ADVANCED AND EVER ADVANCING **MITSUBISHI ELECTRIC**

MITSUBISHI

TRANSISTORIZED INVERTER

FR-A500
E500

FR-A500/E500 series

TECHNICAL MANUAL

INTRODUCTION

1. SCOPE

This Technical Manual describes the Mitsubishi FR-A500 and FR-E500 (Japanese domestic version) Series Transistorized Inverters. The FR-E520(S)-0.1K to 3.7K described in this manual have the specifications corresponding to those of the products of the following serial numbers (SERIAL) and later. Please note that the inverters having the serial numbers before those given below should be handled differently.

Type	SERIAL (Serial Number)
FR-E520(S)-0.1K to 0.4K(C)	A86○○○○○○
FR-E520(S)-0.75K(C)	A86○○○○○○
FR-E520-1.5K, 2.2K(C)	A86○○○○○○
FR-E520-3.7K(C)	A86○○○○○○

A 8 6 ○○○○○○
Symbol Year Month Control number
Serial number
As indicated above, SERIAL consists of 1 symbol character and 8 serial number characters.

2. MODEL-TYPE CORRESPONDENCES

The models (series) and the inverter types indicated above correspond to each other as listed below:

Inverter Series	Symbol	Inverter Type
FR-A500 series	A500	FR-A520-○○K FR-A540-○○K
FR-E500 series	E500	FR-E520-○○K FR-E520S-○○K
All of above two series	COMMON	All of above four types

3. HOW TO IDENTIFY THE CORRESPONDING MODELS

The symbol following the title denotes the model (series) corresponding to that item or the model (series) having that function. (For correspondences, refer to the above table.)

[Example]
- 1.6.29 5-point flexible V/F characteristic [Pr. 71, 100 to 109] A500
  Corresponds to the FR-A500 series.
  It does not correspond to the FR-E500 series.
- 1.6.7 Output frequency range COMMON
  Corresponds to both the FR-A500 and FR-E500 series.

4. SAFETY INSTRUCTIONS

- To ensure correct and safe operation, always read the "Instruction Manual" before using the equipment.
- The Mitsubishi transistorized inverters are not designed or manufactured for use with any equipment or system that will be used under life-endangering conditions.
  Please contact your Mitsubishi sales representative if you are considering the use of any of the products given in this manual with any equipment, system etc. designed for passenger, mobile, medical, aerospace, nuclear energy, power or undersea purposes.
- This product has been manufactured under strict quality control.
  However, when using it with important equipment which will endanger life or any equipment that is expected to give rise to serious loss due to an inverter failure, install safety devices to prevent serious accidents.
- Do not use this equipment with any loads other than three-phase induction motors.

5. MISCELLANEOUS

- Pr. used in the manual is the abbreviation of a parameter and a numeral following that indicates a function number.

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1 SPECIFICATIONS

1.1 Specification List

1.1.1 Ratings

(1) FR-A500

■ 200V class

Applicable motor capacity (Note 1)	kW			0.4	0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5	22	30	37	45	55
	HP		CT	0.5	1	2	3	5	7.5	10	15	20	25	30	40	50	60	75
			VT	1	1.5	3	3	5	10	10	20	25	30	40	50	60	75	100
Output	Rated capacity (kVA) (Note 2)		CT	1.1	1.9	3.1	4.2	6.7	9.2	12.6	17.6	23.3	29	34	44	55	67	82
			VT	1.3	1.9	3.7	4.6	7.1	10.7	14.1	20.7	25.9	30.5	39.2	49.7	58.4	70.8	94.6
	Continuous current (A)		CT	3	5	8	11	17	24	33	46	61	76	90	115	145	175	215
			VT	3.6	5	9.6	12	18	28	37	54	68	80	104	130	154	185	248
	Overl/oad capacity (Note 3)		CT	150% 60 seconds, 200% 0.5 seconds (inverse-time characteristics)														
			VT	120% 60 seconds, 150% 0.5 seconds (inverse-time characteristics)														
	Voltage (Note 4)			Three phase, 200V to 220V 50Hz, 200 to 240V 60Hz											Three phase, 200V to 220V 50Hz, 200 to 230V 60Hz			
	Regen-erative braking torque	Maximum value/time		150% 5 seconds			100% 5 seconds				20% (Note 5)							
		Permissible duty		3%ED					2%ED		Continuous (Note 5)							
Power supply	Rated input AC voltage, frequency			Three phase, 200V to 220V 50Hz, 200 to 240V 60Hz											Three phase, 200V to 220V 50Hz, 200 to 230V 60Hz			
	Permissible AC voltage fluctuation			170 to 242V 50Hz, 170 to 264V 60Hz											170 to 242V 50Hz, 170 to 253V 60Hz			
	Permissible frequency fluctuation			±5%														
	Instantaneous voltage drop immunity			Operation continues at 165V or higher. Operation continues 15ms if voltage drops from rated value to less than 165V.														
	Power supply system capacity (kVA) (Note 6)			1.5	2.5	4.5	5.5	9	12	17	20	28	34	41	52	66	80	100
Protective structure (JEM 1030)				Enclosed type (IP20 NEMA1) (Note 7)											Open type (IP00)			
Cooling system				Self-cooling	Forced air cooling													
Approx. weight (kg (lbs)), with DU				2.0 (4.4)	2.5 (5.51)	3.5 (7.72)	3.5 (7.72)	3.5 (7.72)	6.0 (13.23)	6.0 (13.23)	8.0 (17.64)	13.0 (28.66)	13.0 (28.66)	13.0 (28.66)	30.0 (66.14)	40.0 (88.18)	40.0 (88.18)	55.0 (121.25)

Note:
1. The applicable motor capacity indicated is the maximum capacity applicable when Mitsubishi 4-pole standard motor is used.
2. The rated output capacity indicated assumes that the output voltage is 220V for 200V class and 440V for 400V class.
3. The overload capacity indicated in % is the ratio of the overload current to the inverter's rated current. For repeated duty, allow time for the inverter and motor to return to or below the temperatures under 100% load.
4. The maximum output voltage cannot exceed the power supply voltage. The maximum output voltage may be set as desired below the power supply voltage.
5. The torque indicated is the average value for deceleration from 60Hz to a stop and varies with motor loss.
6. The power supply capacity changes with the values of the power supply side inverter impedances (including those of the input reactor and cables).
7. The open type (IP00) is used when the inboard option is fitted after removal of the option wiring port cover.

■ 400V class

Applicable motor capacity (Note 1)		kW		0.4	0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5	22	30	37	45	55
		HP	CT	0.5	1	2	3	5	7.5	10	15	20	25	30	40	50	60	75
			VT	1	1.5	3	3	5	10	15	20	25	30	40	50	60	75	100
Output	Rated capacity (kVA) (Note 2)		CT	1.1	1.9	3	4.2	6.9	9.1	13	17.5	23.6	29	32.8	43.4	54	65	84
			VT	1.3	2.3	3.6	4.7	6.9	10.6	16.0	20.5	25.9	30.5	39.7	49.5	58.6	72.6	94.7
	Continuous current (A)		CT	1.5	2.5	4	6	9	12	17	23	31	38	43	57	71	86	110
			VT	1.8	3	4.8	6.7	9	14	21	27	34	40	52	65	77	96	124
	Overload capacity (Note 3)		CT	150% 60 seconds, 200% 0.5 seconds (inverse-time characteristics)														
			VT	120% 60 seconds, 150% 0.5 seconds (inverse-time characteristics)														
	Voltage (Note 4)			Three phase, 380V to 480V 50Hz/60Hz														
	Regenerative braking torque	Maximum value/time		100% 5 seconds							20 (Note 5)							
		Permissible duty		2ED							Continuous (Note 5)							
Power supply	Rated input AC voltage, frequency			Three phase, 380V to 480V 50Hz/60Hz														
	Permissible AC voltage fluctuation			323 to 528V 50Hz/60Hz														
	Permissible frequency fluctuation			±5%														
	Power supply system capacity (kVA) (Note 6)			1.5	2.5	4.5	5.5	9	12	17	20	28	34	41	52	66	80	100
Protective structure (JEM 1030)				Enclosed type (IP20 NEMA1) (Note 7)											Open type (IP00)			
Cooling system				Self-cooling			Forced air cooling											
Approx. weight (kg (lbs)) With DU				3.5 (7.72)	3.5 (7.72)	3.5 (7.72)	3.5 (7.72)	3.5 (7.72)	6.0 (13.23)	6.0 (13.23)	13.0 (28.66)	13.0 (28.66)	13.0 (28.66)	13.0 (28.66)	24.0 (52.91)	35.0 (77.16)	35.0 (77.16)	36.0 (79.37)

Note: 1. The applicable motor capacity indicated is the maximum capacity applicable when Mitsubishi 4-pole standard motor is used.
2. The rated output capacity indicated assumes that the output voltage is 220V for 200V class and 440V for 400V class.
3. The overload capacity indicated in % is the ratio of the overload current to the inverter's rated current. For repeated duty, allow time for the inverter and motor to return to or below the temperatures under 100% load.
4. The maximum output voltage cannot exceed the power supply voltage. The maximum output voltage may be set as desired below the power supply voltage.
5. The torque indicated is the average value for deceleration from 60Hz to a stop and varies with motor loss.
6. The power supply capacity changes with the values of the power supply side inverter impedances (including those of the input reactor and cables).
7. The open type (IP00) is used when the inboard option is fitted after removal of the option wiring port cover.

(2) FR-E500

■ 3-phase 200V power supply

	Type FR-E520- □K (C) (Note 8)	0.1K	0.2K	0.4K	0.75K	1.5K	2.2K	3.7K	5.5K	7.5K
Applicable motor capacity(kW) (Note 1)		0.1	0.2	0.4	0.75	1.5	2.2	3.7	5.5	7.5
Output	Rated capacity (kVA) (Note 2)	0.3	0.6	1.2	2.0	3.2	4.4	7.0	9.5	13.1
	Rated current (A) (Note 6)	0.8 (0.8)	1.5 (1.4)	3 (2.5)	5 (4.1)	8 (7)	11 (10)	17.5 (16.5)	24 (23)	33 (31)
	Overload capacity (Note 3)	150% 60 seconds 200% 0.5 seconds (inverse-time characteristics)								
	Voltage (Note 4)	Three phase, 200V to 240V 50Hz/60Hz (280VDC, Note 7)								
Power supply	Rated input AC (DC) voltage, frequency	Three phase, 200V to 240V 50Hz/60Hz (252 to 310VDC, Note 7)								
	Permissible AC (DC) voltage fluctuation	170 to 264V 50Hz/60Hz								
	Permissible frequency fluctuation	±5								
	Power supply system capacity (kVA) (Note 5)	0.4	0.8	1.5	2.5	4.5	5.5	9	12	17
Protective structure (JEM1030)		Enclosed type (IP20), IP40 for dirt-protection structure series								
Cooling system		Self-cooling			Forced air cooling					
Approximate weight (kg)		0.6	0.6	0.8	1.0	1.7	1.7	2.2	4.4	4.9

■ Single-phase 200V power supply

	Type FR-E520S- □ K	0.1K	0.2K	0.4K	0.75K
Applicable motor capacity(kW) (Note 1)		0.1	0.2	0.4	0.75
Output	Rated capacity (kVA) (Note 2)	0.3	0.6	1.2	2.0
	Rated output current (A) (Note 6)	0.8(0.8)	1.5(1.4)	3.0(2.5)	5.0(4.1)
	Overload capacity (Note 3)	150% 60 seconds 200% 0.5 seconds (inverse-time characteristics)			
	Rated output voltage (Note 4)	Three phase, 200V to 240V 50Hz/60Hz			
Power supply	Rated input AC voltage, frequency	Single phase, 200V to 240V 50Hz/60Hz			
	Permissible AC voltage fluctuation	Single phase, 180 to 264V 50Hz/60Hz			
	Permissible frequency fluctuation	Within ±5%			
	Power supply capacity (kVA)	0.5	0.9	1.5	2.5
Protective structure (JEM1030)		Enclosed type (IP20)			
Cooling system		Self-cooling			Forced air cooling
Approximate weight (kg)		0.6	0.6	1.0	1.7

Note:
1. The applicable motor capacity indicated is the maximum capacity applicable when a Mitsubishi 4-pole standard motor is used. Normally, the rated current (at 50Hz) of the motor applied should not exceed the rated current.
2. The rated output capacity indicated assumes that the output voltage is 230V for 200V class and single-phase 200V class.
3. The overload capacity indicated in % is the ratio of the overload current to the inverter's rated current. For repeated duty, allow time for the inverter and motor to return to or below the temperatures under 100% load.
4. The maximum output voltage does not exceed the power supply voltage. The maximum output voltage may be set as desired below the power supply voltage. Use the power supply capacity larger than the indicated.
5. The power supply capacity changes with the values of the power supply side inverter impedances (including those of the input reactor and cables).
6. The rated output current in the parentheses applies when low acoustic noise operation is to be performed at the ambient temperature higher than 40°C (30°C for the dirt-protection structure) with the Pr. 72 (PWM frequency selection) value set to 2kHz or higher.
7. When using a DC power supply
    (1) The guideline for the power supply voltage fluctuation range is 280VDC ±10%, but usually use the power supply at or below 300VDC.
    (2) When DC power is switched on, a larger inrush current flows than in AC power. The number of power-on times should be minimized.
    (3) 300VDC must be reserved to make the torque characteristic equal to when an AC power supply is used.
8. The type code of the dirt-protection structure series ends with C.

1.1.2 Common specifications

(1) FR-A500

Item			Description
Control specifications	Control system		Soft-PWM control/high carrier frequency PWM control (V/F control or advanced magnetic flux vector control can be selected)
	Output frequency range		0.2 to 400Hz
	Frequency setting resolution	Analog input	0.015Hz/60Hz (terminal 2 input: 12 bits/0 to 10V, 11 bits/0 to 5V, terminal 1 input: 12 bits/−10V to +10V, 11bits/−5 to +5V)
		Digital input	0.01Hz
	Frequency accuracy	Analog input	Within ±0.2% of maximum output frequency (25°C ±10°C) (77°F±18°F) for analog input
		Digital input	Within 0.01% of set output frequency for digital input
	Voltage/frequency characteristic		Base frequency set as required between 0 and 400Hz. Constant torque or variable torque pattern can be selected.
	Starting torque		150%: At 0.5Hz (for advanced magnetic flux vector control)
	Torque boost		Manual torque boost
	Acceleration/deceleration time setting		0 to 3600 s (acceleration and deceleration can be set individually), linear or S-pattern acceleration/deceleration mode can be selected.
	DC dynamic brake		Operation frequency (0 to 120Hz), operation time (0 to 10 s), voltage (0 to 30%) variable
	Stall prevention operation level		Operation current level can be set (0 to 200% variable), presence or absence can be selected.
Operational specifications	Frequency setting signal	Analog input	0 to 5VDC, 0 to 10VDC, 0 to ±10VDC, 4 to 20mADC
		Digital input	3-digit BCD or 12-bit binary using operation panel or parameter unit (when the FR-A5AX option is used)
	Input signals	Start signal	Forward and reverse rotation, start signal automatic self-holding input (3-wire input) can be selected.
		Multi-speed selection	Up to 15 speeds can be selected. (Each speed can be set between 0 and 400Hz, running speed can be changed during operation from the PU (FR-DU04/FR-PU04).)
		Second, third acceleration/deceleration time selection	0 to 3600 seconds (up to three different accelerations and decelerations can be set individually.)
		Jog operation selection	Provided with jog operation mode select terminal (Note 1)
		Current input selection	Input of frequency setting signal 4 to 20mADC (terminal 4) is selected.
		Output stop	Instantaneous shut-off of inverter output (frequency, voltage)
		Alarm reset	Alarm retained at the activation of protective function is reset.
	Operation functions		Maximum/minimum frequency setting, frequency jump operation, external thermal relay input selection, polarity reversible operation, automatic restart operation after instantaneous power failure, commercial power supply-inverter switch-over operation, forward/reverse rotation prevention, slip compensation, operation mode selection, offline auto tuning function, online auto tuning function, PID control, programmed operation, computer link operation (RS-485)
	Output signals	Operating status	5 different signals can be selected from inverter running, up to frequency, instantaneous power failure (undervoltage), frequency detection, second frequency detection, third frequency detection, during program mode operation, during PU operation, overload alarm, regenerative brake pre-alarm, electronic overcurrent protection pre-alarm, zero current detection, output current detection, PID lower limit, PID upper limit, PID forward/reverse rotation, commercial power supply-inverter switch-over MC1, 2, 3, operation ready, brake release request, fan fault and fin overheat pre-alarm minor fault. Open collector output, light fault.
		Alarm (inverter trip)	Contact output...change-over contact (230VAC 0.3A, 30VDC 0.3A) Open collector...alarm code (4 bit) output
		For meter	1 signal can be selected from output frequency, motor current (steady or peak value), output voltage, frequency setting, running speed, motor torque, converter output voltage (steady or peak value), regenerative brake duty, electronic overcurrent protection load factor, input power, output power, load meter, and motor exciting current. Pulse train output (1440 pulses/sec./full scale) and analog output (0 to 10VDC).

Item			Description
Display	Operation panel or parameter unit	Operating status	Selection can be made from output frequency, motor current (steady or peak value), output voltage, frequency setting, running speed, motor torque, overload, converter output voltage (steady or peak value), electronic overcurrent protection load factor, input power, output power, load meter, motor exciting current, cumulative energization time, actual operation time, watt-hour meter, regenerative brake duty and motor load factor.
		Alarm definition	Alarm definition is displayed when protective function is activated. 8 alarm definitions are stored. (Four alarm definitions are only displayed on the operation panel.)
	Additional display on parameter unit only	Operating status	Input terminal signal states, output terminal signal states, option fitting status, terminal assignment status
		Alarm definition	Output voltage/current/frequency/cumulative energization time immediately before protective function is activated
		Interactive guidance	Operation guide and troubleshooting by help function
Protective/alarm functions			Overcurrent shut-off (during acceleration, deceleration, constant speed), regenerative overvoltage shut-off, undervoltage, instantaneous power failure, overload shut-off (electronic overcurrent protection), brake transistor alarm (Note 2), ground fault current, output short circuit, main circuit device overheat, stall prevention, overload alarm, brake resistor overheat protection, fin overheat, fan fault, option fault, parameter error, PU disconnection
Environment	Ambient temperature		Constant torque: −10°C to +50°C (non-freezing) (−10°C to +40°C with FR-A5CV□□ attachment) Variable torque: −10°C to +40°C (non-freezing) (−10°C to +30°C with FR-A5CV□□ attachment)
	Ambient humidity		90%RH or less (non-condensing)
	Storage temperature (Note 3)		−20°C to +65°C (−4°F to +149°F)
	Ambience		Indoors. (No corrosive and flammable gases, oil mist, dust and dirt.)
	Altitude, vibration		Maximum 1000m (3280.80 feet) above sea level for standard operation. After that derate by 3% for every extra 500m up to 2500m (91%).

Note:
1. Jog operation may also be performed from the operation panel or parameter unit.
2. Not provided for the FR-A520-11K to 55K and FR-A540-11K to 55K which do not have a built-in brake circuit.
3. Temperature applicable for a short period in transit, etc.

(2) FR-E500

Item				Description	
Control specifications	Control system			Soft-PWM control/high carrier frequency PWM control can be selected. V/F control or general-purpose magnetic flux vector control can be selected.	
	Output frequency range			0.2 to 400Hz (starting frequency variable between 0 and 60Hz)	
	Frequency setting resolution		Analog input	Across terminals 2-5: 1/500 of maximum set frequency (5VDC input), 1/1000 (10VDC, 4-20mADC input)	
			Digital input	0.01Hz (less than 100Hz), 0.1Hz (100Hz or more) when digital setting is made using the control panel	
	Frequency accuracy		Analog input	Within ±0.5% of maximum output frequency (25°C ±10°C)	
			Digital input	Within 0.01% of set output frequency when setting is made from control panel.	
	Voltage/frequency characteristic			Base frequency set as required between 0 and 400Hz. Constant torque or variable torque pattern can be selected.	
	Starting torque			150% or more (at 1Hz), 200% or more (at 3Hz) when general-purpose magnetic flux vector control or slip compensation is selected.	
	Torque boost			Manual torque boost, 0 to 30% may be set.	
	Acceleration/deceleration time setting			0.01, 0.1 to 3600 s (acceleration and deceleration can be set individually), linear or S-pattern acceleration/deceleration mode can be selected.	
	Braking torque		Regenerative (Note 3)	0.1K, 0.2K… 150% or more, 0.4K, 0.75K… 100% or more, 1.5K… 50% or more, 2.2K, 3.7K… 20% or more	
			DC dynamic brake	Operation frequency (0 to 120Hz), operation time (0 to 10 s), operation voltage (0 to 30%) variable	
	Current stall prevention operation level			Operation current level can be set (0 to 200% variable), presence or absence can be selected.	
	Voltage stall prevention operation level			Operation level is fixed, presence or absence can be selected.	
	Fast-response current limit level			Operation level is fixed, presence or absence can be selected.	
	Input signals	Frequency setting signal	Analog input	0 to 5VDC, 0 to 10VDC, 4 to 20mADC, built-in frequency setting potentiometer.	
			Digital input	Entered from control panel.	
		Start signal		Forward and reverse rotation, start signal automatic self-holding input (3-wire input) can be selected.	
		Alarm reset		Used to reset alarm output provided when protective function is activated.	Use Pr. 180 to Pr. 183 for selection
		Multi-speed selection		Up to 15 speeds can be selected. (Each speed can be set between 0 and 400Hz, running speed can be changed during operation from the control panel.)	
		Current input selection		Used to select input of frequency setting signal 4 to 20mADC (terminal 4).	
		Output stop		Instantaneous shut-off of inverter output (frequency, voltage).	
		Second function selection		Used to select second functions (acceleration time, deceleration time, torque boost, base frequency, electronic overcurrent protection).	
		Start signal automatic self-holding selection		Used to select start signal automatic self-holding input. (3-wire input)	
		External thermal relay input		Thermal relay contact input for use when the inverter is stopped by the external relay.	
		PU operation-external operation switching		Used to switch between PU operation and external operation from outside the inverter.	
		V/F-general-purpose magnetic flux switching		Used to switch between V/F control and general-purpose magnetic flux vector control from outside the inverter.	
	Operation functions			Maximum/minimum frequency setting, frequency jump operation, external thermal relay input selection, automatic restart operation after instantaneous power failure, forward/reverse rotation prevention, slip compensation, operation mode selection, offline auto tuning function, PID control, computer link operation (RS-485)	
	Output signals	Operating status		2 open collector output signals can be selected from inverter running, up to frequency, frequency detection, overload alarm, zero current detection, output current detection, PID upper limit, PID lower limit, PID forward/reverse rotation, operation ready, minor fault and alarm, and 1 contact output (230VAC 0.3A, 30VDC 0.3A) can be selected.	
		For meter		1 signal can be selected from output frequency, motor current and output voltage. Pulse train output (1440 pulses/second/full scale).	
Display	Control panel display		Operating status	Output voltage, output current, set frequency, running.	
			Alarm definition	Alarm definition is displayed when protective function is activated. 4 alarm definitions are stored.	
	LED display			Power application (POWER)	

Item		Description
Protective/alarm functions		Overcurrent shut-off (during acceleration, deceleration, constant speed), regenerative overvoltage shut-off, undervoltage (Note 1), instantaneous power failure (Note 1), overload shut-off (electronic overcurrent protection), brake transistor alarm, output short circuit, stall prevention, brake resistor overheat protection, fin overheat, fan failure, parameter error, PU disconnection.
Environment	Ambient temperature	Constant torque : −10°C to +50°C (non-freezing) Variable torque : −10°C to +40°C (non-freezing)
	Ambient humidity	90%RH or less (non-condensing)
	Storage temperature (Note 2)	−20°C to +65°C
	Ambience	Indoors, no corrosive and flammable gases, oil mist, dust and dirt.
	Altitude, vibration	Maximum 1000m above sea level for standard operation. After that derate by 3% for every extra 500m up to 2500m (91%).

Note:
1. When undervoltage or instantaneous power failure has occurred, alarm display or alarm output is not provided but the inverter itself is protected. Overcurrent, regenerative overvoltage or other protection may be activated at power restoration according to the operating status (load size, etc.)
2. Temperature applicable for a short period in transit, etc.
3. The braking torque indicated is a short-duration average torque (which varies with motor loss) when the motor alone is decelerated from 60Hz in the shortest time and is not a continuous regenerative torque. When the motor is decelerated from the frequency higher than the base frequency, the average deceleration torque will reduce. Since the inverter does not contain a brake resistor, use the optional brake resistor when regenerative energy is large. (The optional brake resistor cannot be used with 0.1K and 0.2K.) A brake unit (BU) may also be used.
4. Not provided for the FR-E520(S) -0.1K to 0.4K which are not equipped with a cooling fan.

1.2 Specification comparison list

1.2.1 Specification comparison list

The following table compares characteristic specifications between the FR-A500/FR-E500 series and conventional inverter series:

Item		FR-A500	FR-A200
Capacity range	Single-phase 100V	—	—
	Single-phase 200V	—	—
	Three-phase 200V	0.4K to 55K (15 models)	0.4K to 55K (15 models)
	Three-phase 400V	0.4K to 55K (15 models)	0.4K to 55K (15 models)
Control system	Switching system	Soft-PWM control High carrier frequency sine-wave PWM	High carrier frequency sine-wave PWM
	Control mode	Advanced magnetic flux vector control V/F control selectable	Magnetic flux vector control V/F control selectable
	Device used	IPM (IGBT)	IPM (IGBT)
Motor noise		Ultralow noise	Ultralow noise
	Carrier frequency	0.7kHz to 14.5kHz with Soft-PWM (Value set is an integer between 0 and 15) (Factory setting 2kHz, Soft-PWM mode)	0.7kHz to 14.5kHz (Value is set in 0.1kHz increments) (Factory setting 14.5kHz)
Current limit	Stall prevention	○ (0 to 200%)	○ (0 to 200%)
	Fast-response current limit	○	○
Braking capability	0.4 to 1.5kW	150% (resistor built-in)	150% (resistor built-in)
	2.2 to 3.7kW	100% (resistor built-in)	100% (resistor built-in)
	5.5 to 7.5kW	100% (resistor built-in)	100% (resistor built-in)
	11 to 55kW	20% (capacitor regenerated)	20% (capacitor regenerated)
Instantaneous power failure	Instantaneous immunity	15ms	15ms
	Automatic restart function	Provided as standard	Provided as standard
Operation functions	Multi-speed (compensation)	Maximum 15 speeds (with compensation) Speed can be varied during operation	Maximum 15 speeds (with compensation) Speed can be varied during operation
	Polarity reversible	○	○
	Slip compensation	○	○
	PID action function	○	Made available by using the FR-EPD inboard option. (PI action only)
	Power failure stop function	○	×
	Commercial power supply-inverter switch-over sequence function	○	×
	Brake sequence function	○	×
	High-speed frequency control	○	×
	Stop-on-contact control	○	×
	Output current detection	○	×
	Cooling fan ON-OFF control	○	×
	Retry at alarm	○	○

Item		FR-A500	FR-A200
Operation panel, parameter unit		FR-DU04 operation panel equipped as standard FR-PU04 parameter unit available as option (FR-PU04 has a backlit LCD)	FR-PU02 parameter unit Provided as standard for products of up to 7.5K Not provided as standard for products greater than 7.5K
	Parameter group registration	○	×
	Parameter initial value setting	○	×
	Copy function	○	× (Made available by using the FR-ARW parameter copy unit)
	Language display	FR-DU04: No language display FR-PU04: 8 languages (Japanese, English, German, French, Spanish, Italian, Swedish, Finnish)	FR-PU04: 1 language (Japanese) FR-PU02E: 1 language (English) FR-PU02ER: 4 languages (English, German, French, Spanish)
	FR-PU01	Cannot be used	May be used (with restrictions)
	FR-PU02/FR-ARW	Cannot be used	May be used
	FR-PU03/FR-ARW03	Cannot be used	May be used (with restrictions)
	FR-PU04	May be used	Cannot be used
	FR-DU04	May be used	Cannot be used
	FR-E500 Operation panel	Cannot be used	Cannot be used

○: Available ×: Unavailable △: Available for some models

FR-E500	FR-A024/A044	FR-U100
0.1K to 0.75K (4 models)	—	0.1K to 0.4K (3 models)
0.1K to 0.75K (4 models)	—	0.1K to 0.75K (4 models)
0.1K to 7.5K (9 models)	0.1K to 3.7K (7 models)	0.1K to 1.5K (5 models)
0.4K to 7.5K (7 models)	0.4K to 3.7K (5 models)	—
Soft-PWM control High carrier frequency sine-wave PWM	High carrier frequency sine-wave PWM	Sine-wave PWM High carrier frequency sine-wave PWM for low acoustic noise series
General-purpose magnetic flux vector control V/F control selectable	General-purpose magnetic flux vector control V/F control selectable	V/F control
IPM (IGBT)	IPM (IGBT)	IGBT
Ultralow noise	Ultralow noise	Non-low noise or ultralow noise (low acoustic noise series)
0.7kHz to 14.5kHz with Soft-PWM (Value set is an integer between 0 and 15) (Factory setting 1kHz, Soft-PWM mode)	0.7kHz to 14.5kHz (Value is set in 0.1kHz increments) (Factory setting 1kHz)	Approx. 1kHz (0.7kHz to 14.5kHz (factory setting 7kHz) for low acoustic noise series)
20% (capacitor regenerated, 0.1K or more)	20% (capacitor regenerated, 0.1K or more)	20% (capacitor regenerated, 0.1K or more)
20% (capacitor regenerated)	20% (capacitor regenerated)	—
—	—	—
—	—	—
10ms	10ms	10ms
Provided as standard	Provided as standard	×
Max. 15 speeds (without compensation) Speed can be varied during operation	Max. 15 speeds (without compensation) Speed can be varied during operation	Max. 15 speeds (without compensation) Speed can be varied during operation
×	×	×
○	○	×
○	×	×
○	×	×
×	×	×
×	×	×
×	×	×
×	×	×
○	×	×
○	×	×
○	○	○
Operation panel equipped as standard FR-PU04 parameter unit available as option (FR-PU04 has a backlit LCD)	Some models have the FR-PU03 parameter unit as standard.	No (key sheet equipped as standard) PU operation type may only be connected.
○	×	×
×	×	×
× (Made available by using the FR-PU04 parameter unit)	× (Made available by using the FR-ARW03 parameter copy unit)	×
Operation panel: No language display FR-PU04: 8 languages (Japanese, English, German, French, Spanish, Italian, Swedish, Finnish)	FR-PU03: Japanese FR-PU03E: English	Key sheet: Japanese
Cannot be used	Cannot be used	Cannot be used
Cannot be used	May be used (with restrictions)	Cannot be used
Cannot be used	May be used	May be used (PU operation type only)
May be used	Cannot be used	Cannot be used
Cannot be used	Cannot be used	Cannot be used
May be used	Cannot be used	Cannot be used

Item		FR-A500	FR-A200
Communication function		RS-485 provided as standard FR-A5N☐ inboard option provides compatibility with CC-Link, Device Net ™ and Profibus DP.	Made available by using the FR-EPB inboard option
I/O	Input terminal assignment	20 different functions selectable Assignable to 7 terminals	×
	Output terminal assignment	30 different functions selectable Assignable to 5 terminals	10 different functions selectable Assignable to 4 terminals
	Alarm output assignment	30 different functions selectable Assignable to 1 terminal (A, B, C)	Alarm output only
	PC terminal	○	○
	24V power supply	(PC terminal is used as power supply)	×
	Sink-source logic switch-over	○	×
	Alarm code output	○	○
Frequency setting signals		DC0 to 5V, 0 to 10V DC4 to 20mA DC0 to ±5V,0 to ±10V	DC0 to 5V, 0 to 10V DC4 to 20mA DC0 to ±5V,0 to ±10V
Structure	Control circuit terminals	Screw type terminals (Solderless terminals usable)	Screw type terminals (Solderless terminals usable)
	Main circuit terminals	Screw type terminals (Solderless terminals usable)	Screw type terminals (Solderless terminals usable)
	Control circuit's separate power supply	○	○
	Cooling fan cassette-changing system	○	×
Inboard option		Up to three single-function options may be plugged in	One multi-function option may be fitted.
Setup software		○	× (However, communication software is available)
Harmonic suppression	AC reactor	○	○
	DC reactor	○	Δ (available for 5.5K or more)
	High power factor converter	○	○
Outline dimensions		A200E series intercompatibility attachment (option) available	—

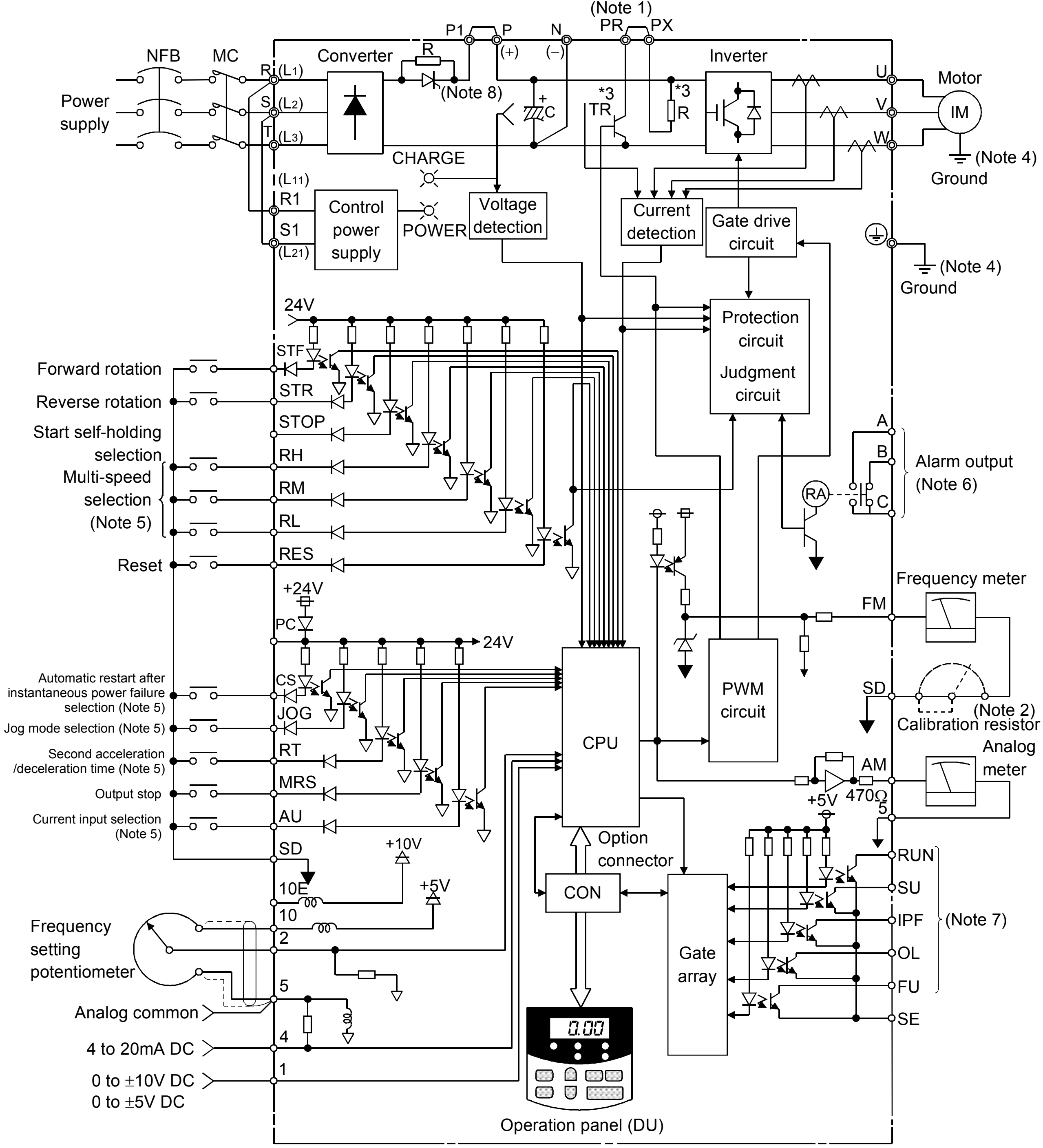
○: Available ×: Unavailable Δ: Available for some models

FR-E500	FR-A024(S)/A044	FR-U100
RS-485 provided as standard CC-Link compatible model available for three-phase 200V class. FR-E5NC plug-in option available for use with three-phase 400V class for compatibility with CC-Link.	Made available by using the FR-CU03 external option	×
11 different functions selectable Assignable to 4 terminals	10 different functions selectable Assignable to 4 terminals	9 different functions selectable Assignable to 3 terminals (multi-function product only)
12 different functions selectable Assignable to 2 terminals	5 different functions selectable Assignable to 2 terminals	3 different functions selectable Assignable to 1 terminal (multi-function product only)
12 different functions selectable Assignable to 1 terminal (A, B, C)	×	×
○	○	○(multi-function product only)
○ (PC terminal is used as power supply)	×	×
× (○ Enabled for 400V class)	×	×
×	×	×
DC0 to 5V,0 to 10V DC4 to 20mA Built-in analog potentiometer	DC0 to 5V,0 to 10V DC4 to 20mA	DC0 to 5V
Plug-in screw type terminals	Screw type terminals (Solderless terminals usable)	Plug-in type terminals
Screw type terminals (Solderless terminals usable)	Screw type terminals (Solderless terminals usable)	Plug-in type terminals
×	×	×
○	×	×
× (○ One option may be fitted to 400V class)	×	×
○	× (However, communication software is available)	×
○	○	○
○	×	×
○	○	×
There is mounting compatibility with U100 series No compatibility with A024 series	—	—

1.3 Standard Connection Diagrams and Terminal Specifications

1.3.1 Internal block diagram

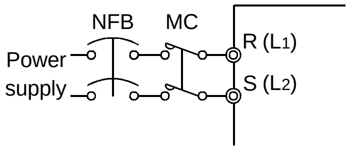
1) FR-A500



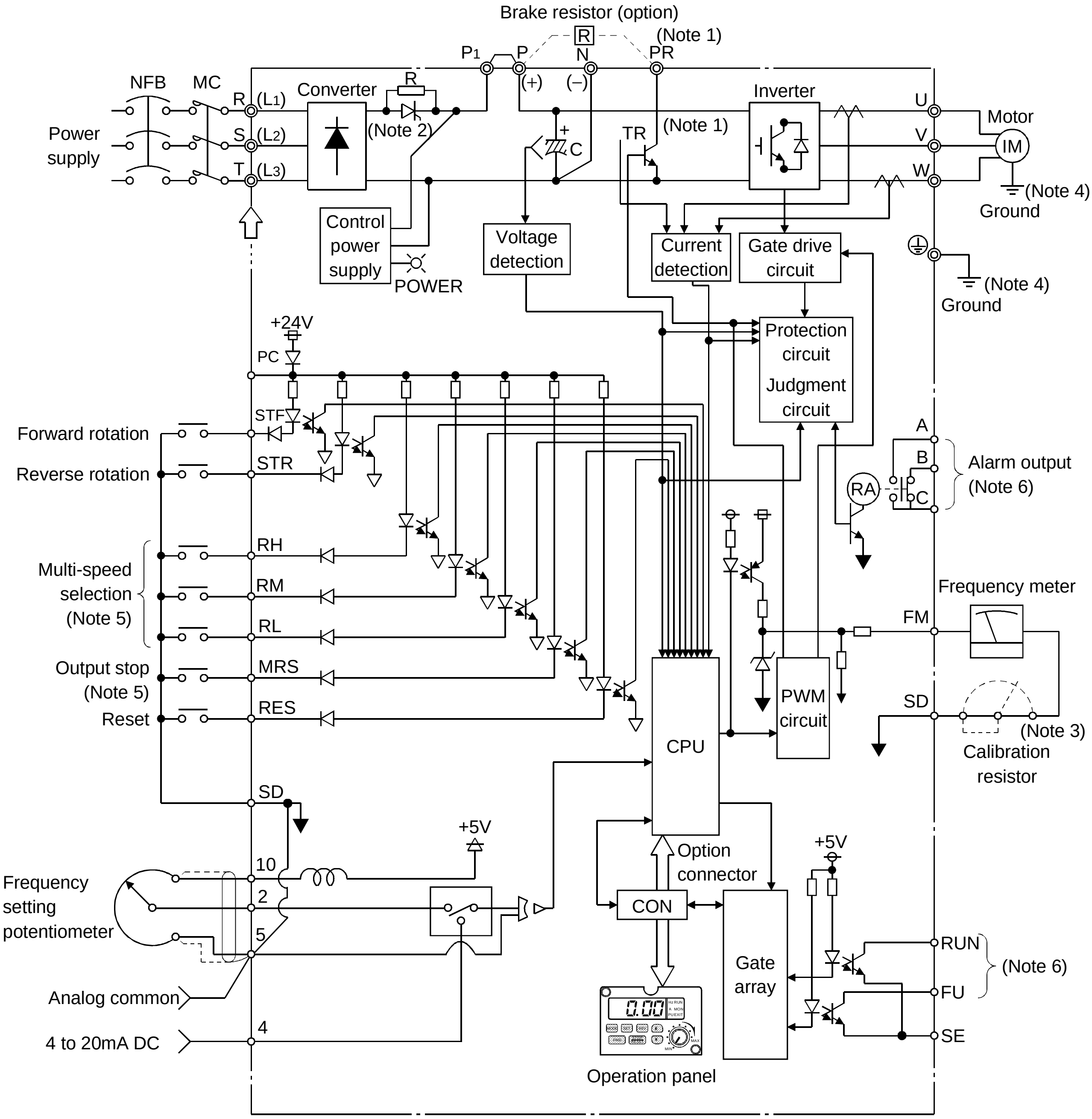
Note:
1. Terminals PR and PX are provided for the FR-A520-0.4K to 7.5K and FR-A540-0.4K to 7.5K. Remove this jumper when using the FR-ABR.
2. Not needed when the operation panel or parameter unit is used for calibration.
3. The FR-A520-11K or more and FR-A540-11K or more are not equipped with the built-in brake resistor and brake transistor marked *3.
4. Always earth the inverter and motor.
5. Input terminal function selection allows terminal functions to be assigned individually.
   Also, the switch-over connector allows achange to source logic.
6. Output terminal function selection allows terminal functions to be assigned individually.
7. Alarm definition can be output in alarm code and output terminal function selection allows terminal functions to be assigned individually. Also, the switch-over connector allows a change to source logic.
8. Replaced by a relay for the FR-A520-30K or more.

(2) FR-E500

- Single-phase 200V power input



- 3-phase 200V power input



Note: 1. The FR-E520-0.1K and 0.2K can not use a brake resistor and do not contain a transistor.
2. Provided for the FR-E520-2.2K to 7.5K
3. Not needed when the operation panel or parameter unit is used for calibration.
4. Always earth the inverter and motor.
5. Input terminal function selection allows terminal functions to be assigned individually.
6. Output terminal function selection allows terminal functions to be assigned individually.

1.3.2 Description of I/O terminal specifications

Terminal Symbol		Terminal Name	Rating, etc.	Description	Corresponding Model		Refer to Section
					A500	E500	
Main circuit, power circuit	R, S, T (L_1, L_2, L_3)	AC power input terminals	A500 3-phase, 200 to 220V 50Hz 200 to 240V 60Hz (230V) (Note 1) 3-phase, 380 to 480V 50/60Hz E500 3-phase, 200 to 240V 50/60Hz Single-phase, 200 to 240V 50/60Hz (Input to terminals R, S (L_1, L_2) for single-phase power input.)	Install a power factor improving AC reactor when installing the inverter near an especially large-capacity power supply or when improving the power supply's power factor. For installation procedure, refer to Section 2.4.7. Keep these terminals open when using the high power factor converter (FR-HC).	○	○	1.4.1
	U, V, W	Inverter output terminals	—	Connect a 3-phase induction motor. Output voltage does not exceed input voltage.	○	○	1.4.3
	R1, S1 (L_{11}, L_{21})	Control circuit power supply terminals	Same rating as that of AC power input terminals R, S, T (L_1, L_2, L_3) Power consumption 22K or less 60VA 30K to 55K 80VA	Connected with AC power input terminals R, S (L_1, L_2) by jumpers. When holding the alarm display or alarm output or when using the high power factor converter (FR-HC), remove these jumpers from across terminals R-R1 (L_1-L_{11}) and S-S1 (L_2-L_{21}) and input external power to these terminals.	○	○	1.4.2
	P, PR (+, PR)	Brake resistor connection terminals	—	Remove the jumper from across terminals PR-PX and connect the optional brake resistor (FR-ABR) across terminals P-PR (+ -PR).	○	○	2.7.5
	PR, RX	Built-in brake circuit connection terminals	—	When terminals PX-PR are connected by a jumper, the built-in brake circuit is valid.	○ 7.5K or less	—	2.7.5
	P, N (+, −)	Brake unit connection terminals	—	Connect any of the optional FR-BU (or BU) brake unit, power return converter (FR-RC) and high power factor converter (FR-HC).	○	○	2.7.5
	P, P1 (+, P_1)	Power factor improving DC reactor connection terminals	—	When using the optional power factor improving DC reactor (FR-BEL), remove the jumper from across terminals P1-P (P1- +) and connect the reactor.	○	○	2.4.7
		Earth terminal	—	Always earth this terminal.	○	○	1.9.7

Note: 1. For the FR-A520-30K to 55K

Terminal Symbol		Terminal Name	Rating, etc.	Description	Corresponding Model		Refer to Section
					A500	E500	
Control circuit (input signals)	STF	Forward rotation start input signal terminal	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	Short STF-SD to provide a forward rotation command and open them to stop. Short STR-SD to provide a reverse rotation command and open them to stop. Short STF-SD and STR-SD at the same time to provide a stop command. During operation, this causes deceleration to a stop. For E500, setting "8888" in Pr. 250 (stop selection) gives a stop command when STR-SD are shorted or a reverse rotation command when STF-SD and STR-SD are shorted at the same time.	○	○	1.4.5
	STR	Reverse rotation start input signal terminal			○	○	
	STOP	Start self-holding selection terminal	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	Short STOP-SD to choose the self-holding start system. If the start signal terminal STF (STR)-SD once shorted are opened, the start signal is held and the inverter continues running. To stop the motor, short, then open terminals STOP-SD. To change the rotation direction, open, then short the start signal terminal STF (STR)-SD. The self-holding start system prevents the inverter from automatically restarting when power is restored after a power failure.	○	— (Note 2)	
	RH, RM, RL	3-speed selection terminals	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	Short RH-SD to perform operation at the frequency set in Pr. 4 from the operation panel or parameter unit. Short RM-SD to perform operation at the frequency set in Pr. 5, or short RL-SD to perform operation at the frequency set in Pr. 6. When any two or more terminals of RH, RM and RL-SD are shorted at the same time, priority is given to the lower-speed terminal. 3-speed selection has higher priority than the analog frequency setting signal.	○ (Note 3)	○ (Note 4)	1.4.7
		Multi-speed selection terminals		For multi-speed selection, setting multi-speed frequencies in Pr. 24 to Pr. 27 and Pr. 232 to Pr. 239 with the operation panel or parameter unit allows up to 15 speeds to be selected by the combinations of shorted portions across RH, RM, RL and REX-SD. Allocate REX to any of the terminals using input terminal function selection. Multi-speed selection has higher priority than the analog frequency setting signal.			

Note: 2. Although there are no terminals, input terminal function selection Pr. 180 to Pr. 183 can be used to assign equivalent functions to other terminals.

3. Input terminal function selection Pr. 180 to Pr. 186 allow terminal functions to be changed.
4. Input terminal function selection Pr. 180 to Pr. 183 allow terminal functions to be changed.

Terminal Symbol		Terminal Name	Rating, etc.	Description	Corresponding Model		Refer to Section
					A500	E500	
Control circuit (input signals)	JOG	Jog mode selection	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	For jog mode selection, short JOG-SD and short/open the start signal terminal STF (STR)-SD to run/stop.	○ (Note 3)	—	1.4.8
	RT	Second acceleration/ deceleration time selection terminal	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	Short RT-SD to choose the second acceleration/deceleration time in Pr. 44 or Pr. 45 (0 to 3600 s), second torque boost in Pr. 46 and second V/F in Pr. 47. For E500, shorting RT-SD also chooses the second electronic overcurrent protection in Pr. 48. When RT-SD are open, the settings of acceleration/deceleration time (0 to 3600 s) in Pr. 7 and Pr. 8, torque boost in Pr. 0 and base frequency in Pr. 3 (and electronic overcurrent protection in Pr. 9 for E500) are used for operation.	○ (Note 3)	— (Note 2)	1.4.10
	MRS	Inverter output stop terminal	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	Shuts off the inverter output and coasts the motor to a stop. When stopping the motor with a mechanical brake etc. This terminal is used to shut off the inverter output. Before applying the brake, short terminals MRS-SD for 20ms or longer. Opening MRS-SD causes the inverter to operate as usual. Hence, while the mechanical brake is operating, keep MRS-SD shorted or open the start signal STF (STR)-SD to set the inverter in a non-output status.	○	○ (Note 4)	1.4.11
	RES	Reset terminal	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	Designed to reset the inverter stopped by the protective circuit operated when an alarm occurs. Immediately sets each portion of the control circuit to the initial state and shuts off the inverter output at the same time. To provide this reset input, short terminals RES-SD for 0.1 second or longer, then open them. Note that the initial reset at power-on is made automatically in the inverter, requiring 0.1 to 0.2 seconds after power-on. During reset, the inverter does not provide output.	○	○	1.4.12
	AU	Current input selection terminal	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	Only when AU-SD are shorted, the 4 to 20mA DC frequency setting signal input to across terminals 4-5 can be used to perform operation. When AU-SD are open, the input signal across terminals 4-5 is invalid. This terminal is overridden by the multi-speed terminal.	○ (Note 3)	— (Note 2)	1.4.6

Terminal Symbol		Terminal Name	Rating, etc.	Description	Corresponding Model		Refer to Section
					A500	E500	
Control circuit (input signals)	CS	Automatic restart after instantaneous power failure selection terminal	Input resistance 4.7kΩ Voltage 21 to 27VDC when open 4 to 6mADC when shorted Photocoupler isolated Controllable by open collector output or no-voltage contact signal	Short CS-SD to enable automatic restart control when power is restored from an instantaneous power failure (no limit to power failure period). Keep terminals CS-SD open if automatic restart operation after power restoration from an instantaneous power failure causes trouble for the machine.	○ (Note 3)	—	1.4.13
	SD	Contact input common terminal	——	Common terminal for the contact input signals and frequency meter. Isolated from the common of the control circuit in A500. Not isolated from terminal 5 in E500 (isolated in three-phase 400V class). Isolated from terminal SE.	○	○	1.4.19
	PC	External transistor common terminal, 24VDC power supply	Power supply voltage range 22 to 26VDC Current consumption 100mA	When inputting the transistor output (open collector) having an external power supply, e.g. a programmable controller (PC), to the inverter, connect the positive common of the external power supply to prevent a malfunction due to leakage current. Terminals PC-SD can be used as a 24VDC, 0.1A power output. When source logic is chosen for A500, this terminal acts as a contact input common.	○	○	1.4.15
	10	Frequency setting power supply terminals	5V±0.2VDC Permissible load current 10mA	Used as a power supply when a frequency setting (speed setting) potentiometer is connected externally. (Terminal 5 is a common)	○	○	1.4.6
	10E		10V±0.4VDC Permissible load current 10mA		○	—	
	2	Frequency setting input terminal (Voltage signal)	Input resistance 10kΩ±1kΩ Maximum permissible voltage 20VDC	When 5VDC is chosen for the input voltage of terminal 2 in Pr. 73, entering 0 to 5VDC to terminal 2 provides the maximum output frequency at 5V, making I/O proportional. (Even an input voltage over 5V is regarded as 5V.)	○	○	
				When 10VDC is chosen for the input voltage of terminal 2 in Pr. 73, entering 0 to 10VDC to terminal 2 provides the maximum output frequency at 10V, making I/O proportional. (Even an input voltage over 10V is regarded as 10V.)	○		
	5	Frequency setting input common terminal	——	Common terminal for frequency setting signals and 0V for the control circuit. Do not earth this terminal to the ground.	○	○	

Terminal Symbol		Terminal Name	Rating, etc.	Description	Corresponding Model		Refer to Section
					A500	E500	
Control circuit (input signals)	1	Frequency setting auxiliary input terminal	Input resistance 10kΩ ±1kΩ Maximum permissible voltage ±20VDC	When the Pr. 73 value is 10 to 15, entering 0 to ±10V(±5V)DC provides the maximum (minimum) output frequency at +10(+5V) (−10(−5V)), making I/O proportional. When the Pr. 73 value is 0 to 5, entering 0 to ±10V(±5V)DC provides the maximum output frequency at +10(+5V) but does not cause the inverter to output at 0 to −10V(−5V). It is added to the signal of terminal 2. Pr. 73 is also used to switch between ±10V and ±5V.	○	—	1.4.6
	4	Frequency setting input terminal (Current signal)	Input resistance 250Ω ±2% Maximum permissible current 30mA	Enter 4 to 20mADC. The maximum output frequency is provided at 20mADC. A 0Hz command is given at 4mADC.	○	○	
Control circuit (output signals)	B-C	Alarm output terminals	Contact output Contact capacity 230VAC 0.3A (power factor = 0.4) 30VDC 0.3A	These contact outputs indicate that the protective function of the inverter is activated and the inverter output shut off. In the normal state, terminals B-C are closed and A-C are open. When an alarm occurs, the internal relay operates to open terminals B-C and close A-C. When this signal is output, the motor coasts.	○ (Note 5)	○ (Note 6)	1.4.16
	A-C				○ (Note 5)	○ (Note 6)	
	RUN	Inverter running terminal	Open collector output Permissible load 24VDC 0.1A	This open collector output is low when the output frequency is higher than the starting frequency and is high during a stop or DC dynamic brake operation. Switched high when the protective function is activated. The 24VDC load power supply used should have less than ±10% ripple (equivalent to 3-phase full-wave rectification).	○ (Note 5)	○ (Note 6)	
	SU	Up-to-frequency terminal	Open collector output Permissible load 24VDC 0.1A	This open collector output is low when the output frequency is within ±10% of the preset frequency (factory setting, can be changed using Pr. 41) and is high during acceleration/deceleration or a stop. The 24VDC load power supply used should have less than ±10% ripple (equivalent to 3-phase full-wave rectification).	○ (Note 5)	— (Note 7)	
	OL	Overload alarm terminal	Open collector output Permissible load 24VDC 0.1A	This open collector output is switched low when the current limit function or stall prevention is activated and switched high when it is deactivated. The 24VDC load power supply used should have less than ±10% ripple (equivalent to 3-phase full-wave rectification).	○ (Note 5)	— (Note 7)	

Note: 5. Output terminal function selection Pr. 190 to Pr. 195 allow terminal functions to be changed.
6. Output terminal function selection Pr. 190 to Pr. 192 allow terminal functions to be changed.
7. Although there are no terminals, output terminal function selection Pr. 190 to Pr. 192 can be used to assign equivalent functions to other terminals.

Terminal Symbol		Terminal Name	Rating, etc.	Description	Corresponding Model		Refer to Section
					A500	E500	
Control circuit (output signals)	IPF	Instantaneous power failure terminal	Open collector output Permissible load 24VDC 0.1A	This open collector output is switched low when the protective circuit is activated due to an instantaneous power failure or undervoltage. The 24VDC load power supply used should have less than ±10% ripple (equivalent to 3-phase full-wave rectification).	○ (Note 5)	—	1.4.16
	FU	Frequency detection terminal	Open collector output Permissible load 24VDC 0.1A	This open collector output is switched low when the output frequency reaches or exceeds the detection frequency set in Pr. 42 or Pr. 43 and is high when it is less than the detection frequency. The 24VDC load power supply used should have less than ±10% ripple (equivalent to 3-phase full-wave rectification).	○ (Note 5)	○ (Note 6)	
	SE	Open collector output common terminal	——	Common for the open collector outputs RUN, SU, OL, IPF and FU. Isolated from the common of the control circuit.	○	○	1.4.19
	FM	Terminal for display (frequency meter)	Photocoupler isolated Permissible load current 1mA	Factory-set to provide approximately 3.5VDC at 60Hz (when FM-SD are open) (Note 8), which is proportional to the output frequency. The output voltage is a 8VDC pulse-shaped waveform. Connect a 1mA moving-coil type DC ammeter. When the frequency is as set in Pr. 55 or the current is as set in Pr. 56 (0 to 500A), the output pulse frequency is 1440 pulses/sec.	○	○	1.4.17
	AM	Analog signal output terminal	Non-isolated 0 to 10VDC Permissible load current 1mA (load impedance 10kΩ or more) Resolution 8 bits	Factory-set to provide 10VDC at the full-scale value of each monitor, which is proportional to each monitor value. When the frequency is as set in Pr. 55 or the current is as set in Pr. 56 (0 to 500A), the output voltage is 10VDC.	○	—	1.4.18
Communication	(PU connector)	Connector for operation panel	Compliant standard: EIA Standard RS-485 Transmission form: Multidrop link system Communication speed: Maximum 19200 baud Overall length: 500m	The operation panel connector enables communication using RS-485.	○	○	1.4.21

Note: 8. Approximately 4.7V for E500.

* The SD, 5 and SE common terminals of the control circuit are all 0V terminals of I/O signals. Do not earth these common terminals to the ground.

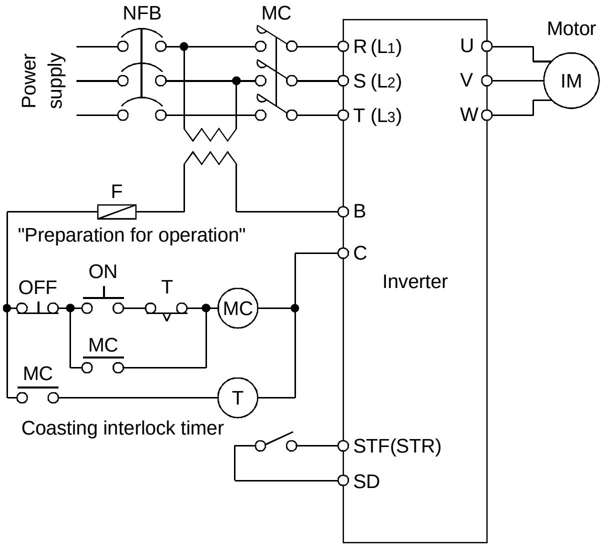
1.4 Information on the Use of the External Terminals

1.4.1 Switching the Inverter Power On/Off

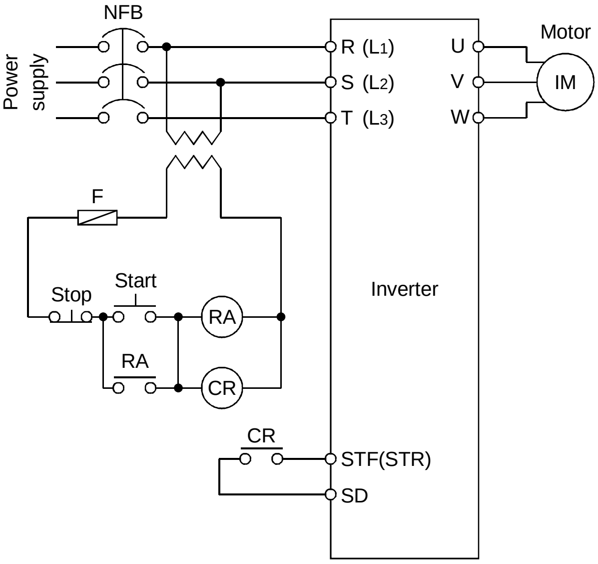
(Terminals R, S, T (L_1, L_2, L_3)) COMMON

(1) No-fuse breaker and magnetic contactor on the inverter power supply side COMMON

1) Use the specified no-fuse breaker with the power supply to protect wiring to the inverter. A no-fuse breaker of greater capacity may be required as compared to commercial power operation because of the low power factor of the power supply resulting from the distorted input current. (See Section 2.6.)
2) While a magnetic contactor need not be provided for operation on the inverter power supply side, it is recommended to install a magnetic contactor to ensure safety at alarm occurrence. The circuit shown in right. Should be made up to protect the inverter from any accident etc. that may be caused by automatic restart when the power is restored after power failure. When the magnetic contactor is used, make up the circuit as shown in Fig. 4.8 and start and stop the motor by switching on/off the signal across terminals STF or STR and SD.
3) Start and stop the motor by switching on/off the signal across the inverter terminals STF or STR and SD. If the MC is used to stop the motor, the motor coasts to a stop because regenerative braking inherent in the inverter is not applied. If the MC is used to start the motor during coasting when, for example, load inertia is extremely large, the protective circuit (overvoltage E.OV1 to E.OV3) may be activated to shut off the inverter output. When performing jog operation, the MC must not be used to start and stop the motor. Otherwise, slow response will result because of a start delay due to the initial reset time (approximately 0.2 seconds) after power on.
4) The cooling fan starts rotating as soon as the power is switched on. However, cooling fan operation selection Pr. 244 may also be used to exercise cooling fan ON-OFF control.



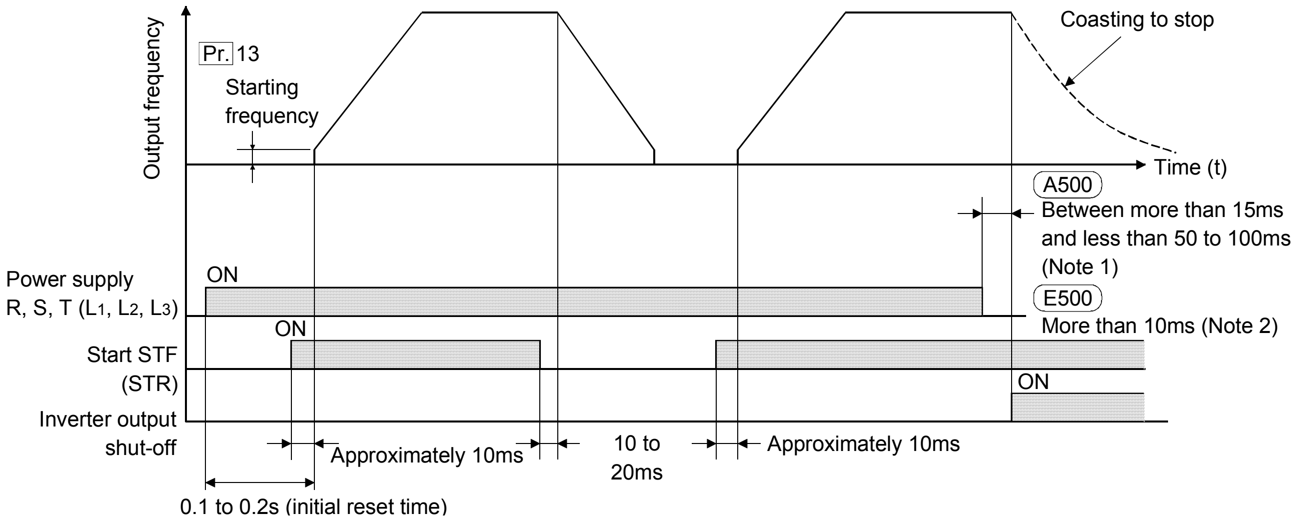
Magnetic Contactor Used with Power Supply



No Magnetic Contactor in the Primary Power Supply (Automatic restart prevented when power is restored)

Note: To protect the converter from repeated inrush current generated at power on, the magnetic contactor in the inverter power supply must not be used frequently to start and stop the motor.

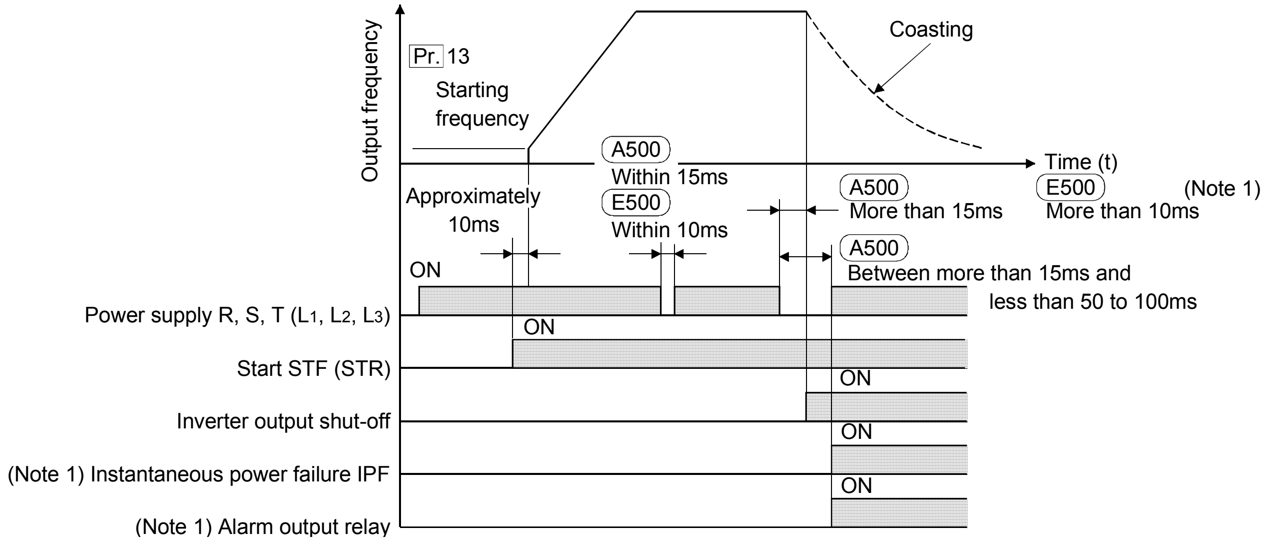
(2) Inverter power on/off timing chart COMMON



Note: 1. The inverter output is shut off immediately (between more than 15ms and less than 50 to 100ms) after the power is switched off.

2. The inverter output is shut off immediately if more than 10ms elapses after the power is switched off and the bus voltage of the inverter falls to or below a certain level.

(3) Inverter instantaneous power failure timing chart COMMON



Note: 1. For A500, activated when the power is restored within 15 to 100ms. Note that the alarm output signal is not switched on when 0 or any of 0.1 to 5 is set in Pr. 57, automatic restart after instantaneous power failure.

For E500, the alarm output is not provided if the power is restored after the inverter output is shut off, and operation resumes at the starting frequency. Note that automatic restart after instantaneous power failure is made when 0 or any of 0.1 to 5 is set in Pr. 57 and the power is restored while the control power remains.

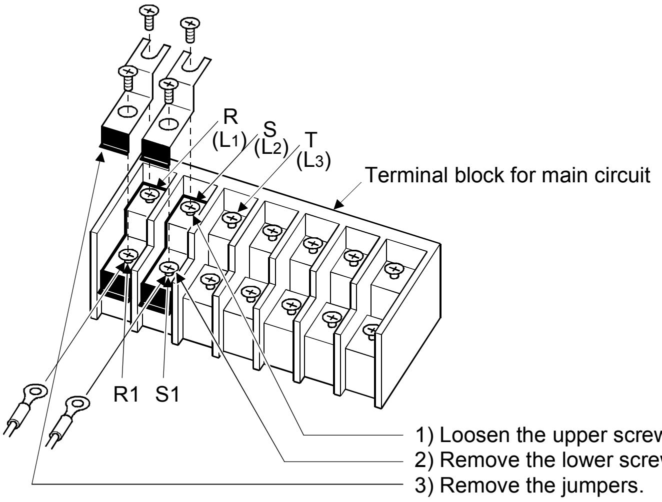
2. An instantaneous power failure of longer than 100ms is identical to a long-time power failure (refer to (2) Inverter power on/off timing chart). If the start signal is on, the inverter is restarted when the power is restored.

1.4.2 Connecting External Power Supply to the Control Circuit (Terminals R1, S1) A500

If any of the protective functions (other than the stall prevention and current limit functions) are activated, the alarm indicator lamp is lit and the corresponding alarm signal is output. If the magnetic contactor etc. in the inverter power supply is switched off by the alarm signal at this time, the control power is lost and the alarm output cannot be kept on. To keep this alarm output on, use the other power supply with the control circuit (power supply with the same voltage as the one used with the main circuit).

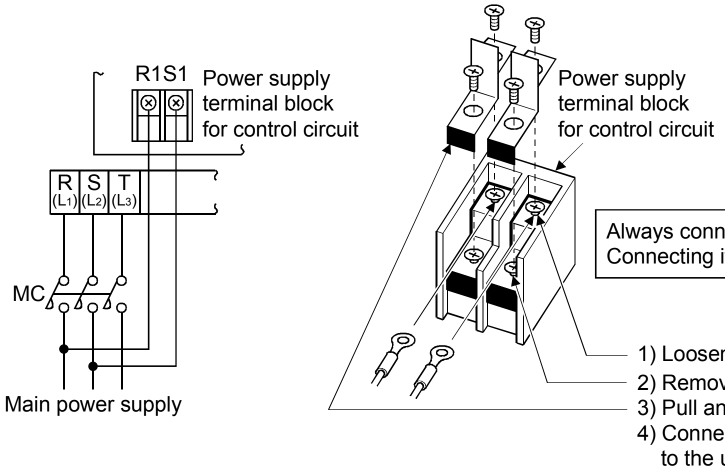
Connection

The other power supply connection terminal block on the printed circuit board is a two-step type terminal block and links are connected across the upper and lower terminals before shipment from the factory. After loosening (and removing) the screws and removing the links as shown below, connect an external power supply in the procedure shown below.



1) Loosen the upper screws.
2) Remove the lower screws.
3) Remove the jumpers.
4) Connect the separate power supply cables for control circuit to the lower terminals (R1, S1).

For FR-A520-0.4K to 3.7K, FR-A540-0.4K to 3.7K



Always connect the separate power supply to the upper terminals. Connecting it to the lower terminals will damage the inverter.

1) Loosen the upper screws.
2) Remove the lower screws.
3) Pull and remove the jumpers.
4) Connect the separate power supply cables for control circuit to the upper terminals (R1, S1).

For FR-A520-5.5K to 55K, FR-A540-5.5K to 55K

(1) The control power supply (terminals R1, S1) should not be switched off when the main circuit power supply (terminals R, S, T (L_1, L_2 and L_3)) are on. When the main circuit power supply is on, a DC voltage exists in the converter output area and the voltage is being applied to the transistors. If a signal enters the transistor gate circuit due to noise etc., the transistors conduct and the terminals P and N (+ and −) are connected, which may damage the transistor modules. When the control power supply is on, an inverse bias voltage is applied to the gate circuit to prevent the transistors from conducting. The circuit should be made up so that the main circuit power supply terminals R, S and T (L_1, L_2 and L_3) are always off when the control power supply terminals R1 and S1 are off.

(2) If the magnetic contactor of the main circuit power supply (terminals R, S, T (L_1, L_2 and L_3)) is switched off (for more than 0.1 second), then on, the inverter is reset. Hence, this method may be used to perform alarm-on reset.

(3) If the primary MC is switched off once (for more than 0.1 second), then on during inverter output (operation), the inverter is initial-reset and the motor is restarted in the coasting state.
If the MC is switched off, the undervoltage (E. UVT) protection is not activated.
Note: The undervoltage protection may be activated when a capacitor (noise filter) is being connected to the terminals R, S and T (L_1, L_2 and L_3).

(4) If the primary MC is switched off, the alarm output signal is not switched on. When the MC is off, the parameter unit (FR-DU04, FR-PU04) can be operated. (The motor cannot be run.)

(5) Capacity (VA) of the other power supply
When the other power is supplied from R1 and S1, 60VA or more is required.
Inrush current of approximately 40A flows (1.3ms).

1.4.3 Switching the inverter output MC on/off (U, V, W) COMMON

If the magnetic contactor is switched on during inverter operation (output), a large starting current activates the current limit function, reducing the output frequency.

(1) Inverter output MC switch-on mode (with fast-response current limit) COMMON

Motor State before MC Switched On / Inverter State	Motor Rotating (Coasting)	Motor at Stop
Inverter operating	MC may be switched on (Note)	MC may be switched on (Note)
Inverter at stop	MC may be switched on (Note)	MC may be switched on (This condition is the best)

Note: The overcurrent protection is not activated but the electronic overcurrent protection may be activated.

(2) Inverter output MC switch-off mode COMMON

Motor State before MC Switched Off / Inverter State	Motor Operating	Motor Rotating (Coasting)	Motor at Stop
Inverter operating	MC may be switched off (The motor coasts to a stop)	—	—
Inverter at stop	—	MC may be switched off	MC may be switched off

1.4.4 Input signals Common

(1) Input terminal function assignment COMMON

The inverter has the input terminals whose functions can be changed by parameter setting.

1) A500

Terminals RL, RM, RH, RT, AU, JOG and CS are assigned functions by Pr. 180 to Pr. 186, respectively.

Parameter Number	Function name	Factory Setting	Setting Range
180	RL terminal function selection	Low-speed operation command (RL)	0 to 99, 9999
181	RM terminal function selection	Middle-speed operation command (RM)	0 to 99, 9999
182	RH terminal function selection	High-speed operation command (RH)	0 to 99, 9999
183	RT terminal function selection	Second function selection (RT)	0 to 99, 9999
184	AU terminal function selection	Current input selection (AU)	0 to 99, 9999
185	JOG terminal function selection	Jog operation selection (JOG)	0 to 99, 9999
186	CS terminal function selection	Automatic restart after instantaneous power failure selection (CS)	0 to 99, 9999

Setting	Signal Name	Functions			
		Pr. 59 = 0 *	Pr. 59 = 1, 2 *	Pr. 79 = 5 *	Pr. 270 = 1, 3 *
0	RL	Low-speed operation command	Remote setting (setting clear)	Programmed operation group selection	Stop-on contact selection 0
1	RM	Middle-speed operation group selection	Remote setting (deceleration)	Programmed operation group selection	
2	RH	High-speed operation command	Remote setting (acceleration)	Programmed operation group selection	
3	RT	Second function selection.			Stop-on contact selection 1
4	AU	Current input selection			
5	JOG	Jog operation selection			
6	CS	Automatic restart after instantaneous power failure selection			
7	OH	External thermal relay input			
8	REX	15-speed selection (combination with RL, RM, RH)			
9	X9	Third function			
10	X10	FR-HC connection (inverter operation enable)			
11	X11	FR-HC connection (instantaneous power failure detection)			
12	X12	PU operation external interlock			
13	X13	External DC dynamic braking start			
14	X14	PID control valid terminal			
15	BRI	Brake opening completion signal			
16	X16	PU-external operation switch-over			
17	X17	Load pattern selection forward/reverse rotation boost			
18	X18	Advanced magnetic flux vector-V/F switch-over			
19	X19	Load torque high-speed frequency			
9999	—	No function			

*When Pr. 59 = "1" or "2", Pr. 79 = "5", and Pr. 270 = "1" or "3", the functions of the RL, RM, RH and RT signals change as listed above.

Note: 1. One function can be assigned to two or more terminals. In this case, the function is activated when one of the terminals assigned is turned on.

2. The speed command priorities are higher in order of jog, multi-speed setting (RH, RM, RL, REX), AU and analog command input.

3: Use common terminals to assign programmed operation group selection, multi-speeds (7 speeds) and remote setting. They cannot be set individually. (Common terminals are used since these functions are designed for speed setting and need not be set at the same time.)

4: Stop-on-contact control selection, Pr. 270 = "1" or "3", uses both the low-speed operation command (RL) and second function selection (RT), and its allocation cannot be changed.

