

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-V1105** 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 charge 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.









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1. Safety Notes

1.1 Notes on Installation








|  Caution | |
|--|--|
|  | <ul style="list-style-type: none">■ 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.<ul style="list-style-type: none">• 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 |
|  | <ul style="list-style-type: none">■ Mount the inverter on a metal surface or other non-flammable surface. Failure to observe this warning may result in a fire. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ Do not place flammable materials near the inverter. Failure to observe this warning may result in a fire. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ 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 | |
|---|---|
|  | <ul style="list-style-type: none">■ Wiring must be performed by qualified personnel. Failure to observe this warning may result in an electric shock or fire due to incorrect wiring. |
|  | <ul style="list-style-type: none">■ Turn off the power before carrying out wiring. Failure to observe this warning may result in an electric shock or fire. |
|  | <ul style="list-style-type: none">■ Connect the ground cable. Failure to observe this warning may result in an electric shock or fire. |
|  | <ul style="list-style-type: none">■ Install the main part of the inverter before wiring. Failure to observe this warning may result in an electric shock or injury. |




|  Caution | |
|--|--|
|  | <ul style="list-style-type: none">■ Do not connect AC power to an output terminal (U, V, or W). Failure to observe this warning may result in injury or fire. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ Do not connect a resistor directly to the DC terminals (P and X). Failure to observe this warning may result in a fire. |
|  | <ul style="list-style-type: none">■ 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 | |
|---|--|
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ Do not touch any switches with wet hands. Failure to observe this warning may result in an electric shock. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ Provide a separate emergency stop switch. Failure to observe this warning may result in injury. |
|  | <ul style="list-style-type: none">■ 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 | |
|--|---|
|  | <ul style="list-style-type: none">■ Do not touch the radiator fins or DC reactor because they become very hot. Failure to observe this warning may result in burns. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ Provide a retaining brake if necessary. Failure to observe this warning may result in injury. |
|  | <ul style="list-style-type: none">■ 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 | |
|---|--|
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ 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 | |
|--|--|
|  | <ul style="list-style-type: none">■ Dispose of this product as industrial wastes. Failure to observe this warning may result in an injury. |

1.6 Others

|  Danger | |
|---|---|
|  | <ul style="list-style-type: none">■ Do not modify this product. Failure to observe this warning may result in an electric shock, injury, failure, damage or fire. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ 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. |
|  | <ul style="list-style-type: none">■ 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.

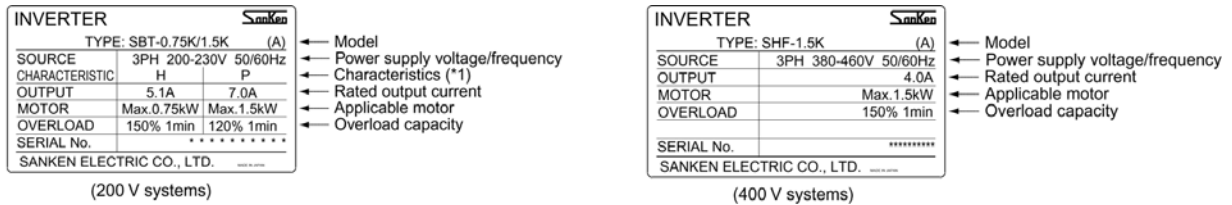


Figure 2.1 Inverter ratings

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.

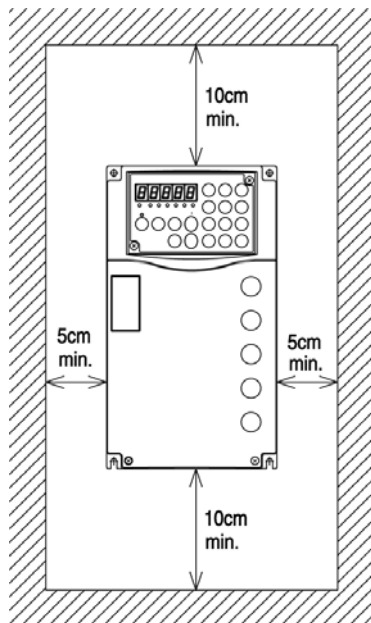


Figure 3.1 Space around the inverter

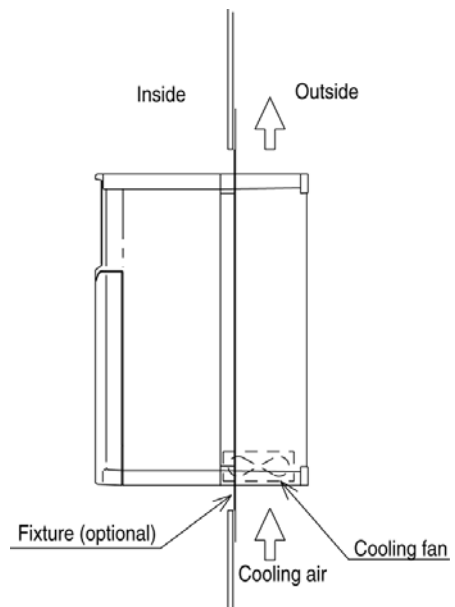


Figure 3.2 Installing the inverter with the radiator fins outside the enclosure



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.

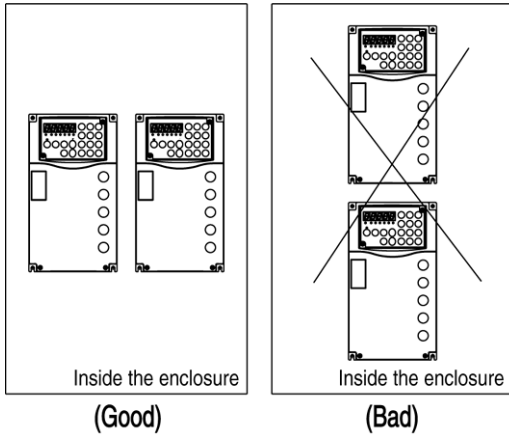


Figure 3.3 Housing in enclosure

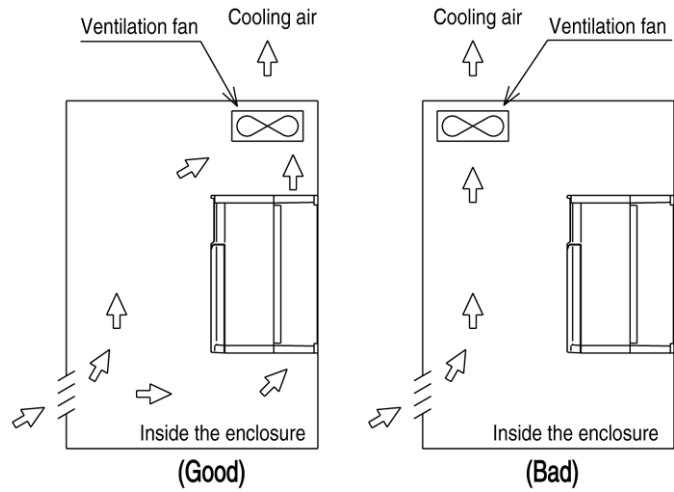


Figure 3.4 Ventilation fan position in enclosure

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).

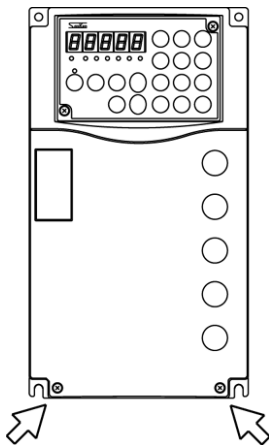


Figure 3.5

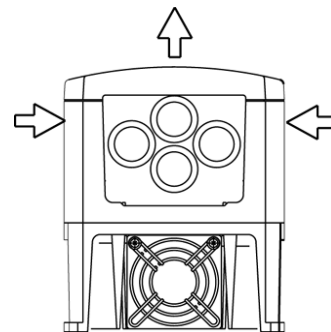


Figure 3.6

(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.

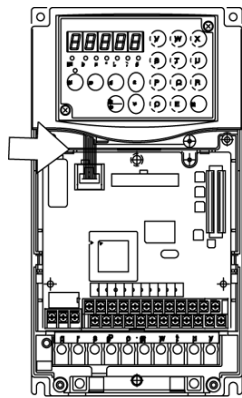


Figure 3.7

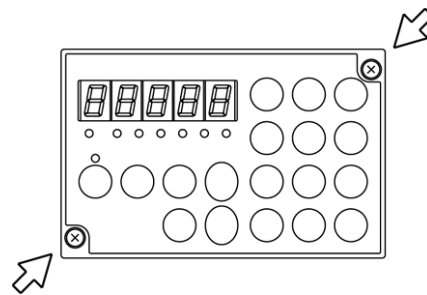


Figure 3.8

- (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).

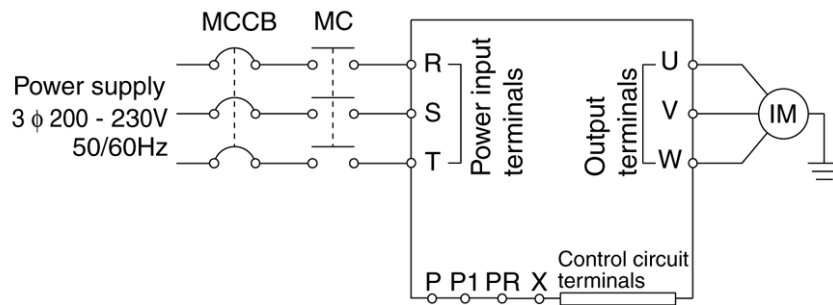


Figure 4.1 Basic wiring diagram of the inverter



- 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.

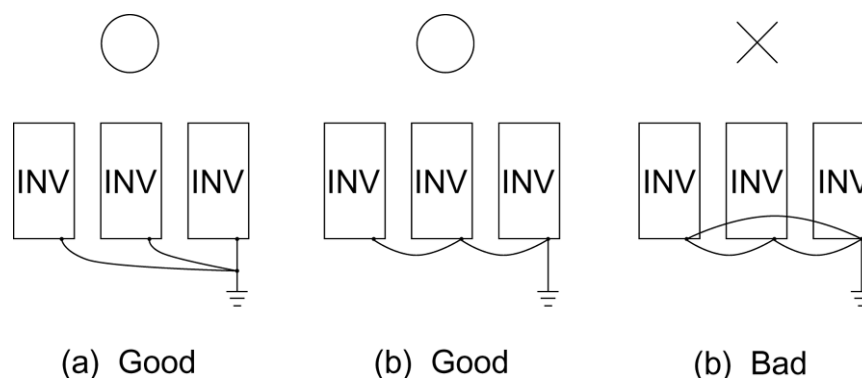


Figure 4.2 Grounding

200V systems

Table 4.3 MCCB and MC capacitors and wire sizes

| Model | Load | Motor capacity | Circuit breaker (MCCB) [A] | Magnetic contactor (MC) | | Main circuit | | | Control circuit | | | | | | | |
|----------------|------------------|----------------|----------------------------|-------------------------|---------------------------|--|-------------|-------------|-----------------|--------------------------------------|----------------|--------------------------------------|----|----|----|------|
| | | | | Rated current [A] | Rated applied current [A] | Recommended wire size [mm ²] | | | Screw diameter | Maximum wire size [mm ²] | Screw diameter | Maximum wire size [mm ²] | | | | |
| | | | | | | Input wire | P/P1 wire | Output wire | | | | | | | | |
| 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 | M3 | 1.25 |
| | 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 | M3 | 1.25 | | | | |
| | 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] | Magnetic contactor(MC) | | Main circuit | | | Control circuit | | | |
|-----------|----------------------------|------------------------|---------------------------|--|-----------|-------------|-----------------|--------------------------------------|----------------|--------------------------------------|
| | | Rated current [A] | Rated applied current [A] | Recommended wire size [mm ²] | | | Screw diameter | Maximum wire size [mm ²] | Screw diameter | Maximum wire size [mm ²] |
| | | | | Input wire | P/P1 wire | Output wire | | | | |
| 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 | | 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) | | | | |
| 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) | | | | |
| 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) | | | | |
| 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 (60°C) when the inverter ambient temperature is 40°C. The values in parentheses are for 600 V bridged-polyethylene insulated wires (90°C).

