								
	Operating environment	Indoor at 1,000 m or lower altitude (No direct sunlight, corrosive or inflammable gases, oil mist, or dust)								

*1 Rated capacity at the output voltage of 400 V

*2 Rated current should be reduced according to outout power when input voltage is 400 VAC or higher.

*3 The maximum carrier frequency varies depending on the capacity of the inverter and the operating status.

*4 The frequency setting range for sensorless vector control is 1 to 130 Hz for a four-pole motor (depends on the number of poles).

*5 The maximum output frequency is at 5 V, 10 V, and 20 mA.

*6 This temperature is for short periods, such as during transportation.

400V system: SPF

		SPF-37K	SPF-45K	SPF-55K
Output	Model			
Output	Applicable motor capacity	37kW	45kW	55kW
Output	Rated capacity (*1)	51.3kVA	62.4kVA	76.2kVA
Output	Rated current (*2)	74A	90A	110A
Output	Overload current rating	120% 1 min		
Output	Rated output voltage	3-phase, 380 V at 50 Hz, 400 V at 50 Hz, 460 V at 60 Hz		
Input	Rated voltage and frequency	3-phase, 380 to 460 V at 50 or 60 Hz (*7)		
Input	Allowable fluctuation	Voltage: −15%, +10% Frequency: ±5% Voltage imbalance: 3% max (*7)		
Input	Power supply impedance	1% or more (Use the optional reactor if less than 1%)		
	Protective structure	Totally enclosed (IP20)		
	Cooling method	Forced air cooling		
	Weight	20 kg	25 kg	32 kg
Control functions	Control method	V/f control or sensorless vector control		
Control functions	High-frequency carrier	Sine wave PWM (carrier frequency: 1 to 14 kHz) (*3)		
Control functions	Output frequency range	0.05 to 200 Hz (starting frequency: 0.05 to 20 Hz variable) (*4)		
Control functions	Frequency setting resolution — Digital setting	0.01 Hz (0.05 to 200 Hz)		
Control functions	Frequency setting resolution — Analog setting	0.1% (10 bits for 0 to 10 V, 4 to 20 mA), 0.2% (9 bits for 0 to 5 V) for maximum output frequency		
Control functions	Frequency accuracy — Digital setting	±0.01% of the output frequency (at -10 to +40°C)		
Control functions	Frequency accuracy — Analog setting	±0.2% of the maximum output frequency (at 25 ±10°C) (*5)		
Control functions	DC braking	Starting frequency (0.2 to 20 Hz), operation time (0.1 to 10 s), braking force (1 to 10 steps)		
Control functions	Additional functions	Restart after momentary power failure, flying start, multi-speed operation, frequency jump, auto alarm recovery, PID control operation, simple scheduled operation, energy-saving operation, torque limiter (for sensorless vector control only)		
Operational functions	Start/stop setting	Operation panel, serial communication (RS485, RS232C), control circuit terminals		
Operational functions	Frequency command setting — Digital setting	Operation panel, serial communication (RS485, RS232C), step setting from terminal board		
Operational functions	Frequency command setting — Analog setting	2 channels, 0 to 5 V, 0 to 10 V, 4 to 20 mA, variable resistor (5 kΩ, 0.3 W or more)		
Operational functions	Input signals	Frequency command, forward run command, reverse run command, acceleration/deceleration time setting, free-run stop/alarm reset, emergency stop, jogging selection, step frequency setting, operation signal hold, torque limiter (sensorless vector control only) [Digital input; 8 channels (arbitrary allocation)] [Analog input; 1 channel for voltage, 1 channel for current and voltage]		
Operational functions	Output signals — Contact output	Alarm batch and multifunctional contact output (1C contact, 250 VAC, 0.3 A)		
Operational functions	Output signals — Monitor signal	Operating, frequency matching, overload alarm, undervoltage, overvoltage, frequency approach [Open-collector output: 3 channels (arbitrary allocation), Analog output: 2 channels]		
Operational functions	LED display	Frequency, output current, synchronous rotation, load factor, output voltage, pressure, line speed (no units), operating, alarm		
Operational functions	Serial communication I/F	RS485, RS232C		
Operational functions	Function extension	Software upgrade by RS232C serial communication supported		
Operational functions	External power supply output	24 VDC, 150 mA (control terminal)		
Operational functions	Protection functions	Current limiting, overcurrent shutoff, motor overload, external thermal alarm, undervoltage, overvoltage, momentary power failure, fin overheat, missing phase		
Operational functions	Warning functions	Overvoltage prevention, current limiting during acceleration/deceleration, brake resistor overheat, overload, overheating of radiator fins		
Environment	Ambient temperature	-10 to +40°C		
Environment	Storage temperature	-20 to +65°C (*6)		
Environment	Ambient humidity	90%RH or less (with no condensation)		
Environment	Operating environment	Indoor at 1,000 m or lower altitude (No direct sunlight, corrosive or inflammable gases, oil mist, or dust)		

*1 Rated capacity at the output voltage of 400 V

*2 Rated current should be reduced according to outout power when input voltage is 400 VAC or higher.