5: When the FR-HC connection (inverter operation enable) signal (X10) is not set, the MRS terminal shares this function.

6: When "7" is set in Pr. 79 and the PU operation external interlock signal (X12) is not assigned, the MRS signal acts as this function.

7: When the load pattern selection forward/reverse rotation boost signal (X17) is not assigned, the second function selection (RT) shares this function.

8: When advanced magnetic flux vector-V/F switch-over signal (X18) is not assigned, the second function selection (RT) shares this function.

2) E500

Terminals RL, RM, RH and MRS are assigned functions by Pr. 180 to Pr. 183, respectively.

Function Number	Function name	Setting Range	Factory Setting
180	RL terminal function selection	0, 8, 16, 18	0, Low-speed operation command (RL)
181	RM terminal function selection	0, 8, 16, 18	1, Middle-speed operation command (RM)
182	RH terminal function selection	0, 8, 16, 18	2, High-speed operation command (RH)
183	MRS terminal function selection	0, 8, 16, 18	6, Output shut-off (MRS)

Setting	Signal Name	Functions	
		Pr. 59 = 0	Pr. 59 = 1, 2 *
0	RL	Low-speed operation command	Remote setting (setting clear)
1	RM	Middle-speed operation command	Remote setting (deceleration)
2	RH	High-speed operation command	Remote setting (acceleration)
3	RT	Second function selection	
4	AU	Current input selection	
5	STOP	Start self-holding	
6	MRS	Output shut-off	
7	OH	External thermal relay input.	
8	REX	15-speed selection (combination with three speeds of RL, RM, RH)	
16	X16	PU operation-external operation switch-over	
18	X18	General-purpose magnetic flux vector-V/F switch-over (OFF: general-purpose magnetic flux vector control, ON: V/F control) (Note 3)	

* When Pr. 59 = "1" or "2", the functions of the RL, RM, RH and RT signals change as listed above.

Note: 1. One function can be assigned to two or more terminals. In this case, the function is activated when one of the terminals assigned is turned on.

2. The speed command priorities are higher in order of multi-speed setting (RH, RM, RL, REX), AU and analog command input.

3. When V/F control is selected by V/F-general-purpose magnetic flux switch-over, the second function is also selected.

4. Use common terminals to assign multi-speeds (7 speeds) and remote setting. They cannot be set individually.
(Common terminals are used since these functions are designed for speed setting and need not be set at the same time.)

(2) Control logic changing A500 E500 (400V class)

In the A500 and E500 (400V class), the input signal control logic can be changed between the sink logic type and source logic type.

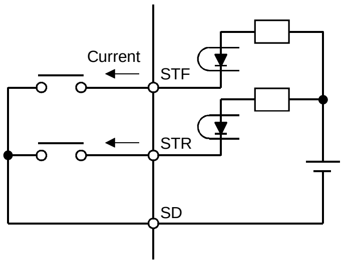
In the sink logic type, a signal switches on when a current flows out of the corresponding signal input terminal. Terminal SD is a common terminal.

In the source logic type, a signal switches on when a current flows into the corresponding signal input terminal. Terminal PC is a common terminal.

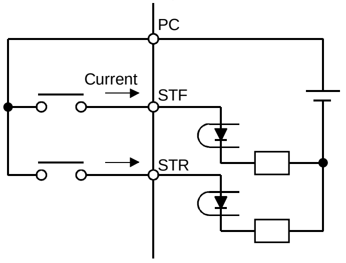
To change the control logic, the position of the connector on the rear surface of the control circuit terminal block must be changed.

The input signal logic is factory-set to sink.

(Output signals may be used in either the sink or source logic, independently of the connector position.)



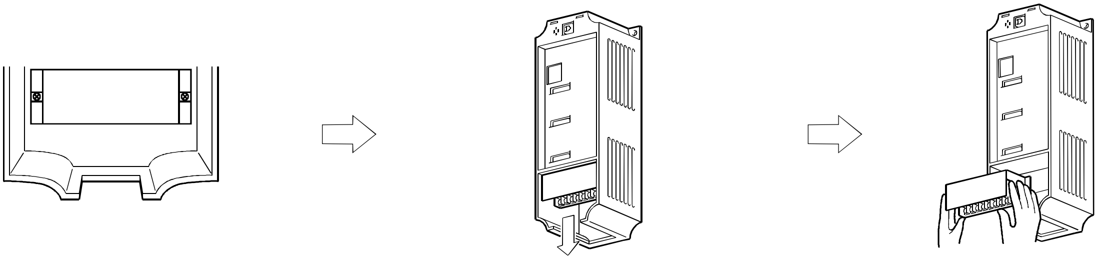
Sink logic type



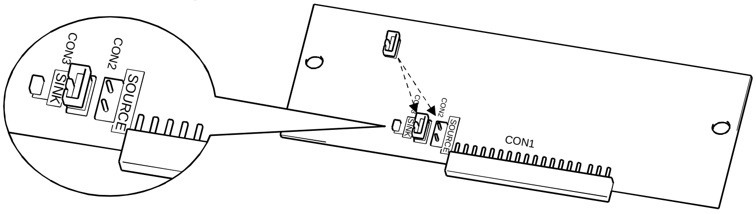
Source logic type

1) For A500

Loosen the two mounting screws in both ends of the control circuit terminal block. (The screws cannot be removed.)With both hands, pull down the terminal block from the back of the control circuit terminals.



Remove the connector from the rear surface of the control circuit terminal block and place in required Logic position (either Sink or Source).



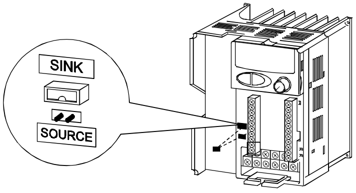
Using care not to bend the pins of the control circuit connector, reinstall the control circuit terminal block and fix it with the mounting screws.

Note: 1. Make sure that the control circuit connector is fitted correctly.
2. While power is on, never disconnect the control circuit terminal block.
3. The sink-source logic change-over connector must be fitted in only one of those positions. If it is fitted in both positions at the same time, the inverter may be damaged.

2) For E500 (400V class)

Using tweezers etc., move the connector from the sink logic position to the source logic position (or from source to sink position).

Change the connector position before switching power on.



Note: 1. In the 200V and 100V classes, the logic cannot be changed.
2. Fit the sink-source logic changeover connector in only one position. If connectors are fitted to both positions simultaneously, the inverter may be damaged.

1.4.5 Run an stop (STF, STR, STOP) COMMON

To start and stop the motor, first switch on the input power supply of the inverter (magnetic contactor in the input circuit, if any, should be switched on during preparation for operation), then start the motor by the forward or reverse rotation start signal.

(1) Two-wire type connection (STF, STR) COMMON

A two-wire type connection is shown below.

1) The forward/reverse rotation signal is used as both the start and stop signals. Switch on either of the forward and reverse rotation signals to start the motor in the corresponding direction. Switch on both or switch off the start signal during operation to decelerate the inverter to a stop.
2) The frequency setting signal may either be given by entering 0 to 5VDC (or 0 to 10VDC) across frequency setting input terminal 2-5 or by setting the required values in the three-speed setting parameters Pr. 4 to Pr. 6 (high, middle, low speeds). (For three-speed operation, refer to Section 1.4.7.)
3) After the start signal has been input, the inverter starts operating when the frequency setting signal reaches or exceeds the starting frequency set in Pr. 13 (factory-set to 0.5Hz).

   If the motor load torque is large or the torque boost value set in Pr. 0 is small, operation may not be started due to insufficient torque until the inverter output frequency reaches about 3 to 6Hz.

   If the minimum frequency limit set in Pr. 2 (factory setting = 0Hz) is 6Hz, for example, merely entering the start signal causes the running frequency to reach the minimum frequency limit of 6Hz according to the acceleration time set in Pr. 7.
4) To stop the motor, operate the DC dynamic brake for the period of DC dynamic brake operation time set in Pr. 11 (factory setting = 0.5 seconds) at not more than the DC dynamic brake operation frequency or at not more than 0.5Hz.

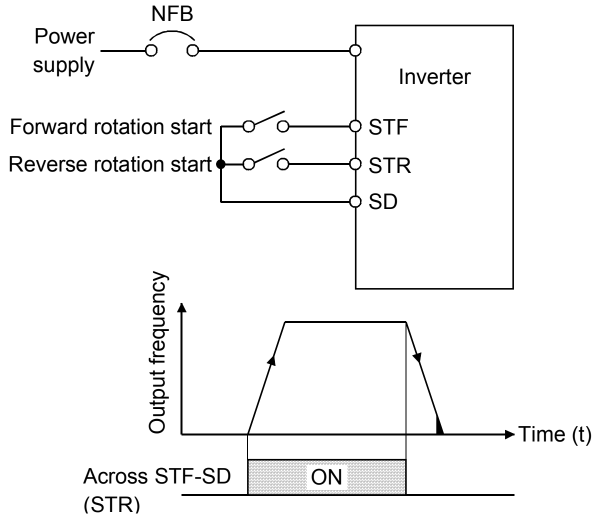
   To disable the DC dynamic brake function, set "0" in either of Pr. 11 (DC dynamic brake operation time) and Pr. 12 (DC dynamic brake voltage).

   In this case, the motor is coasted to a stop at no more than the frequency set in Pr. 10 (DC dynamic brake operation frequency, 0 to 120Hz variable) or at no more than 0.5Hz (when the DC dynamic brake is not operated).
5) If the reverse rotation signal is input during forward rotation or the forward rotation signal is input during reverse rotation, the inverter is switched to the opposite output polarity without going through the stop mode.

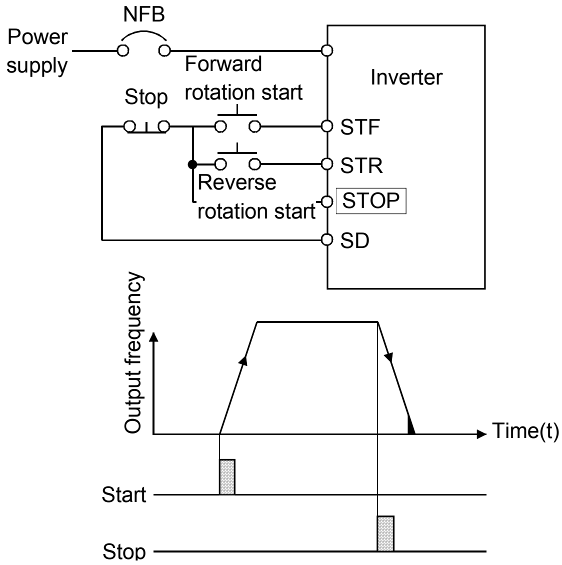
(2) Three-wire type connection (STF, STR, STOP) COMMON

A three-wire type connection is shown below. For E500, assign the start self-holding signal (STOP) to any of the input terminals.

1) Short terminals STOP-SD to enable the start self-holding function. In this case, the forward/reverse rotation signal functions only as a start signal.
2) If the start signal terminal STF (STR)-SD are shorted once, then opened, the start signal is kept on and starts the inverter. To change the rotation direction, short the start signal STR (STF)-SD once, then open it. signals switched on first is made valid and starts the inverter in the corresponding direction.
3) The inverter is decelerated to a stop by opening terminals STOP-SD once. For the frequency setting signal and the operation of DC dynamic brake at a stop time, refer to paragraphs 2) to 4) in (1) Two-wire type connection. The three-wire connection is as shown below.
4) When terminals JOG-SD are shorted, the signal of terminal STOP is invalid and jog operation has precedence. (E500 does not have the JOG signal.)
5) If the output stop terminal MRS-SD are shorted, the self-holding function is not deactivated.



Two-Wire Type Connection Example



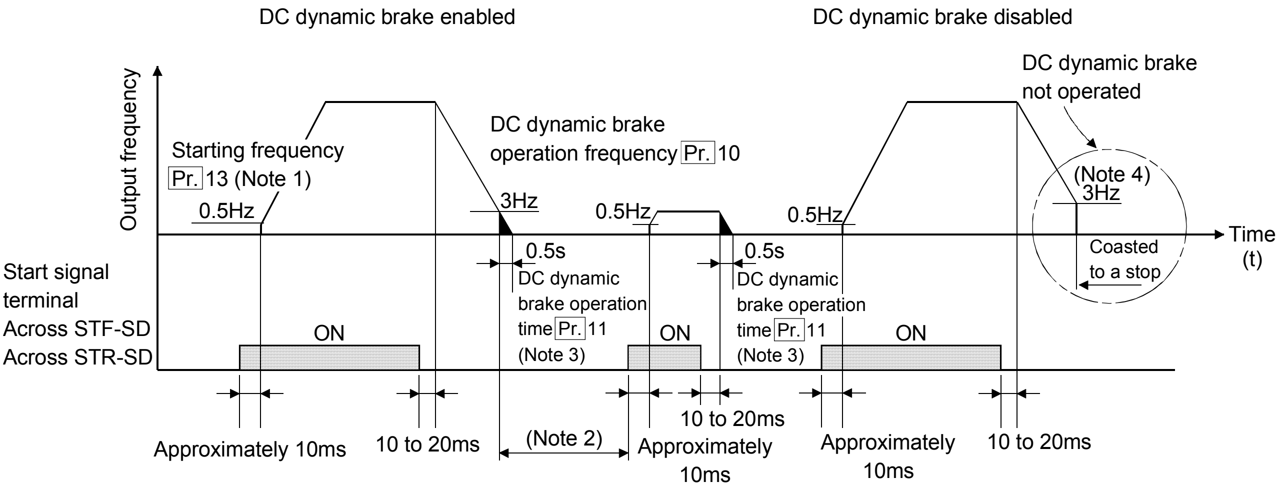
Three-Wire Type Connection Example

DC Dynamic Brake and Coasting to Stop

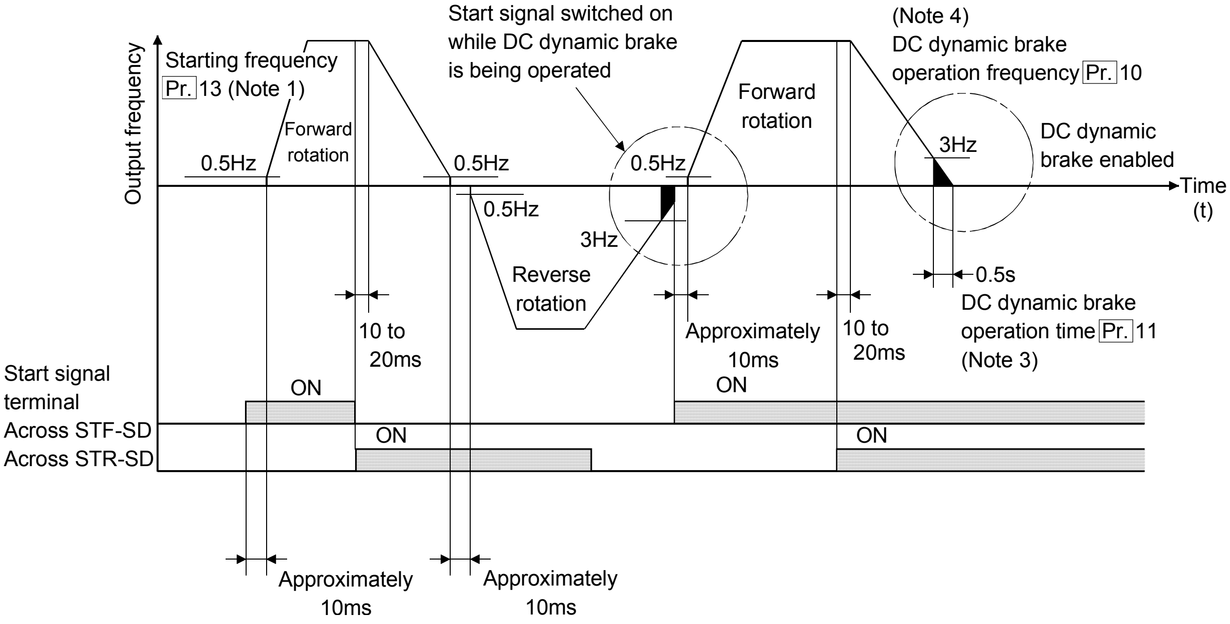
Operation Mode / DC Dynamic Brake	External Operation or Combined Operation Pr. 97 = 0, 2, 3		PU Operation or Combined Operation Pr. 97 = 0, 1, 4	
	Terminals STF (STR)-SD disconnected (Note 1)	Terminals STF (STR)-SD connected (Note 2) and 0V across terminals 2-5	STOP key	Set frequency changed to 0Hz
DC dynamic brake enabled	DC dynamic brake operated at not more than the DC dynamic brake operation frequency set in Pr. 10	DC dynamic brake operated at 0.5Hz or less.	DC dynamic brake operated at not more than the DC dynamic brake operation frequency set in Pr. 10	DC dynamic brake operated at 0.5Hz or less.
DC dynamic brake disabled	Coasted to a stop at not more than the DC dynamic brake operation frequency set in Pr. 10	Coasted to a stop at 0.5Hz or less.	Coasted to a stop at not more than the DC dynamic brake operation frequency set in Pr. 10	Coasted to a stop at 0.5Hz or less.

Note: 1. Also stopped by the STOP key. Refer to Section 1.6.14.

2. For multi-speed operation, the same operation is performed when terminal RH/RM/RL-SD are disconnected.



Start/Stop Timing Chart (for two-wire type)



Forward-Reverse Rotation Switch-Over Timing Chart

Note: 1. The starting frequency Pr. 13 (factory-set to 0.5Hz) may be specified between 0 and 60Hz.
2. If the next start signal is given during DC dynamic brake operation, the DC dynamic brake is disabled and restart is made.
3. The DC dynamic brake operation time Pr. 11 (factory-set to 0.5 s) may be specified between 0 and 10 seconds.
4. The frequency at which the motor is coasted to a stop is not more than the DC dynamic brake operation frequency set in Pr. 10 (factory setting = 3Hz; may be set between 0 and 120Hz) or not more than 0.5Hz.
5. The starting frequency Pr. 13, DC dynamic brake operation time Pr. 11 and DC dynamic brake operation frequency Pr. 10 are the factory-set values.

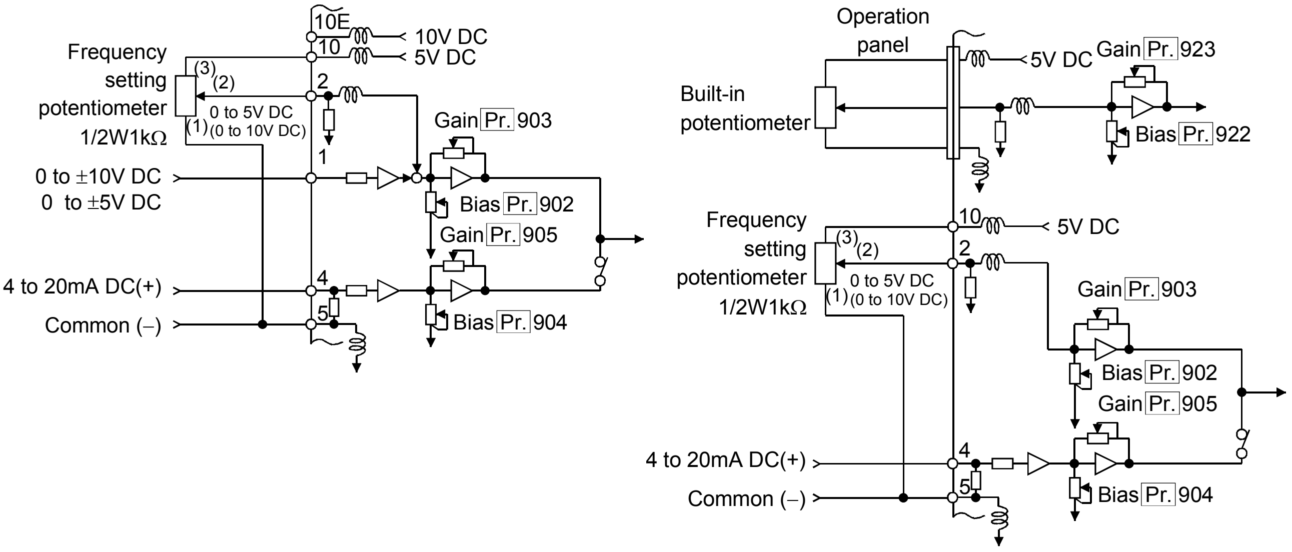
1.4.6 Relationships between frequency setting input signals and output frequencies (10, 10E*, 2, 5, 1*, 4, AU) COMMON

(*10E and 1 are not provided for E500)

The analog frequency setting input signals that may be entered are voltage and current signals.

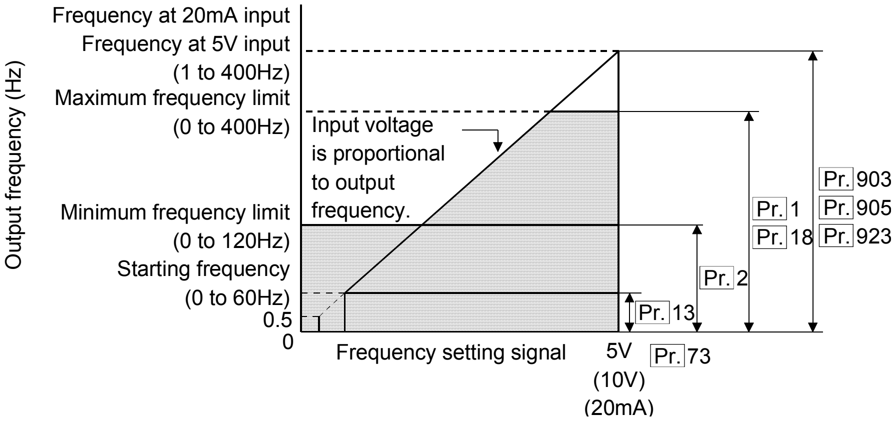
For the relationships between the frequency setting input voltages (currents) and output frequencies, refer to the following diagram. The frequency setting input signals are proportional to the output frequencies. Note that when the input signal is less than the starting frequency, the output frequency of the inverter is 0Hz.

If the input signal of 5VDC (or 10V, 20mA) or higher is entered, the maximum output frequency is not exceeded.



1) A500 2) E500

Analog Input Block Diagram



Relationships between Frequency Setting Inputs and Output Frequencies

(1) Voltage input (10, 10E*, 2, 5) COMMON

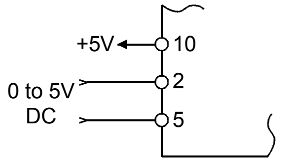
(*10E is not provided for E500)

Enter the frequency setting input signal of 0 to 5VDC (or 0 to 10VDC) across the frequency setting input terminals 2-5. The maximum output frequency is reached when 5V (10V) is input across terminals 2-5.

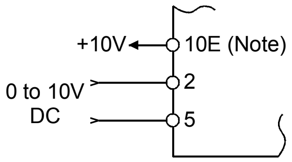
The power supply used may either be the inverter's built-in power supply or an external power supply. For the built-in power supply, terminals 10-5 provide 5VDC output, and terminals 10E-5 (Note) provide 10VDC output.

Note: E500 is not equipped with terminal 10E.

- For operation at 0 to 5VDC, set Pr. 73 to the 0 to 5VDC input. Use terminal 10 for the built-in power supply.



- For operation at 0 to 10VDC, set Pr. 73 to the 0 to 10VDC input. Use terminal 10E (Note) for the built-in power supply.



(2) Operation panel's built-in potentiometer E500

The potentiometer built in the operation panel can be used to set the main speed. It is made valid in the PU operation mode.

Pr. 146 Setting	Frequency Setting Command
0 (factory setting)	Operation panel's built-in potentiometer
1	Digital frequency
9999 (Note 1)	When digital frequency setting = 0.00Hz, the operation panel's built-in potentiometer is valid. (Note 2) When digital frequency setting ≠ 0.00Hz, the digital frequency is valid.

Note: 1. When Pr. 79 = 0, the PU operation mode is selected at power-on.

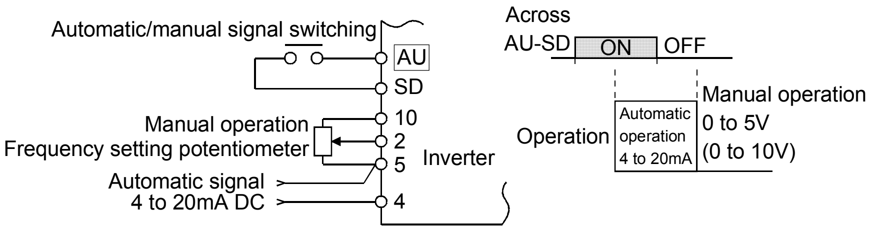
2. During operation with the frequency setting from potentiometer, pressing the ▲ or ▼ key switches to the digital frequency setting and the frequency setting from potentiometer is made invalid.

(3) Current input (4, 5, AU) COMMON

To automatically perform operation under constant pressure and temperature control using a fan, pump etc., enter the controller output signal of 4 to 20mADC to across terminals 4-5.

Terminals AU (Note)-SD must be shorted to use the 4 to 20mADC signal for operation. When the multi-speed signal is input, the current input is ignored.

Note: For E500, assign the current input selection signal (AU) to any of the input terminals.



Manual-Automatic Switching

(4) Auxiliary input (1, 5) A500

A compensation signal may be entered to across the main speed setting terminal 2-5 for synchronous operation, etc.

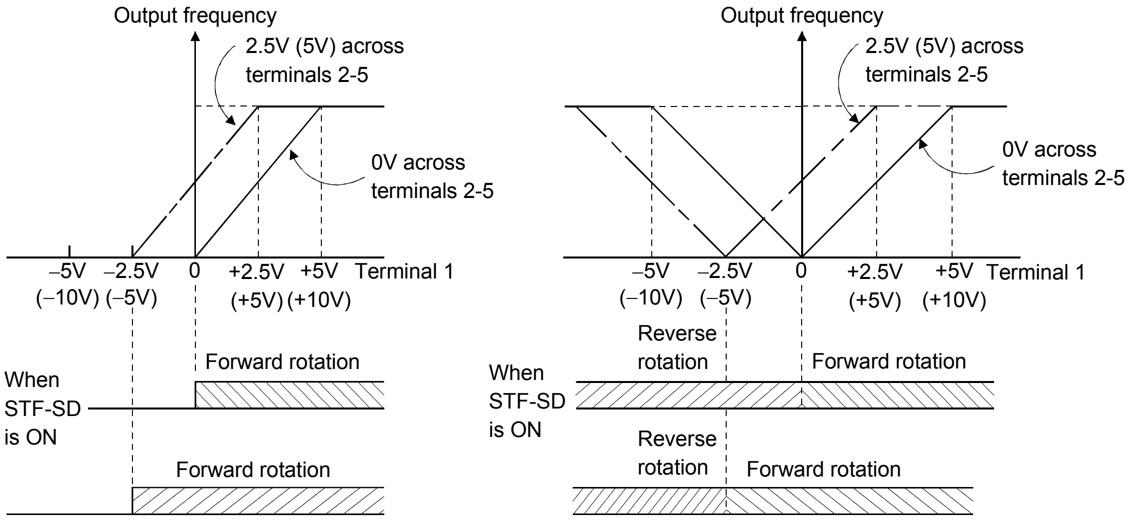
0 to ±5V/10VDC across auxiliary input terminal 1-5

The function of terminal 1 depends on the setting of Pr. 73, frequency command voltage range selection, as follows:

(a) Pr. 73 setting = 0 to 5 (factory setting 1)
The voltage across terminals 1-5 is added to the voltage signal (positive) across terminals 2-5. A negative addition result is regarded as 0 and brings the inverter to a stop.

(b) Pr. 73 setting = 10 to 15
The polarity reversible operation function is selected. The voltage across terminals 1-5 is added to the voltage signal (positive) across terminals 2-5. A positive addition result starts forward rotation (if terminal STF is on) and a negative result starts reverse rotation (STF on).

The compensation signal of terminal 1 may also be added to the multi-speed setting or 4 to 20mA current input.



(a) Pr. 73 setting is 0 to 5

(b) Pr. 73 setting is 10 to 15

Auxiliary Input Characteristics

1) Multi-speed input compensation
Setting "1" in Pr. 28, multi-speed input compensation selection (factory setting = 0), adds the voltage of the auxiliary input terminal 1 to the multi-speed operation in Section 1.4.7.

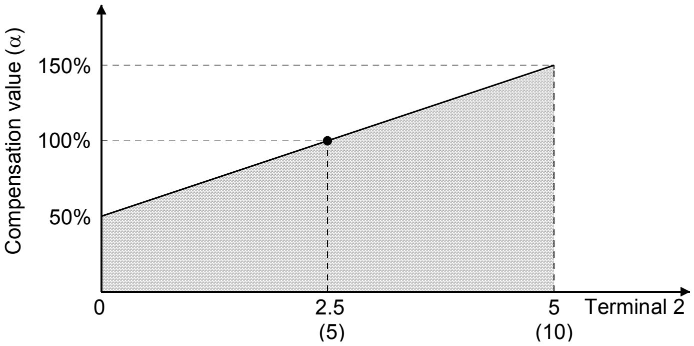
Inverter Output According to Start Signal and Auxiliary Input Terminal Polarity

Pr. 73 Setting	Added Command Voltage	Start Signal Input	
		STF-SD	STR-SD
0 to 5	+	Forward rotation	Reverse rotation
	–	Stop	Stop
10 to 15	+	Forward rotation	Reverse rotation
	–	Reverse rotation	Forward rotation

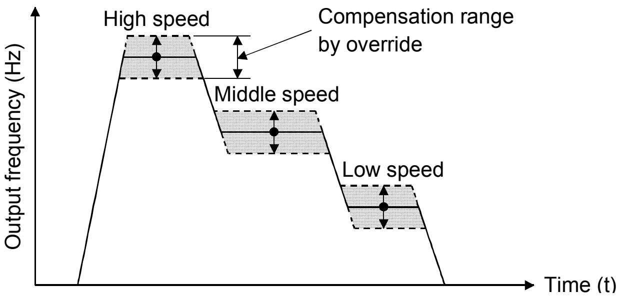
2) Override

For the above auxiliary input, a fixed compensation value is applied to each speed.

The override function allows each speed to be easily changed at a constant rate. Set any of 4, 5, 14 and 15 in Pr. 73 to use the override function. The override allows the multiple speeds set in the parameters, analog input across terminals 1-5, or current input across terminals 4-5 to be changed at a constant rate between 50% and 150% according to the external analog signal input to across terminals 2-5.



Override Setting Signal and Compensation Value

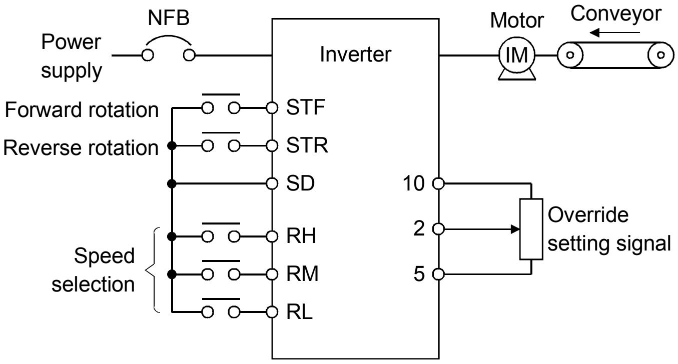


Override Operation for Multiple Speeds

How to find each speed (frequency (f))

$$f = fpr. \times \frac{\alpha}{100} \ [Hz]$$

fpr. : speed setting [Hz]
Multiple speeds
Analog input across terminals 1-5
Current input across terminals 4-5
α : override compensation value [%]
(Analog input across terminals 2-5)



Override Connection Example

3) 4 to 20mA current input compensation

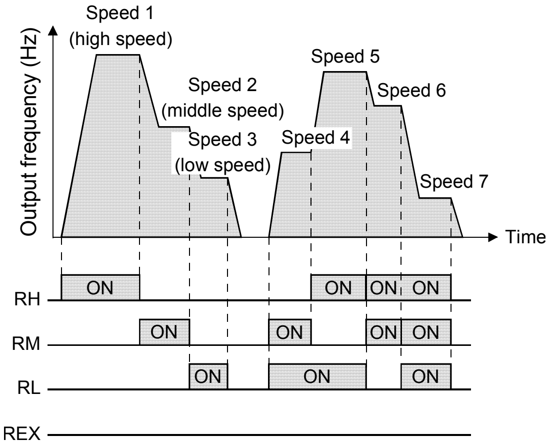
When the current input select terminal AU-SD are shorted, the current input of 4 to 20mADC across frequency setting (current input) terminals 4-5 has precedence over the voltage input across frequency setting (voltage signal) terminals 2-5, but the voltage signal across the auxiliary frequency setting input terminal 1-5 is added to the current input across terminals 4-5.

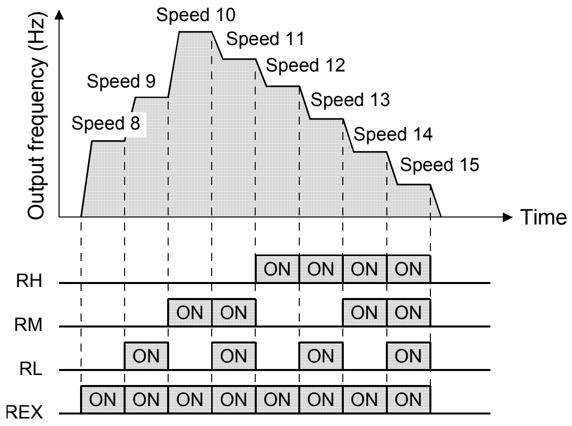
1.4.7 External frequency selection (REX, RH, RM, RL) COMMON

Up to 15 speeds may be selected according to the combination of connecting the multi-speed select terminals REX (Note 1), RH, RM and RL-SD, and multi-speed operation can be performed as shown below by shorting the start signal terminal STF (STR)-SD.

Speeds (frequencies) may be specified optionally from the operation panel or parameter unit as indicated in the table.

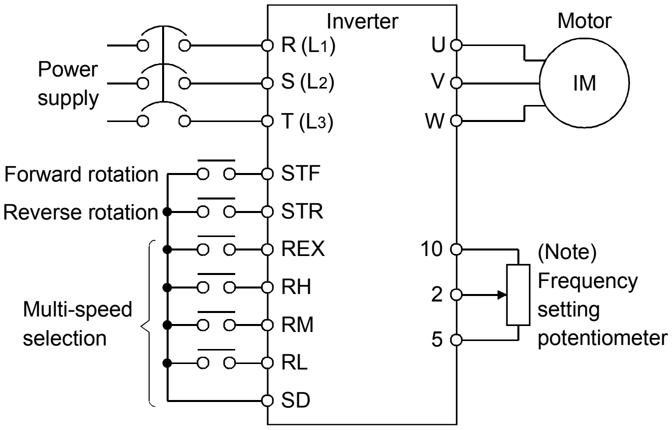
Note:
1. Assign the 15-speed select signal (REX) to any of the input terminals.
2. Each of the multiple speeds may be compensated for by the external analog signal. (Refer to Section 1.4.6 (4).)
3. Has precedence over the main speed setting signal (0 to 5V, 0 to 10V, 4 to 20mA DC).





Multi-Speed Setting

Speed	Terminal Input				Function Number	Set Frequency Range	Remarks
	REX-SD	RH-SD	RM-SD	RL-SD			
Speed 1 (high speed)	OFF	ON	OFF	OFF	Pr. 4	0 to 400Hz	
Speed 2 (middle speed)	OFF	OFF	ON	OFF	Pr. 5	0 to 400Hz	
Speed 3 (low speed)	OFF	OFF	OFF	ON	Pr. 6	0 to 400Hz	
Speed 4	OFF	OFF	ON	ON	Pr. 24	0 to 400Hz,9999	Pr. 6 setting when Pr. 24 = 9999
Speed 5	OFF	ON	OFF	ON	Pr. 25	0 to 400Hz,9999	Pr. 6 setting when Pr. 25 = 9999
Speed 6	OFF	ON	ON	OFF	Pr. 26	0 to 400Hz,9999	Pr. 5 setting when Pr. 26 = 9999
Speed 7	OFF	ON	ON	ON	Pr. 27	0 to 400Hz,9999	Pr. 6 setting when Pr. 27 = 9999
Speed 8	ON	OFF	OFF	OFF	Pr. 232	0 to 400Hz,9999	Pr. 6 setting when Pr. 232 = 9999
Speed 9	ON	OFF	OFF	ON	Pr. 233	0 to 400Hz,9999	Pr. 6 setting when Pr. 233 = 9999
Speed 10	ON	OFF	ON	OFF	Pr. 234	0 to 400Hz,9999	Pr. 5 setting when Pr. 234 = 9999
Speed 11	ON	OFF	ON	ON	Pr. 235	0 to 400Hz,9999	Pr. 6 setting when Pr. 235 = 9999
Speed 12	ON	ON	OFF	OFF	Pr. 236	0 to 400Hz,9999	Pr. 4 setting when Pr. 236 = 9999
Speed 13	ON	ON	OFF	ON	Pr. 237	0 to 400Hz,9999	Pr. 6 setting when Pr. 237 = 9999
Speed 14	ON	ON	ON	OFF	Pr. 238	0 to 400Hz,9999	Pr. 5 setting when Pr. 238 = 9999
Speed 15	ON	ON	ON	ON	Pr. 239	0 to 400Hz,9999	Pr. 6 setting when Pr. 239 = 9999
External setting	OFF	OFF	OFF	OFF	Frequency setting potentiometer	0 to maximum setting	



Multi-Speed Operation Connection Example

Note: When the frequency setting potentiometer is connected, the input signal of the frequency setting potentiometer is ignored if the multi-speed select signal is switched on. (This also applies to the 4 to 20mA input signal.)

Four-Speed Setting Example

Speed	Function Number	Set Value	Terminal Input				Running Frequency (Hz)
			REX-SD	RH-SD	RM-SD	RL-SD	
Speed 1 (high speed)	Pr. 4	60	OFF	ON	OFF	OFF	60
Speed 2 (middle speed)	Pr. 5	30	OFF	OFF	ON	OFF	30
Speed 3 (low speed)	Pr. 6	10	OFF	OFF	OFF	ON	10
Speed 4	Pr. 24	15	OFF	OFF	ON	ON	15
Speed 5	Pr. 25	9999	OFF	ON	OFF	ON	10
Speed 6	Pr. 26	9999	OFF	ON	ON	OFF	30
Speed 7	Pr. 27	9999	OFF	ON	ON	ON	10
Speed 8	Pr. 232	9999	ON	OFF	OFF	OFF	10
Speed 9	Pr. 233	9999	ON	OFF	OFF	ON	10
Speed 10	Pr. 234	9999	ON	OFF	ON	OFF	30
Speed 11	Pr. 235	9999	ON	OFF	ON	ON	10
Speed 12	Pr. 236	9999	ON	ON	OFF	OFF	60
Speed 13	Pr. 237	9999	ON	ON	OFF	ON	10
Speed 14	Pr. 238	9999	ON	ON	ON	OFF	30
Speed 15	Pr. 239	9999	ON	ON	ON	ON	10

1.4.8 Jog operation (JOG*) COMMON

(*JOG is not provided for E500)

(1) Jog operation using external signals A500

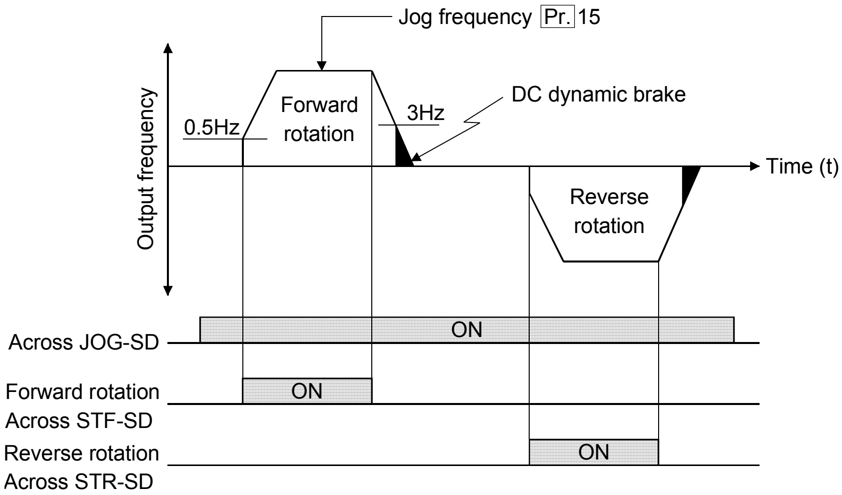
Jog operation can be started/stopped by shorting the jog mode select terminal JOG-SD and shorting/opening the start signal terminal STF or STR-SD. The jog frequency and jog acceleration/deceleration time are set in Pr. 15 (factory setting 5Hz, variable between 0 and 400Hz) and Pr. 16 (factory setting 0.5 seconds, variable between 0 and 3600 seconds), respectively, and their settings can be changed from the operation panel or parameter unit.

(2) Jog operation using operation panel or parameter unit COMMON

Also, the PU operation mode of the operation panel or parameter unit may be used to perform jog operation.

In this case, the jog frequency is set in Pr. 15 and jog acceleration/deceleration time in Pr. 16 and the forward and reverse rotation keys are used to perform jog operation.

In the jog operation mode, multi-speed compensation and polarity reversible operation are made invalid.



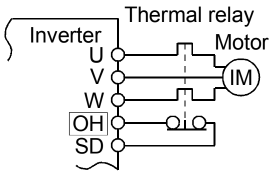
Jog Operation Timing Chart

1.4.9 External thermal relay input (OH) COMMON

When the external thermal relay or thermal relay built in the motor is actuated, the inverter output is shut off and an alarm signal is given to keep the motor stopped in order to protect the motor from overheating. If the thermal relay contact is reset, the motor is not restarted unless the reset terminal RES-SD are shorted for more than 0.1 second and then opened or power-on reset is performed.

The function may therefore be used as an external emergency stop signal input.

Note: Assign the external thermal relay input signal (OH) to any of the input signals.



External Thermal Relay Input Connection Example

1.4.10 Second and third acceleration/deceleration time selection (RT, X9*) COMMON

(*X9 is not provided for E500)

The second and third acceleration/deceleration functions may be used to:

1) Switch between ordinary use and emergency use;
2) Switch between heavy load and light load;
3) Change acceleration/deceleration time according to polygonal pattern acceleration/deceleration;
4) Switch between the main motor and sub motor characteristics; and
5) Switch between the intelligent functions (Note 1) (refer to Section 1.6.20).

The acceleration/deceleration time, torque boost and base frequency depend on the state across terminals RT (X9)-SD as follows:

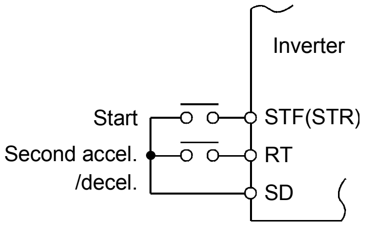
(1) When terminals RT (X9)-SD are open, acceleration is made at an operation start according to the acceleration time set in Pr. 7 and deceleration is made according to the deceleration time set in Pr. 8.
For the torque boost and base frequency, operation is performed at the values set in Pr. 0 and Pr. 3, respectively.

(2) When terminals RT (X9)-SD are shorted, acceleration/deceleration is made according to the time different from the acceleration/deceleration time in paragraph (1). This time is as set in Pr. 44 (Pr.110) or Pr. 45 (Pr. 111).
The torque boost and base frequency use the values set in the second (third) torque boost Pr. 46 (Pr. 112) and the second (third) V/F Pr. 47 (Pr. 113), respectively.

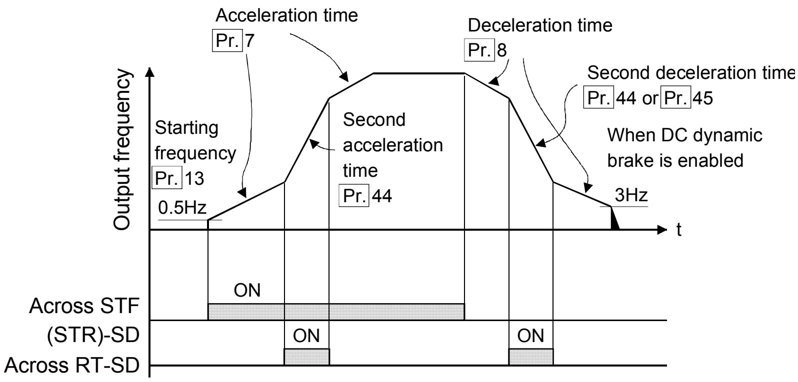
(3) For E500, the value of the electronic overcurrent protection can also be changed. The value is as set in Pr. 48 when terminals RT-SD are shorted, and is as set in Pr. 9 when terminals RT-SD are opened.

- When the second (third) deceleration time set in Pr. 45 (Pr. 111) is 9999
  The acceleration time and deceleration time are equal and as set in the second (third) acceleration/deceleration time Pr. 44 Pr. 110).
- When the second (third) deceleration time set in Pr. 45 (Pr. 111) is between 0 and 3600 s
  The acceleration time is as set in Pr. 44 (Pr. 110) and deceleration time is as set in Pr. 45 (Pr. 111).
- When the second (third) torque boost set in Pr. 46 (Pr. 112) is 9999
  The torque boost value is as set in Pr. 0 when terminals RT (X9)-SD are either open or shorted.
- When the second (third) V/F (base frequency) set in Pr. 47 (Pr. 113) is 9999
  The base frequency is as set in Pr. 3 when terminals RT (X9)-SD are either open or shorted.
- When the second electronic overcurrent protection set in Pr. 48 is 9999 for E500
  The electronic overcurrent protection value is as set in Pr. 9 when terminals RT (X9)-SD are either open or shorted.

Note: 1. Not provided for E500.
2. For E500, assign the second function selection signal (RT) to any of the input terminals.
3. For A500, assign the third function selection signal (X9) to any of the input terminals.



Second Acceleration/Deceleration Connection Example



Example of Using Second Acceleration/Deceleration

For A500, the RT signal activated condition can be set in Pr. 155.

Parameter Number	Function Name	Setting Range	Setting	Description	Factory Setting
155	RT signal activated condition selection	0, 10	0	Made valid immediately by switching the RT signal on-off.	○
			10	Made valid only when the RT signal is on at constant speed. (Invalid during acceleration/deceleration)	—

For E500, the function is made valid immediately by switching the RT signal on-off.

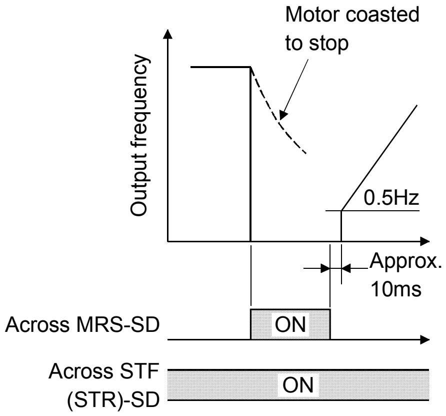
1.4.11 Inverter output stop (MRS) COMMON

Short the output stop terminal MRS-SD during inverter output to cause the inverter to immediately stop the output. Open terminals MRS-SD to resume operation in about 10ms. Terminal MRS may be used as described below:

(1) To stop the motor by mechanical brake (e.g. electromagnetic brake)
Terminals MRS-SD must be shorted when the mechanical brake is operated and be opened before motor restart.

(2) To provide interlock to disable operation by the inverter
After MRS-SD have been shorted, the inverter cannot be operated if the start signal is given to the inverter.

(3) To coast the motor to stop
Ordinarily, the motor is decelerated according to the preset deceleration time and is stopped by operating the DC dynamic brake at 3Hz or less. By using terminal MRS, the motor is coasted to a stop.



Output Stop Timing Chart

1.4.12 Reset signal (RES) Common

Used to reset the alarm stop state established by the inverter's protective function activated. The reset signal immediately sets the control circuit to the initial (cold) sate, e.g. initializes the electronic overcurrent protection and built-in brake resistor overheat protection circuit. It shuts off the inverter output at the same time. During reset, the inverter output is kept shut off. To give this reset input, short terminals RES-SD for more than 0.1 s. When the shorting time is long, the operation panel or parameter unit displays the initial screen, which is not a fault. Operation is enabled within 0.2 s after terminals RES-SD are opened.

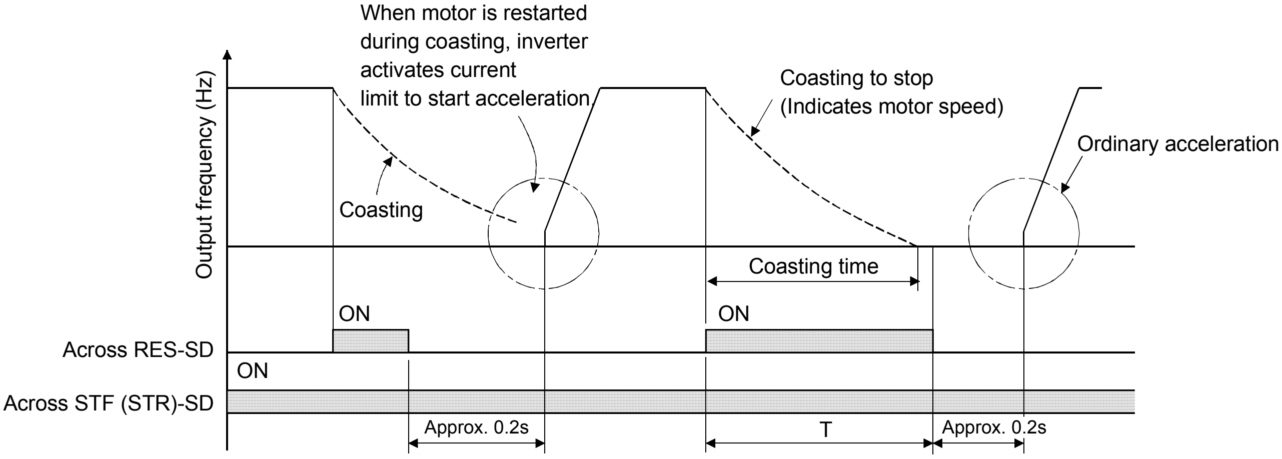
The reset terminal is used to reset the inverter alarm stop state. If the reset terminal is shorted, then opened while the inverter is running, the motor may be restarted during coasting (refer to the timing chart below) and the output may be shut off due to overvoltage.

Note: Frequent resetting will make the electronic overcurrent protection and brake resistor overheat protection invalid.

Setting any of 1, 3, 15 and 17 in reset selection Pr. 75 allows the accidental input of the reset signal during operation to be unaccepted.

Setting of Reset Input Selection Pr. 75

Pr. 75 Setting	Reset Selection	PU Disconnection Detection	PU Stop Selection
0	Reset input normally enabled	Operation is continued unchanged if the PU is removed.	Only in the PU operation mode, the motor is decelerated to a stop when the [STOP] key is pressed.
1	Reset input is enabled only when protective function is activated		
2	Reset input normally enabled	When the PU is removed, the PU displays error and the inverter output is shut off.	
3	Reset input is enabled only when protective function is activated		
14	Reset input normally enabled	Operation is continued unchanged if the PU is removed.	In any of the PU, external and communication operation modes, the motor is decelerated to a stop when the [STOP] key is pressed.
15	Reset input is enabled only when protective function is activated		
16	Reset input normally enabled	When the PU is removed, the PU displays error and the inverter output is shut off.	
17	Reset input is enabled only when protective function is activated		



T: Should be longer than the time of coasting to stop.

Reset Input Timing Chart during Normal Operation

1.4.13 Automatic restart after instantaneous power failure selection (CS*) (COMMON)

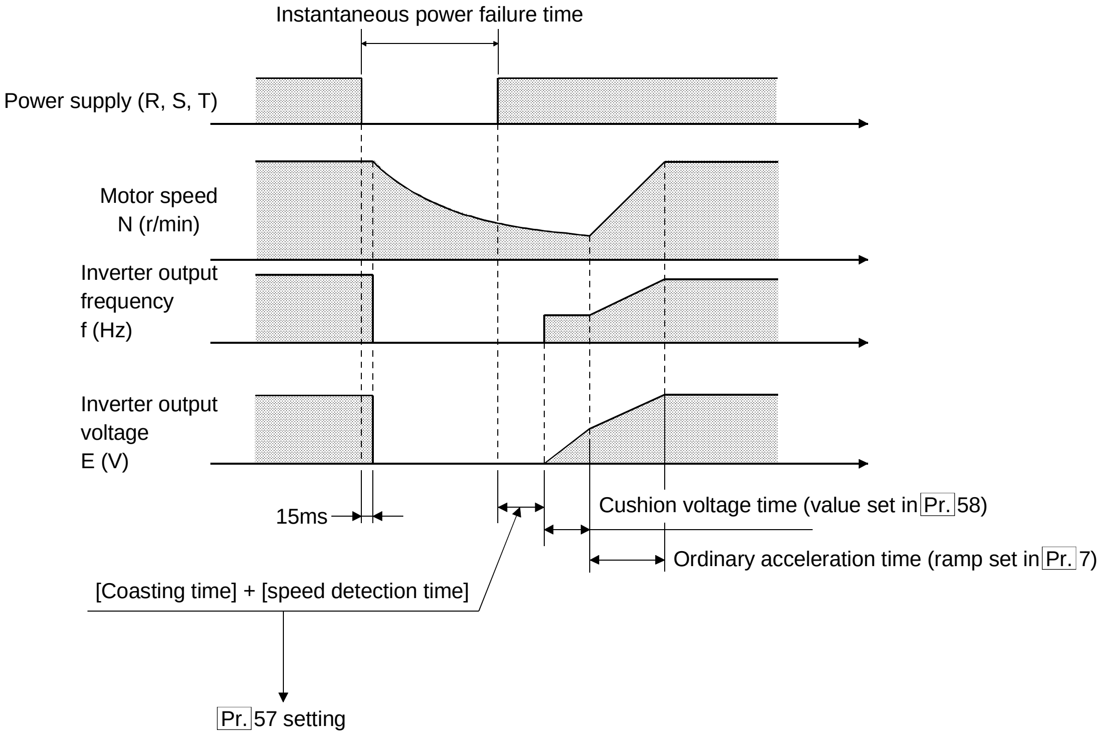
(*CS is not provided for (E500))

This function allows the motor to be restarted automatically when power is restored after an instantaneous power failure. (For more information, refer to Section 1.6.19.)

(1) With frequency search (A500)

Detecting the speed of the coasting motor during power restoration, this function allows the motor to smoothly return to its original speed.

1) To disable automatic restart after instantaneous power failure
   Set 9999 (factory setting) in Pr. 57 (reset time for automatic restart after instantaneous power failure) to disable automatic restart after instantaneous power failure.
2) To enable automatic restart after instantaneous power failure
   Change 9999 (factory setting) in Pr. 57 to 0 and change the Pr. 162 value to 0 (factory setting). By shorting terminals CS-SD, the motor, if it is coasting, restarts automatically at the time of power restoration after instantaneous power failure. Note that if the time to restore the power is longer than the coasting-to-stop time, the motor is restarted after it has stopped once.
   When the function of automatic restart after instantaneous power failure has been selected, power-related alarm outputs (instantaneous power failure (E.IPF) and undervoltage (E.UVT)) are not provided if an instantaneous power failure occurs. Note that the inverter cannot be operated when terminals CS-SD are open.
3) When you do not use the function of automatic restart after instantaneous power failure
   In this case, the motor speed is not detected for smooth restart but the current limit function is utilized for restart. Depending on the magnitude (load inertia, etc.) of the load, acceleration may be made after the motor speed has significantly reduced. If the load inertia is extremely large, the protective circuit may be activated (E.OV1 to E.OV3 or E.THT).
   Action taken for E.OVT
   ・ Increase the value set in Pr. 22.

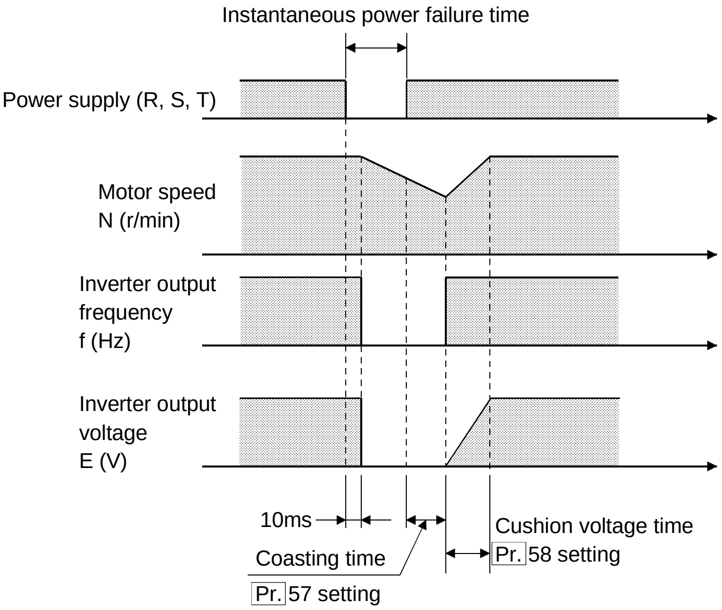


Timing Chart for Restart with Frequency Search

(2) Without frequency search COMMON

This function allows the motor to restart at the time of power restoration at the frequency before the occurrence of an instantaneous power failure and return to its original speed.

1) To disable automatic restart after instantaneous power failure
   Set 9999 (factory setting) in Pr. 57 (reset time for automatic restart after instantan-eous power failure) to disable automatic restart after instantaneous power failure.
2) To enable automatic restart after instantaneous power failure
   Change 9999 (factory setting) in Pr. 57 to 0. For A500, further change the Pr. 162 value to 1.
   If power is restored while control power remains, the motor restarts at the frequency before the occurrence of an instantaneous power failure.
   If control power is lost during a long instantaneous power failure, the operation of automatic restart after instantaneous power failure is not performed at the time of power restoration and the motor starts at the starting frequency. In this case, the operation performed is as described in paragraph
3) When you do not use the function of automatic restart after instantaneous power failure
   In this case, the motor speed is not detected for smooth restart but the current limit function is utilized for restart. Depending on the magnitude (load inertia etc.) of the load, acceleration may be made after the motor speed has significantly reduced. If the load inertia is extremely large, the protective circuit may be activated (E.OV1 to E.OV3 or E.THT).
   Action taken for E.OVT
   · Increase the value set in Pr. 22.

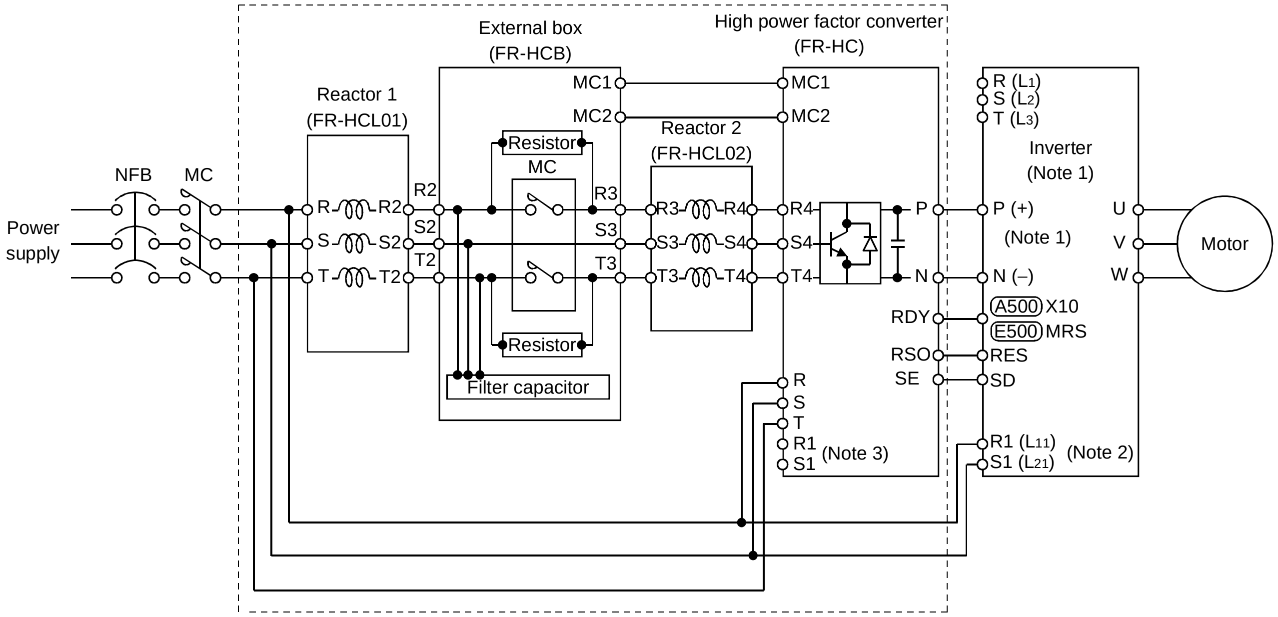


Timing Chart for Restart without Frequency Search

1.4.14 High power factor converter connection (X10*, X11*) COMMON

(*X10 and X11 are not provided for E500)

Used with the inverter in accordance with the Japanese harmonic suppression guidelines issued by the Ministry of International Trade and Industries, the high power factor converter (FR-HC) is an optional high power factor inverter unit designed to suppress harmonics to the input power supply.
For E500, set "0" in Pr. 30 and make connections as shown below.
For A500, set "2" in Pr. 30 and make connections as shown below.
Terminal MRS may be used when the FR-HC connection (inverter operation enable) signal (X10) (Note) is not used. Also, when the computer link inboard option (FR-A5NR) is used and the setting is made to hold the mode at the time of an instantaneous power failure, holding operation is performed by the FR-HC connection (instantaneous power failure detection) signal (X11).
Note: Allocate the FR-HC connection signals (X10, X11) to any of the input terminals.



Note: 1. Always keep the inverter's power input terminals R, S, T open.
If connections are made to them accidentally, the inverter will be damaged. Also, reverse polarity of terminals P and N will damage the high power factor converter and inverter.
2. For A500 , separate power may be supplied to terminals R1 and S1.
3. Make no connections to the terminals R1 and S1 of the high power factor converter.

High Power Factor Converter Connection and Wiring Example

Having a power return function, the high power factor converter returns power in the regenerative mode. For A500 7.5K or less, the brake circuit built in the inverter is not activated.
Undervoltage and instantaneous power failure are detected by the high power factor converter. When the protective function of the high power factor converter is activated, the inverter operation enable signal shuts off the inverter output. The undervoltage and instantaneous power failure protective functions of the inverter itself are made invalid.

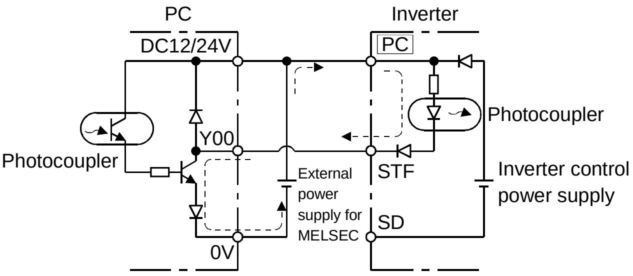
When you need automatic restart after instantaneous power failure, choose automatic restart after instantaneous power failure in the inverter and also set the parameter to activate automatic restart after instantaneous power failure in the high power factor converter. The inverter restarts in accordance with the automatic restart after instantaneous power failure of the high power factor converter.

1.4.15 24VDC and external transistor common (PC) COMMON

When the transistor output (open collector) of a programmable controller (PC) having an external power supply is input to the inverter, supply external interface power to prevent a malfunction from occurring due to leakage current as shown on the right.

Making connections as shown on the right supplies external power to the photocoupler in the inverter as indicted by the dotted lines. Since terminal SD is not connected, no power is supplied to the photocoupler from the control power supply of the inverter.

Also, terminals PC-SD may be used as a 24VDC 0.1A power output. When using terminals PC-SD as a 24VDC power supply, a malfunction due to leakage current cannot be prevented.

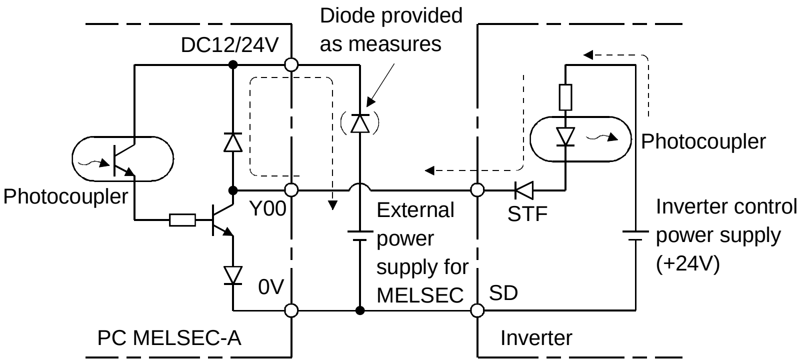


Terminal PC Connection Example

When terminal PC is not used

When the control power supply voltage in the inverter connected with the output module (open collector output) of the programmable controller has become higher than the external power supply voltage of the PC as shown below, a current indicated by the dotted lines flows if the transistor of the PC is not on, accidentally giving the inverter a command signal.

- Measures
  (1) Insert a diode to prevent leakage current.
  (2) Use an all-point independent type output module (such as AY40A).



Connection Example without Terminal PC Being Used

1.4.16 Output signals (RUN, SU, IPF, OL, FU, A, B, C) COMMON

(1) Output terminal function assignment COMMON

The inverter has output terminals whose functions can be changed by parameter setting.

1) A500

When Pr. 76 = 0 (factory setting), terminals RUN, SU, IPF, OL, FU, A, B and C are assigned functions by Pr. 190 to Pr. 195 respectively.

Parameter Number	Function Name	Setting Range	Factory Setting
190	RUN terminal function selection	0 to 199, 9999	0 (inverter running (RUN))
191	SU terminal function selection	0 to 199, 9999	1 (up to frequency (SU))
192	IPF terminal function selection	0 to 199, 9999	2 (instantaneous power failure/undervoltage (IPF))
193	OL terminal function selection	0 to 199, 9999	3 (overload alarm (OL))
194	FU terminal function selection	0 to 199, 9999	4 (output frequency detection (FU))
195	ABC terminal function selection	0 to 199, 9999	99 (alarm output (ABC))

Setting		Signal Name	Function	Operation	Related Parameters
Positive logic	Negative logic				
0	100	RUN	Inverter running	Output during operation when the inverter output frequency rises to or above the starting frequency.	—
1	101	SU	Up to frequency	Refer to Pr. 41 "up-to-frequency sensitivity".	Pr. 41
2	102	IPF	Instantaneous power failure or undervoltage	Output at occurrence of an instantaneous power failure or undervoltage.	—
3	103	OL	Overload alarm	Output while stall prevention function is activated.	Pr. 22, 23, 66, 148, 149, 154
4	104	FU	Output frequency detection	Refer to Pr. 42 Pr. 43 (output frequency detection).	Pr. 42, 43
5	105	FU2	Second output frequency detection	Refer to Pr. 50 "second output frequency detection".	Pr. 50
6	106	FU3	Third output frequency detection	Refer to Pr. 116 "third output frequency detection".	Pr. 116
7	107	RBP	Regenerative brake pre-alarm	Output when 85% of the regenerative brake duty set in Pr. 70 is reached.	Pr. 70
8	108	THP	Electronic overcurrent protection prealarm	Output when the electronic overcurrent protection cumulative value reaches 85% of the preset level.	Pr. 9
9	109	PRG	Program mode	Output in the program mode.	Pr. 79, 200 to 231
10	110	PU	PU operation mode	Output when the PU operation mode is selected.	Pr. 17 = 0 to 3
11	111	RY	Inverter operation ready	Output when the inverter can be started by switching the start signal on and while it is running.	—
12	112	Y12	Output current detection	Refer to Pr. 150 and Pr. 151 (output current detection).	Pr. 150, 151
13	113	Y13	Zero current detection	Refer to Pr. 152 and Pr. 153 (zero current detection).	Pr. 152, 153
14	114	FDN	PID lower limit	Refer to Pr. 128 to Pr. 134 (PID control).	Pr. 128 to 134
15	115	FUP	PID upper limit		
16	116	RL	PID forward-reverse rotation output		
17	—	MC1	Commercial power supply-inverter switch-over MC1	Refer to Pr. 135 to Pr. 139 (commercial power supply-inverter switch-over).	Pr. 135 to 139
18	—	MC2	Commercial power supply-inverter switch-over MC2		
19	—	MC3	Commercial power supply-inverter switch-over MC3		

Setting		Signal Name	Function	Operation	Related Parameters
Positive logic	Negative logic				
20	120	BOF	Brake open request	Refer to Pr. 278 to Pr. 285 (brake sequence function).	Pr. 278 to 285
25	125	FAN	Fan failure output	Output at the time of fan failure.	—
26	126	FIN	Fin overheat prealarm	Output when the heat sink temperature reaches about 85% of the fin overheat protection activating temperature.	—
98	198	LF	Light fault output	Output when a minor fault occurs.	—
99	199	ABC	Alarm output	Output when the inverter's protective function is activated to stop the output (major fault).	—
9999		—	No function	—	—

2) E500

Terminals RUN, FU, A, B and C are assigned functions by Pr. 190 to Pr. 192, respectively.

Parameter Number	Function Name	Setting Range	Factory Setting
190	RUN terminal function selection	0 to 99	0 (inverter running (RUN))
191	FU terminal function selection	0 to 99	4 (output frequency detection (FU))
192	ABC terminal function selection	0 to 99	99 (alarm output (ABC))

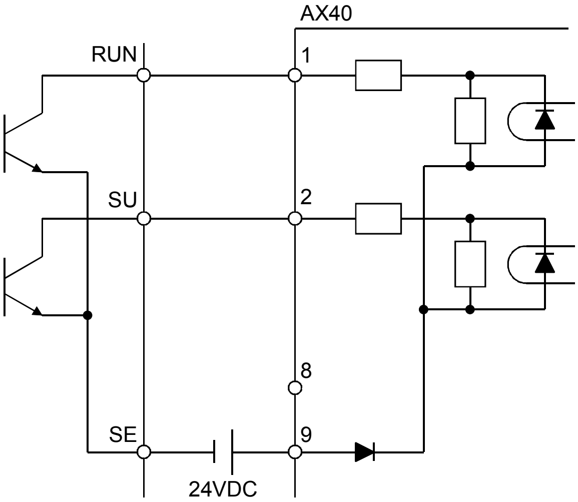
Setting	Signal Name	Function	Operation	Related Parameters
Positive logic				
0	RUN	Inverter running	Output during operation when the inverter output frequency rises to or above the starting frequency	—
1	SU	Up to frequency	Refer to Pr. 41 "up-to-frequency sensitivity".	Pr. 41
3	OL	Overload alarm	Output while stall prevention function is activated.	Pr. 22, 23, 66, 154
4	FU	Output frequency detection	Refer to Pr. 42, Pr. 43 (output frequency detection).	Pr. 42, 43
11	RY	Inverter operation ready	Output when the inverter can be started by switching the start signal on.	—
12	Y12	Output current detection	Refer to Pr. 150 and Pr. 151 (output current detection).	Pr. 150, 151
13	Y13	Zero current detection	Refer to Pr. 152 and Pr. 153 (zero current detection).	Pr. 152, 153
14	FDN	PID lower limit	Refer to Pr. 128 to Pr. 134 (PID control).	Pr. 128 to 134
15	FUP	PID upper limit		
16	RL	PID forward-reverse rotation output		
98	LF	Light fault output	Output when a minor fault occurs.	—
99	ABC	Alarm output	Output when the inverter's protective function is activated to stop the output (major fault).	—

(2) Open collector output signal control logic (A500)

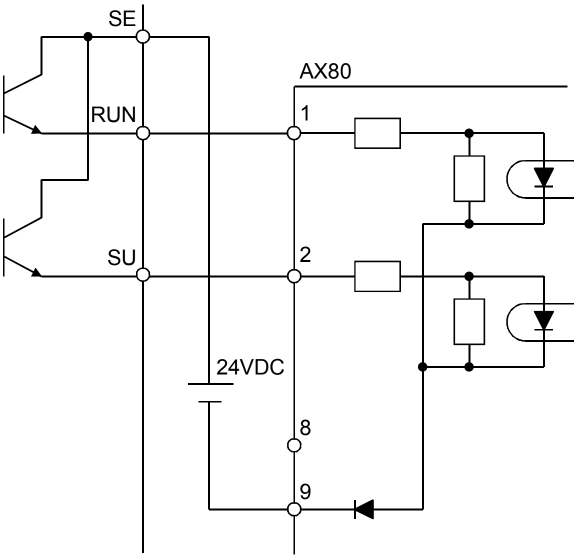
Either of the sink and source logic types may be used as the output signal control logic. The connector position etc. need not be changed.

In the sink logic type, a signal switches on when a current flows out of the corresponding signal input terminal. Terminal SE is a common terminal.

In the source logic type, a signal switches on when a current flows into the corresponding signal input terminal. Terminal SE is a common terminal.



Sink Logic Type



Source Logic Type

(3) Alarm output (contact output) (COMMON)

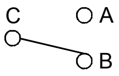
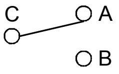
For alarm output, a changeover contact is used and its operation is shown in the right table.

When any of the protective functions have been activated, the ALARM lamp is lit and remains lit. If the contact is opened by the magnetic contactor etc. in the inverter power supply, the inverter control power is lost and the alarm output signal cannot be kept on. To keep the alarm output signal on, the alarm output contact (across terminals B-C) must be kept open by the external circuit. For (A500), the alarm output signal can be kept on by using terminals R1, S1 to connect the control circuit with the other power supply. (Refer to Section 1.4.2.)

In this case, if the current limit function, stall prevention, fan failure or brake discharge resistor overheat protection function is activated, the alarm output is not switched on, terminals B-C remain closed, and the ALARM lamp is not lit.

When protective functions have been activated, their history can be read in the monitoring mode of the operation panel or parameter unit.

Alarm Relay Operation and Lamp On/Off

Status	Contact Operation	ALARM Lamp	Terminals
Normal or inverter power off	The relay coil is kept de-energized and the N/C (normally closed) contact closed.	Off	
Alarm	When the protective function is activated, the relay coil is energized, the N/C contact is opened, and the N/O (normally open) contact closed. However, the contact does not operate when a fan failure occurs.	On	

(4) Description of the output functions (COMMON)

The following description assumes that the logic setting is positive.

1) Inverter running (RUN) (COMMON)

The output signal is ON (low) when the inverter is running at or above the starting frequency, and is OFF (high) during inverter stop and DC dynamic brake operation.

2) Up-to-frequency (SU) (COMMON)

The output is provided (switched low) when the output frequency (estimated speed for advanced (general-purpose) magnetic flux vector control) has reached the preset frequency. The up-to-frequency signal sensitivity (*) is set in Pr. 41 and is adjustable between ±1 and ±100% with respect to the set frequency (fs).

When the speed is changed by switching the speed command from one to another as in multi-speed operation, the output of SU is not switched off but is kept on if the other speed is included in the up-to-frequency sensitivity range.

A long acceleration/deceleration time will make the output instable.

3) Frequency detection (FU, FU2 (Note 1), FU3 (Note 1)) (COMMON)

The output is switched on when the output frequency (estimated speed for advanced (general-purpose) magnetic flux vector control) has reached or exceeded the frequency set in the output frequency detection parameter.