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

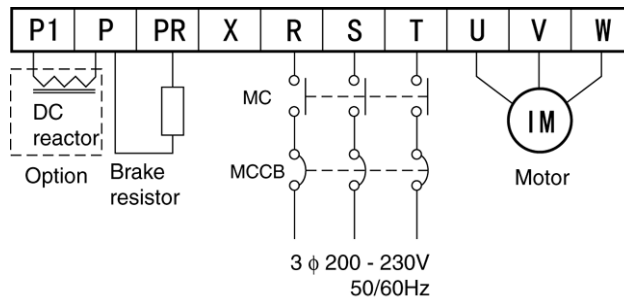


Figure 4.3.1 SBT-0.75K/1.5K - 3.7K/5.5K

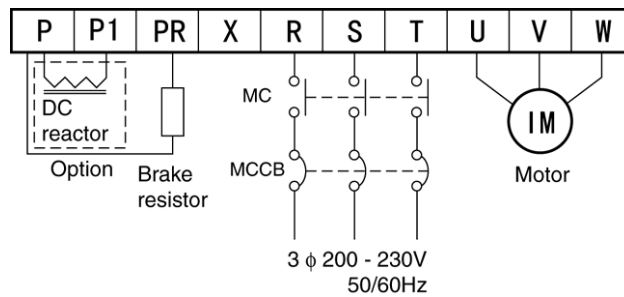


Figure 4.3.2 SBT-5.5K/7.5K - 7.5K/11K

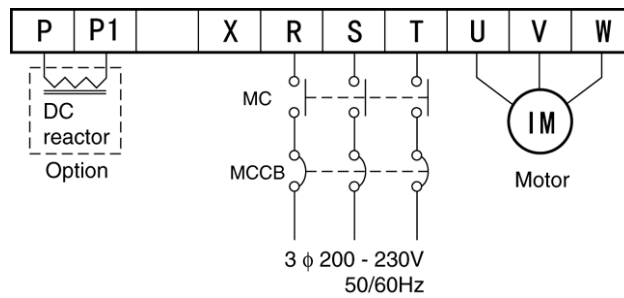


Figure 4.3.3 SBT-11K/15K

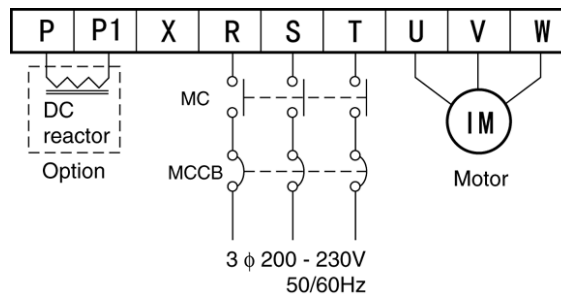


Figure 4.3.4 SBT-15K/18.5K

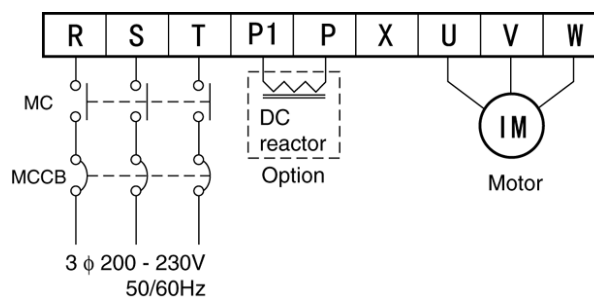


Figure 4.3.5 SBT-18.5K/22K - 22K/30K

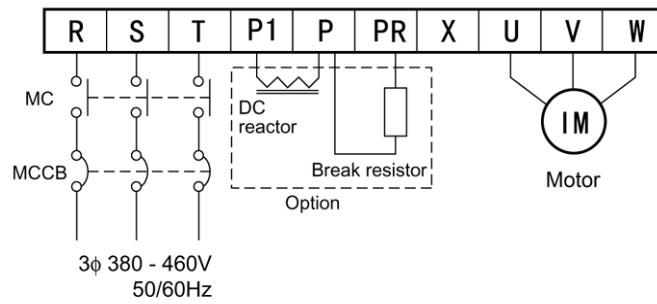


Figure 4.3.6 SHF-1.5K-4.0K SPF-2.2K-5.5K

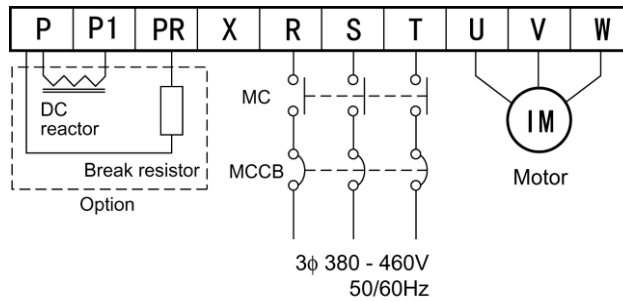


Figure 4.3.7 SHF-5.5K-15K SPF-7.5K-18.5K

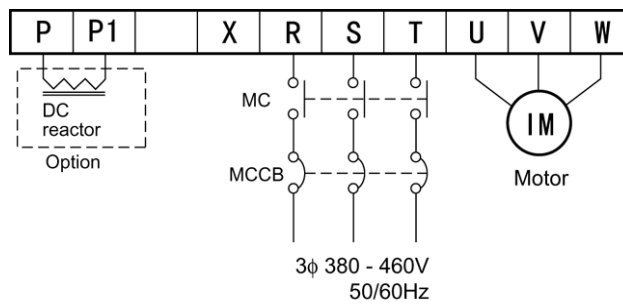


Figure 4.3.8 SHF-18.5K-22K SPF-22K-30K

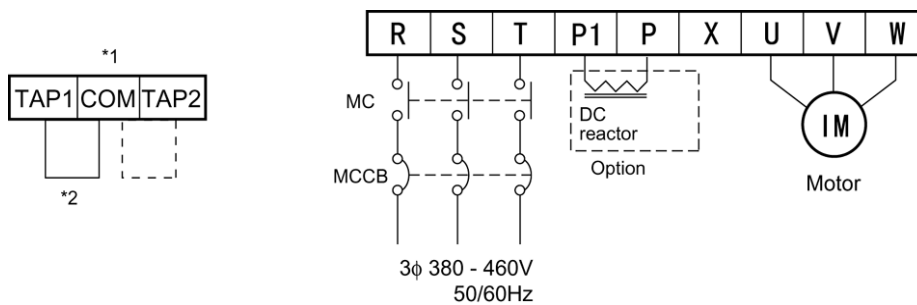


Figure 4.3.9 SHF-30K-55K SPF-37K-55K

*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

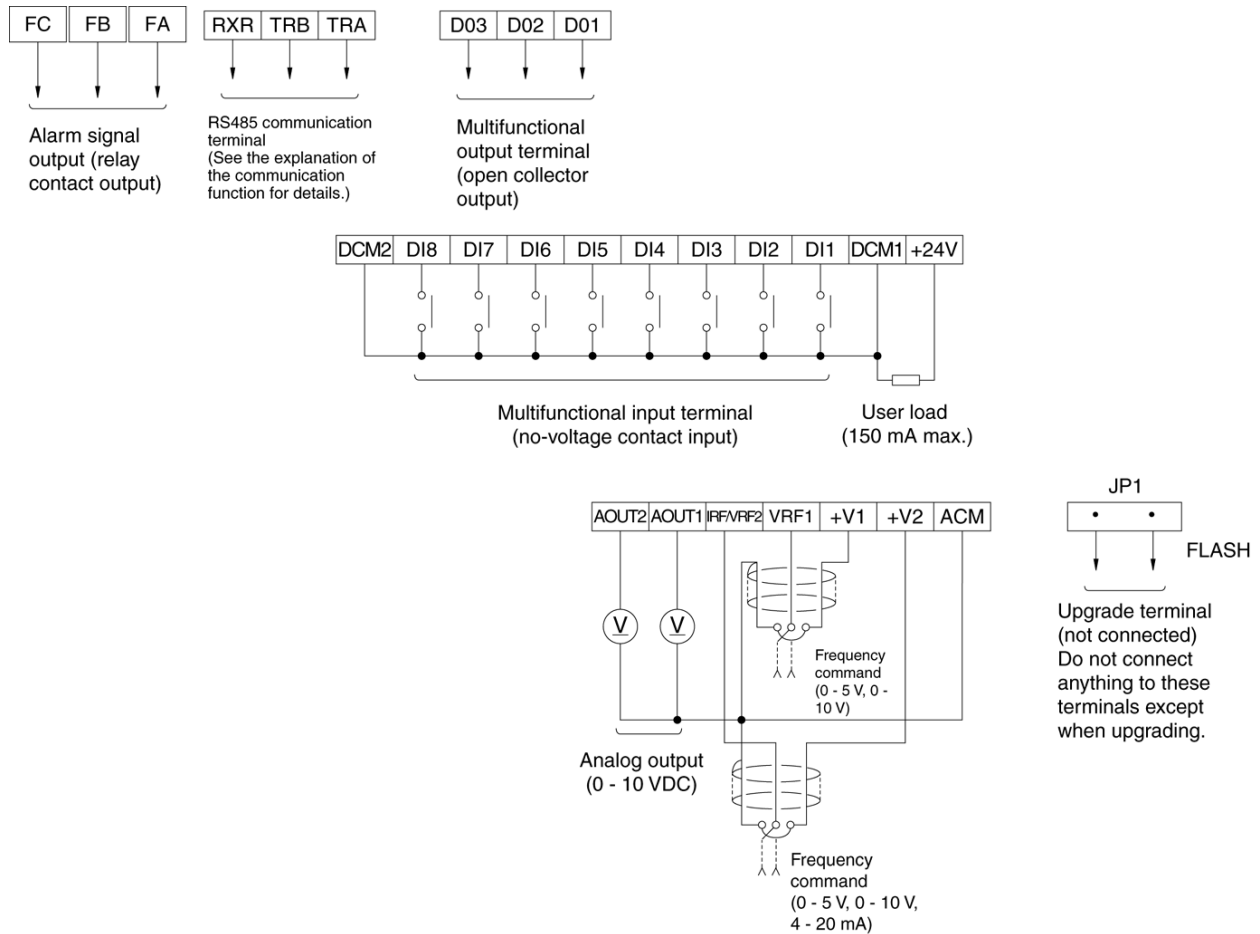


Figure 4.4 Control circuit connections

1) Frequency setting using variable resistor

- Use a 5 k Ω 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).

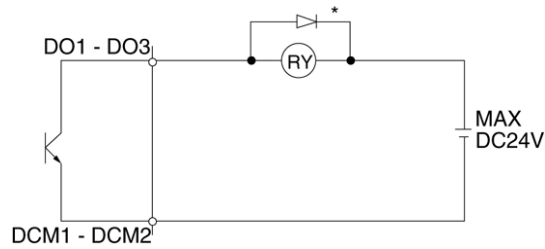
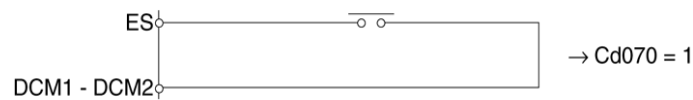


Figure 4.5 Example of using multifunctional output (open collector output)

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



◆ Normally closed signal

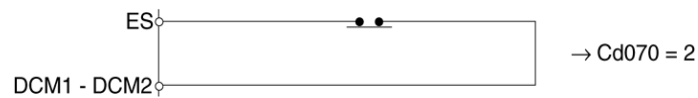


Figure 4.6 ES-terminal signal mode switching

(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.

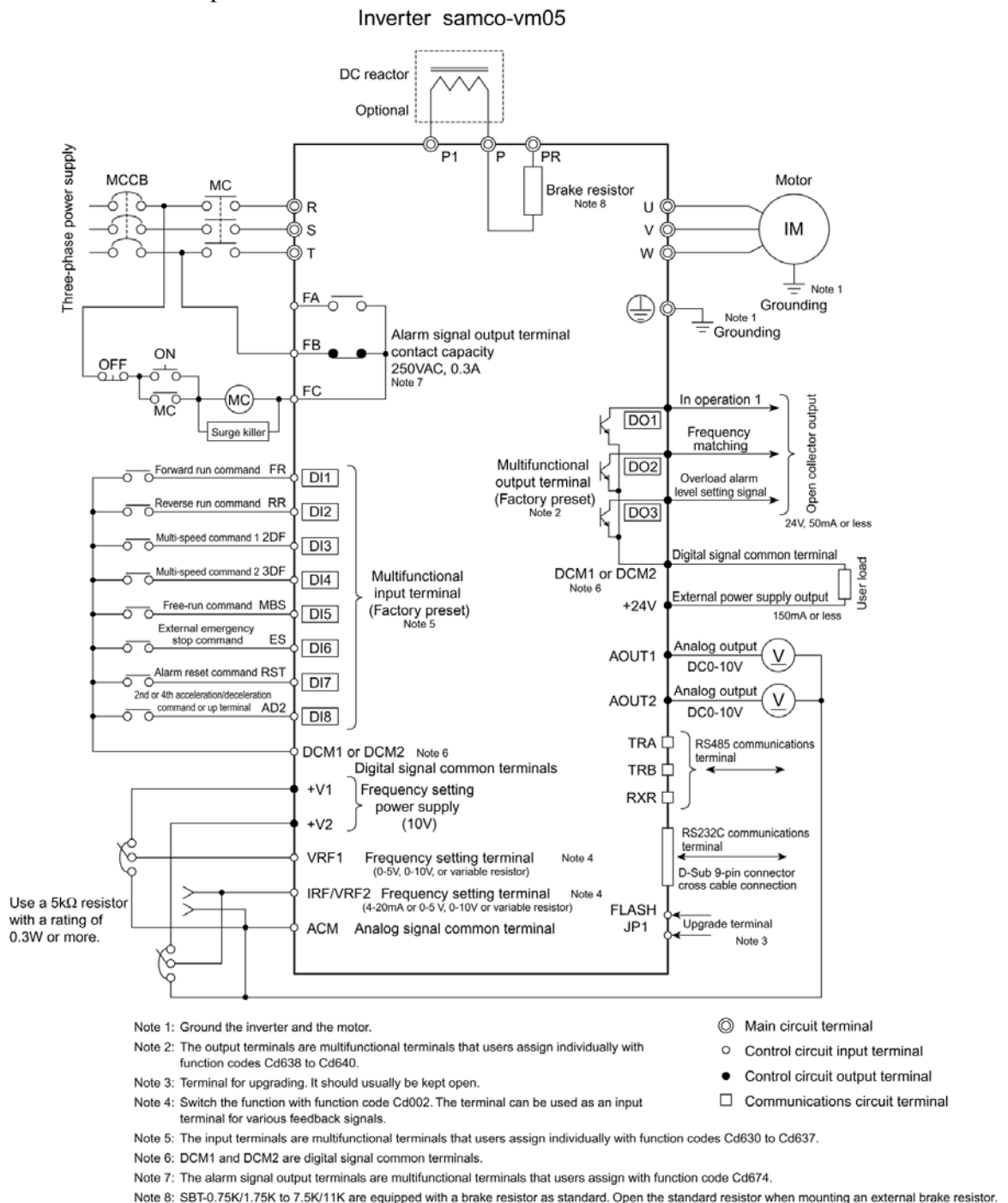
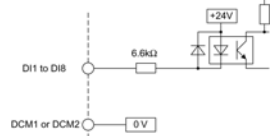
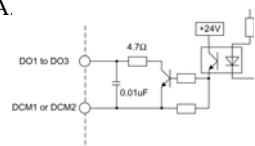
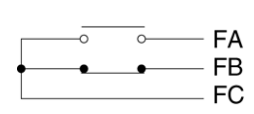


Figure 4.7 Example of terminal connections

Table 4.7 Control circuit terminals

| Symbol | Terminal | Description | |
|-------------------------|--|---|--|
| DCM1 DCM2 | Digital signal common terminals | <ul style="list-style-type: none"> Common terminals for digital I/O signals and for +24 V power supply | |
| Input terminals | DI1 DI2 DI3 DI4 DI5 DI6 DI7 DI8 | Multifunctional input terminals (Function selection with Cd630 to Cd637)  <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Common terminal for analog signals |
| | +V1 | Variable resistor connection terminal for frequency setting VRF1 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Power cannot be supplied from this terminal. Connect only a variable resistor. |
| | VFR1 | Analog voltage input terminal | <ul style="list-style-type: none"> 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) | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> +24 VDC power (maximum allowable output current: 150 mA) |
| | AOUT1 AOUT2 | Internal analog output terminal (2-channel output) | <ul style="list-style-type: none"> 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) | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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.) | <ul style="list-style-type: none"> Send/receive terminals |
| | RXR | | <ul style="list-style-type: none"> Terminal resistor shorting terminal |
| | JP1 | Upgrade jumper | <ul style="list-style-type: none"> 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

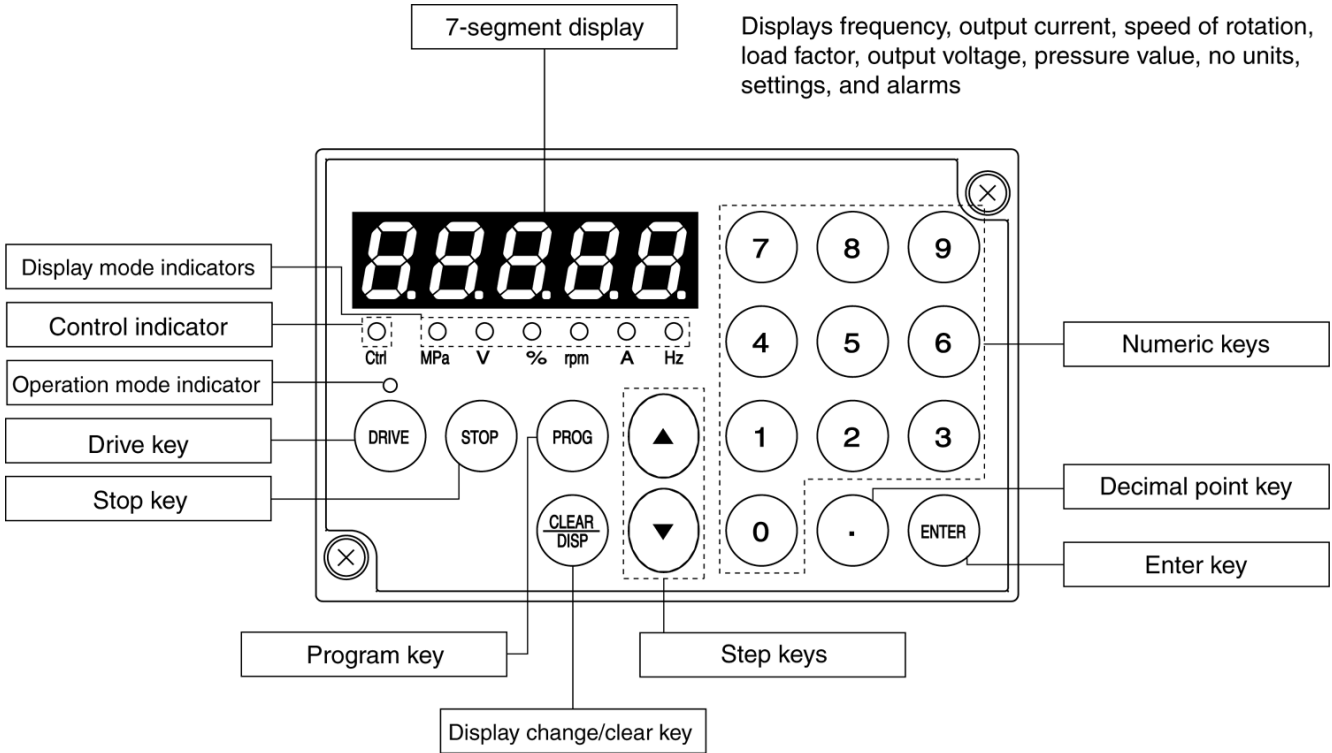
| Function code No. | Output terminal name | Data range | Initial value (symbol) |
|-------------------|----------------------|------------|----------------------------------|
| Cd638 | DO1 | 0 to 99 | 1 (In operation 1) |
| Cd639 | DO2 | 0 to 99 | 5 (Frequency matching) |
| Cd640 | DO3 | 0 to 99 | 8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



5.2 Operation Panel Keys

| Classification | Key symbol | Description of function |
|--------------------------|------------|--|
| Drive key | | <ul style="list-style-type: none"> Starts forward or reverse run. (The direction of rotation is switched by Cd130.) |
| Stop key | | <ul style="list-style-type: none"> Stops operation. Resets the alarm in the alarm stop status. |
| Display change/clear key | | <ul style="list-style-type: none"> 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 key operation invalid. |
| Step keys | | <ul style="list-style-type: none"> In Status Display mode, increments the frequency. |
| | | <ul style="list-style-type: none"> In Status Display mode, decrements the frequency. |
| Program key | | <ul style="list-style-type: none"> Toggles the mode between Status Display and Function Code Display. |
| Enter key | | <ul style="list-style-type: none"> Confirms numeric data indicated on the 7-segment display. |
| Numeric keys | | <ul style="list-style-type: none"> In Status Display mode, allows direct frequency setting. |
| Decimal point key | | <ul style="list-style-type: none"> 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  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  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

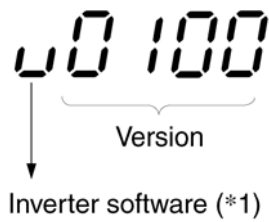
| Operation command | Display |
|------------------------------|---------|
| Not under external operation | ○ |
| Under external operation | ● |

○ 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



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  or  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 |  status. | All numerals on the 7-segment display remain flashing in the stop status. |
| Numeric keys or  |  | Enter a numeric value. (Press the ENTER key to confirm an entry using the numeric keys.) |
|  |  | The 7-segment display stops flashing. <div style="border: 1px solid black; padding: 2px; display: inline-block;">Check the direction of rotation.</div> |
|  |  | 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 |
|--|--|---|
| |  or  | Status Display mode (frequency display). |
| Numeric key  |  | Displays the rightmost input value. |
| Numeric key  |  | The display shifts to the left each time a key is pressed. |
|  |  or  | 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  key to return to the previous display.
- To stop the direct frequency setting (after using the numeric keys), press the  key rather than  to return to the Status Display mode.

(2) Step setting

- Press the  or  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 |
|--|---|--|
| |  or  | Status Display mode (frequency/speed of rotation or no units display). |
|  or  |   ↓   | Pressing the  key or  key displays the current set frequency. While the  key or  key is held down the value is incremented or decremented. When the  key or  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. |

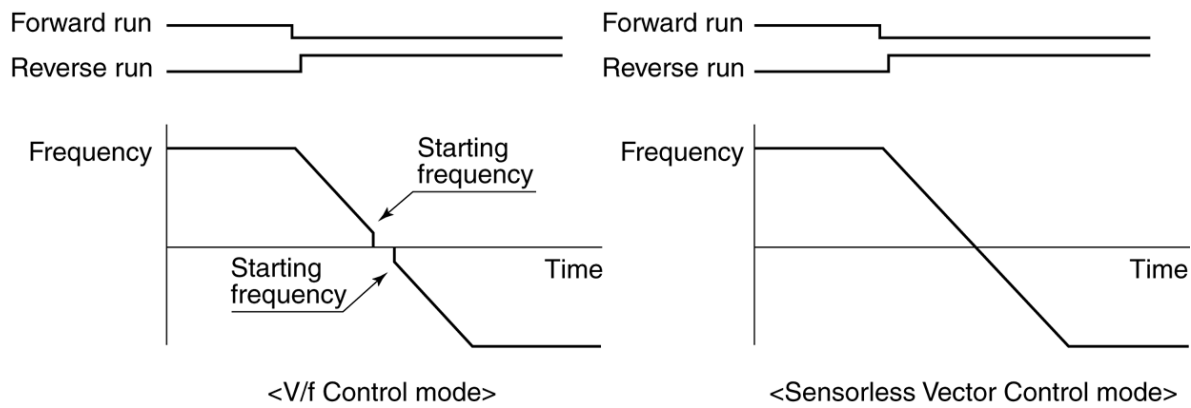
6.3.2 Operation with external signals

- (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.

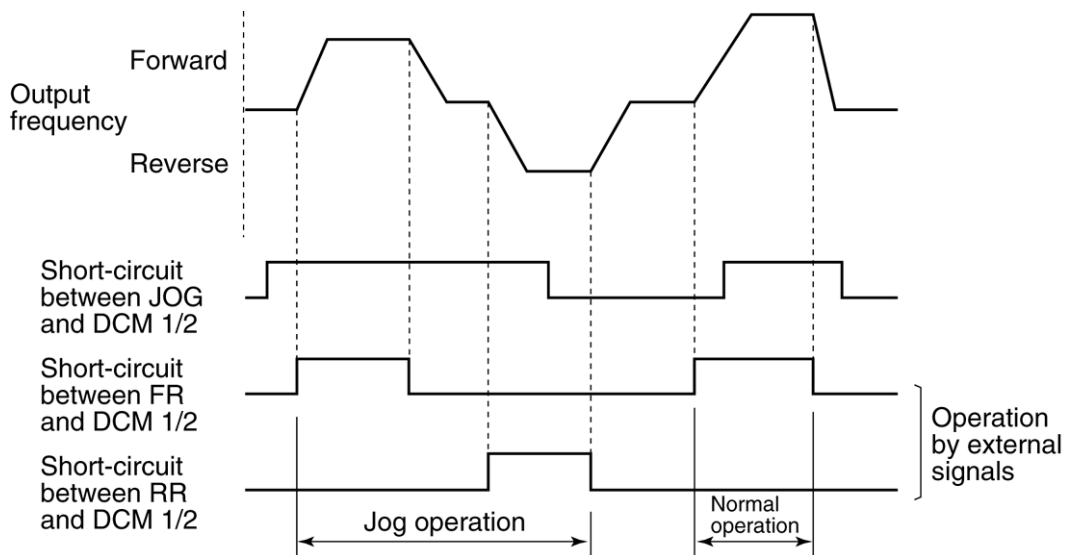
Note 2: If the operation signal is turned off and a signal to drive the motor in the opposite direction from the present direction of rotation is input before the inverter stops, the inverter operates according to the value of Cd071 (motor control mode selection).