*3 The maximum carrier frequency varies depending on the capacity of the inverter and the operating status.

*4 The frequency setting range for sensorless vector control is 1 to 130 Hz for a four-pole motor (depends on the number of poles).

*5 The maximum output frequency is at 5 V, 10 V, and 20 mA.

*6 This temperature is for short periods, such as during transportation.

*7 For SPF-45K and SPF-55K, a tap (TAP1 or TAP2) must be switched according to variable input ranges. Refer to section 4.2 Terminal Connection Diagrams for details.

11.2 Communication Specifications

| Physical-layer electrical characteristics	RS485 communication	RS232C communication
Network configuration	Two-wire bus configuration (multi-drop link)	1-to-1 configuration with three wires
Transmission distance	500 m total (with terminating resistor)	About 5 m max
Number of units connected	32 max	1
Connection cable	Shielded twisted-pair cable recommended	Shielded cable recommended
Communication power supply	Insulated from the inverter	
Communication speed [bps]	19200, 9600, 4800, 2400, and 1200 selectable	
Modulation	Baseband	
Communication type	Half-duplex communication	
Synchronization	Asynchronous	
Communication control	Polling or selecting (partial contention)	
Data format	Character code data or binary data	
Data length	8 bits	
Character code	ASCII	
Stop bit	1 or 2 bits selectable	
Error checking method	Parity bit and 1-byte checksum data (The parity bit is Even, Odd, or None.)	
Message end code	CR+LF or CR+CR (No codes are attached to a binary-format message.)	

12. External Dimensions

(1) SBT-0.75K/1.5K - SBT-3.7K/5.5K
SHF-1.5K - SHF-4.0K
SPF-2.2K - SPF-5.5K
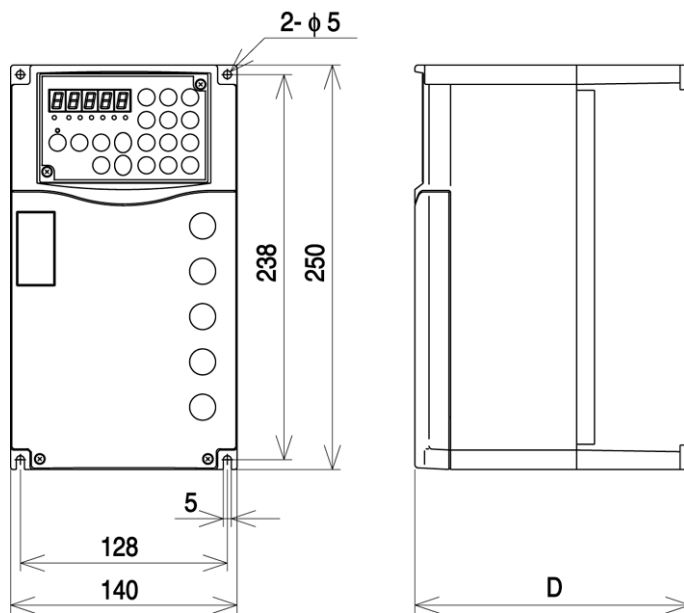
Model	D
SBT-0.75K/1.5K	145
SBT-1.5K/2.2K SBT-2.2K/3.7K SBT-3.7K/5.5K SHF-1.5K SHF-2.2K SHF-4.0K SPF-4.0K SPF-5.5K	170