FU : Set in Pr. 42 (Pr. 43 for reverse rotation)

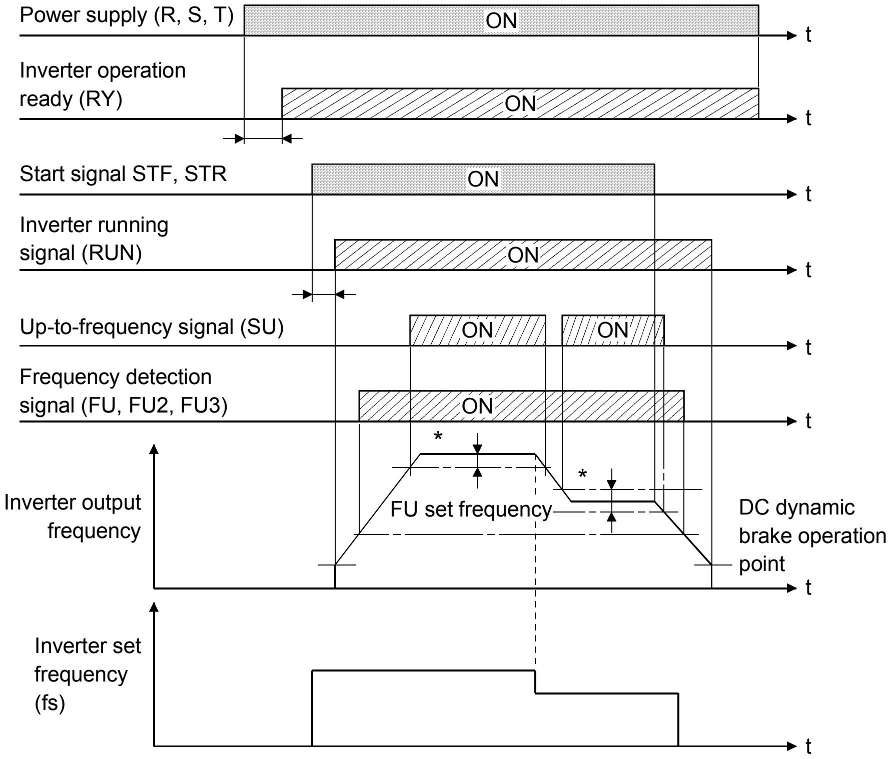
FU2 : Set in Pr. 50 (second output frequency detection) (Note 1)

FU3 : Set in Pr. 116 (third output frequency detection) (Note 1)

Note: 1. Not provided for (E500).

4) Inverter operation ready (RY) (COMMON)

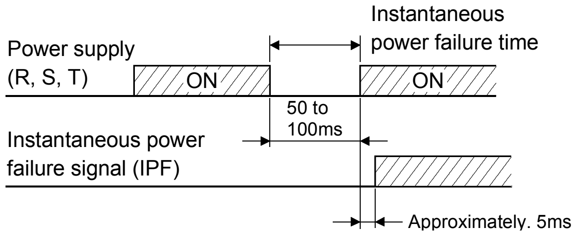
The output signal turns on when the inverter is ready to be started by switching on the start signal. The output is also ON during operation.



5) Instantaneous power failure (IPF) (A500)

The output is provided (switched low) when the instantaneous power failure or undervoltage protection is activated during inverter operation.

By selecting the function of automatic restart after instantaneous power failure (by setting a value other than 9999 in Pr. 57), the IPF/UVT signal is not output if an instantaneous power failure or undervoltage occurs.

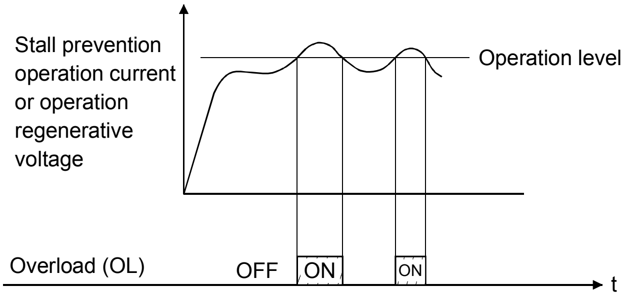


6) Overload (OL) (COMMON)

The output signal is switched on (low) for more than 100ms when stall prevention is activated due to the excess of the output current over the following value and is switched off (high) when stall prevention is deactivated due to the fall of the output current or regenerative voltage below the predetermined value.

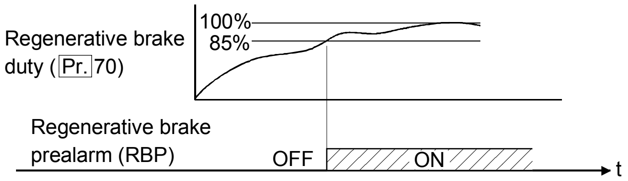
- Pr. 22: Stall prevention operation level
- Pr. 23: Stall prevention operation level at double speed
- Pr. 66: Stall prevention operation level reduction starting frequency
- Pr. 148 (Note 1): Stall prevention level at 0V input
- Pr. 149 (Note 1): Stall prevention level at 10V input
- Pr. 154: Voltage reduction selection during stall prevention operation

Note: 1. Not provided for (E500).



7) Regenerative brake pre-alarm (RBP) (A500)

The pre-alarm signal is output (switched low) when 85% of the regenerative brake duty set in Pr. 70 is reached. The pre-alarm signal is reset (switched high) when the duty falls below 85%.



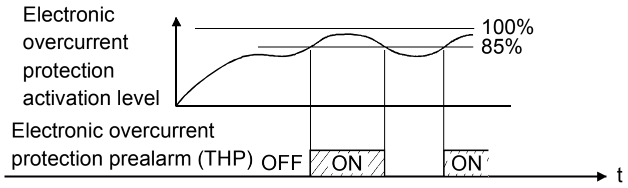
8) Electronic overcurrent protection pre-alarm (THP) (A500)

The pre-alarm signal is output (switched low) when the electronic overcurrent protection cumulative value reaches 85% of the preset level. The pre-alarm signal is reset (switched high) when the value falls below 85%.

- Electronic overcurrent protection cumulative value

  0%: Lower than the value set in Pr. 9

  100%: Electronic overcurrent protection activation value

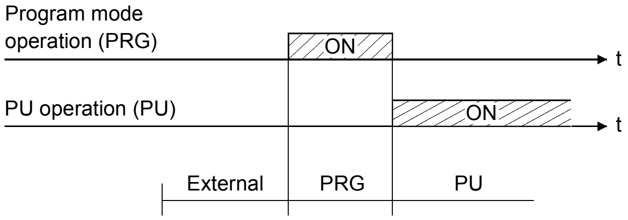


9) Program mode operation (PRG) (A500)

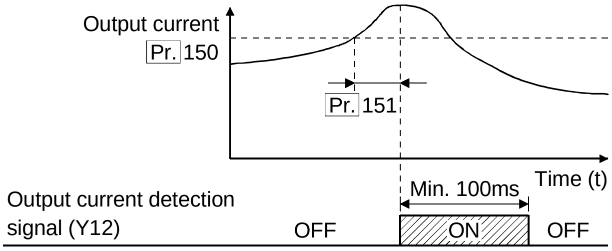
The output is provided (switched low) when 5 is set in Pr. 79, programmed operation mode.

10) PU mode operation (PU) (A500)

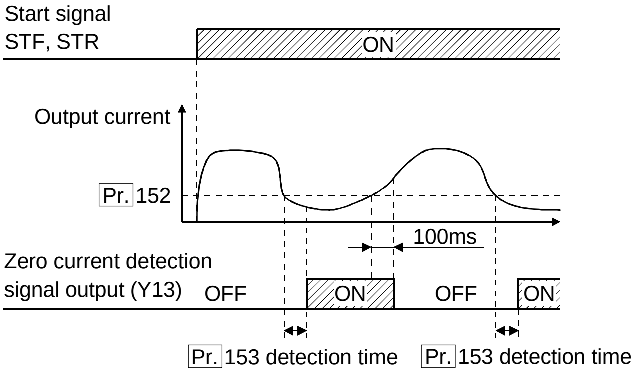
The output is provided (switched low) when the PU operation mode is selected.



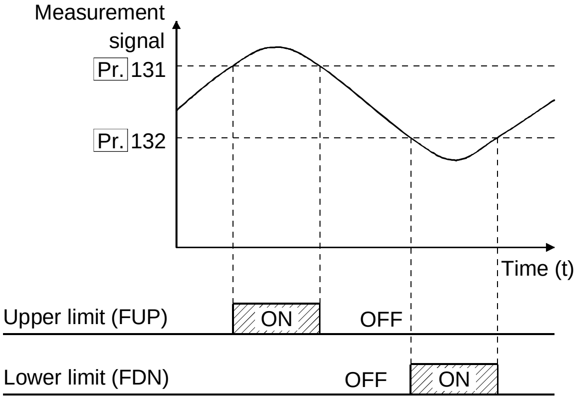
11) Output current detection (Y12) COMMON
The output is provided (switched low) when the output current remains higher than the value set in Pr. 150 for longer than the time set in Pr. 151 during inverter operation.
This signal can be utilized for over-torque detection, etc.



12) Zero current detection (Y13) COMMON
The output is provided (switched low) when the output current remains lower than the value set in Pr. 152 for longer than the time set in
Pr. 153 during inverter operation. If the condition does not hold, the signal remains on for approximately 100ms.
This signal can be utilized to detect whether or not output torque exists, for example.



13) PID upper, lower limits (FUP, FDN)
PID forward-reverse rotation output (RL) COMMON
Made valid when the X14 signal is turned on to start PID control.
The upper limit (FUP) is output (switched low) when the measurement signal exceeds the upper limit value set in Pr. 131, and the lower limit (FDN) is output (switched low) when the measurement signal exceeds the lower limit value set in Pr. 132.
The PID forward-reverse rotation output (RL) is provided (switched low) when the output indication of the parameter unit is forward rotation (FWD). This output is not provided when the indication is reverse rotation (REV) or stop (STOP).

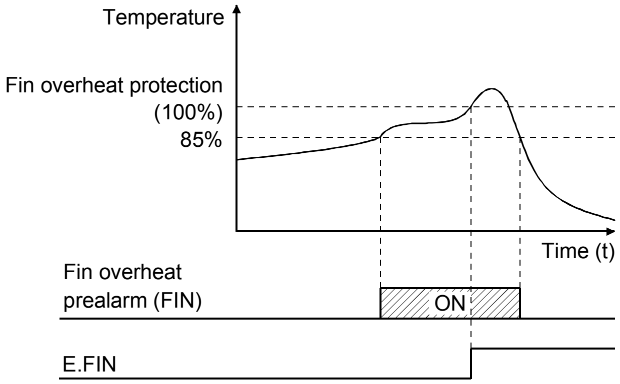


14) Commercial power supply-inverter switch-over (MC1, MC2, MC3) A500
When "1" is set in Pr. 135 to choose the commercial power supply-inverter switch-over sequence, the MC1 signal for MC across power supply-inverter, MC2 signal for MC across power supply-motor and MC3 signal for MC across inverter output-motor are output in accordance with the setting of the commercial power supply-inverter switch-over sequence.
These signals allow automatic changeover to commercial power supply operation in a system which cannot be stopped at occurrence of an inverter alarm, for example.
Note that this function is not activated at the time of the CPU error among the inverter alarms.
For more information, refer to Section 1.6.32.

15) Brake open request (BOF) A500
This function is activated when "7" or "8" is set in Pr. 60 to choose the brake sequence mode. Operate the electromagnetic brake according to the ON-OFF of the brake open request signal (BOF).
For details, refer to Section 1.6.44.

16) Fan failure output (FAN) A500
The output is provided (switched low) at the time of a fan failure.
However, the inverter does not come to an alarm stop and continues running.

17) Fin overheat prealarm (FIN) A500
The output is provided (switched low) when the heat sink temperature reaches about 85% of the fin overheat protection activating temperature.



18) Light fault output (LF) COMMON
The output is provided (switched low) when a minor fault occurs.

19) Alarm output (ABC) COMMON
The output is provided (switched low) when the inverter's protective function is activated to stop the output (major fault).

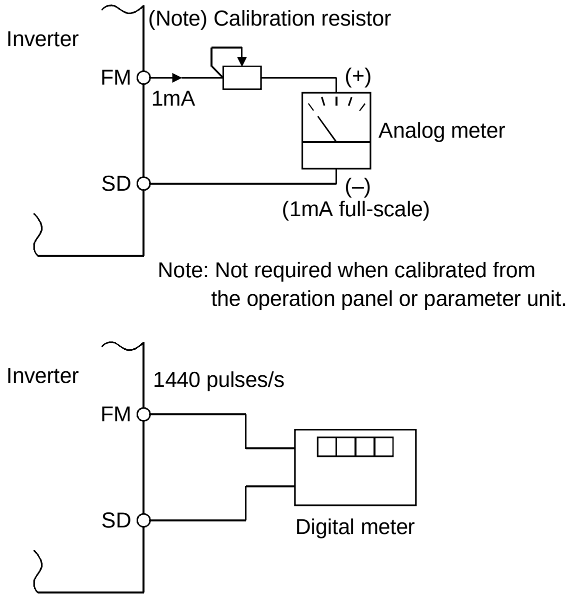
1.4.17 Meter connection and adjustment (FM) (COMMON)

The output frequency etc. of the inverter can be indicated by a DC ammeter of 1mA full-scale and max. 300Ω internal resistance or a commercially available digital meter which is connected across terminals FM-SD.

The meter can be calibrated from the operation panel or parameter unit. Note that the reading varies according to the wiring distance if the meter is placed away from the inverter. In this case, connect a calibration resistor in series with the meter as shown below and adjust until the reading matches the operation panel or parameter unit indication (meter monitoring mode).

Install the meter within 200m (50m for the digital meter) of the inverter and connect them by at least 0.3mm^2 twisted or shielded cables.

Types of Meters Connected



Note: Not required when calibrated from the operation panel or parameter unit.

Types of Meters Connected

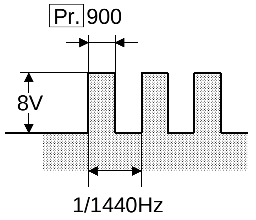
★ Up to two meters may be used in parallel but a digital meter cannot be used with an analog meter.

Output waveform of terminal FM

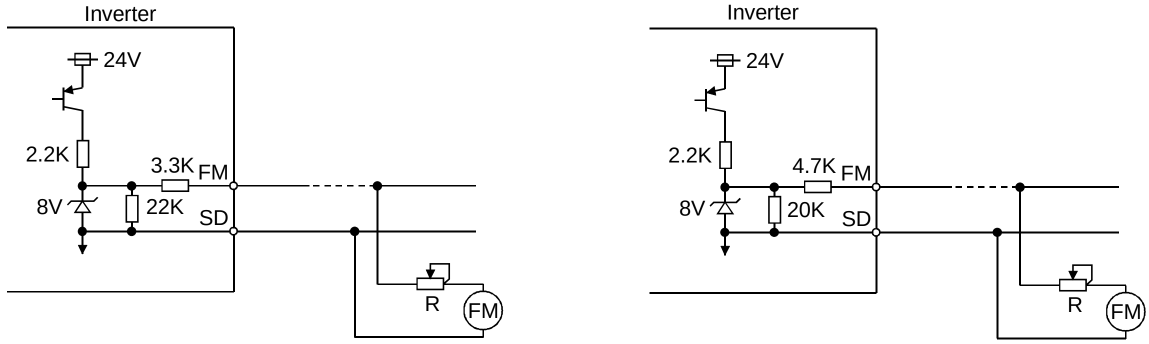
The output signal of terminal FM has a pulse waveform as shown in the table below and the number of its pulses is proportional to the inverter output frequency.

The output voltage (average voltage) is also proportional to the output frequency.

Terminal FM Output Voltage

	Specifications
Output waveform	
Number of output pulses (pulses/sec)	Max. 2400 pulses/s Set a full-scale value which achieves 1400 pulses/s. Pr. 55: frequency monitoring reference Pr. 56: current monitoring reference
Output voltage	0 to 8VDC maximum (Note 1) (Approximately 3.5V (Note 3) at 1400 pulses/s)

Note:
1. 0.5V or less when a DC ammeter of 300Ω internal resistance is connected to measure the output voltage.
2. Value in parentheses indicates factory setting.
3. Approximately 4.7V for (E500)



1) (A500) 2) (E500)

Examples of Inverters and Frequency Meters

Adjustment

- Analog meter

  To adjust the reading of an analog meter (ammeter), turn the calibration resistor to change the current.

  When using the operation panel or parameter unit for adjustment, change the pulse width of the output waveform (adjust the current through the adjustment of the output voltage) to adjust the reading.

  Note: It is not recommended to use a voltage type meter because it is easily affected by a voltage drop, induction noise etc. and cannot provide a correct reading if the wiring distance is long.

- Digital meter

  Since the digital meter counts and displays the number of pulses, adjust it from the operation panel or parameter unit.

  The inverter output, at which the reference pulses of 1440 pulses/s are output, can be set in Pr. 55 when frequency monitoring is used as reference, or in Pr. 56 when current monitoring is used as reference.

[Example] 1. To set the output across FM-SD to 1440 pulses/s at the inverter output frequency of 120Hz, set 120 (Hz) in Pr. 55. (Factory setting: 60Hz)

2. To set the output across FM-SD to 1440 pulses/s at the inverter output current of 15A, set 15 (A) Pr. 56. (Factory setting: rated inverter current)

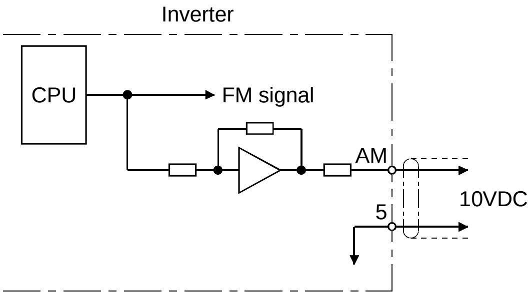
1.4.18 Analog output adjustment (AM) A500

A full-scale 10VDC analog signal can be output from across terminals AM-5.

The analog output level can be calibrated by the operation panel or parameter unit. Terminal AM function selection can be set in Pr. 158.

Since terminal AM is not isolated from the control circuit of the inverter, use a shielded cable of shorter than 30m.

The output signal from terminal AM delays about several 100ms in output and therefore cannot be used as a signal for control which requires fast response.



Terminal AM Output Circuit

Adjustment

Set the reference output value of the inverter which outputs the full-scale voltage 10VDC.

Set it in Pr. 55 for frequency monitoring reference, or in Pr. 56 for current monitoring reference.

Use Pr. 901, terminal AM output calibration, to adjust the output voltage.

[Example] 1. To set the output across AM-5 to 10VDC at the inverter output frequency of 90Hz, set 90Hz in Pr. 55. (Factory setting: 60Hz)

2. To set the output across AM-5 to 10VDC at the inverter output current of 20A, set 20A in Pr. 56. (Factory setting: rated inverter current)

1.4.19 Control circuit common terminals (SD, 5, SE) (COMMON)

Terminals SD, 5 and SE are all common terminals (0V) for I/O terminals. In (A500), they are isolated from each other. In (E500), terminals SD and 5 are not isolated (isolated in the 400V class). Terminals SD and SE and terminals 5 and SE are isolated.

Do not earth these terminals.

Terminal SD is a common terminal for the contact input terminals (STF, STR, STOP (Note), RH, RM, RL, JOG (Note), RT (Note), MRS, RES, AU (Note), CS (Note) and frequency output signal (FM). It is photocoupler isolated from the internal control circuit.

Terminal 5 is a common terminal for the frequency setting analog input signals. It is a 0V terminal of the internal control circuit and should be protected from external noise using a shielded or twisted cable.

Terminal SE is a common terminal for the open collector output terminals (RUN, SU (Note), OL (Note), IPF (Note), FU). It is photocoupler isolated from the internal control circuit.

Note: Not provided for (E500)

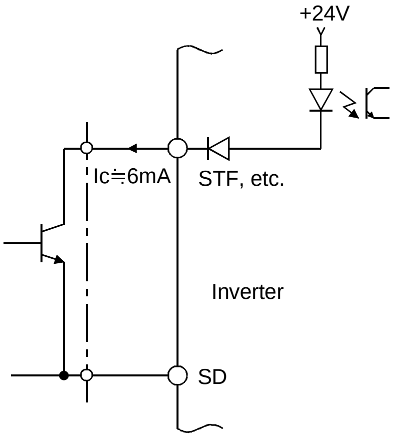
1.4.20 Signal inputs by contactless switches (COMMON)

If a transistor is used instead of a contacted switch as shown on the right, the input signals of the inverter can control terminals STF, STR, STOP (Note), RH, RM, RL, JOG (Note), RT (Note), MRS, RES, AU (Note), CS (Note).

Note: Not provided for (E500).

★ Electrical characteristics required for the external transistor

- I_C : Collector current [10mA or more]
  If the rating is small, the external transistor may be damaged or the inverter input may not be active.
- V_{CEX} : Open-time permissible collector-to-emitter voltage [30V or more]
  If the rating is small, the external transistor may be damaged.
- $V_{CE(sat)}$: Conduction-time collector-to-emitter saturation voltage [3V or less]
  If the saturation voltage is large, the inverter input may not be active.
- I_{CEX} : Collector shut-off current (leakage current) [100μA or less]
  If the shut-off current is large, it may be accidentally input to the inverter.



External Signal Input by Transistor

Note: 1. When using an external transistor connected with the external power supply, use terminal PC to prevent a fault from occurring due to leakage current. (Refer to Section 1.4.15.)

2. Note that an SSR (solid-state relay) has a relatively large leakage current at OFF time and it may be accidentally input to the inverter.

1.4.21 Connection to PU connector COMMON

(1) When connecting the operation panel or parameter unit using a connection cable

<Recommended cable connector>

- Parameter unit connection cable (FR-CB2☐) (option) or the following connector and cable.
- Connector: RJ45 connector
  Example: 5-554720-3, Nippon AMP
- Cable: Cable conforming to EIA568
  (e.g. 10BASE-T cable)
  Example: SGLPEV 0.5mm × 4P,
  MITSUBISHI CABLE
  INDUSTRIES, LTD.

<When using the operation panel on E500 >

A back cover and a relay adaptor are required to use the operation panel. Use the optional FR-E5P (set of cover and adaptor). Also, when using the built-in potentiometer, recalibrate the bias (Pr. 922) and gain Pr. 923) with the cable fitted.

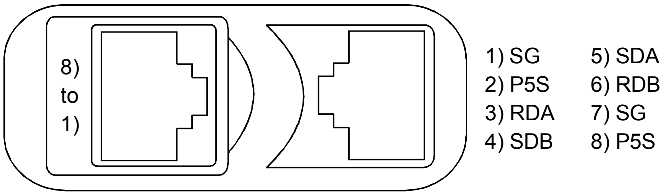
Note: Max. wiring length is 20m.

(2) For RS-485 communication

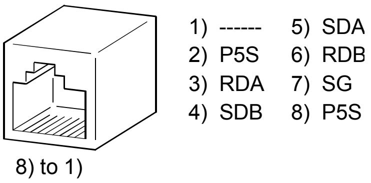
With the operation panel disconnected, the PU connector can be used for communication operation from a personal computer etc.

<PU connector pin-outs>

Viewed from the inverter (receptacle side) front



For A500



For E500

Use the connector and cable as detailed below.

- Connector: RJ45 connector
  Example: 5-554720-3, Nippon AMP
- Cable: Cable conforming to EIA568
  (e.g. 10BASE-T cable)
  Example: SGLPEV 0.5mm × 4P,
  MITSUBISHI CABLE
  INDUSTRIES, LTD.

Note:
1. Do not connect to the LAN board, FAX modem socket or telephone modular connector of the computer. Since they are difference in electrical specifications, the products may be damaged.
2. Pins 2 and 8 (P5S) are the power supply for operation panel or parameter unit. Do not use them for RS-485 communication.
3. For E500, keep pin 1 open when making RS-485 communication.
4. When the communication port of the personal computer has RS-232C specifications, prepare an RS-485/RS-232C converter.

1.5 Function (Parameter) List

1.5.1 FR-A500

Function	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Basic functions	0	Torque boost (Note 1)	0 to 30%	6%/4%/3%/2% (Note 9)	Motor torque adjustment	1.6.9
	1	Maximum frequency	0 to 120Hz	120Hz	Output frequency limit	1.6.7
	2	Minimum frequency	0 to 120Hz	0Hz		
	3	Base frequency	0 to 400Hz	60Hz	Frequency at rated motor torque	1.6.9
	⊙ 4	Multi-speed setting (high speed)	0 to 400Hz	60Hz	Multi-speed operation speeds	1.6.6
	⊙ 5	Multi-speed setting (middle speed)	0 to 400Hz	30Hz		
	⊙ 6	Multi-speed setting (low speed)	0 to 400Hz	10Hz		
	7	Acceleration time	0 to 3600 s/ 0 to 360 s	5 s/15 s (Note 6)	Acceleration/ deceleration time setting	1.6.8
	8	Deceleration time	0 to 3600 s/ 0 to 360 s	5 s/15 s (Note 6)		
	9	Electronic thermal O/L relay	0 to 500A	Rated output current	Motor overheat protection	1.6.12
Standard operation functions	10	DC injection brake operation frequency	0 to 120Hz, 9999	3Hz	Stopping accuracy adjustment	1.6.10
	11	DC injection brake operation time	0 to 10 s, 8888	0.5 s		
	12	DC injection brake voltage	0 to 30%	4%/2% (Note 6)		
	13	Starting frequency	0 to 60Hz	0.5Hz	Motor torque adjustment	1.6.7
	14	Load pattern selection (Note 1)	0 to 5	0	V/F characteristic pattern selection	1.6.9
	15	Jog frequency	0 to 400Hz	5Hz	Jog operation	1.6.6 1.6.8
	16	Jog acceleration/deceleration time	0 to 3600 s/ 0 to 360 s	0.5 s		
	17	MRS input selection	0,2	0	Output stop input selection	1.6.13
	18	High-speed maximum frequency	120 to 400Hz	120Hz	Operation over 120Hz	1.6.7
	19	Base frequency voltage (Note 1)	0 to 1000V, 8888, 9999	9999	Max. output voltage limit	1.6.9
	20	Acceleration/deceleration reference frequency	1 to 400Hz	60Hz	Acceleration/ deceleration time setting	1.6.8
	21	Acceleration/deceleration time increments	0,1	0		
	⊙ 22	Stall prevention operation level	0 to 200%, 9999	150%	Current limit	1.6.15
	23	Stall prevention operation level at double speed	0 to 200%, 9999	9999		
	⊙ 24	Multi-speed setting (speed 4)	0 to 400Hz, 9999	9999	Multi-speed operation speeds	1.6.6
	⊙ 25	Multi-speed setting (speed 5)	0 to 400Hz, 9999	9999		
	⊙ 26	Multi-speed setting (speed 6)	0 to 400Hz, 9999	9999		
	⊙ 27	Multi-speed setting (speed 7)	0 to 400Hz, 9999	9999		
	28	Multi-speed input compensation	0, 1	0		
	29	Acceleration/deceleration pattern	0, 1, 2, 3	0	Acceleration/ deceleration time changing pattern	1.6.8
	30	Regenerative function selection	0, 1, 2	0	Use of FR-ABR brake resistor	1.6.11
	31	Frequency jump 1A	0 to 400Hz, 9999	9999	Frequency jump operation (Avoidance of resonance phenomenon)	1.6.16
	32	Frequency jump 1B	0 to 400Hz, 9999	9999		
	33	Frequency jump 2A	0 to 400Hz, 9999	9999		
	34	Frequency jump 2B	0 to 400Hz, 9999	9999		
	35	Frequency jump 3A	0 to 400Hz, 9999	9999		
	36	Frequency jump 3B	0 to 400Hz, 9999	9999		
	37	Speed display	0,1 to 9998	0	Speed indication change-over	1.6.5

Function	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Output terminal functions	41	Up-to-frequency sensitivity	0 to 100%	10%	Output signal ON-OFF point adjustment	1.4.16
	42	Output frequency detection	0 to 400Hz	6Hz		
	43	Output frequency detection for reverse rotation	0 to 400Hz, 9999	9999		
Second functions	44	Second acceleration/deceleration time	0 to 3600 s/ 0 to 360 s	5 s	Operational function for sub motor When one inverter is used to perform switch-over operation of two motors	1.6.8
	45	Second deceleration time	0 to 3600 s/ 0 to 360 s, 9999	9999		
	46	Second torque boost (Note 1)	0 to 30%, 9999	9999		1.6.9
	47	Second V/F (base frequency) (Note 1)	0 to 400Hz, 9999	9999		
	48	Second stall prevention operation current	0 to 200%	150%	Stop-on-contact operation	1.6.15
	49	Second stall prevention operation frequency	0 to 400Hz, 9999	0		
	50	Second output frequency detection	0 to 400Hz	30Hz	Output signal ON-OFF point adjustment	1.4.16
Display functions	⊙ 52	DU/PU main display data selection	0 to 20, 22, 23, 24, 25, 100	0	Selection of various monitor displays	1.6.18
	⊙ 53	PU level display data selection	0 to 3, 5 to 14, 17, 18	1		
	⊙ 54	FM terminal function selection	1 to 3, 5 to 14, 17, 18, 21	1		
	⊙ 55	Frequency monitoring reference	0 to 400Hz	60Hz	External meter calibration	1.6.5 1.6.18
	⊙ 56	Current monitoring reference	0 to 500A	Rated output current		
Automatic restart functions	57	Restart coasting time	0, 0.1 to 5 s, 9999	9999	Restart operation	1.6.19
	58	Restart cushion time	0 to 60 s	1.0 s		
Additional function	59	Remote setting function selection	0, 1, 2	0	Speed adjustment from remote location	1.6.6
Operation selection functions	60	Intelligent mode selection	0 to 8	0	Intelligent operation	1.6.20
	61	Reference I for intelligent mode	0 to 500A, 9999	9999		
	62	Ref. I for intelligent mode accel.	0 to 200%, 9999	9999		
	63	Ref. I for intelligent mode decel.	0 to 200%, 9999	9999		
	64	Starting frequency for elevator mode	0 to 10Hz, 9999	9999		
	65	Retry selection	0 to 5	0	Retry operation	1.6.21
	66	Stall prevention operation level reduction starting frequency	0 to 400Hz	60Hz	Constant-output region high-speed operation	1.6.15
	67	Number of retries at alarm occurrence	0 to 10,101 to 110	0	Retry operation	1.6.21
	68	Retry waiting time	0 to 10 s	1 s		
	69	Retry count display erasure	0	0		
	70	Special regenerative brake duty	0 to 15%/0 to 30%/0% (Note 10)	0%	Use of external brake resistor	1.6.11
	71	Applied motor	0 to 8, 13 to 18, 20, 23, 24	0	Use of special-purpose motor	1.6.12 1.6.26
	⊙ 72	PWM frequency selection	0 to 15	2	Noise, leakage current reduction	1.6.22
	73	0-5V/0-10V selection	0 to 5, 10 to 15	1	Analog frequency setting selection	1.6.6
	74	Filter time constant	0 to 8	1		1.6.23
	⊙ 75	Reset selection/disconnected PU detection/PU stop selection	0 to 3, 14 to 17	14	Reset function selection	1.6.14
	76	Alarm code output selection	0, 1, 2, 3	0	Digital output of alarm definition	1.6.17
	⊙ 77	Parameter write disable selection	0, 1, 2	0	Parameter data change inhibit	1.6.2

Function	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Operation selection functions	78	Reverse rotation prevention selection	0, 1, 2	0	Limitation of rotation in one direction	1.6.3
	79	Operation mode selection	0 to 8	0	Operation mode selection	1.6.1
Motor constants	80	Motor capacity	0.4 to 55kW, 9999	9999	For advanced magnetic flux vector control	1.6.24
	81	Number of motor poles	2, 4, 6, 12, 14, 16, 9999	9999		
	82	Motor exciting current (Note 4)	0 to , 9999	9999	For optional motor constant setting	1.6.26
	83	Rated motor voltage	0 to 1000V	200/400V (Note 2)	For auto tuning	
	84	Rated motor frequency	50 to 120Hz	60Hz		
	89	Speed control gain	0 to 200.0%	100%	For slip compensation	1.6.24
	90	Motor constant (R1) (Note 4)	0 to, 9999	9999	For optional motor constant setting	1.6.26
	91	Motor constant (R2) (Note 4)	0 to, 9999	9999		
	92	Motor constant (L1) (Note 4)	0 to, 9999	9999		
	93	Motor constant (L2) (Note 4)	0 to, 9999	9999		
	94	Motor constant (X)	0 to, 9999	9999		
	95	Online auto tuning selection	0, 1	0	For online auto tuning	1.6.27
	96	Auto tuning setting/status	0, 1, 101	0	For online auto tuning	1.6.26
5-point flexible V/F characteristics	100	V/F1 (first frequency) (Note 1)	0 to 400Hz, 9999	9999	For optional output characteristic setting	1.6.29
	101	V/F1 (first frequency voltage) (Note 1)	0 to 1000V	0		
	102	V/F2 (second frequency) (Note 1)	0 to 400Hz, 9999	9999		
	103	V/F2 (second frequency voltage) (Note 1)	0 to 1000V	0		
	104	V/F3 (third frequency) (Note 1)	0 to 400Hz, 9999	9999		
	105	V/F3 (third frequency voltage) (Note 1)	0 to 1000V	0		
	106	V/F4 (fourth frequency) (Note 1)	0 to 400Hz, 9999	9999		
	107	V/F4 (fourth frequency voltage) (Note 1)	0 to 1000V	0		
	108	V/F5 (fifth frequency) (Note 1)	0 to 400Hz, 9999	9999		
	109	V/F5 (fifth frequency voltage) (Note 1)	0 to 1000V	0		
Third functions	110	Third acceleration/deceleration time	0 to 3600 s/ 0 to 360 s, 9999	9999	Operational functions for sub motors When one inverter is used to perform switch-over operation of three motors	1.6.8
	111	Third deceleration time	0 to 3600 s/ 0 to 360 s, 9999	9999		
	112	Third torque boost (Note 1)	0 to 30.0%, 9999	9999		1.6.9
	113	Third V/F (base frequency) (Note 1)	0 to 400Hz, 9999	9999		
	114	Third stall prevention operation current	0 to 200%	150%		1.6.15
	115	Third stall prevention operation frequency	0 to 400Hz	0		
	116	Third output frequency detection	0 to 400Hz, 9999	9999		1.4.16
Communication functions	117	Station number	0 to 31	0	Communication operation with personal computer	1.6.30
	118	Communication speed	48, 96, 192	192		

Func-tion	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Communication functions	119	Stop bit length/data length	0, 1 (data length 8) 10, 11 (data length 7)	1	Communication operation with personal computer	1.6.30
	120	Parity check presence/absence	0, 1, 2	2		
	121	Number of communication retries	0 to 10, 9999	1		
	122	Communication check time interval	0, 0.1 to 999.8 s, 9999	0		
	123	Waiting time setting	0 to 150ms, 9999	9999		
	124	CR, LF presence/absence selection	0,1,2	1		
PID control	128	PID action selection	10, 11, 20, 21	10	For operation under PID control	1.6.31
	129	PID proportional band	0.1 to 1000%, 9999	100%		
	130	PID integral time	0.1 to 3600 s, 9999	1 s		
	131	Upper limit	0 to 100%, 9999	9999		
	132	Lower limit	0 to 100%, 9999	9999		
	133	PID action set point for PU operation	0 to 100%	0%		
	134	PID differential time	0.01 to 10.00 s, 9999	9999		
Commercial power supply-inverter switch-over	135	Commercial power supply-inverter switch-over sequence output terminal selection	0, 1	0	For commercial power supply-inverter switch-over operation	1.6.32
	136	MC switch-over interlock time	0 to 100.0 s	1.0 s		
	137	Start waiting time	0 to 100.0 s	0.5 s		
	138	Commercial power supply-inverter switch-over selection at alarm occurrence	0, 1	0		
	139	Automatic inverter-commercial power supply switch-over frequency	0 to 60.00Hz, 9999	9999		
Backlash	140	Backlash acceleration stopping frequency (Note 7)	0 to 400Hz	1.00Hz	Backlash compensation	1.6.8
	141	Backlash acceleration stopping time (Note 7)	0 to 360 s	0.5 s		
	142	Backlash deceleration stopping frequency (Note 7)	0 to 400Hz	1.00Hz		
	143	Backlash deceleration stopping time (Note 7)	0 to 360 s	0.5 s		
Display	144	Speed setting switch-over	0, 2, 4, 6, 8, 10, 102, 104, 106, 108, 110	4	Speed indication change-over	1.6.5
Additional functions	148	Stall prevention level at 0V input	0 to 200%	150%	Analog setting of current limit level	1.6.15
	149	Stall prevention level at 10V input	0 to 200%	200%		
Current detection	150	Output current detection level	0 to 200%	150%	Current detection signal output	1.6.33
	151	Output current detection period	0 to 10 s	0		
	152	Zero current detection level	0 to 200.0%	5.0%		
	153	Zero current detection period	0 to 1 s	0.5 s		
Sub functions	154	Voltage reduction selection during stall prevention operation	0, 1	1	Selection of voltage reduction during stall prevention operation	1.6.15
	155	RT activated condition	0, 10	0	Second function activated condition selection	1.4.10
	156	Stall prevention operation selection	0 to 31, 100, 101	0	Current limit	1.6.15
	157	OL signal waiting time	0 to 25 s, 9999	0		

Function	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Sub functions	158	AM terminal function selection	1 to 3, 5 to 14, 17, 18, 21	1	Selection of various monitor displays	1.6.18
Additional function	⊙ 160	User group read selection	0, 1, 10, 11	0	User group parameter read selection	1.6.34
Automatic restart after instantaneous power failure	162	Automatic restart after instantaneous power failure selection	0, 1	0	Automatic restart operation	1.6.19
	163	First cushion time for restart	0 to 20 s	0 s		
	164	First cushion voltage for restart	0 to 100%	0%		
	165	Restart stall prevention operation level	0 to 200%	150%		
Initial monitor	170	Watt-hour meter clear	0	0	Monitor value clearing	1.6.35
	171	Actual operation hour meter clear	0	0		
User functions	173	User group 1 registration	0 to 999	0	Registration and deletion of parameters to and from user group	1.6.34
	174	User group 1 deletion	0 to 999, 9999	0		
	175	User group 2 registration	0 to 999	0		
	176	User group 2 deletion	0 to 999, 9999	0		
Terminal assignment functions	180	RL terminal function selection	0 to 99, 9999	0	Input terminal function selection	1.4.4
	181	RM terminal function selection	0 to 99, 9999	1		
	182	RH terminal function selection	0 to 99, 9999	2		
	183	RT terminal function selection	0 to 99, 9999	3		
	184	AU terminal function selection	0 to 99, 9999	4		
	185	JOG terminal function selection	0 to 99, 9999	5		
	186	CS terminal function selection	0 to 99, 9999	6		
	190	RUN terminal function selection	0 to 199, 9999	0	Output terminal function selection	1.4.16
	191	SU terminal function selection	0 to 199, 9999	1		
	192	IPF terminal function selection	0 to 199, 9999	2		
	193	OL terminal function selection	0 to 199, 9999	3		
	194	FU terminal function selection	0 to 199, 9999	4		
	195	ABC terminal function selection	0 to 199, 9999	99		
Additional function	199	User's initial value setting	0 to 999, 9999	0	Optional setting of initial parameter values	1.6.36
Programmed operation	200	Programmed operation minute/second selection	0 to 3	0	Programmed operation	1.6.37
	201 to 210	Program set 1 1 to 10	0-2: Rotation direction 0-400, 9999: Frequency 0-99.59: Time	0 9999 0		
	211 to 220	Program set 2 11 to 20	0-2: Rotation direction 0-400, 9999: Frequency 0-99.59: Time	0 9999 0		
	221 to 230	Program set 3 21 to 30	0-2: Rotation direction 0-400, 9999: Frequency 0-99.59: Time	0 9999 0		
	231	Timer setting	0 to 99.59	0		

Function	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Multi-speed operation	⊙ 232	Multi-speed setting (speed 8)	0 to 400Hz, 9999	9999	Multi-speed (15-speed) operation speeds	1.6.6
	⊙ 233	Multi-speed setting (speed 9)	0 to 400Hz, 9999	9999		
	⊙ 234	Multi-speed setting (speed 10)	0 to 400Hz, 9999	9999		
	⊙ 235	Multi-speed setting (speed 11)	0 to 400Hz, 9999	9999		
	⊙ 236	Multi-speed setting (speed 12)	0 to 400Hz, 9999	9999		
	⊙ 237	Multi-speed setting (speed 13)	0 to 400Hz, 9999	9999		
	⊙ 238	Multi-speed setting (speed 14)	0 to 400Hz, 9999	9999		
	⊙ 239	Multi-speed setting (speed 15)	0 to 400Hz, 9999	9999		
Sub functions	⊙ 240	Soft-PWM setting	0, 1	1	Noise, leakage current, noise reduction	1.6.22
	244	Cooling fan operation selection	0, 1	0	Elongation of cooling fan life	1.6.38
Stop selection function	250	Stop selection	0 to 100 s, 9999	9999	Deceleration to stop, coasting to stop selection	1.6.39
Power failure stop function	261	Power failure stop selection	0, 1	0	Selection of deceleration to stop at power failure	1.6.40
	262	Subtracted frequency at deceleration start	0 to 20Hz	3Hz		
	263	Subtraction starting frequency	0 to 120Hz, 9999	60Hz		
	264	Power-failure deceleration time 1	0 to 3600/0 to 360 s	5 s		
	265	Power-failure deceleration time 2	0 to 3600/0 to 360 s, 9999	9999		
	266	Power-failure deceleration time switch-over frequency	0 to 400Hz	60Hz		
Selection function	270	Stop-on-contact/load torque high-speed frequency control selection	0, 1, 2, 3	0	Control selection	1.6.41
High-speed frequency control	⊙ 271	High-speed setting maximum current	0 to 200%	50%	High-speed frequency control	1.6.42
	⊙ 272	Mid-speed setting minimum current	0 to 200%	100%		
	⊙ 273	Current averaging range	0 to 400Hz, 9999	9999		
	⊙ 274	Current averaging filter constant	1 to 4000	16		
Stop on contact	275	Stop-on-contact exciting current low-speed multiplying factor	0 to 1000%, 9999	9999 (Note 5)	Stop-on-contact control	1.6.43
	276	Stop-on-contact PWM carrier frequency	0 to 15, 9999	9999 (Note 5)		
Brake sequence functions	278	Brake opening frequency (Note 3)	0 to 30Hz	3Hz	Electromagnetic brake sequence control	1.6.44
	279	Brake opening current (Note 3)	0 to 200%	130%		
	280	Brake opening current detection time (Note 3)	0 to 2 s	0.3 s		
	281	Brake operation time at start (Note 3)	0 to 5 s	0.3 s		
	282	Brake operation frequency (Note 3)	0 to 30Hz	6Hz		
	283	Brake operation time at stop (Note 3)	0 to 5 s	0.3 s		
	284	Deceleration detection function selection (Note 3)	0, 1	0		
	285	Overspeed detection frequency	0 to 30Hz, 9999	9999		
Droop	286	Droop gain	0 to 100%	0%	Load balance adjustment	1.6.45
	287	Droop filter time constant	0.00 to 1.00 s	0.3 s		

Function	Parameter Number	Name	Setting Range		Factory Setting		Purpose, Application, Etc.	Refer to Section
Calibration functions	⊙ 900	FM terminal calibration	——		——		For external meter calibration	1.6.5
	⊙ 901	AM terminal calibration	——		——			
	902	Frequency setting voltage bias	0 to 10V	0 to 60Hz	0V	0Hz	Calibration of output frequency to frequency setting signal	1.6.6
	903	Frequency setting voltage gain	0 to 10V	1 to 400Hz	5V	60 Hz		
	904	Frequency setting current bias	0 to 20mA	0 to 60Hz	4mA	0Hz		
	905	Frequency setting current gain	0 to 20mA	1 to 400Hz	20 mA	60 Hz		
Additional function	990	Buzzer control	0, 1		1		Operation panel or parameter unit buzzer selection	1.6.48

Note: 1. Indicates the parameter settings which are ignored when the advanced magnetic flux vector control mode is selected.
2. The factory setting of the FR-A540 (400V class) is 400V.
3. Can be set when Pr. 80, Pr. 81 ≠ 9999, Pr. 60 = 7 or 8.
4. Can be accessed when Pr. 80, Pr. 81 ≠ 9999, Pr. 77 = 801.
5. Can be accessed when Pr. 270 = 1 or 3, Pr. 80, Pr. 81 ≠ 9999.
6. The setting depends on the inverter capacity.
7. Can be accessed when Pr. 29 = 3.
8. If the Pr. 77 (parameter write inhibit selection) value is 0 (factory setting), the values of the parameters marked ⊙ can be changed during operation. (However, the Pr. 72 and Pr. 240 values cannot be changed during external operation.)
9. The setting depends on the inverter capacity: (0.4K, 0.75K)/(1.5K to 3.7K)/(5.5K, 7.5K)/(11K or more).
10. The setting depends on the inverter capacity: (0.4K to 1.5K)/(2.2K to 7.5K)/(11K or more).

1.5.2 FR-E500

Function	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Basic functions	0	Torque boost (Note 1)	0 to 30%	6%/4% (Note 8)	Motor torque adjustment	1.6.9
	1	Maximum frequency	0 to 120Hz	120Hz	Output frequency limit	1.6.7
	2	Minimum frequency	0 to 120Hz	0Hz		
	3	Base frequency(Note 1)	0 to 400Hz	60Hz	Frequency at rated motor torque	1.6.9
	⊙ 4	Multi-speed setting (high speed)	0 to 400Hz	60Hz	Multi-speed operation speeds	1.6.6
	⊙ 5	Multi-speed setting (middle speed)	0 to 400Hz	30Hz		
	⊙ 6	Multi-speed setting (low speed)	0 to 400Hz	10Hz		
	7	Acceleration time	0 to 3600 s/ 0 to 360 s	5 s/10s (Note 2)	Acceleration/ deceleration time setting	1.6.8
	8	Deceleration time	0 to 3600 s/ 0 to 360 s	5 s/10s (Note 2)		
	9	Electronic thermal O/L relay	0 to 500A	Rated output current (Note 4)	Motor overheat protection	1.6.12
Standard operation functions	10	DC injection brake operation frequency	0 to 120Hz	3Hz	Stopping accuracy adjustment	1.6.10
	11	DC injection brake operation time	0 to 10 s	0.5 s		
	12	DC injection brake voltage	0 to 30%	6%		
	13	Starting frequency	0 to 60Hz	0.5Hz	Motor torque adjustment	1.6.7
	14	Load pattern selection (Note 1)	0 to 3	0	V/F characteristic pattern selection	1.6.9
	15	Jog frequency	0 to 400Hz	5Hz	Jog operation	1.6.6
	16	Jog acceleration/deceleration time	0 to 3600 s/0 to 360 s	0.5 s		1.6.8
	18	High-speed maximum frequency	120 to 400Hz	120Hz	Operation over 120Hz	1.6.7
	19	Base frequency voltage (Note 1)	0 to 1000V, 8888,9999	9999	Max. output voltage limit	1.6.9
	20	Acceleration/deceleration reference frequency	1 to 400Hz	60Hz	Acceleration/ deceleration time setting	1.6.8
	21	Acceleration/deceleration time increments	0,1	0		
	⊙ 22	Stall prevention operation level	0 to 200%	150%	Current limit	1.6.15
	23	Stall prevention operation level at double speed (Note 5)	0 to 200%, 9999	9999		
	⊙ 24	Multi-speed setting (speed 4)	0 to 400Hz, 9999	9999	Multi-speed operation speeds	1.6.6
	⊙ 25	Multi-speed setting (speed 5)	0 to 400Hz, 9999	9999		
	⊙ 26	Multi-speed setting (speed 6)	0 to 400Hz, 9999	9999		
	⊙ 27	Multi-speed setting (speed 7)	0 to 400Hz, 9999	9999		
	29	Acceleration/deceleration pattern	0,1,2	0	Acceleration/ deceleration time changing pattern	1.6.8
	30	Regenerative function selection	0,1	0	Use of external brake resistor	1.6.11
	31	Frequency jump 1A	0 to 400Hz, 9999	9999	Frequency jump operation (Avoidance of resonance phenomenon)	1.6.16
	32	Frequency jump 1B	0 to 400Hz, 9999	9999		
	33	Frequency jump 2A	0 to 400Hz, 9999	9999		
	34	Frequency jump 2B	0 to 400Hz, 9999	9999		
	35	Frequency jump 3A	0 to 400Hz, 9999	9999		
	36	Frequency jump 3B	0 to 400Hz, 9999	9999		
	37	Speed display	0, 0.01 to 9998	0	Speed indication change-over	1.6.5
	38	Frequency at 5V (10V) input	1 to 400Hz	60Hz (Note 6)	Calibration of output frequency to frequency setting signal	1.6.6
	39	Frequency at 20mA input	1 to 400Hz	60Hz (Note 6)		

Function	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Output terminal functions	41	Up-to-frequency sensitivity	0 to 100%	10%	Output signal ON-OFF point adjustment	1.4.16
	42	Output frequency detection	0 to 400Hz	6Hz		
	43	Output frequency detection for reverse rotation	0 to 400Hz, 9999	9999		
Sond functions	44	Second acceleration/deceleration time	0 to 3600 s/0 to 360 s	5 s/10 s (Note 2)	Operational function for sub motor When one inverter is used to perform switch-over operation of two motors	1.6.8
	45	Second deceleration time	0 to 3600 s/ 0 to 360 s, 9999	9999		
	46	Second torque boost (Note 1)	0 to 30%, 9999	9999		1.6.9
	47	Second V/F (base frequency) (Note 1)	0 to 400Hz, 9999	9999		
	48	Second electronic overcurrent protection	0 to 500A, 9999	9999		1.6.12
Display functions	⊙ 52	DU/PU main display data selection	0,23,100	0	Selection of various monitor displays	1.6.18
	⊙ 54	FM terminal function selection	0,1,2	0		
	⊙ 55	Frequency monitoring reference	0 to 400Hz	60Hz		1.6.5
	⊙ 56	Current monitoring reference	0 to 500A	Rated output current		
Automatic restart functions	57	Restart coasting time	0 to 5 s, 9999	9999	Restart operation	1.6.19
	58	Restart cushion time	0 to 60 s	1.0 s		
Additional function	59	Remote setting function selection	0,1,2	0	Speed adjustment from remote location	1.6.6
Operation selection functions	60	Shortest acceleration/deceleration mode	0,1,2,11,12	0	Intelligent operation	1.6.20
	61	Reference current	0 to 500A, 9999	9999		
	62	Reference current for acceleration	0 to 200%, 9999	9999		
	63	Reference current for deceleration	0 to 200%, 9999	9999		
	65	Retry selection	0,1,2,3	0	Retry operation	1.6.21
	66	Stall prevention operation level reduction starting frequency (Note 5)	0 to 400Hz	60Hz	Constant-output region high-speed operation	1.6.15
	67	Number of retries at alarm occurrence	0 to 10, 101 to 110	0	Retry operation	1.6.21
	68	Retry waiting time	0.1 to 360 s	1 s		
	69	Retry count display erasure	0	0		
	70	Special regenerative brake duty	0 to 30%	0%	Use of external brake resistor	1.6.11
	71	Applied motor (Note 5)	0,1,3,5,6,13, 15,16,23,100,101, 103,113,123,105, 115,106,116	0	Use of special-purpose motor	1.6.12 1.6.26
	⊙ 72	PWM frequency selection	0 to 15	1	Noise, leakage current reduction	1.6.22
	73	0-5V/0-10V selection	0,1	0	Analog frequency setting selection	1.6.6
	74	Filter time constant	0 to 8	1		1.6.23
	75	Reset selection/disconnected PU detection/PU stop selection	0 to 3,14 to 17	14	Reset function selection	1.6.14
	77	Parameter write disable selection	0,1,2	0	Parameter data change inhibit	1.6.2
	78	Reverse rotation prevention selection	0,1,2	0	Limitation of rotation in one direction	1.6.3
	79	Operation mode selection (Note 5)	0 to 4,6 to 8	1	Operation mode selection	1.6.1

Function	Parameter Number	Name	Setting Range	Factory Setting	Purpose, Application, Etc.	Refer to Section
Motor constants	80	Motor capacity	0.1 to 7.5kW, 9999	9999	For general-purpose magnetic flux vector control	1.6.25
	82	Motor exciting current	0 to 500A, 9999	9999	For auto tuning	1.6.26
	83	Rated motor voltage	0 to 1000V	200V/400V		
	84	Rated motor frequency	50 to 120Hz	60Hz		
	90	Motor constant (R1) (Note 5)	0 to 50Ω, 9999	9999		
	96	Auto-tuning setting/status (Note 5)	0, 1	0		
Communication functions	117	Station number	0 to 31	0	Communication operation with personal computer	1.6.30
	118	Communication speed	48,96,192	48		
	119	Stop bit length/data length	0,1 (data length 8) 10,11 (data length 7)	1		
	120	Parity check presence/absence	0,1,2	2		
	121	Number of communication retries	0 to 10,9999	1		
	122	Communication check time interval	0 to 999.8 s, 9999	0		
	123	Waiting time setting	0 to 150, 9999	9999		
	124	CR, LF presence/absence selection	0,1,2	1		
PID control	128	PID action selection	0,20,21	0	For operation under PID control	1.6.31
	129	PID proportional band	0.1 to 1000%, 9999	100%		
	130	PID integral time	0.1 to 3600 s, 9999	1 s		
	131	Upper limit	0 to 100%, 9999	9999		
	132	Lower limit	0 to 100%, 9999	9999		
	133	PID action set point for PU operation	0 to 100%	0%		
	134	PID differential time	0.01 to 10.00 s, 9999	9999		
Additional function	146	frequency setting command selection	0, 1, 9999	0	Built-in potentiometer selection	1.4.6
Current detection	150	Output current detection level	0 to 200%	150%	Current detection signal output	1.6.33
	151	Output current detection period	0 to 10 s	0		
	152	Zero current detection level	0 to 200.0%	5.0%		
	153	Zero current detection period	0.05 to 1 s	0.5 s		
Sub function	156	Stall prevention operation selection	0 to 31,100	0	Current limit	1.6.15
Additional function	160	User group read selection	0, 1, 10, 11	0	User group parameter read selection	1.6.34
Initial monitor	171	Actual operation hour meter clear	0	0	Monitor value clearing	1.6.35
User functions	173	User group 1 registration	0 to 999	0	Registration and deletion of parameters to and from user group	1.6.34
	174	User group 1 deletion	0 to 999,9999	0		
	175	User group 2 registration	0 to 999	0		
	176	User group 2 deletion	0 to 999,9999	0		
Terminal assignment functions	180	RL terminal function selection	0 to 8, 16, 18	0	Input terminal function selection	1.4.4
	181	RM terminal function selection	0 to 8, 16, 18	1		
	182	RH terminal function selection	0 to 8, 16, 18	2		
	183	MRS terminal function selection	0 to 8, 16, 18	6		
	190	RUN terminal function selection	0 to 99	0	Output terminal function selection	1.4.16
	191	FU terminal function selection	0 to 99	4		
	192	A, B, C terminal function selection	0 to 99	99		

Func-tion	Parameter Number	Name	Setting Range		Factory Setting		Purpose, Application, Etc.	Refer to Section
Multi-speed operation	⊙ 232	Multi-speed setting (speed 8)	0 to 400Hz, 9999		9999		Multi-speed(15-speed) operation speed	1.6.6
	⊙ 233	Multi-speed setting (speed 9)	0 to 400Hz, 9999		9999			
	⊙ 234	Multi-speed setting (speed 10)	0 to 400Hz, 9999		9999			
	⊙ 235	Multi-speed setting (speed 11)	0 to 400Hz, 9999		9999			
	⊙ 236	Multi-speed setting (speed 12)	0 to 400Hz, 9999		9999			
	⊙ 237	Multi-speed setting (speed 13)	0 to 400Hz, 9999		9999			
	⊙ 238	Multi-speed setting (speed 14)	0 to 400Hz, 9999		9999			
	⊙ 239	Multi-speed setting (speed 15)	0 to 400Hz, 9999		9999			
Sub functions	240	Soft-PWM setting	0,1		1		Noise, leakage current, noise reduction	1.6.22
	244	Cooling fan operation selection	0,1		0		Elongation of cooling fan life	1.6.38
	245	Rated motor slip	0 to 50%, 9999		9999		For slip compensation	1.6.28
	246	Slip compensation response time	0.01 to 10 s		0.5 s			
	247	Constant-output region slip compensation selection	0, 9999		9999			
	249	Ground fault detection at start	0, 1		0		Ground fault detection	1.6.46
Stop selection function	250	Stop selection	0 to 100 s, 1000 to 1100 s, 8888, 9999		9999		Deceleration to stop, coasting to stop selection	1.6.39
Calibration functions	900	FM terminal calibration	——		——		For external meter calibration	1.6.5
	902	Frequency setting voltage bias	0 to 10V	0 to 60Hz	0V	0Hz	Calibration of output frequency to frequency setting signal	1.6.6
	903	Frequency setting voltage gain	0 to 10V	1 to 400Hz	5V	60 Hz		
	904	Frequency setting current bias	0 to 20mA	0 to 60Hz	4mA	0Hz		
	905	Frequency setting current gain	0 to 20mA	1 to 400Hz	20mA	60Hz		
	922	Built-in frequency setting potentiometer bias	0 to 5V	0 to 60Hz	0V	0Hz	Calibration of output frequency to built-in potentiometer	1.6.6
	923	Built-in frequency setting potentiometer gain	0 to 5V	1 to 400Hz	5V	60Hz		

Note: 1. Indicates the parameter of which setting is ignored when the general-purpose magnetic flux vector control mode is selected.

2. The setting depends on the inverter capacity: (0.1K to 3.7K)/(5.5K to 7.5K).
3. Since calibration is made before shipment from the factory, the settings differ slightly between inverters. The inverter is preset to provide a frequency slightly higher than 60Hz.
4. Set to 85% of the rated inverter current for the 0.1 to 0.75K.
5. If "2" is set in Pr. 77 (parameter write inhibit selection), the setting cannot be changed during operation.
6. If the Pr. 77 (parameter write inhibit selection) value is 0 (factory setting), the values of the parameters marked ⊙ can be changed during operation. (However, the Pr. 72 value may only be changed during PU operation.)
7. Can be accessed when Pr. 80 ≠ 9999 and Pr. 77 = 801.

   4% for the FR-E540-5.5K and 7.5K.

1.6 FUNCTIONS (PARAMETER)

1.6.1 Operation mode selection [Pr. 79] COMMON

You can choose the operation mode such as PU or external operation mode. The operation mode is factory-set to allow the PU operation or external operation to be selected, (and the external operation mode is selected for A500 or the PU operation mode selected for E500 at power-on). Set the corresponding value to select the required mode from among various modes, e.g. the mode in which PU operation is chosen at power-on (set value 1), the mode in which external signals and operation panel (parameter unit) are used for the running frequency setting and start signal, and the programmed operation (not available for E500) mode.

Parameter Number	Set Value	Description	Parameter Display	Frequency Setting	Start Signal	At Power-On	Corresponding Model	
							A500	E500
79	0	PU or external operation may be selected.	PU	Operation panel (parameter unit)		× (Note 2)	○ (Factory setting)	○
			EXT	External signal (STF, STR)		○ (Note 2)		
	1	PU operation only allowed	PU	Operation panel (parameter unit)		○	○	○ (Factory setting)
	2	External operation only allowed	EXT	External signal (STF, STR)		○	○	○
	3	PU-external signal combined operation	PU+E	Operation panel (PU)	STF,STR	○	○	○
	4			External signal	Operation panel (PU)	○		
	5	Programmed or PU operation may be selected.	PRG	Pr. 200 to Pr. 231	STF (Note 1)	○	○	×
			PU	Operation panel (parameter unit)		×		
	6	PU or external operation may be selected during operation (switch-over mode).	PU	Operation panel (parameter unit)		×	○	○
			EXT	External signal (STF, STR)		○		
	7	PU and external operations may be interlocked by X12 (MRS) signal.	PU	Operation panel (parameter unit)		×	○	○
			EXT	External signal (STF, STR)		○		
	8	PU or external operation may be selected by X12 (MRS) signal.	PU	Operation panel (parameter unit)		Depending on terminal	○	○
			EXT	External signal (STF, STR)		Depending on terminal		

Note: 1. For details of group selection RH, RM, RL and timer reset STR, refer to Pr. 200 to Pr. 231.

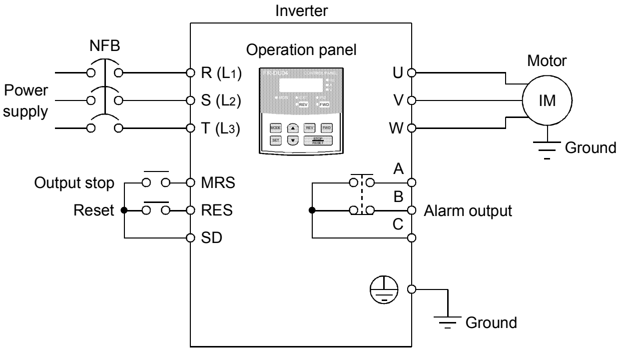
2. For E500, the PU operation mode is chosen at power-on when Pr. 146 = 9999.

(1) PU operation COMMON

After making connections as shown on the right and changing the required functions (parameter values) from the factory settings, set frequencies from the operation panel (parameter unit) and start operation.

For E500, PU operation is selected at power-on when Pr. 79 is as factory-set (Pr. 79=1).

Operation with the potentiometer of the operation panel is enabled in the PU operation mode. For more information, refer to Section 1.4.6 (2).



Connection Example for PU Operation

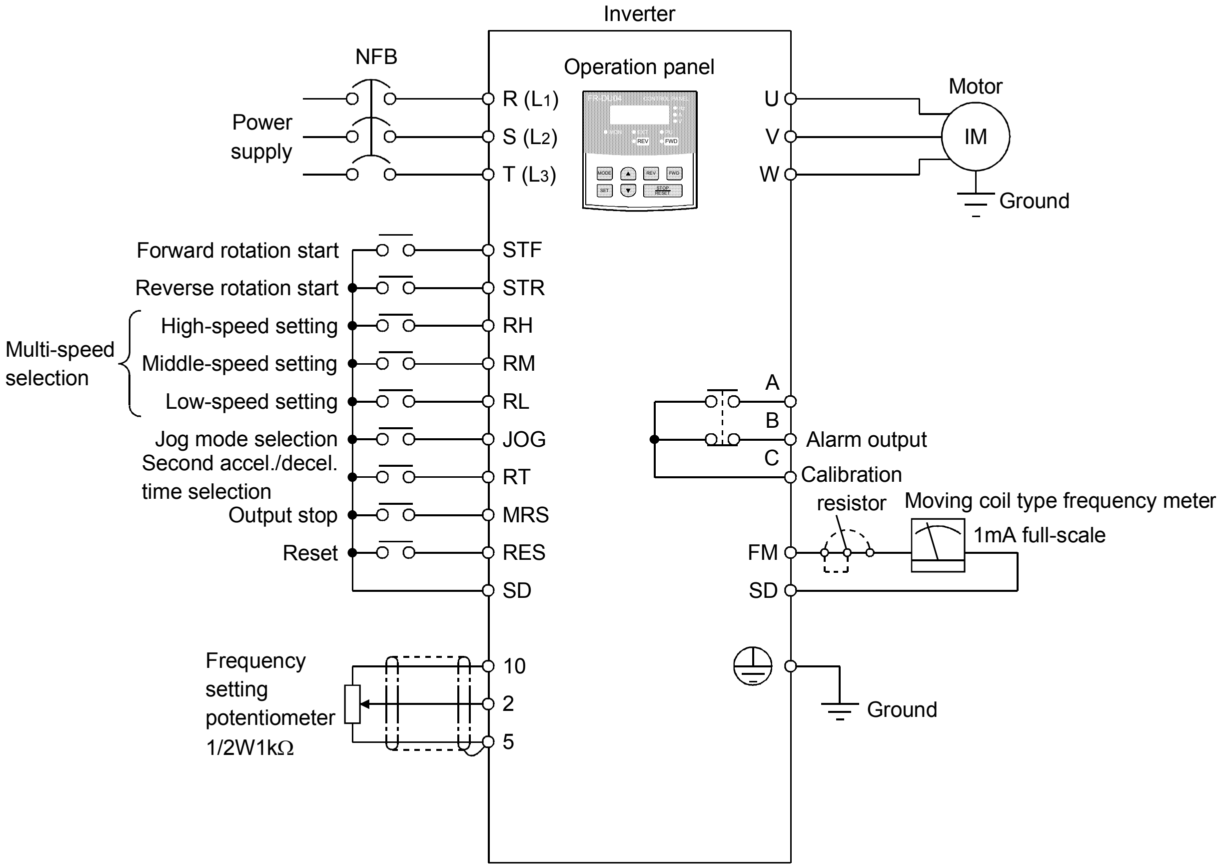
Note: The motor and inverter must be grounded. For the grounding method, refer to Section 1.9.7.

(2) External operation COMMON

After making connections as shown in the below example and setting the functions (parameter values), you can enter the external running signal, set frequency, and perform various operations. How to use the external terminals will be described below.

For A500, external operation is selected at power-on when Pr. 79 is as factory-set (Pr. 79 = 0)

When you have selected the PU operation mode for required function (parameter) setting etc., return to external operation before starting operation.



Connection Example for External Operation

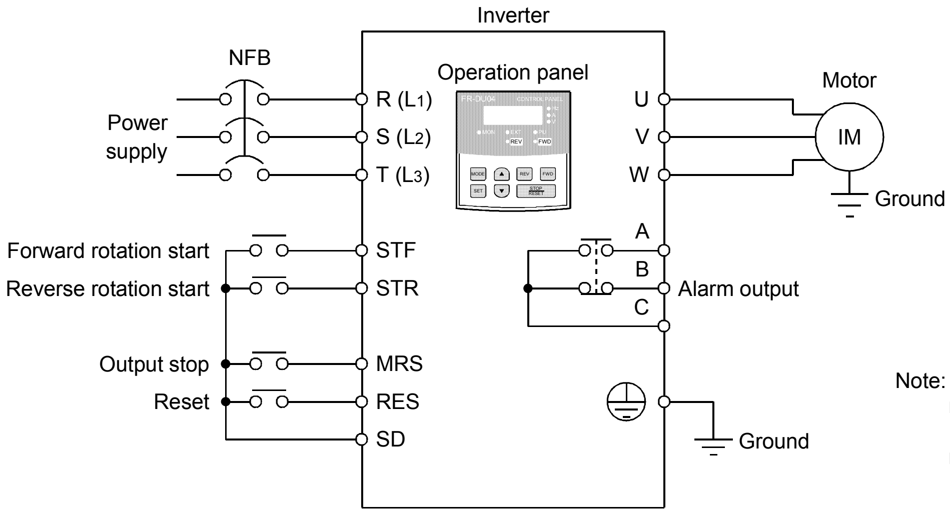
Note: The motor and inverter must be grounded.
For the grounding method, refer to Section 1.9.7.

(3) Combined operation (performing operation by entering external signal as start signal and setting running frequency from operation panel)

Make connections as shown below and set "3" in Pr. 79, operation mode selection.

The running frequency is set from the operation panel but the external signals accepted are the multi-speed setting signals only. The multi-speed setting signals override the digital setting on the operation panel.

For E500, however, when the running frequency has been with the potentiometer of the operation panel, the multi-speed setting signals are invalid.

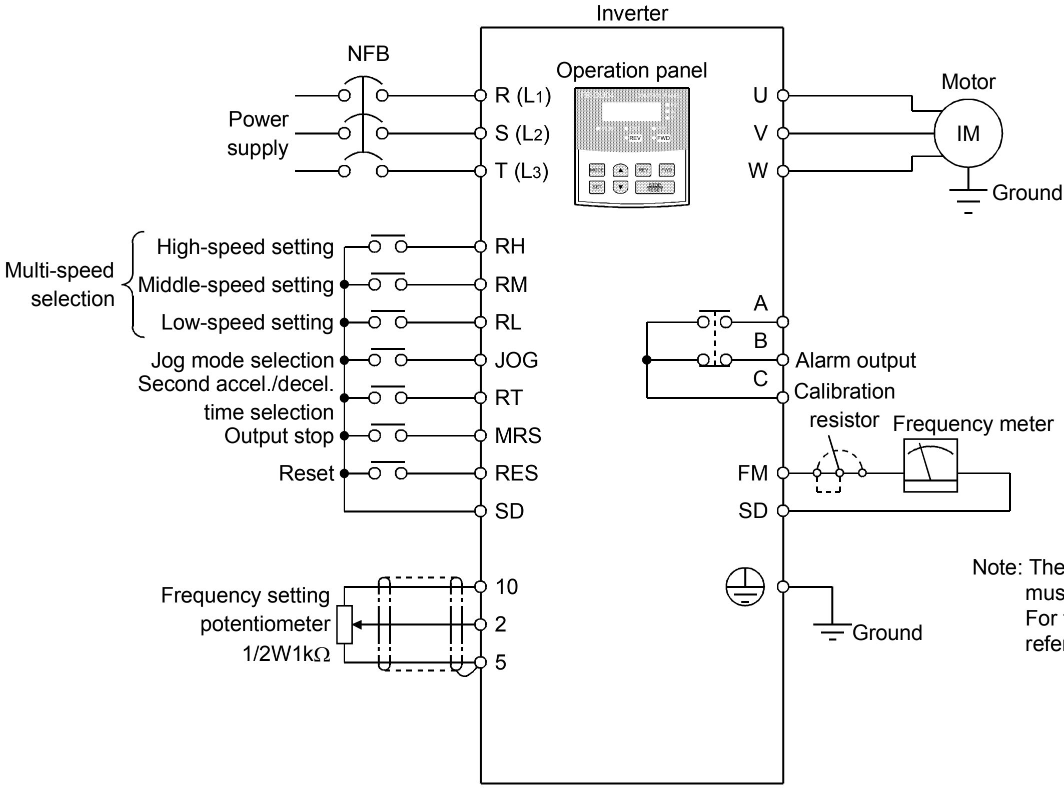


Note: The motor and inverter must be grounded.
For the grounding method, refer to Section 1.9.7.

Connection Example for Combined Operation [start: external signal, running frequency: operation panel]

(4) Combined operation (performing operation by providing start signal from operation panel and setting running frequency from external potentiometer) COMMON

Make connections as shown below and set "4" in Pr. 79, operation mode selection.



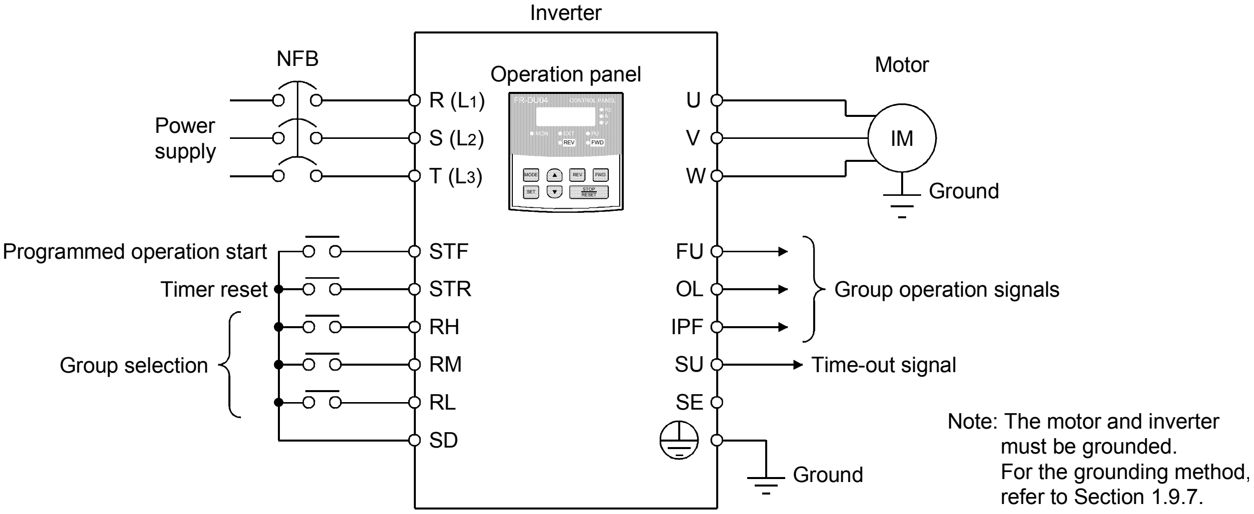
Note: The motor and inverter must be grounded.
For the grounding method, refer to Section 1.9.7.

Connection Example for Combined Operation [start: operation panel, running frequency: external signal]

(5) Programmed operation (A500)

Make connections as shown below and automatic operation is performed under the control of the timer in the inverter according to the operation time, frequency and rotation direction preset from the operation panel.

Set "5" in the operation mode selection Pr. 79 and "3" (programmed operation block output) in the output in terminal function switching Pr. 76.



Note: The motor and inverter must be grounded. For the grounding method, refer to Section 1.9.7.

Connection Example for Programmed Operation

1) Restrictions on the operation mode.

During programmed operation, no PU operations, external operations and combined operations can be made.

When the programmed operation start signal (STF) and timer reset signal (STR) are on, switching between the PU operation mode and external operation mode cannot be done.

Setting "5" (programmed operation) in Pr. 79 disables the following functions from being used if the corresponding inboard option is installed:

Orientation control
PLG feedback control
12-bit digital input
PI control

2) Input terminal information

When the programmed operation is performed by setting "5" (programmed operation) in Pr. 79, the following terminals are made valid and invalid as indicated below:

Valid and Invalid Terminals in Programmed Operation Mode

Valid Terminals	Invalid Terminals	Terminals Used for Programmed Operation
RES MRS RT CS	AU STOP 2 4 1 JOG	STF STR RH RM RL

3) Operation at the time of instantaneous power failure

If a power failure occurs during programmed operation, the motor is coasted and the intemal timer is reset. Therefore the programmed operation is not restarted when the power is restored.

To restart the programmed operation, switch the programmed operation start signal (terminal STF) once off, then on.

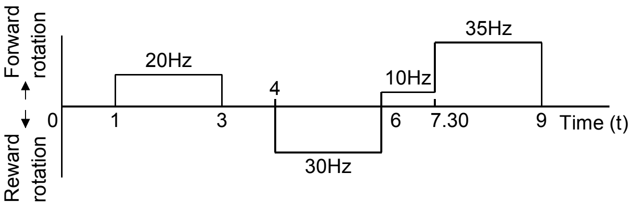
The programmed operation is then started from the initial state.

4) Setting of operation time, frequency and rotation direction

With the above three items defined as one point, 10 points are grouped as follows:

	Set Point	Rotation Direction, Frequency, Starting Time
Group 1	No.1	Pr. 201
	2	Pr. 202
	3	Pr. 203
	4	Pr. 204
	⋮	⋮
	10	Pr. 210
Group 2	No.11	Pr. 211
	⋮	⋮
	20	Pr. 220
Group 3	No.21	Pr. 221
	⋮	⋮
	30	Pr. 230

Use parameters Pr. 200 to Pr.232 for this setting.