- 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.



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.)



- (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).

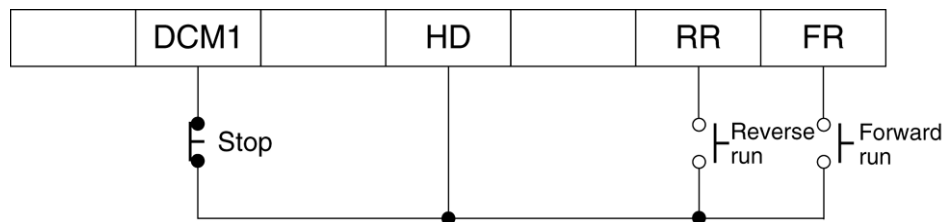


Figure 6.1 Operation signal hold circuit

- (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 |
|---|----------------------------------|---|
| | 5000 or 5000 | Status Display mode |
|  | Cd | Function Code Display mode |
| Numeric keys   | Cd 98 | Specify Cd098 |
|  | 0 | Input wait status |
|  | ! | Specify read (Enter 9 to clear the records.) |
|  | ××××× | Display the most recent alarm |
|  or  | ××××× End |  key to read older alarm data  Key to read newer alarm data No record |
|  | Cd 98 | Function Code Display mode |
|  | 5000 or 5000 | Status Display mode |

6.5 Operational Error Displays

Table 6.1 Operational error displays

| Display | Description |
|---------------|--|
| <i>Er A</i> | Frequency cannot be set from the operation panel. |
| <i>Er b</i> | The specified function code number is not defined. |
| <i>Er C</i> | The input value is beyond the input range. Motor constants are not registered for Cd053 (motor type). |
| <i>Er E</i> | No operations are permitted from the operation panel. |
| <i>Er L</i> | Function code data cannot be changed because the inverter is in operation. |
| <i>Er n</i> | Function code data cannot be changed because the operation panel is locked. |
| <i>Er H</i> | The input setting conflicts with the installed option board. |
| <i>Er U</i> | The input setting conflicts with the installed option board. |
| <i>Er S</i> | The constants of the connected motor cannot be tuned automatically. |
| <i>Er u</i> | Function code data cannot be changed because the voltage is low (<i>LUX</i>). |
| <i>Er d</i> | The user's initialization data is not registered. Register the user's initialization data using Cd099 = 99. |
| <i>Er o</i> | 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. |
| <i>Er r</i> | The memory contents cannot be transferred from the operation panel to the inverter. (Copy function) |
| <i>Er t</i> | 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). |
| <i>Er P</i> | A password is necessary. Please contact the retailer. |
| <i>Er io</i> | 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. |
| <i>off L.</i> | 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) \neq (Cd120 set value) and (Cd085 set value) \neq (Cd002 set value) -1 and Cd002 \neq 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) \neq (Cd120 set value) and (Cd086 set value) \neq (Cd002 set value) -1 and Cd002 \neq 7, 8, 9, 10, 11, 12 | Er120 Er002 Er002 |
| Cd101 | Operation mode selection | 1 2 | This value can be set when Cd071 \neq 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 \neq 0. The following values can be set: (Cd120 set value) \neq (Cd002 set value) -1 and "Cd002 \neq (7, 8, 9, 10, 11, 12 and" (Cd120 set value) \neq (Cd085 set value) and (Cd120 set value) \neq (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 \neq 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.

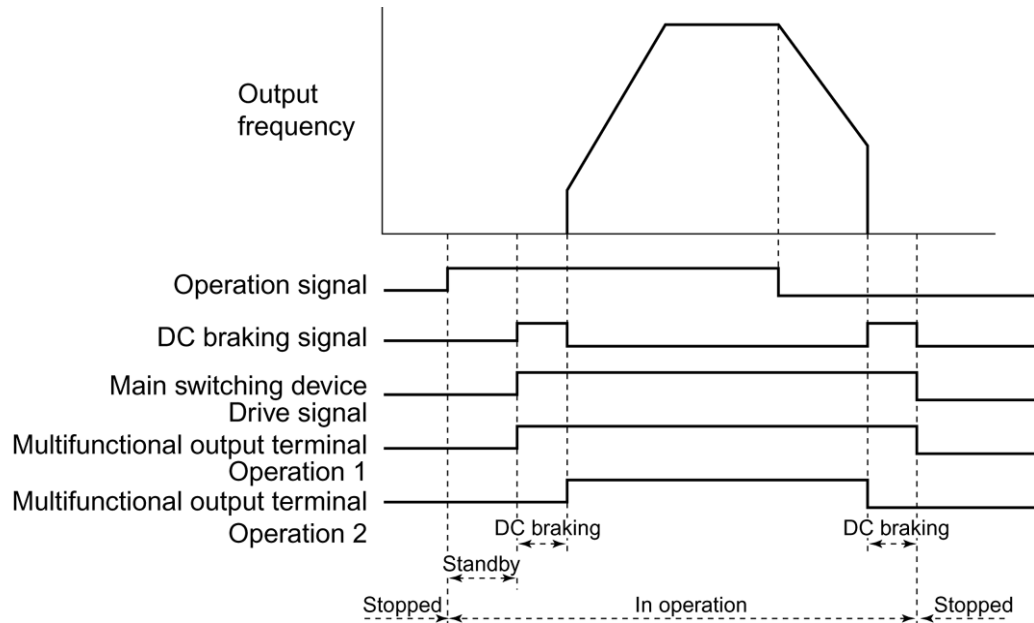
Depending on the combination of function settings, however, a single input may be used for two functions (e.g. Cd002 = 0 to 5 V, Cd120 = 0 to 5 V). Allocate functions to the input terminals so that the two channels (VRF1 and IRF/VRF2) do not duplicate (conflict with) each other.


6.7 Other Displays

Table 6.3 Other displays

| Display | Description |
|---------------|---|
| <i>in it</i> | Flashes during the initialization of data |
| <i>rEAdY</i> | Displayed for a function code requiring confirmation |
| <i>in itY</i> | Flashes during the initialization of user's data |
| <i>dEC id</i> | Flashes when user's initialization data is confirmed |
| <i>CoPY</i> | Flashes during data transfer when copying |
| <i>F ind</i> | Flashes when searching for a function code in user's data that is different from default data |
| <i>ZEro</i> | 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 <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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


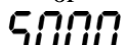













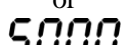
7.1 Changing Settings (Function Code Display Mode)






- The functions are set in Function Code Display mode. Press the  key to toggle the mode between Status Display and Function Code Display.

Status Display mode  Function Code Display mode



* To set Cd008 = 15

| Operation | Display | Description |
|---|--|---|
| |  or  | Status Display mode |
|  |  | Function Code Display mode |
| Numeric key  |  | Enter a function code number directly using the numeric keys. |
|  |  | The data of the specified function code number is read and displayed, and the operation panel waits for numeric data input. |
| Numeric keys   |  | Enter a numeric value using the numeric keys. Each time a numeral is entered, the display shifts to the left. |
|  |  | 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.) |
|  |  or  | The display returns to the Status Display mode. |

- To correct numeric input, press the  key to return to the previous display.
- To cancel function code data input, press the  key to return to Function Code Display mode. (To cancel a change after pressing  once, do not press  again but press the  key twice to return to Function Code Display mode.)
- Copy function (Cd084)

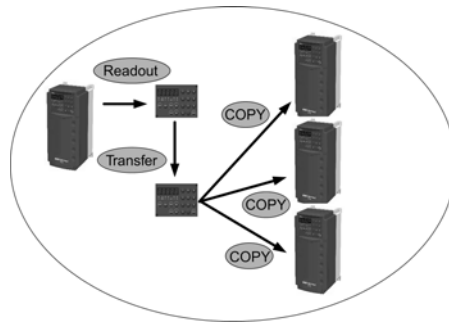
This function transfers function code data from the inverter to the operation panel or to another inverter. This function is useful when setting the same function code data to multiple inverters. The same function code can be set to multiple inverters since after setting the function code data to one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



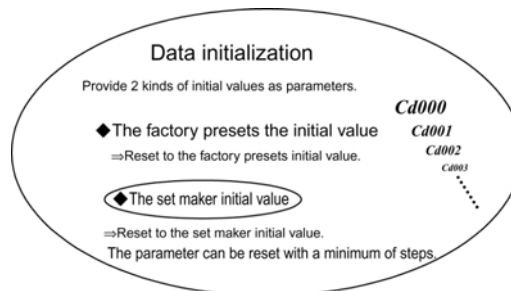
● Data initialization (Cd099)

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.

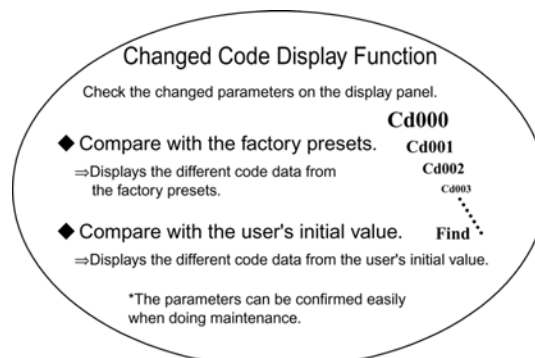
This is useful when checking the difference between current function code data and the factory presets or user's initial value. The function code data can be confirmed easily when doing maintenance.

<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 |
|---|---------------------------|---|
| | 5000 OR 5000 | Status Display mode |
|  | Cd | Function Code Display mode |
| Numeric keys   | Cd 99 | Enter a function code number directly using the numeric keys. |
|  | 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 | Enter a numeric value using the numeric keys. |
|  * | { 1 r-ERdy | 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. |
|  | 5000 OR 5000 | 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 r-ERdy | The display toggles between the value and “ready” to indicate the confirmation mode. |
|  | Cd 99 | The display returns to the Function Code Display mode. |
|  | 5000 OR 5000 | 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 |
|  | <i>Cd</i> | Function Code Display mode |
| Numeric keys   | <i>Cd 53</i> | Enter a function code number directly using the numeric keys. |
|  | 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. |
|  | 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. |
|  | 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. |
|  | <i>Cd 53</i> | The input numeric value is stored as the new setting and the display returns to the Function Code Display mode. |
|  | 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 |
|---|---------------------------|---|
| | 5000 or 5000 | Status Display mode |
|  | <i>Cd</i> | Function Code Display mode |
| Numeric keys   | <i>Cd 54</i> | Enter a function code number directly using the numeric keys. |
|  | <i>P 00</i> | The data of the specified function code number is read. |
|   | <i>- 00</i> | Change the number of motor poles using the step keys. |
| Numeric keys   | <i>- 10</i> | Change the data using the numeric keys. |
|  | <i>Cd 54</i> | The input numeric value is stored as the new setting and the display returns to the Function Code Display mode. |
|  | 5000 or 5000 | The display returns to the Status Display mode. |

● Setting Cd140

* To display differences from the factory presets

| Operation | Display | Description |
|---|-----------------------------|---|
| | 5000 | Status Display mode |
|  | Cd | Function Code Display mode |
| Numeric keys    | Cd 140 | Enter a function code number directly using the numeric keys. |
|  | 0 | The data of the specified function code number is read. |
| Numeric key  | ! | Change the data using the numeric keys. |
|  | F ind | Searching for code numbers of functions where user's settings differ from the factory presets (F ind 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. |
|  | CdXXX | When the code number of a function code whose settings have been changed is displayed, press  to display the function code data. Pressing  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. |
|  | Cd 140 | The display returns to the Function Code Display mode. |
|  | 5000 | 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.

| 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: 50Hz 2: 60Hz | 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: CRLF 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: $\times 1$ 2: $\times 2$ 3: $\times 4$ | 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 | Selection of input terminal DI1 | 0: Not used 1: FR 2: RR 3:2DF 4:3DF 5: MBS | 1 | 1 | |
| 631 | Selection of input terminal DI2 | 6: ES 7: RST 8: AD2 9:AD3 10:JOG | | 2 | |
| 632 | Selection of input terminal DI3 | 11: FR+JOG 12: RR+JOG 13: FR+AD2 | | 3 | |
| 633 | Selection of input terminal DI4 | 14: RR+AD2 15: FR+AD3 16: RR+AD3 | | 4 | |
| 634 | Selection of input terminal DI5 | 17: FR+2DF 18: RR+2DF 19: FR+3DF | | 5 | |
| 635 | Selection of input terminal DI6 | 20: RR+3DF 21: FR+2DF+3DF | | 6 | |
| 636 | Selection of input terminal DI7 | 22: RR+2DF+3DF 23: FR+AD2+2DF | | 7 | |
| 637 | Selection of input terminal DI8 | 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 | | 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 × preset frequency/ no. of motor poles flashes. | 120 × preset frequency/ no. of motor poles lights. |
| 4 | 0 [%] flashes. | Output current/inverter rated current × 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.

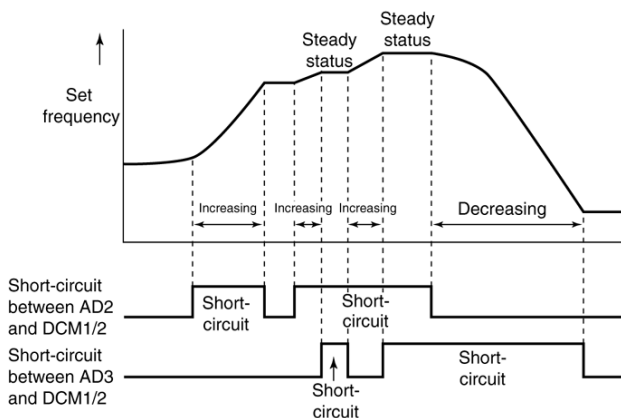
2) Increasing or decreasing the set frequency

- 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.

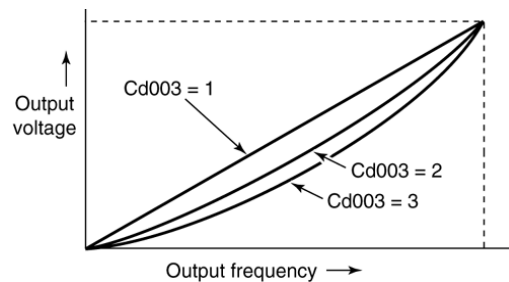
Cd003 V/f Pattern Selection

- 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)

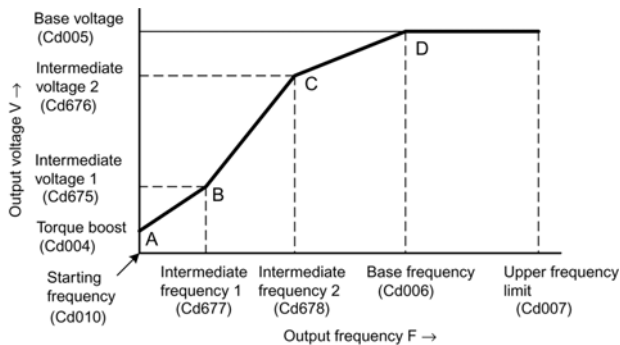
Cd003=3: Square-law decreasing V/f strong (for reduced torque load)



- 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.)

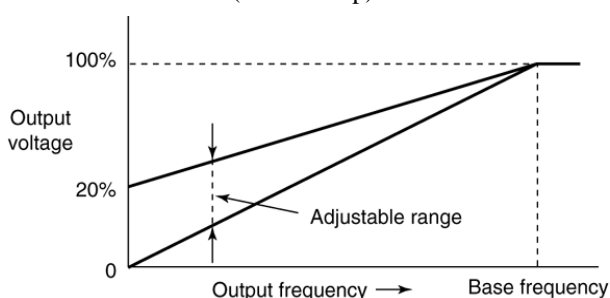
- When Cd003=2 or 3, the inverter can be operated more effectively with Cd045=1 (provides a function to limit the output current during constant power operation).

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

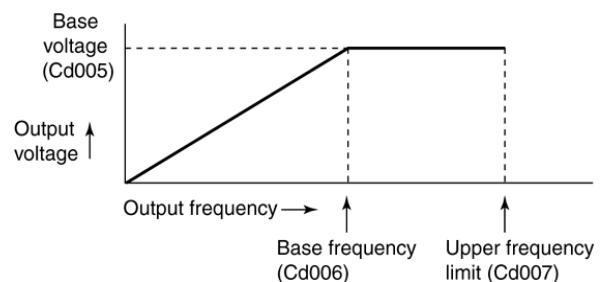
- These functions determine the V/f pattern including the base voltage and the base frequency appropriate to the characteristics of the motor in use.

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)

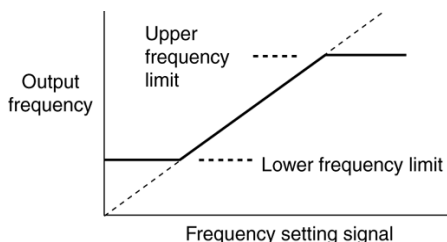


Note: General-purpose inverters do not output a voltage higher than the input voltage. Therefore, the range of automatic voltage control specified by the above functions depends on the highest possible input voltage. Cd005=230V may be set for a 200V system, for example, but 230V will not actually be 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.

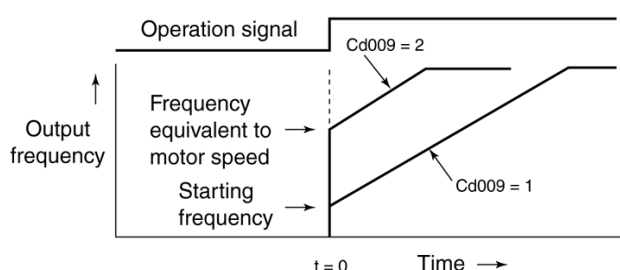
- Although a lower frequency than the lower limit can be specified, an output frequency lower than the lower limit is not actually output.
- The lower frequency limit must be greater than the starting frequency (Cd010) and the operation start frequency (Cd011).



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.

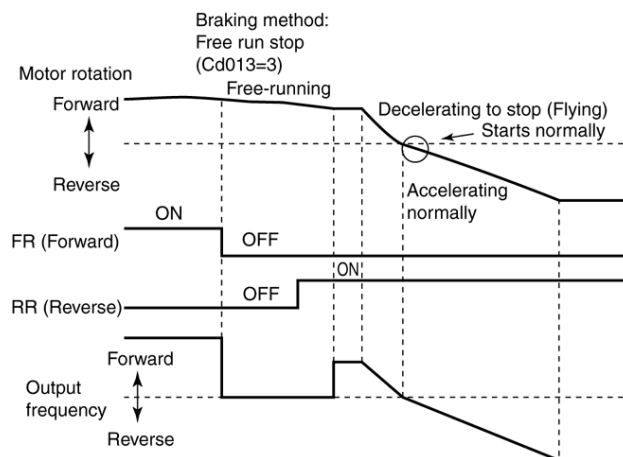
Cd009 Starting Method

- 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.