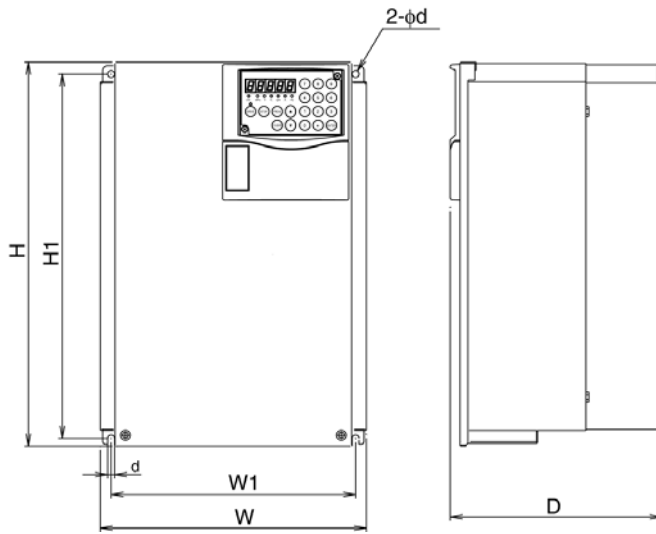(Unit: mm)

(2) SBT-5.5K/7.5K - SBT-15K/18.5K
     SHF-5.5K - SHF-15K
     SPF-7.5K - SPF-18.5K
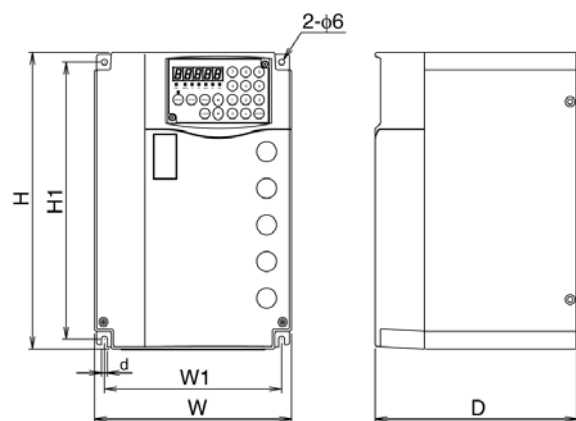
Model	H	H1	W	W1	D	d
SBT-5.5K/7.5K SBT-7.5K/11K	300	280	200	180	205	6
SBT-11K/15K SBT-15K/18.5K	360	340	240	220	205	6
SHF-5.5K SHF-7.5K SHF-11K	300	280	200	180	205	6
SHF-15K	360	340	240	220	205	6
SPF-7.5K SPF-11K SPF-15K	300	280	200	180	205	6
SPF-18.5K	360	340	240	220	205	6

(Unit: mm)

(3) SBT-18.5K/22K - SBT-22K/30K
SHF-18.5K - SHF-55K
SPF-22K - SPF-55K

Model	H	H1	W	W1	D	d
SBT-18.5K/22K	390	370	270	248	215	7
SBT-22K/30K					240	
SHF-18.5K	390	370	270	248	215	7
SHF-22K					240	
SHF-30K	440	420	340	318	240	7
SHF-37K						
SHF-45K	550	530	340	318	260	7
SHF-55K						
SPF-22K	390	370	270	248	215	7
SPF-30K					240	
SPF-37K	440	420	340	318	240	7
SPF-45K						
SPF-55K	550	530	340	318	260	7

(Unit: mm)