Programmed Operation Setting Example

No.1 Forward rotation at 20Hz, 1 hour 0 minutes
→Pr. 201 = 1, 20, 1:00
No.2 Stop, 3 hours 0 minutes
→Pr. 202 = 0, 0, 3:00
No.3 Reverse rotation at 30Hz, 4 hours 0 minutes
→Pr. 203 = 2, 30, 4:00
No.4 Forward rotation at 10Hz, 6 hours 0 minutes
→Pr. 204 = 1, 10, 6:00
No.5 Forward rotation at 35Hz, 7 hours 30 minutes
→Pr. 205 = 1, 35, 7:30
No.6 Stop, 9 hours 0 minutes
→Pr. 206 = 0, 0, 9:00

- Time is 0 when both the start and group select signals are input.
- If either the set value or time is 9999, it is regarded as no setting.

● Setting the frequency and rotation direction

PU Screen Display

```
201 SetPRG 1
Direction 1
Set            30.00Hz
Time
```

Rotation direction – 1: forward rotation, 2: reverse rotation, 3 and up = error, 0: stop
Frequency ——— 0.1Hz increments
· To make a stop, write 0 to the roration direction and frequency.
· Set 9999 for no setting.

●Setting the time

PU Screen Display

```
201 SetPRG 1
Direction 1
Set            30.00Hz
Time            4 : 30s
```

Hour Minute — in units of minutes Pr.200 = 1, 3
Minute Second — in units of seconds Pr.200 = 0, 2

To select the time unit, use parameter Pr.200 (programmed operation minute/second selection).
· The input of 1:80 (excess of 59 minutes or 59 seconds) results in error.
· Set 9999 for no setting.

Note: When using the operation panel for setting, read the parameters, then set the rotation direction, frequency and time of day in this order.

● Base time

Programmed operation is performed under the control of the internal timer (RAM).

i) The timer range is between 0 and 99.59.
When Pr. 200 = 0, the maximum time is 99 minutes 59 seconds
When Pr. 200 = 1, the maximum time is 99 hours 59 minutes

ii) Resetting the base time
The base time is cleared by the timer reset terminal, inverter reset terminal, or power-off.

iii) The base time may be set optionally in Pr. 231.
This can be used for time matching.

iv) When Pr.200 = 2 or 3, the voltage monitoring value displayed is replaced by the base time.

v) Timer accuracy
Instantaneous error: ± 0.16s
Cumulative error (± 50ppm due to the accuracy of the crystal oscillator)
FR-A independent: Error of max. 4.5s every day24Hr × 60 × 60 × 50ppm = 4.32s

(6) Switch-over mode COMMON

By setting "6" in Pr. 79 "operation mode selection", you can select between PU operation, external operation and computer link operation (when FR-A5NR option is used with A500) while continuing the operating status.

Operation Mode Switching	Switching Operation/Operating Status	Corresponding Model	
		A500	E500
External operation to PU operation	Select the PU operation mode. • Rotation direction is the same as that of external operation. • Set frequency is as set by the potentiometer (frequency setting potentiometer). (Note that the setting will disappear when power is switched off or the inverter is reset.)	○	○
External operation to computer link operation	Mode change command to computer link mode is transmitted from the computer. • Rotation direction is the same as that of external operation. • Set frequency is as set by the potentiometer (frequency setting potentiometer). (Note that the setting will disappear when power is switched off or the inverter is reset.)	○ (Note 1)	×
PU operation to external operation	Press the external operation key of the parameter unit. • Rotation direction is determined by the external operation input signal. • Set frequency is determined by the external frequency setting signal.	○	○
PU operation to computer link operation	Mode change command to computer link mode is transmitted from the computer. • Rotation direction and set frequency are the same as those of PU operation.	○ (Note 1)	×
Computer link operation to external operation	The switch-over command to the external mode is sent from the computer. • Rotation direction is determined by the external operation input signal. • Set frequency is determined by the external frequency setting signal.	○ (Note 1)	×
Computer link operation to PU operation	Select the PU operation mode with the operation panel or parameter unit. • Rotation direction and set frequency are the same as those of computer link operation.	○ (Note 1)	×

Note: 1. Computer link operation is enabled when the FR-A5NR option is used with A500.

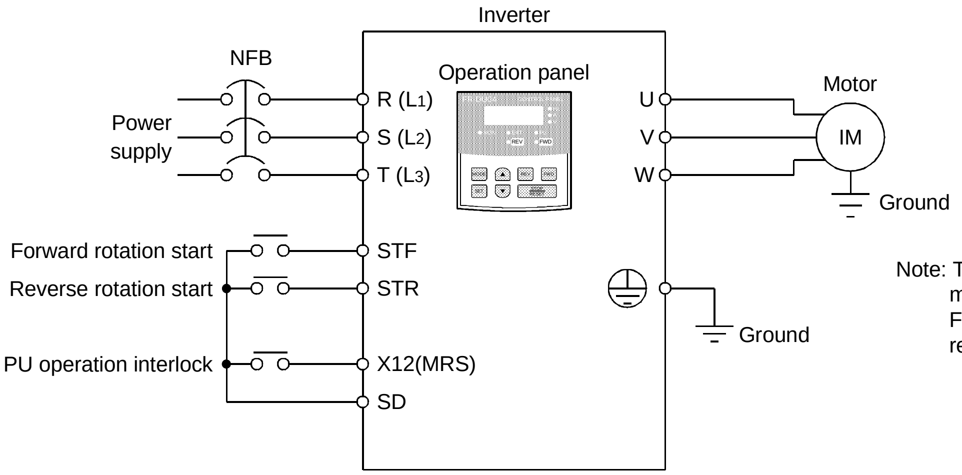
2. When switch-over is selected for E500, the potentiometer setting of the operation panel is made invalid if Pr. 146 = 1 or 9999.

(7) PU operation interlock (edit enable signal) COMMON

Make connections as shown below and set "7" in Pr. 79, operation mode selection. Switching ON-OFF the signal across X12 (MRS)-SD allows PU operation to be interlocked.

Note: 1. The X12 signal may be assigned to any terminal for A500 only.

2. For E500 and A500, if the X12 signal is not assigned to any terminal, the MRS signal acts as the PU operation interlock signal and the ordinary output stop function in the PU operation mode is not activated.



Note: The motor and inverter must be grounded. For the grounding method, refer to Section 1.9.7.

Connection Example for PU Operation Interlock

The following table indicates the functions of the X12 (MRS) signal when the Pr. 79 setting is 7 (PU operation interlock).

X12 (MRS) Signal Functions

Pr. 79 Setting	X12 (MRS) -SD	Function
7	Shorted (ON)	• Output stopped during external operation. • Operation mode can be switched to PU operation mode. • Parameter values can be rewritten in PU operation mode. • PU operation allowed.
	Open (OFF)	• Forcibly switched to external operation mode. • External operation allowed. • Switching to PU operation mode inhibited.

Operation Mode Switching Operation

Operating Condition		X12 (MRS)-SD	Operation Mode (Note 4)	Operating Status	Parameter Write	Switching to PU Operation Mode
Operation mode	Status					
PU	During stop	Shorted → open (Note 3)	External	During stop	Allowed → disallowed	Disallowed
	During operation	Shorted → open (Note 3)		If external operation frequency setting and start signal are entered, operation is performed in that status.	Allowed → disallowed	Disallowed
External	During stop	Open → shorted	External	During stop	Disallowed → disallowed	Allowed
		Shorted → open			Disallowed → disallowed	Disallowed
	During operation	Open → shorted		During operation → output stop	Disallowed → disallowed	Disallowed
		Shorted → open		Output stop → during operation	Disallowed → disallowed	Disallowed

Note: 1. For A500, when Pr. 79 = 7 and the PU operation external interlock signal (X12 (MRS)) is OFF, network operation such as computer link cannot be used.

2. If the X12 (MRS) signal is on, the operation mode cannot be switched to the PU operation mode when the start signal (STF, STR) is on.

3. The operation mode switches to the external operation mode independently of whether the start signal (STF, STR) is on or off. Therefore, the motor is run in the external operation mode when the X12 (MRS) signal is switched off with either of STF or STR on.

4. When an alarm occurs, the inverter can be reset by pressing the [RESET] key of the operation panel.

5. When the MRS signal is used as the PU interlock signal, switching the MRS signal on and rewriting the Pr. 79 value to other than 7 in the PU operation mode causes the MRS signal to provide the ordinary MRS function (output stop). Also, as soon as 7 is set in Pr. 79, the MRS signal acts as a PU interlock signal.

6. For A500, when the MRS signal is used as the PU operation external interlock signal, the signal logic conforms to the Pr. 17 setting. When Pr. 17 = 2, ON in the above description is replaced by OFF and OFF by ON.

(8) Operation mode switching by external signal

COMMON

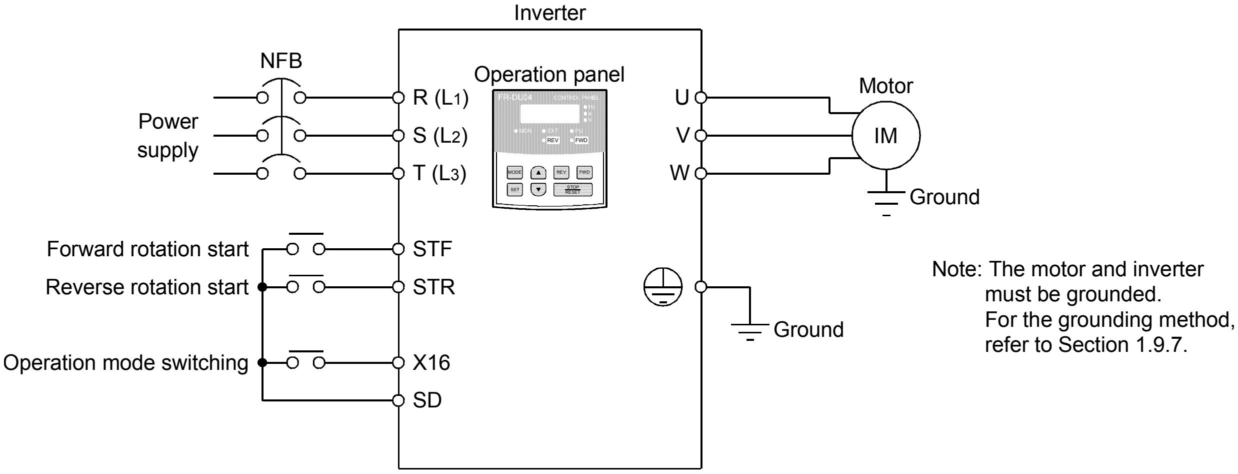
Make connections as shown below and set "8"in Pr. 79, operation mode selection. The operation mode can be changed by switching ON-OFF the signal across X16-SD.

Pr. 79 Setting	X16-SD	Fixed Mode	Remarks
8	Shorted (ON)	External operation mode	Cannot be changed to PU operation mode.
	Open (OFF)	PU operation mode	Cannot be changed to external operation mode.

Short X16-SD in the PU operation mode to forcibly change it to the external operation mode. Open X16-SD to switch to the PU operation mode.

Note that this switching is only enabled during an inverter stop and cannot be done during operation.

Note: Allocate the X16 signal to any of the input terminals.



Connection Example for Operation Mode Switching by External Signal

1.6.2 Parameter write inhibit selection [Pr. 77] COMMON

Writing can be inhibited so that the functions set from the operation panel cannot be changed accidentally.

Parameter Number	Set Value	Description	Factory Setting
77	0	Parameter write enabled only during a stop in PU operation mode	○
	1	Parameter write disabled	—
	2	Write always enabled including during operation	—

Note: 1. After parameter write is inhibited, write is only enabled for Pr. 77 and Pr. 79.
After changing the Pr. 77 value to 0 to enable parameter write, change the set value of the function which requires changing.

2. When operation mode selection (Pr. 79) is external operation only (set value 2), change the Pr. 79 value to 0 once, choose the PU operation mode, and select parameter write inhibit.

List of Exceptions to Pr. 77, Parameter Write Inhibit Selection, for A500

Pr. 77 Setting	0 (Write enabled only during stop in PU operation mode)					1 (Write inhibit)					2 (Write always enabled)	
Operation mode Pr. 79 setting	PU (PU+E)		EXT	PU+E	PRG	PU	PU+E		EXT	PRG	0 to 4, 7, 8	5
	0, 1, 3 7, 8	5	0, 2, 7, 8	4	5	0, 1, 5, 7, 8	3	4	0, 2	5		
PU operation frequency	○		—			○		—	—		○	
Pr. 4 to 6,22,24 to 27, 52 to 56,75,160,232 to 239,271 to 274,900,901	○		○			×					○	
Pr. 72,240	○		×	○		×					○	
Pr. 200 to 231	×	○	×	×	○	×					×	○
Pr. 77	○		×	○	×	○			×		○	
Pr. 79	×		× (Write enabled during stop)			○					×	
Remarks	○ Indicates that write is also enabled during operation. × Indicates that write is disabled during operation in external operation mode.					○ Indicates that write is enabled. × Indicates that write is disabled.					○ Indicates that write is always enabled. × Indicates that write is disabled during operation.	

Note: For A500, Pr. 23, 48, 49, 60, 61, 66, 71, 79 to 81, 83, 84, 95, 96, 100 to 109, and 135 to 139 are write-disabled during inverter operation if write is always enabled.

List of Exceptions to Pr. 77, Parameter Write Inhibit Selection, for E500

Pr. 77 Setting	0 (Write enabled only during stop in PU operation mode)			1 (Write inhibit)				2 (Write always enabled)
Operation mode Pr. 79 setting	PU(PU+E)	EXT	PU+E	PU	PU+E		EXT	0 to 4,7,8
	0, 1, 3, 7, 8	0, 2, 7, 8	4	0, 1, 7, 8	3	4	0, 2	
PU operation frequency	○	—		○		—	—	○
Pr. 4 to 6,22,24 to 27,52, 54 to 56,232 to 239	○	○		×				○
Pr. 72	○	×	○	×				○
Pr. 77	○	×	○	○				○
Pr. 79	×	× (Write enabled during stop)		○				×
Remarks	○ Indicates that write is also enabled during operation. × Indicates that write is disabled during operation in external operation mode.			○ Indicates that write is enabled. × Indicates that write is disabled.				○ Indicates that write is always enabled. × Indicates that write is disabled during operation.

Note: Pr. 23, 66, 71, 79, 90 and 96 are write-disabled during inverter operation if write is always enabled.

1.6.3 Reverse rotation prevention selection [Pr. 78] COMMON

Disallows the motor from running only in the reverse or forward direction when it is desired to run the motor only in one direction.

This function is valid in any operation mode for the reverse or forward rotation key on the operation panel (parameter unit) and the reverse or forward rotation start input signal terminal STR or STF.

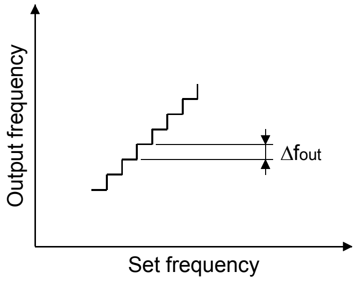
Parameter Number	Set Value	Description	Factory Setting
78	0	Both forward and reverse rotations allowed	○
	1	Reverse rotation disallowed (forward rotation only allowed)	—
	2	Forward rotation disallowed (reverse rotation only allowed)	—

1.6.4 Frequency resolution COMMON

The running frequency of the inverter can be set by either the analog input to the frequency setting input terminal or the digital input from the operation panel or parameter unit. The operation panel allows setting in increments of 0.01Hz up to 100Hz and 0.1Hz at more than 100Hz, and the parameter unit allows setting in increments of 0.01Hz from its ten-key pad.

(1) Output frequency resolution COMMON

For the output frequency resolution Δf_{OUT}, refer to the common specifications in Section 1.1.2. The output frequency resolution does not change if the output frequency varies between 0 and 400Hz.



Output Frequency Resolution

(2) Set frequency resolution COMMON

The set frequency resolution for the digital input is determined by the number of digits set by the operation panel (parameter unit). The set frequency resolution for the analog input is determined by the number of analog-to-digital converter bits.

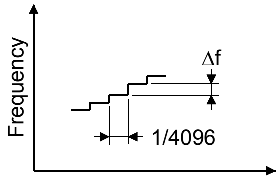
For a voltage signal:

$$\Delta f = \frac{\text{Frequency setting voltage gain (Pr.903)}}{4096} \text{ [Hz]}$$

For a current signal:

$$\Delta f = \frac{\text{Frequency setting current gain (Pr.905)}}{4096} \text{ [Hz]}$$

Set Frequency Resolution

Input Condition	Frequency Resolution (Δ f)
Analog input COMMON (Note 1) Across 2-5 Across 1-5 (Note 2) Across 4-5	 For how to find Δf, see above. 0V to 5V 0V to 10V 0mA to 20mA Terminal 4 Frequency setting input signal
Digital input (Setting from operation panel or parameter unit)	Δf = 0.01Hz (Δf = 0.1Hz at less than 100Hz for operation panel)
Digital input (Note 1) (From option)	Depends on the setting resolution of the FR-A5AX (12-bit digital input), FR-A5NR (computer link) or other option.

Note: 1. Since the frequency resolution in the inverter is 0.01Hz, control cannot be exercised if the resolution setting is less than 0.01Hz.

2. Terminal 1 is not provided for E500.

1.6.5 Motor frequency, speed display [Pr. 37, 55, 56, 144*, 900, 901*]

COMMON

(*Pr. 144 and 901 are not provided for E500.)

The output frequency of the inverter can be displayed on the frequency monitor of the operation panel (parameter unit). Also the output current of the output terminal FM for meter (frequency meter) can be indicated by a 1mA DC ammeter etc.

In addition, the motor speed (r/min), load shaft speed, line speed (m/min), etc. can be displayed.

(1) Speed display [Pr. 37, Pr. 144]

1) A500

When the running speed monitor display of the operation panel (parameter unit) is selected, the output frequency can be displayed in motor speed (r/min) or load speed (value proportional to the motor speed). In the V/F mode, the speed displayed differs from the actual speed by a motor slip value since the inverter output frequency is displayed in terms of synchronous speed. During constant-speed operation, the motor speed is approximate to the display value because the motor slip is several percent. However, during acceleration/deceleration or low-speed operation of less than about 6Hz, the actual speed and display value may differ greatly. When the advanced magnetic flux vector control mode has been selected, this display provides the estimated value of the actual speed (estimated value derived from motor slip calculation).

Parameter Number	Name	Setting Range	Factory Setting
37	Speed display	0, 1 to 9998	0 (Frequency setting)
144	Speed setting change-over	0, 2, 4, 6, 8, 10, 102, 104, 106, 108, 110	4

Set the stall prevention operation level in Pr. 48 and Pr. 114.
Refer to the following list to set values in Pr. 49 and Pr. 115.
Pr. 114 and Pr. 115 are made valid by switching on the X9 signal. Set "9" in any of Pr. 180 to Pr. 186 to allocate the terminal used to input the X9 signal.
By changing the Pr. 37 and Pr. 144 values, the units of the running speed setting in the PU operation mode and parameter setting used for frequency setting can be changed from the frequency to the motor speed or machine speed. Refer to the following combinations:

Running Speed Monitor Display	Parameter Setting Unit Running Speed Setting Unit	Pr. 37 Setting	Pr. 144 Setting
Speed of 4-pole motor (r/min)	Hz	0	0
Motor speed (r/min)	r/min	0	2 to 10
		1 to 9998	102 to 110
		0	102 to 110
Machine speed	Hz	1 to 9998	0
	r/min	1 to 9998	2 to 10

Note: 1. During PLG feedback control, the data displayed is the same as in advanced magnetic flux vector control. Note that the speed displayed is the actual speed from the PLG.
2. When the running speed display has been selected with "0" set in Pr. 37 and "0" in Pr. 144, the monitor display shows the speed reference for a 4-pole motor (1800r/min is displayed at 60Hz).
3. To change the PU main monitor (PU main display) or PU level meter (PU level display), refer to Pr. 52 and Pr. 53.
4. As the operation panel display is 4 digits, "----" is displayed when the monitored value exceeds "9999".

2) E500
The setting method is similar to that of A500 but only Pr. 37 is used for setting as it does not have Pr. 144.

Parameter number	Name	Setting Range	Factory Setting
37	Speed display	0,0.01 to 9998	0 (Output frequency)

To display the machine speed, set the machine speed for 60Hz operation in Pr. 37.
Also, use the frequency as the units of the running speed setting in the PU operation mode and parameter setting used for frequency setting.
Note: 1. Refer to Pr. 52 and Pr. 53 when it is desired to change the monitor (PU main display) of the operation panel or the PU level meter (PU level display).
2. As the operation panel shows a value in 4 digits, any monitor value over "9999" is shown as "----".

(2) Output signal of meter (frequency meter) terminal FM COMMON [Pr. 55, Pr. 56, Pr. 900]
Set any of "1, 2, 5, 6, 11, 17 and 18" in Pr. 54 (FM terminal function selection) to output a pulse train of constant pulse width proportional to the frequency (current) from terminal FM. (Note 1) Terminal FM is factory-set to output a pulse train of approximately 3.5VDC (Note 2) average voltage and 24 times higher speed than the output frequency at the output frequency of 60Hz with terminals FM-SD open. The output of terminal FM can be provided with reference to the frequency monitoring value (Pr. 55) or the current monitoring value (Pr. 56) depending on the setting of Pr. 54 (FM terminal function selection).
Note: 1. For E500, setting "0" (factory setting) in Pr. 54 (FM terminal function selection) provides the output frequency and setting "1" outputs a pulse train proportional to the output current.
2. Approximately 4.7V for E500.

Parameter number	Name	Setting Range	Factory Setting
55	Frequency monitoring reference setting	0 to 400Hz	60Hz
56	Current monitoring reference setting	0 to 500A	Rated output current
900	Meter (frequency meter) calibration (average output voltage)	Approximately 0 to 8V	(Note 2) Approxi-mately 3.5V

The average output voltage and pulse speed across terminals FM-SD can be changed.

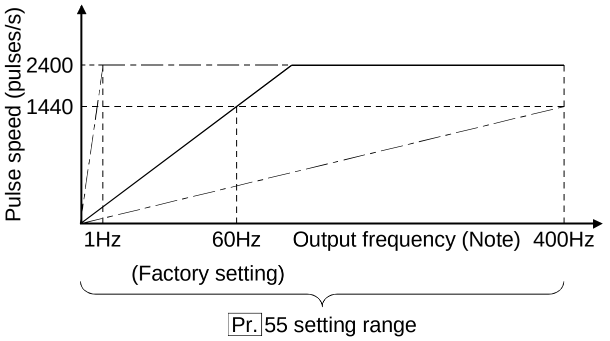
The function of changing the average output voltage across terminals FM-SD is used to calibrate a 1mA meter (frequency meter). The function of changing the pulse speed can be used at the maximum operating output frequency of 100Hz or higher or to maintain the compatibility with the FR-K/K3/K400 series inverters. (See the table below.)

Compatibility with Pulse Trains of FR-K/K3/K400 Series Inverters

Max. Inverter Output Frequency	Pr. 55 Setting	Pulse Speed
60Hz	60	24 inverter output frequency
120Hz	120	12 inverter output frequency
240Hz	240	6 inverter output frequency

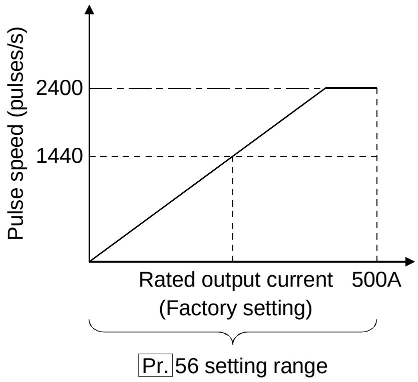
1) Frequency monitoring reference setting [Pr. 55]
   Set the inverter output frequency (Note) so that the pulse speed at terminal FM is 1440 [pulses/s]. As shown on the top right, the pulse speed is proportional to the inverter output frequency. Note that the maximum speed of the pulse train is 2400 [pulses/s].

Note: For (A500), Pr. 54 allows the output frequency to be replaced by the other frequency depending on its setting. (Refer to Section 1.6.18.)



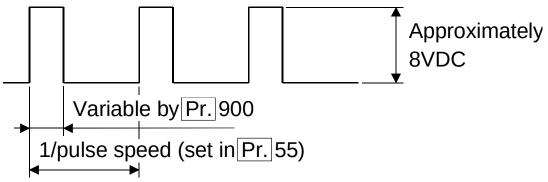
Terminal FM Pulse Speed (Frequency reference)

2) Current monitoring reference setting [Pr. 56]
   Set the current reference value (refer to Section 1.6.18) so that the pulse speed at terminal FM is 1440 [pulses/s]. As shown below, the pulse speed is proportional to the inverter output current. Note that the maximum speed of the pulse train is 2400 [pulses/s].



Terminal FM Pulse Speed (Current reference)

3) Meter (frequency meter) calibration [Pr. 900]
   The output voltage of terminal FM has a pulse waveform as shown below.
   Connect an analog frequency meter (1mA moving-coil type DC ammeter) across inverter terminals FM-SD, call Pr. 900, and press the ▲ / ▼ key as appropriate. This changes the pulse width and the average value of the output voltage, thus allowing the frequency meter to be calibrated.



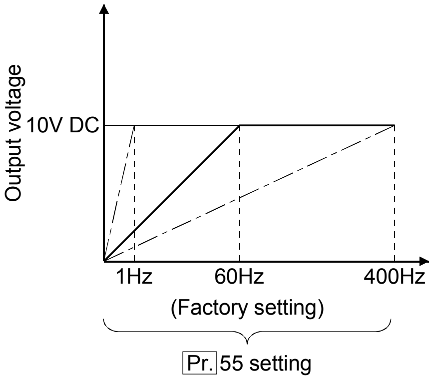
Output Waveform of Terminal FM

(3) Output signal of analog output terminal AM [Pr. 55, Pr. 56, Pr. 901] (A500)

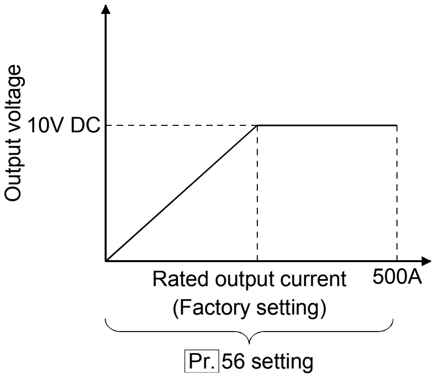
Set any of "1, 2, 5, 6, 11, 17 and 18" in Pr. 158 (AM terminal function selection) to output an analog voltage proportional to the frequency (current) from terminal AM. Terminal AM is factory-set to output an approximately 10VDC voltage at the output frequency of 60Hz when terminals AM-5 are opened. The maximum output voltage is 10VDC.

The output of terminal AM can be selected between the frequency monitoring reference and the current monitoring reference depending on the Pr. 54 setting. (Refer to Section 1.6.18.)

1) Frequency monitoring reference setting [Pr. 55]
   Set the frequency reference value (refer to Section 1.6.18) so that the output voltage of terminal AM is 10VDC.
   As shown below, the output voltage is proportional to the frequency.



Output Voltage of Terminal AM
(Frequency reference)



Output Voltage of Terminal AM
(Current reference)

2) Current monitoring reference setting [Pr. 56]
Set the current reference value (refer to Section 1.6.18) so that the output voltage of terminal AM is 10VDC.
As shown below, the output voltage is proportional to the current value.

3) Output voltage calibration [Pr. 901]
The output voltage of terminal AM is an analog voltage of 0 to 10VDC. Call Pr. 901 and press the ▲ / ▼ key as appropriate. This changes the output voltage and allows calibration.

1.6.6 Frequency setting
[Pr. 4 to 6, 15, 16, 24 to 28*, 38*, 39*, 59, 73, 232 to 239, 902 to 905, 922*, 923*] COMMON

(*Pr. 28 is not provided for E500. Pr. 38, 39, 922 and 923 are not provided for A500)

Set the frequencies from the operation panel (parameter unit) or using the voltage signals of the frequency setting input terminals. In addition, the frequencies can be set using the current signal terminal, or for A500, from a programmable controller (PC) via the PC link unit (inboard option), the digital input unit (inboard option) etc. For further details of the options, refer to the corresponding documents.

(1) PU operation mode (Operation mode indication PU, PU +E) COMMON

1) For continuous operation, directly enter the running frequency from the operation panel (parameter unit).

2) For E500, operation may be performed with the built-in potentiometer of the operation panel. For details on making the built-in potentiometer valid, refer to Section 1.4.6 (2).

3) For jog operation (PU operation), directly preset the jog operation frequency in Pr. 15.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
15	Jog frequency	0 to 400Hz	0.01Hz	5Hz

(2) Multi-speed operation (External operation mode - operation mode indication EXT, PU + E)
[Pr. 4 to 6, Pr. 24 to 27, Pr. 232 to 239] COMMON

1) To specify three-speed operation, directly set the high-speed, middle-speed and low-speed running frequencies in the PU operation mode or external operation mode. They may be changed during operation. (For full information on the operation procedure, refer to Section 1.4.7.)

2) If two or more terminals of RH, RM and RL have been switched on, the lower speed terminal has priority over the others.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	External Terminal Name
4	High speed (speed 1)	0 to 400Hz	0.01Hz	60Hz	RH
5	Middle speed (speed 2)			30Hz	RM
6	Low speed (speed 3)			10Hz	RL

3) Multi-speed operation of up to 15 speeds can be performed through the combinations of input signals of the external terminals for multi-speed operation (REX, RH, RM, RL). Directly set the running frequencies of high, middle and low speeds and speeds 4 to 15, and start operation. (For details of the operation procedure, refer to Section 1.4.7.)

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
24 to 27	Speeds 4 to 7	0 to 400Hz, 9999	0.01Hz	9999
232 to 239	Speeds 8 to 15			

Note: 1. Setting of 9999 in any function number makes the corresponding speed setting invalid.
2. When 9999 has been set to all of speeds 4 to 15, three-speed operation may only be performed.
3. The frequencies of speeds 1 to 15 can be changed from the operation panel (parameter unit) during operation.

4) When the frequency setting is made in the PU mode for combined operation, the external terminals for multi-speed operation are made valid. (However, they are invalid during operation using the built-in potentiometer for E500.)

(3) Analog input (External operation mode) COMMON
In the external frequency setting, the frequencies can be set by analog inputs of 5VDC, 10VDC and 20mADC and their combinations as indicated on the following page:

Analog Input Types of A500

Input (DC)	Input Terminals	Input Resistance	DC Power Supply	Selected Signals and Related Parameters	Auxiliary Input Override	Factory Setting	Refer to Section
0 to +5V	2-5	10kΩ±1kΩ	Built-in (terminal 10) or external	REX, RH, RM, RL signals...OFF Pr. 73,902,903	Terminal 1 auxilary input	○	1.6.6(4) 1.6.6(5)
0 to +10V	2-5	10kΩ±1kΩ	Built-in (terminal 10E) or external	REX, RH, RM, RL signals...OFF Pr. 73,902,903	Terminal 1 auxilary input	—	1.6.6(4) 1.6.6(5)
4 to 20mA	4-5	250Ω±2%	External	AU signal...ON Pr. 73,904,905	Terminal 1 auxilary input Terminal 2 override	○	1.6.6(6) 1.6.6(7)
0 to ±5V	1-5	10kΩ±1kΩ	External	Pr. 73,902,903	Terminal 2 override	—	1.6.6(9)
0 to ±10V	1-5	10kΩ±1kΩ	External	Pr. 73,902,903	Terminal 2 override	—	1.6.6(9)

Note: The input signal of 5V or 10V may be selected by using Pr. 73, frequency command voltage range selection. Use Pr. 902 to Pr. 905 to set frequencies at the maximum input voltage and current.

Analog Input Types of E500

Input (DC)	Input Terminals	Input Resistance	DC Power Supply	Selected Signals and Related Parameters	Factory Setting	Refer to Section
0 to ±5V	2-5	10kΩ±1kΩ	Built-in (terminal 10) or external	REX, RH, RM, RL signals...OFF Pr. 38,73,902,903	○	1.6.6(4) 1.6.6(5)
0 to +10V	2-5	10kΩ±1kΩ	External	REX, RH, RM, RL signals...OFF Pr. 38,73,902,903	—	1.6.6(4) 1.6.6(5)
4 to 20mA	4-5	250Ω±2%	External	AU signal...ON Pr. 39,904,905	—	1.6.6(6) 1.6.6(7)

Note: The input signal of 5V or 10V may be selected by using Pr. 73, frequency command voltage range selection. Use Pr. 902 to 905 to set frequencies at the maximum input voltage and current.

(4) 0-5V/0-10V (frequency command voltage range) selection [Pr. 73] COMMON

1) A500

Depending on the Pr. 73 setting, the analog inputs (frequency setting input signals) can be combined as described below:

a) The input voltage of terminal 2 is used independently as 0 to 5V or 0 to 10V.

b) By entering input (0 to ±5V or 0 to ±10V) to terminal 1, forward-reverse rotation switching operation can be performed depending on the polarity, as with a servo. [Polarity reversible operation]

c) The value obtained by adding the auxiliary input (±input) of terminal 1 to the main speed setting signal of terminal 2 can be used as frequency setting. [Auxiliary input operation]

d) The signal of terminal 1 is used as the main speed setting signal and operation is performed at the frequency setting derived by multiplying the signal by 50 to 150% according to the 0 to 5V (or 0 to 10V) signal of terminal 2. [Override function]

e) The 4 to 20mA signal of terminal 4 can be used as the main speed setting signal to perform the auxiliary input operation and override operation in the above paragraphs c) and d).

f) By setting "1" in Pr. 28, multi-speed input compensation selection, multiple speeds can be used as the main speed setting signals to perform the auxiliary input operation and override operation as in the above paragraphs c) and d).

[Operation by independent command input]
When the frequency setting signal is input to any of terminals 2, 1 and 4, operation is performed at the frequency matching the command voltage range set in Pr. 73 and the gain and bias set in Pr. 902 to Pr. 905.

[Operation by several command inputs]
When the frequency setting signals are input from two of terminals 2, 1 and 4, operation is performed with the two setting signals compensated for by addition (or override) according to the value set in Pr. 73.

- AU, REX, RH, RM, RL signals ... OFF

Compensation	Pr. 73 Setting		Input Voltage		Input Current Terminal 4	Set Frequency Formula (Note) f_0: Pr. 903 voltage gain, Pr. 902 = 0Hz
	Without polarity reversible	With polarity reversible	Terminal 2 [V2]	Terminal 1 [V1]		
Addition compensation	0	10	0 to 10V	0 to ±10V	Invalid	$f_0 \times (V_2 + V_1)/10$
	1 (factory setting)	11	0 to 5V			$f_0 \times (V_2 + 0.5V_1)/5$
	2	12	0 to 10V	0 to ±5V		$f_0 \times (V_2 + 2V_1)/10$
	3	13	0 to 5V			$f_0 \times (V_2 + V_1)/5$
Override	4	14	0 to 10V	0 to ±10V		$f_0 \times V_1 \times (V_2 + 5)/100$
	5	15	0 to 5V	0 to ±5V		$f_0 \times V_1 \times (V_2 + 2.5)/25$

Note: The maximum value is f_0, and the minimum value is 0Hz without polarity reversible or is reverse-side f_0 with polarity reversible. (Negative valid)

[Example] When Pr. 73 = 1, V2 = 3V, V1 = -2V, Pr. 903 = 60Hz, and Pr. 902 = 0Hz
Set frequency = 60 × (3 - 0.5 × 2)/5 = 24Hz

- AU signal ... ON, REX, RH, RM, RL signals ... OFF

Compensation	Pr. 73 Setting		Input Voltage		Input Current Terminal 4 [I]	Set Frequency Formula (Note) f_0: Pr. 905 voltage gain, Pr. 904 = 0Hz
	Without polarity reversible	With polarity reversible	Terminal 2 [V2]	Terminal 1 [V1]		
Addition compensation	0	10	Invalid	0 to ±10V	0 to 20mA	$f_0\{(I - 4)/16 + V_1/10\}$
	1 (factory setting)	11				$f_0\{(I - 4)/16 + V_1/10\}$
	2	12		0 to ±5V		$f_0\{(I - 4)/16 + V_1/5\}$
	3	13				$f_0\{(I - 4)/16 + V_1/5\}$
Override	4	—	0 to 10V	Invalid		$f_0 \times (I - 4) \times (V_2+5)/160$
	5	—	0 to 5V			$f_0 \times (I - 4) \times (V_2+2.5)/80$

Note: The maximum value is f_0, and the minimum value is 0Hz without polarity reversible or is negative (reverse rotation) valid with polarity reversible.

- Multi-speed operation (any of REX, RH, RM and RL signals ON)

Pr. 28 Setting	Compensation	Pr. 73 Setting		Input Voltage		Input Current Terminal 4	Set Frequency Formula (Note) f_R: multi-speed setting frequency f_0: Pr. 903 voltage gain, Pr. 902 = 0Hz
		Without polarity reversible	With polarity reversible	Terminal 2 [V2]	Terminal 1 [V1]		
0 (factory setting)	No	—	—	Invalid	Invalid	Invalid	f_R
1 (with compensation)	Addition compensation	0	10	Invalid	0 to ±10V		$f_R + (f_0 \times V_1/10)$
		1	11				$f_R + (f_0 \times V_1/10)$
		2	12		0 to ±5V		$f_R + (f_0 \times V_1/5)$
		3	13				$f_R + (f_0 \times V_1/5)$
	Override	4	—	0 to 10V	Invalid		$f_R \times (V_2 + 5)/10$
		5	—	0 to 5V			$f_R \times (V_2 + 2.5)/10$

Note: The maximum value is the maximum frequency limit, and the minimum value is 0Hz without polarity reversible or is negative (reverse rotation) valid with polarity reversible.

2) (E500)

An independent command input can be used to perform operation.

When the frequency setting signal is entered into any of terminals 2, 1 and 4, operation is performed at the frequency which corresponds to the command voltage range set in Pr. 73, the gain in Pr. 38 or Pr. 39, or the gain and bias set in Pr. 902 to Pr. 905.

- AU, REX, RH, RM, RL signals ... OFF

Pr. 73 Setting	Input Voltage Terminal 2 [V2]	Input Current Terminal 4	Set Frequency Formula (Note) f_0: Pr. 38 or Pr. 903 gain, Pr. 902 = 0Hz
0 (factory setting)	0 to 5V	Invalid	$f_0 \times V_2/5$
1	0 to 10V		$f_0 \times V_2/10$

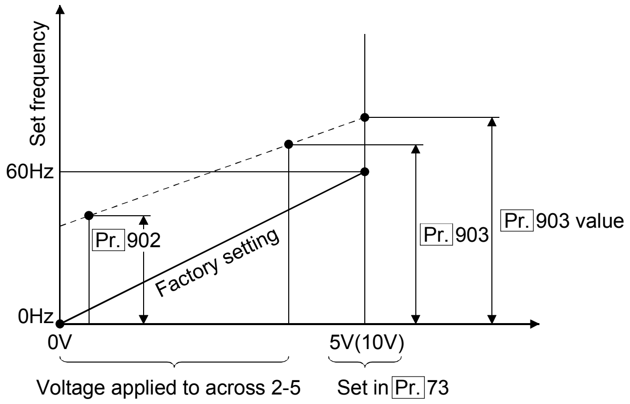
Note: The maximum value is f_0 and the minimum value is 0Hz.

- AU signal ... ON, REX, RH, RM, RL signals ... OFF
  Set frequency formula (Note) I: input current, f_0 = Pr. 39 or Pr. 905 current gain, Pr. 904 = 0Hz
  4mA

Note: The maximum value is f_0 and the minimum value is 0Hz.

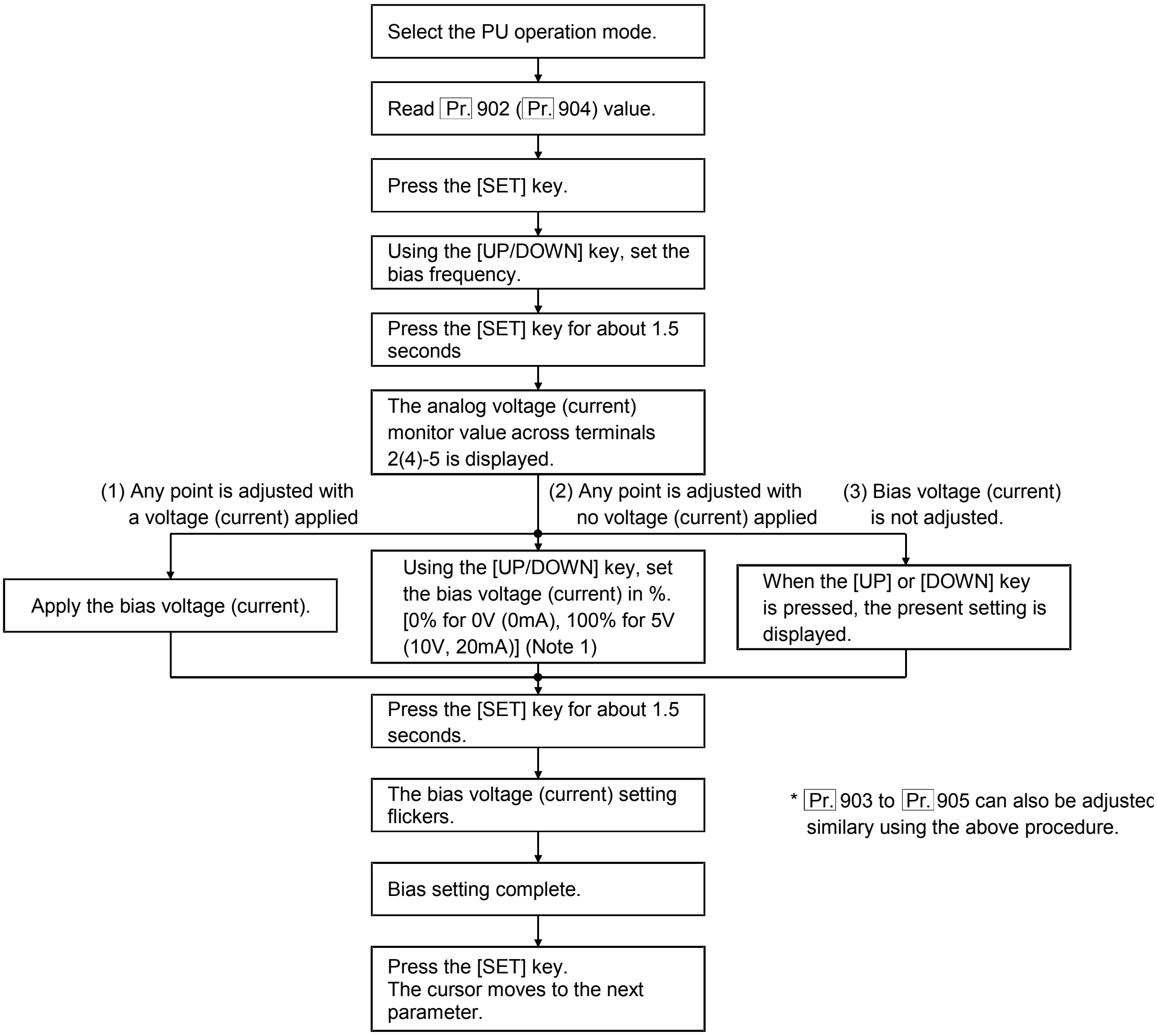
(5) Frequency setting voltage bias, gain [Pr. 38, 902, 903] (COMMON)

1) Set the relationship between the frequency setting input signal entered across terminals 2-5 and the output frequency.
   The relationship between the frequency setting input voltage and output frequency is as shown on the right.
2) When using Pr. 902 and Pr. 903 to set the frequency setting bias and gain, a voltage may either be applied or not applied to across terminals 2-5.



Frequency Setting Voltage Bias, Gain

When operation panel (FR-DU04) is used (A500 only)



Select the PU operation mode.

Read Pr. 902 (Pr. 904) value.

Press the [SET] key.

Using the [UP/DOWN] key, set the bias frequency.

Press the [SET] key for about 1.5 seconds

The analog voltage (current) monitor value across terminals 2(4)-5 is displayed.

(1) Any point is adjusted with a voltage (current) applied

Apply the bias voltage (current).

(2) Any point is adjusted with no voltage (current) applied

Using the [UP/DOWN] key, set the bias voltage (current) in %. [0% for 0V (0mA), 100% for 5V (10V, 20mA)] (Note 1)

(3) Bias voltage (current) is not adjusted.

When the [UP] or [DOWN] key is pressed, the present setting is displayed.

Press the [SET] key for about 1.5 seconds.

The bias voltage (current) setting flickers.

Bias setting complete.

Press the [SET] key.
The cursor moves to the next parameter.

* Pr. 903 to Pr. 905 can also be adjustec similary using the above procedure.

Note: 1. For the voltage across the frequency setting power supply terminal 10 - 5 (10E (not provided for E500)) built into the inverter, the voltage set in Pr. 73 (frequency command voltage range selection) is used as reference.

For A500
- Pr. 73 is any of 1, 3, 5, 11, 13 and 15: 5V
- Pr. 73 is any of 0, 2, 4, 10, 12 and 14: 10V

For E500
- Pr. 73 is 0: 5V
- Pr. 73 is 1: 10V

2. If the Pr. 903 or Pr. 905 (gain adjustment) value is changed, the Pr. 20 value does not change.
The input signal to terminal 1 (frequency setting auxiliary input) is added to the frequency setting signal.

3. For the operation procedure using the parameter unit (FR-PU04), refer to the FR-PU04 instruction manual.

3) Since the voltage (5VDC±0.2V or 10VDC ±0.4V (Note)) across the frequency setting power supply terminal 10 - 5 (10E (Note)) varies between inverters, the output frequency with respect to the voltage across the frequency setting input terminal 2-5 is, strictly speaking, different between inverters. When controlling several inverters using COMMON frequency setting input signals, for example, the frequency setting voltage gain must be calibrated using Pr. 903, frequency setting voltage gain.

Note: Not provided for E500.

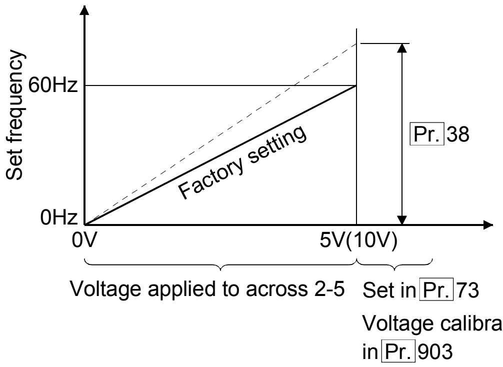
4) In the external operation mode, the analog frequency setting voltage and output frequency are factory-set so that the output frequency is 0Hz at the input voltage of 0V and 60Hz at 5V (or 10V). They are proportional to each other between the above values as indicated by the continuous line in the previous diagram. This relationship may be changed as desired as indicated by the dotted line, for example.

5) When applying a voltage for calibration, the difference between the frequency setting input voltages in Pr. 902 and Pr. 903 should be not less than 0.5V. If it is less than 0.5V, a setting error will occur.

6) The line (dotted line) connecting the frequencies set in Pr. 902 and Pr. 903 represents the relationship between the input voltage and set frequency.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
902	Frequency setting voltage bias	0 to 60Hz	0.01Hz	0Hz
903	Frequency setting voltage gain	1 to 400Hz	0.01Hz	60Hz

7) For E500, the frequency at 5V (10V) input can be set in Pr. 38. Pr. 38 allows the setting of the frequency only and the voltage set in Pr. 903 (factory-set to 5V (10V)) is used as the reference.



Frequency Setting Voltage Bias, Gain for E500

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
38	Frequency at 5V (10V) input	1 to 400Hz	0.01Hz	60Hz

(6) Frequency setting current bias, gain [Pr. 39, 904, 905] COMMON

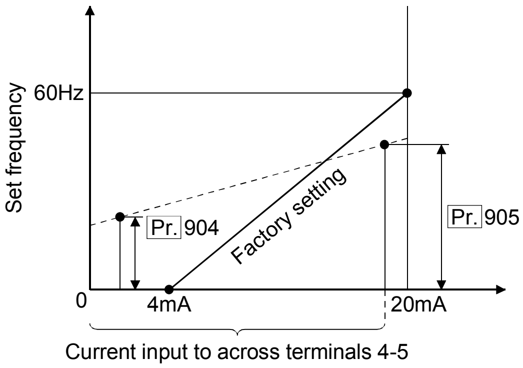
1) Set the relationship between the frequency setting input signal input to terminal 4 and the output frequency. The relationship between the frequency setting input current and output frequency is as shown below.

2) When setting the frequency setting gain in Pr. 905, it is not necessary to input a current across terminals 4-5. However, the input impedance of the frequency setting current input terminal 4 varies between inverters (250Ω±2%). Hence, the output frequency with respect to the frequency setting current input is, strictly speaking, different between inverters. When controlling several inverters using COMMON frequency setting input signals, for example, it is necessary to make calibration using the frequency setting current gain, Pr. 905, and bias, Pr. 904. For the setting method, refer to the Pr. 902 adjustment procedure (Section 1.6.6 (5)).

3) In the external operation mode, the 4-20mA frequency setting current and output frequency are factory-set so that the output frequency is 0Hz at the input current of 4mA and 60Hz at 20mA. They are proportional to each other between the above values as indicated by the continuous line in the following diagram.

4) When applying a current for calibration, the difference between the frequency setting input currents in Pr. 904 and Pr. 905 should be not less than 2mA. If it is less than 2mA, a setting error will occur.

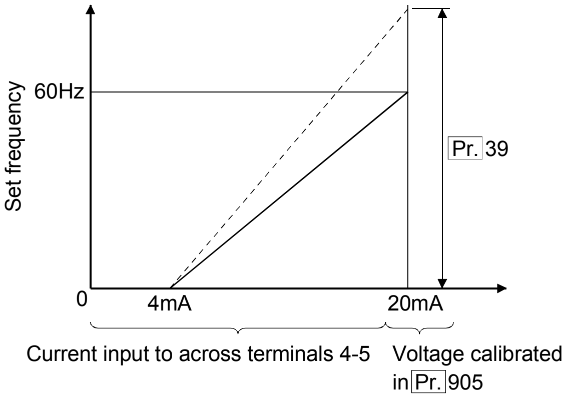
5) The frequency setting accuracy is ± 0.3%.



Frequency Setting Current Bias, Gain

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
904	Frequency setting current bias	0 to 60Hz	0.01Hz	0Hz
905	Frequency setting current gain	1 to 400Hz	0.01Hz	60Hz

6) For E500, the frequency at 20mA input can be set in Pr. 39. Pr. 39 allows the setting of the frequency only and the voltage set in Pr. 905 (factory-set to 20mA) is used as the reference.



Frequency Setting Current Bias, Gain for E500

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
39	Frequency at 20mA input	1 to 400Hz	0.01Hz	60Hz

(7) Built-in potentiometer bias, gain [Pr. 922, 923] E500

1) Make setting to make the built-in potentiometer valid. (Refer to Section 1.4.6 (2).)
2) For the setting method, refer to the Pr. 902 adjustment procedure (Section 1.6.6 (5)).

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
922	Built-in potentiometer bias	0 to 60Hz	0.01Hz	0Hz
923	Built-in potentiometer gain	0 to 400Hz	0.01Hz	60Hz

(8) Forward-reverse operation by analog ± input (External operation mode) [Pr. 73] A500

1) The auxiliary analog input terminal 1 allows forward or reverse operation to be performed using only the frequency setting signal without using the start signal (terminal STF or STR). Pr. 73 allows selection between enable and disable of polarity reversible operation.
2) The motor is not started until the analog input voltage equivalent to or greater than the starting frequency in Pr. 13 is entered. When polarity has been switched, the motor is decelerated to 0.5Hz and then run in the opposite direction at the starting frequency.
3) When the voltage signal is input to analog input terminal 2 or the current signal input to terminal 4, this signal is added to the voltage of terminal 1 to perform polarity reversible operation.

(9) Auxiliary analog input (External operation mode A500

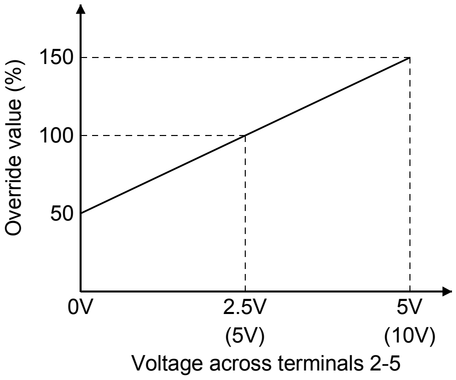
In the external operation mode, the frequency setting of the analog voltage input (across terminals 2-5) or analog current input (across terminals 4-5) can be compensated for by the auxiliary analog input.

To enable the auxiliary analog input, enter 0 to ± 5VDC or 0 to ± 10VDC across terminals 1-5. (Refer to Section 1.4.6.)

(10) Override compensation input (External operation mode) A500

Analog compensation (override) of a given ratio can be made on the frequency setting signal (main setting) of the auxiliary analog voltage input (across terminals 1-5) or the analog current input (across terminals 4-5).

As the compensation ratio, input 0 to 5VDC (or 0 to 10VDC) to analog voltage input terminal 2-5. The ratio (override value) is 50% of the main setting at 0VDC, 100% at 2.5VDC (or 5VDC), and 150% at 5VDC (10VDC).



Override Value

(11) Multi-speed input compensation selection (External operation mode) [Pr. 28] (A500)
The frequency setting of three-speed operation or multi-speed operation can be compensated for by the analog input. Since the parameter is factory-set to compensation disable, set "1" in Pr. 28 to make the compensation enabled. The following three different compensations are available depending on the setting of Pr. 73:

1) Override compensation (Pr. 73 setting = 4 or 5)
   .... across analog input terminals 2-5
2) Addition compensation (Pr. 73 setting = 0 to 3)
   .... across analog input terminals 1-5
3) Addition compensation allowing forward-reverse rotation reversible operation depending on polarity (Pr. 73 setting = 10 to 13)
   .... across analog input terminals 1-5

Parameter Number	Setting	Description	Start Terminal	STF ON		STR ON		Factory Setting
			Polarity of terminal 1	+	–	+	–	
73	0 to 5	Polarity reversible disable		Forward rotation	Stop	Reverse rotation	Stop	1
	10 to 15	Polarity reversible enable		Forward rotation	Reverse rotation	Reverse rotation	Forward rotation	—

(12) Stepless speed setting [Pr. 59] (COMMON)
By setting "1"or "2" in Pr. 59, the functions of the RH and RM signals can be changed to the remote setting input function. This function may be set either in the PU or external operation mode.
Note that this function is different from the function of the optional motorized speed setter (FR-FK).

Note: After RH-SD and RM-SD are kept opened for more than about one minute, the running frequency setting at that time is stored into memory (E^2ROM). Switch power off once, then on again to resume operation with this setting.

Parameter Number	Function Name	Setting Range	Setting	Description	Factory Setting
59	Remote setting function	0, 1, 2	0	Without remote setting function	○
			1	With remote setting function, with frequency setting storage function (Note)	—
			2	With remote setting function, without frequency setting storage function	—

1) At the time of acceleration
When RH-SD are shorted, the set frequency increases. The increased speed at this time depends on the Pr. 44 (second acceleration/deceleration time) setting.
Note: 1. Open RH-SD to stop the increase in set frequency and keep that set frequency unchanged.

2) At the time of deceleration
When RM-SD are shorted, the set frequency decreases. The decreased speed at this time depends on the Pr. 45 (second deceleration time) setting. When the Pr. 45 setting is 9999, the decreased speed is the same value as in Pr. 44.
Note: 1. Open RM-SD to stop the decrease in set frequency and keep that set frequency unchanged.

3) Output frequency

For (A500)

External operation: Frequency set by RH or RM + external operation frequency other than multi-speed (To select enable of auxiliary input (terminal 1), set "1" in Pr. 28.)

PU operation: Frequency set by RH or RM + PU operation frequency

For (E500)

External operation: Frequency set by RH or RM + analog frequency command from operation panel's frequency setting potentiometer or from outside inverter (i. e. external setting).

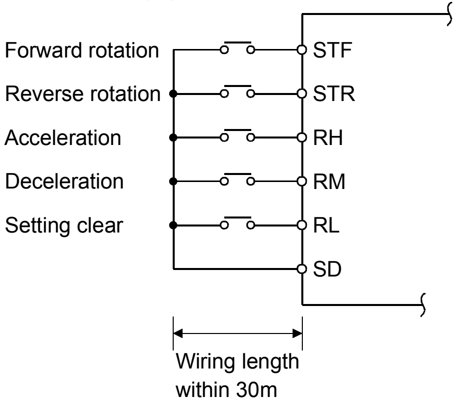
PU operation: Frequency set by RH or RM + PU digital frequency

4) Storage of set frequency

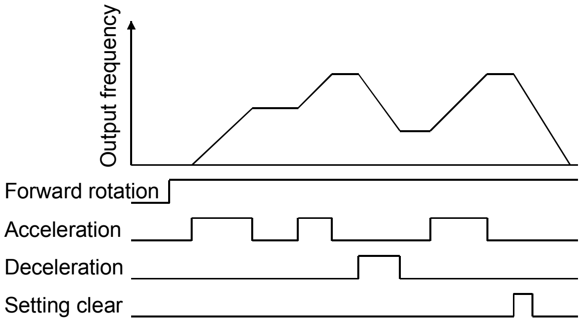
When the Pr. 59 value is 1, opening RH-SD and RM-SD for more than 1 minute stores the set frequency into memory (E^2ROM). When the Pr. 59 value is 2, the set frequency is not stored. Hence, when the power is switched off and is then switched on again, the set frequency is reset to 0Hz.

5) Clearing the set value

Short RM-SD to clear the set frequency to 0Hz. This also clears the value stored in memory (E^2ROM).



Connection Example for Remote Operation



Signal ON-OFF Example for Remote Operation

Note: 1. When the acceleration/deceleration signal turns on, the set frequency varies according to the ramp set in Pr. 44 or Pr. 45. Also, the acceleration/ deceleration time of the output frequency is as set in Pr. 7/Pr. 8. Hence, the actual output frequency varies in the time of longer setting.

2. When the remote operation function has been selected (1 or 2 is set in Pr. 59), the following function is invalid:
   · Multi-speed operation

3. When either of the following functions has been selected, the remote operation function is invalid:
   · Jog operation mode
   · Programmed operation mode

4. If RH-SD are kept shorted, operation cannot be performed above the maximum frequency limit.

5. Use the control cables of within 30m wiring length.

(13) Jog operation (External operation mode) [Pr. 15, Pr. 16] (COMMON)

For (A500), turn on the signal across terminals JOG-SD to perform jog operation with the start input signal terminal STF (or STR).

The parameter unit may also be used to perform jog operation (Note 1).The parameter unit may also be used to perform jog operation (Note 1). Use Pr. 15 to set the jog operation frequency and Pr. 16 to set the jog acceleration/deceleration time.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
15	Jog frequency	0 to 400Hz	0.01Hz	5Hz
16	Jog acceleration/ deceleration time	0 to 3600 s /0 to 360 s	0.1 s/ 0.01 s	0.5 s

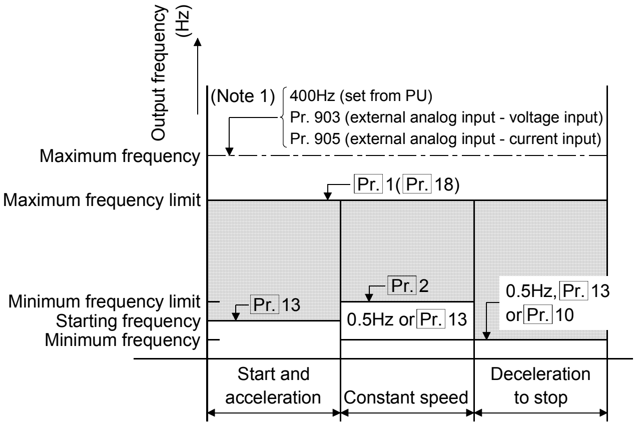
Note: 1. (E500) cannot perform jog operation in the external operation mode but can perform it in the PU operation mode.

1.6.7 Output frequency range [Pr. 1, 2, 13, 18] COMMON

The output frequency range is 0.2 to 400Hz. However, the actually operable frequencies have the following restrictions according to the function (parameter) settings, operation mode, etc.:

- Three-speed or multi-speed setting in the PU or external operation mode
  The output frequency is available up to 400Hz but the maximum output frequency depends on the maximum frequency limit.
- Analog input in the external operation mode
  The maximum output frequency depends on the frequency setting voltage gain set in Pr. 903 (refer to Section 1.6.6 (5)) and the maximum frequency limit.
- The starting frequency is set in Pr. 13.
- The constant-speed frequency is output up to 0.5Hz (when the Pr. 13 value is 0.5Hz or more) or Pr. 13 value (when the Pr. 13 value is less than 0.5Hz).
- For deceleration to a stop made by turning off the start signal, the output frequency is output up to the DC dynamic brake operation frequency set in Pr. 10. For deceleration to a stop made by giving the command frequency of 0Hz (start signal is on), the output frequency is output up to the above constant speed frequency.

From the above, the running frequency range is summarized as shown on the right.
The setting conditions of the relevant functions (parameters) are indicated in the right table.



Output Frequency Range

Note 1: Depends on the frequency setting method.

Functions Related to Output Frequencies

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
1	Maximum frequency limit	0 to 120Hz	0.01Hz	120Hz
2	Minimum frequency limit	0 to 120Hz	0.01Hz	0Hz
13	Starting frequency	0 to 60Hz	0.01Hz	0.5Hz
18	High-speed maximum frequency limit	120 to 400Hz	0.01Hz	120Hz
903	Frequency setting voltage gain	1 to 400Hz	0.01Hz	60Hz
905	Frequency setting current gain	1 to 400Hz	0.01Hz	60Hz

(1) Maximum frequency limit [Pr. 1, Pr. 18] COMMON

Using the operation panel (parameter unit), set the maximum frequency limit that can be output.

Set the maximum frequency limit of 0 to 120Hz in Pr. 1.

Set the maximum frequency limit of 120 to 400Hz in Pr. 18. The most recent maximum frequency limit set in Pr. 1 or Pr. 18 is valid.

The maximum frequency that can be output is as follows:

1) Using external analog input (voltage signal) The maximum frequency that can be output is the lower value of the most recent maximum frequency limit set in Pr. 1 or Pr. 18 and the frequency setting voltage gain set in Pr. 903. The output frequency is clamped at the maximum frequency limit if the frequency setting input given is greater than the maximum frequency limit.

2) Using external analog input (current signal) The maximum frequency that can be output is the lower value of the most recent maximum frequency limit set in Pr. 1 or Pr. 18 and the frequency setting current gain set in Pr. 905. The output frequency is clamped at the maximum frequency limit if the frequency setting input given is greater than the maximum frequency limit.

3) Using PU

The maximum frequency that can be output is the most recent maximum frequency limit set in Pr. 1 or Pr. 18.

(2) Minimum frequency limit [Pr. 2] COMMON

Using the operation panel (parameter unit), set the minimum frequency limit that can be output during constant-speed operation. When the analog frequency setting input signal is used, the output frequency is clamped and does not drop below the minimum frequency limit if that frequency setting input signal is less than the minimum frequency limit in Pr. 2 (this also applies to the input of 0). Any value less than the minimum frequency limit may be set from the operation panel (parameter unit) but the output frequency does not become less than the minimum frequency limit (with the exception of the jog frequency).

(3) Starting frequency [Pr. 13] COMMON

Set the frequency which allows direct-on line starting when the start signal is switched on across terminals STF (or STR)-SD.

This function is used with the torque boost (Pr. 0) to mainly adjust the starting torque. The rise in starting frequency not only raises the corresponding output voltage but also increases the starting current along with the starting torque. The following value is recommended as a guide to setting the starting frequency to keep the starting current less than the stall prevention operation current:

0.5Hz (factory setting) for general application.

3Hz for an elevator, etc.

When the elevator is started at a low starting frequency, the load may slip down as soon as the mechanical brake is released due to insufficient starting torque. To prevent this, use the above frequency as a guideline. The inverter cannot be started if the frequency setting is less than the starting frequency.

1.6.8 Output frequencies and acceleration and deceleration times [Pr. 7, 8, 16, 20, 21, 29, 44, 45, 110*, 111*, 140 to 143*] COMMON

(*Pr. 110, 111 and 140 to 143 are not provided for E500.)

When the frequency is varied during start/acceleration, deceleration/stop operation etc., the inverter changes the output frequency linearly (linear acceleration/deceleration) to reach the set frequency so that excessive load is not applied to the motor and inverter. Linear acceleration/deceleration is constant in the ratio of frequency to time. S-pattern acceleration/deceleration may also be set in Pr. 29. The acceleration and deceleration times set in Pr. 7, Pr. 8, Pr. 44 , Pr. 45, Pr. 110 and Pr. 111 are the lengths of time required for the output frequency to change up to the acceleration/deceleration reference frequency set in Pr. 20. The setting of the acceleration/deceleration time is based on Pr. 20, acceleration/deceleration reference frequency, independently of whether the operation mode is the external or PU operation mode.

Acceleration/deceleration time setting =

$$\frac{\text{Acceleration/deceleration reference frequency, (Pr. 20)}}{\text{Change in output frequency.}} \times \left[\text{Acceleration/deceleration time for change in output frequency}\right]$$

The minimum input increments of the acceleration/deceleration time setting are factory-set to 0.1 s. (When the value is set from the operation panel with Pr. 21 = 0, the setting increments are 1 second for the setting of 1000 seconds or more.) By changing the setting of Pr. 21 to 1, the acceleration/deceleration time can be set in increments of 0.01 second. (In this case, the maximum setting is 360 seconds. When the value is set from the operation panel with Pr. 21 = 1, the setting increments are 0.1 second for the setting of 100 seconds or more.)

1) External operation mode COMMON
   (Using frequency setting signal terminal 2-5)
   (Example 1) Acceleration is made to the output frequency of 50Hz in 2.5 s at the Pr. 20 (acceleration/deceleration reference frequency) setting of 60Hz (factory setting).

   · Acceleration time, Pr. 7, setting $= \frac{60\text{Hz}}{50\text{Hz}} \times 2.5\text{ s} = 3.0\text{ s}$

   (Example 2) Acceleration is made to the output frequency of 90Hz in 12.5 s at the Pr. 20 (acceleration/deceleration reference frequency) setting of 90Hz.

   · Acceleration time, Pr. 7, setting $= \frac{90\text{Hz}}{90\text{Hz}} \times 12.5\text{ s} = 12.5\text{ s}$

2) Three-speed operation and PU operation mode COMMON
   (Example 1) Acceleration is made to the output frequency of 80Hz in 4 s at the Pr. 20 (acceleration/deceleration reference frequency) setting of 60Hz (factory setting).

   · Acceleration time, Pr. 7, setting $= \frac{60\text{ Hz}}{80\text{Hz}} \times 4.5\text{ s} = 3.0\text{ s}$

   (Example 2) Acceleration is made to the output frequency of 60Hz in 15 s at the Pr. 20 (acceleration/deceleration reference frequency) setting of 120Hz.

   · Acceleration time, Pr. 7, setting $= \frac{120\text{ Hz}}{60\text{ Hz}} \times 15\text{s} = 30\text{ s}$

The setting conditions of the related functions (parameters) are indicated in the table below. The factory settings of the acceleration and deceleration times are temporary and should be changed to actually operable values, which vary according to the load conditions (load torque and load GD^2 reflected back to the motor shaft) and motor conditions (motor torque capability and motor GD^2).
Refer to Section 2.1.5 for the way of calculating the acceleration/deceleration time according to the load conditions and motor conditions.
When the load conditions are unknown, perform the operation and determine the acceleration/deceleration time which does not activate stall prevention.

Functions Related to Acceleration and Deceleration Times

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
7	Acceleration time	0 to 3600 s	0.01/0.1 s (Note 1)	5 s for 7.5K or less (10 s for E500 5.5K and 7.5K) 15 s for 11K or more
8	Deceleration time	0 to 3600 s	0.01/0.1 s (Note 1)	5 s for 7.5K or less (10 s for E500 5.5K and 7.5K) 15 s for 11K or more
16	Jog acceleration/deceleration time	0 to 3600 s	0.01/0.1 s (Note 1)	0.5 s
20	Acceleration/deceleration reference frequency	1 to 400Hz	0.01Hz	60Hz
21	Acceleration/deceleration time increments	0,1	—	0
44	Second acceleration/deceleration time	0 to 3600 s	0.01/0.1 s (Note 1)	5 seconds (10 s for E500 5.5K and 7.5K)
45	Second deceleration time	0 to 3600 s, 9999		9999 (Note 2)
110	Third acceleration/deceleration time	0 to 3600 s, 9999		9999
111	Third deceleration time	0 to 3600 s, 9999		9999

Note: 1. The minimum setting increments are changed by the setting of Pr. 21.

2. This function is made invalid when 9999 is set. (The value set in Pr. 44 is used as the second deceleration time.)

(1) Acceleration time [Pr. 7] COMMON

Calculate the period of time required for linear acceleration from a stop to the maximum operating frequency under the load and motor conditions used. Using the following formula, calculate the acceleration time from stop to the acceleration/deceleration reference frequency, Pr. 20, and set it in Pr. 7.

Acceleration/deceleration time setting =

$$\frac{\text{Acceleration/deceleration reference frequency, (Pr. 20)}}{\left[\text{Maximum operating frequency}\right]-\left[\text{Starting frequency (Pr. 13)}\right]}\times\left[\text{Acceleration time from stop to maximum operating frequency}\right]$$

(2) Deceleration time [Pr. 8] COMMON

Calculate the period of time required for linear deceleration from the maximum operating frequency to a stop under the load and motor conditions used. Using the following formula, calculate the deceleration time from the acceleration/deceleration reference frequency, Pr. 20, to a stop, and set it in Pr. 8.

Deceleration time setting =

$$\frac{\text{Acceleration/deceleration reference frequency, (Pr. 20)}}{\text{Maximum operating frequency}-\text{DC dynamic brake frequency}}\times\left[\text{Deceleration time from maximum operating frequency to stop}\right]$$

(3) Second acceleration/deceleration time [Pr. 44] COMMON

Short the second function selection signal terminal RT-SD to ignore the acceleration and deceleration times set in Pr. 7 and Pr. 8 and use the acceleration/deceleration time set in Pr. 44. In this case, the acceleration time is equal to the deceleration time.

(4) Second deceleration time [Pr. 45] COMMON
Short the second function selection signal terminal RT-SD to change the acceleration/deceleration time setting to the value set in Pr. 44. In this case, the acceleration time is equal to the deceleration time.
To set the acceleration time and deceleration time separately, set the second deceleration time in Pr. 45 and the second acceleration time in Pr. 44. Setting of 9999 (factory setting) in Pr. 45 causes the second deceleration time to be the value set in Pr. 44, making the acceleration and deceleration times equal.

(5) Third acceleration/deceleration time [Pr. 110] A500
Short the third function selection signal terminal X9-SD to ignore the acceleration and deceleration times set in Pr. 7 and Pr. 8 and use the acceleration/deceleration time set in Pr. 110. In this case, the acceleration time is equal to the deceleration time. Set "9999" in Pr. 110 to make this function invalid.
When both the RT and X9 signals are on, Pr. 100 and Pr. 111 are made valid.

(6) Third deceleration time [Pr. 111] A500
Short the third function selection signal terminal X9-SD to change the acceleration/deceleration time setting to the value set in Pr. 110. In this case, the acceleration time is equal to the deceleration time.
To set the acceleration time and deceleration time separately, set the third deceleration time in Pr. 111 and the third acceleration time in Pr. 110. Setting of 9999 (factory setting) in Pr. 111 causes the third deceleration time to be the value set in Pr. 111, making the acceleration and deceleration times equal.
When both the RT and X9 signals are on, Pr. 100 and Pr. 111 are made valid.

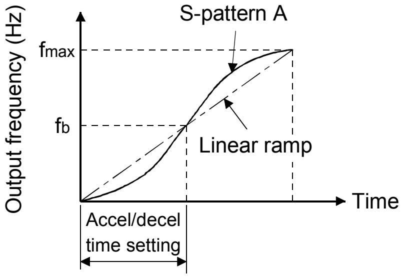
(7) Acceleration/deceleration time for jog operation [Pr. 16] COMMON
Allows the acceleration/deceleration time to be set for jog operation in the PU or external operation mode. For E500, however, jog operation cannot be performed in the external operation mode. For jog operation, the acceleration time is equal to the deceleration time. For details of the operation procedure, refer to Section 1.4.8.
In the external operation mode, jog operation can be performed by shorting the jog mode terminal JOG-SD.
The setting of the acceleration/deceleration time is as described in (1) and (2) Acceleration and deceleration times, Pr. 7, Pr. 8.
Note: The set jog acceleration/deceleration time is the acceleration/deceleration time until the acceleration/deceleration reference frequency, (Pr. 20), is reached.

(8) S-pattern acceleration/deceleration [Pr. 29] COMMON
Generally acceleration/deceleration is constant in the ratio of frequency to time. This acceleration/deceleration ramp can be changed into an S -pattern (two standard patterns).

Parameter Number	Name	Setting	Description	Factory setting
29	Acceleration/ deceleration pattern selection	0	Linear acceleration/ deceleration	○
		1	S-pattern acceleration/ deceleration A	—
		2	S-pattern acceleration/ deceleration B	—
		3 (Note)	Backlash compensation acceleration/ deceleration	—

Note: For E500, backlash compensation acceleration/deceleration cannot be selected.

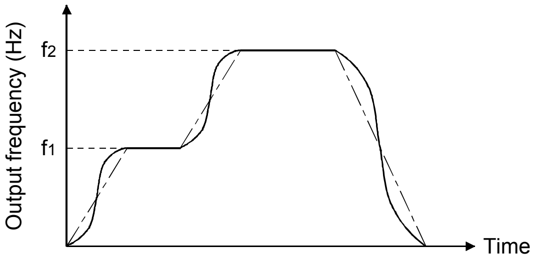
1) S-pattern acceleration/deceleration A COMMON
Type A is maximum in acceleration speed near the base frequency (fb) as shown below. Hence, it makes fast acceleration/deceleration in a large motor-generated torque range and smooth acceleration/deceleration in a small torque range, by making use of the motor torque. Therefore, as compared to linear acceleration/deceleration, type A can reduce the acceleration/deceleration time to reach 120Hz or greater, at which the motor output torque is small, (e.g. application to machine tools).



S-Pattern Acceleration/Deceleration A

Note: For S-pattern acceleration/deceleration A, the acceleration and deceleration time settings (Pr. 7, Pr. 8, Pr. 16, Pr. 44, Pr. 45, Pr. 110, Pr. 111) should be the acceleration and deceleration times required to reach the base frequency, Pr. 3, not the acceleration/ deceleration reference frequency, Pr. 20. For example, when acceleration/deceleration is made to 120Hz in 3 seconds at the base frequency,(Pr. 3), of 60Hz, set 1.5 seconds in Pr. 7 and Pr. 8.