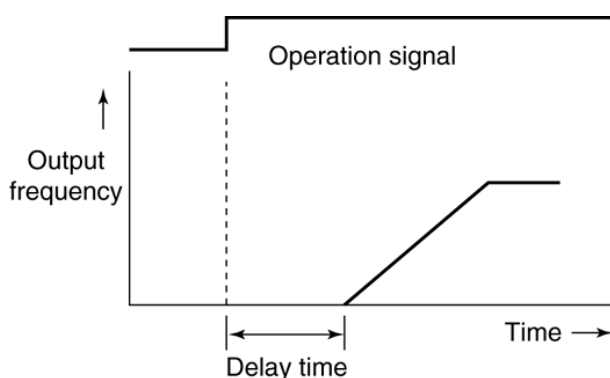
This function is useful for starting or stopping the inverter using only an external frequency command.

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.

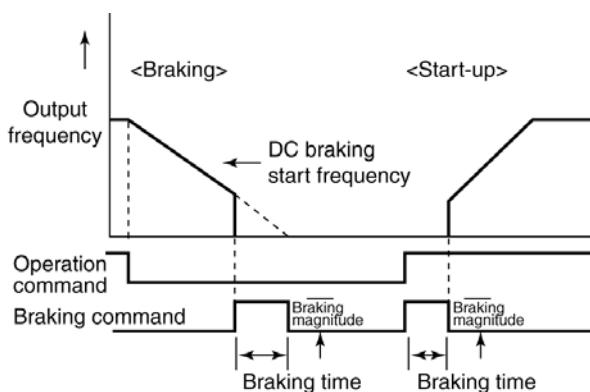
- If the output frequency is greater than the DC braking start frequency when a set frequency lower than the operation start frequency is specified, the output frequency is reduced to the DC braking start frequency, and DC braking is applied as in (1).
- If the output frequency is less than the DC braking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

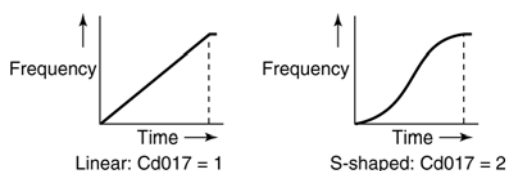
Note 2: During DC braking, the motor may overheat because the self cooling effect of the motor's own rotation is ineffective. Therefore, it is recommended to set the DC braking force at a relatively low level to prevent the motor from overheating, or to attach a thermal relay to the motor.

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.



Cd017 Acceleration/Deceleration Curve

- Linear and S-shaped acceleration/deceleration frequency curves can be selected.



- 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

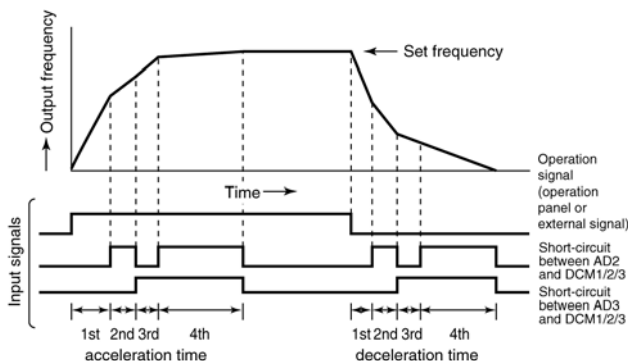
During the frequency lock, the inverter operates at a fixed frequency of 20 Hz. When the lock is released, acceleration begins again from 20 Hz to 50 Hz.

- (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.

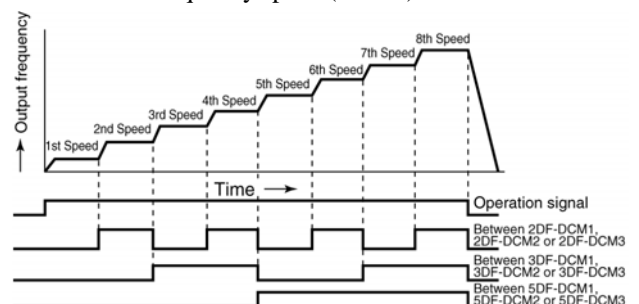
Cd028=0.1 - 60Hz (in 0.01Hz steps)

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-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:

- 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).
- 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.

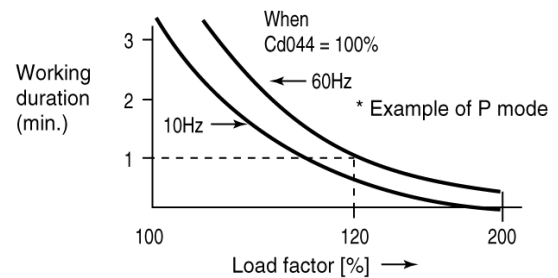
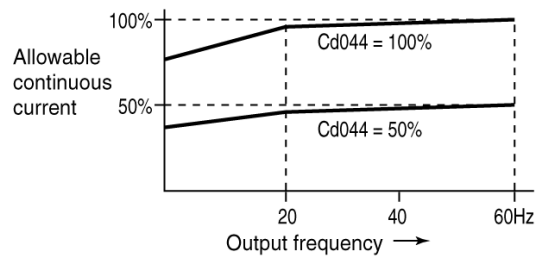
Example 1: To drive a 2.2 kW motor using SBT-3.7K, set the function code as follows:

$$\text{Cd044} = \frac{\text{(rated current of 2.2 kW motor)}}{\text{(rated current of SBT-3.7K: 17.6 A)}} \times 100\%$$

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,

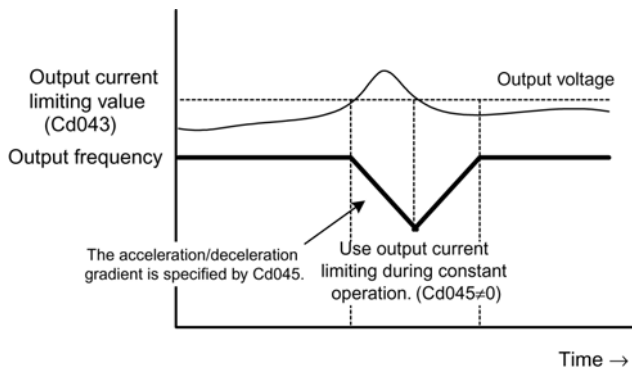
Cd023: 1st acceleration/deceleration time)

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
- oCR : 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  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 .
- Acceptable settings and the corresponding display values are shown below.
 - Input one of four even numbers from 2 to 8 for the number of poles.

| | | | |
|---|---|---|---|
| 2 | 4 | 6 | 8 |
|---|---|---|---|

- 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])

- 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 | | | | | |

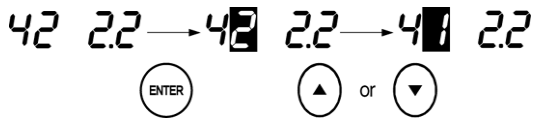
[Δ indicates a space]
(in [kW])

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

42 22

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.

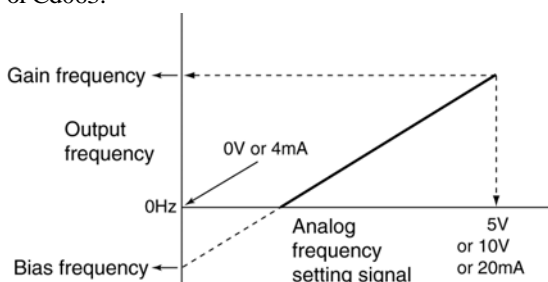
| | |
|-------|---------------------------|
| Cd054 | Bias Frequency (VRF1) |
| Cd055 | Gain Frequency (VRF1) |
| Cd062 | Bias Frequency (IRF/VRF2) |
| Cd063 | Gain Frequency (IRF/VRF2) |

- 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.

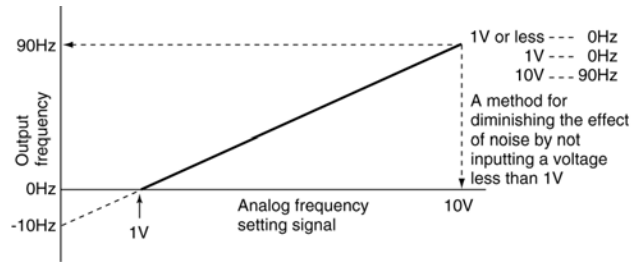
Cd054, Cd062=0 to ±600Hz (in 0.1Hz step)
Cd055, Cd063=0 to ±600Hz (in 0.1Hz step)
“Pxxx” is displayed for plus, and “-xxx”, for minus.

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.

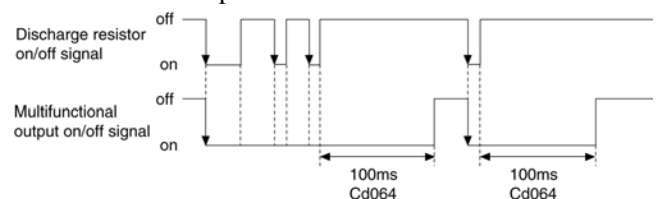
Cd061 Instability Elimination

- 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 multifunctional 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.

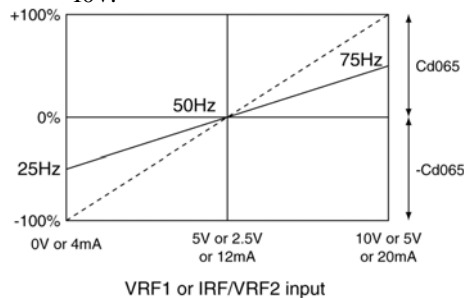
Example: When the Discharge Resistor on Signal Output Time Cd064=0.1 s.



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.



- 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

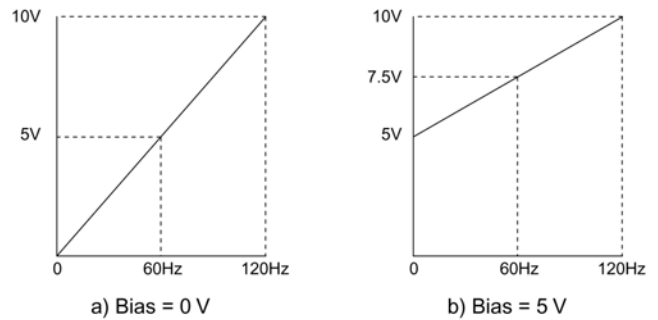
- This function is used to select the operation of the MBS input signal input to the multifunctional input terminal.
Cd067=1: Level operation
Cd067=2: Edge operation
Edge operation will accept MBS input once between OFF and ON.

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: Pxxx
Minus: -xxx
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 10V.



- 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/VRF2terminal:

Inputs a feedback signal in the form of a current signal (4mA to 20mA (specified by “Cd120=5”)).

VRF1terminal:

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.)

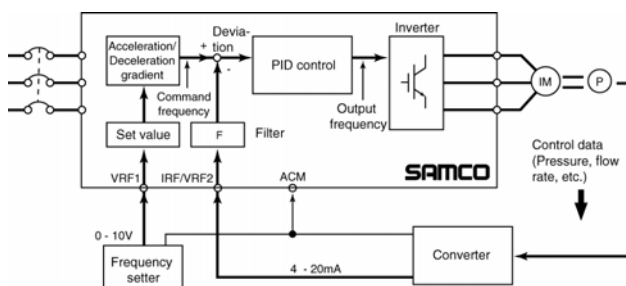


Figure 7.1

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.

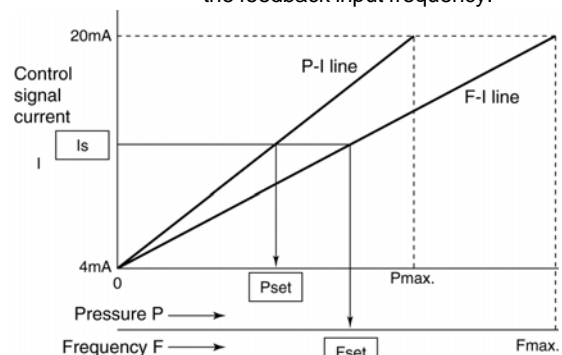
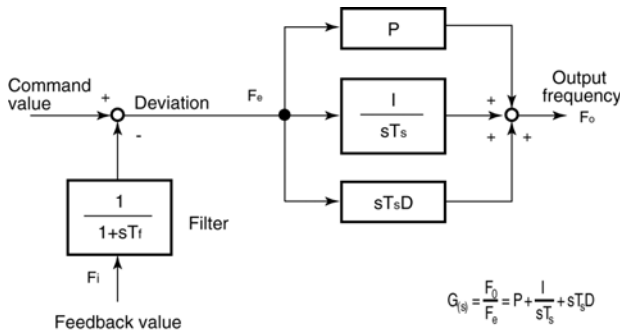


Figure 7.2

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.



- 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.

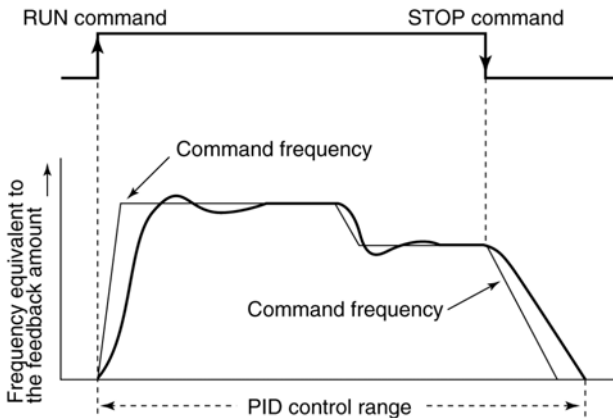


Figure 7.4

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?

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

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) × 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

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. Yes

Are characteristics satisfied?

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

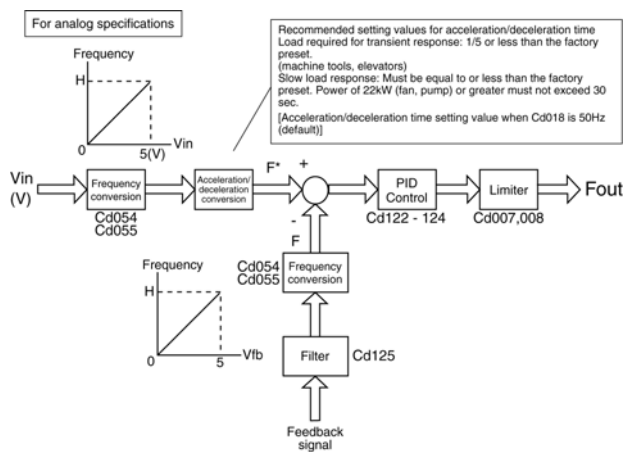


Figure 7.5

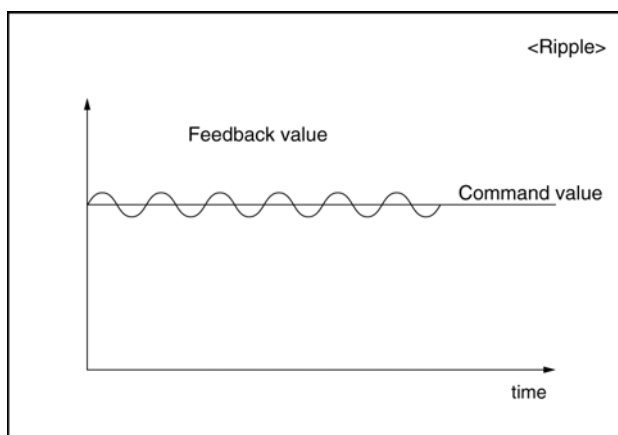


Figure 7.6

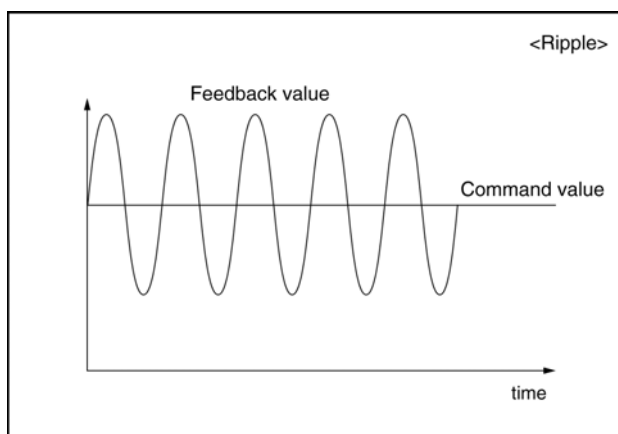


Figure 7.7

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 "GRL" 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

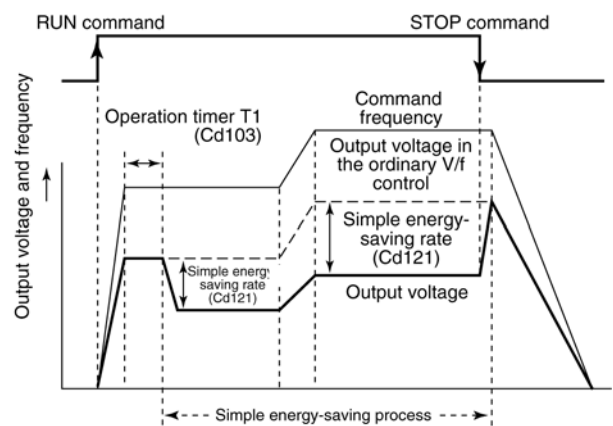
Cd071=6 Simple Energy-Saving Control Mode

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.)

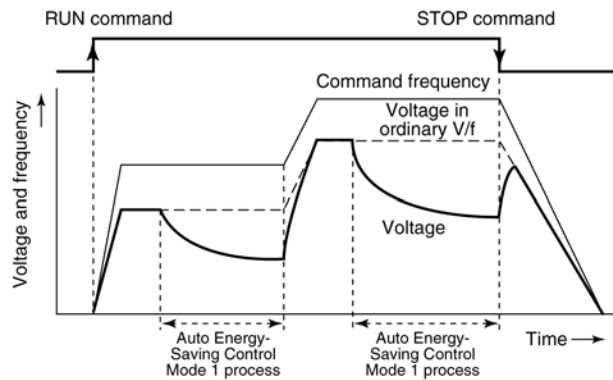
1) Related function code

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.

- 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 multi-functional 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 V_{in} 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 →

$$V_{out} = V_{in} - (V_{in} \times 100\%) = 0 \text{ (V)}$$

VRF1=5V input →

$$V_{out} = V_{in} + (V_{in} \times 0\%) = V_{in} \text{ (V)}$$

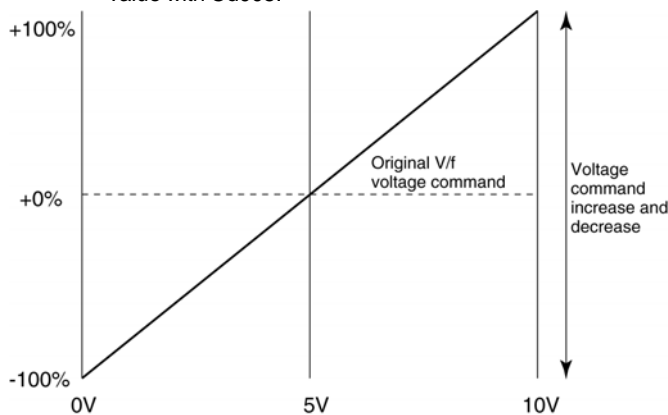
VRF1=10V input →

$$V_{out} = V_{in} + (V_{in} \times 100\%) = 2V_{in} \text{ (V)}$$

V_{in} = Current voltage command

V_{out} = 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 →

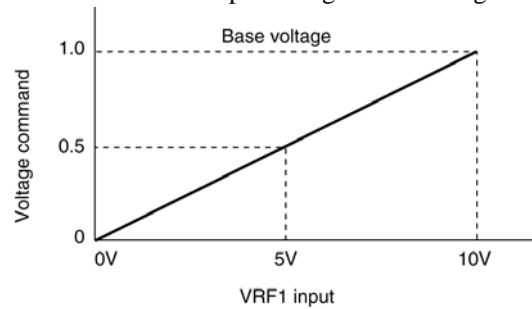
$$\text{Output voltage} = \text{Base voltage} \times 0$$

VRF1=5V input →

$$\text{Output voltage} = \text{Base voltage} \times 0.5$$

VRF1=10V input →

$$\text{Output voltage} = \text{Base voltage} \times 1.0$$



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.