(4) Operation panel
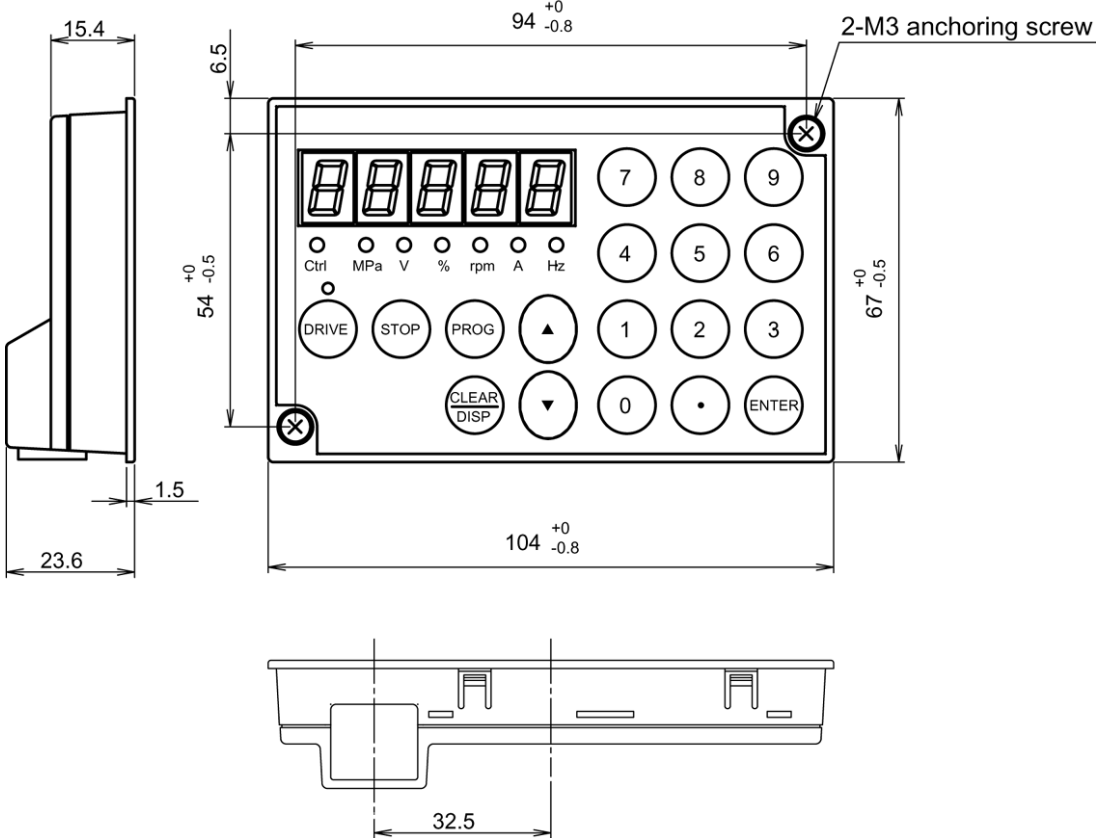
Attaching location of operation panel
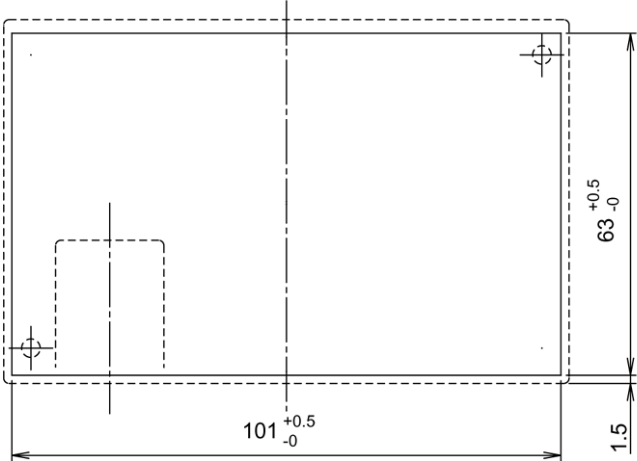
13. Options

● The following optional board built into the inverter is available.

Name	Type	Function	Applicable inverter
PG feedback board	SB-PG	Detect the motor speed with the detector (PG) to operate speed control function and position control function. · Keep the motor speed constant when the load changes. · Can stop the machine tool at fixed position.	SAMCO-vm05 All models
Feed pump system board	SWS	The constant feed pump system that can attach up to 7 pumps can be constructed without PDI controller or PLC controller. The inverter driving fixed system and circuit system, automatic control function of auxiliary pump, regular switching function and other control functions are available. In addition, this can be used as a multifunctional relay output function.	SAMCO-vm05 Models less than 55 Kw
Current output board	SAS	The state of the inverter monitoring value (output frequency, output current, output voltage, etc.) can be output by 4-20 mA current value.	SAMCO-vm05 All models
Digital input board	SDI	The frequency setting of the inverter can be performed very accurately with the external 4 digits BCD or 16 bit binary digital signal input.	SAMCO-vm05 All models
PC transfer program for upgrade	FMTP	This application software upgrades the control program of the inverter using an external PC.	SAMCO-vm05 All models (Not for sale) For details, ask the distributor.

● The inverter can mount 2 optional boards simultaneously. (Install first optional board to slot 1 on the basic inverter. Install second optional board to slot 2 on the first optional board mounted on slot 1.)
The 2 optional boards can be installed simultaneously provided that a combination of optional boards is available. The combination list is as follows.

Slot 1 / Slot 2	Not mounted	SB-PG	SWS	SAS	SDI
Not mounted	—	○	○	○	○
SB-PG	—	×	×	×	×
SWS	—	×	×	×	○
SAS	—	○	○	×	○
SDI	—	×	○	×	×

○ : Available   × : Not available

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