2) S-pattern acceleration/deceleration B COMMON
Type B makes S-pattern acceleration /deceleration when the frequency setting (running frequency by the external input signal or from the operation panel) changes to compensate for the shock occurring at start and stop, thereby preventing the collapse of cargo being transferred. For instance, acceleration/deceleration is made in an S-pattern in a range where the set frequency changes as shown below (e.g. application to transfer machines)

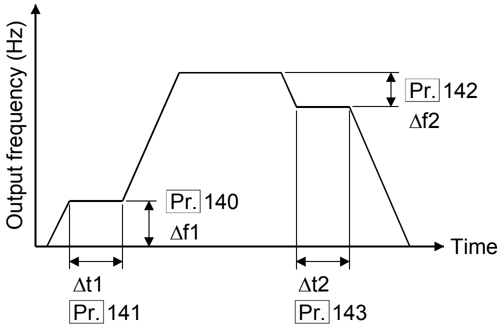


S-Pattern Acceleration/Deceleration B

(9) Backlash compensation [Pr. 29, 140 to 143] A500
The gears of a speed reducer etc. have meshing clearances which create a dead zone between forward rotation and reverse rotation. This dead zone is called backlash and this clearance does not allow a mechanical system to follow up the motor speed if the motor has started running. Specifically, when the direction of rotation is changed or when operation is switched from constant speed to deceleration, excessive torque is produced on the motor shaft, resulting in abrupt motor current increase or regenerative status. This can be avoided by the "backlash compensation" function.

Set "3" in Pr. 29 to make the backlash compensation function, Pr. 140 to Pr. 143, accessible.

Note that the acceleration/deceleration pattern for the backlash compensation is the linear acceleration /deceleration. The acceleration/deceleration time is increased by the stop time.



Backlash CompensationFunction

Related to Backlash Compensation

Parameter number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Remarks
29	Acceleration/deceleration pattern selection	0,1,2,3	—	0	3:Backlash compensation
140	Stopping frequency for backlash acceleration	0 to 400Hz	0.01Hz	1Hz	Made valid when Pr. 29= 3
141	Stopping frequency for backlash acceleration	0 to 360 s	0.1 s	0.5 s	
142	Stopping frequency for backlash acceleration	0 to 400Hz	0.01Hz	1Hz	
143	Stopping frequency for backlash acceleration	0 to 360 s	0.1 s	0.5 s	

1.6.9 Output frequencies and output voltages [Pr. 0, 3, 14, 19, 46, 47, 112*, 113*] COMMON

(*Pr. 112 and 113 are not provided for E500.)

The inverter controls not only the output frequency but also the output voltage. The relationship between the output frequency and voltage is as follows:

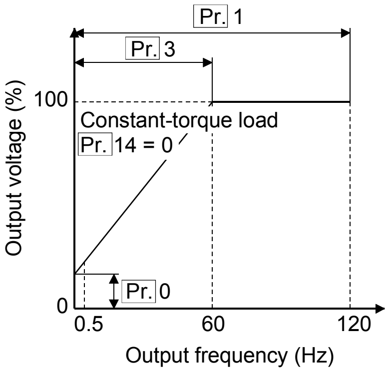
- Pr. 14 allows the load pattern to be selected between a linear ramp (for constant torque load) and a square curve (for variable torque load) for the ratio of the output voltage to the output frequency at not more than the base frequency.
- When the base frequency is reached, the output voltage is maximum and is almost equal to the input power supply voltage. At no less than the base frequency, the output voltage is kept constant. Pr. 19 allows setting of the output voltage at not less than the base frequency. Note that the voltage output is less than the power supply voltage.
- The output voltage varies according to the power supply voltage. The voltage is limited to within the base frequency voltage set in Pr. 19.
- Set the base frequency in Pr. 3 (V/F).
- Set the output voltage at the output frequency of 0 in Pr. 0 (manual torque boost) to control the motor starting torque.
- % indicated for the torque boost (manual), Pr. 0, assumes that the output voltage at not less than the base frequency (nearly equal to the power supply voltage) is 100%. When a value has been set in Pr. 19, base frequency voltage, that value is regarded as 100%.

Functions Related to Output Voltage

Parameter Number	Name	Setting Range		Minimum Setting Increments	Factory Setting	
3	V/F (base frequency)	0 to 400Hz		0.01Hz	60Hz	
47	Second V/F (base frequency)	0 to 400Hz, 9999		0.01Hz	9999	
113 (Note 1)	Third V/F (base frequency)	0 to 400Hz, 9999		0.01Hz	9999	
19	Base frequency voltage	0 to 1000V, 9999		0.1V	9999	
0	Torque boost (manual)	0 to 30%		0.1%	A500 0.75K or less 6% 1.5K to 3.7K 4% 5.5K, 7.5K 3% 11K or more 2%	E500 6% for other than below 400V 5.5K, 7.5K 4%
46	Second torque boost (manual)	0 to 30%, 9999		0.1%	9999	
112 (Note 1)	Third torque boost (manual)	0 to 30%, 9999		0.1%	9999	
14	Load pattern selection	0	Constant torque	—	○	
		1	Variable torque	—	—	
		2	For elevation (boost 0% for reverse rotation)	—	—	
		3	For elevation (boost 0% for forward rotation)	—	—	
		4 (Note 1)	Constant torque-elevation (boost 0% for reverse rotation) change-over	—	—	
		5 (Note 1)	Constant torque-elevation (boost 0%for forward rotation) change-over	—	—	

Note: 1. Not available for E500.

The setting conditions of the relevant functions (parameters) and the relationship between the factory-set output frequency and output voltage are indicated in the previous table and the following diagram.



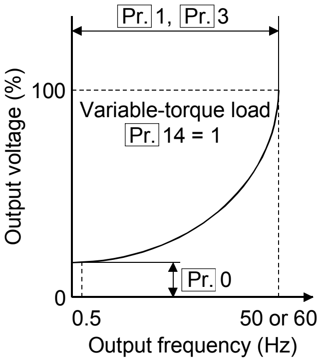
Factory-Set Output Frequency vs. Output Voltage

(1) Load pattern selection [Pr. 14] COMMON
Allows the optimum V/F characteristic to be selected according to the load torque characteristic and operation method. This function is made invalid when advanced magnetic flux vector control (general-purpose magnetic flux vector control) is chosen.

1) Selection of constant-torque load COMMON
Specify 0 to drive a load which is constant in load torque if the speed varies, e.g. conveyor, cart, roll drive.

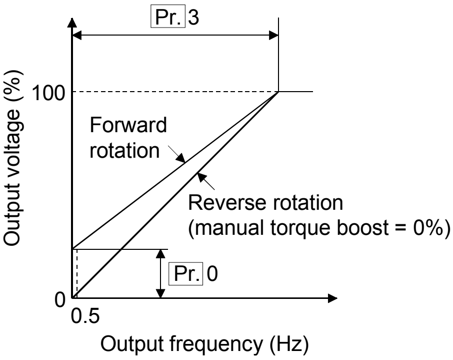
2) Selection of variable-torque load COMMON
Specify 1 to drive a load of which torque changes in proportion to the square of the speed, e.g. fan, pump. Note that 0 (for constant-torque load) should be specified if any of the following applies to the fan or pump:
(a) Blower with a large inertia (GD^2) is accelerated in a short time.
(b) Load torque is constant, e.g. rotary pump, gear pump.
(c) Load torque increases at low speed, e.g. screw pump.

When the variable-torque load has been selected, the maximum frequency limit set in Pr. 1 should be equal to or less than the base frequency set in Pr. 3 (normally 50 or 60) unless the motor capacity is considerably sufficient. When the variable-torque load has been selected, the output voltage is approximately proportional to the square of the output frequency.



Output Frequency vs. Output Voltage when Variable-Torque Load Is Selected

3) Selection of elevated load COMMON
Set "2" in Pr. 14, load pattern selection, for an elevated load which is kept in the driving mode during forward rotation and in the regenerative mode during reverse rotation. In this case, the torque boost set in Pr. 0 is made valid during forward rotation and the manual torque boost is automatically set to 0% during reverse rotation as shown below.



Output Voltage for Elevated Load

Set "3" in Pr. 14 for an elevated load that is in the driving mode during reverse rotation and in the regenerative mode during forward rotation according to the load weight, e.g. counterweight system.
When continuous regeneration occurs as in the elevated load, setting the base frequency voltage, Pr. 19, to the rated voltage is effective to suppress a trip due to a current generated at the time of regeneration.

4) Changing of load pattern selection (A500)
Set "4" or "5" in Pr. 14 to change the load pattern selection according to the RT signal.

Pr. 14 Setting	RT Signal	Output Characteristic
4	ON	For constant-torque load (same as in setting of 0)
	OFF	For elevation (boost for reverse rotation 0%) (same as in setting of 2)
5	ON	For constant-torque load (same as in setting of 0)
	OFF	For elevation (boost for forward rotation 0%) (same as in setting of 3)

The RT signal may be replaced by the X17 signal.

(2) Base frequency [Pr. 3] (COMMON)
Second base frequency [Pr. 47] (COMMON)
Third base frequency [Pr. 113] (A500)

The base frequency indicates a frequency at the rated torque of the motor. It is 50Hz or 60Hz for standard motors.

To perform the switch-over operation of two (or three) motors by one inverter, the base frequency dedicated to one motor can be set in Pr. 47 (Pr. 113). (Made valid when terminals RT (X9)-SD are shorted.) Set "9999" (factory setting) in Pr. 47 (Pr. 113) to set the same value as in Pr. 3.

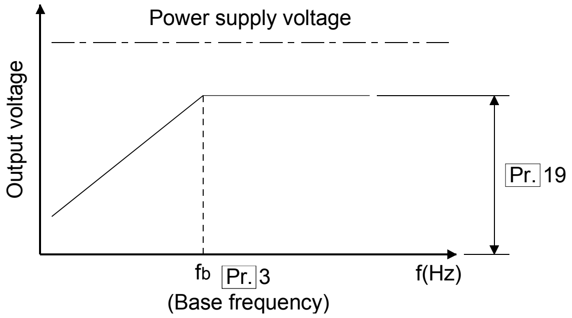
For (A500), Pr. 113 is made valid when both the RT and X9 signals are on.

The base frequency of a standard motor is determined as follows:

1) When a new machine is installed, it is recommended to set the base frequency to 60Hz because 60Hz can be output even in a 50Hz district and the motor torque may be utilized more effectively by setting the base frequency to 60Hz instead of 50Hz.
2) Set the base frequency to 50Hz when using the inverter with the existing machine which is driven by the commercial power supply in a 50Hz district.
3) Generally, setting the base frequency to higher than 60Hz has no advantage.
4) The following depends on whether the base frequency has been set to 50Hz or 60Hz:
   (a) Selection of data on the torque capability of the standard motor used with the inverter.
   (b) Rated torque value (in %) of the standard motor corresponding to 100% torque.

If the base frequency used is other than 50Hz or 60Hz, a special motor designed to meet that base frequency is required.

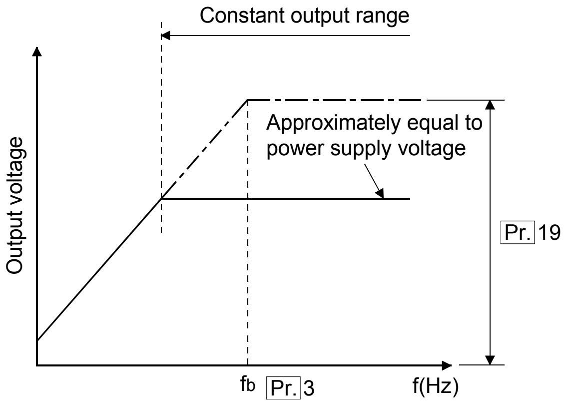
(3) Base frequency voltage [Pr. 19] (COMMON)
When the value set is equal to or less than the power supply voltage, the maximum output voltage of the inverter is the value set in Pr. 19. If the power supply voltage rises, the output voltage does not exceed the set value.



Base Frequency Voltage

The base frequency voltage may be utilized for the following cases:

1) Regenerative frequencies are high (such as continuous regeneration).
   At the time of regeneration, the output voltage may become higher than the V/F reference value, causing an overcurrent trip due to the increase in motor current. This can be prevented.
2) Fluctuation of power supply voltage is large. If the power supply voltage exceeds the rated motor voltage, excessive torque or increased motor current may cause the speed to fluctuate greatly or the motor to overheat. This can be prevented.
3) To expand the constant-output characteristic range.
   The constant output range is above the base frequency. To expand the constant output range by reducing the minimum setting 50Hz of the base frequency, set the base frequency voltage to higher than the power supply voltage. In this case, the motor used should be of special specifications.



Output Voltage Derived by Setting Base Frequency Voltage to Higher than Power Supply Voltage

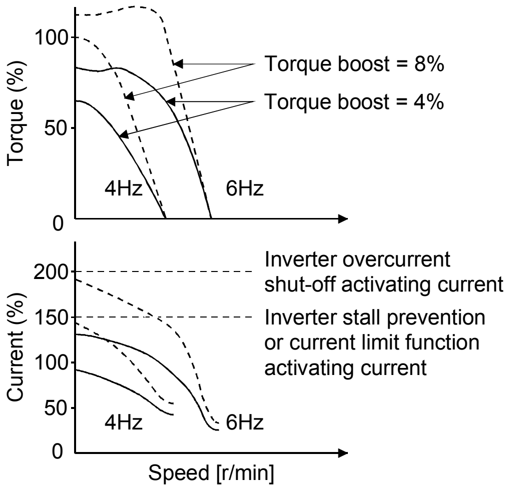
(4) Manual torque boost [Pr. 0] COMMON
Second manual torque boost [Pr. 46] COMMON
Third manual torque boost [Pr. 112] A500

Allows the output voltage at the output frequency of 0Hz to be set to control the motor starting torque. Change the setting of the torque boost only when the starting torque is not appropriate. To perform switch-over operation of two (or three) motors by one inverter, the manual torque boost dedicated to one motor can be set in Pr. 46 (Pr. 112). (Made valid when terminals RT (X9)-SD are shorted.) Set "9999" (factory setting) in Pr. 46 (Pr. 112) to define the same value as in Pr. 0.

When both the RT and X9 signals are on in A500, Pr. 112 is made valid.

1) To increase the starting torque.

The following figure shows the motor torque and current characteristic examples in which the starting frequency (Pr. 13) is suppressed to a low value and the torque boost is increased so that the motor may be started at the starting current lower than the stall prevention current.



Torque Boost, Motor Torque and Current Examples

Note: 1. When the torque boost setting is greater than the factory setting, the continuously usable frequency range is narrowed because the no-load current of the motor increases. When the torque boost value is 8%, for example, the frequency of 15Hz or less cannot be used continuously.

2. If the starting frequency (Pr. 13) setting is too high, the starting current increases, activating the current limit function.

3. Too high setting of the torque boost saturates the magnetic flux of the motor iron core, which increases the motor current and activates the current limit function.

2) To suppress motor vibration at low frequency.

Vibration may be suppressed by setting the torque boost value to lower than the factory setting (this is applicable only when the motor capacity is sufficient). In this case, the motor starting torque is reduced.

Change the torque boost setting according to actual operation and check that the above problem does not occur.

Note: 1 When using the inverter-dedicated motor (constant-torque motor), change the setting as follows:
0.75K or less ... 6%, 1.5K to 3.7K ... 4%,
5.5K or more ... 2%

2 If the setting of A500 5.5K or 7.5K is as indicated below, this parameter value is automatically changed by changing the Pr. 71 setting:

1) When Pr. 0 value is 3%(factory setting). When the Pr. 71 setting is changed from the value for choosing the standard motor (0, 2 to 8, 20, 23, 24) to the value for choosing the constant-torque motor (1, 13 to 18), the Pr. 0 setting is automatically changed to 2%.

2) When Pr. 0 value is 2%.

When the Pr. 71 setting is changed from the value for choosing the constant-torque motor (1, 13 to 18) to the value for choosing the standard motor (0, 2 to 8, 20, 23, 24), the Pr. 0 setting is automatically changed to 3% (factory setting).

1.6.10 DC injection brake [Pr. 10 to 12] COMMON

The motor driven by the inverter is decelerated to a stop by the DC dynamic brake at 3Hz or less. The DC dynamic brake operation time and torque (DC dynamic brake voltage) are adjustable.

In addition, the DC dynamic brake operation frequency, Pr. 10 (factory-set to 3Hz) can also be changed.

Functions Related to DC Dynamic Brake

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
10	DC dynamic brake operation frequency	0 to 120Hz, 9999 (Note 1)	0.01Hz	3Hz
11	DC dynamic brake operation time	0 to 10 s, 8888 (Note 2)	0.1 s	0.5 s
12	DC dynamic brake voltage	0 to 30%	0.1%	E500 6% A500 7.5K or less: 4% 11K or more: 2%

Note: 1. 9999 may be set for A500. When 9999 is set in Pr. 10, the motor is decelerated to the frequency set in Pr. 13 (starting frequency), at which the DC dynamic brake is applied.

2. 8888 may be set for A500. When 8888 is set in Pr. 11, DC dynamic brake is started by shorting X13-SD and kept applied while these terminals are shorted.

3. When using the inverter-dedicated motor (constant-torque motor), change the setting of Pr. 12 (DC dynamic voltage) as follows:
3.7K or less ... 4%, 5.5K or more ... 2%

4. Setting 0 (seconds) in the DC dynamic brake operation time disables the DC dynamic brake and causes the regenerative brake to be applied down to 0.5Hz (frequency set in Pr. 13 if the Pr. 13 value is less than 0.5Hz) or the DC dynamic brake operation frequency, coasting the motor to a stop.

5. A longer time should be set if load inertia is too large to stop the motor in the brake operation time of 0.5 seconds.

6. Setting 0 (%) in the DC dynamic brake voltage coasts the motor to a stop at 0.5Hz (frequency set in Pr. 13 if the Pr. 13 value is less than 0.5Hz) or the DC dynamic brake operation frequency. (Refer to Section 1.4.5.)

7. A too high DC dynamic brake voltage may cause an overcurrent trip. Reduce the voltage setting if an overcurrent trip occurs during the DC dynamic brake operation.

8. If the Pr. 12 setting of FR-A500-5.5K, 7.5K is as indicated below, this parameter value is automatically changed by changing the Pr. 71 setting:

1) When Pr. 12 value is 4% (factory setting)
When the Pr. 71 setting is changed from the value for choosing the standard motor (0, 2 to 8, 20, 23, 24) to the value for choosing the constant-torque motor (1, 13 to 18), the Pr. 12 setting is automatically changed to 2%.

2) When Pr. 12 value is 2%
When the Pr. 71 setting is changed from the value for choosing the constant-torque motor (1, 13 to 18) to the value for choosing the standard motor (0, 2 to 8, 20, 23, 24), the Pr. 12 setting is automatically changed to 4% (factory setting).

1.6.11 Regenerative brake duty (%ED) [Pr. 30, 70] COMMON

(1) Regenerative brake duty COMMON

FR-A500 -7.5K or less has a built-in brake resistor. Its standard duty is as listed below.

When increasing the brake resistor duty or using the E500, an external brake resistor must be connected to the inverter and also the setting must be changed according to the resistor.

If the set duty is exceeded, the brake resistor overheat protection function is activated. For full information on the brake resistor overheat protection function, refer to Section 1.7.4.

Functions Related to Regenerative Brake Duty

Parameter Number	Name	Setting Range (Value)	Minimum Setting Increments	Factory Setting	Permissible Brake Duty	Inverter Capacity	
						A500	E500
30	Regenerative brake duty change selection	0	—	○	3%	200V 3.7K or less	All capacities (Note 3)
					2%	200V 5.5K, 7.5K	—
						400V 7.5K or less	—
					0%	11K or more (Note 3)	—
		1 (special)		—	Set in Pr. 70	All capacities	All capacities (Note 3)
		2 (high power factor converter connection) (Note 1)		—	—	All capacities	—
70	Special regenerative brake duty	0 to 15%	0.1%	0%	Refer to Technical Note No. 22.	1.5K or less	—
		0 to 30%				2.2K to 7.5K	All capacities (Note 3)
		(None)				11K or more (Note 3)	—

Note: 1. Not provided for E500.

2. For E500, the brake resistor is not built in.

3. The FR-E520-0.1K, 0.2K, FR-A520-11K or more and FR-A540-11K or more cannot use the brake resistor.

(2) High power factor converter connection COMMON

For connection with the high power factor converter, refer to Section 1.4.14.

1) A500

Set "2" in Pr. 30. Using any of Pr. 180 to Pr. 186, assign the following signals to the input terminals:

X10: FR-HC connection (inverter operation enable signal) (Note 1)

To provide protective coordination with the high power factor converter (FR-HC), the inverter output is shut off by the inverter operation enable signal.

Note: 1. The MRS signal may be used instead of the X10 signal.

X11:FR-HC connection (instantaneous power failure detection signal)

When the computer link inboard option (FR-A5NR) is used and the setting is made to hold the mode at the time of instantaneous power failure occurrence, the holding operation is performed by this signal. The instantaneous power failure detection signal of the high power factor converter is input.

At this time, the Pr. . 70 setting is made invalid.

2) E500

Set "0" in Pr. 30. The input signals are not allocated.

1.6.12 Electronic thermal relay [Pr. 9, 48*, 71] COMMON

(*Pr. 48 is a different function for A500.)

Specify the operation level of the electronic thermal relay which stops the transistor output on detection of motor overloading. The factory setting is the rated inverter output current (85% of the rated inverter current for the 0.75K or less). Set this value according to the applied motor. Refer to Section 1.7.5 for more information on the operation characteristic and setting of the electronic thermal relay used with the standard motor.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
9	Electronic thermal relay	0 to 500A	0.01A	Rated output current (Note 2)
48 (Note 3)	Second electronic thermal relay	0 to 500A, 9999	0.01A	9999

Note: 1. Setting 0 disables the electronic thermal relay in the motor protection range.
2. 85% of the rated inverter current for the 0.75K or less.
3. Different function for A500.

When running the Mitsubishi constant-torque motor dedicated for inverters, make the following setting to allow the electronic thermal relay dedicated to this motor to be set in Pr. 9. (Refer to Sections 1.6.25 and 1.6.26.)

Procedure 1. Set "1"in Pr. 71, applied motor.
2. Set the current value of the constant-torque motor in Pr. 9, electronic thermal relay.

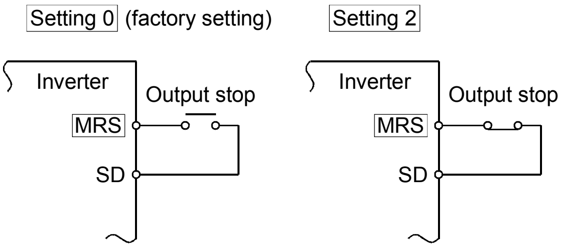
By turning on the RT signal in E500, thermal relay operation is performed as set in Pr. 48. Assign the RT signal to any of the input terminals by input terminal function selection. When the RT signal is on, the other second function is also selected.

1.6.13 Output stop circuit selection [Pr. 17] A500

Terminal MRS (output stop) can be changed to the normally closed (N/C contact) input feature. In this case, set "2" in Pr. 17.

Terminal MRS Switching

Pr. 17 Setting	Terminal MRS Function	
	Normally open input	Normally closed input
0	○	
2		○



Terminal MRS Connection Example

1.6.14 Reset terminal function selection, PU disconnection detection, PU stop selection [Pr. 75] COMMON

(1) Reset terminal function selection

The RES (reset) terminal is normally enabled for input. When terminals RES-SD are turned on during normal operation, the inverter shuts off the output, coasting the motor to a stop and also clearing the data of the electronic thermal relay and regenerative brake duty detection. Set any of "1", "3", "15" and "17" in Pr. 75 to enable the reset input only when the protective function is activated.

(2) PU disconnection detection yes/no selection
No problem arises (operation continues) if the operation panel (parameter unit) is disconnected during operation. However, if the PU is disconnected during operation in the PU operation mode, there is no means of stopping the motor except by performing a power-on reset. Set any of "2", "3", "16" and "17" in Pr. 75 to stop the output of the inverter simultaneously with the disconnection of the operation panel (parameter unit) (the motor is coasted to a stop) and provide an alarm output (E.PUE).

(3) PU stop selection
You can choose the mode in which the motor is stopped by the [STOP] key of the operation panel (parameter unit).
Set any of "0" to "3" in Pr. 75 to make the [STOP] key of the operation panel (parameter unit) valid in the PU operation mode only, or set any of "14 to 17" to make the [STOP] key valid in any operation mode.
When the motor is stopped by the [STOP] key input from the operation panel (parameter unit) in the external operation mode, restart the motor in the following procedure:

1) For operation panel
   - (a) After completion of deceleration to a stop, turn off the STF or STR signal.
   - (b) Call the operation mode selection screen and press the [SET] key.
   - (c) Turn on the STF or STR signal.

2) For parameter unit (FR-PU04)
   - (a) After completion of deceleration to a stop, turn off the STF or STR signal.
   - (b) Press the [EXT] key.
   - (c) Turn on the STF or STR signal.

Reset Terminal Function Choices

Pr. 75 Setting	Reset Terminal Function Selection		PU Disconnection Yes/No Selection		PU Stop Selection	
	Reset normally enable	Reset enable at alarm only	PU disconnectable	PU disconnection alarm output	PU stopped in PU mode only	PU stopped in any mode
0	○		○		○	
1		○	○		○	
2	○			○	○	
3		○		○	○	
14 (factory setting)	○		○			○
15		○	○			○
16	○			○		○
17		○		○		○

1.6.15 Stall prevention (current limit)
[Pr. 22, 23, 48*, 49*, 66, 114*, 115*, 148*, 149*, 154*, 156, 157*) COMMON

*Pr. 48 is a different function for E500.
Pr. 49, 114, 115, 148, 149, 154 and 157 are not provided for E500.

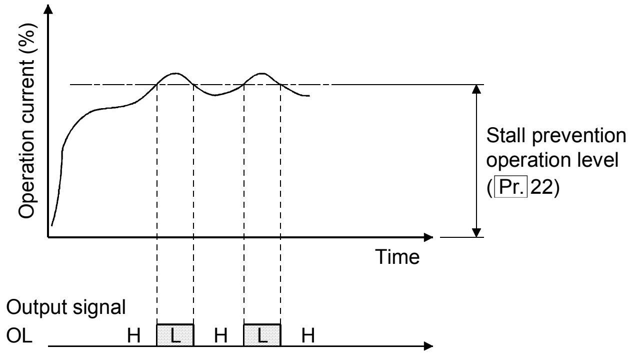
(1) Stall prevention (current limit) operation level
[Pr. 22] COMMON
Allows setting of the current level at which stall prevention is activated (% value in relation to the rated inverter output current).
Allows the output signal to be provided from the open collector output when the stall prevention is activated.
If the output current of the inverter exceeds the stall prevention operation level, the current limit function is activated to control the output transistor so that the current beyond that value does not flow.
If impact overload occurs, the overcurrent protection function is activated to prevent the inverter from tripping.

If the overload persists, the motor is decelerated according to the acceleration/deceleration setting and current value. Generally, the motor is decelerated on a ramp of deceleration from 60Hz within 0.1 second. If the overload persists for a long time, the motor may be decelerated to a stop and the electronic thermal relay activated.

Functions Related to Stall Prevention Operation

Parameter Number	Name		Setting Range	Minimum Setting Increments	Factory Setting
22	Stall prevention operation level (current)		0 to 200%, 9999 (Note 2)	0.1%	150%
48 (Note 1)	Second stall prevention operation level	Current	0 to 200%	0.1%	150%
49 (Note 1)		Frequency	0 to 400Hz, 9999	0.01Hz	0Hz
114 (Note 1)	Third stall prevention operation level	Current	0 to 200%	0.1%	150%
115 (Note 1)		Frequency	0 to 400Hz	0.01Hz	0Hz
23	Double-speed stall prevention	Operation level 2 (current)	0 to 200%, 9999	0.1%	9999
66		Reduction starting frequency	0 to 400Hz	0.01Hz	60Hz

Note:
1. Not provided for E500.
2. 9999 can be set for A500. Refer to paragraph (4).
3. When the stall prevention is activated, the output signal is switched on-off as shown on the right. When the second (third) stall prevention is activated, the output signal is also switched on-off.
4. Higher priority is given to the smaller setting of Pr. 22 and Pr. 48.
5. When the current level setting is 0, the stall prevention is not activated.

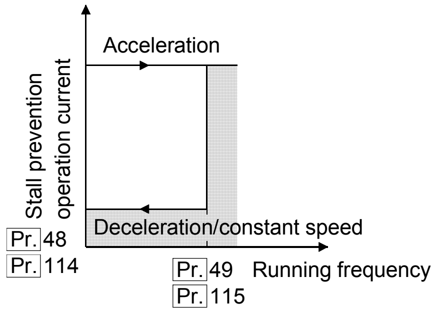


Output Signal on Activation of Stall Prevention

(2) Second, third stall prevention operation levels [Pr. 48, 49, 114, 115] A500

By setting the second (third) stall prevention operation level, the stall prevention operation region can be set. This can be used for stop-on-contact control, for example.

Also, the stall prevention operation can be changed by turning on-off the RT (X9) signal.



Second (Third) Stall Prevention Operation

Pr. 49 Setting	Pr. 115 Setting	Operation
0		Second (third) stall prevention function is not activated.
0.01Hz to 400Hz		Second (third) stall prevention function is activated according to the frequency as shown above. (Note 1)
9999	Cannot be set.	Second stall prevention function is activated according to the RT signal. RT signal ON Stall level Pr. 48 RT signal OFF Stall level Pr. 22

Note: 1. The third stall prevention function is made valid by turning on the X9 signal. Assign the X9 signal to any of the input terminals.
2. Even if the setting value "0" is set in the first digit of the three digits, it will not be displayed. However, if "0" is set in only one digit, it will indicate the setting value "000".
3. When the stall prevention operation level signal input function is selected (Pr. 22 = 9999), setting "9999" in Pr. 49 changes the stall prevention operation level from the value of the stall prevention operation level signal (terminal 1 input) to the value set in Pr. 48 when the RT signal switches on.
4. When both the RT and X9 signals are on, the third stall prevention function is selected.
5. When the RT (X9) signal is on, the second (third) functions such as second (third) acceleration/deceleration time are also selected.

(3) Double-speed stall prevention [Pr. 23, 66] COMMON

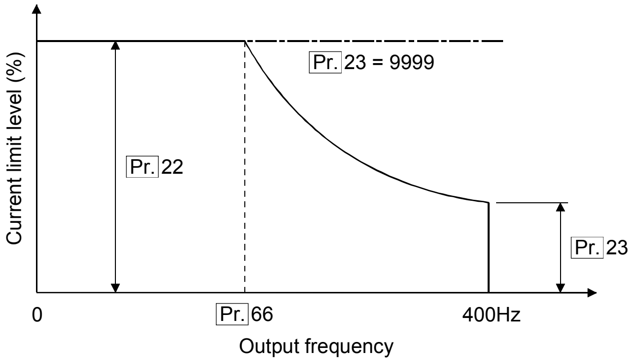
When the motor is accelerated up to the constant output range of not less than 60Hz, the motor may not be accelerated because the current does not increase if the motor slip increases. To improve the acceleration characteristic in this case, the current limit level in the constant output range is reduced in inverse proportion to the frequency. Set in Pr. 66 the frequency at which the reduction of the current limit level is started, and set in Pr. 23 the reduction ratio at 400Hz fixed.

$$\text{Double-speed stall prevention level} = \left(\frac{\boxed{\text{Pr.}}\ 22 - A}{\boxed{\text{Pr.}}\ 22 - B}\right) \times \left(\frac{\boxed{\text{Pr.}}\ 23 - 100}{100}\right)$$

$$\text{where } A = \frac{\boxed{\text{Pr.}}\ 66\ (\text{Hz}) \times \boxed{\text{Pr.}}\ 22\ (\%)}{\text{Output frequency (Hz)}}$$

$$B = \frac{\boxed{\text{Pr.}}\ 66\ (\text{Hz}) \times \boxed{\text{Pr.}}\ 22\ (\%)}{400\ (\text{Hz})\ (\text{Note 1})}$$

(Note 1) Set "9999" in Pr. 23 to make the current limit level constant up to 400Hz with the value set in Pr. 22.



Double-Speed Stall Prevention Level

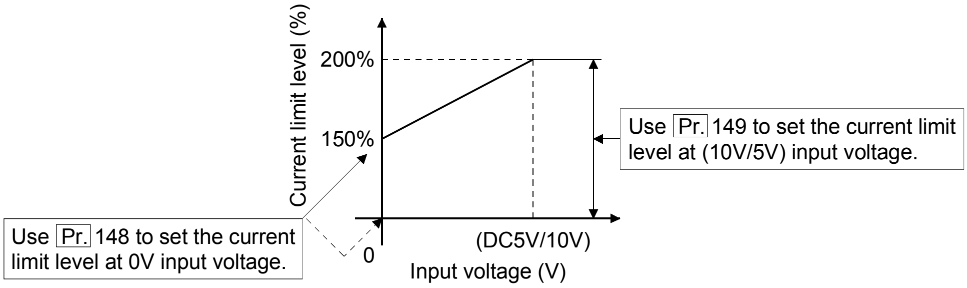
(4) Variable stall prevention operation level [Pr. 22, 148, 149] A500

Set "9999" in Pr. 22 to make the stall prevention operation level variable according to the voltage applied to terminal 1.
(The fast-response current limit level does not change.)

Enter 0 to 5V (or 0 to 10V) to terminal No. 1. When 9999 is set in Pr. 22, the function of the auxiliary input terminal is changed automatically to the stall prevention operation level signal input.

Functions Related to Variable Stall Prevention Operation Level

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Remarks
22	Stall prevention level	0 to 200%, 9999	0.1%	150%	9999: analog input
148	Current limit level at 0V input voltage	0 to 200%	0.1%	150%	(Bias)
149	Current limit level at (10V/5V) input voltage	0 to 200%	0.1%	200%	(Gain)



Note: 1. To switch between 0 to 5V and 0 to 10V, change the terminal 1 input voltage by changing the Pr. 73 setting.

2. When Pr. 22 = 9999, the terminal 1 input is exclusively used for setting the stall prevention level.
Therefore, the auxiliary input and override functions of terminal 1 are not activated.

(5) Stall prevention operation selection [Pr. 154, 156] COMMON

Pr. 156 can be set to disable the stall prevention operation (fast-response current limit function) or to stop operation with the OL signal output.

[Setting example]

Fan/pump 0

Elevator/traveling machine 9

(Makes stopping distance unchanged at the time of deceleration.)

Pr. 156 Setting	Fast-Response Current Limit Function Selection (Note 2) ○ ... Activated × ... Not activated	Stall Prevention Operation Selection ○ ... Activated × ... Not activated			OL Output Signal ○ ... Operation continued × ... Operation stopped (Note 1)
		During acceleration	During constant speed	During deceleration	
0 (factory setting)	○	○	○	○	○
1	×	○	○	○	○
2	○	×	○	○	○
3	×	×	○	○	○
4	○	○	×	○	○
5	×	○	×	○	○
6	○	×	×	○	○
7	×	×	×	○	○
8	○	○	○	×	○
9	×	○	○	×	○
10	○	×	○	×	○
11	×	×	○	×	○
12	○	○	×	×	○
13	×	○	×	×	○
14	○	×	×	×	○
15	×	×	×	×	○

<table>
<tr><th colspan="2" rowspan="2">Pr. 156 Setting</th><th rowspan="2">Fast-Response Current Limit Function Selection (Note 2)
○ ... Activated
× ... Not activated</th><th colspan="3">Stall Prevention Operation Selection
○ ... Activated
× ... Not activated</th><th rowspan="2">OL Output Signal
○ ... Operation continued
× ... Operation stopped (Note 1)</th></tr>
<tr><th>During acceler-ation</th><th>During constant speed</th><th>During deceler-ation</th></tr>
<tr><td colspan="2">16</td><td>○</td><td>○</td><td>○</td><td>○</td><td>×</td></tr>
<tr><td colspan="2">17</td><td>×</td><td>○</td><td>○</td><td>○</td><td>×</td></tr>
<tr><td colspan="2">18</td><td>○</td><td>×</td><td>○</td><td>○</td><td>×</td></tr>
<tr><td colspan="2">19</td><td>×</td><td>×</td><td>○</td><td>○</td><td>×</td></tr>
<tr><td colspan="2">20</td><td>○</td><td>○</td><td>×</td><td>○</td><td>×</td></tr>
<tr><td colspan="2">21</td><td>×</td><td>○</td><td>×</td><td>○</td><td>×</td></tr>
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<tr><td colspan="2">23</td><td>×</td><td>×</td><td>×</td><td>○</td><td>×</td></tr>
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<tr><td colspan="2">25</td><td>×</td><td>○</td><td>○</td><td>×</td><td>×</td></tr>
<tr><td colspan="2">26</td><td>○</td><td>×</td><td>○</td><td>×</td><td>×</td></tr>
<tr><td colspan="2">27</td><td>×</td><td>×</td><td>○</td><td>×</td><td>×</td></tr>
<tr><td colspan="2">28</td><td>○</td><td>○</td><td>×</td><td>×</td><td>×</td></tr>
<tr><td colspan="2">29</td><td>×</td><td>○</td><td>×</td><td>×</td><td>×</td></tr>
<tr><td colspan="2">30</td><td>○</td><td>×</td><td>×</td><td>×</td><td>×</td></tr>
<tr><td colspan="2">31</td><td>×</td><td>×</td><td>×</td><td>×</td><td>×</td></tr>
<tr><td rowspan="2">100</td><td>Driven load</td><td>○</td><td>○</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>Regenerative load</td><td>×</td><td>×</td><td>×</td><td>×</td><td>○</td></tr>
<tr><td rowspan="2">101</td><td>Driven load</td><td>×</td><td>○</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>Regenerative load</td><td>×</td><td>×</td><td>×</td><td>×</td><td>○</td></tr>
</table>

Note: 1. When "Operation not continued for OL signal output" is selected, the "E.OLT" alarm code (stopped by stall prevention) is displayed and operation stopped. (Alarm stop display "E.OLT")

2. If the load is heavy, the lift is predetermined, or the acceleration/deceleration time is short, the stall prevention may be activated and the motor not stopped in the preset acceleration/deceleration time. Therefore, set optimum values for the Pr. 156 stall prevention operation level.

For (A500), the output voltage can be reduced. When the voltage reduces, an overcurrent trip is more unlikely to occur but the torque reduces. When the reduction in torque will not give rise to any problem, set "0" in Pr. 154. Pr. 154 is not provided for (E500).

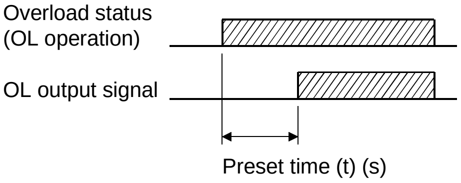
Pr. 154 Setting	Operation	Factory Setting
0	Output voltage reduced	—
1	Output voltage not reduced	○

Note: 3. The setting "101" of Pr. 156 is not available for (E500).

(6) OL signal output timer [Pr. 157] (A500)

The overload alarm (OL) signal can be output if it has persisted for longer than the time set in Pr. 157.

Pr. 157 Setting	Signal Output	Factory Setting
0	Output according to overload (OL) operation.	○
0.1 to 25	Output after preset time (seconds).	—
9999	Overload (OL) alarm signal is not output.	—



1.6.16 Frequency jump [Pr. 31 to 36] COMMON

If motor mechanical resonance occurs, this function allows the running frequency, at which the mechanical resonance has occurred, to be avoided (jumped).

The frequency jump is disabled when the value is as factory-set (9999).

Frequency Jump Functions

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
31	Frequency jump 1A	0 to 400Hz 9999	0.01Hz	9999
32	Frequency jump 1B			
33	Frequency jump 2A			
34	Frequency jump 2B			
35	Frequency jump 3A			
36	Frequency jump 3B			

(1) Frequency jump area

Up to three areas may be specified in any order.

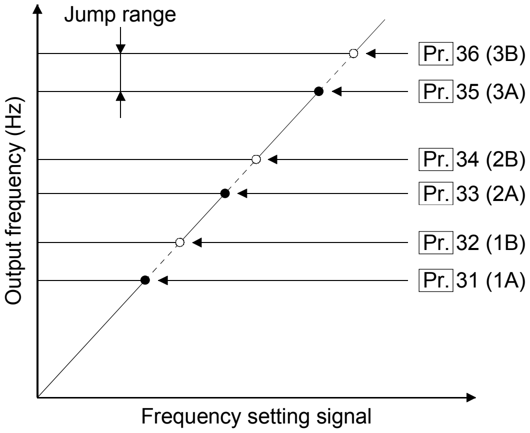
(2) Frequency jump range

The range is determined by setting the top and bottom points to be avoided, not a jump value.

(3) Jump point

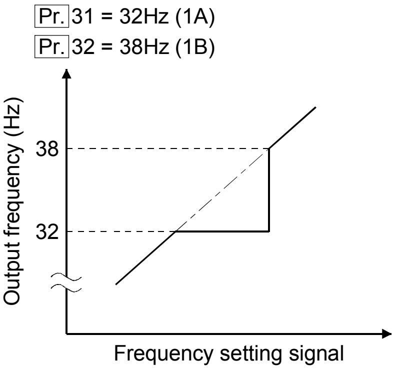
In the jump range, set the jump point at which operation is performed.

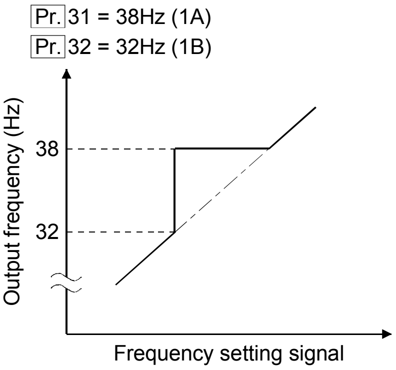
If the jump range setting is between 32 and 38Hz, for example, determine at which frequency, 32Hz or 38Hz, the operation is to be performed when the frequency setting signal is within the above range. This jump point is defined by the frequency set in Pr. 31, Pr. 33 or Pr. 35 (frequency jump 1A, 2A or 3A).



Frequency Jump Setting

Note: The frequency jump is not activated during acceleration/deceleration.
(The running frequency within the set area is valid.)





1.6.17 Output signal selection [Pr. 76] A500

By setting the output terminal switch-over function, Pr. 76, you can choose the output methods of four terminals SU, IPF, OL and FU.

Output Terminal Functions

Output Terminal	Pr. 76 Setting			
	0 (factory setting) (Note 1)	1 (Note 2)	2	3 (programmed operation output) (Note 3)
SU	Up-to-frequency (Pr. 191 = 1)	Alarm code bit 3	During normal operation ... Running status signal (Same as in setting of 0) (Note 1) At alarm occurrence ... Alarm code signal (Note 2)	Output at time-out
IPF	Instantaneous power failure (Pr. 192 = 2)	Alarm code bit 2		Third group operation
OL	Overload alarm (Pr. 193 = 3)	Alarm code bit 1		Second group operation
FU	Frequency detection (Pr. 194 = 4)	Alarm code bit 0		First group operation

Note: 1. The running status signal (setting = 0) changes according to the output terminal assignment set in Pr. 191 to Pr. 194. (The above assignment is as factory-set.) For further details, refer to Section 1.4.4.

2. For full information on the alarm definitions and alarm codes, refer to Section 1.7.

3. For details of programmed operation, refer to Section 1.6.1 (5).

1.6.18 Multi-function monitoring displays [Pr. 52 to 56*, 158*] COMMON

(*Pr. 53 and 158 are not provided for E500.)

(1) A500

1) The operating status of the inverter can be indicated simultaneously in four places, e.g. operation panel (parameter unit) and external instruments. The data displayed can be chosen as desired from among about 20 different types depending on the Pr. 52 to Pr. 54 settings.

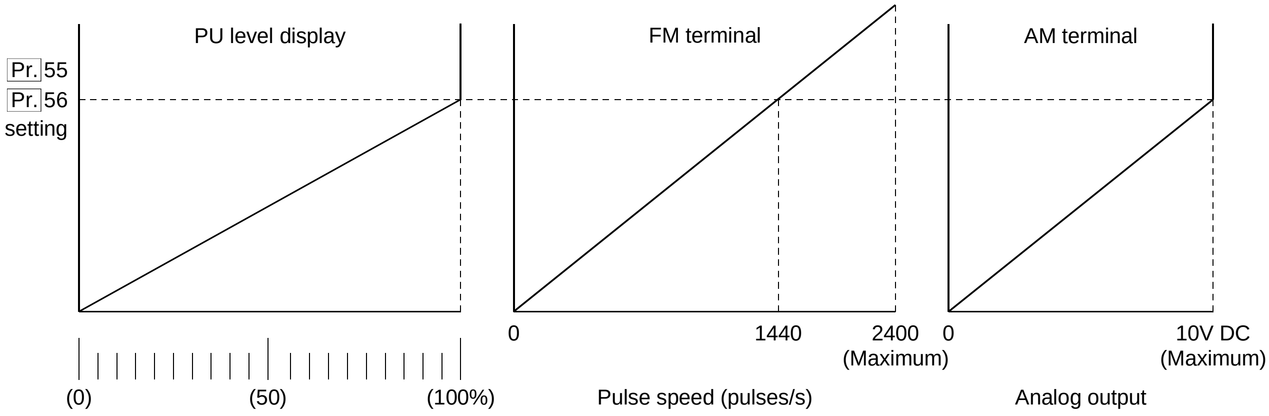
Monitoring-Related Functions

Parameter Number	Name	Description	Factory Setting
52	DU/PU main display data selection	Shown on 4-digit LED of operation panel Shown on large-sized numeral 5-digit liquid crystal display of PU	0 (Hz, A or V selected)
53	PU level display data selection	Indicated by liquid crystal bar (analog) of PU	1 (output frequency Hz)
54	FM terminal function selection	Indicated by external analog meter	1 (output frequency indicated in Hz)
158	AM terminal function selection	Indicated by analog meter from terminal AM	1 (output frequency indicated in Hz)

2) Analog monitoring reference setting [Pr. 55, 56]
Among the analog displays (PU level display, FM terminal and AM terminal), the full-scale value can be set in Pr. 55 (frequency) and Pr. 56 (current) for the following frequency and current display data:

Analog Monitoring Functions

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Monitor Display Data	Pr. 53 Setting PU Level Display	Pr. 54 Setting FM Terminal	Pr. 158 Setting AM Terminal
55	Frequency monitoring reference	0 to 400Hz	0.01Hz	60Hz	Output frequency (Hz)	1	1	1
					Frequency setting (Hz)	5	5	5
					Running speed (Pr. 37, Pr. 144)	6	6	6
56	Current monitoring reference	0 to 500A	0.01A	Rated inverter output current	Output current (A)	2	2	2
					Output current peak (A)	11	11	11
					Load meter (%)	17	17	17
					Motor exciting current (A)	18	18	18



Analog Monitoring Setting

3) Display data selection [Pr. 52 to 54, 158]

Display Data List

Signal Type	Display Unit	Parameter Setting					Full-Scale Value of FM, AM, Level Meter
		Pr. 52		Pr. 53	Pr. 54	Pr. 158	
		DU LED	PU main monitor	PU level meter	FM terminal	AM terminal	
No display	——	×	×	0	×	×	——
Output frequency	Hz	0/100	0/100	1	1	1	Pr. 55
Output current	A	0/100	0/100	2	2	2	Pr. 56
Output voltage	V	0/100	0/100	3	3	3	400V or 800V
Alarm display	——	0/100	0/100	×	×	×	——
Frequency setting	Hz	5	*	5	5	5	Pr. 55
Running speed	r/min	6	*	6	6	6	Pr. 55 value converted into Pr. 37 value
Motor torque	%	7	*	7	7	7	Rated torque of applied motor × 2
Converter output voltage	V	8	*	8	8	8	400V or 800V
Regenerative brake duty	%	9	*	9	9	9	Pr. 70
Electronic overcurrent protection load factor	%	10	*	10	10	10	Protection operation level
Output current peak value	A	11	*	11	11	11	Pr. 56
Converter output voltage peak value	V	12	*	12	12	12	400V or 800V
Input power	kW	13	*	13	13	13	Rated power of inverter rating × 2
Output power	kW	14	*	14	14	14	Rated power of inverter rating × 2
Input terminal status	——	×	*	×	×	×	——
Output terminal status	——	×	*	×	×	×	——
Load meter**	%	17	17	17	17	17	Pr. 56
Motor exciting current	A	18	18	18	18	18	Pr. 56
Position pulse	——	19	19	×	×	×	——
Cumulative operation time	hr	20	20	×	×	×	——
Reference voltage output	——	×	×	×	21	21	1440Hz is output to FM terminal. Full-scale voltage is output to AM terminal.
Orientation status	——	22	22	×	×	×	
Actual operation time	hr	23	23	×	×	×	——
Motor load factor	%	24	24	×	×	×	Rated inverter current × 2
Cumulative power	kW	25	25	×	×	×	——

When 100 is set in Pr. 52, the monitored values during stop and during operation differ as indicated below:
(The LED on the left of Hz flickers during a stop and is lit during running.)

	Pr. 52		
	0	100	
	During operation/during stop	During stop	During operation
Output frequency	Output frequency	Set frequency	Output frequency
Output current	Output current		
Output voltage	Output voltage		
Alarm display	Alarm display		

During an error, the output frequency at error occurrence is shown. During output shut-off (MRS signal ON), the data displayed is the same as during a stop.
During offline auto tuning, the tuning status monitor has priority.

Note:
1. The monitoring of items marked × cannot be selected.
2. By setting "0" in Pr. 52, the monitoring of "output frequency to alarm display" can be selected in sequence by the SHIFT key.
3. *"Frequency setting to output terminal status" on the PU main monitor are selected by "other monitor selection" of the parameter unit (FR-PU04).
4. **The load meter is displayed in %, with the current set in Pr. 56 regarded as 100%.
5. The motor torque display is valid only in the advanced magnetic flux vector control mode.
6. The actual operation time displayed by setting "23" in Pr. 52 is calculated using the inverter operation time. (Inverter stop time is not included.) Set "0" in Pr. 171 to clear it.
7. When Pr. 53 = "0", the level meter display of the parameter unit can be erased.
8. By setting "1, 2, 5, 6, 11, 17 or 18" in Pr. 53, the full-scale value can be set in Pr. 55 or Pr. 56.
9. The cumulative operation time and actual operation time are calculated from 0 to 65535 hours, then cleared, and recalculated from 0.
   When the operation panel (FR-DU04) is used, the display shows "----" after 9999 or more hours have elapsed.
   Whether 9999 or more hours have elapsed or not can be confirmed on the parameter unit (FR-PU04).
10. When the operation panel (FR-DU04) is used, the display unit is Hz, V or A only.
11. The orientation status functions when the FR-A5AP option is used. If the option is not used, "22" may be set in Pr. 52 and the value displayed remains "0" and the function is invalid.
12. Since 1440 pulses/sec are output from the FM terminal when "21" is set in Pr. 54, a 1mA ammeter can be connected to the FM terminal for use as an FM output for calibration. Use Pr. 900 to make fine adjustment needed due to the cable length between inverter and meter. (Refer to Section 1.6.5 (2).)
13. 10VDC is output from the AM terminal when "21" is set in Pr. 158. A DC voltmeter can be connected to the AM terminal to make full-scale calibration of the meter using Pr. 901, AM terminal calibration. (Refer to Section 1.6.5 (3).)
14. The motor torque is indicated in absolute value and is therefore not indicated by a negative value.

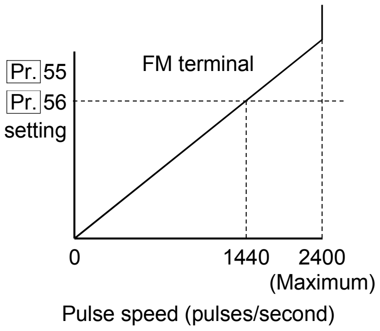
(2) E500

1) The operating status of the inverter can be indicated simultaneously in two places, i.e. operation panel (parameter unit) and external device.
The data displayed on the external device can be chosen by the Pr. 54 setting.

Parameter Number	Name	Description	Factory Setting
54	FM terminal function selection	Indicated by external analog meter	0 (output frequency indicated in Hz)

2) Analog monitoring reference setting [Pr. 55, Pr. 56].
Among the analog displays (FM terminal), the full-scale value can be set in Pr. 55 (frequency) and Pr. 56 (current) for the frequency and current display data.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting
55	Frequency monitoring reference	0 to 400Hz	0.01Hz	60Hz
56	Current monitoring reference	0 to 500A	0.01A	Rated inverter output current



Analog Monitoring Setting

3) Operation panel (parameter unit) display data selection.
   By pressing the monitor key of the operation panel (parameter unit), the data displayed can be changed between the output frequency, output current, output voltage and alarm display. For the alarm display, the history of four past alarms can be shown by pressing the read key. When the value set in Pr. 37 (speed display) is other than "0", the speed is displayed instead of the output frequency.

Signal Type	Unit	Parameter Setting			Full-Scale Value of FM, AM, Level Meter
		Pr. 52		Pr. 54	
		Control panel LED	PU main monitor	FM terminal	
No display		×	×	0	
Output frequency	Hz	0/100	0/100	0	Pr. 55
Output current	A	0/100	0/100	1	Pr. 56
Output voltage	——	0/100	0/100	2	400V or 800V
Alarm display	——	0/100	0/100	×	——
Actual operation time	10hr	23	×	×	——

When 100 is set in Pr. 52, the monitored values during stop and during operation differ as indicated below:

	Pr. 52		
	0	100	
	During operation/during stop	During stop	During operation
Output frequency	Output frequency	Set frequency	Output frequency
Output current	Output current		
Output voltage	Output voltage		
Alarm display	Alarm display		

During an error, the output frequency at error occurrence is shown. During output shut-off (MRS signal ON), the data displayed is the same as during a stop.
During offline auto tuning, the tuning status monitor has priority.

Note:
1. The monitoring of items marked × cannot be selected.
2. By setting "0" in Pr. 52, the monitoring of "output frequency to alarm display" can be selected in sequence by the SHIFT key.
3. Running speed on the PU main monitor is selected by "other monitor selection" of the parameter unit (FR-PU04).
4. The actual operation time displayed by setting "23" in Pr. 52 is calculated using the inverter operation time. (Inverter stop time is not included.) Set "0" in Pr. 171 to clear it.
5. The actual operation time is calculated from 0 to 99990 hours, then cleared, and recalculated from 0. If the operation time is less than 10 hours there is no display.
6. When the control panel is used, the display unit is Hz or A only.

1.6.19 Automatic restart after instantaneous power failure (commercial power supply-inverter switch-over) [Pr. 57, 58, 162 to 165*] COMMON

(*Pr.162 to 165 are not provided for .)

You can restart the inverter without stopping the motor (with the motor coasting) when the commercial power supply is switched to the inverter operation or when the power is restored after an instantaneous power failure. (When automatic restart operation is set to be enabled, E.UVT and E.IPF among the alarm output signals will not be output at occurrence of an instantaneous power failure.)

(1) Restart selection [Pr. 162] COMMON (For E500, operation is performed only using a system which has no frequency search.)

1) With frequency search A500.
Set "0" in Pr. 162 to choose the system in which a direct current is applied to the motor to detect the speed for a smooth start at the time of power restoration or inverter operation selection. Since the DC dynamic brake is applied instantaneously on detection of the speed, the speed may decrease if the inertia is small.

(Note 1) When the inverter is two or more ranks higher in capacity than the motor, an overcurrent (OCT) alarm may occur, disabling a start.

(Note 2) If two or more motors are connected to a single inverter, this function will not work normally. (A proper start cannot be made.)

2) Without frequency search COMMON.
When 1 is set in Pr. 162 for A500 or when E500 is used, the operation of automatic restart after instantaneous power failure is performed in a reduced-voltage starting system where the output voltage is gradually raised with the set frequency unchanged, independently of the coasting speed of the motor.
This system is not a motor coasting speed detection system (frequency search system) as in 1) With frequency search, but is a system where the output frequency at the occurrence of an instantaneous power failure is output. Hence, if the instantaneous power failure time is longer than 0.2 seconds, the inverter cannot store and hold the output frequency at the occurrence of an instantaneous power failure and starts from 0Hz.

(2) Setting COMMON

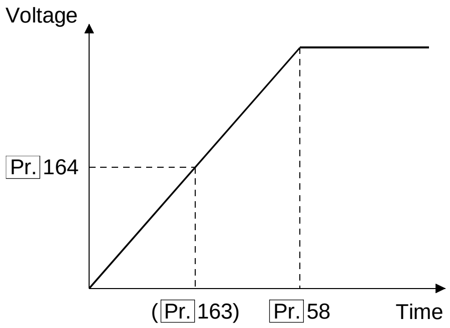
1) Coasting time for automatic restart after instantaneous power failure [Pr. 57] COMMON.
Coasting time is a period of time from the detection of the motor speed to the start of restart control (at the set frequency for E500).
Set "0" in Pr. 57 to make an automatic restart after instantaneous power failure. The coasting time is automatically set to the following value:

[Coasting time when Pr. 57 = 0]
0.1K to 1.5K ..... 0.5 seconds
2.2K to 7.5K ..... 1.0 seconds
11K to 55K .... 3.0 seconds

Proper operation may not be performed depending on the load inertia and running frequency. If so, adjust the coasting time between 0.1 and 5 seconds according to the load specifications.

2) Cushion time for automatic restart after instantaneous power failure [Pr. 58] COMMON
Cushion time is a length of time required to raise the voltage to a value equivalent to the motor speed (set frequency for E500) after detection of the motor speed.
Usually, operation can be performed with the factory setting. The cushion time can be adjusted according to the load inertia and torque.

3) Restart adjustment [Pr. 163 to 165] A500
The voltage rise at a restart can be adjusted as shown below:



Voltage rise time

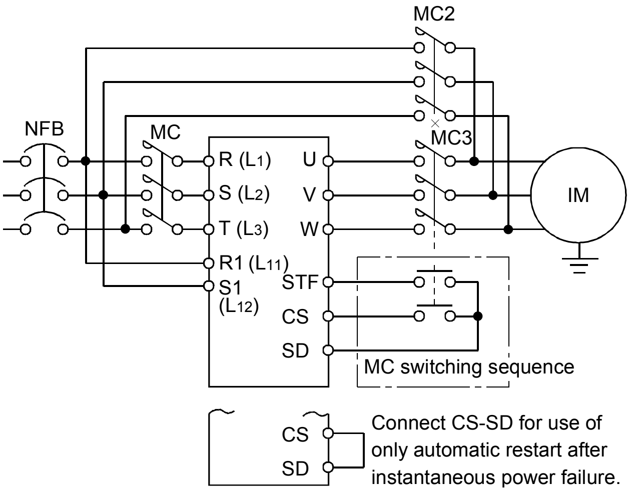
The stall prevention operation level at a restart can be set using Pr. 165.

(3) Connection COMMON

For A500, the above operation is enabled when terminals CS-SD are turned on.

When terminals CS-SD are OFF at the Pr. 57 setting of 0 or any of 0.1 to 5, external or PU operation cannot be performed.

For E500, setting any value other than 9999 in Pr. 57 starts the operation of automatic restart after instantaneous power failure. The external terminal wiring is not needed.



Connect CS-SD for use of only automatic restart after instantaneous power failure.

1.6.20 Intelligent operation mode [Pr. 60 to 64*] COMMON

(*Pr. 64 is not provided for E500.)

Depending on the setting of Pr. 60 (intelligent operation mode selection), the inverter performs operation after self-selecting more suitable parameters independently of the parameter values individually set. This function is effective when proper parameter values are unknown.

During intelligent operation, the parameter values do not match the actual operation parameters.

Intelligent Operation Mode

Pr. 60 Setting	Item	Description		Parameters Changed (Values)	Control System Selection		Corresponding Model	
					Advanced (general-purpose) magnetic flux vector	V/F	A500	E500
0	Ordinary mode	Ordinary operation mode in which parameters are set individually.		—	Valid	Valid	○	○
1	Shortest acceleration/ deceleration mode I	While simultaneously activating current limit, makes acceleration/ deceleration in the shortest time, independently of the acceleration/deceleration time setting.	Current limit value 150%	Pr. 7: acceleration time Pr. 8: deceleration time Pr. 22: current limit value	Valid Acceleration/ deceleration is made in advanced (general-purpose) magnetic flux vector system	Valid Acceleration/ deceleration is made in V/F system.	○	○
2	Shortest acceleration/ deceleration mode II	Current limit value 180% Using the self-learning system, automatically sets the parameter values of acceleration/deceleration time and torque boost so that the current during acceleration/ deceleration approaches the rated current of the inverter.		Pr. 0: torque boost Pr. 7: acceleration time Pr. 8: deceleration time	Valid Acceleration/ deceleration is made in advanced (general-purpose) magnetic flux vector system	Valid Acceleration/ deceleration is made in V/F system.	○	○
3	Optimum acceleration/ deceleration mode						○	×

Pr. 60 Setting	Item	Description		Parameters Changed (Values)	Control System Selection		Corresponding Model	
					Advanced (general-purpose) magnetic flux vector	V/F	A500	E500
4	Energy–saving mode (automatic V/F)	Performs the online true tuning of the output voltage so that the output power is minimized during the constant–speed operation.		Pr. 0: torque boost Pr. 14: load pattern selection	Invalid Having the equivalent effect, ignores energy-saving mode selection.	Valid	○	×
5	Elevator mode I	Performs the online turning of the torque boost to provide sufficient torque for heavy load and prevent over-excitation for light load.	Current limit value 150%	Pr. 0: torque boost Pr. 13: starting frequency Pr. 19: voltage at base frequency Pr. 22: current limit value	Invalid Having the equivalent effect, ignores energy-saving mode selection.	Valid	○	×
6	Elevator mode II		Current limit value 180%				○	×
7	Brake sequence mode I	Switches the output terminal to provide a brake control signal. (For details, refer to Section 1.6.44.)		—	Valid	Invalid	○	×
8	Brake sequence mode II						○	×
11	Shortest acceleration/ deceleration mode I	While simultaneously activating current limit, makes acceleration/ deceleration in the shortest time, independently of the acceleration/deceleration time setting. Use this mode when using the brake resistor or brake unit for E500.	Current limit value 150%	Pr. 7: acceleration time Pr. 8: deceleration time Pr. 22: current limit value	Valid Acceleration/ deceleration is made in advanced (general-purpose) magnetic flux vector system	Valid Acceleration/ deceleration is made in V/F system.	×	○
12	Shortest acceleration/ deceleration mode II		Current limit value 180%				×	○

Dedicated parameters are available so that the performance of the intelligent operation may be further improved.

Only when any of 1 to 6, 11 and 12 is set in Pr. 60, intelligent mode, the parameters listed on the next page are made valid. These parameters are all factory-set to 9999.

When the Pr. 60 setting is changed, the dedicated parameters Pr. 61 to Pr. 64 automatically return to the factory setting (9999) unconditionally.

- The intelligent selection, Pr. 60, setting may be made only while the inverter is at a stop. That setting cannot be changed during operation.
- If the intelligent operation mode has been selected, the input of the JOG signal or RT (second function selection) signal during an inverter stop causes ordinary operation to be performed, giving precedence to the jog operation or second function selection.
  After the intelligent operation has been started, JOG and RT are unaccepted

Parameters Designed Exclusively for Intelligent Mode

Parameter Number	Name	Setting Range and Description	Valid Mode
61	Reference current (A)	9999: rated inverter current 0 to 500: reference = setting (rated motor current)	Shortest acceleration/deceleration Optimum acceleration/deceleration Elevator
62	Current reference value for acceleration (%)	9999: limit value = 150% (180%) 0 to 200: limit value = setting	Shortest acceleration/deceleration
		9999: optimum value = 100% 0 to 200: optimum value = setting	Optimum acceleration/deceleration
63	Current reference value for deceleration (%)	9999: limit value = 150% (180%) 0 to 200: limit value = setting	Shortest acceleration/deceleration
		9999: optimum value = 100% 0 to 200: optimum value = setting	Optimum acceleration/deceleration
64 (Note 1)	Elevator mode starting frequency	9999: starting frequency = 2Hz 0 to 10: starting frequency = setting	Elevator

Note 1 : Not provided for E500.

(1) Shortest acceleration/deceleration modes I, II COMMON

Makes acceleration/deceleration while simultaneously activating the current limit function of the inverter.

Merely setting 1 (current limit value 150%) or 2 (current limit value 180%) in Pr. 60, intelligent selection, allows operation to be performed in the shortest acceleration/deceleration mode I or II.

When using the brake resistor or brake unit for E500, set 11 (current limit value 150%) or 12 (current limit value 180%) in Pr. 60.

Note that when proper values are set in Pr. 7 (acceleration time) and Pr. 8 (deceleration time), acceleration/deceleration time may be shorter than in the selection of these modes.

1) Control method.

The settings of Pr. 7 (acceleration time), Pr. 8 (deceleration time) and Pr. 22 (current limit level) are ignored.

Since the inverter itself attempts to change the shortest time (0 seconds) has been set, acceleration/

deceleration is made with the current limit function being activated. The shortest acceleration/deceleration modes I and II are different only in the current limit value.

★ Return Pr. 60 to 0 (ordinary mode) to make the settings of Pr. 7 (acceleration time), Pr. 8 (deceleration time) and Pr. 22 (stall level) valid. Pr. 61 to 64 also return to the factory setting (9999) automatically.

★ Since acceleration/deceleration is made with the current limit function being activated, the acceleration/deceleration speed always varies according to the load conditions.

2) Application examples.

● Appropriate applications

- It is desired to make acceleration/deceleration in a shorter time for a machine tool etc. but the design values of machine constants are unknown.
- It is desired to perform operation using the capabilities of the inverter and motor to the maximum.
- It is desired to make acceleration/deceleration with constant torque.

● Inappropriate applications

- Machine has large inertia (more than 10 times), e.g. a fan.
  Since the current limit function will be activated for a long time, this type of machine may be brought to an alarm stop due to motor overloading, etc.
- It is desired to always perform operation with a constant acceleration/deceleration time.
- It is desired to always perform operation making sure the inverter and motor have enough capability.

3) Setting of dedicated parameters

By setting the dedicated parameters, the application range can be made wider.

In the factory setting, the current limit function is activated at the 150% (180%) value of the rated inverter current.

★ If Pr. 60 to Pr. 63 have been set once, changing the setting of Pr. 60 (intelligent selection) automatically returns them to the factory setting (9999). Hence, the dedicated parameters must be set after the Pr. 60 value has been set.

Pr. 61 : Set the current value (A) which is the reference of the current limit value.

9999 : Rated inverter current
0 to 500 : Set value (rated motor current) is defied as reference.

For example, when the motor and inverter are different in capacity and it is desired to define the motor rating as reference, set the reference current value.

Pr. 62 : Set the current level (%) for acceleration.

9999 : 150% is the limit value in mode I.
180% is the limit value in mode II.
0 to 200 : Set value is the limit value (%).

Set when it is desired to limit the torque for acceleration.

Pr. 63 : Set the current level (%) for deceleration.

9999 : 150% is the limit value in mode I.
180% is the limit value in mode II.
0 to 200 : Set value is the limit value (%).

Set when it is desired to limit the torque for deceleration.

(2) Optimum acceleration/deceleration mode (A500)

Set "3" in Pr. 60, intelligent selection, and repeat the operation of the actual machine to automatically set Pr. 0 (torque boost), Pr. 7 (acceleration time) and Pr. 8 (deceleration time) so that the magnitude of the current value during acceleration/decele-ration may be made optimum by the self-learning of the inverter.

1) Control method.

At the initial time when the optimum acceleration/deceleration mode has been selected, operation is performed at the values of the torque boost, acceleration time and deceleration time set in Pr. 0, Pr. 7 and Pr. 8.
When operation is started, the peak value and average value are imported to the inverter from the motor current during acceleration/ deceleration.
This current is compared with the reference current (factory setting = rated inverter current) to judge whether Pr. 0, Pr. 7 and Pr. 8 should be increased or decreased, and more appropriate values are calculated by arithmetic operation. The operation results are set in Pr. 0, Pr. 7 and Pr. 8 as the optimum values at that point.
After that, operation is performed under the conditions of Pr. 0, Pr. 7 and Pr. 8 set, and more appropriate values are set in Pr. 0, Pr. 7 and Pr. 8 as required. Hence, repeating the operation allows the optimum acceleration/deceleration operation to be performed, independently of the initial settings.

★ The change of any setting is suppressed to within 40% in a single operation.

★ The optimum values are operated on only when acceleration is made from a stop to 30Hz or more or when deceleration is made from 30Hz or more to a stop.

2) Storage of optimum parameters.

The optimum values of Pr. 0, Pr. 7 and Pr. 8 are written to both the parameter RAM and E^2ROM only three times after the optimum acceleration/deceleration mode has been selected or after the power is switched on or the inverter is reset. At or after the fourth attempt, they are not stored into E^2ROM.
Hence, after power-on or inverter reset, the values changed at the third time are valid.
Operation and PU display are performed according to the most recent optimum values.
Even the values changed at the fourth or later time may be stored into E^2ROM by reading Pr. 0, Pr. 7 and Pr. 8 with the PU and performing write operation.

Pr. 0, Pr. 7 and Pr. 8 Setting Update

Number of Optimum Value Changes	E^2ROM Value	RAM Value	Operating Condition (RAM value)	PU Display (RAM value)
Within 3 times	Updated	Updated	Updated	Updated
4 or more times	Unchanged from third value	Updated	Updated	Updated

3) Application examples

- Appropriate applications
  - Automatic transfer machine, etc. which is small in load change and is operated in a predetermined pattern.
- Inappropriate applications
  - Machine which changes in load and operation conditions.

Since the next parameters are determined according to the current acceleration/ deceleration status, mis-setting is made if the conditions change, resulting in a fault, e.g. acceleration/deceleration is not made, alarm stop is effected by the overcurrent protective function.

4) Setting of dedicated parameters

By setting the dedicated parameters, the application range can be made wider.

In the factory setting, the 100% value of the rated inverter current is judged as the optimum current value.

★ If Pr. 61 to Pr. 63 have been set once, changing the setting of Pr. 60 (intelligent selection) automatically returns them to the factory setting (9999). Hence, the dedicated parameters must be set after the Pr. 60 value has been set.

Pr. 61 : Set the current value (A) which is the reference of the optimum current value.

9999 : Rated inverter current

0 to 500 : Set value (rated motor current) is defied as reference.

For example, when the motor and inverter are different in capacity and it is desired to define the motor rating as reference, set the reference current value.

Pr. 62 : Set the optimum current level (%) for acceleration.

9999 : 100% is the optimum value.

0 to 200 : Set value is the optimum value (%).

Set when it is desired to limit the average current for acceleration.

Pr. 63 : Set the optimum current level (%) for deceleration.

9999 : 100% is the optimum value.

0 to 200 : Set value is the optimum value (%).

Set when it is desired to limit the average current for deceleration.

(3) Energy-saving mode (A500)

Set "4" in Pr. 60, intelligent selection, to perform operation with the minimum output power.

1) Control method

After the output frequency has become constant (acceleration or deceleration is complete), the output voltage is reduced gradually and operation is performed with the output power (product of current and voltage) being minimum.

When the output current begins to increase due to the increase in load torque, the output voltage is increased up to the normal V/F pattern to provide the torque required to maintain the speed.

The output voltage is controlled within the range of +0% to -30% in relation to the normal V/F pattern, and the settings of Pr. 0 (torque boost) and Pr. 14 (load pattern selection) are ignored.

★ By returning Pr. 60 to 0 (ordinary mode), the settings of Pr. 0 and Pr. 14 are made valid.

2) Restrictions.

- When advanced magnetic flux vector control is selected, the selection of the energy-saving mode is made invalid. (The advanced magnetic flux vector control has the equivalent effect to the energy-saving mode.)
- When the PLG feedback function has been selected with the inboard option (FR-A5AP) fitted to the inverter, the selection of the energy-saving mode is made invalid.

3) Application examples

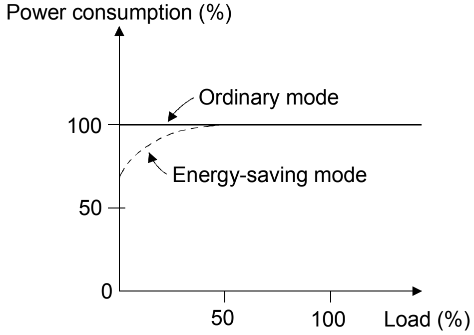
- ● Appropriate applications.
  - Machine which is operated for a long time at constant speed, e.g. fan, air conditioner.
- ● Inappropriate applications.
  - Application in which large load torque is applied
    Since there is naturally little power consumption loss, no energy-saving effect is produced.
  - Machine which makes frequent acceleration/deceleration
    Torque is required for acceleration/ deceleration and no energy-saving effect is produced.

4) Dedicated parameters.

When constant speed is achieved in the energy-saving mode, the output voltage is automatically tuned and there are no dedicated parameters to be set.

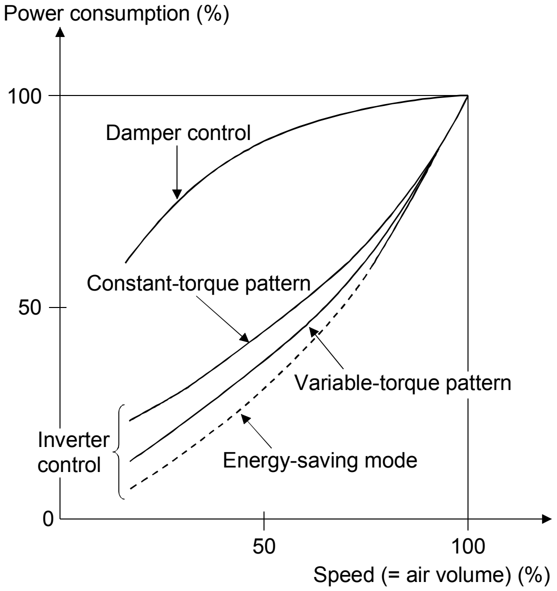
5) Energy-saving effect

The energy-saving effect depends greatly on the load magnitude.



Guideline of Energy-Saving Mode

In applications such as air conditioning equipment, inverter operation produces a larger energy-saving effect on the running cost than damper control by commercial power supply operation. The energy-saving effect depends greatly on the speed (load).



Energy-Saving Effect by
Air-Conditioning Equipment

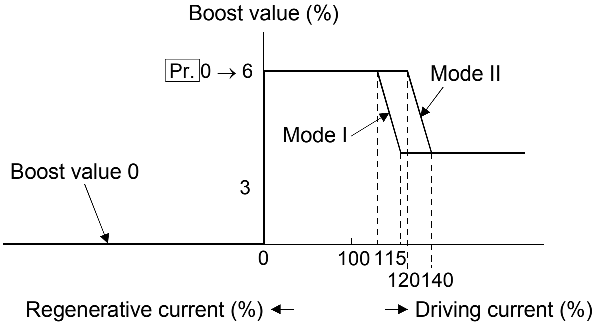
(4) Elevator modes I, II (A500)

Operation can be performed to match the load characteristic of an elevator equipped with counterweight.

Set "5" (current limit value 150%) or "6" (current limit value 180%) in Pr. 60, intelligent selection, to perform operation in the elevator mode I or II.

1) Control method

Sufficient torque is generated for the drive mode load. For the regenerative load and no load, the torque boost value is controlled with respect to the Pr. 0 setting as shown below to prevent an overcurrent trip due to overexcitation.



Torque Boost Characteristic
(Torque boost setting = 6%)

The starting frequency is factory-set to 2Hz, the current limit level to 150% (or 180%), and the base frequency voltage to 220V.

Hence, the Pr. 13 (starting frequency), Pr. 19 (base frequency voltage) and Pr. 22 (current limit value) values are ignored.

The elevator modes I and II are different only in current limit level.

★ By returning Pr. 60 to 0 (ordinary mode), the Pr. 0, Pr. 13, Pr. 19 and Pr. 22 values are made valid.
Pr. 61 and Pr. 64 also return to the factory setting (9999).

2) Restrictions.