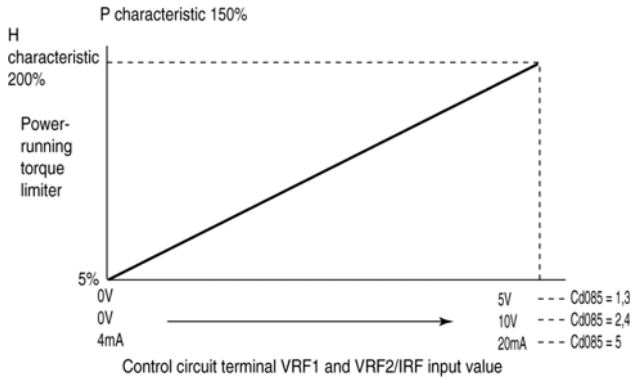
Note 6: The copy function is not available on the remote operation panel (optional).

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=1 or 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.

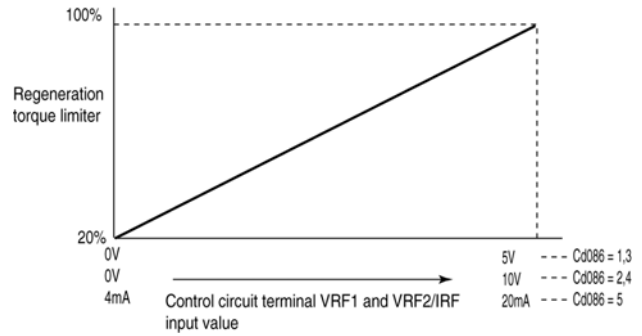


Note 1: The power-running torque limiter varies in the range of 5% to 200% of the value that is input to the control terminal (for H characteristic) or in the range of 5% to 150% of the value that is input to the control terminal (for P characteristic)

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.



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 "OV" and "LV" 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 acceleration/deceleration (Cd017=2) in the acceleration/deceleration mode. The shape of the S-shaped acceleration/deceleration curve can be set independently 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:

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

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

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

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

- 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.

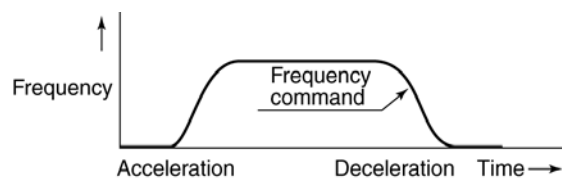
Cd018=50(Hz)

Cd019=5 (in seconds)

Cd023=5 (in seconds)

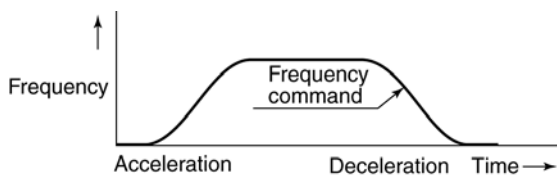
Example 1) Cd090=100, Cd091=100, Cd092=100, Cd093=100, Cd094=100, Cd095=100

- 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 acceleration/deceleration mode, the current limiting function may operate depending on the magnitude of the load inertia.



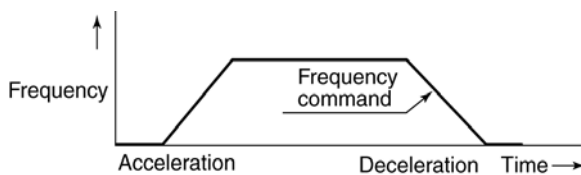
Example 2) Cd090=100, Cd091=100, Cd092=0, Cd093=100, Cd094=100, Cd095=0

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.



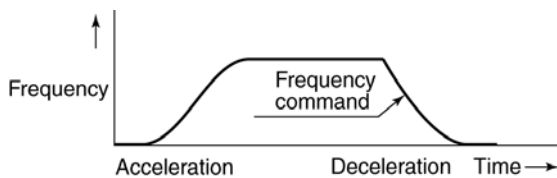
Example 3) Cd090=0, Cd091=0, Cd092=0, Cd093=0, Cd094=0, Cd095=0

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



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.



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 \blacktriangle and \blacktriangledown keys to read the last five alarms issued. Every time the \blacktriangle or \blacktriangledown 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

- Set the required function code.
- Identify this value as the user's initialization value with Cd099=99.
- The confirmation message "*r-ERdy*" and the set value start flashing. Press the \blacktriangle key to confirm the value.
- "*dEE id*" keeps flashing while the user's initialization value is being stored. Wait until "*dEE id*" disappears.
- Once "*dEE 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

- Execute Cd099=3 to initialize the function code data to the user's initialization data determined with Cd099=99.
- The confirmation message "*r-ERdy*" and the set value start flashing. Press the \blacktriangle key to confirm the value.
- "*in ity*" keeps flashing while the function code data is being initialized to the user's initialization data. Wait until "*in ity*" disappears.
- "*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: "*dEE id*" and "*in ity*" are not displayed for serial communication function.

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).

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.

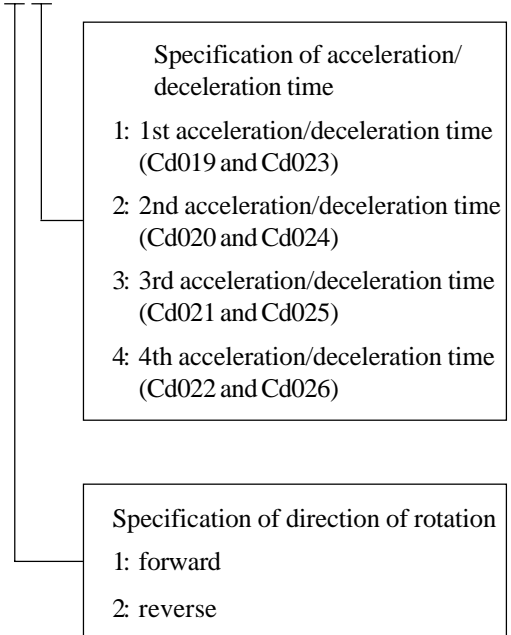
- 2) Starting a simple scheduled operation
- Set “Cd101=1” (Simple Scheduled Operation).
The Simple Scheduled Operation function is enabled in V/f and Sensorless Vector Control modes.
 - Only the forward run command is valid as an operation command on the operation panel, external control circuit terminals, 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



- 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

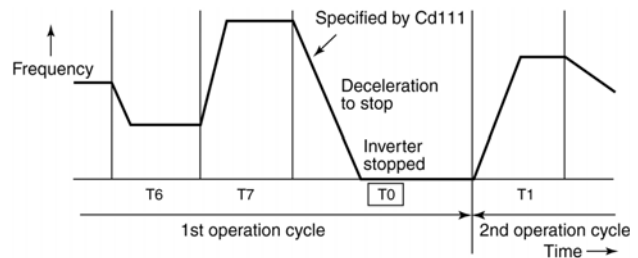
T0. While the operation stop timer is in operation, the inverter always decelerates to stop the motor.

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).

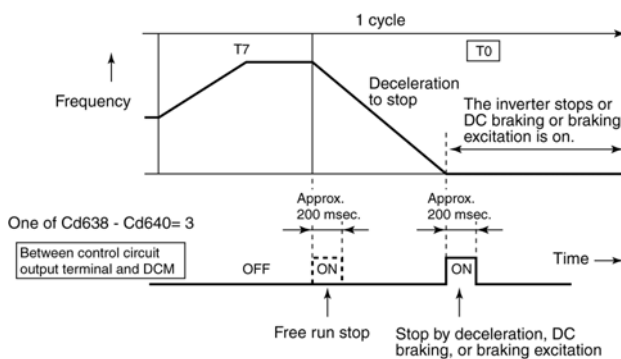
- Operation timer T4: Determined by the value of Cd032 (= 0 to 600Hz).
- Operation timer T5: Determined by the value of Cd033 (= 0 to 600Hz).
- Operation timer T6: Determined by the value of Cd034 (= 0 to 600Hz).
- Operation timer T7: Determined by the value of Cd035 (= 0 to 600Hz).

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.

- 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.

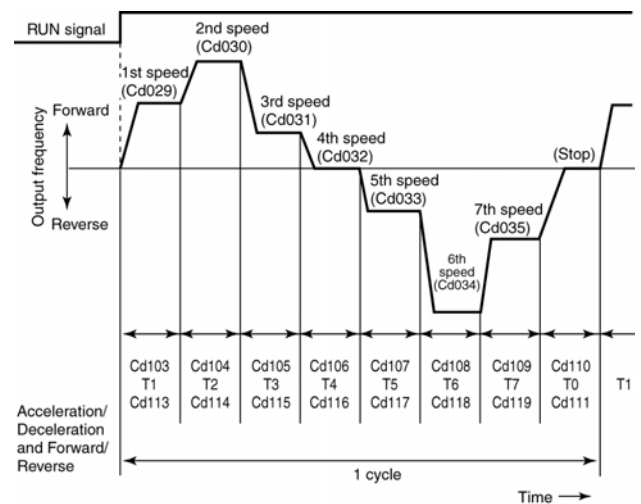


Note 1: The Simple Scheduled Operation Cycle End signal is output each time the operation stop timer T0 works.

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.

- 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)



- 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.

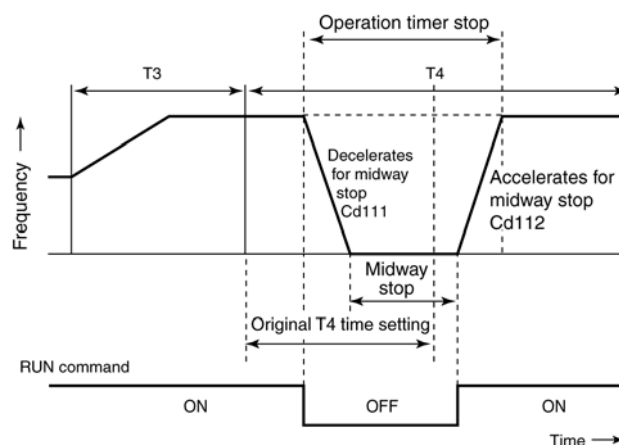
Setting method

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.

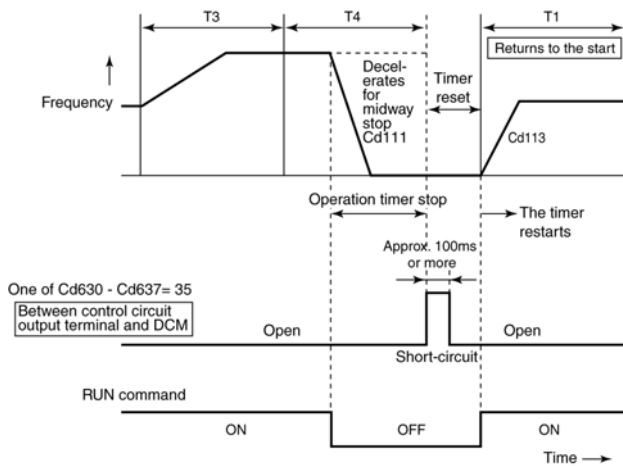


8) Function to reset the simple scheduled operation timer when held by the Midway Stop function

- 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.

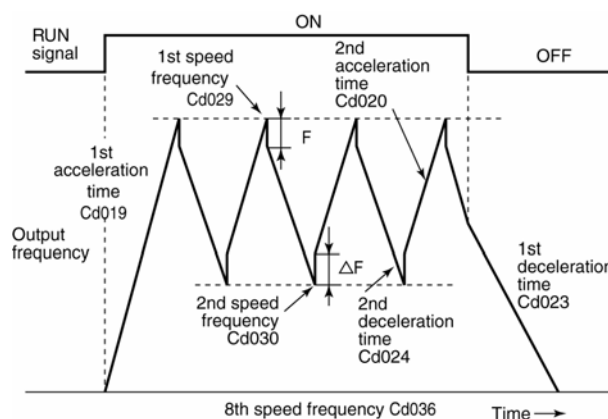
New set frequency when the output frequency reaches the 1st speed frequency:

$$1st\ speed\ frequency - 8th\ speed\ frequency (\Delta F)$$

New set frequency when the output frequency reaches the 2nd speed frequency:

$$2nd\ speed\ frequency + 8th\ speed\ frequency (\Delta F)$$

- 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).

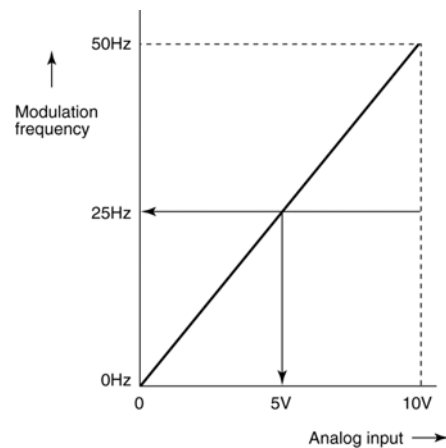
Setting and changing

- 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 $\pm 600\text{Hz}$

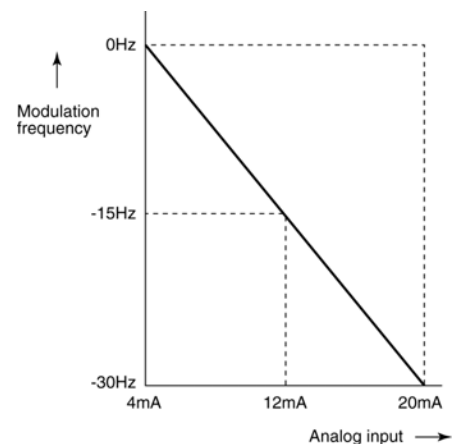
The gain frequency indicates the value by which the set frequency is changed when the analog command specified by Cd120 is at its maximum value. In other words, it is the gain

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

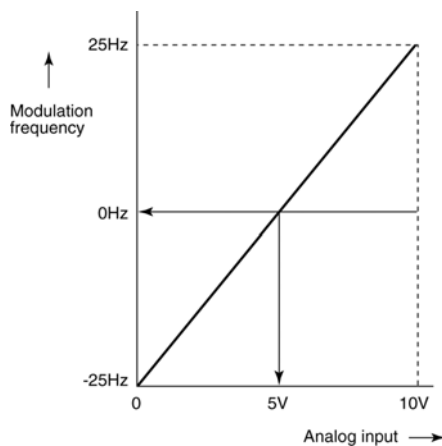
polarity of the gain frequency (Cd055 or Cd063). If you want to modulate the original set frequencies (1st and 2nd speed frequencies) up and down, specify an offset value using the disturb modulation rate (Cd121).

The offset should be

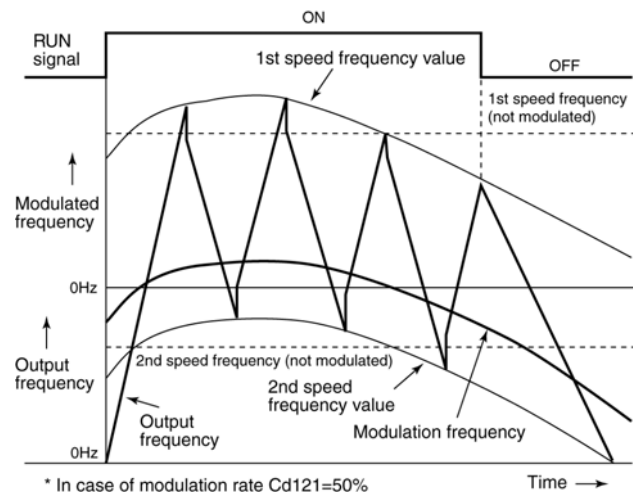
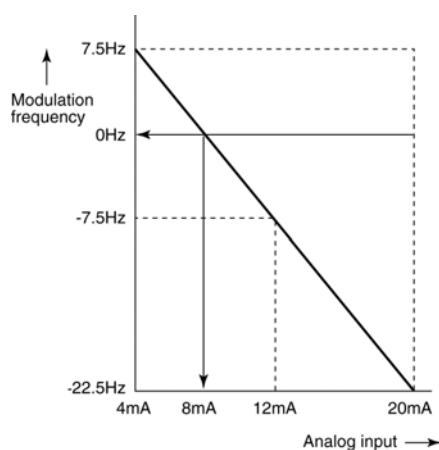
$$Cd121 = 0\% \text{ to } 50\%.$$

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.)



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  key on the operation panel.

Cd130=1: Forward run

Cd130=2: Reverse run

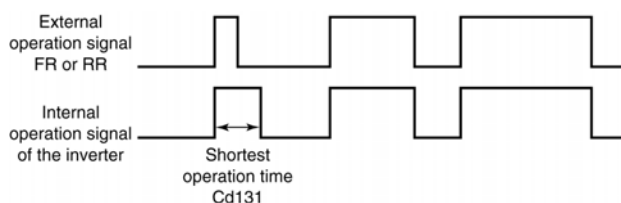
Note: The direction of rotation of the motor is fixed by Cd050.

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, “ $E_r d$ ” 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.

Cd641 Start Standby Time

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 - 120.0s: Start standby time

Cd642=0.05 - 60.00Hz: Start standby frequency

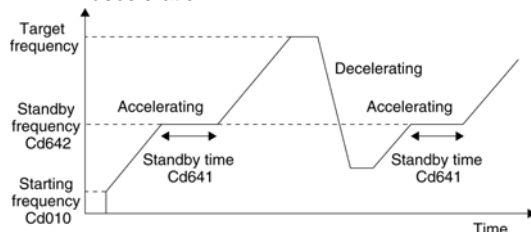
- When a value other than 0 is set with Cd641, the inverter locks the frequency for the time set with Cd641 (output frequency standby) after accelerating to the frequency set with Cd642.

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.



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.

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

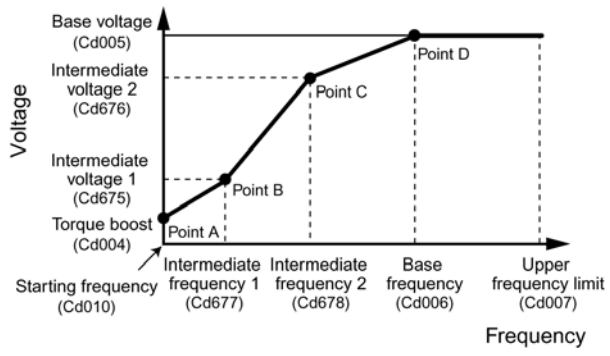
Cd676 Optional V/f pattern intermediate voltage 2

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

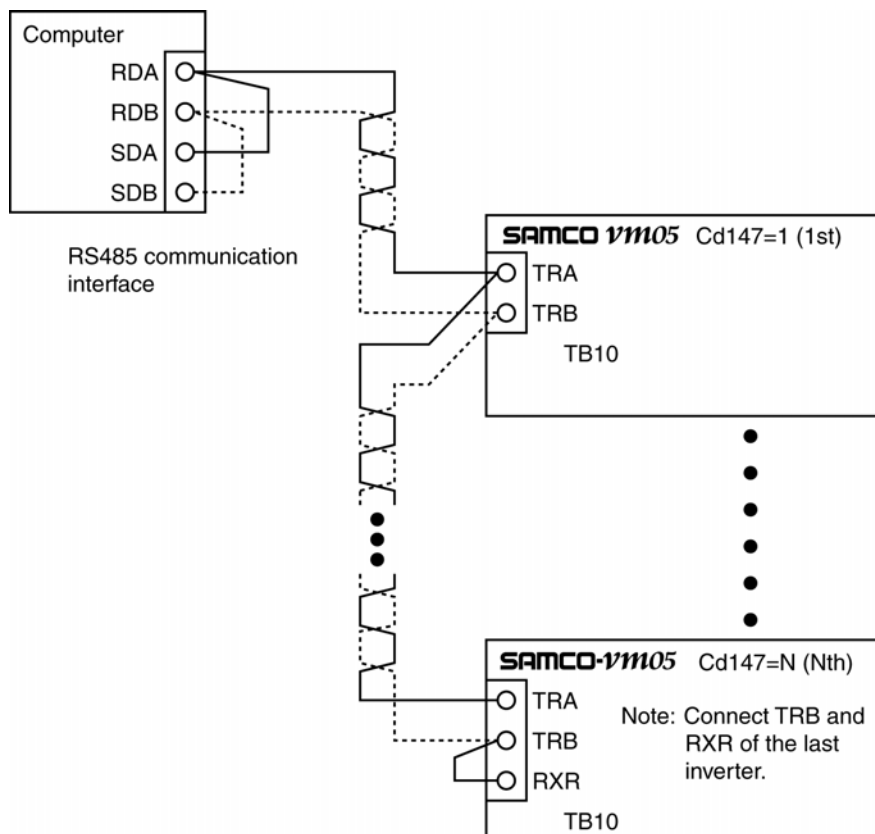
- The serial communication function is an interface function that controls the inverter using serial signals from a computer. This function controls inverter start/stop, frequency setting, operation status monitoring, and function code reading and setting.
- The inverter has an RS232C and an RS485 communication 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)

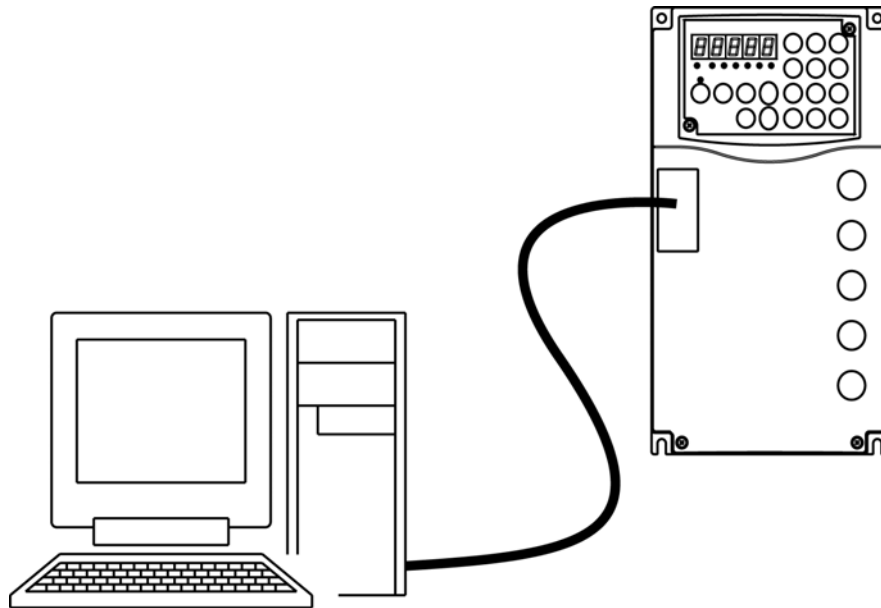
| Terminal symbol | Terminal name | Function |
|-----------------|--------------------------------|---|
| TRA | Send-receive data terminal (+) | Use the positive signal terminal (+) to connect a computer via the RS485 interface. |
| TRB | Send-receive data terminal (-) | Use the negative signal terminal (-) 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.

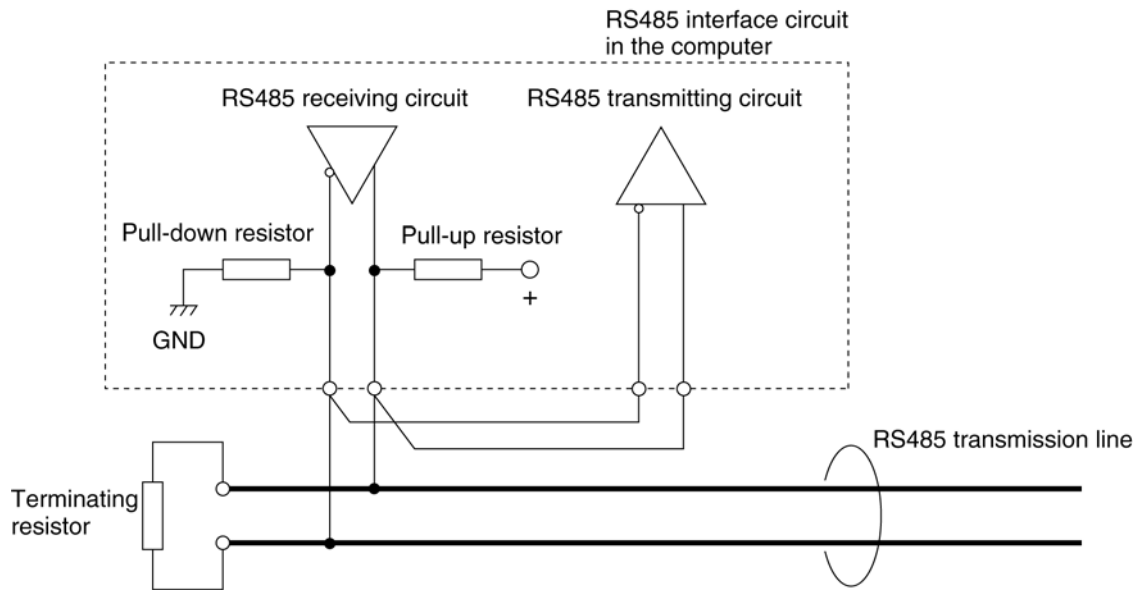
*2 Set Cd002=14 for frequency setting by serial communication.

(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).



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

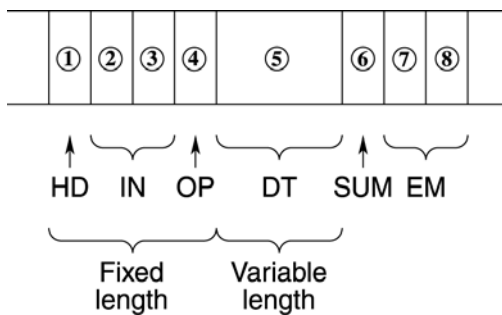
- Messages have the following two formats:

- 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)



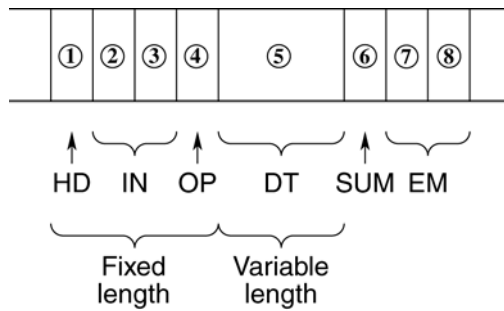
| Item | Name | Description | | | | | | | | | | |
|---------------|------|--|-----|-----|-----|-----|-----|-----|-----|-----|--|--|
| ① | HD | Start code Message transmission start code (*: ASCII code 2AH) | | | | | | | | | | |
| ②③ | IN | Inverter number Destination inverter number (Data length: 2 bytes 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" <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td><td></td><td></td> </tr> </table> Code number Code data • The data length and format are determined for each command. For details, see Details of message formats. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | | | | | |
| 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 | Inverter number | 01 | (2) 30H “0” |
| ③ | | | (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. <div style="text-align: center;"> <table border="1" style="margin: auto;"> <tr> <td>(1)</td> <td>(2)</td> <td>(3)</td> <td>(4)</td> <td>(5)</td> </tr> </table> <p>⑤ Data area</p> </div> <ul style="list-style-type: none"> The data length and format are determined for each command. For details, see Details of message formats. | (1) | (2) | (3) | (4) | (5) |
| (1) | (2) | (3) | (4) | (5) | | | |
| 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 |
|---|---|---|---|---|

 .

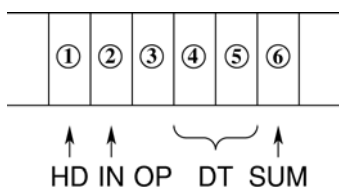
Example 4: When -50 Hz is set with Cd054

The read data (DT) is

| | | | | |
|---|---|---|---|---|
| - | 0 | 5 | 0 | 0 |
|---|---|---|---|---|

 .

3) Message from computer to inverter (Binary format)

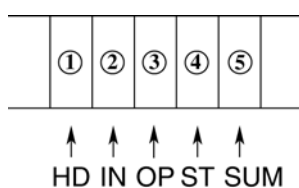


| Item | Name | Description |
|------|------|--|
| ① | HD | Start code Message transmission start code (“@”: ASCII code 40H) |
| ② | IN | Inverter number Destination inverter number Example: 14H for Inverter number 20 |
| ③ | OP | Command code Inverter command code |
| ④ ⑤ | DT | Setting data Send data 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)



| 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 | <ul style="list-style-type: none"> Reading the alarm number <pre>* 0 1 A SUM EM</pre> | <ul style="list-style-type: none"> External thermal alarm (18) <pre>* 0 1 A 0 0 0 1 8 SUM EM</pre> <ul style="list-style-type: none"> The response is 0 if no alarm is detected. See list of alarm codes for details of the alarm numbers. |
| B | <ul style="list-style-type: none"> Reading the function code data (*1) Cd007 "Upper frequency limit" <pre>* 0 1 B 0 0 7 SUM EM</pre> | <ul style="list-style-type: none"> Cd007: 60 [Hz] <pre>* 0 1 B 0 6 0 0 0 SUM EM</pre> <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Reading the output frequency <pre>* 0 1 C SUM EM</pre> | <ul style="list-style-type: none"> Output frequency: 50 [Hz] <pre>* 0 1 C 0 5 0 0 0 SUM EM</pre> <ul style="list-style-type: none"> The frequency data is multiplied by 100. |
| D | <ul style="list-style-type: none"> Reading the output current <pre>* 0 1 D SUM EM</pre> | <ul style="list-style-type: none"> Output current: 12 [A] <pre>* 0 1 D 0 0 1 2 0 SUM EM</pre> <ul style="list-style-type: none"> The current data is multiplied by 10. |
| E | <ul style="list-style-type: none"> Reading the DC voltage <pre>* 0 1 E SUM EM</pre> | <ul style="list-style-type: none"> DC voltage: 150 [V] <pre>* 0 1 E 0 1 5 0 0 SUM EM</pre> <ul style="list-style-type: none"> The voltage data is multiplied by 10. |
| F | <ul style="list-style-type: none"> Reading the fin temperature <pre>* 0 1 F SUM EM</pre> | <ul style="list-style-type: none"> Fin temperature: 50 [°C] <pre>* 0 1 F 0 0 0 5 0 SUM EM</pre> <ul style="list-style-type: none"> The fin temperature data is multiplied by 1. |
| G | <ul style="list-style-type: none"> Reading the load factor <pre>* 0 1 G SUM EM</pre> | <ul style="list-style-type: none"> Load factor: 40 [%] <pre>* 0 1 G 0 0 0 4 0 SUM EM</pre> <ul style="list-style-type: none"> The load factor data is multiplied by 1. |
| H | <ul style="list-style-type: none"> Reading Operation Status 1 <pre>* 0 1 H SUM EM</pre> | <ul style="list-style-type: none"> The operation status is returned as bit data. <pre>* 0 1 H 0 0 0 0 X SUM EM</pre> <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Reading Operation Status 2 <pre>* 0 1 I SUM EM</pre> | <ul style="list-style-type: none"> The operation status is returned as bit data. <pre>* 0 1 I 0 X X X X SUM EM</pre> <ul style="list-style-type: none"> The data has a four-byte format. See Operation Status 2 data for the bit correspondence of data X. |
| J | <ul style="list-style-type: none"> Reading the input status of the control terminal board <pre>* 0 1 J SUM EM</pre> | <ul style="list-style-type: none"> The terminal status is returned as bit data. <pre>* 0 1 J 0 X X X X SUM EM</pre> <ul style="list-style-type: none"> The data has a four-byte format. See Control Terminal Board Input Status data for the bit correspondence of data X. |
| K | <ul style="list-style-type: none"> Reading the output voltage <pre>* 0 1 K SUM EM</pre> | <ul style="list-style-type: none"> Output voltage: 100 [V] <pre>* 0 1 K 0 1 0 0 0 SUM EM</pre> <ul style="list-style-type: none"> The voltage data is multiplied by 10. |
| L | <ul style="list-style-type: none"> VRF1 control terminal input value <pre>* 0 1 L SUM EM</pre> | <ul style="list-style-type: none"> The VRF1 control terminal input value is returned. <pre>* 0 1 L 0 1 0 2 3 SUM EM</pre> <ul style="list-style-type: none"> Up to 1023 (10 bits) are returned for the maximum input (10 V). |
| M | <ul style="list-style-type: none"> IRF/VRF2 control terminal input value <pre>* 0 1 M SUM EM</pre> | <ul style="list-style-type: none"> The IRF/VRF2 control terminal input value is returned. <pre>* 0 1 M 0 1 0 2 3 SUM EM</pre> <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Writing the function code data Writing 50 Hz to Cd008 "Lower frequency limit" <pre>* 0 1 N 0 0 8 0 5 0 0 0 SUM EM</pre> <ul style="list-style-type: none"> Set the frequency data multiplied by 100. | <ul style="list-style-type: none"> Normal write <pre>* 0 1 N e F F F 0 SUM EM</pre> <ul style="list-style-type: none"> Interference error (Example: Interference with Cd007) <pre>* 0 1 N e 0 0 0 7 SUM EM</pre> <p style="text-align: center;">Interference code number</p> <ul style="list-style-type: none"> Setting error (Example: Locked) <pre>* 0 1 N e F F F 5 SUM EM</pre> <p style="text-align: center;">Error code</p> <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Setting the output frequency Setting the output frequency to 55 Hz <pre>* 0 1 O 0 5 5 0 0 SUM EM</pre> <ul style="list-style-type: none"> Set the frequency data multiplied by 100. | <ul style="list-style-type: none"> Same as for code data write <pre>* 0 1 O e F F F 0 SUM EM</pre> <p style="text-align: center;">Error code (Example: 0 Hz)</p> <ul style="list-style-type: none"> "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 | <ul style="list-style-type: none"> Forward run command <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>P</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | P | SUM | EM | <ul style="list-style-type: none"> Transmission from inverter to computer <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>OP</td><td>ST</td><td>SUM</td><td>EM</td> </tr> </table> <p style="text-align: center;">└─</p> <p style="text-align: center;">Command execution status</p> <p style="text-align: center;">0: Normal</p> <p style="text-align: center;">1: Operation control is not permitted</p> <p style="text-align: center;">2: No operation in alarm status</p> | * | 0 | 1 | OP | ST | SUM | EM |
| * | 0 | 1 | P | SUM | EM | | | | | | | | | | |
| * | 0 | 1 | OP | ST | SUM | EM | | | | | | | | | |
| Q | <ul style="list-style-type: none"> Reverse run command <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>Q</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | Q | SUM | EM | | | | | | | | |
| * | 0 | 1 | Q | SUM | EM | | | | | | | | | | |
| R | <ul style="list-style-type: none"> Stop command <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>R</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | R | SUM | EM | | | | | | | | |
| * | 0 | 1 | R | SUM | EM | | | | | | | | | | |
| S | <ul style="list-style-type: none"> Alarm Reset command <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>S</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | S | SUM | EM | <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>S</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | S | SUM | EM | |
| * | 0 | 1 | S | SUM | EM | | | | | | | | | | |
| * | 0 | 1 | S | SUM | EM | | | | | | | | | | |
| X | <ul style="list-style-type: none"> Automatic Alarm Permitted command <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>X</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | X | SUM | EM | <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>X</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | X | SUM | EM | |
| * | 0 | 1 | X | SUM | EM | | | | | | | | | | |
| * | 0 | 1 | X | SUM | EM | | | | | | | | | | |
| Y | <ul style="list-style-type: none"> Automatic Alarm Prohibited command <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>Y</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | Y | SUM | EM | <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>Y</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | Y | SUM | EM | |
| * | 0 | 1 | Y | SUM | EM | | | | | | | | | | |
| * | 0 | 1 | Y | SUM | EM | | | | | | | | | | |
| Z | <ul style="list-style-type: none"> Command A is returned if an automatic alarm is received. | <ul style="list-style-type: none"> Automatic alarm <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>Z</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | Z | SUM | EM | | | | | | | |
| * | 0 | 1 | Z | SUM | EM | | | | | | | | | | |
| a | <ul style="list-style-type: none"> Selecting inverters for batch operation Selecting inverter number 1 <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>a</td><td>SUM</td><td>EM</td> </tr> </table> | * | 0 | 1 | a | SUM | EM | <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>a</td><td>ST</td><td>SUM</td><td>EM</td> </tr> </table> <p style="text-align: center;">└─</p> <p style="text-align: center;">Command execution status</p> <p style="text-align: center;">0: Normal</p> <p style="text-align: center;">1: Operation control is not permitted</p> <p style="text-align: center;">2: No operation in alarm status</p> <p style="text-align: center;">└─</p> <p style="text-align: center;">Command repetition</p> | * | 0 | 1 | a | ST | SUM | EM |
| * | 0 | 1 | a | SUM | EM | | | | | | | | | | |
| * | 0 | 1 | a | ST | SUM | EM | | | | | | | | | |
| b | <ul style="list-style-type: none"> Selecting the direction of rotation of batch-operation inverters Selecting forward run for inverter number 1 <table border="1"> <tr> <td>*</td><td>0</td><td>1</td><td>b</td><td>0</td><td>SUM</td><td>EM</td> </tr> </table> <p style="text-align: center;">↑</p> <p style="text-align: center;">Direction of rotation (Forward: 0, Reverse: 1)</p> | * | 0 | 1 | b | 0 | SUM | EM | | | | | | | |
| * | 0 | 1 | b | 0 | SUM | EM | | | | | | | | | |
| c | <ul style="list-style-type: none"> Releasing batch operation <table border="1"> <tr> <td>*</td><td>3</td><td>5</td><td>c</td><td>SUM</td><td>EM</td> </tr> </table> <ul style="list-style-type: none"> Sent with inverter number 35. | * | 3 | 5 | c | SUM | EM | <ul style="list-style-type: none"> No response is returned. The command is ignored if operation control is not permitted. | | | | | | | |
| * | 3 | 5 | c | SUM | EM | | | | | | | | | | |

| OP-CD | Example of communication data (inverter number 1) | | | | | | | |
|---|---|--|---|-----|-----|-----|----|---|
| | Transmission from computer to inverter | Transmission from inverter to computer | | | | | | |
| d | <ul style="list-style-type: none"> Batch Start command The selected inverters are started simultaneously. <table border="1" style="margin-left: 40px;"> <tr> <td>*</td><td>3</td><td>3</td><td>d</td><td>SUM</td><td>EM</td> </tr> </table> <ul style="list-style-type: none"> Sent with inverter number 33. | * | 3 | 3 | d | SUM | EM | <ul style="list-style-type: none"> No response is returned. The command is ignored if operation control is not permitted. |
| | * | 3 | 3 | d | SUM | EM | | |
| <ul style="list-style-type: none"> Batch Start command The selected inverters are started simultaneously. <table border="1" style="margin-left: 40px;"> <tr> <td>*</td><td>3</td><td>4</td><td>d</td><td>SUM</td><td>EM</td> </tr> </table> <ul style="list-style-type: none"> Sent with inverter number 34. | * | 3 | 4 | d | SUM | EM | | |
| * | 3 | 4 | d | SUM | EM | | | |
| e | <ul style="list-style-type: none"> Batch Start command The selected inverters are started simultaneously. <table border="1" style="margin-left: 40px;"> <tr> <td>*</td><td>3</td><td>3</td><td>d</td><td>SUM</td><td>EM</td> </tr> </table> <ul style="list-style-type: none"> Sent with inverter number 33. | * | 3 | 3 | d | SUM | EM | |
| | * | 3 | 3 | d | SUM | EM | | |
| <ul style="list-style-type: none"> Batch Start command The selected inverters are started simultaneously. <table border="1" style="margin-left: 40px;"> <tr> <td>*</td><td>3</td><td>4</td><td>d</td><td>SUM</td><td>EM</td> </tr> </table> <ul style="list-style-type: none"> Sent with inverter number 34. | * | 3 | 4 | d | SUM | EM | | |
| * | 3 | 4 | d | SUM | EM | | | |