- When advanced magnetic flux vector control is selected, the selection of the elevator mode is made invalid. (Advanced magnetic flux vector control is more advantageous in performance.)

3) Applications.

● Appropriate application.
  - Elevator with counterweight

● Inappropriate application.
  - Maximum torque may be insufficient for an elevator subjected to the load of higher than the rating.
    For an elevator without counterweight, setting "2" or "3" in Pr. 14 (load pattern selection) and setting a proper value in Pr. 19 (base frequency voltage) makes the maximum torque larger and is more advantageous than the selection of the elevator mode.

4) Setting of dedicated parameters.

By setting the dedicated parameters, the application range can be made wider.

In the factory setting, the current limit function is activated at the 150% (180%) value of the rated inverter current.

★ If Pr. 61 and Pr. 64 have been set once, changing the Pr. 60 (intelligent selection) setting automatically returns them to the factory setting (9999). Hence, the dedicated parameters must be set after Pr. 60 has been set.

Pr. 61 :Used to set the current value (A) which is the reference of the current limit value.

9999	: Rated inverter current
0 to 500	: Set value (rated motor current) is defined as reference.

When the motor and inverter are different in capacity, for example, and it is desired to define the motor rating as reference, set the reference current value in this parameter.

Pr. 64 :Used to set the starting frequency (Hz) in the elevator mode.

9999	: Starting frequency is set to 2Hz.
0 to 10	: Set value is the starting frequency (Hz).

Set this parameter when it is desired to increase/decrease the starting torque.

(5) Brake sequence modes I, II (A500)

This function outputs a brake control signal from the inverter to operate the mechanical brake at an appropriate time.

This function works only in the advanced magnetic flux vector control mode which is optimum for elevator applications, and cannot be used in the V/F control mode.

For details, refer to Section 1.6.44.

1.6.21 Retry function [Pr. 65,67,68,69] COMMON

When an alarm occurs in the inverter, this function allows the inverter to automatically reset the alarm, makes a restart and resumes operation.

(1) Retry operation functions

Functions Related to Retry Operation

Parameter Number	Name	Setting Range	Set Value	Operation	Factory Setting
67	Number of retries at alarm occurrence	0 to 10 times, 101 to 110	0	Retry operation is not performed.	○
			1 to 10	Retry operation is performed the number of preset times, with alarm output not provided during operation.	—
			101 to 110	Retry operation is performed the number of (setting - 100) times, with alarm output provided during operation.	—
68	Retry waiting time	0 to 10 s (Note)	0 to 10 (Note)	Retry operation is started after preset time has elapsed.	1
69	Successful retry count display and erase	0	0	Displays the number of past successful retries. Set "0" to clear the number of successful retries.	0

Note: 0 to 360 for E500.

1) Retry operation

When an alarm has occurred, the inverter stops the output. When the time set in Pr. 68 has elapsed, the inverter resets the alarm and restarts at the starting frequency (Note 1).

When no alarm occurs within a period five times longer than the time set in Pr. 68, it is regarded that retry has succeeded and the Pr. 69 (number of successful retries) value is incremented by 1. (Refer to the chart on the right.)

When an alarm occurs within a period five times longer than the time set in Pr. 68, the inverter restarts again after the time set in Pr. 68 has elapsed.

When retries are made more than the number of times set in Pr. 67 ((setting - 100) times when the setting is any of 101 to 110), retry count excess alarm [E.RET] causes the inverter output to stop.

Note: 1. If an IPF or UVT alarm has occurred with the function of automatic restart after instantaneous power failure being selected, the inverter starts during coasting. This is not included in the number of alarm retries. If the alarm that has occurred is other than the above, the inverter does not restart during coasting but restarts at the starting frequency.

2. When using this function, care must be taken not to make operators hazardous since this function causes the inverter to restart operation automatically after the retry waiting time set in Pr. 68 has elapsed.

3. When the inverter is reset at the time of restart made by the retry function, thermal cumulative data such as the electronic thermal relay and regenerative brake duty are not cleared. (This is different from power-on reset.)

2) Alarm output

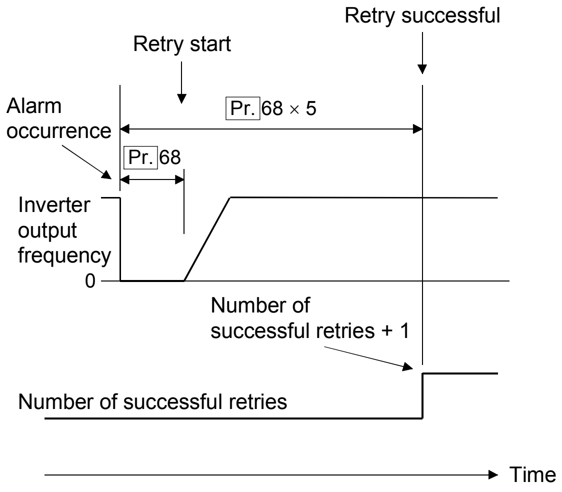
No alarm is output during retry operation selection if any of 1 to 10 is set in Pr. 67.

An alarm is output when a retry count excess alarm [E.RET] occurs.

When any of 101 to 110 is set in Pr. 67, an alarm is output during retry operation.

3) Alarm definition storage

The definition of only the alarm that has occurred first is stored into E^2ROM, and that of any alarm occurring during retry operation is not stored.



Retry Operation Chart

(2) Retry selection function

Set the Pr. 65 value to choose alarms to be reset for retry.

1) A500

Errors Reset for Retry	Pr. 65 Setting					
Display	0	1	2	3	4	5
E.OC1	●	●		●	●	●
E.OC2	●	●		●	●	
E.OC3	●	●		●	●	●
E.OV1	●		●	●	●	
E.OV2	●		●	●	●	
E.OV3	●		●	●	●	
E.THM	●					
E.THT	●					
E.IPF	●				●	
E.UVT	●				●	
E.FIN						
E. BE	●				●	
E. GF	●				●	
E. LF						
E.OHT	●					
E.OLT	●				●	
E.OPT	●				●	
E.OP1	●				●	
E.OP2	●				●	
E.OP3	●				●	
E. PE	●				●	
E.PUE						
E.RET						
E.CPU						
E.MB1	●				●	
E.MB2	●				●	
E.MB3	●				●	
E.MB4	●				●	
E.MB5	●				●	
E.MB6	●				●	
E.MB7	●				●	
E.P24						
E.CTE						

Note: ● indicates the errors selected for retry.

2) E500

Errors Reset for Retry	Pr. 65 Setting			
Display	0	1	2	3
E.OC1	●	●		●
E.OC2	●	●		●
E.OC3	●	●		●
E.OV1	●		●	●
E.OV2	●		●	●
E.OV3	●		●	●
E.THM	●			
E.THT	●			
E.FIN				
E. BE	●			
E.OHT	●			
E.OLT	●			
E.OPT	●			
E. PE	●			
E.PUE				
E.RET				
E.CPU				

Note: ● indicates the errors selected for retry.

1.6.22 PWM carrier frequency [Pr. 72,240] COMMON

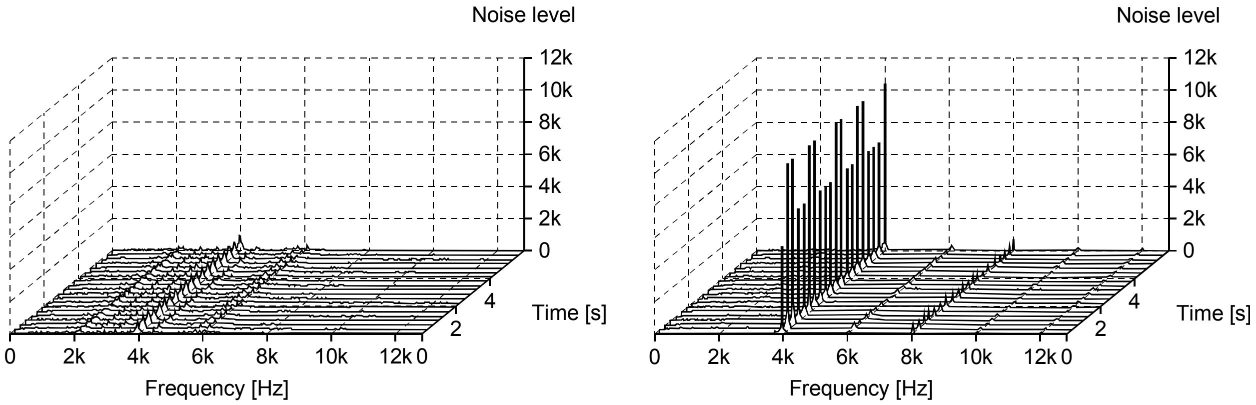
Allows the PWM control carrier frequency of the inverter to be changed.

To avoid the resonance frequency of a mechanical system or a motor, or to reduce inverter-generated noise and leakage current, changing the carrier frequency may produce an effect.

When the carrier frequency setting is low, making Soft-PWM control valid allows the metallic tone of motor noise to be changed into an inoffensive complex tone.

Parameter Number	Name	Set Value	Description
72	PWM frequency selection	0 to 15	Set value indicates a [kHz] value. However, 0 is equal to 0.7kHz and 15 to 14.5kHz.
240	Soft-PWM setting	0	Soft-PWM invalid
		1	Soft-PWM is made valid when any of "0 to 5" is set in Pr. 72.

Note: Note that when the E500 is run with 2kHz or more set in Pr. 72 at the ambient temperature of higher than 40°C, the rated output current of the inverter must be reduced for use. (Refer to Section 1.1.1 (2).)



(a) With Soft-PWM
Distributed frequency components provide an inoffensive tone with little metallic sound.

(b) Without Soft-PWM
Concentrated frequency components provide an offensive metallic sound.

Motor Noise Data Examples (SF-JR 4-pole 3.7kW motor at carrier frequency of 2kHz)

1.6.23 Input filter constant [Pr. 74] COMMON

Allows the filter constant in the inverter to be changed in relation to an external analog input signal.

★Increase the set value when installing the inverter in a place with much external noise or when stable operation cannot be performed due to the influence of noise.
A higher set value decreases the response level.

Parameter Number	Name	Setting Range	Setting Increments	Factory Setting
74	Input filter constant	0 to 8	integer	1

Set value 0: About 1ms response delay
Set value 8: About 1s response delay

This function is invalid for the following digitally set values:

PU operation	Multi-speed setting
12-bit digital input	Computer and PC link

1.6.24 Selection of advanced magnetic flux vector control

[Pr. 80,81,89] (A500)

Advanced magnetic flux vector control is a control system which allows low-speed torque to be improved by dividing the motor current into an exciting current and a torque current and making voltage compensation to flow a motor current which meets the load torque.

The magnitude of a load torque (i.e. motor slip) is estimated from the magnitude of the torque current on the basis of more accurate motor constants, thereby controlling the output frequency (slip compensation) to make the actual motor speed nearer to the speed command value.

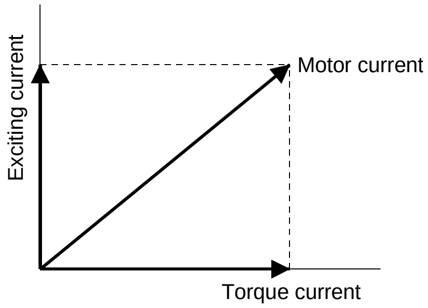
(1) Conditions of advanced magnetic flux vector control selection

Advanced magnetic flux vector control may only be utilized effectively when all of the following conditions are satisfied.

If any of the conditions cannot be satisfied, torque shortage, speed fluctuation or another fault may have occurred. Choose V/F control to perform operation.

- The motor capacity is equal to or one rank lower than the inverter capacity.
  Note that the motor capacity should be 0.4kW or more.
- The motor type is the Mitsubishi standard motor or Mitsubishi constant-torque motor. When any other motor (other standard motor, other constant-torque motor) is used, use this function after performing offline auto tuning with the auto tuning function (refer to Section 1.6.26).
- The number of motor poles is any of 2, 4 or 6. (4 poles only for the constant-torque motor)
- Single-motor operation (one motor for one inverter) is performed.
- The wiring length between the inverter and motor is within 30m. (If the length is over 30m, perform offline auto tuning with the cables wired.)

Advanced magnetic flux vector control can be chosen by setting the capacity, poles and type of the motor used.



Vector Division of Motor Current

(2) How to select advanced magnetic flux vector control

Advanced magnetic flux vector control is selected by merely setting any value other than 9999 in Pr. 80 (motor capacity) and Pr. 81 (number of poles). V/F control is chosen when either of the Pr. 80 and Pr. 81 settings is 9999.

When using Mitsubishi's constant-torque motor (SF-JRCA), set "1" in Pr. 71. (When using the SF-JRC, perform the offline auto tuning .)

When using Mitsubishi's standard motor (SF-JR, 4P, 1.5kW or less), set "20" in Pr. 71.

Note: By switching on-off the signal across X18-SD, you can select between V/F control and magnetic flux vector control for operation. (Refer to the table on the next page.)

(3) Information on advanced magnetic flux vector control

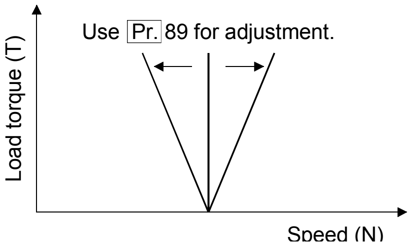
- A little inferior in speed fluctuation improvement to V/F control.
- There is an arithmetic operation delay of 0.1 to 0.2s at start-up.
- Applications suitable for advanced magnetic flux vector control.
  - Machines requiring a large starting torque
  - Machines requiring a sufficient low-speed torque
  - Machines varying greatly in load
- Applications unsuitable for advanced magnetic flux vector control.
  - Grinders, lapping machines and other machines for which speed fluctuation at low speed is important

Functions Related to Advanced Magnetic Flux Vector Control

Parameter Number	Name	Setting Range	Set Value	Description	Factory Setting
80	Motor capacity	9999, 0.4 to 55kW	9999	V/F control is selected.	○
			0.4 to 55	Set motor capacity (kW).	—
81	Number of motor poles	9999, 2, 4, 6 12, 14, 16	9999	V/F control is selected.	○
			2, 4, 6	Set the number of motor poles.	—
			12, 14, 16	Switch on the signal across X18-SD to choose V/F control if you have set the number of motor poles. 12: Corresponding to 2-pole motor 14: Corresponding to 4-pole motor 16: Corresponding to 6-pole motor	—

(4) Fine adjustment method for advanced magnetic flux vector control

- For adjustment of motor speed fluctuation due to load variation.
  Pr. 89 can be used to adjust motor speed fluctuation when the load varies. (When you have changed the conventional model FR-A200E series for the FR-A500 series, advanced magnetic flux vector control is effective when motor speed does not match.)

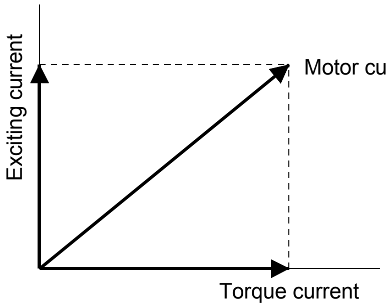


1.6.25 Selection of general-purpose magnetic flux vector control

[Pr. 80] E500

General-purpose magnetic flux vector control is a control system which allows low-speed torque to be improved by dividing the motor current into an exciting current and a torque current and making voltage compensation to flow a motor current which meets the load torque.

General-purpose magnetic flux vector control can be chosen by setting the capacity and type of the motor used.



Vector Division of Motor Current

(1) Conditions of general-purpose magnetic flux vector control selection

General-purpose magnetic flux vector control may only be utilized effectively when all of the following conditions are satisfied.

If any of the conditions cannot be satisfied, torque shortage, speed fluctuation or other fault may have occurred. Choose V/F control to perform operation.

- The motor capacity is equal to or one rank lower than the inverter capacity.
  Note that the motor capacity should be 0.1kW or more.
- The number of motor poles is any of 2, 4, or 6. (4 poles only for the constant-torque motor. The number of poles need not be set.)
- Single-motor operation (one motor for one inverter) is performed.
- The wiring length between the inverter and motor is within 30m. (If the length is over 30m, perform offline auto tuning with the cables wired.)

(2) How to select general-purpose magnetic flux vector control

General-purpose magnetic flux vector control is selected by merely setting any value other than 9999 in Pr. 80 (motor capacity). V/F control is chosen when the Pr. 80 setting is 9999.

When using Mitsubishi's constant-torque motor (SF-JRCA), set "1" in Pr. 71. (When using the SF-JRC, perform the offline auto tuning .)

Functions Related to General-Purpose Magnetic Flux Vector Control

Parameter Number	Name	Setting Range	Set Value	Description	Factory Setting
80	Motor capacity	9999, 0.1 to 3.7kW	9999	V/F control is selected.	○
			0.1 to 3.7	Set motor capacity (kW).	—

1.6.26 Offline auto tuning function [Pr. 71,82 to 84,90 to 94*,96] COMMON

(*Pr. 91 to 94 are not provided for E500.)

By using the offline auto tuning function, you can run the motor with the optimum operating characteristics under advanced (general-purpose) magnetic flux vector control.
Tuning data (motor constants) can be copied to another inverter with the FR-DU04 operation panel or FR-PU04 parameter unit.
Note that a high-slip motor, high-speed motor or other special motor cannot be tuned. Also, the highest speed should be 120Hz.

Auto Tuning-Related Functions for A500

Parameter Number	Name	Setting Range	Set Value	Description			Factory Setting
71	Applied motor (Note 1)	0 to 6, 13 to 16, 20, 23, 24	0	Standard motor (more than 1.5kW)			○
			1	Constant-torque motor			—
			2	Standard motor (5-point flexible V/F characteristics)			
			20	Mitsubishi SF-JR standard motor (1.5kW or less)			
			3	Standard motor	"Offline auto tuning setting" is selected.		
			13	Constant-torque motor			
			23	Mitsubishi SF-JR standard motor (1.5kW or less)			
			4	Standard motor	Auto tuning data read or change setting enabled		
			14	Constant-torque motor			
			24	Mitsubishi SF-JR standard motor (1.5kW or less)			
			5	Standard motor	Star connection	Direct input of motor constants enabled	
			15	Constant-torque motor			
			6	Standard motor	Delta connection		
			16	Constant-torque motor			
			7	Standard motor	Star connection	Direct input of motor constants + offline auto tuning	
			17	Constant-torque motor			
			8	Standard motor	Delta connection		
			18	Constant-torque motor			
82	Motor exciting current	0 to 500A, 9999	9999	Motor exciting current (A) can be set as desired.			○
			0 to 500A				—
83	Rated motor voltage	0 to 1000V	0 to 1000V	Set the rated motor voltage (V).			200 (Note 4)
84	Rated motor frequency	50 to 120Hz	50 to 120Hz	Set the rated motor frequency (Hz).			60
90	Motor constant (R1)	9999, 0 to 50Ω	9999	Tuning data (Note 2)			○
			0 to 50Ω				—
91	Motor constant (R2)	9999, 0 to 50Ω	9999				○
			0 to 50Ω				—
92	Motor constant (L1)	9999, 0 to 1000.0mH	9999				○
			0 to 1000.0mH				—
93	Motor constant (L2)	9999, 0 to 1000.0mH	9999				○
			0 to 1000.0mH				—
94	Motor constant (X)	9999, 0 to 100%	9999				○
			0 to 100%				—
96	Auto tuning setting/status	0, 1, 101 (Note 3)	0	"Offline auto tuning is not performed" is selected.			○
			1	Offline auto tuning is performed without motor running.			—
			101 (Note 3)	Offline auto tuning is performed with motor running.			○

Note: 1. The electronic overcurrent protection characteristics are also selected simultaneously.
2. The values measured by auto tuning are set automatically.
3. Select "101" to increase tuning accuracy.
4. The factory setting is 400V for the 400V class.

Auto Tuning-Related Functions for (E500)

Parameter Number	Name	Setting Range	Set Value	Description			Factory Setting
71	Applied motor (Note 1)	0, 1, 3, 5, 6, 13, 15, 16, 23, 100, 101, 103, 105, 106, 113, 115, 116, 123	0, 100	Electronic overcurrent protection thermal characteristics suitable for standard motor			○(0)
			1, 101	Electronic overcurrent protection thermal characteristics suitable for Mitsubishi constant-torque motor			—
			3, 103	Standard motor	"Offline auto tuning setting" is selected.		
			13, 113	Constant-torque motor			
			23, 123	Mitsubishi SF-JR standard motor (1.5kW or less)			
			5, 105	Standard motor	Star connection	Direct input of motor constants enabled	
			15, 115	Constant-torque motor			
			6, 106	Standard motor	Delta connection		
			16, 116	Constant-torque motor			
82	Motor exciting current	0 to 500A, 9999	9999	Motor exciting current (A) can be set as desired.			○
			0 to 500A				—
83	Rated motor voltage	0 to 1000V	0 to 1000V	Set the rated motor voltage (V).			200
84	Rated motor frequency	50 to 120Hz	50 to 120Hz	Set the rated motor frequency (Hz).			60
90	Motor constant (R1)	9999, 0 to 50Ω	9999	Tuning data (Note 2)			○
			0 to 50Ω				—
96	Auto tuning setting/status	0, 1	0	"Offline auto tuning is not performed" is selected.			○
			1	Offline auto tuning is performed without motor running.			—

Note: 1. The electronic overcurrent protection characteristics are also selected simultaneously.
2. The values measured by auto tuning are set automatically.
3. The factory setting of the 400V class is 400V.

(1) Checking the wiring and load

Before starting the auto tuning, make the following checks:

1) Make sure that the motor is connected and advanced (general-purpose) magnetic flux vector control is selected. Note that when the tuning is started, the motor should be at a stop.
2) Auto tuning may be made if the motor is connected with a load (e.g. friction, stationary load). However, tuning can be made more accurately as the load is smaller. The turning accuracy does not change if the inertia is large.
3) For (A500), when "101" (auto tuning is performed with motor running) is set in Pr. 96 (auto tuning setting/status), note the following:
   a) During tuning, torque is not sufficient.
   b) Problems should not arise if the motor is run up to nearly the rated motor frequency (Pr. 84 setting).
   c) The brake should be open.
   d) The motor should not be run by external force.
4) If "1" (tuning is performed without motor running) is set in Pr. 96, the motor may run slightly. Therefore, fix the motor securely with a mechanical brake, or before tuning, make sure that there will be no problem in safety if the motor runs.
   *This instruction must be followed especially for vertical lift applications.
   Note that if the motor runs slightly, tuning performance is unaffected.
5) Auto tuning will not be performed properly if it is performed when the optional noise reducing reactor (FR-BOL) or surge voltage suppression filter (FR-ASF-H) is connected between the inverter and motor. Remove them before starting tuning.

(2) Parameter setting

Using Pr. 80 and Pr. 81 (Pr. 80 for E500,) select the advanced (general-purpose) magnetic flux vector control. After that, refer to the parameter details list and set the following parameters:

1) Pr. 96 (auto tuning setting/status)
   Set "1" or "101".
   - For setting of "1"
     --------- Tuning is made without the motor running.
   - For setting of "101"
     --------- Tuning is made with the motor running.

2) Pr. 9 (electronic thermal relay)
   -------- Set the rated motor current (A).

3) Pr. 83 (rated motor voltage)(note)
   -------- Set the rated motor voltage (V)

4) Pr. 84 (rated motor frequency)(note)
   -------- Set the rated motor frequency (Hz).

5) Pr. 71 (applied motor)
   -------- Refer to the following and select the value:
   - Standard motor-------------------Setting "3"
   - Constant-torque motor ---------Setting "13"
   - Mitsubishi standard motor SF-JR 4 poles (1.5kW or less) -------------------Setting "23"

Note: Pr. 83 and Pr. 84 are only displayed when the advanced (general-purpose) magnetic flux vector control is selected.
In these parameters, set the values given on the motor plate.
When the standard motor has more than one rated value, set 200V/60Hz or 400V/60Hz.

(3) Auto tuning operation

For PU operation, press the [FWD] or [REV] key.
For external operation, turn on the start switch (short terminals STF or STR-SD).
For E500, only auto tuning in the no-rotation mode is available.

Reference: Auto tuning time (factory setting)

Auto Tuning Setting	Time
1: No-rotation mode	Approximately 25s
101: Rotation mode	Approximately 40s (note 1)

Note: 1. Offline auto tuning time varies with acceleration and deceleration time settings as indicated below:
Auto tuning time
= acceleration time + deceleration time
+ approximately 30 seconds

2. When "101" is set in Pr. 96, guard against hazard because the motor rotates.
3. During auto tuning, the I/O signal states are as indicated below:

For A500

	Valid signals
Input signals	STOP OH MRS RT,CS RES STF/STR

	Valid terminals
Output terminals	RUN OL IPF FM,AM A.B.C

For E500

	Valid signals
Input signals	MRS RES STF STR

	Valid terminals
Output terminals	RUN FM A.B.C

- To force tuning to end
  Enter the MRS or RES signal or press the [STOP] key to end.

Note 4: Special caution should be exercised when a sequence has been designed to open the mechanical brake with the RUN signal.

After end of the auto tuning, confirm the Pr. 96 value.

- Normal end: ------------ "3" or "103" is displayed.
- Error-activated end: --- Any of "9", "91", "92" and "93" is displayed.
  When tuning ends normally, press the [STOP] key for PU operation. For external operation, turn off the start switch (open terminals STF or STR-SD). This operation deactivates the auto tuning and the PU's monitor display returns to the ordinary indication.
  Without this operation, the next operation cannot be done. When tuning was ended due to an error, the auto tuning did not end normally and motor constants have not been set. Reset the inverter (refer to Section 1.4.12) and start tuning all over again.
- Error-activated end display definitions

Error Display	Error Cause	Remedy
9	Inverter trip	Re-set.
91	Current limit (stall prevention) function was activated.	Increase acceleration/deceleration time. Pr. 156.
92	Inverter output voltage reached 75% of rated value.	Check for fluctuation of power supply voltage.
93	Calculation error	Check the motor wiring and re-set.

Note: Auto tuning cannot be made if the current limit (stall prevention) function is activated during auto tuning.

(4) Monitoring the offline tuning status

During tuning, the Pr. 96 value is displayed on the main monitor and level meter as listed below. On the operation panel, the values 1, 2, 3, 9, 91, 92, 93, 101, 102 and 103 (Note) are displayed as on the PU. (When Pr. 51 = "1" (factory setting))

Note: For E500, 101 to 103 are not displayed.

- Operation panel (FR-DU04) display
  (For inverter trip)

	1. Setting	2. Tuning in progress	3. Completion	Error-activated end
Displayed value (Note)	1 →	2 →	3	9
	101 →	102 →	103	

Note: For E500, 101 to 103 are not displayed.

- Parameter unit (FR-PU04) main monitor
  (For inverter trip)

	1. Setting	2. Tuning in progress	3. Completion	Error-activated end
Display (Note)	1 --- STOP PU	TUNE 2 STF FWD PU	TUNE 3 COMPLETION STF STOP PU	TUNE 9 ERROR STF STOP PU
	101 --- STOP PU	TUNE 102 STF FWD PU	TUNE 103 COMPLETION STF STOP PU	

Note: For E500, 101 to 103 are not displayed.

- PU level meter
  Displays 0% (start) to full-scale 100% (end) to indicate the progress status.

1.6.27 Online auto tuning function [Pr. 95] A500

By online auto tuning, the motor conditions are tuned rapidly at the start. This enables precise operation unaffected by motor temperatures and steady high-torque operation down to super-low speed.

After setting the Pr. 80 and Pr. 81 values, select online auto tuning with Pr. 95.

Perform this tuning when much higher-torque, more stable operation is required at low speed for advanced magnetic flux vector operation.

Note: Before starting online auto tuning, perform offline auto tuning. Data must be calculated.

Parameter Number	Name	Setting Range	Set Value	Description	Factory Setting
95	Online auto tuning selection	0, 1	0	Online auto tuning is not made.	○
			1	Online auto tuning is made.	—

(1) Operating conditions

1) Data required for online auto tuning is calculated in offline auto tuning. Before starting the operation of this function, always execute the offline auto tuning once more. The offline auto tuning is also required for use of the Mitsubishi standard motor (SF-JR) or constant-torque motor (SF-JRCA).
2) Offline auto tuning should be carried out with 101 (motor running) set in Pr. 96 and with the motor disconnected from the load. (The motor may be connected with inertia load.)

(2) Operating procedure

1) Read the Pr. 96 value and make sure that its setting is "3" or "103" (offline auto tuning complete).
2) Set "1" in Pr. 95 to select the online auto tuning.
3) Before starting operation, make sure that the following parameter values have been set:

Parameter Number	Description
9	(Used as either the rated motor current or electronic overcurrent protection parameter)
71	Applied motor
80	Motor capacity (down to one rank lower, between 0.4kW and 55kW)
81	Number of motor poles

4) Give the run command in the PU or external operation mode.

Note:
1. If any of the inverter starting conditions are not satisfied, e.g. when MRS is input, if the set frequency is lower than the starting frequency (Pr. 13) value, or during an inverter error, the online auto tuning is not activated.
2. For a restart during deceleration or DC dynamic brake operation, the online auto tuning is not activated.
3. The online auto tuning is invalid for programmed operation or jog operation.
4. When automatic restart after instantaneous power failure is selected, it overrides the online auto tuning.
5. For use in vertical lift application, examine the use of a brake sequence for brake opening timing at the start. Though the tuning ends in about a maximum of 500ms after starting, enough torque is not provided during that period. Therefore, note that the load may drop due to gravity.
6. Zero current detection and output current detection are also valid during the online auto tuning.
7. The RUN signal is not output during the online auto tuning. The RUN signal switches on at a start.
8. When programmed operation is selected (Pr. 79 = 5), the online auto tuning is invalid and is not executed.
9. If the period between inverter stop and restart is within 4 seconds, the online auto tuning is executed but operation will not reflect the tuning results.

1.6.28 Slip compensation [Pr. 245 to 247] (E500)

The inverter output current may be used to assume motor slip to keep the motor speed constant.

$$\text{Rated slip} = \frac{\text{Synchronous speed at base frequency - rated speed}}{\text{Synchronous speed at base frequency}} \times 100\ [\%]$$

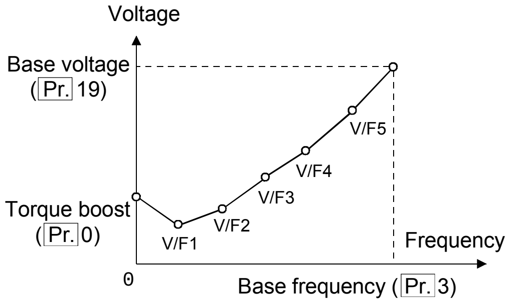
Parameter Number	Name	Setting	Function
245	Rated slip	0 to 50%	Used to set the rated motor slip.
		9999	Slip compensation is not made.
246	Slip compensation time constant	0.01 to 10 s	Used to set the slip compensation response time. (Note)
247	Constant-output region slip compensation selection	0	Slip compensation is not made in the constant output range (frequency range above the frequency set in Pr. 3).
		9999	Slip compensation is made in the constant output range.

Note: When this value is made smaller, response will be faster. However, as load inertia is greater, a regenerative overvoltage (OVT) error is more liable to occur.

1.6.29 5-point flexible V/F characteristic [Pr. 71,100 to 109] (A500)

When V/F control has been selected in Pr. 80 or Pr. 81, set "2" in Pr. 71 and define five points as shown on the right to perform operation in the V/F pattern connected by straight lines in sequence. The five points can be set as desired within the range of the base frequency, Pr. 3, and base voltage, Pr. 19.
Note that if you attempt to set the same frequency in any two of the five points, an outside-of-range error occurs.

Applications
On machines where a static friction coefficient is large and a dynamic friction coefficient is small, for example, a large torque is required at start-up only, therefore set a V/F pattern which will increase the voltage only in the low speed range .



Note 1: When values other than 9999 have been set in both Pr. 80 and Pr. 81, the setting of the 5-point flexible V/F characteristic is ignored and operation is performed under advanced magnetic flux vector control.
2: The setting of inappropriate V/F values will cause excessive current, abnormal machine collision or vibration during acceleration and deceleration. Therefore, set the V/F values with extreme care.

Functions Related to the 5-Point Flexible V/F Characteristic

Parameter Number	Pr. 71 Setting = 2				
	Name	Setting Range	Set Value	Description	Factory Setting
100	V/F1 (first frequency)	9999, 0 to 400Hz	9999	V/F1 is not set.	○
			0 to 400	Set V/F1 frequency.	—
101	V/F1 (first frequency voltage)	0 to 1000V	0 to 1000	Set V/F1 voltage.	0
102	V/F2 (second frequency)	9999, 0 to 400Hz	9999	V/F2 is not set.	○
			0 to 400	Set V/F2 frequency.	—
103	V/F2 (second frequency voltage)	0 to 1000V	0 to 1000	Set V/F2 voltage.	0
104	V/F3 (third frequency)	9999, 0 to 400Hz	9999	V/F3 is not set.	○
			0 to 400	Set V/F3 frequency.	—
105	V/F3 (third frequency voltage)	0 to 1000V	0 to 1000	Set V/F3 voltage.	0
106	V/F4 (fourth frequency)	9999, 0 to 400Hz	9999	V/F4 is not set.	○
			0 to 400	Set V/F4 frequency.	—
107	V/F4 (fourth frequency voltage)	0 to 1000V	0 to 1000	Set V/F4 voltage.	0
108	V/F5 (fifth frequency)	9999, 0 to 400Hz	9999	V/F5 is not set.	○
			0 to 400	Set V/F5 frequency.	—
109	V/F5 (fifth frequency voltage)	0 to 1000V	0 to 1000	Set V/F5 voltage.	0

1.6.30 Computer link operation [Pr. 117 to 124] COMMON

Communication operation can be performed by RS-485 from the PU connector of the inverter.

To make communication between the personal computer and inverter, initial setting of the communication specifications must be made to the inverter. If the initial setting is not made or there is any setting fault, data communication cannot be made.

Note: After making the initial setting of the parameters, always reset the inverter. Communication is disabled unless the inverter is reset after changing the communication-related parameters.

Communication specifications

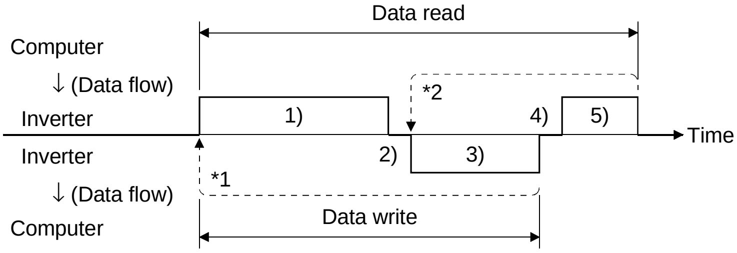
Conforming standard			RS-485
Number of inverters connected			1:N (max. 32 inverters)
Communication speed			Selected between 19200, 9600 and 4800bps
Control protocol			Asynchronous
Communication method			Half-duplex
Communication specifications	Character system		ASCII (7 bits/8 bits) selectable
	Stop bit length		Selectable between 1 bit and 2 bits.
	Terminator		CR/LF (presence/absence selectable)
	Check system	Parity check	Selected between presence (even/odd) or absence
		Sumcheck	Present
	Waiting time setting		Selectable between presence or absence

Parameter Number	Name	Setting Range		Description	Factory Setting
117	Station number	0 to 31		Station number specified for communication from the PU connector. Set the inverter station numbers when two or more inverters are connected to one personal computer.	0
118	Communication speed	48		4800 baud	—
		96		9600 baud	—
		192		19200 baud	○
119	Stop bit length/ data length	8 bits	0	Stop bit length 1 bit	—
			1	Stop bit length 2 bits	○
		7 bits	10	Stop bit length 1 bit	—
			11	Stop bit length 2 bits	—
120	Parity check presence/ absence	0		Absent	—
		1		Odd parity present	—
		2		Even parity present	○
121	Number of communication retries	0 to 10		Set the permissible number of retries at occurrence of data receive error. If the number of consecutive errors exceeds the permissible value, the inverter will come to an alarm stop.	1
		9999 (65535)		If a communication error occurs, the inverter will not come to an alarm stop. At this time, the inverter can be coasted to a stop by MRS or RESET input. During an error, the light fault signal (LF) is given to the open collector output. Allocate the used terminal with any of Pr. 190 to Pr. 195 (output terminal function selection). Note: Pr. 190 to Pr. 192 for E500.	—
122	Communication check time interval	0		No communication	○
		0.1 to 999.8		Set the communication check time [seconds] interval. If a no-communication state persists for longer than the permissible time, the inverter will come to an alarm stop.	—
		9999		Stop the communication check.	—
123	Waiting time setting	0 to 150ms		Set the waiting time between data transmission to the inverter and response.	—
		9999		Set with communication data.	○
124	CR, LF presence/ absence selection	0		Without CR/LF	—
		1		With CR	○
		2		With CR/LF	—

Computer programming

(1) Communication protocol

Data communication between the computer and inverter is performed using the following procedure:



*1.If a data error is detected and a retry must be made, execute retry operation from the user program. The inverter comes to an alarm stop if the number of consecutive retries exceeds the parameter setting.

*2.On receipt of a data error occurrence, the inverter returns “retry data 3” to the computer again. The inverter comes to an alarm stop if the number of consecutive data errors reaches or exceeds the parameter setting.

(2) Communication operation presence/absence and data format types

Communication operation presence/absence and data format types are as follows:

No.	Operation		Run Command	Running Frequency	Parameter Write	Inverter Reset	Monitoring	Parameter Read
1)	Communication request is sent to the inverter in accordance with the user program.		A'	A	A	A	B	B
2)	Inverter data processing time		Present	Present	Present	Absent	Present	Present
3)	Reply data from the inverter (Data 1 is checked for error)	No error Request accepted	C	C	C	Absent	E E'	E
		With error Request rejected	D	D	D	Absent	F	F
4)	Computer processing delay time		Absent	Absent	Absent	Absent	G	G
5)	Answer from computer in response to reply data 3 (Data 3 is checked for error)	No error No processing	Absent	Absent	Absent	Absent	G	G
		With error data 3 is output	Absent	Absent	Absent	Absent	H	H

(3) Data format

Hexadecimal data is used.

Data is automatically transferred in ASCII between the computer and inverter.

·Data format types

1) Communication request data from computer to inverter

[Data format]

Format A

*3 ENQ	Inverter station number	Instruction code	*5 Waiting time	Data	Sum check	*4
1	2 3	4 5	6	7 8 9 10	11 12	13 ←Number of characters

Format A'

*3 ENQ	Inverter station number	Instruction code	*5 Waiting time	Data	Sum check	*4
1	2 3	4 5	6	7 8	9 10	11 ←Number of characters

[Data read]

Format B

*3 ENQ	Inverter station number	Instruction code	*5 Waiting time	Sum check	*4
1	2 3	4 5	6	7 8	9 ←Number of characters

Note:
1. The inverter station numbers may be set between H00 and H1F (stations 0 and 31) in hexadecimal.
2. *3 indicates the control code.
3. *4 indicates the CR or LF code.
   When data is transmitted from the computer to the inverter, codes CR (carriage return) and LF (line feed) are automatically set at the end of a data group on some computers. In this case, setting must also be made from the inverter according to the computer.
   Also, the presence and absence of the CR and LF codes can be selected using Pr. 124.
4. *5 When Pr. 123 "waiting time setting" ≠ 9999, Create the communication request data with no "waiting time" in the data format.
   (The number of characters decreases by 1.)

2) Reply data from inverter to computer during data write

[No data error detected]

Format C

*3 ACK	Inverter station number		*4
1	2	3	4

←Number of characters

[Data error detected]

Format D

*3 NAK	Inverter station number		Error code	*4
1	2	3	4	5

←Number of characters

3) Reply data from inverter to computer during data read

[No data error detected]

Format E

*3 STX	Inverter station number		Read data				*3 ETX	Sum check		*4
1	2	3	4	5	6	7	8	9	10	11

Format E'

*3 STX	Inverter station number		Read data		*3 ETX	Sum check		*4
1	2	3	4	5	6	7	8	9

←Number of characters

[Data error detected]

Format F

*3 NAK	Inverter station number		Error code	*4
1	2	3	4	5

4) Reply data from computer to inverter during data read

[No data error detected]

Format G

*3 ACK	Inverter station number		*4
1	2	3	4

←Number of characters

[Data error detected]

Format H

*3 NAK	Inverter station number		*4
1	2	3	4

←Number of characters

(4) Data definitions

1) Control codes

Signal	ASCII Code	Description
STX	H02	Start of Text (Start of data)
ETX	H03	End of Text (End of data)
ENQ	H05	Enquiry (Communication request)
ACK	H06	Acknowledge (No data error detected)
LF	H0A	Line Feed
CR	H0D	Carriage Return
NAK	H15	Negative Acknowledge (Data error detected)

2) Inverter station number

Specify the station number of the inverter which communicates with the computer.

3) Instruction code

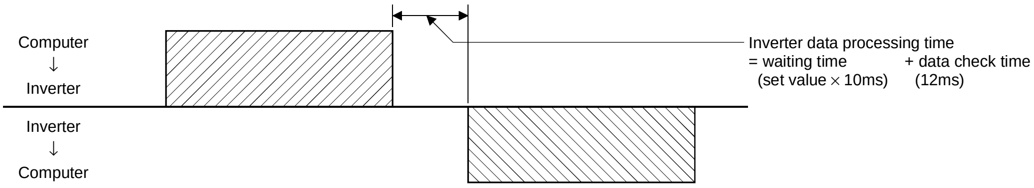
Specify the processing request (e.g. operation, monitoring) given by the computer to the inverter. Hence, the inverter can be run and monitored in various ways by specifying the instruction code as appropriate.

4) Data

Indicates the data such as frequency and parameters transferred to and from the inverter. The definitions and ranges of set data are determined in accordance with the instruction codes.

5) Waiting time

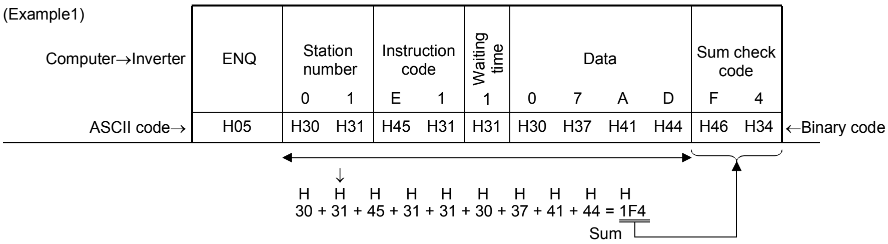
Specify the waiting time between the receipt of data at the inverter form the computer and the transmission of reply data. Set the waiting time in accordance with the response time of the computer between 0 and 150ms in 10ms increments (e.g. 1 = 10ms, 2 = 20ms).



6) Sum check code

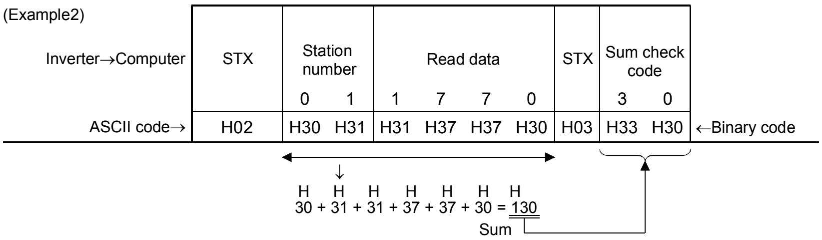
The sum check code is 2-digit ASCII (hexadecimal) representing the lower 1 byte (8 bits) of the sum (binary) derived from the checked ASCII data.

(Example1)



Computer→Inverter	ENQ	Station number	Instruction code	Waiting time	Data	Sum check code	
		0 1	E 1	1	0 7 A D	F 4	
ASCII code→	H05	H30 H31	H45 H31	H31	H30 H37 H41 H44	H46 H34	←Binary code

(Example2)



Inverter→Computer	STX	Station number	Read data	STX	Sum check code	
		0 1	1 7 7 0		3 0	
ASCII code→	H02	H30 H31	H31 H37 H37 H30	H03	H33 H30	←Binary code

7) Error code

If any error is found in the data received by the inverter, its definition is sent back to the computer together with the NAK code.

Note: 1. When the data from the computer has an error, the inverter will not accept that data.

2. Any data communication, e.g. run command, monitoring, is started when the computer gives a communication request. Without the computer's command, the inverter does not return any data. For monitoring, therefore, design the program to cause the computer to provide a data read request as required.

3. Data for link parameter expansion setting differs as indicated below between access to Pr. 0 to Pr. 99 values and access to Pr. 100 to Pr. 905:

		Instruction Code	Data
Link parameter expansion setting	Read	H7F	H00: Pr. 0 to Pr. 99 values are accessible.
	Write	HFF	H00: Pr. 0 to Pr. 99 values are accessible. H01: Pr. 100 to Pr. 59, Pr. 200 to P Pr. 231 and Pr. 090 to Pr. 905 values are accessible. H02: Pr. 160 to Pr. 199 and Pr. 232 to Pr. 285 values are accessible. H03: Pr. 300 to Pr. 399 values are accessible. H09: Pr. 990 value is accessible.

(5) Instructions for the program

1) When there is an error in data from the computer, the inverter does not accept that data. Therefore, always insert a data error retry program in the user program.

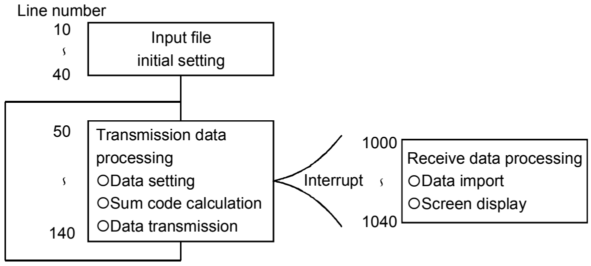
2) Since any data communication, such as operation command or monitoring, is always requested by the computer, the inverter will not return data without the computer's request. Hence, design the program so that the computer gives a data read request for monitoring, etc. as required.

3) Program example

When the operation mode is switched to computer link operation

```
                                               Initial setting of I/O file
  10 OPEN "COM1: 9600, E, 8, 2, HD" AS#1       : Communication file opening
  20 COMST1, 1, 1: COMST1, 2, 1                : Circuit control signal (RS, ER) ON/OFF setting
  30 ON COM (1) GOSUB*REC                      : Interrupt definition at data receive
  40 COM (1) ON                                : Interrupt enable
  50 D$= "01FB10002"                           Transmission data setting
  60 S=0
  70 FOR I=1 TO LEN (D$)
  80 A$=MID$ (D$, I, 1)
  90 A=ASC (A$)                                Sum code calculation
 100 S=S+A
 110 NEXTI
 120 D$=CHR$ (&H5) +D$+RIGHT$ (HEX$ (S) , 2)   : Addition of control and sum codes
 130 PRINT#1, D$                               Data transmission
 140 GOTO 50
1000 *REC                                      Interrupt data receive
1010 IF LOC (1)=0 THEN RETURN                  : Interrupt occurrence at data receive
1020 PRINT "RECEIVE DATA"
1030 PRINT INPUT$ (LOC (1) , #1)
1040 RETURN
```

General flowchart



(6) Setting items and set data

After completion of parameter setting, set the instruction codes and data and start communication from the computer to allow various types of operation control and monitoring.

<table>
<tr><th>No.</th><th colspan="2">Item</th><th colspan="2">Instruction Code</th><th>Description</th><th>Number of Data Digits</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Operation mode</td><td>Read</td><td colspan="2">H7B</td><td>H0000: Communication option operation (not provided for E500)
H0001: External operation
H0002: Communication operation (PU connector)</td><td rowspan="2">4 digits</td></tr>
<tr><td>Write</td><td colspan="2">HFB</td><td>H0000: Communication option operation (not provided for E500)
H0001: External operation
H0002: Communication operation (PU connector)</td></tr>
<tr><td rowspan="7">2</td><td rowspan="7">Monitoring</td><td>Output frequency [speed]</td><td colspan="2">H6F</td><td>H0000 to HFFFF: Output frequency (hexadecimal) in 0.01Hz increments
[Speed (hexadecimal) in 1r/min increments if Pr. 37 = 1 to 9998 or Pr. 144 = 2 to 10, 102 to 110.]</td><td>4 digits</td></tr>
<tr><td>Output current</td><td colspan="2">H70</td><td>H0000 to HFFFF: Output current (hexadecimal) in 0.1A increments</td><td>4 digits</td></tr>
<tr><td>Output voltage</td><td colspan="2">H71</td><td>H0000 to HFFFF: Output voltage (hexadecimal) in 0.1V increments</td><td>4 digits</td></tr>
<tr><td>Special monitor</td><td colspan="2">H72</td><td>H0000 to HFFFF: Monitored data selected by instruction code HF3</td><td>4 digits</td></tr>
<tr><td rowspan="2">Special monitor selection No.</td><td>Read</td><td>H73</td><td rowspan="2">H01 to H0E Monitor selection data
<table>
<tr><th>Data</th><th>Description</th><th>Increments</th><th>Data</th><th>Description</th><th>Increments</th></tr>
<tr><td>H01</td><td>Output frequency</td><td>0.01Hz</td><td>H09</td><td>Regenerative brake</td><td>0.1%</td></tr>
<tr><td>H02</td><td>Output current</td><td>0.01A</td><td>H0A</td><td>Electronic overcurrent protection load factor</td><td>0.1%</td></tr>
<tr><td>H03</td><td>Output voltage</td><td>0.1V</td><td>H0B</td><td>Output current peak value</td><td>0.01A</td></tr>
<tr><td>H05</td><td>Frequency setting</td><td>0.01Hz</td><td>H0C</td><td>Converter output voltage peak value</td><td>0.1V</td></tr>
<tr><td>H06</td><td>Running speed</td><td>1r/min</td><td>H0D</td><td>Input power</td><td>0.01kW</td></tr>
<tr><td>H07</td><td>Motor torque</td><td>0.1%</td><td>H0E</td><td>Output power</td><td>0.01kW</td></tr>
</table></td><td rowspan="2">2 digits</td></tr>
<tr><td>Write</td><td>HF3</td></tr>
<tr><td>Alarm definition</td><td colspan="2">H74 to H77</td><td>H0000 to HFFFF: Two most recent alarm definitions
Alarm definition display example (instruction code = H74)
Read data: [Example]H30A0
(Previous alarm THT)
(Most recent alarm OPT)

$$\underbrace{\overset{b15}{0}\;0\;1\;1\;0\;0\;0\;\overset{b8}{0}}_{\text{Previous alarm (H30)}}\;\underbrace{\overset{b7}{1}\;0\;1\;0\;0\;0\;0\;\overset{b0}{0}}_{\text{Most recent alarm (HA0)}}$$

Alarm data
<table>
<tr><th>Data</th><th>Description</th><th>Data</th><th>Description</th><th>Data</th><th>Description</th></tr>
<tr><td>H00</td><td>No alarm</td><td>H51</td><td>UVT</td><td>HB1</td><td>PUE</td></tr>
<tr><td>H10</td><td>0C1</td><td>H60</td><td>OLT</td><td>HB2</td><td>RET</td></tr>
<tr><td>H11</td><td>0C2</td><td>H70</td><td>BE</td><td>HC1</td><td>CTE</td></tr>
<tr><td>H12</td><td>0C3</td><td>H80</td><td>GF</td><td>HC2</td><td>P24</td></tr>
<tr><td>H20</td><td>0V1</td><td>H81</td><td>LF</td><td>HD5</td><td>MB1</td></tr>
<tr><td>H21</td><td>0V2</td><td>H90</td><td>OHT</td><td>HD6</td><td>MB2</td></tr>
<tr><td>H22</td><td>0V3</td><td>HA0</td><td>OPT</td><td>HD7</td><td>MB3</td></tr>
<tr><td>H30</td><td>THT</td><td>HA1</td><td>OP1</td><td>HD8</td><td>MB4</td></tr>
<tr><td>H31</td><td>THM</td><td>HA2</td><td>OP2</td><td>HD9</td><td>MB5</td></tr>
<tr><td>H40</td><td>FIN</td><td>HA3</td><td>OP3</td><td>HDA</td><td>MB6</td></tr>
<tr><td>H50</td><td>IPF</td><td>HB0</td><td>PE</td><td>HDB</td><td>MB7</td></tr>
</table></td><td>4 digits</td></tr>
</table>

<table>
<tr><th>No.</th><th colspan="2">Item</th><th>Instruction Code</th><th>Description</th><th>Number of Data Digits</th></tr>
<tr><td>3</td><td colspan="2">Run command</td><td>HFA</td><td>H00 to HFF: Run Command
<table><tr><td>b7</td><td></td><td></td><td></td><td></td><td></td><td></td><td>b0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table>(For example 1)
[Example 1] H02
... Forward rotation
[Example 2] H00
... Stop
b0: ——
b1: Forward rotation (STF)
b2: Reverse rotation (STR)
b3: ——
b4: ——
b5: ——
b6: ——
b7: ——</td><td>2 digits</td></tr>
<tr><td>4</td><td colspan="2">Inverter status monitor</td><td>H7A</td><td>H00 to HFF: Inverter status monitor
<table><tr><td>b7</td><td></td><td></td><td></td><td></td><td></td><td></td><td>b0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table>(For example 1)
[Example 1] H02
... During forward rotation
[Example 2] H80
... Stop due to alarm
b0: Inverter running (RUN) *
b1: Forward rotation (STF)
b2: Reverse rotation (STR)
b3: Up to frequency (SU) *
b4: Overload (OL) *
b5: Instantaneous power failure (IPF) *
b6: Frequency detection (FU) *
b7: Alarm occurrence *
*The output data depends on the Pr. 190 to Pr. 195 settings.</td><td>2 digits</td></tr>
<tr><td>5</td><td colspan="2">Running frequency write (E^{2}ROM)</td><td>HEE</td><td>H0000 to H9C40: 0.01Hz increments (hexadecimal)
To change the running frequency consecutively, write data to the inverter RAM. (Instruction code: HED)</td><td>4 digits</td></tr>
<tr><td>6</td><td colspan="2">Inverter reset</td><td>HFD</td><td>H9696: Resets the inverter.
As the inverter is reset on start of communication by the computer, the inverter cannot send reply data back to the computer.</td><td>4 digits</td></tr>
<tr><td>7</td><td colspan="2">All clear</td><td>HFC</td><td>All parameters return to the factory settings.
Any of four different clear operations is performed according to the data.
<table><tr><th>Pr.
Data</th><th>Communication Pr.</th><th>Calibration</th><th>Other Pr.</th><th>HEC
HF3
HFF</th></tr><tr><td>H9696</td><td>○</td><td>×</td><td>○</td><td>○</td></tr><tr><td>H9966</td><td>○</td><td>○</td><td>○</td><td>○</td></tr><tr><td>H5A5A</td><td>×</td><td>×</td><td>○</td><td>○</td></tr><tr><td>H55AA</td><td>×</td><td>○</td><td>○</td><td>○</td></tr></table>When all parameter clear is executed for H9696 or H9966, communication-related parameter settings also return to the factory settings. When resuming operation, set the parameters again.</td><td>4 digits</td></tr>
<tr><td>8</td><td colspan="2">User clear</td><td>HFC</td><td>H9669: User clear is made.
<table><tr><th>Communication Pr.</th><th>Calibration</th><th>Other Pr.</th><th>HEC
HF3
HFF</th></tr><tr><td>○</td><td>×</td><td>○</td><td>○</td></tr></table></td><td>4 digits</td></tr>
<tr><td>9</td><td colspan="2">Parameter write</td><td>H80 to HE3</td><td rowspan="2">Refer to the data list (Appendix 1) and write and/or read parameter values as required.
Note that some parameters may not be accessible.</td><td>4 digits</td></tr>
<tr><td>10</td><td colspan="2">Parameter read</td><td>H00 to H63</td><td></td></tr>
<tr><td rowspan="2">11</td><td rowspan="2">Link parameter expansion setting</td><td>Read</td><td>H7F</td><td rowspan="2">H00 to H6C and H80 to HEC parameter values are changed.
H00: Pr. 0 to Pr. 99 values are accessible.
H01: Pr. 100 to Pr. 159 , Pr. 200 to Pr. 231 and Pr. 900 to Pr. 905 values are accessible.
H02: Pr. 160 to Pr. 199 and Pr. 232 to Pr. 285 values are accessible.
H03: Pr. 300 to Pr. 399 values are accessible.
H09: Pr. 990 value is accessible.</td><td rowspan="2">2 digits</td></tr>
<tr><td>Write</td><td>HFF</td></tr>
</table>

No.	Item		Instruction Code	Description	Number of Data Digits
12	Second parameter changing (Code FF = 1)	Read	H6C	When setting the programmed operation (data code H3D to H5A, HBD to HAD) parameters H00: Running frequency H01: Time $\longrightarrow$ $\underbrace{\boxed{6}\boxed{3}}_{\text{Time (Min.)}}\underbrace{\boxed{3}\boxed{8}}_{\text{Min. (s)}}$ H02: Rotation direction When setting the bias and gain (data code H5E to H6A, HDE to HED) parameters. H00: Offset/gain H01: Analog H02: Analog value of terminal	2 digits
		Write	HEC		

(7) Error code List

The corresponding error code in the following list is displayed if an error is detected in any communication request data form the computer.

Error Code	Item	Definition	Inverter Operation
H0	Computer NAK error	The number of errors consecutively detected in communication request data from the computer is greater than allowed number of retry times.	Brought to an alarm stop (E.PUE) if error occurs continuously more than the allowable number of retry times.
H1	Parity error	The parity check result does not match the specified parity.	
H2	Sum check error	The sum check code in the computer does not match that of the data received by the inverter.	
H3	Protocol error	Data received by the inverter is in the wrong protocol, data receive is not completed within the given time, or CR and LF are not as set in the parameter.	
H4	Framing error	The stop bit length is not as specified.	
H5	Overrun error	New data has been sent by the computer before the inverter completes receiving the preceding data.	
H6	———	———	———
H7	Character error	The character received is invalid (other than 0 to 9, A to F, control code).	Does not accept receive data but is not brought to alarm stop.
H8	———	———	———
H9	———	———	———
HA	Mode error	Parameter write was attempted in other than the computer link operation mode or during inverter operation.	Does not accept or receive data but is not brought to alarm stop.
HB	Instruction code error	The specified command does not exist.	
HC	Data range error	Invalid data has been specified for parameter write, frequency setting, etc.	
HD	———	———	———
HE	———	———	———
HF	———	———	———

(8) Communication specifications for RS-485 communication

Operation Location	Item	Operation Mode		
		Communication Operation from PU Connector	External Operation	Computer Link Operation (inboard option used)
Computer user program via PU connector	Run command (start)	Enable	Disable	Disable
	Running frequency setting	Enable	Enable (Combined mode)	Disable
	Monitoring	Enable	Enable	Enable
	Parameter write	Enable (Note 4)	Disable (Note 4)	Disable (Note 4)
	Parameter read	Enable	Enable	Enable
	Inverter reset	Enable	Enable	Enable
	Stop command (Note 3)	Enable	Enable	Enable
Computer user program via inboard option (Note 5)	Run command	Disable	Disable	Enable (Note 1)
	Running frequency setting	Disable	Disable	Enable (Note 1)
	Monitoring	Enable	Enable	Enable
	Parameter write	Disable (Note 4)	Disable (Note 4)	Enable (Note 4)
	Parameter read	Enable	Enable	Enable
	Inverter reset	Disable	Disable	Enable
	Stop command (Note 3)	Enable	Enable	Enable
Control circuit terminal	Inverter reset	Enable	Enable	Enable
	Run command	Disable	Enable	Enable (Note 1)
	Running frequency setting	Disable	Enable	Enable (Note 1)

Note: 1. As set in the operation and speed command write parameters.
2. At occurrence of RS-485 communication fault, the inverter cannot be reset from the computer.
3. As set in Pr. 75.
4. As set in Pr. 77.
5. E500 does not have an inboard option.

(9) Operation at alarm occurrence

Fault Location	Description		Operation Mode		
			Communication Operation (PU connector)	External Operation	Computer link Operation (inboard option used)
Inverter fault	Inverter operation		Stop	Stop	Stop
	Communication	PU connector	Continued	Continued	Continued
		Inboard option (Note 3)	Continued	Continued	Continued
Communication error (Communication from PU connector)	Inverter operation		Stop/continued (Note 1)	Continued	Continued
	Communication	PU connector	Stop	Stop	Stop
		Inboard option (Note 3)	Continued	Continued	Continued
Communication error (Inboard option) (Note 3)	Inverter operation		Continued	Continued	Stop/continued (Note 2)
	Communication	PU connector	Continued	Continued	Continued
		Inboard option	Stop	Stop	Stop

Note: 1. Can be selected using the corresponding parameter (factory-set to continued).
2. Can be selected using the corresponding parameter (factory-set to stop).
3. E500 does not have an inboard option.

(10) Communication error

Fault Location	Error Message
Communication error (Communication from PU connector)	E.PUE
Communication error (Inboard option) (Note)	E.OP1 to E.OP3

Note: E500 does not have an inboard option.

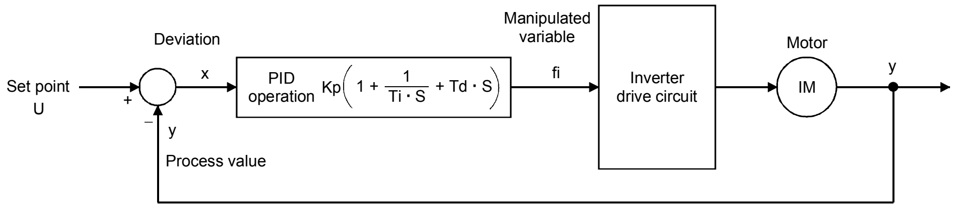
1.6.31 PID control [Pr. 128 to 134] COMMON

The inverter can be used to exercise process control, e.g. flow rate, air volume or pressure.
The voltage input signal (0 to ±5V or 0 to 0±10V) or Pr. 133 setting is used as a set point and the 4 to 20mA current input signal used as a feedback value to constitute a feedback system for PID control.

Parameter Number	Name	Setting Range	Description			Factory setting
128	PID action selection	0 (Note 1)	PID action is not done.			○ (E500)
		10 (Note 2)	For heating, pressure control, etc.	Deviation value signal input (terminal 1)	PID reverse action	○ (A500)
		11 (Note 2)	For cooling, etc.		PID forward action	—
		20	For heating, pressure control, etc.	Process value input (terminal 4)	PID reverse action	—
		21	For cooling, etc.		PID forward action	—
129	PID proportional band	0.1 to 1000%	If the proportional band is narrow (parameter setting is small), the manipulated variable varies greatly with a slight change of the process value. Hence, as the proportional band narrows, the response sensitivity (gain) improves but the stability deteriorates, e.g. hunting occurs. Gain Kp = 1/proportional band			100%
		9999	No proportional control			—
130	PID integral time	0.1 to 3600 s	Time required for the integral (I) action to provide the same manipulated variable as that for the proportional (P) action. As the integral time decreases, the set point is reached earlier but hunting occurs more easily.			1 s
		9999	No integral control.			—
131	Upper limit	0 to 100%	Set the upper limit. If the feedback value exceeds the setting, the FUP signal is output. (Process value of 4mA is equivalent to 0% and 20mA to 100%.)			—
		9999	No function			○
132	Lower limit	0 to 100%	Set the lower limit. (If the process value goes out of the setting range, an alarm can be output. In this case, the process value of 4mA is equivalent to 0% and 20mA to 100%.)			—
		9999	No function			○
133	PID action set point for PU operation	0 to 100%	Only valid for the PU command in the PU operation or PU/external combined mode. For external operation, the voltage across 2-5 is the set point. (Pr. 902 value is equivalent to 0% and Pr. 903 value to 100%.)			0%
134	PID differential time	0.01 to 10.00 s	Time only required for the differential (D) action to provide the same process value as that for the proportional (P) action. As the differential time increases, greater response is made to a deviation change.			—
		9999	No differential control.			○

Note: 1. Not provided for A500.
2. Not provided for E500.

(1) Basic PID control configuration



Kp: Proportional constant Ti: Integral time S: Operator Td: Differential time

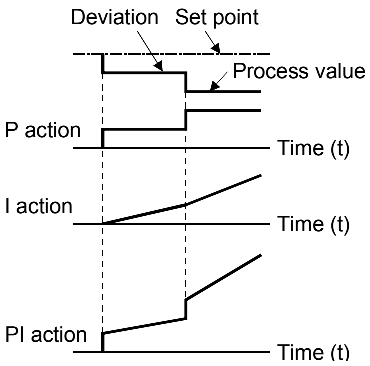
(2) PID action overview

1) PI action

A combination of proportional control action (P) and integral control action (I) for providing a manipulated variable in response to deviation and changes with time.

[Operation example for stepped changes of process value]

Note: PI action is the sum of P and I actions.

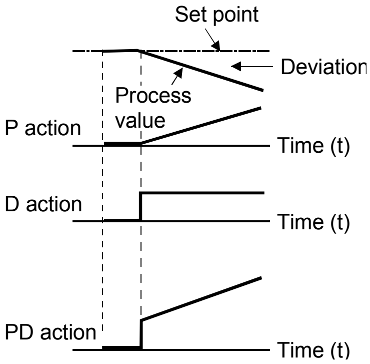


2) PD action

A combination of proportional control action (P) and differential control action (D) for providing a manipulated variable in response to deviation speed to improve the transient characteristic.

[Operation example for proportional changes of process value]

Note: PD action is the sum of P and D actions.



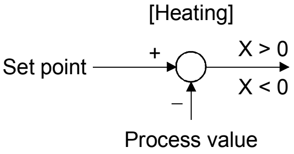
3) PID action

The PI action and PD action are combined to utilize the advantages of both actions for control.

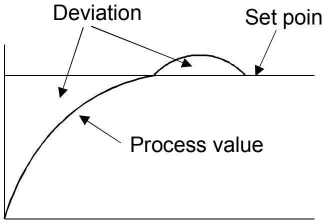
Note: The PID action is the sum of P and I and D actions.

4) Reverse action

Increases the manipulated variable (output frequency) if deviation X (set point - process value) is positive, and decreases the manipulated variable if deviation is negative.

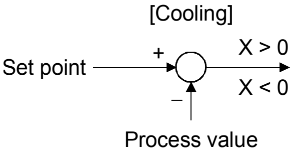


Cold → fi up
Hot → fi down

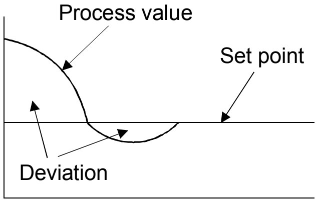


5) Forward action

Increases the manipulated variable (output frequency) if deviation X (set point - process value) is negative, and decreases the manipulated variable if deviation is positive.



Too cold → fi down
Hot → fi up

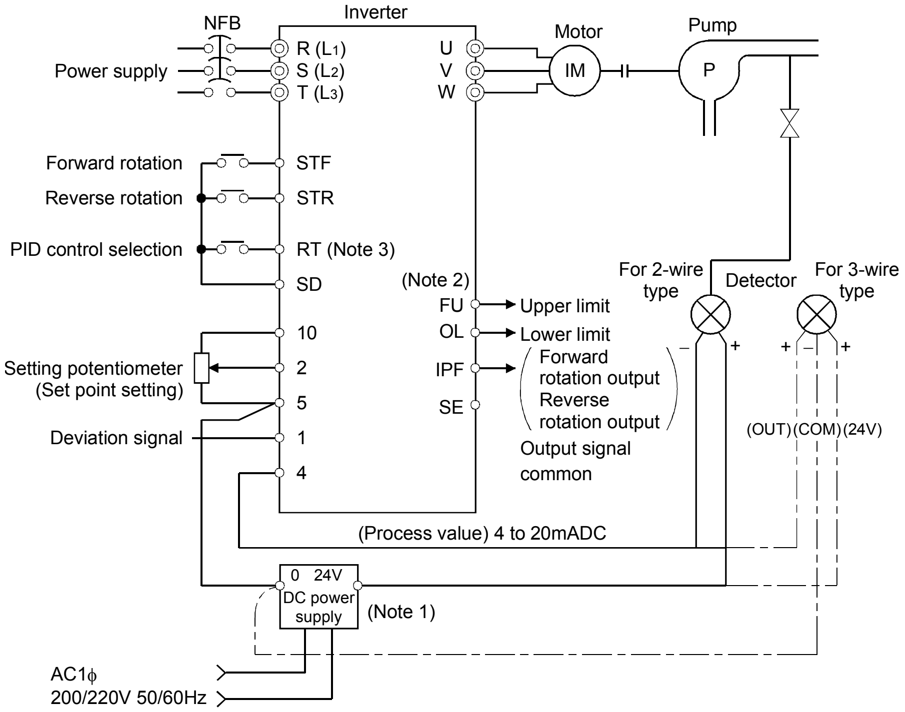


Relationships between deviation and manipulated variable (output frequency)

	Deviation	
	Positive	Negative
Reverse action	↗	↘
Forward action	↘	↗

(3) Wiring example

- Sink logic
- Pr. 183 = 14
- Pr. 192 = 16
- Pr. 193 = 14
- Pr. 194 = 15



Note: 1. The power supply must be selected in accordance with the power specifications of the detector used.
2. The output signal terminals used depends on the Pr. 191 to Pr. 194 settings.
3. The input signal terminals used depends on the Pr. 180 to Pr. 186 settings.

(4) I/O signals and PID control selection

Signal		Terminal Used	Function	Description	Remarks	
Input	X14 (Note)	Depending on Pr. 180 to Pr. 186	PID control selection	Switch on X14 to select PID control.	Set any of "10, 11, 20" and "21" in Pr. 128.	
	2	2	Set point input	Enter the set point for PID control.		
	1	1	Deviation signal input	Enter the deviation signal calculated externally.		
	4	4	Process value input	Enter the 4 to 20mA process value signal from the detector.		
Output	FUP	Depending on Pr. 191 to Pr. 195 (Depending on Pr. 190, Pr. 191 for E500)	Upper limit output	Output to indicate that the process value signal exceeded the upper limit value.	(Pr. 128 = 20, 21)	Open collector output
	FDN		Lower limit output	Output to indicate that the process value signal exceeded the lower limit value.		
	RL		Forward (reverse) rotation direction output	"Hi" is output to indicate that the output indication of the parameter unit is forward rotation (FWD) or "Low" to indicate that it is reverse rotation (REV) or stop (STOP).	(Pr. 128 = 10, 11, 20, 21)	
	SE	SE	Output terminal common	Common to terminals FUP, FDN and RL		

Note: Not provided for E500.

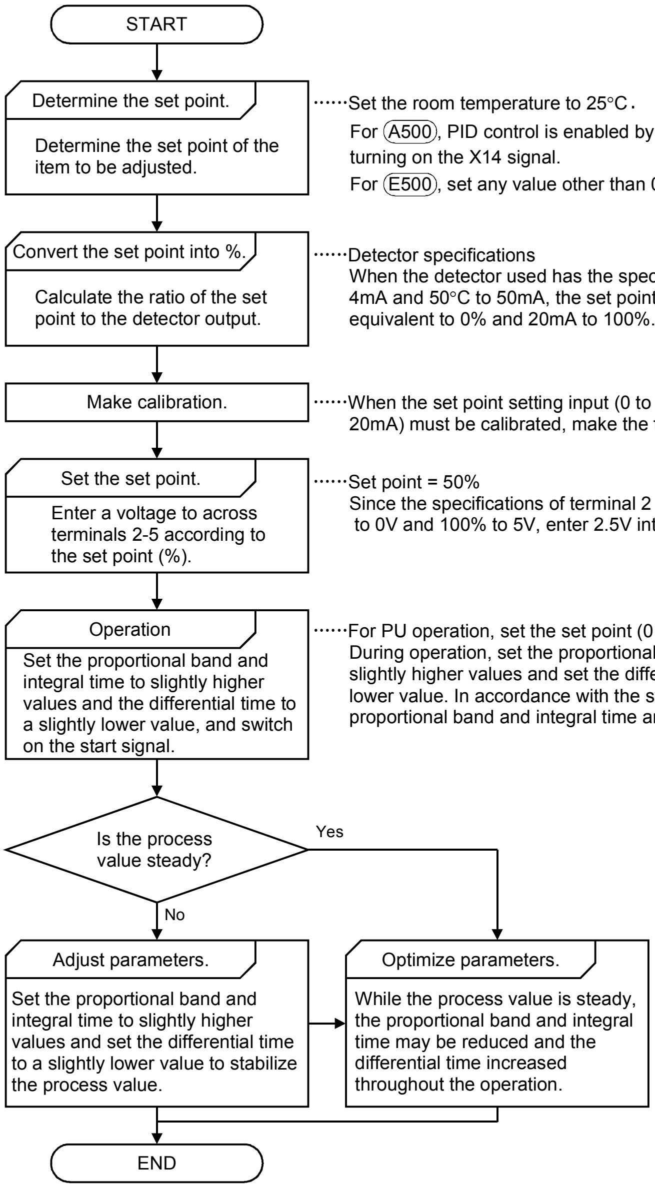
- For A500, switch on the X14 signal to start PID control. When this signal is off, ordinary inverter operation is performed without the PID action being done.
- To exercise PID control for E500, set any value other than 0 in Pr. 128.
- Enter the set point across inverter terminals 2-5 or into Pr. 133 and enter the process value signal across inverter terminals 4-5.
- For A500, when entering the externally calculated deviation signal, enter it across terminals 1-5. At this time, set "10" or "11" in Pr. 128.

Item	Entry	Description	
Set point	Across terminals 2-5	Set 0V as 0% and 5V as 100%.	When "1, 3, 5, 11, 13 or 15" is set in Pr. 73 (5V selected for terminal 2).
		Set 0V as 0% and 10V as 100%.	When "0, 2, 4, 10, 12 or 14" is set in Pr. 73 (10V selected for terminal 2).
Set point	Pr. 133	Set the set point (%) in Pr. 133.	
Deviation signal (Note)	Across terminals 1-5	Set −5V as −100%, 0V as 0% and +5V as +100%.	When "2, 3, 5, 12, 13 or 15" is set in Pr. 73 (5V selected for terminal 1).
		Set −10V as −100%, 0V as 0% and +10V as +100%.	When "0, 1, 4, 10, 11 or 14" is set in Pr. 73 (10V selected for terminal 1).
Process value	Across terminals 4-5	4mA is equivalent to 0% and 20mA to 100%.	

Note: Not provided for (E500).

(5) Calibration example

A detector of 4mA at °C and 20mA at °C is used to adjust the room temperature to 25°C under PID control. The set point is given to across inverter terminals 2-5 (0-5V).



……Set the room temperature to 25°C.
For (A500), PID control is enabled by setting the Pr. 128 value and turning on the X14 signal.
For (E500), set any value other than 0 in Pr. 128.

……Detector specifications
When the detector used has the specifications that 0°C is equivalent to 4mA and 50°C to 50mA, the set point of 25°C is 50% because 4mA is equivalent to 0% and 20mA to 100%.

……When the set point setting input (0 to 5V) and detector output (4 to 20mA) must be calibrated, make the following calibration*.

……Set point = 50%
Since the specifications of terminal 2 are such that 0% is equivalent to 0V and 100% to 5V, enter 2.5V into terminal 2.

……For PU operation, set the set point (0 to 100%) in Pr. 133.
During operation, set the proportional band and integral time to slightly higher values and set the differential time to a slightly lower value. In accordance with the system operation, reduce the proportional band and integral time and increase the differential time.

*When calibration is required, use Pr. 902 to Pr. 905 to calibrate the detector output and set point setting input in the PU mode during an inverter stop.

(6) Set point input calibration

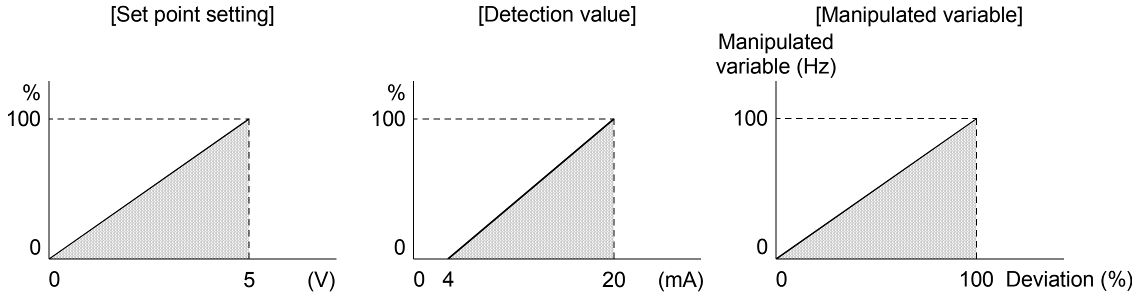
1) Apply the input voltage of 0% set point setting (e.g. 0V) to across terminals 2-5.
2) Make calibration using Pr. 902. At this time, enter the frequency which should be output by the inverter at the deviation of 0% (e.g. 0Hz).
3) Apply the voltage of 100% set point setting (e.g. 5V) to across terminals 2-5.
4) Make calibration using Pr. 903. At this time, enter the frequency which should be output by the inverter at the deviation of 100% (e.g. 60Hz).

(7) Detector output calibration

1) Apply the output current of 0% detector setting (e.g. 4mA) to across terminals 4-5.
2) Make calibration using Pr. 904.
3) Apply the output current of 100% detector setting (e.g. 20mA) to across terminals 4-5.
4) Make calibration using Pr. 905.

Note: The frequencies set in Pr. 904 and Pr. 905 should be the same as set in Pr. 902 and Pr. 903.

The results of the above calibration are as shown below:



Note:
1. If the multi-speed (RH, RM, RL) signal or jog operation (jog) signal is entered with the X14 signal on, PID control is stopped and multi-speed or jog operation is started.
2. When "20" or "21" is set in Pr. 128, note that the input across inverter terminals 1-5 is added to the set point across terminals 2-5.
3. When "5" (programmed operation mode) is selected for Pr. 79, PID control operation cannot be performed. In this setting, programmed operation is performed.
4. When "6" (switch-over mode) is selected for Pr. 79, PID is made invalid.
5. When "9999" is set in Pr. 22, the stall prevention level is the value entered from terminal 1. When using terminal 1 as the edit input terminal for PID, therefore, set a value other than "9999" in Pr. 22.
6. When "1" (online auto tuning) is selected for Pr. 95, PID control is made invalid.
7. When the terminal functions are changed using Pr. 180 to Pr. 186 and/or Pr. 190 to Pr. 195 (E500 is Pr. 180 to Pr. 183, Pr. 190 to Pr. 192), the other functions may be affected. Confirm the functions of the corresponding terminals before making settings.

1.6.32 Commercial power supply-inverter switch-over sequence

[Pr. 135 to 139] (A500)

When run at full speed at 60Hz (or 50Hz), the motor can be operated by the commercial power supply more efficiently than by the inverter.

Also, when the motor cannot be stopped long for maintenance/inspection of the inverter, it is recommended to provide a commercial power supply circuit.

To switch between inverter operation and commercial power supply operation, an interlock must be provided to stop the motor once and then start the inverter so that the inverter may not result in an overcurrent alarm.

As a standard feature, the (A500) has the commercial power supply-inverter switch-over sequence function which outputs timing signals to actuate the magnetic contactors to allow a complicated switch-over interlock between commercial power supply and inverter in the internal CPU of the inverter.

A typical example will be explained below.

(1) Wiring

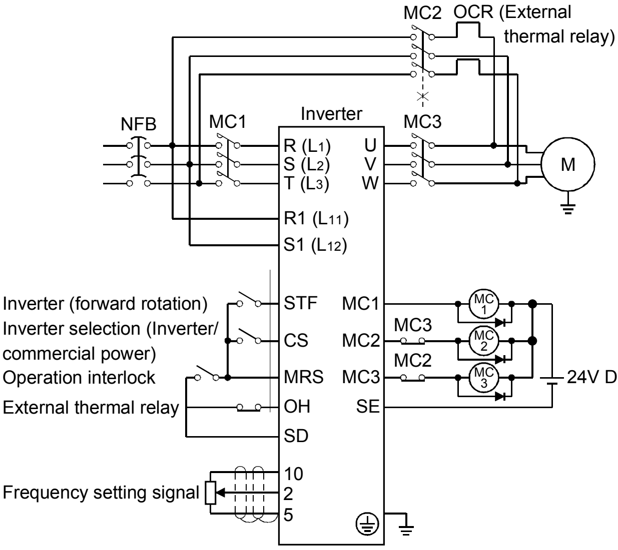
1) Main circuit
- Connect MC1 to the inverter input side.
- Connect MC2 to the commercial power supply operation side.
- Connect MC3 to the inverter output side.

2) Input signals (for details, refer to the next page)
- Across CS-SD: Enter the switch-over signal between commercial power supply operation and inverter operation. Close these terminals to choose inverter operation.
- Across STF (STR)-SD: Enter the forward (reverse) rotation start signal of the inverter.
- Across MRS-SD: Enter the operation interlock signal. Open these terminals to interlock both inverter operation and commercial power supply operation.

3) Output signals (for details, refer to the next page)
- Across MC1-SE: Outputs the inverter input side magnetic contactor MC1 operation timing signal.
- Across MC2-SE: Outputs the inverter output side magnetic contactor MC3 operation timing signal.
- Across MC3-SE: Outputs the commercial power supply operation magnetic contactor MC2 operation timing signal.

(2) Operation method

1) To perform commercial power supply operation.
Cancel the operation interlock signal (close terminals across MRS-SD). When terminals across MRS-SD are open, commercial power supply operation is performed.



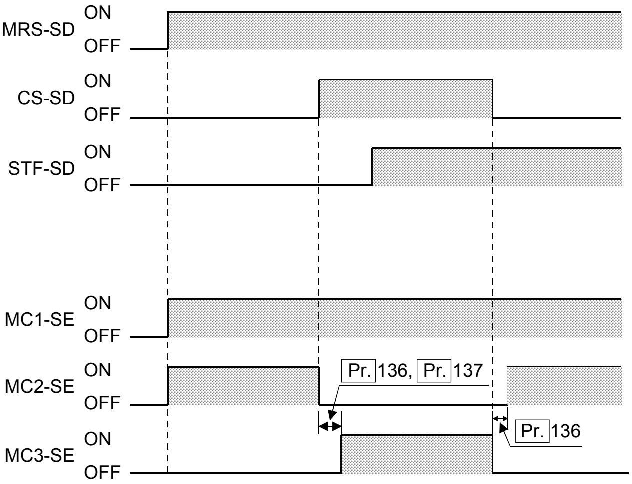
Commercial Power Supply-Inverter Switch-Over Sequence Function Connection Example

2) To perform inverter operation.
Cancel the operation interlock signal (close terminals across MRS-SD) and close terminals CS-SD. Inverter operation is performed by turning on-off the inverter start signal (terminal STF (STR)).

3) To switch from inverter operation to commercial power supply operation.
Close, then open terminals CS-SD.

4) To switch from commercial power supply. operation to inverter operation.
Open, then close terminals CS-SD and switch on the inverter start signal (terminal STF (STR)). If the function of automatic restart after instantaneous power failure has already been set at this time, switch-over is performed smoothly without motor speed being reduced.

★ When Pr. 138 = 1, the occurrence of an alarm during inverter operation automatically switches inverter operation to commercial power supply operation.



MC Operation Timing Example

(3) How to use I/O signals

1) Input terminal functions

By choosing the value of the commercial power supply-inverter switch-over sequence function, Pr. 135, the functions of the inverter terminals change as listed on the right. Therefore, they should be fully noted when you have performed all parameter clear operation, for example.

Terminal Symbol	Pr. 135 = 0	Pr. 135 = 1
STF(STR)	Inverter forward (reverse) rotation start	Inverter forward (reverse) rotation start
CS	Automatic restart after instantaneous power failure selection	Inverter operation/commercial power supply operation selection
MRS	Output stop	Motor operation interlock

When this function is used (Pr. 135 = "1"), the input signals are switched on-off as indicated below:

Signal	Terminal Used	Function	On-Off	MC Operation (○: ON, : OFF)		
				MC1	MC2	MC3
MRS	MRS	Operation enable/disable selection	Commercial power supply-inverter operation enable --------------------------------ON	○	—	—
			Commercial power supply-inverter operation disable --------------------------------OFF	○	×	Unchanged
CS	Depending on Pr. 180 to Pr. 186	Inverter-commercial power supply switch-over	Inverter operation ON	○	×	○
			Commercial power supply operation ----------------- OFF	○	○	×
STF (STR)	STF (STR)	Inverter operation command (invalid for commercial power supply) (Note)	Forward (reverse) rotation --------------------------------ON	○	×	○
			Stop -------------------------OFF	○	×	○
OH	Depending on Pr. 180 Pr. 186	External thermal relay input	Motor normal--------------ON	○	—	—
			Motor fault -----------------OFF	×	×	×
RES	RES	Operating condition initialization	Initialization----------------ON	Unchanged	×	Unchanged
			Normal operation --------OFF	○	—	—

Note: 1. In the above MC Operation field, [-] indicates that MC1 is on, MC2 is off and MC3 is on in inverter operation and MC1 is on, MC2 is off and MC3 is off in commercial power supply operation. [Unchanged] indicates that the status before signal-on or signal-off is held.

2. The CS signal only functions when the MRS signal is on. STF (STR) only functions when MRS and CS are on.
3. MC1 switches off when an inverter fault occurs.
4. If the MRS signal is not switched on, neither commercial power supply nor inverter operation can be performed.

2) Output terminal functions
Assign the MC1 to MC3 functions to the output terminals of the inverter or FR-A5AR option.

3) Output interface specifications

- For use with DC circuit
  Use the inverter terminals or option unit (FR-A5AR).

- AC circuit
  Use the option unit (FR-A5AR). The output terminals of the inverter cannot be used with the AC circuit as they have open collector specifications. (If they are used with the AC circuit, the output transistor will be damaged.)

- Permissible current
  The permissible current should be fully noted when the outputs of the inverter or option unit are used to drive the magnetic contactors.
  When the following permissible current is not enough, always use relays etc. in between.
  - Permissible current of inverter
    : 24VDC 0.1A
  - Permissible current of option unit
    : 230VAC 0.3A
    30VDC 0.3A

- Magnetic contactor change-over timing
  The switch-over sequence function of the inverter may be used to time the switch-over, but to ensure safety, always use magnetic contactors equipped with machine interlock mechanism as the inverter output side MC3 and commercial power supply operation side MC2.

(4) Parameter setting
Select whether the commercial power supply-inverter switch-over sequence function is activated or not. When the setting is 0 (commercial power supply-inverter switch-over sequence function is not selected), the inverter operates as an ordinary inverter which does not have the commercial power supply-inverter switch-over sequence function, and the parameter settings of Pr. 136 to Pr. 139 are ignored.

Pr. 135 Setting	Description	MC Operation Signal Output Signal		
		MC1 (Input side)	MC2 (Output side)	MC3 (Commercial power side)
0	Commercial power supply-inverter switch-over sequence function is not selected. (Same as ordinary inverter)	No output	No output	No output
1	Commercial power supply-inverter switch-over sequence function is selected. (Sequence output is provided) When MC1 to MC3 are assigned using Pr. 190 to Pr. 195 (output terminal function selection), open collector outputs are provided from the inverter. When they are not assigned, relay outputs are provided from the FR-A5AR (option).	Output from MC1	Output from MC2	Output from MC3

When you have selected the commercial power supply-inverter switch-over sequence function, the MCs operate in accordance with the parameter settings listed below:

MC Operation-Related Functions

Parameter Number	Name	Setting Range	Set Value	Operation	Factory Setting
136	MC switch-over interlock time	0 to 100 seconds	0 to 100	Set the operation interlock time of the commercial power supply operation MC2 and inverter operation MC3. Set a time longer than the turn-on time of the corresponding MC, MC2 or MC3.	1.0 s
137	Restart waiting time (MC3 turn-on time)	0 to 100 seconds	0 to 100	Set time from when the ON signal enters the inverter operation MC3 to when it actually switches on. (Note)	1.0 s
138	Commercial power supply-inverter switch-over selection at inverter alarm	0, 1	0	The inverter stops when an inverter fault occurs (MC1 to MC3 all switch off).	○
			1	When an inverter fault occurs (except external thermal relay), inverter operation is automatically switched to commercial power supply operation (MC2: ON, MC1, MC3: OFF).	—
139	Automatic inverter-commercial power supply switch-over frequency	9999, 0 to 60Hz	9999	Automatic switch-over is not performed.	○
			0 to 60	The motor is started and stopped by the inverter, and when the output frequency reaches or exceeds the set frequency, inverter operation is automatically switched to commercial power supply operation.	—

Note: When the function of automatic restart after instantaneous power failure has been selected in Pr. 57, the coasting speed must be detected after the MC3 has turned on to connect the motor to the inverter. Hence, this time must be set a little longer than the turn-on time of the MC3 so that the speed may be detected after the inverter operation MC has turned on. If the time setting is shorter than the MC3 turn-on time, the coasting time cannot be detected properly and an alarm may take place.
When the function of automatic restart after instantaneous power failure is not selected, the inverter starts at the starting frequency after the time set in Pr. 137 has elapsed.

(5) Instructions

1) Main circuit.
Note the phase rotation of the power supply.
If the phase rotation of the power supply is different, the motor will rotate in the opposite direction when inverter operation is switched to commercial power supply operation and vice versa. Hence, machine or motor shaft damage, inverter overcurrent alarm or other fault may take place.

2) Control circuit.
Always connect the control power supply (terminals R1, S1 (L_{11}, L_{21})) before the input side MC1. If the control power supply is connected after the input side MC1, the commercial power supply-inverter switch-over sequence function is not activated. Therefore, the input side MC1 cannot turn on and inverter operation cannot be performed.

3) Inverter alarm.
For E.CPU among the inverter alarms, the commercial power supply-inverter switch-over sequence function, which provides commercial power supply backup at alarm occurrence, for example, is not activated.

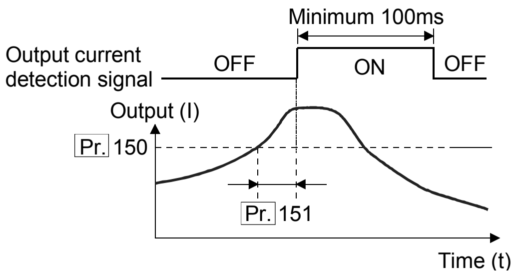
4) Installation of external thermal relay.
When using an external thermal relay, connect it in the commercial power supply operation side and do not connect it in the inverter output side.
When connected in the output side of the 400V class, small-capacity inverter for low acoustic noise operation, the external thermal relay may operate unnecessarily.

5) Parameter setting.
Since all clear operation returns Pr. 135 to the factory setting, the commercial power supply-inverter switch-over sequence function will not be activated.
Before starting operation, always set the related parameters.

1.6.33 Current detection function [Pr. 150 to 153] COMMON

(1) Output current detection [Pr. 150,151]

If the output current remains higher than the Pr. 150 setting during inverter operation for longer than the time set in Pr. 151, the output current detection signal (Y12) is output from the inverter's open collector output terminal. (Use any of Pr. 190 to Pr. 195 (E500 is Pr. 190 to Pr. 192) to assign the terminal used for Y12 signal output.)



Parameter Number	Description
150	Set the output current detection level. 100% is the rated inverter current.
151	Set the output current detection time. Set a period of time from when the output current rises to or above the Pr. 150 setting to when the output current detection signal (Y12) is output.

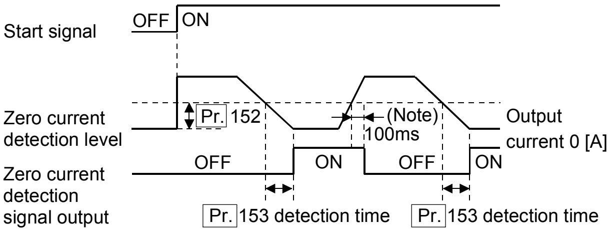
Note: 1. Once switched on, the output current detection signal is held on for at least 100ms.
2. This function is also valid during execution of the online or offline auto tuning.

(2) Zero current detection [Pr. 152,153]

If the output current remains lower than the Pr. 152 setting during inverter operation for longer than the time set in Pr. 153, the zero current detection (Y13) signal is output from the inverter's open collector output terminal. (Use any of Pr. 190 to Pr. 195 (E500 is Pr. 190 to Pr. 192) to assign the terminal used for Y13 signal output.)

When the inverter's output current falls to "0", torque will not be generated. This may cause a gravity drop when the inverter is used in vertical lift application.

To prevent this, the output current "zero" signal can be output from the inverter to close the mechanical brake when the output current has fallen to "zero".



Parameter Number	Description
152	Set the zero current detection level. Set this parameter to define the percentage of the rated current at which the zero current will be detected.
153	Set the zero current detection time. Set a period of time from when the output current drops to or below the Pr. 152 setting to when the zero current detection signal (Y13) is output.

Note: 1. If the current falls below the preset detection level but the timing condition is not satisfied, the zero current detection signal is held on for about 100ms.
2. This function is also valid during execution of the online or offline auto tuning.
3. The zero current detection level setting should not be too high, and the zero current detection time setting not be too long. Otherwise, the detection signal may not be output when torque is not generated at a low output current.
4. To prevent the machine and equipment from resulting in hazardous conditions by use of the zero current detection signal, install a safety backup such as an emergency brake.

1.6.34 User group selection [Pr. 160,173 to 176] COMMON

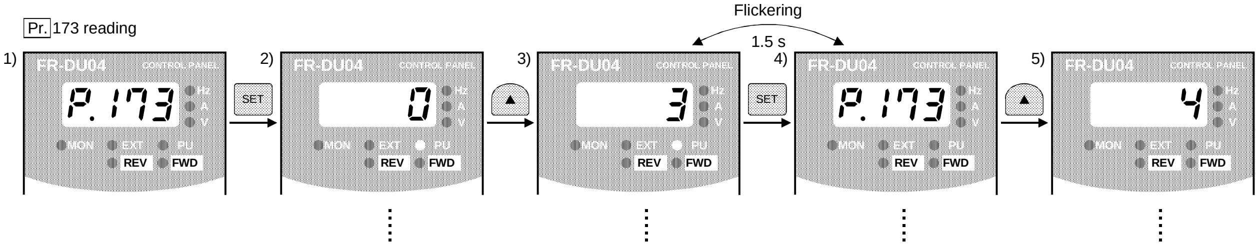
From among all parameters, a total of 32 parameters can be registered to two different user groups.
The registered parameters may only be accessed for reading and writing. Other parameters than those registered to the user groups cannot be read.
By setting the required value in Pr. 160, the user groups can be made valid or invalid.

Pr. 160 Setting	Description
0	All parameters can be accessed for reading and writing (Factory setting)
1	Parameters registered to user group 1 may only be accessed for reading and writing.
10	Parameters registered to user group 2 may only be accessed for reading and writing.
11	Parameters registered to user groups 1 and 2 may only be accessed for reading and writing.

Use the following parameters to register and delete user groups:

Parameter Number	Function Name	Setting Range	Remarks	Factory Setting
173	User group 1 registration	0 to 999		0
174	User group 1 deletion	0 to 999, 9999	9999: Batch deletion	0
175	User group 2 registration	0 to 999		0
176	User group 2 deletion	0 to 999, 9999	9999: Batch deletion	0

(1) Parameter registration to user group (when registering Pr. 3 to user group 1)



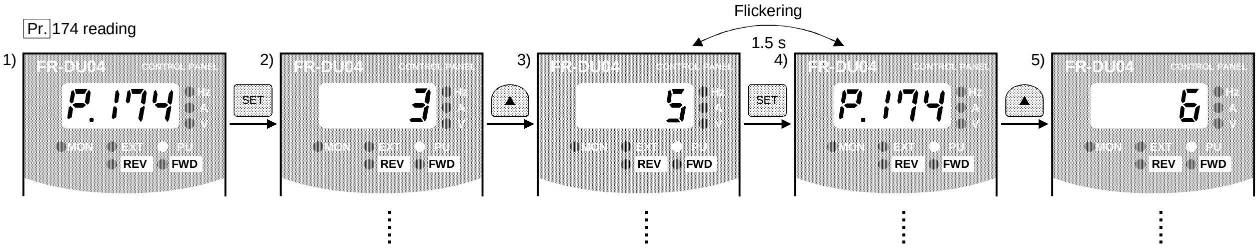
The number of parameters registered for user setting appears.

Using the [UP/DOWN] key, choose the parameter number to be registered.

Pr. 3 is registered to user group 1.

Using the [UP/DOWN] key, move to the next parameter to be registered.
Using the [SET] key, make registration.

(2) Parameter deletion from user group (when deleting Pr. 5 from user group 1)



The number of parameters registered for user setting appears.

Using the [UP/DOWN] key, choose the parameter number to be deleted.

Pr. 5 is deleted from user group 1.

Using the [UP/DOWN] key, choose the parameter to be deleted.
Using the [SET] key, make deletion.

Note:
1. Pr. 77, Pr. 160 and Pr. 991 values can always be read independently of the user group setting.
2. When Pr. 173 or Pr. 174 is read, the number of parameters registered to user group 1 appears. When Pr. 175 or Pr. 176 is read, the number of parameters registered to user group 2 appears.
3. "0" set in the second digit of the 2-digit Pr. 160 setting is not displayed. However, it is displayed when "0" is set in the first digit only.
4. When "9999" is set in Pr. 174 or Pr. 176, the parameters registered to the corresponding user group is batch-deleted.

1.6.35 Watt-hour meter, actual operation hour meter clear [Pr. 170*,171]

(*Pr. 170 is not provided for E500.)

By writing 0 in the corresponding parameters, the watt-hour meter (Note) and actual operation hour meter are cleared.

Parameter Number	Function Name	Setting Range	Factory Setting
170 (Note)	Watt-hour meter clear	0	0
171	Actual operation hour meter clear	0	0

Note: Not provided for E500.

1.6.36 User's initial value setting [Pr. 199] A500

From among the parameters, you can set user-only parameter initial values. These values may be set to 16 parameters.

By performing user clear operation from the operation panel or parameter unit, you can initialize the parameters to the user-set initial values. Note that the parameters of which initial values have not been set are initialized to the factory settings by user clear operation.

You can read the user's initial value list in the help mode of the parameter unit (FR-PU04).

Parameter Number	Setting Range	Factory Setting
199	0 to 999, 9999	0

The read value of Pr. 199 is displayed as the number of parameters registered.

(1) To set "1" in Pr. 7 and "2" in Pr. 8 as user's initial values. (Operation from the FR-DU04)

1) Set "1" (target initial value) in Pr. 7.

↓

2) Set "2" (target initial value) in Pr. 8.

↓

3) Press the [SET] key to read Pr. 199. The number of parameters having user's initial values are then displayed.

↓

4) Further press the [SET] key for 1.5 seconds. The parameter setting screen is then displayed.

↓

5) Select Pr. 7 and Pr. 8 with the [UP/DOWN] key and press the [SET] key for 1.5 seconds to enter.

↓

6) Through the above steps, the initial values of Pr. 7 and Pr. 8 are registered.

The settings of the parameters whose numbers are set in Pr. 199 (i.e. Pr. 7 = 1, Pr. 8 = 2 in the above example) are user's initial values.

(2) Deletion of user's initial values

By writing "9999" to Pr. 199 (and pressing the [SET] key for 1.5 seconds), the user's initial values registered are batch-deleted.

Note: 1. When user's initial values for Pr. 902 to Pr. 905 are set, one parameter uses the area of two parameters for registration.
2. As this setting is concerned with user-cleared initial values, the parameter numbers which cannot be cleared cannot be set.
3. The operation panel (FR-DU04) cannot be used to refer to user's initial values.
4. Values cannot be registered to Pr. 201 to Pr. 231.

1.6.37 Programmed operation [Pr. 200 to 231] (A500)

By presetting the time of day, motor rotation direction and running frequency, the automatic operation of the inverter can be performed according to the settings.
The time of day, motor rotation direction and running frequency are grouped into a single point of functions, one group consists of 10 points, and a total of up to 30 points, i.e. 3 groups, can be set.
For the programmed operation method, refer to Section 1.6.1 (5).

Setting of Reference Time of Day and Unit

Parameter Number	Name	Setting Range	Description			Factory Setting
200	Time unit	0, 1, 2, 3	Setting	Unit	PU monitor	—
			0	Min./sec.	Voltage	○
			1	Hr./min.	Voltage	—
			2	Min./sec.	Reference time of day	—
			3	Hr./min.	Reference time of day	—
231	Time setting	0 to 99.59	Set reference time of day.			0

Program Setting

Parameter Number	Name		Rotation Direction		Running Frequency		Time of Day	
			Setting range	Factory setting	Setting range	Factory setting	Setting range	Factory setting
201	Group 1	Program 1 set	0: Stop 1: Forward rotation 2: Reverse rotation	0	9999: No setting 0 to 400Hz	9999	0 to 99•59	0
202		Program 2 set						
203		Program 3 set						
204		Program 4 set						
205		Program 5 set						
206		Program 6 set						
207		Program 7 set						
208		Program 8 set						
209		Program 9 set						
210		Program 10 set						
211	Group 2	Program 11 set	0: Stop 1: Forward rotation 2: Reverse rotation	0	9999: No setting 0 to 400Hz	9999	0 to 99•59	0
212		Program 12 set						
213		Program 13 set						
214		Program 14 set						
215		Program 15 set						
216		Program 16 set						
217		Program 17 set						
218		Program 18 set						
219		Program 19 set						
220		Program 20 set						
221	Group 3	Program 21 set	0: Stop 1: Forward rotation 2: Reverse rotation	0	9999: No setting 0 to 400Hz	9999	0 to 99•59	0
222		Program 22 set						
223		Program 23 set						
224		Program 24 set						
225		Program 25 set						
226		Program 26 set						
227		Program 27 set						
228		Program 28 set						
229		Program 29 set						
230		Program 30 set						

1.6.38 Cooling fan operation selection [Pr.244] COMMON

You can control the operation of the cooling fan built in the inverter (provided for the forced air cooling inverter only).

Pr.244 Setting	Description	Factory Setting
0	Operated at power on (independently of whether the inverter is running or at a stop).	○
1	Cooling fan on-off control valid (The cooling fan is always on while the inverter is running. During a stop, the inverter status is monitored and the fan switches on-off according to temperature.)	—

In either of the following cases, fan operation is regarded as faulty, [FN] is shown on the operation panel, and the fan fault (FAN) (Note) and light fault (LF) signals are output.

1) Pr.244 = "0"
   When the fan comes to a stop with power on.
2) Pr.244 = "1"
   When the fan comes to a stop during the fan ON command or the fan starts during the fan OFF command.
   Note: Not provided for E500.

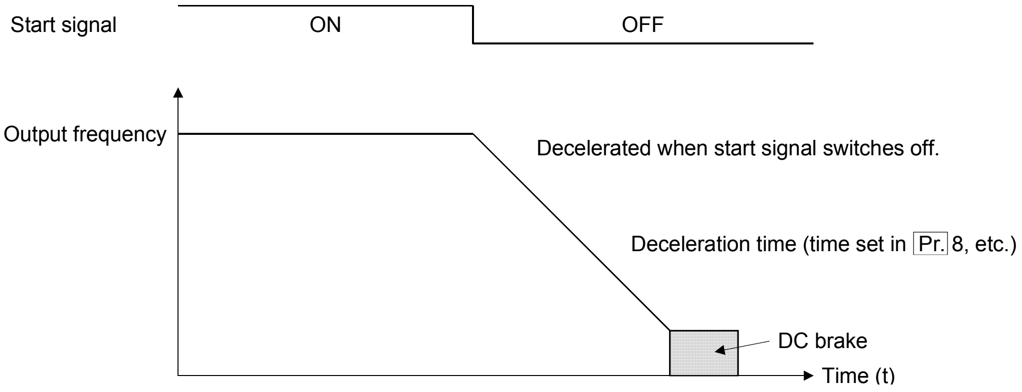
1.6.39 Stop selection [Pr.250] COMMON

Used to select the stopping method (deceleration to a stop or coasting) when the start signal (STF/STR) switches off.

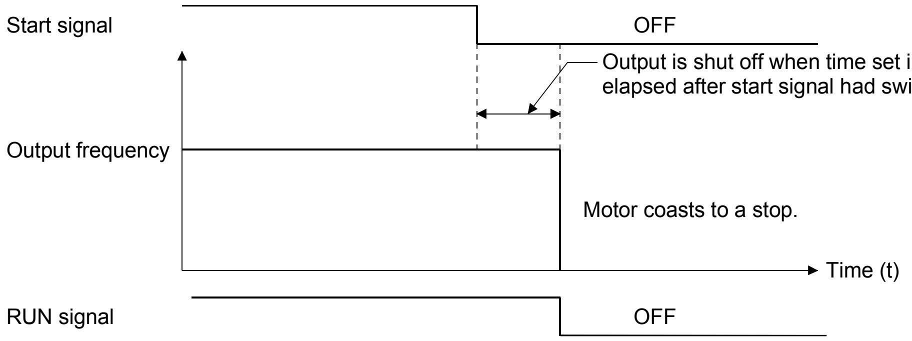
Parameter Number	Name	Set Value	Description	Factory Setting
250	Stop selection	0 to 100 s	Output is shut off when preset time has elapsed after start signal had turned off.	—
		1000 to 1100 s (Note)	Output is shut off when (preset time - 1000 seconds) have elapsed after start signal had turned off. Functions of terminals STF, STR are changed.	—
		8888 (Note)	Functions of terminals STF, STR are changed.	—
		9999	Ordinary operation. Motor is decelerated to stop when start signal turns off.	○

Note: Not provided for A500.

1) Pr.250 = "9999"
   When the start signal switches off, the motor is decelerated to a stop.



2) Pr. 250 = 0 to 100 seconds (output is shut off after present time)
The output is shut off when the time set in Pr. 250 has elapsed after the start signal was switched off. The motor coasts to a stop.



3) When the Pr. 250 value is 8888 for E500 the functions of terminals STF, STR change as indicated below.

STF ------ Start signal,
STR ----- Rotation direction signal

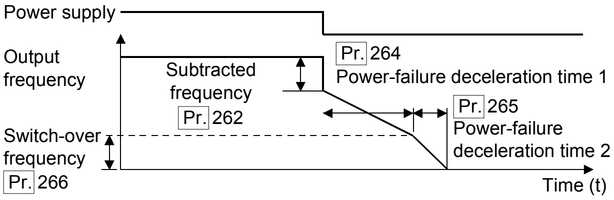
STF	STR	Inverter Operating Status
OFF	OFF	Stop
OFF	ON	
ON	OFF	Forward rotation
ON	ON	Reverse rotation

4) When the Pr. 250 value is between 1000 to 1100 seconds. for E500, the functions of terminals STF, STR are the same as when Pr. 250 = 8888. The way of stopping when the start signal turns off is to shut off the output (coasting to stop) after (Pr. 250 setting - 1000 seconds.).

Note:
1. The RUN signal switches off when the output stops.
2. When the start signal is switched on again during motor coasting, the motor starts at 0Hz.
3. When Pr. 250 = 0, output is shut off in the shortest time.

1.6.40 Power failure stop function [Pr. 261 to 266] (A500)

When an instantaneous power failure or undervoltage occurs, the inverter can be decelerated to a stop.
Remove the jumper from across terminals R-R1 (L1-L11) and S-S1 (L2- L21) and connect the control circuit terminals R1-P (L11- +)and S1-N (L21- −) to route the power supply wiring of the other system.



Parameter Number	Name	Set Value	Description	Factory Setting
261	Power failure stop selection	0	Coasting to stop. When undervoltage or power failure occurs, the inverter output is shut off.	○
		1	When undervoltage or power failure occurs, the inverter is decelerated to a stop.	—
262	Subtracted frequency at deceleration start	0 to 20Hz	Normally, operation can be performed with the factory setting unchanged. The frequency can be adjusted within the range 0 to 20Hz according to the load specifications (inertia moment, torque).	3Hz
263	Subtraction starting frequency	0 to 120Hz	If the output frequency at occurrence of undervoltage or power failure is equal to or greater than the frequency set in Pr. 263, deceleration starts at the value found by subtracting the frequency set in Pr. 262 from the output frequency at that time. If the output frequency at occurrence of undervoltage or power failure is less than the frequency set in Pr. 263, the inverter is decelerated to a stop, starting at the output frequency at that time.	60Hz
		9999	The inverter is decelerated to a stop, starting at the value found by subtracting the frequency set in Pr. 262 from the output frequency at occurrence of undervoltage or power failure.	—
264	Power-failure deceleration time 1	0 to 3600 s (Pr. 21=0) 0 to 360 s (Pr. 21=1)	Set a deceleration slope down to the frequency set in Pr. 266. Set the slope in terms of time required for deceleration from the frequency set in Pr. 20 to 0Hz.	5 s
265	Power-failure deceleration time 2	0 to 3600 s (Pr. 21=0) 0 to 360 s (Pr. 21=1)	Set a deceleration slope below the frequency set in Pr. 266. Set the slope in terms of time required for deceleration from the frequency set in Pr. 20 to 0Hz.	—
		9999	Same slope as in Pr. 264	○
266	Power-failure deceleration time switch-over frequency	0 to 400Hz	Set the frequency at which the deceleration slope is switched from the Pr. 264 setting to the Pr. 265 setting.	60Hz

Note: 1. This function is invalid when the automatic restart after instantaneous power failure function is activated.
2. If (output frequency at occurrence of undervoltage or power failure) minus (frequency set in Pr. 262) is negative, the calculation result is regarded as 0Hz.
3. The power failure stop function is not activated during a stop or error.
4. If power is restored during deceleration, the inverter is kept decelerating to a stop.
To restart, switch off the start signal once, then switch it on again.
5. When the high power factor converter is used (Pr. 30 = 2), this function is made invalid.
6. If power-failure deceleration operation is set, some loads may cause the inverter to trip and the motor to coast.
If enough regenerative energy is not given by the motor, the motor will coast.

1.6.41 Stop-on-contact, load torque high-speed frequency selection

[Pr. 270] A500

This function is used to select stop-on-contact control and/or load torque high-speed frequency control.
For the operation and other information of the corresponding functions, refer to their detailed descriptions.

Pr. 270 Setting	Load Torque High-Speed Frequency Control (X19)	Stop-On-Contact Control (RL, RT)	Multi-Speeds (7 speeds) (RH, RM, RL)
0	×	×	○
1	×	○	○
2	○	×	○
3	○	○	○

★Under the following conditions, the functions of Pr. 270 settings "1 to 3" are made invalid:
- PU operation
- Programmed operation
- PU + external combined
- PID control
- Remote setting function mode
- Orientation control (option FR-A5AR)
- Jog operation (common to PU and external operations)

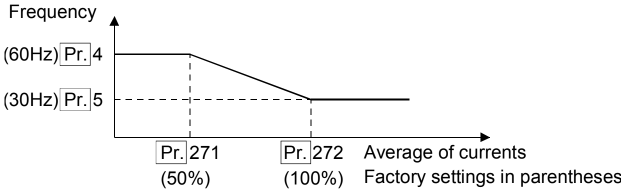
1.6.42 Load torque high-speed frequency control

[Pr. 4,5,270 to 274] A500

This function is designed to increase speed automatically under light load, for example to minimize the incoming/outgoing time in a multi-story parking lot. More specifically, the magnitude of the load is judged according to the average current at a certain time after starting to perform operation at higher than the preset frequency under light load.

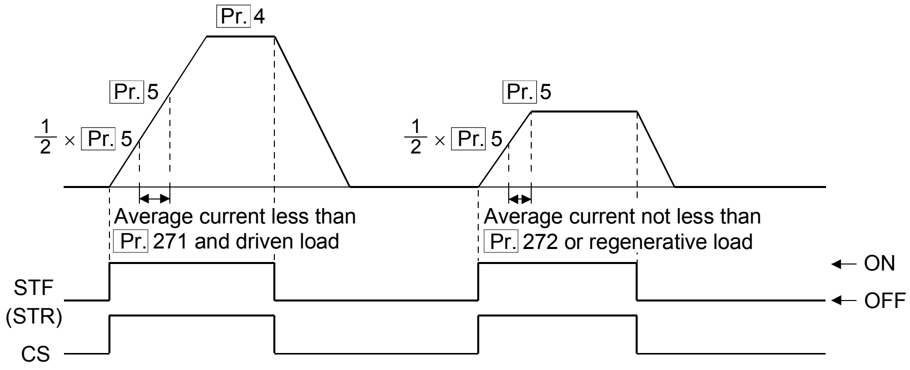
Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Remarks
4	High-speed frequency	0 to 400Hz	0.01Hz	60Hz	Any value set above 120Hz is regarded as 120Hz.
5	Middle-speed frequency	0 to 400Hz	0.01Hz	30Hz	Any value set above 120Hz is regarded as 120Hz.
270	Stop-on-contact, load torque high-speed frequency selection	0, 1, 2, 3	1	0	Set "2" or "3" to select load torque high-speed frequency control.
271	High-speed setting maximum current	0 to 200%	0.1%	50%	
272	Low-speed setting maximum current	0 to 200%	0.1%	100%	
273	Current averaging range	0 to 400Hz, 9999	0.01Hz	9999	
274	Current averaging filter constant	1 to 4000	1	16	Set the time constant of the primary delay filter with respect to the output current. (Time constant [ms] = 0.75 × Pr. 274) A larger set value provides higher stability but lowers response level.

When the X19 signal (load detection high-speed frequency function selection) is turned on to start operation with 2 or 3 set in Pr. 270 (stop-on-contact, load torque high-speed frequency selection), the inverter automatically varies the maximum frequency between Pr. 4 and Pr. 5 settings according to the average current flowing during acceleration from half of the frequency of the Pr. 5 setting to the frequency set in Pr. 5. (This function is invalid for acceleration stopped midway or a regenerative load.)
When the value set in Pr. 273 is other than 9999, the average current is the average of currents during acceleration from half of the frequency of the Pr. 273 setting to the frequency set in Pr. 273.



Frequency vs. Average Current

Note: 1. If the current averaging area includes the constant-output region, the output current may increase in the constant-output region.
2. Note that when the current is small, the frequency rises and the deceleration time increases.



Load Torque High-Speed Frequency Control Operation Example

Note: When terminal CS and multi-speed terminal are turned on at the same time, operation is performed in accordance with the multi-speed setting.

When this function is selected, the fast-response current limit function is not activated.
This function is activated at every start. Therefore, note that the running speed changes with every different load magnitude.

★Under the following conditions, the load torque high-speed frequency control function is made invalid:

- PU operation
- Multi-speed operation
- Programmed operation
- PU + external combined
- PID control
- Remote setting function mode
- Orientation control (with FR-A5AR inboard option)
- 12-bit digital speed input (with FR-A5AX inboard option)
- Jog operation (common to PU and external operations)

1.6.43 Stop-on-contact control [Pr.6,270,275,276] (A500)

To ensure accurate positioning at the upper limit etc. of a lift, stop-on-contact control causes a mechanical brake to be closed while the motor is developing a holding torque to keep the load in contact with a mechanical stopper etc.

This function suppresses vibration which is liable to occur when the load is stopped upon contact in vertical motion applications, ensuring steady precise positioning.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Remarks
6	Low-speed frequency	0 to 400Hz	0.01Hz	10Hz	Activated as output frequency for stop-on-contact control. Setting of above 30Hz is regarded as 30Hz.
270	Stop-on-contact, load torque high-speed frequency selection	0, 1, 2, 3	1	0	Set "1" or "3" to choose stop-on-contact control.
275	Stop-on-contact exciting current low-speed multiplying factor	0 to 1000%, 9999	1%	9999	Valid for advanced magnetic flux vector control. Set "9999" to make this function invalid.
276	Stop-on-contact PWM carrier frequency	0 to 15, 9999	1	9999	Valid at output frequency of 3Hz or less. Set "9999" to make this function invalid.

When selected, stop-on-contact control is exercised by turning on the RL and RT signals at the same time. Also, advanced magnetic flux vector control must be selected.

The frequency for stop-on-contact should be as low as possible (about 2Hz). The setting of over 30Hz is regarded as 30Hz. When stop-on-contact control is exercised at the time of PLG feedback control, PLG feedback control is overridden by the stop-on-contact control mode.

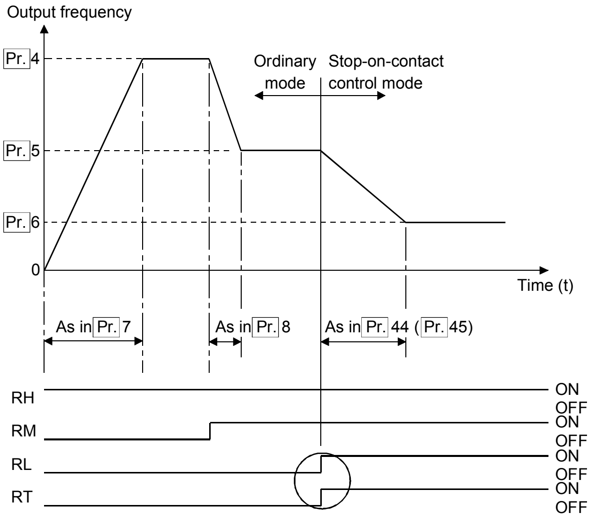
Stop-on-contact control can increase low-speed excitation for advanced magnetic flux vector control and increase torque. Normally set it between 130 and 80%. A too large setting may cause an overcurrent (OCT) alarm to occur more easily or the machine to vibrate in a stop-on-contact status.

Unlike the servo-lock function, the stop-on-contact function cannot stop and hold a load for a long time. Stop-on-contact control continued for an extended period can cause motor overheat. Therefore, after a stop, immediately hold the load with a mechanical brake.

For stop-on-contact during traversing, operation can be performed with the inverter's current limit value reduced.

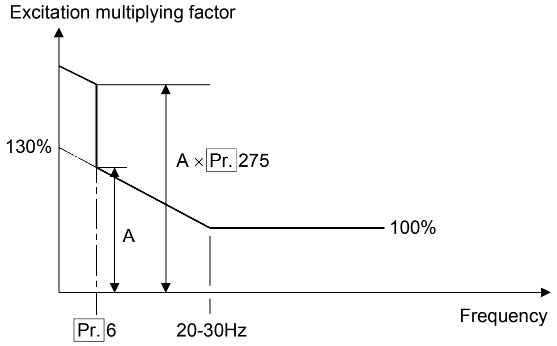
★Under the following conditions, the stop-on-contact control function is made invalid:

- PU operation
- Programmed operation
- PU + external combined
- PID control
- Remote setting function mode
- Orientation control (with FR-A5AR inboard option)
- Jog operation (common to PU and external operations)



Switched to stop-on-contact control mode when both RL and RT turn on.
(RL and RT may be turned on in any sequence with any delay between them)

Stop-on-Contact Control Mode Switch-Over Timing Chart



Stop-on-Contact Excitation Multiplying Factor Example

Operation Mode (External)	Ordinary Operation		Stop-on-Contact Control		Remarks
RL, RT terminals / Main function	RL	RT	RL	RT	
	Either is OFF		ON	ON	
Output frequency for a stop on contact	Multi-speeds 0 to 5V, 0 to 10V 4 to 20mA		Pr. "low-speed frequency"		
Stall prevention operation level	Pr. 22 (stall prevention operation level)		Pr. 48 (second stall prevention operation current)		When RL and RT are on, Pr. 49 (second stall prevention operation frequency) is invalid.
Exciting current low-speed multiplying factor			The current is compensated for by the multiplying factor (0 to 1000%) set in Pr. 275 before RL and RT are switched on.		
Carrier frequency	Pr. 72 "PWM frequency selection"(0 to 15)		Pr. 276 (stop-on-contact PWM carrier frequency) (0 to 15, 9999)		
Fast-response current limit	Yes		No		

1.6.44 Brake sequence circuit function [Pr. 60,278 to 285] A500

This function outputs a brake control signal from the inverter to operate the mechanical brake at a proper time.

To activate this function, you can either input or not input the mechanical brake operation confirmation signal to the inverter.

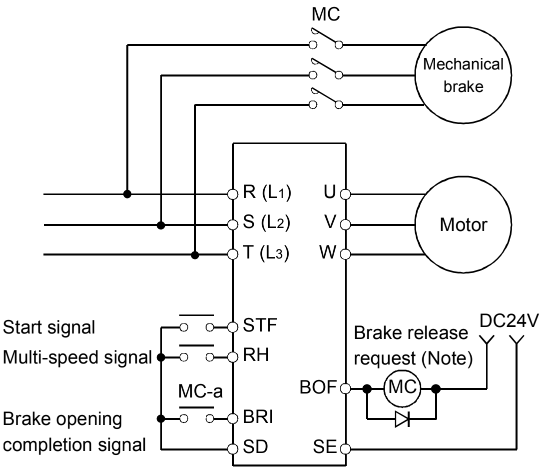
Note that this function is only valid for the external operation under advanced magnetic flux vector control which is the most appropriate for vertical lift applications, and cannot be used for V/F control.

Parameter Number	Name	Setting Range	Increments	Factory Setting	Remarks
60	Intelligent mode selection	0 to 8	1	0	7, 8: Brake sequence
278	Brake opening frequency	0 to 30Hz	0.01Hz	3Hz	
279	Brake opening current	0 to 200%	0.1%	130%	Rated inverter current = 100%
280	Brake opening current detection time	0 to 2 s	0.1 s	0.3 s	
281	Brake operation time at start	0 to 5 s	0.1 s	0.3 s	
282	Brake operation frequency	0 to 30Hz	0.01Hz	6Hz	Can be set only when Pr. 282 ≥ Pr. 278.
283	Brake operation time at stop	0 to 5 s	0.1 s	0.3 s	
284	Deceleration speed detection function selection	0, 1	1	0	0: Not selected, 1: Selected
285 (Note)	Overspeed detection frequency	0 to 30Hz, 9999	0.01Hz	9999	9999: Overspeed not detected

Note: Made valid for PLG feedback control (with FR-A5AP inboard option).

(1) Operation

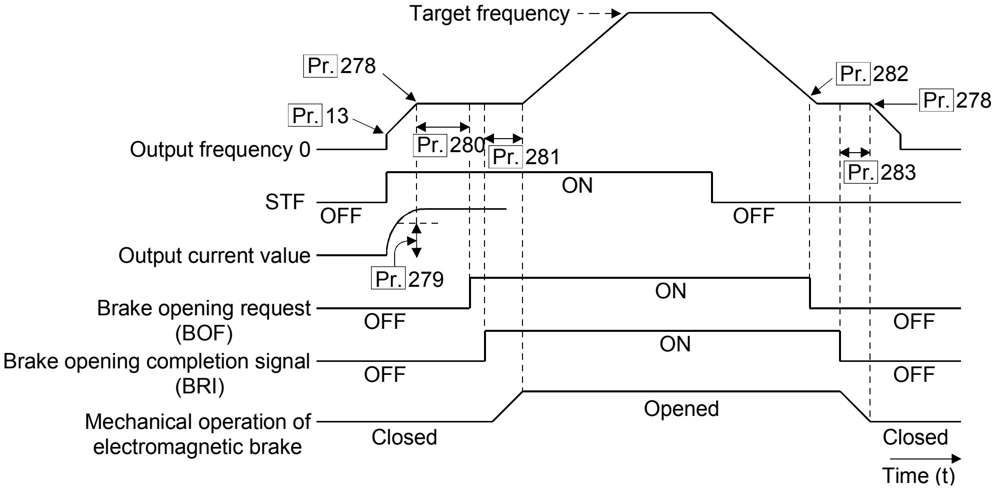
1) When mechanical brake operation confirmation signal is input.
First choose advanced magnetic flux vector control. Set "7" in Pr. 60 and enter the brake opening completion signal from BRI. The brake opening request is output from BOF. (For wiring, refer to the figure on the right.)
When the start signal is input form the inverter, output begins at the starting frequency. When the brake opening frequency set in Pr. 278 is reached and the output current exceeds the brake opening current set in Pr. 279, the brake opening request is output from BOF after the brake opening current detection time set in Pr. 280 has elapsed.
When the brake opening completion signal is input from BRI, acceleration is restarted after the start-time brake operation time set in Pr. 281 has elapsed.



Note: Note the permissible current of the inverter's internal transistor.

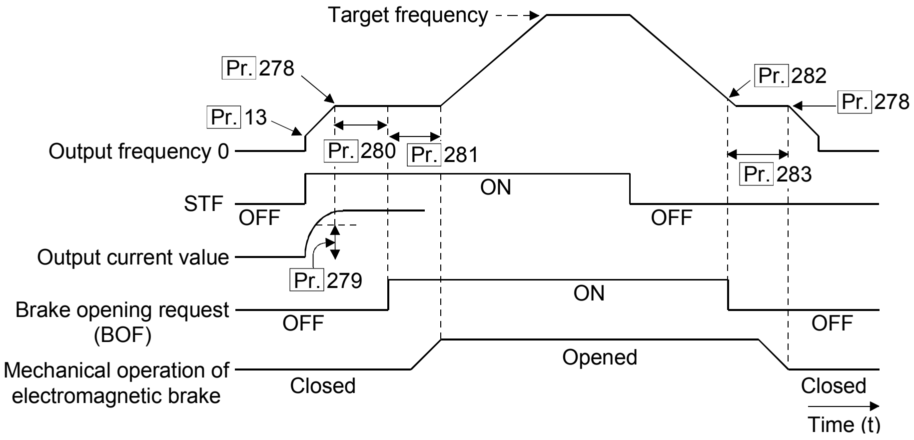
Brake Sequence Circuit Connection Example

At a stop, the brake opening request (BOF) is turned off when speed is decreased down to the brake closing frequency set in Pr. 282. The inverter stops when the stop-time brake operation time set in Pr. 283 elapses after the brake opening completion signal (BRI) has turned off.



Brake Sequence Operation Timing Chart (when operation confirmation signal is provided)

2) When mechanical brake operation confirmation signal is not input.
Operation is similar to the operation performed when the mechanical brake operation confirmation signal is input. For operation, refer to the operation timing chart.



Brake Sequence Operation Timing Chart (when operation confirmation signal is not provided)

(2) Instructions

When the coil of the magnetic contactor for the brake is connected to the output signal (BOF) of the inverter, take care so that the permissible current of the inverter's transistor output should not be exceeded. If it is exceeded, consider taking action by using a commercially available relay, for example. Note that the coils of the relay and magnetic contactor must be connected with surge suppressors.

This function is made valid only when advanced magnetic flux vector control is selected and external operation is performed. As it is invalid when the conventional V/F control system is selected, carefully check the Pr. 80 and Pr. 81 settings. Also when this function is selected, the function of automatic restart after instantaneous power failure is not activated.

(3) Protective functions

If any of the following errors occur in the brake sequence mode, the inverter results in an alarm, shuts off the output and switches off the brake opening request signal (BOF terminal). On the operation panel (FR-DU04) LED and parameter unit (FR-PU04) screen, the following errors are displayed:

Error Display	Error Display
E.MB1	(Detected frequency) - (output frequency)> Pr. 286 in the PLG feedback control mode. (Overspeed detection function)
E.MB2	Deceleration is not normal during deceleration operation (Use Pr. 284 to select this function.) (Except stall prevention operation)
E.MB3	Brake opening request signal (BOF) switched on though the motor is at a stop. (Gravity drop prevention function)
E.MB4	More than 2 seconds after the run command (forward or reverse rotation) is input, the brake opening request signal (BOF) does not switch on.
E.MB5	More than 2 seconds after the brake opening request signal switched on, the brake opening completion signal (BRI) does not switch on.
E.MB6	Though the inverter had switched on the brake opening request signal (BOF), the brake opening completion signal (BRI) switched off during that period.
E.MB7	More than 2 seconds after the brake opening request signal (BOF) switched off at a stop, the brake opening completion signal (BRI) does not switch off.

1.6.45 Droop control [Pr. 286,287] (A500)

This function balances the load in proportion to the load torque with or without PLG, and provides speed drooping characteristics. This is effective in balancing the load when using multiple inverters.

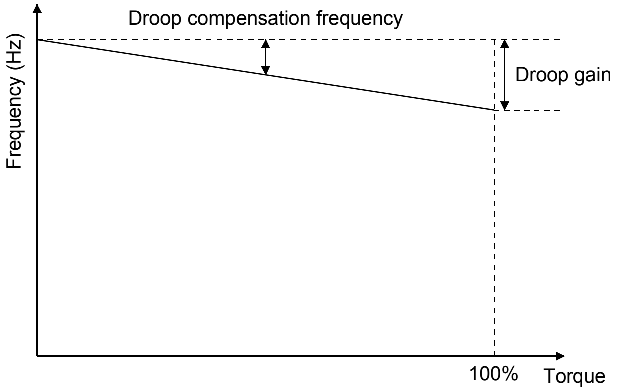
Parameter Number	Name	Setting range	Details	Factory Setting
286	Droop gain	0 to 100%	Set the drooping amount at the rated torque as a percentage with respect to the rated frequency. When the setting value is "0", the function will be invalid (no droop control).	0%
287	Droop filter time constant	0.00 to 1.00s	Set the time constant of the filter applied on the torque amount current.	0.3 s

Under advanced magnetic fiux vector control or under vector control (when FR-A5AP is fitted), this function varies the output frequency according to the magnitude of the torque current. The drooping amount at the rated torque is set by the droop gain as a percentage using the rated frequency as a reference.

$$\text{Droop compensation Frequency} = \frac{\text{Amount of torque current after filtering}}{\text{Rated current}} \times \frac{\text{Rated frequency} \times \text{droop gain}}{100}$$

Confirm the following items when using the droop control.

1) This function is valid when Pr. 286 ≠ "0" during unbalanced flux vector and vector control.
2) This function is valid when the operation state is constant speed operation.
3) The upper limit of the droop compensation frequency is 120Hz.
4) The rated current which follows is the value set in Pr. 9 "Motor rated current (electronic thermal O/L relay)".



Droop Control Operation Chart

1.6.46 Ground fault detection presence/absence at start [Pr. 249] (E500)

You can select whether ground fault detection is made or not when starting the inverter (STF etc.). Ground fault detection is only made immediately after the start signal is entered into the inverter.

Parameter Number	Name	Setting range	Setting	Details	Factory Setting
249	Ground fault detection presence/absence at start	0, 1	0	Ground fault detection not made.	○
			1	Ground fault detection made. Since detection is made at a start, about 20ms output delay occurs at every start.	—

Note: 1. When a ground fault is detected with "1" set in Pr. 249, alarm output "E.GF" is detected and the output is shut off.
2. When a ground fault occurs during operation, the protective function is not activated.
3. When the motor capacity is 100W or less, ground fault protection may not be provided.

1.6.47 Parameter unit language change-over [Pr. 145] COMMON

You can choose the display language of the FR-PU04 parameter unit.

Pr. 145 Setting	Display Language	Factory Setting
0	Japanese	○
1	English	—
2	German	—
3	French	—
4	Spanish	—
5	Italian	—
6	Swedish	—
7	Finnish	—

Note :NA and EC version inverters are factory set to "1" (English).

1.6.48 Parameter unit operation sound selection [Pr. 990] COMMON

You can select whether the operation sound "blip" is provided or not when the operation panel (FR-DU04) or parameter unit (FR-PU04) keys are pressed.
The operation panel of the E500 does not provide the operation sound.

Pr. 990 Setting	Key Operation Sound	Factory Setting
0	Not provided	—
1	Provided	○

1.6.49 LCD contrast [Pr. 991] COMMON

You can adjust the contrast of the parameter unit (FR-PU04) LCD. Change the value with the [UP/DOWN] key to desired brightness and enter it with the [WRITE] key.

Pr. 991 Setting	Description
0	Bright
to	53 (Factory setting)
63	Dark

Note: If you do not press the [WRITE] key, the LCD contrast setting is not stored.

1.7 Protective functions

The FR-A500 and FR-E500 series have the following protective functions. When the protective circuit is activated, the IPM gate is shut off to stop the output and protect the devices. At this time, the operation panel (parameter unit) display is automatically switched to the corresponding alarm indication given below and the motor is coasted to a stop. To restart the motor, use the reset terminal (switch on-off RS-SD) or switch off input power once to reset the inverter. The inverter may also be reset by the PU operation panel.

The protective function list is given below.

Protective Function List

The following protective functions are designed to protect the inverter itself (except the electronic are thermal relay) and may also be activated when the inverter has become faulty.

Function Name		Description		Display		Corresponding Model	
				(Operation panel)	(Parameter unit)	A500	E500
Overcurrent shut-off Main circuit device overheat (IPM)		When the inverter output current has reached or exceeded about 200% of the rated current during acceleration/deceleration or constant-speed operation, or when the main circuit device (IPM) has overheated due to cooling fan stop, overload etc. the protective circuit is activated to stop the inverter output.	During acceleration	E.OC1 (OC1)	Oc During Acc	○	○
			During constant speed (Note 1)	E.OC2 (OC2)	Steady Spd Oc	○	○
			During deceleration	E.OC3 (OC3)	Oc During Dec	○	○
Regenerative overvoltage shut-off		When the main circuit DC voltage in the inverter has reached or exceeded the specified value during acceleration/deceleration or constant-speed operation due to regenerative energy at the time of motor braking, the protective circuit is activated to stop the inverter output. This function may also be activated by a surge voltage generated in the power supply system.	During acceleration	E.Ov1 (OV1)	Ov During Acc	○	○
			During constant speed (Note 1)	E.Ov2 (OV2)	Steady Spd Ov	○	○
			During deceleration	E.Ov3 (OV3)	Ov During Dec	○	○
Overload shut-off (electronic thermal relay)	Motor	When the electronic thermal relay built in the inverter detects motor overheat due to overload or cooling capability reduction during constant-speed operation, the protective circuit is activated to stop the inverter output. When a multi-pole motor or more than one motor are driven, for example, the motor(s) cannot be protected by the electronic thermal relay. In this case, provide a thermal relay in the inverter output side.		E.THM (THM)	Motor Ovrload	○	○
	Inverter	When the current more than 150% of the rated output current flows and this does not result in overcurrent shut-off (OC) (less than 200%), the inverse-time characteristic actuates the electronic thermal relay to protect the main circuit transistors, stopping the inverter output. (Overload immunity: 150%, 60 seconds.)		E.THT (THT)	Inv.Overload	○	○

Function Name	Description	Display		Corresponding Model	
		(Operation panel)	(Parameter unit)	A500	E500
Instantaneous power failure protection	If a power failure has occurred in excess of 15ms (this applies also to inverter input shut-off), this function is activated to stop the inverter output to prevent the control circuit from operating incorrectly. At this time, the alarm output contacts are opened (across B-C) and closed (across A-C). (Note 1) If a power failure persists for more than 100ms, the alarm output is not provided, and if the start signal is on at the time of power restoration, the inverter will restart. (If a power failure is instantaneous within 15ms, the control circuit operates properly.)	E.I PF (IPF)	Inst.Pwr.Loss	○	—
Undervoltage protection	When the power supply voltage of the inverter has reduced, the control circuit cannot operate properly, resulting in reduced motor torque or overheating. To prevent this, if the power supply voltage reduces below about 150V (300V for the 400V class), this function stops the inverter output.	E.UVT (UVT)	Under Voltage	○	—
Fin overheat	If the cooling fin overheats, the temperature sensor is activated to stop the inverter output.	E.FIN (FIN)	H/Sink O/Temp	○	○
Brake resistor overheat protection	Inverters of 7.5K or less contains a brake resistor. When the regenerative brake duty from the motor has reached 85% of the specified value, pre-alarm (RB indication) occurs. If the specified value is exceeded, the brake circuit operation is stopped temporarily to protect the brake resistor from overheating. (If the brake is operated in this state, regenerative overvoltage shut-off will occur.) When the brake resistor has cooled, the brake operation is resumed.	No indication (E.OV3 (OV3))	No indication (Regenerative overvoltage shut-off may take pace if brake operation is performed while protective circuit is being activated.)	○	—
Brake transistor alarm detection	If the brake circuit fault has occurred due to damaged brake transistors etc., this function stops the inverter output. In this case, the inverter power must be switched off immediately.	E. bE (BE)	Br.Cct. Fault	○	○
Output side ground fault overcurrent protection	This function stops the inverter output if a ground fault occurs in the inverter's output (load) side and a ground fault current flows. A ground fault occurring at low ground resistance may activate the overcurrent protection (OC1 to OC3). Ground fault is detected at start only for E500. Use Pr. 249 to set whether protective function is activated or not.	E. GF (GF)	Ground Fault	○	○
External thermal relay operation (Note 3)	If the external thermal relay designed for motor overheat protection or the internally mounted temperature relay in the motor switches on (relay contacts "open"), the inverter output can be stopped if those contacts have been entered into the inverter. If the relay contacts are reset automatically, the inverter will not restart unless it is reset.	E.OHT (OHT)	OH Fault	○	○

Function Name	Description	Display		Corresponding Model	
		(Operation panel)	(Parameter unit)	A500	E500
Inboard option fault	If the inboard option dedicated to the inverter results in a setting error or a connection fault, the inverter output is stopped.	E.OPT (OPT)	Option Fault	○	—
Option slot alarm	Stops the inverter output if a functional fault (such as communication error of the communication option) occurs in the inboard option loaded in any slot.	E.OP1 to E.OP3 (0P1 to 0P3)	Option slot alarm 1 to 3	○	—
Parameter error	Indicates that alarm has occurred in any stored parameter (e.g. E^2ROM fault).	E. PE (PE)	Corrupt Memory	○	○
Retry count exceeded	If operation cannot be resumed within the number of retries set, this function stops the inverter output.	E.rET (RET)	Retry No Over	○	○
Open output phase protection	This function stops the inverter output when any of the three phases (U, V, W) on the inverter's output side (load side) opens.	E. LF (LF)	—	○	○
CPU error	If the arithmetic operation of the built-in CPU does not end within a predetermined period, the inverter self-determines it has an alarm and stops the output.	E.CPU (CPU)	CPU Fault	○	○
PU disconnection	When communication between the inverter and PU is stopped, e.g. when the PU has been removed at the Pr. 75 setting of 2 or 3, the inverter output is stopped.	E.PUE (PUE)	—	○	○
24VDC power output short circuit	When 24VDC power output from the PC terminal is shorted, this function shuts off the power output. At this time, all external contact inputs switch off. The inverter cannot be reset by entering the RES signal. To reset, use the operation panel or switch power off, then on again.	E.P24 (P24)	—	○	—
Operation panel power short circuit	When the operation panel power (P5S of the PU connector) is shorted, this function shuts off the power output. At this time, the operation panel (parameter unit) cannot be used and RS-485 communication from the PU connector cannot be made. To reset, enter the RES signal or switch power off, then on again.	E.CTE (CTE)	—	○	—
Brake sequence error	This function stops the inverter output if a sequence error occurs during the use of the brake sequence function (Pr. 278 to Pr. 285).	E.MB1 to E.MB7 (MB1 to MB7)	—	○	—

Function Name		Description	Display		Corresponding Model	
			(Operation panel)	(Parameter unit)	A500	E500
Current limit stall prevention	During acceleration	When a current not less than 150% (Note 2) of the rated inverter current flows in the motor, the increase in frequency is stopped until the load current reduces to prevent the inverter from resulting in overcurrent shut-off. When the current has reduced below 150%, the frequency is increased again.	E.OLT (OLT)	OL code is displayed on the main monitor. Stll Prev STP is displayed at a stop.	○	○
	During constant speed (Note 2)	When a current not less than 150% (Note 2) of the rated inverter current flows in the motor, the frequency is decreased until the load current reduces to prevent the inverter from resulting in overcurrent shut-off. When the current has reduced below 150%, the frequency returns to the set value.			○	○
	During deceleration	When the brake capability is exceeded due to the excessive regenerative energy of the motor, the decrease in frequency is stopped to prevent the inverter from resulting in overvoltage shut-off. When the regenerative energy has reduced, deceleration is resumed. When a current not less than 150% (Note 2) of the rated inverter current flows in the motor, the decrease in frequency is stopped until the load current reduces to prevent the inverter from resulting in overcurrent shut-off. When the current has reduced below 150%, the frequency is decreased again.			○	○
Fan stop (Note 4)		For the inverter which contains a cooling fan, FN is displayed on the operation panel when the cooling fan stops due to a fault or operates differently from the setting of Pr. 244 "cooling fan operation selection". The inverter does not stop output.	Fn (FN)	——	○	○

Note: 1. Constant speed is achieved when the output frequency is within the ± 3Hz range of the set frequency. For example, the speed may always be constant when slow acceleration/deceleration is made from an external potentiometer at a small setting of acceleration/deceleration time.

2. Indicates that the stall prevention operation level has been set to 150% (factory setting). If this value is changed, stall prevention is operated at the new value.

3. When the protective function is activated and the inverter stops its output (the motor is coasted to a stop), the inverter is kept stopped. Unless reset, the inverter cannot restart. To reset the inverter, use any of the following methods: switch power off once, then on again; short reset terminal RES-SD for more than 0.1 second, then open; press the [RESET] key of the parameter unit (use the help function of the parameter unit). If RES-SD is kept shorted, the operation panel will show "Err." or the parameter unit will show that the inverter is being reset.

4. The inverter does not stop the output and continues running.

Alarm code output (A500)

Set "1" (alarm code output normally) or "2" (alarm code output at alarm only) in Pr. 76, output terminal function switching, to output the alarm definition as a 4-bit digital signal. The output signal is output from the open collector output terminals supplied with the inverter.

Correspondences between the alarm definitions and alarm codes are as follows. The operation panel (parameter unit) also displays the error number to provide the alarm definition in details.

Alarm Code Output List

Alarm Definition (Protective Function)		Display (Operation Panel)	Output Terminal Signal On-Off (Note)				Alarm Code
			SU	IPF	OL	FU	
Normal operation		—	0	0	0	0	0
Overcurrent shut-off	During acceleration	E. OC1	0	0	0	1	1
	During constant speed	E. OC2	0	0	1	0	2
	During deceleration	E. OC3	0	0	1	1	3
Regenerative overvoltage shut-off		E. OV1 to E. OV3	0	1	0	0	4
Electronic thermal relay	Motor protection	E. THM	0	1	0	1	5
	Inverter protection	E. THT	0	1	1	0	6
Instantaneous power failure		E. IPF	0	1	1	1	7
Undervoltage		E. UVT	1	0	0	0	8
Fin overheat		E. FIN	1	0	0	1	9
Brake transistor alarm		E. BE	1	0	1	0	A
Output side ground fault overcurrent		E. GF	1	0	1	1	B
External thermal relay operation		E. OHT	1	1	0	0	C
Stall-activated stop		E. OLT	1	1	0	1	D
Inboard option alarm		E. OPT	1	1	1	0	E
Option slot alarm		E. OP1 to E. OP3					
Parameter error		E. PE	1	1	1	1	F
PU disconnection		E. PUE					
Retry count excess		E. RET					
Output open phase protection		E. LF					
CPU error		E. CPU					

Note: 0. Output transistor off

1. Output transistor on (common terminal SE)

1.7.1 Overcurrent Protection (OC1 to OC3) COMMON

To protect the IPM from overcurrent, the output current of the inverter is detected and the following protective function activated.

Also, when the IPM is overheated due to fan stop, overload etc. the detection signal from the IPM causes the protective function to be activated.

Rated output current (100%)	Maximum current allowed to flow continuously.
Overload capacity (150% or higher)	Current allowed to flow for one minute continuously. Sufficient cooling time is required for repeated use.
Current limit activation (stall prevention activation)	Activates the current limit function.
Overcurrent shut-off (200% or higher)	Activates the protective circuit instantaneously to shut off the transistor gate. Causes the electronic thermal relay to shut off the gate to protect the transistor if a current greater this value flows continuously for a long time.

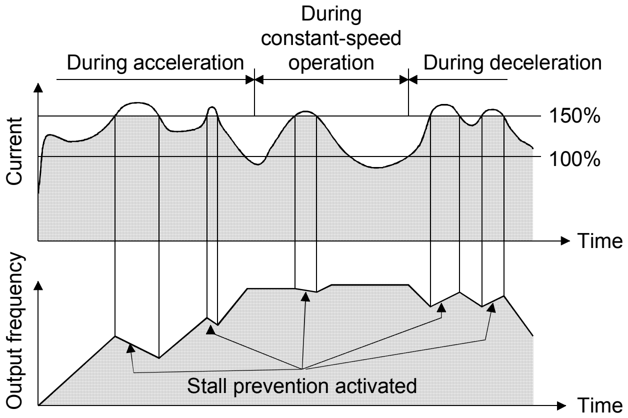
1.7.2 Stall prevention function and current limit function COMMON

Both functions are activated against the output current (factory-set activation level = 150% of the rated output current). If a rise in current is sharp, the overcurrent protection is activated because the stall prevention function cannot suppress the current. Better for current suppression (limit) capability than the stall prevention function, the current limit function has a less possibility of activating the overcurrent protection, thus ensuring operation highly resistant to overload.

You can make selection to activate these functions using Pr. 156.

Note that if an overload state persists, the electronic thermal relay (E. THT) may be operated. Unlike the stall prevention, the current limit function does not function against regenerative overvoltage during deceleration.

(1) Stall prevention (during acceleration, during constant-speed operation)
The inverter has a function for limiting the motor current. If the current reaches or exceeds 150% of the rated current, the inverter lowers the output frequency during acceleration or constant-speed operation to reduce the load current, and waits for the decrease of the load current. When the current returns to within 150%, the inverter increases the frequency again, accelerates and operates at the set frequency.
The current limit function may not be able to prevent overcurrent shut-off if the current changes suddenly as in a short circuit occurring in the output side.



Operation for Stall Prevention

(2) Stall prevention (during deceleration)
If the current reaches or exceeds 150% of the rated current, the inverter increases the output frequency to reduce the load current, and waits for the decrease of the load current. When the current returns to within 150%, the inverter decreases the frequency again and decelerates to the set frequency or to a stop.

1.7.3 Regenerative overvoltage protection (OV1 to OV3) COMMON

When the motor is decelerated by the inverter, the output frequency falls according to the deceleration time set value. When the load is light or inertia is large, the motor speed may exceed the synchronous speed and enter the power generation range. At this time, the rotation energy of the load is converted (regenerated) into electric energy and consumed by the motor itself and in the inverter.

The regenerative overvoltage function is provided to prevent the built-in capacitor terminal voltage from rising abnormally due to large regenerative energy when motor slip has increased.

Braking torque of approximately 20% of the rated motor torque is generated by the regenerative energy consumed in the motor and inverter. When the brake unit is used, braking torque of 100 to 150% of the rated torque is generated by the electrical energy consumed by the discharge resistor.

The regenerative energy of the transistorized inverter is not returned to the commercial power supply. Fit the power supply regenerating converter (FR-RC) option to return the regenerative energy to the power supply.

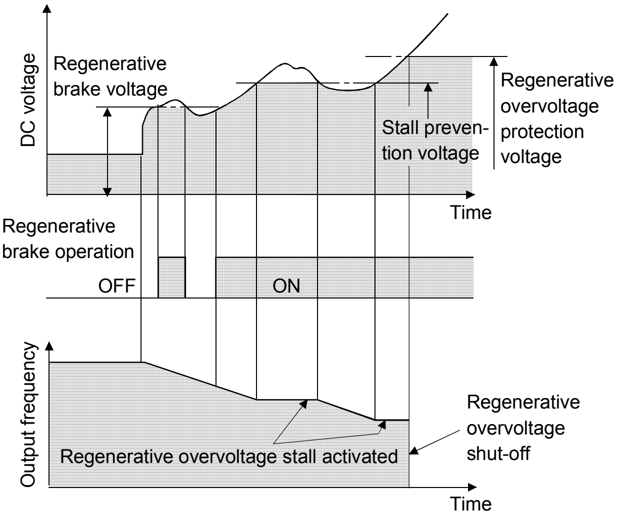
[Stall prevention]

If the regenerative energy from the motor has become excessive and the regenerative brake torque (current) has exceeded the specified value during motor deceleration, the stall prevention stops the fall of the output frequency to prevent regenerative overvoltage shut-off from being activated. If the deceleration time is extremely short or the load GD^2 is very large, the stall prevention may not be enough to prevent regenerative overvoltage shut-off.

Deceleration start ↓	
Regenerative brake operation --------------- (approximately 360VDC) (Note 1) ↓	Switches on the brake transistor to start a current in the brake discharge resistor.
Regenerative brake duty excessive ------- ↓	Stops use of the regenerative brake temporarily if the regenerative brake value exceeds the specified value. Resumes use of the regenerative brake when the brake discharge resistor has cooled down.
Regenerative overvoltage shut-off --------------- (approximately 400VDC) (Note 1)	Instantly activates the protective circuit to shut off the transistor gate.

Note: 1. The voltage values indicated are for the 200V series inverters. Double the values for the 400V series inverters.

2. The stall prevention function is not available for regenerative overvoltage during constant-speed operation. For a negative load (falling during elevating operation) which will always be in the regenerative mode, fit the power supply regenerating converter option or use the brake resistor having a sufficiently large heat capacity and the inverter having the corresponding capacity to prevent regenerative overvoltage shut-off from being activated.



Regenerative Overvoltage Stall Prevention

1.7.4 Brake resistor overheat protection and brake transistor alarm detection COMMON

(1) Brake resistor overheat protection A500

Any of the FR-A500 inverters 0.4K to 7.5K have a built-in regenerative brake discharge resistor. This brake resistor has a heat capacity 100 to 150% of the rated torque and is used for a short time (within 5 seconds continuously).

If the regenerative brake beyond the above value is required (the brake transistor ON time has exceeded the permissible value), the brake resistor overheat protection is activated to shut off the brake transistor gate. The regenerative brake may be used again when the discharge resistor has cooled after the regenerative brake is shut off.

The heat capacity can be increased by using the external brake discharge resistor instead. Refer to Section 2.1.6. The brake resistor overheat protection function is reset to the initial (cold) state by switching on the inverter power or the reset signal (across terminals RES and SD). Unnecessary reset and power-off should therefore be avoided. The inverter must not be installed on any combustible surface, such as wood, because the temperature of the built-in brake resistor reaches approximately 200°C maximum.

If the brake transistor output voltage becomes excessive during deceleration, the regenerative overvoltage protection may be activated to stop the inverter output.

(2) Brake transistor alarm detection (BE) COMMON

When the regenerative brake transistor has been damaged due to an external brake discharge resistor wiring fault etc., this function detects the fault, shuts off the inverter output, and gives the alarm output signal. When this alarm output signal is provided, shut off the inverter power supply to protect the discharge resistor from overheating.

1.7.5 Electronic Thermal O/L Relay (THM, THT) (COMMON)

(1) Function

On detecting the overload of the motor or transistor, the electronic thermal relay in the inverter stops the transistor operation and output and keeps them stopped.

(2) Characteristics

Overload shut-off (electronic thermal O/L relay operation) characteristics are shown on the next page.

- The characteristic indicated by the dotted line is valid when the motor current is 150% or greater.
- The characteristics indicated by the continuous lines are valid when the motor current is less than 150%.