Note: Read/write data formats of Cd053 (Number of poles, voltage, and capacity of motor)
The Cd053 data format has a 5-digit format.

X Y 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.

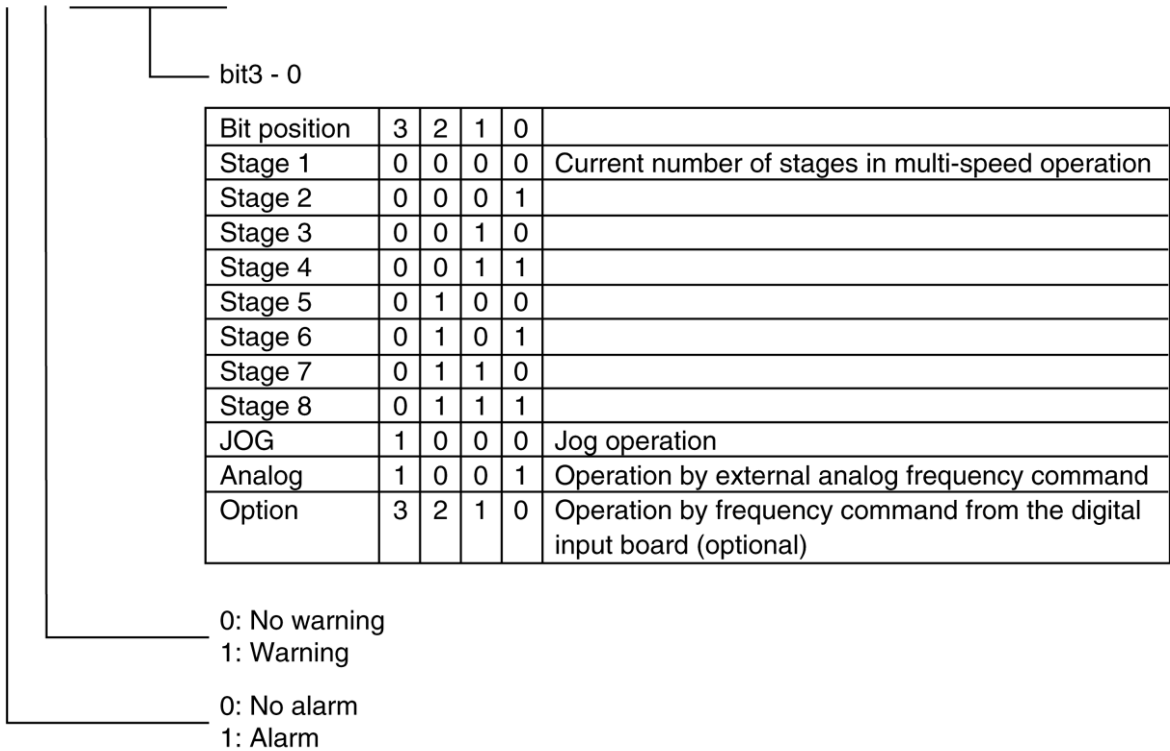
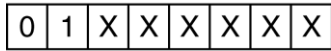
| OP-CD | Example of communication data (inverter number 1) | |
|-------|---|--|
| | Transmission from computer to inverter | Transmission from inverter to computer |
| O | <ul style="list-style-type: none"> Setting the output frequency Setting the output frequency to 55 Hz <div style="border: 1px solid black; display: inline-block; padding: 2px;">“@” 01H “O” 15H 7CH SUM</div> <ul style="list-style-type: none"> Set the frequency data by a multiple of 100. | <div style="border: 1px solid black; display: inline-block; padding: 2px;">“@” 01H “O” ST SUM</div> <ul style="list-style-type: none"> “ST” returns the contents of the error code. |
| P | <ul style="list-style-type: none"> Forward run command <div style="border: 1px solid black; display: inline-block; padding: 2px;">“@” 01H “P” SUM</div> | <div style="border: 1px solid black; display: inline-block; padding: 2px;">“@” 01H “P” ST SUM</div> <p style="margin-left: 20px;"> Command execution status 0: Normal termination 1: Abnormal termination or operation control not permitted</p> <p style="margin-left: 20px;"> Command repetition</p> |
| Q | <ul style="list-style-type: none"> Reverse run command <div style="border: 1px solid black; display: inline-block; padding: 2px;">“@” 01H “Q” SUM</div> | |
| R | <ul style="list-style-type: none"> Stop command <div style="border: 1px solid black; display: inline-block; padding: 2px;">“@” 01H “R” SUM</div> | |
| S | <ul style="list-style-type: none"> Alarm Reset command <div style="border: 1px solid black; display: inline-block; padding: 2px;">“@” 01H “S” SUM</div> | |

(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

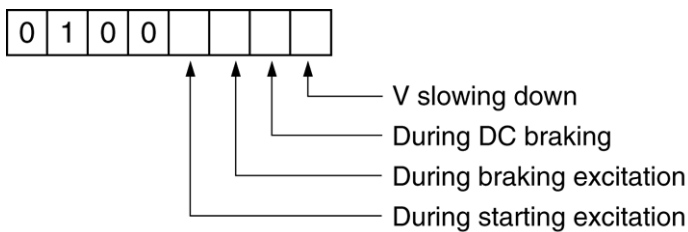
Operation Status 1 data is returned in one byte.



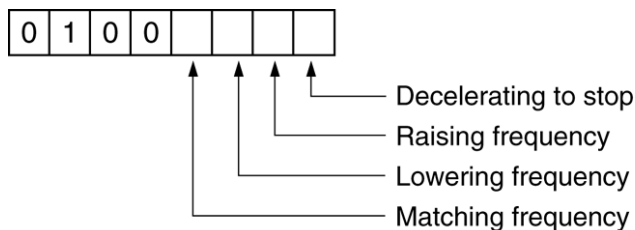
2) Operation Status 2

Operation Status 2 data is returned in four bytes.

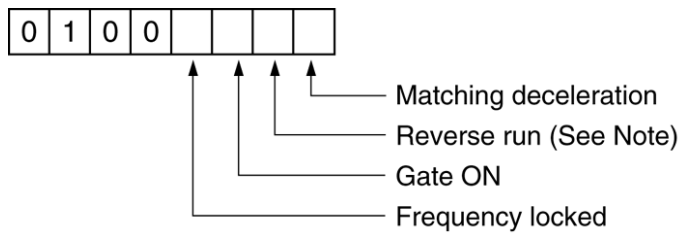
- Byte 1



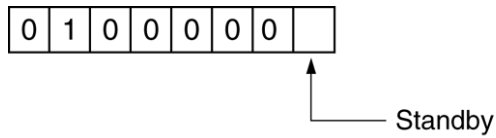
- Byte 2



- Byte 3



- Byte 4

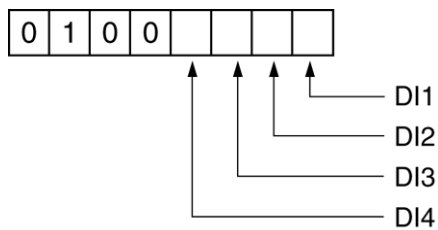


Note: The Reverse Run bit remains 1 even when the inverter stops after reverse run. If it is necessary to confirm forward or reverse run, also check the Gate ON bit status.

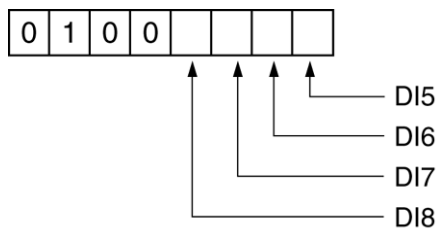
3) Control Terminal Board Input Status

Input status data is returned in four bytes.

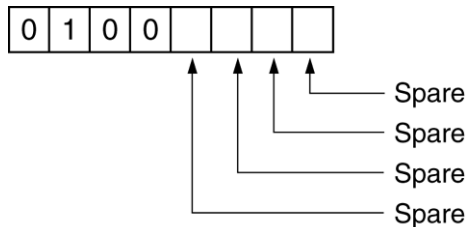
- Byte 1



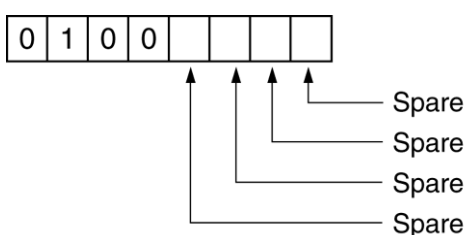
- Byte 2



- Byte 3



- Byte 4



(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 | OCA | 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

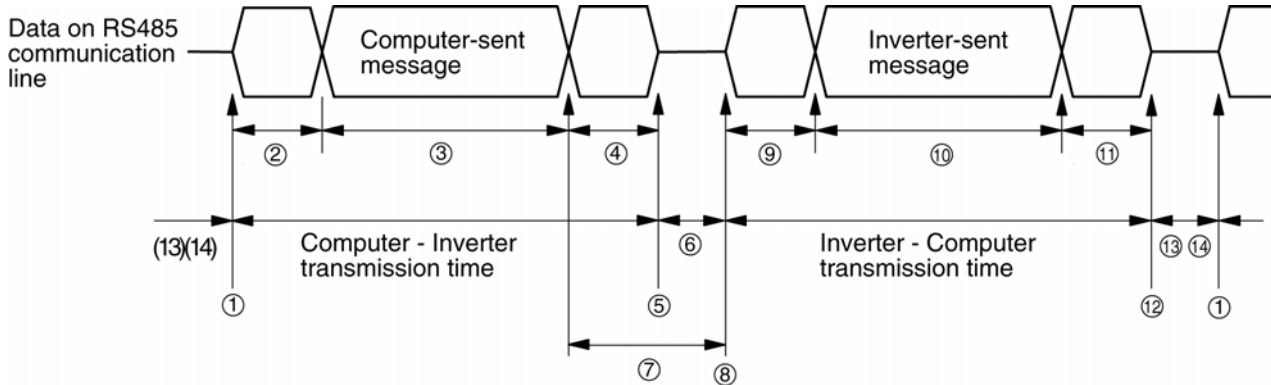
1) Basics

- 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 μ s 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 μ s 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.

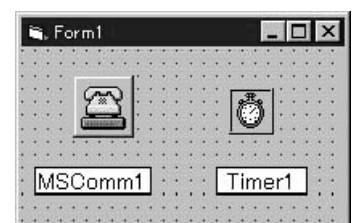
(8) Sample program

Example 1) N₈₈-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

    MsgBox "Received Data="& Msg   'Display received data

    MSComm1.PortOpen=False       'Close communication port
End
End Sub

Private Sub Timer1_Timer()       'Receive time out processing
    MsgBox "Communication Timeout"
End

```

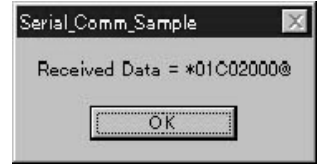
End Sub

'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 → | | | | | | | | | | | | | | | | |
|----------------|---|----------------|---------------------------|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F | |
| Lower 4 bits ↓ | 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 | l | | | | ヤ | シ | フ | ワ | | ● |
| | D | ^C R | ← | - | = | M |] | m | } | | | | ユ | ス | ヘ | ン | | ○ |
| | E | ^S O | ↑ | . | > | N | ^ | n | ~ | | | | ヨ | セ | ホ | ゝ | | ◊ |
| | 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 |
|-----------------|---|---|
| <i>Su</i> | Protection against overvoltage has been activated | Deceleration time too short |
| <i>Sc</i> | Current limiting during acceleration/deceleration | Acceleration (deceleration) time too short |
| <i>Scn</i> | Current limiting during constant power operation | Load too heavy Output frequency too high |
| <i>oL</i> | Overload warning | Load too heavy Inverter will stop unless an action is taken |
| <i>tH</i> | 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 (<i>oH</i>) (The abnormal radiator fin temperature differs depending upon the output frequency, output current and other factors) |
| <i>dboH</i> | Overheating of brake resistor | Brake resistor capacity too low. (%ED is small) Brake resistor stops to prevent heat damage. |
| <i>oPtEr</i> | Option error | Two mounted option boards are conflicting with each other. |
| <i>FbEr</i> | 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-segment 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 |
|--|---|
|  | 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.) |
|  | 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. |
|   Numeric keys   Decimal point keys | Keys valid in the Function Code Display mode |
|  | During alarm status, this key does nothing. |

Table 8.3 List of alarms

| Alarm display | Description | Check points | Actions |
|----------------|---|--|--|
| <i>AL 1</i> *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. |
| <i>AL 2</i> *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. |
| <i>AL 3</i> *1 | System abnormality | | |
| <i>AL 4</i> *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. |
| <i>AL 5</i> *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. |
| <i>AL 9</i> *2 | System abnormality | | |
| <i>AL 10</i> | System abnormality | Turn off the power so the CHARGE lamp turns off, turn the power on again and check the alarm. | Contact your supplier. |
| <i>ACEr</i> | Overload prevention alarm during acceleration | Current limit value: Setting for Cd043 too low? | Increase the set value. Increase acceleration and deceleration time. |
| <i>CnEr</i> | Overload prevention alarm during constant power operation | | |
| <i>dCEr</i> | Overload prevention alarm during deceleration | | |
| <i>ES</i> | External thermal alarm | Motor overheated? | Reduce the load. |
| <i>oH</i> | Fin temperature abnormality | Fan stopped? Ambient temperature too high? | Check fan operation. Increase the ventilation. |
| <i>LuA</i> | Undervoltage during acceleration | Does power supply satisfy conditions? Has the voltage dropped? Any phase failure? | Examine/improve power supply conditions. |
| <i>Lun</i> | Undervoltage during constant power operation | | |
| <i>Lud</i> | Undervoltage during deceleration | | |
| <i>oCH</i> | Main switching device temperature abnormality | Fan stopped? Ambient temperature too high? | Check fan operation. Increase the ventilation. |
| <i>oCA</i> *3 | Overcurrent during acceleration | Abrupt acceleration/deceleration rate? | Increase acceleration and deceleration time. |
| <i>oCn</i> *3 | Overcurrent during constant power operation | Output short-circuited or ground fault? | Correct the short-circuit or ground fault. |
| <i>oCd</i> *3 | Overcurrent during deceleration | Main switching device abnormality? | Contact your supplier. |
| <i>oCPA</i> | 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 |
|----------------|---|--|---|
| <i>oLPn</i> | 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. |
| <i>oLPd</i> | 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. |
| <i>oLR</i> | 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. |
| <i>oLn</i> | Overload during constant power operation | | |
| <i>oLd</i> | Overload during deceleration | | |
| <i>ouR</i> | Overvoltage during acceleration | Did start-up occur during free run? | Flying start. |
| <i>oun</i> | 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. |
| <i>oud</i> | Overvoltage during deceleration | Excessive deceleration? | Increase the deceleration time (so that GD ² of the load is met). |
| <i>ouP</i> | Brake resistor protection overvoltage | Braking frequency too high? | Reduce the braking frequency. Increase the brake resistor capacity. |
| <i>oPEn</i> | 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. |
| <i>GAL 1</i> | 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. |
| <i>PonG</i> *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

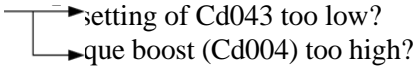
Table 8.4 List of protection operations

| 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. | <i>dbOH</i> |
| 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. | <i>AL Er</i> <i>dLEr</i> <i>LnEr</i> |
| 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. | <i>ES</i> |
| 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. | <i>AL 1</i> <i>AL 10</i> |

9. Troubleshooting

| Problem | Check Points | |
|---|--|--|
| Motor does not rotate | Main circuit | <ul style="list-style-type: none"> • Voltages at terminals R, S, T normal? • Is the motor wired correctly? |
| | Load | <ul style="list-style-type: none"> • Load too heavy? • Motor locked? |
| | Operation panel | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • Wrong wiring of output terminals U, V and W? • Is the wiring for forward and reverse run mixed up? | |
| Rotation speed does not increase | <ul style="list-style-type: none"> • Make sure that the upper frequency limit function (Cd007) is not activated. • Make sure that output current limiting function is not activated. <div style="display: inline-block; vertical-align: middle; margin-left: 10px;">  </div> • Load too heavy? | |
| Rotation is not constant | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • Acceleration/deceleration time too short? • Make sure that output current limiting function is not activated. • Load too heavy? | |
| Motor heating up | <ul style="list-style-type: none"> • Wrong setting for V/f pattern? • Torque boost too high? | |
| Rotation speed changes abnormally during operation | <ul style="list-style-type: none"> • Is the load fluctuating? • Make sure that output current limiting function is not activated. <ul style="list-style-type: none"> → 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 | <ul style="list-style-type: none"> · Ambient temperature, relative humidity · Confirm operating environment | <ul style="list-style-type: none"> · Visual inspection: · Use measuring instrument. · Use thermometer and hygrometer. | · Satisfy standard specifications. |
| | Power supply voltage | <ul style="list-style-type: none"> · Power supply voltage of the inverter is normal. | <ul style="list-style-type: none"> · Measure interphase voltage of R, S, T power input terminals. · Use tester and multimeter. | · Satisfy standard specifications of input. |
| | Appearance and structural parts | <ul style="list-style-type: none"> · There is no abnormal vibration or noise. · There is no loosening of bolts. · There is no deformations or breakage. · There is no adhesion of dust or dirt. | <ul style="list-style-type: none"> · Tighten bolts. · Visual inspection | · There is no abnormality. |
| Main circuit | General | <ul style="list-style-type: none"> · Megger check · There is no deformations or dirt. · There is no adhesion of dust or dirt. | <ul style="list-style-type: none"> · Tighten bolts. · Visual inspection | · There is no abnormality. |
| | Connection conductors and wires. | <ul style="list-style-type: none"> · There is no distortion or dirt on conductors · There is no discoloration because of overheating. | <ul style="list-style-type: none"> · Visual inspection | · There is no abnormality. |
| | Main module | <ul style="list-style-type: none"> · Check resistance between terminals. | <ul style="list-style-type: none"> · 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 | <ul style="list-style-type: none"> · There is no burning or breakage. | <ul style="list-style-type: none"> · Visual inspection | · There is no abnormality. |
| | Main electrolytic capacitor | <ul style="list-style-type: none"> · There is no liquid leaks. · There is no loosening of safety valves. · Measure electrical capacitance. | <ul style="list-style-type: none"> · Visual inspection · Measure with capacity meter | <ul style="list-style-type: none"> · There is no abnormality. · More than 85% of rated capacity. |
| | Relay magnetic contactor | <ul style="list-style-type: none"> · There is no chatter during operation. · There is no rough surface on the contact. · There is no abnormal noise when the switch is ON. | <ul style="list-style-type: none"> · Visual and hearing inspection | · There is no abnormality. |

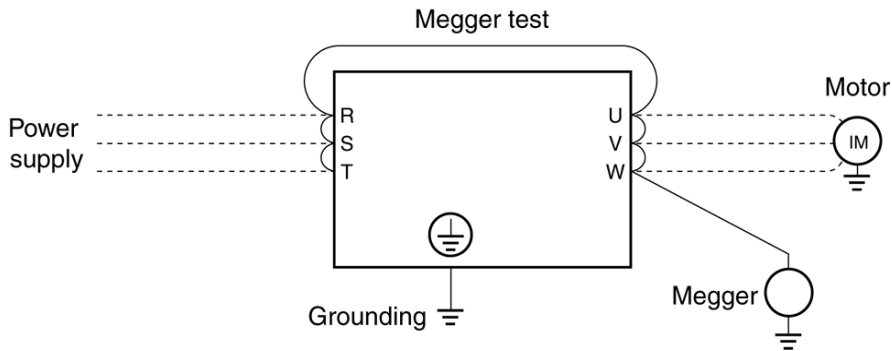
| Inspection item | | Inspection details | Method and measuring instrument | Criteria |
|-------------------------|-----------------------|--|--|---|
| Main circuit | Resistor | · Check if there is no disconnection. · There is no odors or cracks because of overheating. | · Odor and visual inspection · Remove one-side and check with tester. · Use tester and multimeter. | · There is no abnormality. · Less than $\pm 10\%$ 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 contamination or 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.



 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.

 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)

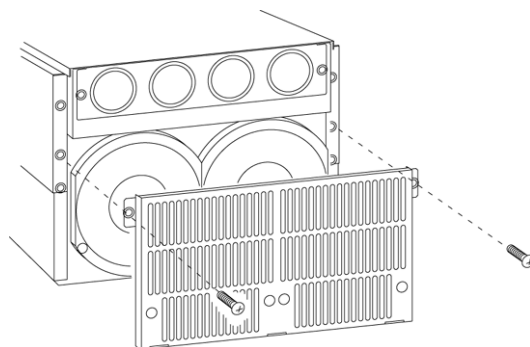
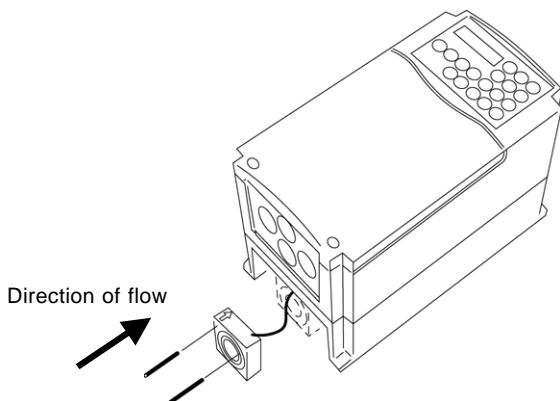


Figure 10.3
Connector position (small-capacity models)

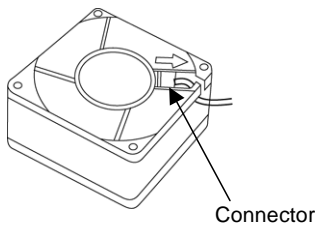


Figure 10.4
Connector position (7.5K class)

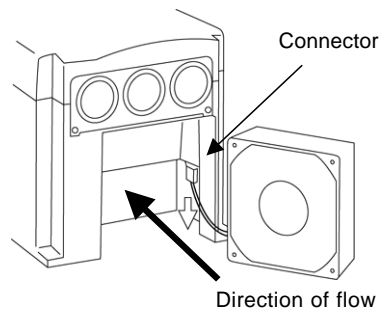
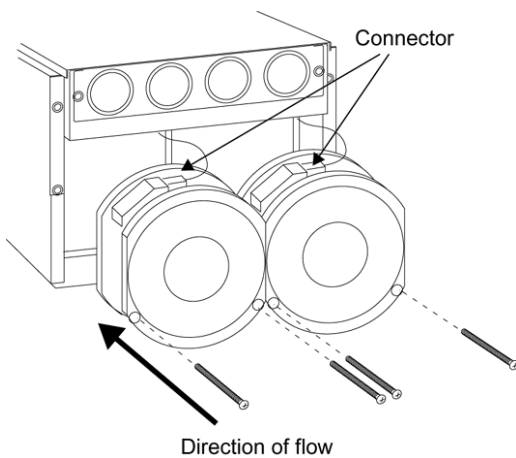


Figure 10.5
Connector position (55K class)



● 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 approximately 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:

$$\text{Power factor [\%]} = \frac{\text{Power [kW]}}{\sqrt{3} \times \text{Voltage [V]} \times \text{Current [A]}} \times 100$$

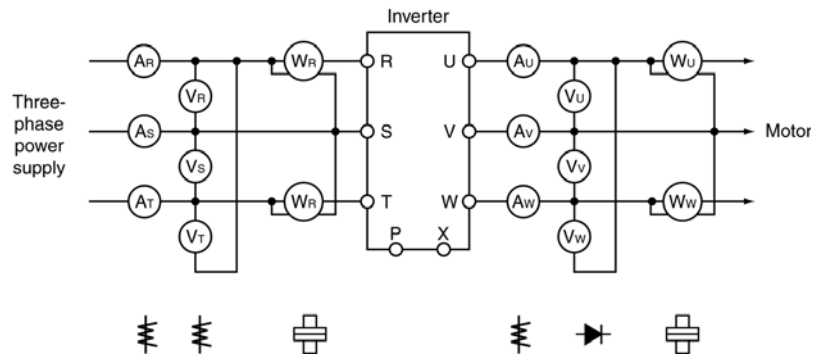








Table 10.3 Main circuit measuring instruments

| Symbol | Measuring points | Measuring instruments |
|---|---------------------------|--|
|  | Power supply voltage | Moving-iron type AC voltmeter |
|  | Power supply current | Moving-iron type AC ammeter |
|  | 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.) |
|  | Output voltage | Rectifier type AC voltmeter or digital power meter |
|  | Output current | Moving-iron type AC ammeter or digital power meter |
|  | 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 | | | |
|------------------------------|------------------------------|--|---|--------------------|--------|---------------|--------|---------------|--------|---------------|---------|--------------|---------|-------------|---------|---------------|---------|---------------|---------|-------------|---------|---------|--|
| Output | Load (*1) | H | P | H | P | H | P | H | P | H | P | H | P | H | P | H | P | H | P | H | P | | |
| | 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 | 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 | 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 | 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 | 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: $\pm 10\%$ Frequency: $\pm 5\%$ 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) | | | | | | | | | | | | | | | | | | | | |
| | | 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) | | | | | | | | | | | | | | | | | | | | |
| | | 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 | $\pm 0.01\%$ of the output frequency (at -10 to +40°C) | | | | | | | | | | | | | | | | | | | | |
| | | Analog setting | $\pm 0.2\%$ of the maximum output frequency (at 25 $\pm 10^\circ\text{C}$) (*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 | | | | | | | | | | | | | | | | | | | | |
| | | Analog setting | 2 channels, 0 to 5 V, 0 to 10 V, 4 to 20 mA, variable resistor (5 k Ω , 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) | | | | | | | | | | | | | | | | | | | | |
| | | 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) | | | | | | | | | | | | | | | | | | | | |
| | | 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) | | | | | | | | |
| | | 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) | | | | | | | | |
| | | 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 | | | | | | | | |
| | | 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) | | | | | | | | |
| | | 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 output 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) | | |
| | | 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) | | |
| | | 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 | | |
| | | 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) | | |
| | | 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, fan 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 output 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.

400V system: SPF

| 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) | | | | | | | | |
| | | 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) | | | | | | | | |
| | | 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 | | | | | | | | |
| | | 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) | | | | | | | | |
| | | 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 output 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

| Model | | SPF-37K | SPF-45K | SPF-55K |
|------------------------------|------------------------------|--|---|---------|
| Output | Applicable motor capacity | 37kW | 45kW | 55kW |
| | Rated capacity (*1) | 51.3kVA | 62.4kVA | 76.2kVA |
| | Rated current (*2) | 74A | 90A | 110A |
| | 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 (*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 |
| 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) | |
| | | 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) | |
| | | 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 | |
| | | 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) | |
| | | 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, fan 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 | |
| | 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 output 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.

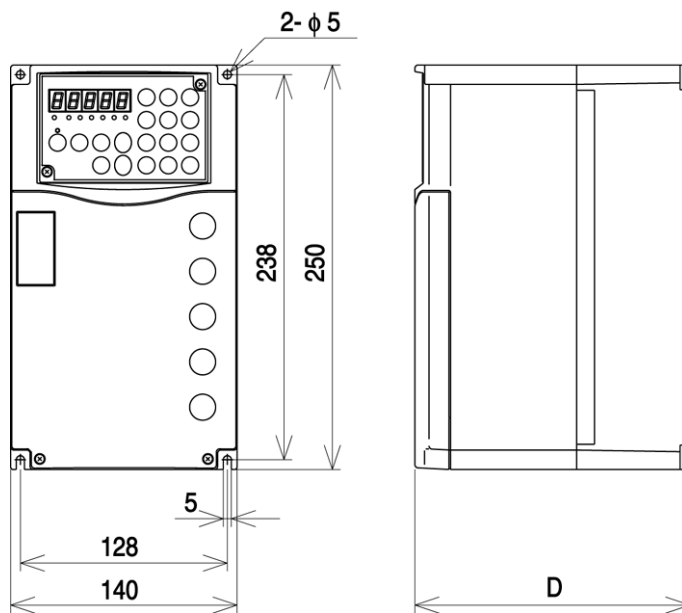
*7 For SPF-45K and SPF-55K, a tap (TAP1 or TAP2) must be switched according to variable input ranges. Refer to section 4.2 Terminal Connection Diagrams for details.

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

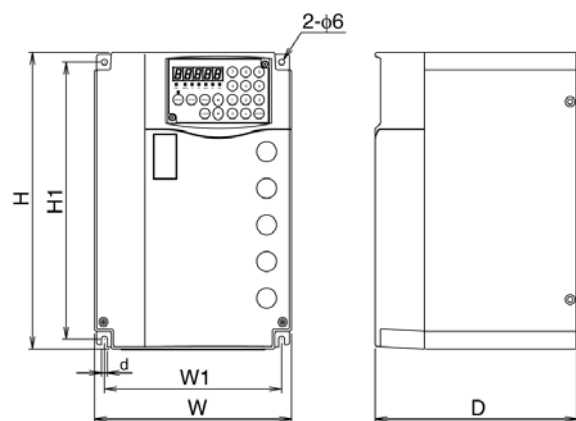
- (1) SBT-0.75K/1.5K - SBT-3.7K/5.5K
 SHF-1.5K - SHF-4.0K
 SPF-2.2K - SPF-5.5K



| 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)

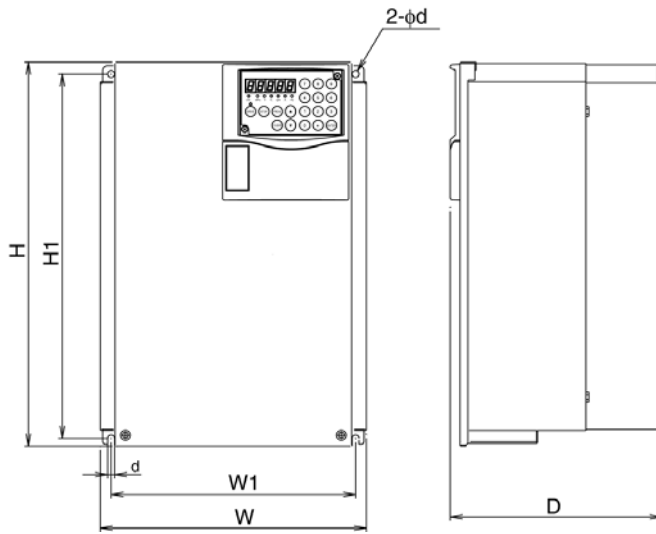
- (2) SBT-5.5K/7.5K - SBT-15K/18.5K
 SHF-5.5K - SHF-15K
 SPF-7.5K - SPF-18.5K



| 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)

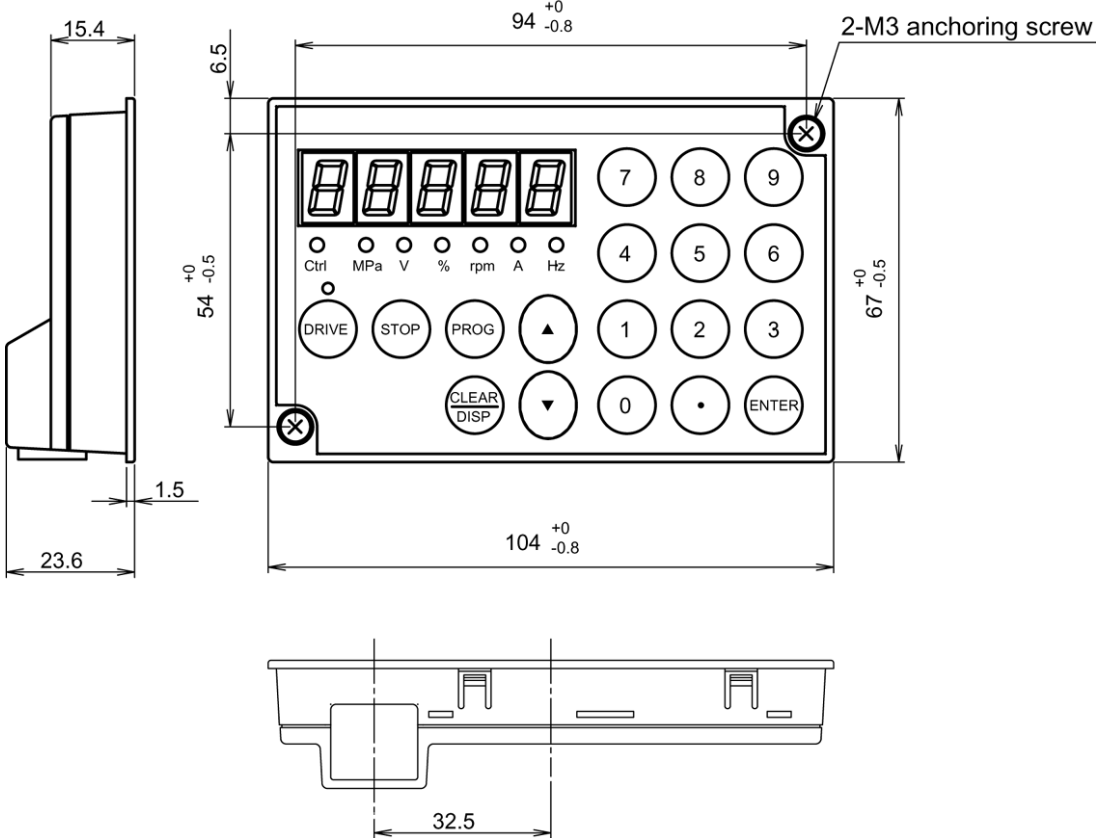
- (3) SBT-18.5K/22K - SBT-22K/30K
 SHF-18.5K - SHF-55K
 SPF-22K - SPF-55K



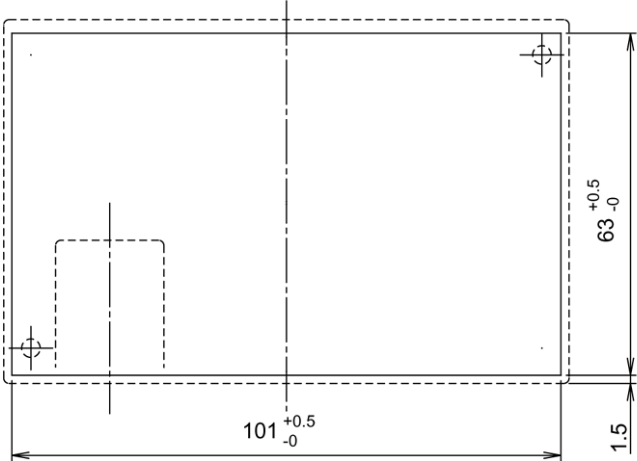
| Model | H | H1 | W | W1 | D | d |
|------------------------------|-----|-----|-----|-----|------------|---|
| SBT-18.5K/22K SBT-22K/30K | 390 | 370 | 270 | 248 | 215 240 | 7 |
| SHF-18.5K SHF-22K | 390 | 370 | 270 | 248 | 215 240 | 7 |
| SHF-30K SHF-37K | 440 | 420 | 340 | 318 | 240 | 7 |
| SHF-45K SHF-55K | 550 | 530 | 340 | 318 | 260 | 7 |
| SPF-22K SPF-30K | 390 | 370 | 270 | 248 | 215 240 | 7 |
| SPF-37K SPF-45K | 440 | 420 | 340 | 318 | 240 | 7 |
| 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 | FMTF | 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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