  The characteristics indicated by the continuous lines can be adjusted by changing the current value of the electronic thermal relay setting. Considering the temperature-rise characteristic of the motor, the 60 minute or longer continuous operation range is divided as shown according to the frequency.
- When the electronic thermal relay dedicated to a Mitsubishi inverter-driven, constant-torque motor has been set and operation is performed at no less than 6Hz, only the operational curve indicating "30Hz or higher" functions among the characteristics on the next page if the output frequency is 6 to 30Hz.

  Note: The operation characteristic of the electronic thermal relay varies slightly depending on the output frequency. To protect the motor sufficiently, use a motor which has a built-in thermal relay.
- When the motor of up to 1.5kW is run under advanced magnetic flux vector control for (A500) or under general-purpose magnetic flux vector control for (E500), it can be run with the same characteristics as those of the electronic thermal relay dedicated Mitsubishi inverter-driven constant-torque motor.

(3) Setting the electronic thermal O/L relay

Define the protection characteristic of the electronic thermal relay on the basis of the rated current value of the motor as indicated below:

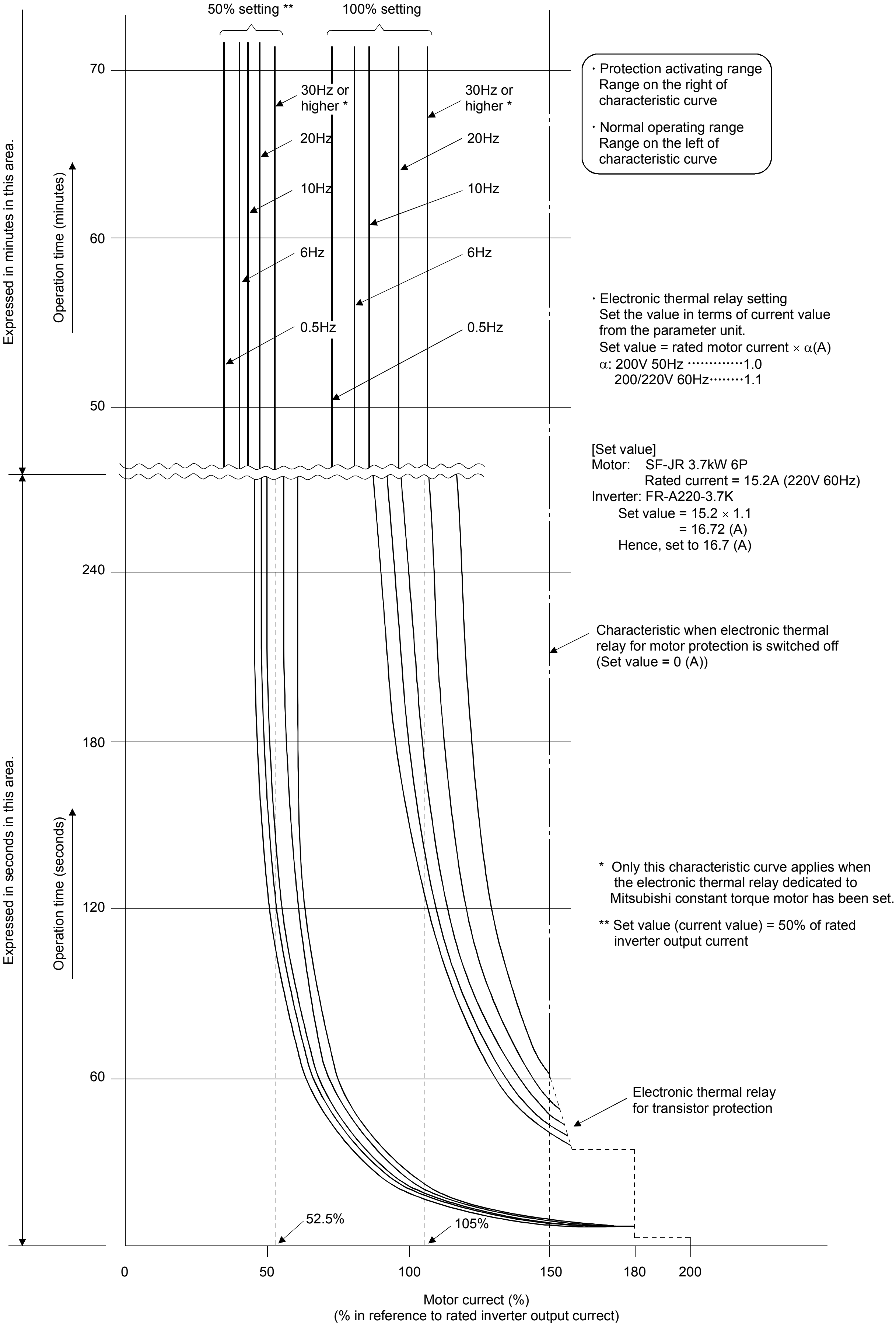
Set value = rated current value × α (A)

α: 200V (400V) 50Hz--------------------1.0
200/220V (400/440V) 60Hz-------1.1

Set the value in terms of amperes from the parameter unit. (Pr. 9)

Note: 1. The protective function using the electronic thermal relay is reset to the initial (cold) state when the inverter power is switched on or the reset signal is input. Unnecessary reset or power-off should therefore be avoided.

2. Use a thermal relay in the inverter output side when running a multi-pole motor of eight or more poles or more than one motor. In this case, when 0(A) is set to the electronic thermal O/L relay (Pr. 9,) from the operation panel (parameter unit), the electronic thermal O/L relay is turned off in the region indicated by the continuous line on the next page.



- Protection activating range
  Range on the right of characteristic curve
- Normal operating range
  Range on the left of characteristic curve

- Electronic thermal relay setting
  Set value in terms of current value from the parameter unit.
  Set value = rated motor current × α(A)
  α: 200V 50Hz ··············1.0
  200/220V 60Hz········1.1

[Set value]
Motor: SF-JR 3.7kW 6P
Rated current = 15.2A (220V 60Hz)
Inverter: FR-A220-3.7K
Set value = 15.2 × 1.1
= 16.72 (A)
Hence, set to 16.7 (A)

Characteristic when electronic thermal relay for motor protection is switched off (Set value = 0 (A))

* Only this characteristic curve applies when the electronic thermal relay dedicated to Mitsubishi constant torque motor has been set.

** Set value (current value) = 50% of rated inverter output current

Electronic thermal relay for transistor protection

Electronic Thermal Relay Operation Characteristics

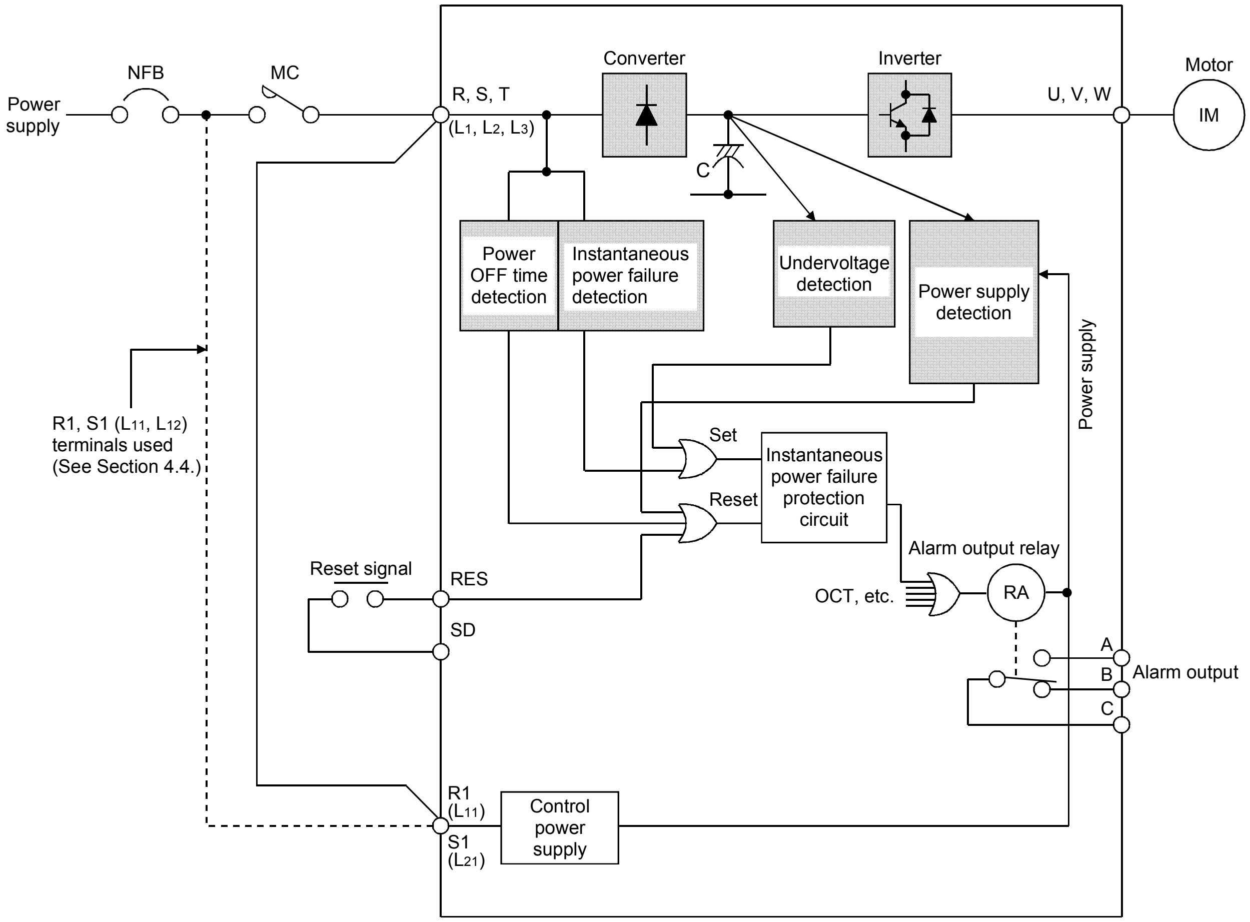
1.7.6 Instantaneous Power Failure Protection (IPF) A500

(1) Instantaneous power failure protection (IPF)
If the power supply voltage of the inverter has reduced or the power is lost due to instantaneous power failure, etc., this function activates the protective circuit and shuts off the IPM gate to stop the output.
Operation is continued properly if the instantaneous power failure is within 15ms (alarm output is not provided). If it exceeds 15ms, the instantaneous power failure protection circuit is activated to stop the inverter output. An alarm output is provided (terminals B and C are disconnected) when the instantaneous power failure is within approximately 100ms. When the power failure is longer than approximately 100ms, alarm output is not provided. (Refer to the operation timing chart in Section 1.4.1 (2), (3).)
When the power is restored after the instantaneous power failure, the inverter must be restarted after the motor has stopped completely. Set a value other than 9999 in Pr. 57 (automatic restart after instantaneous power failure) to make a restart while the motor is coasting.

(2) Power supply undervoltage protection (UVT)
Activates the protective function if the power supply voltage drops below approximately 150VAC (approximately 300VAC for the 400V series).

(3) Reset
Once activated, the instantaneous power failure protection function remains activated. To reset, switch off the start signal, then use any of the following methods:

- Connect the reset signal terminal RES and terminal SD for more than 0.1 second.
- Switch the inverter power off (for more than 0.1 second), then on.
- Use the [RESET] key of the operation panel or parameter unit to reset.
- Reset by using the help function of the PU.
- The protective circuit is automatically reset by the reset function if the power failure persists for longer than approximately 100ms.



Instantaneous Power Failure Protection Circuit Block Diagram

Explanation of the Instantaneous Power Failure Protection Circuit Block Diagram

When the inverter power supply (R, S, T terminals) is switched on, the converter smoothing capacitor (C) is charged. In the meantime, when the control power supply (R1, S1 terminals) is established, the power supply establishment pulse resets the instantaneous power failure protection circuit to the initial state. If the DC voltage of the smoothing capacitor is reduced by an instantaneous power failure (longer than 15ms and within approximately 100ms) or a power supply voltage reduction during inverter operation, the undervoltage detection circuit is activated to set the instantaneous power failure protection circuit and shut off the inverter at the gate. When the power is then restored, an alarm display is provided and the alarm output relay is switched on (terminals B-C open, A-C closed).

The reset function is activated when the inverter power remains off for more than approximately 100ms. (Alarm is not output.)

If the alarm output relay is switched on (terminals B-C open, A-C closed) by other than the instantaneous power failure protection circuit to switch off the inverter power supply MC, the control power is lost, whereby the alarm display and alarm output relay are switched off (terminals B-C closed, A-C open).

1.7.7 Inverter Status and Reset Method at Occurrence of Alarm COMMON

	Alarm Occurrence	Reset Terminal Connected	Output Stop Terminal Connected
IPM	Gate is shut off instantly.	Gate is shut off instantly.	Gate is shut off instantly.
Frequency meter display	Reset to 0Hz instantly.	Reset to 0Hz instantly.	Reset to 0Hz instantly.
Operation panel	Alarm code indication	Short terminals to erase the indication once. When terminals RES-SD are kept shorted, Err. appears.	Value being monitored is reset to 0 instantly. Note that this depends on the data monitored.
Parameter unit display	Indicates alarm definition. Frequency, current, etc. at alarm occurrence can be read in the monitoring mode.	Display is cleared once. Keep terminals RES and SD connected to display (flicker) the communication alarm display screen. Frequency and current at alarm occurrence are cleared.	Value being monitored is reset to 0 instantly. Note that this depends on the data monitored.
Alarm output (relay output)	Switched on instantly. (terminals B and C disconnected)	Switched off instantly. (terminals B and C connected)	No operation
RUN signal	Switched off instantly.	Switched off instantly.	Switched off instantly.
SU signal	Switched off instantly.	Switched off instantly.	Switched off instantly.
Reset method	Reset or switch the power off, then on.	Disconnect terminals RES - SD.	Disconnect terminals MRS - SD.

Note: If an alarm has occurred, the IPM gate is instantaneously shut off to stop the output. Hence, the inverter power may remain on. If the power is switched off by using the magnetic contactor etc., the inverter control power is lost and the alarm signal cannot be output. To keep only the alarm signal on, keep the alarm output contact (across terminals A and C) closed in the external circuit.

The alarm definition is stored in the inverter and can be read later.

1.8 Use of the Inverter with Single-Phase Power Supply

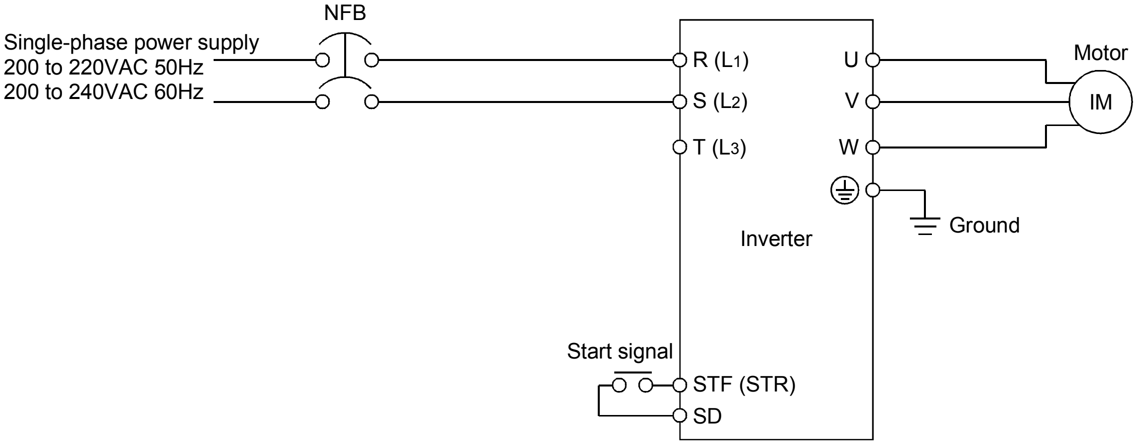
1.8.1 Use of the inverter with single-phase power supply COMMON

When the inverter is used with a single-phase power supply input, the peak of the capacitor charging current is larger than when it is used with a three-phase power supply input, increasing the temperatures of the converter and capacitor. Hence, a single-phase power supply input cannot be used at the rated output current, but may be used if the output current is made lower than that for a three-phase power supply input.

For E500, the inverters of single-phase 200V specifications are available.

Rating for Single-Phase Power Supply Input (200V Class)

Type	FR-A520-0.4K	FR-A520-0.75K	FR-A520-1.5K	FR-A520-2.2K	FR-A520-3.7K
Rated output current (A)	1.5	2.5	4	5	9
Rated output voltage	3-phase 200 to 220VAC 50Hz, 200 to 240VAC 60Hz				
Power supply voltage	Single-phase 200 to 220VAC 50Hz, 200 to 240VAC 60Hz				
Power supply capacity (kVA)	1.5	2.5	4.5	5.5	9
AC input current (A)	4.5	7.6	11.2	12.9	17.4



Example of Circuit Using Single-Phase Power Supply

Note:
1. Always connect the single-phase power supply to the power supply side terminals R, S (L_1, L_2) of the inverter.
2. Use the inverter with a power supply having sufficient capacity. If the power equipment capacity is small, the output voltage will fluctuate greatly due to load.

1.9 Instructions for Using the Inverter

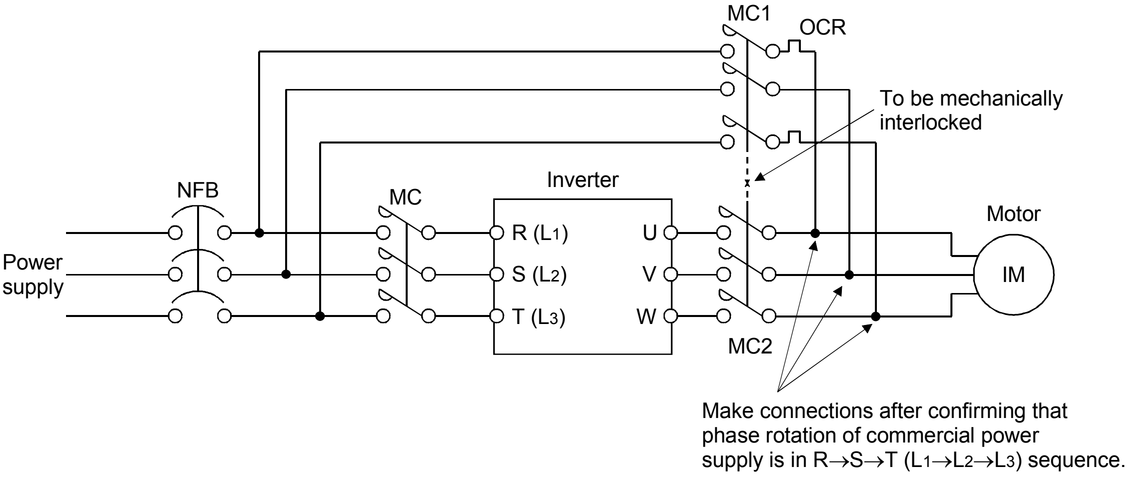
The FR series inverters are highly reliable products. However, its product life may be shortened or the product damaged if peripheral circuit assembling is incorrect or it is operated or handled inadequately. Before starting operation, always recheck the following points:

1.9.1 Instructions for the inverter output side

Do not connect the power supply to the inverter output side terminals (U, V, W).

Application of power damages the inverter module. Especially when there is a commercial power supply-inverter switch-over circuit, use mechanically interlocked magnetic contactors (MC1, MC2) as shown below to prevent accidental application of commercial power to the inverter output side. To select the magnetic contactors, refer to Section 2.6.2 and use the ones which have sufficient capacities from the magnetic switch data. If the magnetic contactors used have small capacities, they may be connected with the commercial power supply by arcs at current shut-off.

Also make connections so that the motor rotates in the same direction (phase rotation) in both the commercial power supply operation and inverter operation.



Commercial Power Supply-Inverter Switch-Over Circuit

A short circuit or ground fault on the inverter output side may damage the inverter module.

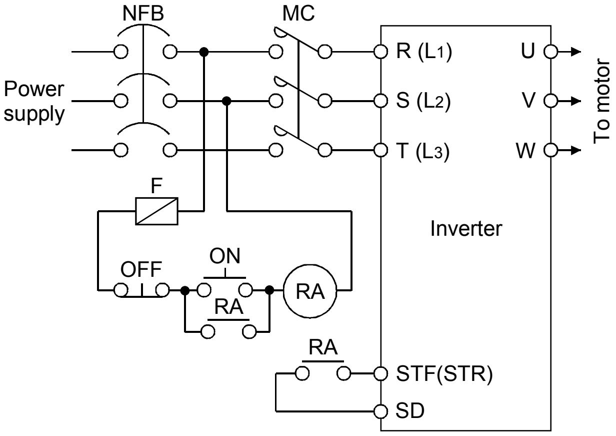
The inverter module may be damaged by short circuits repeated due to a peripheral circuit defect or a ground fault occurring due to improper wiring or reduced motor insulation resistance. Before running the inverter, fully check the circuits and insulation resistance of the circuit.

1) Before switching power on, fully check the to-ground insulation and phase-to-phase insulation in the inverter's secondary side.
   For an especially old motor or in a hostile atmosphere, securely check the motor's insulation resistance, etc.
2) When star-delta start is made during commercial power supply operation or a pole-change motor is used, make up a circuit which provides mechanical interlock and sufficient timing so that the circuit is not shorted on the inverter secondary side (including arc short).

1.9.2 Magnetic contactor on the inverter power supply side

Do not use the inverter power supply side magnetic contactor to start/stop the inverter.

As shown on the right, always use the start signal (ON-OFF across terminals STF-SD or STR-SD) to start/stop the inverter. (Refer to Section 1.4.1.)



Inverter's Start/Stop Circuit Example

1.9.3 Inverter restart

The inverter may trip if it is restarted while the motor is coasting.

When the motor is driven by the inverter, direct-on line starting is always made at a low frequency to suppress the motor starting current and the frequency is increased gradually. Hence, when the coasting motor is started by the inverter, the inverter attempts to draw the motor into the starting frequency. However, if the load energy is large, a large current may flow to the inverter side due to the power returned from the motor to the inverter, causing an overcurrent shut-off (OCT). Therefore, provide a coasting interlock circuit so that the inverter may only start the motor at a motor stop state. (Refer to Section 3.2.2.)

Since a similar phenomenon will take place when the reset (RES) terminal is used during inverter operation, note the design of the circuit. (Refer to Section 1.4.12.)

However, the fast-response current limit function of the inverter makes it difficult to trip the inverter if the inverter is restarted during coasting.

Note that the function of automatic restart after instantaneous power failure may be used to restart the inverter while the motor is coasting. (E500 may only be restarted at occurrence of an instantaneous power failure.)

1.9.4 Regenerative brake

Connect only a discharge resistor designed for external regenerative brake to terminals P and PR (+ and PR).

Do not connect an electromagnetic brake. When using an external, large thermal-capacity discharge resistor for regenerative brake, always remove the wiring of the built-in discharge resistor for regenerative brake or the jumper.

1.9.5 I/O signals

Apply only a voltage of within the permissible value to the inverter I/O signal circuits.

The I/O devices may be damaged if a voltage higher than the value indicated in Section 1.3.2 is applied to the inverter I/O signal circuits or reverse polarity is used. Before using the inverter, make sure that the frequency setting potentiometer is connected correctly across terminals 10-5 to prevent a short circuit.

1.9.6 Connection to a large-capacity power supply

When connecting the inverter near a large-capacity power supply, insert a power factor improving reactor.

The inverter input current varies with the impedance of the power supply (i.e. the power supply's power factor varies). For the power supply capacity of 1000KVA or more, insert a power factor improving reactor. (For details, refer to Section 2.4.7.)

1.9.7 Grounding

Always ground the motor and inverter.

(1) Purpose of grounding

Generally, an electrical apparatus has an earth terminal and this must be connected to the ground before use.

An electrical circuit is usually insulated by an insulating material and encased. However, it is impossible to manufacture an insulating material which can shut off a leakage current completely, and actually, a slight current flow into the case.

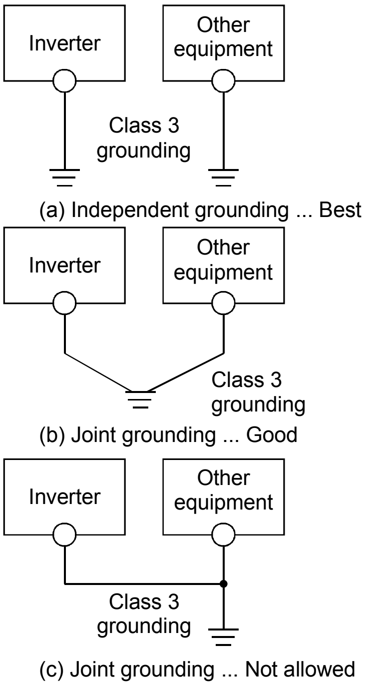
The purpose of grounding the case of an electrical apparatus is to prevent someone from getting an electric shock from this leakage current when touching it.

To avoid the influence of external noise, this grounding is important for audio equipment, sensors, computers and other apparatuses which handle low-level signals or operate very fast.

(2) Grounding methods and grounding work

As described previously, grounding is roughly classified into an electrical shock prevention type and a noise-affected malfunction prevention type. Therefore, these two types should be discriminated clearly and the following work must be done to prevent the leakage current having the inverter's harmonic components from entering the malfunction prevention type grounding:

1) Where possible, use independent grounding for the inverter. (Refer to the figure on the right.) If independent grounding ((a) in figure on the right.) is impossible, use joint grounding ((b) in figure on the right.) where the inverter is connected with the other equipment at a grounding point. Joint grounding as in ((c) in figure on the right.) must be avoided as the inverter is connected with the other equipment by a common ground cable.
   Also a leakage current including many harmonic components flows in the ground cables of the inverter and inverter-driven motor. Therefore, they must use the independent grounding method and be separated from the grounding of equipment sensitive to the aforementioned noise.
   In a tall building, it will be a good policy to use the noise-affected malfunction prevention type grounding with steel frames and carry out electric shock prevention type grounding using the independent grounding method.
2) Use Class 3 grounding (grounding resistance 100Ω or less) for the 200V class inverter, and use special Class 3 grounding (grounding resistance 10Ω or less) for the 400V class inverter.
3) Use the thickest possible ground cable. The ground cable should be of not less than the size indicated in the table on the right.
4) The grounding point should be as near as possible to the inverter to minimize the ground cable length.
5) Run the ground cable as far away as possible from the I/O wiring of equipment sensitive to noises and run them in parallel in the minimum distance.
6) Use one wire in a 4-core cable with the ground terminal of the motor and ground it on the inverter side.



Grounding Methods

Ground Cable Sizes

Motor Capacity	Ground Cable Size	
	200V class	400V class
3.7kW or less	3.5mm^2	2mm^2
5.5, 7.5kW	5.5 mm^2	3.5 mm^2
11 to 15kW	14 mm^2	8 mm^2
18.5 to 37kW	22 mm^2	14 mm^2
45, 55kW	38 mm^2	22 mm^2

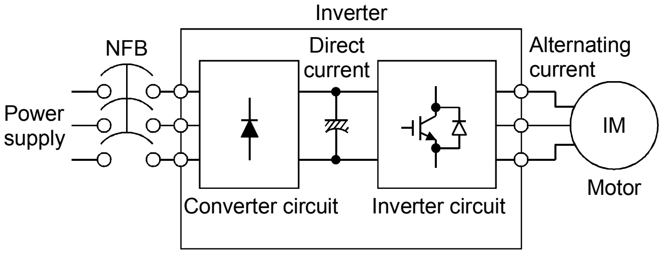
Note: The above sizes are derived from the "Electrical Equipment Baseline" issued by the Ministry of International Trade and Industry and the "Internal Wiring Regulations" issued by the Japan Electrical Association.

2 SELECTION

2.1 Selecting the Inverter

2.1.1 Principle and control system of the inverter Common COMMON

(1) Principle COMMON



Inverter Structure

The inverter rectifies commercial power into a direct current once in the converter circuit and converts it into an alternating current of desired frequency in the inverter circuit.

The speed (N) of the induction motor is expressed by the following formula:

$$N = \frac{f\ (\text{frequency})}{P\ (\text{number of motor poles})} \times (1-S)\ [\text{r/min}]$$

Where S is motor slip

By changing the frequency (f) as desired in the inverter, the motor speed can be varied freely.

Actually, when the frequency (f) is varied, the output voltage (V) is also changed to produce a sufficient motor torque.

(2) Control system

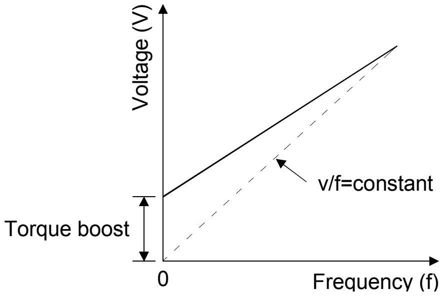
1) V/F control COMMON

When varying the frequency (f), the conventional transistorized inverter exercise control to make the ratio of frequency (f) to V (output voltage) (V/f) constant as indicated by the dotted line in the figure below. This system is therefore called V/F control.

In this system, a sufficient torque will not be developed since the actually effective voltage reduces due to a voltage drop in the wiring and motor's primary winding. This phenomenon has greater influence as the speed gets lower. (Low-speed torque will be short.)

Hence, a voltage drop is pre-estimated to increase the voltage (torque boost (Note)) as indicated by the continuous line in the figure below to compensate for the torque shortage at low speed.

To make up for this disadvantage, we developed advanced magnetic flux vector control, magnetic flux vector control and general-purpose magnetic flux vector control.



Note: If the torque boost is too large, the torque is developed sufficiently but an excessive current flows, causing the inverter to be more easily resulting in an overcurrent (OCT) trip.

Comparison between Mitsubishi Transistorized Inverter Control Systems

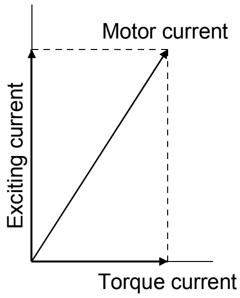
Item		V/F control	General-Purpose Magnetic Flux Vector Control	Magnetic Flux Vector Control	Advanced Magnetic Flux Vector Control
Motor used with inverter		Standard motor (Mitsubishi, others)	Standard motor (Mitsubishi, others)	Standard motor (Mitsubishi, others)	Standard motor (Mitsubishi, others)
Auto tuning function		Unnecessary	Unnecessary	As standard	As standard
Starting/low-speed torque (Short time)		1Hz: 30% or less 3Hz: 30% 6Hz: 80%	1Hz:30% to 50% 3Hz: 150% 6Hz: 200%	1Hz: 150% 3Hz: 150% 6Hz: 150%	0.5Hz: 150% 3Hz: 150% 6Hz: 150%
Speed detector (PLG)		Unnecessary	Unnecessary	Unnecessary	Unnecessary
Speed control range		1:10	1:15	1:20	1:120 (driving mode)
Slip compensation	Yes/No	Not provided	Not provided [Slip compensation parameters provided individually]	Provided	Provided
	Charac-teristic	Speed fluctuation ratio: 2 to 5% (Depends on load magnitude)	Speed fluctuation ratio: 2 to 5% (Depends on load magnitude)	Speed fluctuation ratio: 1% (Not influenced by load)	Speed fluctuation ratio: 1% (Not influenced by load)
Torque control		Not provided	Not provided	Not provided	Not provided
Speed control		Enabled by PLG + option	Not provided	Enabled by PLG + option	Enabled by PLG + option
Control response level		10 to 20rad/s	20 to 30rad/s	20 to 30rad/s	20 to 30rad/s
Applications		Fan, pump, general industrial machines, etc.	General industrial machines, transfer machines, etc.	General industrial machines, transfer machines, vertical lift applications, etc.	General industrial machines, transfer machines, vertical lift applications, etc.
Applicable models		All models of FR series	FR-A024, FR-E500 series	FR-A200, FR-A201 series	FR-A500 series

2) General-purpose magnetic flux vector control E500

The output current of the inverter is divided into an exciting current and a torque current by vector operation and the voltage is compensated for to flow a motor current which meets the load torque, thereby improving the low-speed torque. This system provides a high (200%) torque at 6Hz.

If the motor constants vary slightly (when the inverter is used with the another manufacturers motor, for example), this system provides a stable, large, low-speed torque without specific motor constant setting or tuning, achieving high versatility.

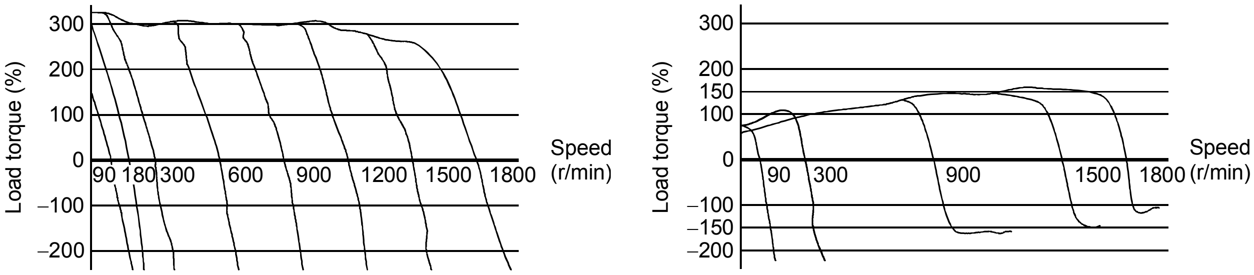
As the inverter pre-stores the motor constants required for arithmetic operation, simply setting the motor capacity executes the general-purpose magnetic flux vector control.



The output current (motor current) of the inverter is divided into an exciting current (current required to generate a magnetic flux) and a torque current (current proportional to load torque) by vector operation according to each phase of the current relative to the output voltage. (Refer to the figure on the right.)

When the motor current varies due to load fluctuation, the voltage drop of the motor's primary side (including the wiring) also changes, affecting the magnitude of the exciting current.

This voltage drop is found from the motor and primary wiring constants and torque current magnitude, and the output voltage of the inverter is compensated for (increased/decreased) to keep the primary magnetic flux of the motor constant.

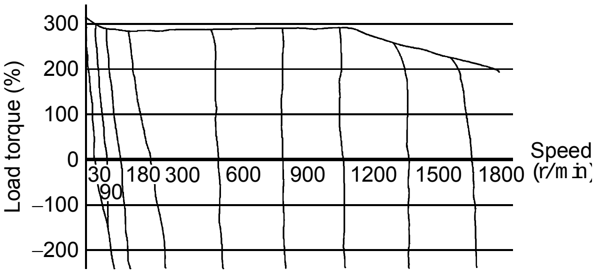


(a) General-purpose magnetic flux vector control (b) V/F control

Speed-Torque Characteristic Example for General-Purpose Magnetic Flux Vector Control
(use of inverter with 0.75kW 4-pole motor)

Also, the motor speed varies with load fluctuation. You can choose the slip compensation function which estimates the motor slip from the output current of the inverter to keep the motor speed constant. (The control method is different from that of A500.)

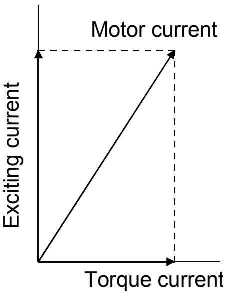
At this time, the torque characteristic is as shown on the right.



Speed-Torque Characteristic Example for General-Purpose Magnetic Flux Vector Control when Slip Compensation Is Selected
(Use of inverter with 0.75kW 4-pole motor)

3) Advanced magnetic flux vector control A500

The output current of the inverter is divided into an exciting current and a torque current by vector operation and the frequency and voltage are compensated for to flow a motor current which meets a load torque, thereby improving a low-speed torque and speed accuracy. This system provides a high (150%) torque at 0.5Hz. The output current (motor current) of the inverter is divided into an exciting current (current required to generate a magnetic flux) and a torque current (current proportional to load torque) by vector operation according to each phase of the current relative to the output voltage. (Refer to the figure on the right.)

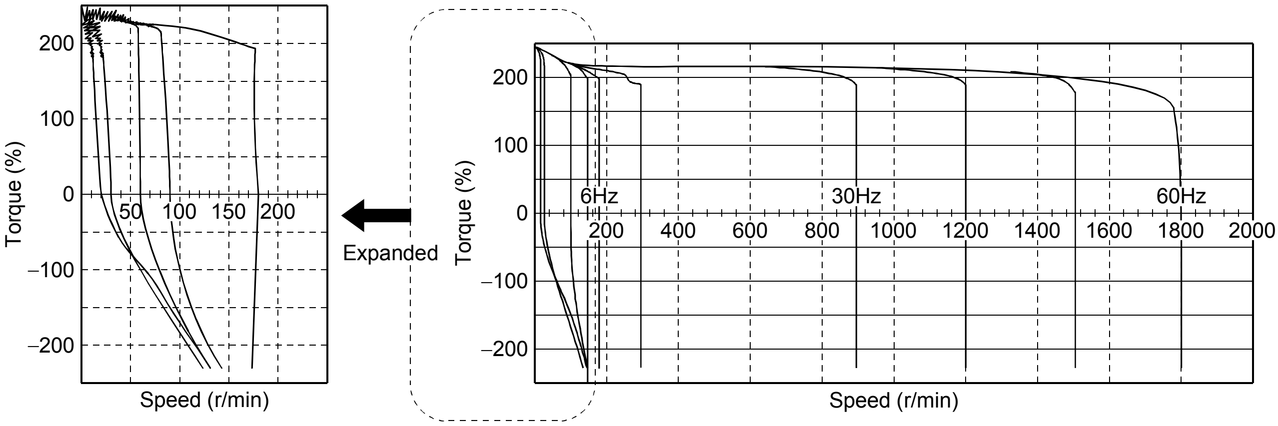


The actual motor speed is estimated from the torque current and the output frequency is compensated for (increased/decreased) to achieve the preset speed. <Slip compensation>

When the motor current varies due to load fluctuation, the voltage drop of the motor's primary side (including the wiring) also changes, affecting the magnitude of the exciting current.

This voltage drop is found from the motor and primary wiring constants and torque current magnitude, and the output voltage of the inverter is compensated for (increased/decreased) to keep the primary magnetic flux of the motor constant.

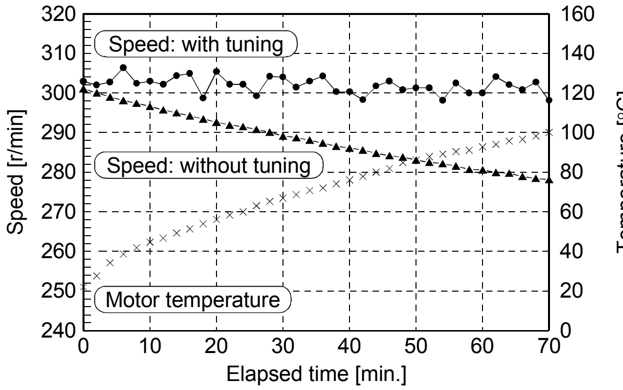
★ Advanced magnetic flux vector control is different in grey-shadowed areas from general-purpose magnetic flux vector control and can develop a high torque down to a low speed.



Speed-Torque Characteristic Example for Advanced Magnetic Flux Vector Control
(Online auto tuning selected, inverter used with 3.7kW 4-pole motor)

Also, when the online auto tuning is selected, the motor is tuned rapidly when starting, allowing high-accuracy operation unaffected by motor temperatures and high-torque, stable operation down to an ultra-low speed.

The motor temperature-speed fluctuation characteristic example is shown on the right.



Motor Temperature-Speed Fluctuation Characteristic Example
(SF-JR 3.7kW 4-pole motor)
(Online auto tuning selected, repeated operation at 90% duty)

2.1.2 Rated capacity of the inverter COMMON

The rated capacity of the inverter is calculated on the basis of the rated output current.

Rated inverter capacity (kVA)
$=\sqrt{3} \times$ rated output voltage (V) $\times$
rated output current (A) $\times 10^{-3}$

The rated output current is a current value which the inverter can output continuously at the rated output voltage. The inverter must always be used at no more than this current value.
The overload capacity is defined as the permissible value of a current beyond the rated output current of the inverter. The overload capacity of the FR-A500, FR-E500 series inverter is 150% for one minute. At a start or for instantaneous overload, the inverter must be used at not more than the overload capacity.
The capacity of the transistorized inverter is classified on the basis of the rated motor output (kW). This rated capacity applies to the operation of one general-purpose squirrel-cage induction motor of two to six poles especially when there are no restrictions on acceleration time and starting torque. The capacity must be selected accordingly when running a special motor or driving several motors in parallel by one inverter, or when an operation pattern or load torque has been specified.

(1) Operation of one motor COMMON
Select the inverter to satisfy the following condition:

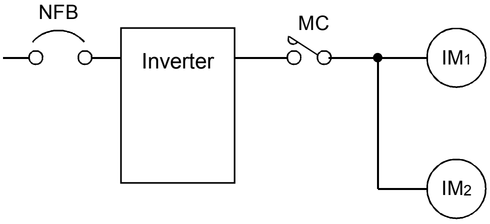
Rated inverter output current ≥
rated motor current × 1.1

(The current that flows when a standard motor is driven by the inverter is about 1.1 times larger than the current that flows when the motor is run with the commercial power supply.)

Note: When the inverter is used continuously at rated torque at 50Hz, note the permissible continuous torque of the motor.
For more information, refer to the catalog/manual of the corresponding inverter series.

(2) Operation of two or more motors COMMON
When two or more motors are connected to one inverter and the output side magnetic contactor is used to start/stop the motors during inverter operation, how to select the inverter capacity differs depending on how start-up is made.

1) Simultaneous start

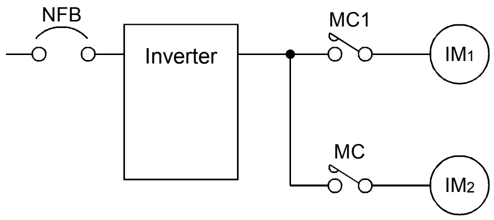


When two or more motors are always switched on-off at the same time, select the inverter to satisfy the following condition:

Rated inverter output current ≥
sum of rated currents of all motors × 1.1

[Example] Operation of three SF-JR 1.5kW 4-pole motors (rated current 6.0A, starting current 48.4A)
Select the FR-A520-5.5K inverter rated at (6.0A × three motors × 1.1) 19.8A or more and having current limit function.

2) Sequential start



When motors are started from the first one. When the current limit function is activated, the frequency changes abruptly. In a sequential start, therefore, the speeds of the motors already started change suddenly. According to the machine specifications, therefore:

- When the fast-response current limit function of the inverter is utilized to minimize the inverter capacity
  Rated inverter output current ≥ sum of rated currents of all motors × 1.1

- When it is not desired to affect the motors already started <The point is to make selection so that the current limit function is not activated>
  Rated inverter output current ≥ sum of rated currents of motors already started × 1.1 + starting current of motor started last (Note)

Note: Motor starting current: Select the inverter so that the starting current of the motor is 6 to 8 times greater than the rated current of the motor.

[Example] Operation of three SF-JR 1.5kW 4-pole motors (rated current 6.0A, starting current 48.4A)

- When the fast-response current limit function of the inverter is utilized to minimize the inverter capacity
  Select the FR-A520-5.5K inverter rated at (6.0A × three motors × 1.1 =) 19.8A or more and having current limit function.
- When it is not desired to affect the motors already started
  Select the FR-A520-18.5K inverter rated at (6.0A × two motors × 1.1 + 48.4A =) 61.6A or more and having current limit function.

(3) Light motor load COMMON

If the load is extremely light as compared to the rated torque of the motor used, the motor current is smaller than the rated current. Hence, cost may be reduced by using an inverter having a smaller rated capacity than the motor capacity. In this case, the following must be noted in determining the rated inverter capacity:

An exciting current (no-load current), 30 to 50% of the rated motor current, flows in a standard motor, if under no load. For this reason, an inverter with extremely small rated capacity cannot be used.

Under a light load, the ripple factor of the current is higher than that under a rated load if the effective current value is the same. Since the inverter detects the instantaneous crest value of the motor current to provide protection against overcurrent, the current limit function may be activated at the crest value due to a ripple even if the effective current value is small.

For light-load operation, therefore, it is the best policy to select the inverter capacity which corresponds to the capacity of the motor used.

(4) Special motor (e.g. constant-torque motor dedicated to inverter use)

Different in motor electrical circuit constants from a standard motor, a motor dedicated to inverter for increased torque at low frequency may be more instable in motor characteristic or be larger in current ripple especially in the low frequency range (about 20Hz or less). When the inverter is used with such a special motor (different in electrical design from the standard motor), select the inverter capacity after fully checking the motor characteristics, noting the following:

1) Choose the inverter capacity one or two ranks higher than the standard.
2) Match the V/F pattern with the motor characteristic using Pr. 0 (torque boost).
3) Insert a reactor (FR-BOL) in the inverter output circuit to suppress the current ripple of the motor.

(5) For selection of the advanced magnetic flux vector control system (A500)

Select the advanced magnetic flux vector control for a load which requires a large starting torque (1Hz 150% torque) or a load which requires a 130 to 140% average acceleration torque to decrease the acceleration time.

The advanced magnetic flux vector control may only be used under the following conditions:

1) The applied motor is a standard squirrel-cage motor (2, 4 or 6 poles) or constant-torque motor (4 poles).
2) The inverter capacity is equal to or one rank higher than the motor capacity.
3) The number of motors connected to the inverter is one, i.e. single-motor operation.

★ If the motor used is other than the above requirement as stated in 1), perform auto tuning.

(6) For selection of the general-purpose magnetic flux vector control system (E500)

Select the general-purpose magnetic flux vector control when you need a large starting torque (3Hz 200% torque) for a small capacity or when it is desired to shorten the acceleration time.

When choosing the general-purpose magnetic flux vector control, set the capacity (kW) of the applied motor.

When using a constant-torque motor, set "1". (constant-torque motor) in Pr. 71 (applied motor selection).

When using the general-purpose magnetic flux vector control mode, there are the following restrictions:

1) Standard squirrel-cage motor (0.1kW or more) whose capacity is equal to or one rank lower than the inverter capacity. 200V class 4-pole constant-torque motor (SF-JRCA) is applicable to 0.4 to 3.7kW.
2) The number of motor poles is 2, 4 or 6. (4 poles only for constant-torque motor) You need not set the number of motor poles.
3) Single-motor operation (one motor is run by one inverter).

If any of the above conditions are not satisfied, excellent operation characteristics may not be provided.

2.1.3 Starting Torque and Starting Current of the Motor (COMMON)

When the general-purpose motor is full-voltage started with the commercial power supply, the starting current is generally about 6 to 7 times larger than the rated motor current and the motor starting torque is approximately 150 to 250% of the rated motor torque.

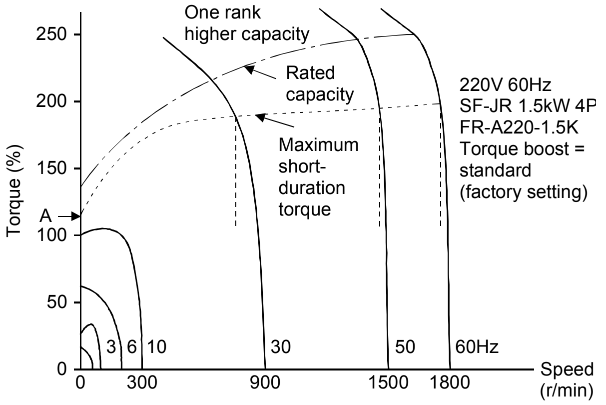
However, the starting and acceleration characteristics of the motor used with the inverter are restricted by the overload capacity of the inverter used and are different from those when the motor is full-voltage started with the commercial power supply.

Since the motor is accelerated with the motor starting/acceleration current kept within the overload capacity (150% of the rated output current) of the inverter, the starting torque and acceleration torque are smaller than those when the motor is full-voltage started with the commercial power supply. Speed-torque and speed-current characteristic examples of the general-purpose motor are as shown in the figures on the right. When the motor is used with the inverter of the corresponding capacity, the torque at the speed corresponding to the intersection of (150% of the rated inverter output current) and the current characteristic at each frequency is the maximum torque (short-duration rating) generated by the motor. In the example shown on the right, the starting torque at the speed of 0 is 118% (point A).

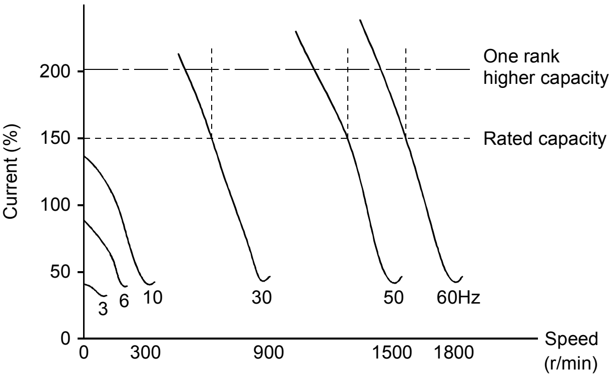
When the capacity of the inverter used with the motor is increased by one rank, the starting torque and maximum torque increase in proportion to the rise in overload capacity as shown on the right. When the starting torque and acceleration torque are insufficient, it is effective to increase the inverter capacity by one rank.

Changing in proportion to the square of the voltage, the motor-generated torque is influenced by the inverter output voltage.

Since the output voltage of the FR series inverter changes in proportion to the change in input voltage (power supply voltage) of the inverter, the motor speed varies, changing the motor current.



V/F Control Speed-Torque Characteristic



V/F Control Speed-Current Characteristic

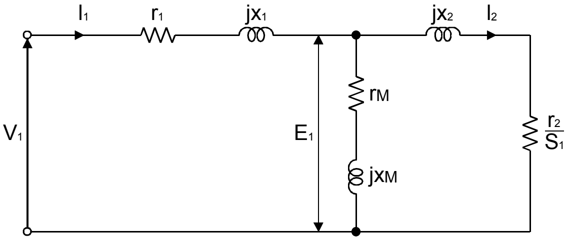
2.1.4 Starting Torque Boost COMMON

The ideal constant-torque characteristic is provided when the ratio of the inverter output voltage (V) to output frequency (f) is as indicated by the broken line in the figure on the right and the torque characteristic in the constant V/f control area is as indicated by the continuous line in the figure on the right. In the low frequency area, however, since the airgap magnetic flux of the motor, i.e. E_1/f, is reduced by a voltage drop due to the primary resistance (r_1) of the induction motor as shown in the motor equivalent circuit (Refer to the figure on the right), the motor torque drops as indicated by the broken line in the figure on the right.

To prevent the torque from reducing at low frequencies, compensate for the voltage drop due to the primary resistance to compensate for the inverter output voltage as indicated by the continuous line in the figure on the right. This allows the airgap magnetic flux to be approximately constant and the torque characteristic to be close to the constant torque characteristic as shown in the figure on the right.

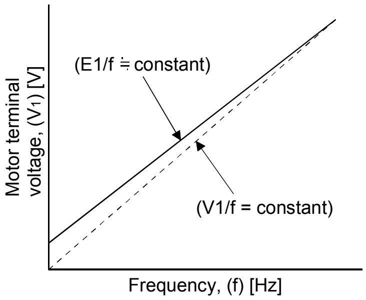
The FR series inverters have a function to adjust the inverter output voltage (torque boost). When the starting load torque is large, the primary motor current (I_1) is higher than in the equivalent circuit in right figure and E_1 is reduced by the voltage drop of the primary resistance (r_1). To compensate for this, the torque boost function raises the inverter output voltage.

For details of the torque boost, refer to Section 1.6.9.

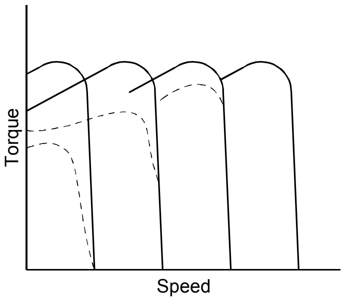


V_1: Primary phase voltage
I_1: Primary current
I_2: Secondary currecnt (value converted to the primary side)
r_1: Primary resistance
r_2: Secondary resistance (value converted to the primary side)
r_M: Iron loss resistance
x_M: Exciting teactance
x_1: Primary leak reactance
x_2: Secondary leak reactance (value converted to the primary side)
S_1: Slip

Equivalent Circuit of the Motor



Terminal Voltage versus Frequency



Torque Characteristic

2.1.5 Acceleration/Deceleration Time of the Motor COMMON

To suppress the motor starting current within the overload capacity of the inverter, start the motor at a low frequency (factory set to 0.5Hz) and increase the frequency little by little. When the motor is decelerated from the set frequency, gradually decrease the frequency to prevent the DC bus voltage from being increased excessively by the regenerative energy from the motor. For these reasons, when the motor is accelerated and decelerated by the inverter, the acceleration time and deceleration time between zero and the maximum frequency must be set in advance.

(1) Setting the acceleration time and deceleration time COMMON

The acceleration time and deceleration time set must be longer than those found from the torque generated by the inverter-driven motor, the load torque, and the motor and load inertia (GD^2).

If the acceleration time setting is too short, the overcurrent protective function (OC1) is activated to stop the inverter. If the deceleration time setting is too short, the overcurrent protective function (OC3) or regenerative overvoltage protective function (OV3) is activated to stop the inverter.

The acceleration or deceleration time (function number Pr. 7 or Pr. 8) value set from the parameter unit (PU) is the length of time between zero and the acceleration/deceleration reference frequency (function number Pr. 20).

The time required to reach the set frequency can be calculated by proportion as indicated in Exercise 1. The frequency is found from the operating speed and the number of motor poles by using the formula below, with slip ignored:

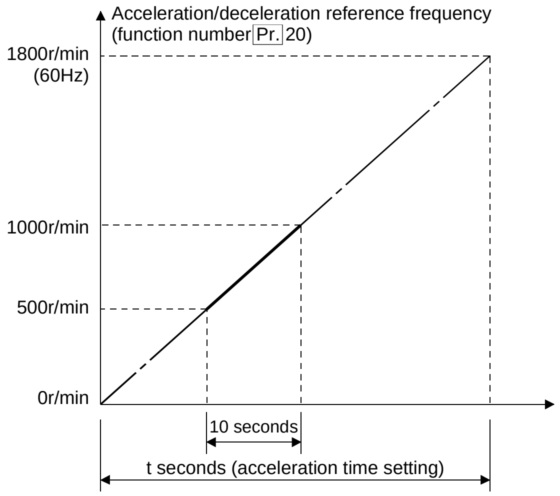
$$\text{Frequency [Hz]} = \frac{\text{speed [r/min]} \times \text{number of poles}}{120}$$

Exercise 1:

When a four-pole motor is accelerated from 500 to 1000rpm in 10 seconds, acceleration time setting is as follows (assuming that the acceleration/deceleration reference frequency is the factory setting of 60Hz):

$$t = \frac{1800\text{r/min}}{(1000 - 500)\text{r/min}} \times 10\text{s} = 36\text{s}$$

Hence, the acceleration time (Pr. 7) is set to 36 seconds.

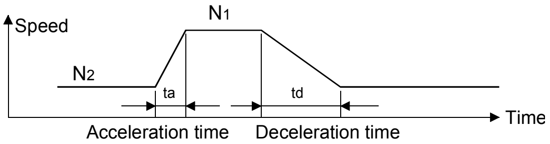


Acceleration Time Setting

Note : When the acceleration time or deceleration time is set without enough examination, set a long time and check during operation that the OL display on the parameter unit is not lit.

When this display is not lit, reduce the set value and make the test again. Repeat this operation until the optimum acceleration or deceleration time is obtained.

(2) Calculation of acceleration and deceleration COMMON



Acceleration/Deceleration Operation Pattern

★ For full information on how to calculate acceleration and deceleration times, refer to any of the following manuals according to the operation pattern:

- Technical Note No. 22 : Capacity Selection (Data Part)
- Technical Note No. 23 : Capacity Selection (Continuous Operation)
- Technical Note No. 24 : Capacity Selection (Cyclic Operation)
- Technical Note No. 25 : Capacity Selection (Elevating Operation)

1) Expressions for calculating the acceleration and deceleration times (simple method)

$$\text{Acceleration time (ta)} = \frac{GD^2{}_T \times \Delta N}{38.2 \times (T_M \times \alpha - T_L\text{max})} + tc \text{ [sec.]}$$

$$\text{Deceleration time (td)} = \frac{GD^2{}_T \times \Delta N}{38.2 \times (T_M \times \beta + T_L\text{min})} \text{ [sec.]}$$

where,

$GD^2{}_T$: Full GD^2 = motor $GD^2{}_M$ + load $GD^2{}_L$ (reduced to an equivalent GD^2 at the motor shaft) [kgf ·m^2]

ΔN : Difference between motor speeds before and after acceleration/ deceleration $N_1 - N_2$ [r/min {rpm}]

T_M : Rated motor torque

$$T_M = \frac{9550 \times P}{N} \quad \text{[N·m\{·m\}]}$$

$T_L$max : Maximum load torque (reduced to an equivalent GD^2 at the motor shaft) [N ·m {kg ·m}]

$T_L$min : Minimum load torque (reduced to an equivalent GD^2 at the motor shaft) [N ·m {kg ·m}]

α : Acceleration torque coefficient (Note)

β : Brake torque coefficient (regenerative braking torque factor) (Note)

P : Rated motor output [kW]

N : Motor synchronous speed at 60Hz [r/min {rpm}]

Note: Refer to the Technical Note No. 22 (Data Part).

2) Calculation and setting example of the acceleration and deceleration times (non-linear acceleration mode)
Make calculations and settings as described below according to the running frequency actually used
(Maximum output frequency = 60Hz)
Use α and β in the Technical Note No. 22 (Data Part).

$N_2 = 0$

$$N_1 = \frac{120 \times \text{acceleration/deceleration reference frequency (} \boxed{\text{Pr.}}\text{20)}}{\text{number of motor poles}}$$

Calculate ta and td and set the acceleration and deceleration times as follows:
Acceleration time (Pr. 7) > ta
Deceleration time (Pr. 8) > td

When rapid response is required, set the smallest values to a degree that expressions are satisfied. When slow acceleration and deceleration are required, set to the required times.

Exercise 2 : Calculated in the conventional unit system

A conveyor is driven by the SF-JR 2.2kW 4P motor and FR-A520-2.2K inverter (V/F control). Suppose that $GD^2_M = 0.035$ [kgf ·m^2], $GD^2_L = 0.15$ [kgf ·m^2], $T_L max = 9.8$ [kg ·m], $T_L min = 5.88$ [kg ·m], and the acceleration and deceleration times are as short as possible

$GD^2_T = 0.035 + 0.15 = 0.185$ [kgf ·m^2]

$$\Delta N = N_1 - N_2 = \frac{120 \times 60}{4} - 0 = 1800 \text{[rpm/min]}$$

(When the acceleration/deceleration reference frequency is the factory setting of 60Hz.)

$$T_M = \frac{9550 \times 2.2}{1800} 11.67 \text{ [kg ·m]}$$

From Technical Note No. 22 (Data Part)
Supposing that the torque boost is standard, $\alpha = 1.25$

$$ta = \frac{0.185 \times 1800}{38.2 \times (11.67 \times 1.25 - 9.8)} = 1.82 \text{ [seconds]}$$

$\beta = 1.0$

$$td = \frac{0.185 \times 1800}{38.2 \times (11.67 \times 1.0 + 5.88)} = 0.50 \text{ [seconds]}$$

Hence, set the acceleration time to 1.9 seconds or longer and the deceleration time to 0.5 seconds or longer.

(3) When there is a restriction on acceleration time (linear acceleration mode) COMMON

The acceleration and deceleration times found in the preceding section are those for the non-linear acceleration mode in which the motor is accelerated to prevent the overcurrent protection from being activated even when the stall prevention function of the inverter is activated. When the stall prevention is activated, the acceleration and deceleration times may become longer than their set values. When in the linear acceleration mode in which the motor is accelerated to prevent the stall prevention from being activated so that the acceleration and deceleration times match the cycle time, or when the acceleration time found by expression has exceeded the required value, select the magnetic flux vector control mode (set function numbers Pr. 80 and Pr. 81), raise the torque boost (adjust the function number Pr. 0), or increase the inverter capacity to raise the inverter current immunity during acceleration. Alternatively, the motor capacity may be increased (and the inverter capacity increased at the same time) to raise the motor acceleration torque.

2.1.6 Deceleration Characteristic of the Inverter COMMON

To shorten the acceleration time, the torque boost is raised or the inverter capacity or motor capacity is increased. To reduce the deceleration time, add a brake unit or increase the capability of the built-in brake (increase the inverter capacity).

When the motor is decelerated by the inverter, the inverter gradually lowers the output frequency at a slope of the set deceleration time. If you try to decelerate the motor in a shorter time than when it is coasted to a stop, the motor is run at not less than the synchronous speed of the given frequency. Hence, the motor acts as an induction generator and its rotating energy is partly consumed in the motor winding and partly accumulated in the capacitor inside the inverter. This energy is consumed by the discharge resistor to provide the resultant braking action of the motor.

[Built-in brake resistor protection] A500

Any inverter of 7.5K and below is provided on its rear surface with a discharge resistor for regenerative braking. When the brake resistor is used up to its rating, the temperature rises considerably. The inverter has a protective function to protect this resistor against use beyond its rating. When this protective function is activated, the built-in brake circuit is shut-off to disable the braking action. Therefore, the terminal voltage of the capacitor rises to activate the regenerative overvoltage shut-off (OV1 to OV3), coasting the motor to a stop. Since this protective function returns to the initial state when the inverter is reset, the brake resistor is regarded as cold at the time of automatic restart. Note that operation performed by repeating reset will cause the brake resistor to overheat.

Note: The brake discharge resistor on the rear surface of the inverter unit will rise to a high temperature. Carefully select the installation place of the inverter.

★For full information on how to select the brake resistor, brake unit and other braking units, refer to any of the following manuals according to the operation pattern:

- Technical Note No. 22 : Capacity Selection (Data Part)
- Technical Note No. 23 : Capacity Selection (Continuous Operation)
- Technical Note No. 24 : Capacity Selection (Cyclic Operation)
- Technical Note No. 25 : Capacity Selection (Elevating Operation)

(1) Built-in brake unit A500

The built-in brake can provide 100 to 150% of the rated motor torque but must be used within 5 seconds (duty: less than 2 to 3%ED). Select the inverter which satisfies the conditions after finding the permissible duty time, as in the Technical Note No. 22 (Data Part).

When a higher brake duty is required, select the external brake resistor or brake unit in accordance with Paragraphs (2) or (4). In this case, disconnect the link from the built-in brake resistor.

1) The maximum braking torque (% relative to the motor output used with the inverter) value of the built-in brake unit is shown in Section 1.1.1. When the braking torque required is above this value, the inverter capacity must be increased. The addition of the external brake resistor does not increase the braking torque.

2) The regenerative braking duty (Pr. 70) value of the built-in brake resistor is indicated in Section 1.1.1. if the duty required is above this value, use the external brake resistor (FR-ABR, MYS, MRS) or brake unit (BU, FR-BU).

* When further larger braking capability is required, fit the power supply regenerating converter (FR-RC).

(2) External brake resistor COMMON

When the inverter is used in excess of the maximum duty of the built-in brake resistor, the external brake resistor may be installed. In this case, the link across PX on the built-in brake resistor must be disconnected.

Note: The A500 11K or greater and E500 0.2K or less cannot use an external brake resistor.

(3) DC dynamic braking COMMON

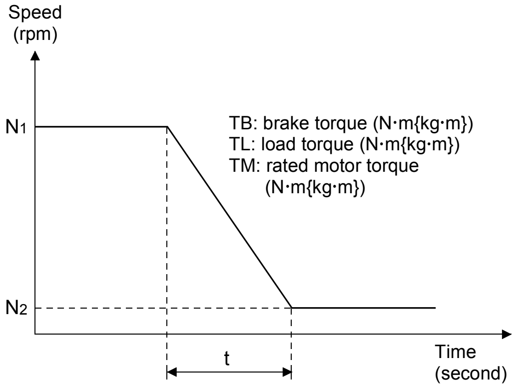
The DC dynamic brake is applied during deceleration. Since the braking torque generated by the DC dynamic brake depends also on the winding resistance of the motor, it cannot be determined uniformly, but an average of more than 50% braking torque is provided in the factory-set state.

In addition, the setting of the DC dynamic brake time (Pr. 11), DC dynamic brake voltage (Pr. 12) and DC dynamic brake frequency (Pr. 10) allows the positioning accuracy to be adjusted according to the load.

(4) Selection of the BU brake unit COMMON

The BU brake unit is used when the brake capability required is greater than that of the built-in brake unit or external brake resistor. In this case, the capability of the built-in brake unit is not added to that of the BU brake unit.

To select the BU brake unit, determine the required deceleration pattern as shown below.



Deceleration Pattern

1) Calculate the brake torque required to decelerate the motor in the determined deceleration pattern:

$$T_B = \frac{GD^2T \times (N_1 - N_2)}{38.2 \times t} - T_L\text{min [N} \cdot \text{m]}$$

2) Calculate the percentage of the calculated torque (T_B) to the rated torque of the motor used (T_M) to find the required brake torque coefficient (β) :

$$\text{Brake torque coefficient } (\beta) = \frac{T_B}{T_M}$$

3) From the Technical Note No. 22 (Data Part), select the brake unit which satisfies the brake torque coefficient (β).

4) Using the following expression, find the power WMECH returned from the load, and using the data manual, make sure that the intersection of the deceleration time of t seconds and the permissible brake unit power (W_{RS}) is below the curve of the brake unit used (refer to the Technical Note No. 22 (Data Part)). (The motor-

compensated power is ignored. For more information, refer to the Technical Notes No. 23 to No.25.)

$W_{MECH} = 0.1047 \times T_B \times (N_1 + N_2)/2$ [W]

5) When using the brake unit frequently (more than 10 times/hour as a guideline), ensure that the value calculated by the following expression is within the permissible continuous power(W_{RC}) (refer to the Technical Note No. 22 (Data Part)).

$$W = W_{MECH} \times \frac{\text{brake operation time}}{\text{1-cycle time}} \text{ [W]}$$

Exercise 3 : Calculated in the conventional unit system

It is desired to decelerate a 3.7kW 4P motor from 1750 to 0rpm in two seconds.

Assuming that:

Load torque (T_L) (reflected to the motor shaft)
: 10% of 3.7kW 4P = 1.96 [N · m]

Load GD^2_L (reflected to the motor shaft)
: 10 times greater than 3.7kW 4P = 0.73 [kgf · m^2]

Rated motor torque (T_M) : 19.9 [N · m] on 3.7kW 4P

The brake torque is calculated as follows:

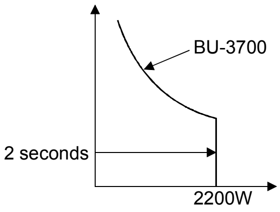
$$T_B = \frac{(0.073n + 0.73)}{38.2 \times 2} \times (1750 - 0) - 1.96 = 16.4\ [N \cdot m]$$

$$\text{Brake torque coefficient } (\beta) = \frac{T_B}{T_M} = \frac{16.4}{19.9} = 0.82$$

Since the brake torque coefficient (β) must be 0.82 or higher, select the brake unit combination, in which the brake torque coefficient (β) = 1.0, from the Technical Note No. 22 (Data Part). Hence, the brake unit used in this case is the BU-3700.

W_{MECH} = 0.1047 × 16.4 × (1750 + 0)/2 = 1502 [W]

Since the energy of 2200 [W] is consumed in two seconds, the BU-3700 brake unit can be used according to the data manual. (1502 [W] < 2200 [W])



Exercise 4 :

It is desired to repeat the start and stop of the load used in Exercise 3 at intervals of 15 seconds.

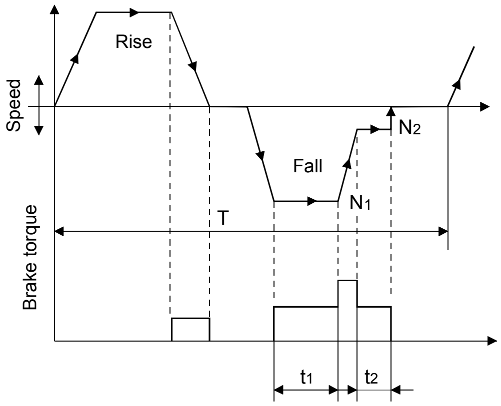
$$W = 1502 \times \frac{2}{15} = 200\ [W]$$

The BU-3700 can be used because its permissible continuous power is 300W according to the data in the manual. In addition to this calculation, it is also necessary to examine whether the motor may be used repeatedly.

(5) Continuous use of the BU brake unit COMMON

When the motor is used in the brake region, select a brake unit which satisfies the condition that the brake resistor power consumed continuously is not more than the permissible continuous power of the brake unit.

When a negative load is operated repeatedly as shown below, find the power returned from the load in the whole region where the negative load is applied during other than deceleration and check that it is within the permissible continuous power (W_{RC}) in the Data Part of Technical Note 22.



Operation Pattern of the Continuous Regenerative Duty Load

(6) Combination of the brake unit and inverter COMMON

A larger brake unit may be required when the repeated use of the brake unit is frequent or a negative load is driven. When a larger brake unit is used, the inverter capacity must also be increased. When higher brake capability is required, select the FR-RC power supply regenerating unit.

2.2 Motor Characteristics

2.2.1 Characteristics of the induction motor

There are the following relationships between the speed, voltage, frequency, magnetic flux density, torque and other factors of an induction motor:

$$N = \frac{120f}{p}(1 - S)$$

$$B = K_1 \frac{V}{f}$$

$$T = K_2 \frac{V}{f} I = K_3 \left(\frac{V}{f}\right)^2$$

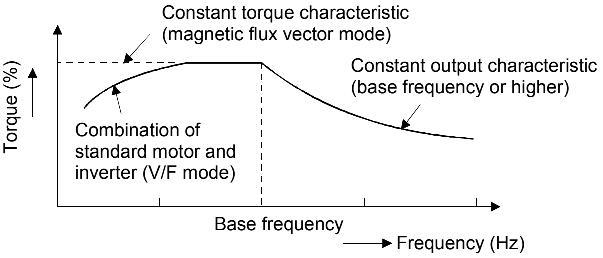
$$P = K_4TN = K_5Tf = K_6VI$$

N : Speed
f : Frequency
p : Number of poles
S : Slip
B : Magnetic flux density
P : Output
T : Torque
V : Terminal voltage
I : Motor current
K_1 to K_6 : Constants

When a three-phase standard motor is used, the value of magnetic flux density (B) is maximum at 50Hz and cannot be increased beyond that value. In addition, the power supply cannot be used continuously at more than the rated current value, in principle. To run the standard motor without burnout, voltage (V) and frequency (f) must be controlled to be constant or below the constant value.

As indicated by the above expression, making the voltage (V) and frequency (f) constant causes the motor torque at the rated current to be constant independently of the a frequency (f). Therefore, by controlling the voltage and frequency to be kept constant, the torque characteristic is made constant. However, a voltage drop due to the primary impedance cannot be ignored in the low frequency range and the torque lowers as shown below. Refer to Section 2.1.4.

The advanced magnetic flux vector control and general-purpose magnetic flux vector control compensate for a voltage drop due to the primary impedance and therefore provide an ideal constant-torque characteristic.



Motor Torque

Due to the inverter characteristic, a voltage above the power supply voltage cannot be developed at the frequency of higher than 50Hz or 60Hz or higher. For this reason, the voltage (V) is kept constant, only the frequency (f) is changed, and the torque is inversely proportional to the frequency, i.e. the constant output characteristic is achieved with the voltage (V) kept constant.

2.2.2 Torque Generated by a Motor Driven by an Inverter

When the motor is driven with a commercial power supply, the torque curve is as shown in Section 2.1.3 (an example for 1.5kW). When the inverter is used as a power supply, however, the overload capacity of the inverter suppresses the maximum torque to be less than the maximum value of the motor. This value is the maximum short duration torque. Hence, the use of a large-capacity inverter raises the overload capacity, leading to the increase in maximum short duration torque. For the values for the standard combinations, refer to the Technical Note No. 22 (Data Part).

In the low frequency range, the torque value changes according to the V/f pattern of the inverter output and the electrical constant of the motor. The selection of advanced magnetic flux vector control in the FR-A500 series minimizes the reduction of torque. In the V/F mode, the torque boost function also allows the torque to be raised especially in the low frequency range.

Refer to Section 2.1.4 "Starting torque boost". For the torque value increased by the torque boost function, refer to the Technical Note No. 22 (Data Part).

2.2.3 Continuous Motor Output Characteristic

When the motor is driven from the inverter, its power factor and efficiency are lower than those of the motor driven with a sine wave (commercial power supply) due to the influence of harmonics included in the inverter output. Therefore, since the motor current increases and the motor temperature rises to generate the same load torque, the inverter must be used with its output reduced. Because the self-cooling fan of the motor has a lesser effect, especially at lower than 30Hz, the load torque must be reduced for continuous use.

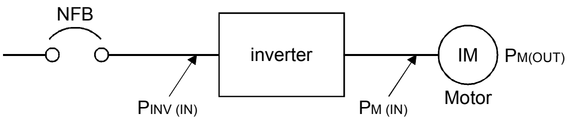
Refer to the corresponding inverter series manual for the permissible continuous operation torque of the three-phase, 200V 50Hz/200V 60Hz/220V 60Hz standard motor driven from the inverter.

When the motor is run continuously with the rated torque up to the low speed range, examine the use of a constant-torque motor given in Section 2.3.2.

However, the SF-JR 0.4 to 1.5kW 4-pole motor can be run continuously at the rated torque in the 6 to 60Hz range under the combination of advanced magnetic flux vector control or general-purpose magnetic flux vector control.

2.2.4 Efficiency

(1) Finding the overall efficiency



$P_{INV(IN)}$: Inverter input power [kW]
$P_{M(IN)}$: Motor input power [kW]
$P_{M(OUT)}$: Motor output [kW]

- Inverter efficiency (ηINV) Indicates the efficiency of the inverter itself and is found by the following expression from the inverter input power ($P_{INV(IN)}$) and the motor input power ($P_{M(IN)}$) (= inverter output power):

$$\eta_{INV} = \frac{P_{M(IN)}}{P_{INV(IN)}} \times 100\ [\%]$$

- Motor efficiency (ηM) Indicates the efficiency of the motor driven by the inverter and is found by the following expression:

$$\eta_{M} = \frac{P_{M(OUT)}}{P_{M(IN)}} \times 100\ [\%]$$

- Overall efficiency (ηT) Indicates the efficiency of the inverter and motor combined and is found by the following expression:

$$\eta_{T} = \eta_{INV} \times \eta_{M} = \frac{P_{M(OUT)}}{P_{INV(IN)}} \times 100\ [\%]$$

(2) Motor efficiency

The motor efficiency in Section 2.2.4 (1) is further developed as indicated by the following expression:

$$\eta_{M} = \frac{P_{M(OUT)}}{P_{M(IN)}} \times 100 = \frac{P_{M(OUT)}}{P_{M(OUT)} + \text{motor loss}} \times 100\ [\%]$$

Main motor losses are iron loss, stator copper loss and rotor copper loss. When the load torque decreases, the ratio of the above losses to the output increases, reducing the efficiency. Similarly, if the load torque remains the same, the decrease in output frequency results in reduced efficiency.

The reduction in motor terminal voltage (i.e. inverter output voltage) decreases the motor torque and the increases in motor slip and rotor copper loss reduces the efficiency.

2.2.5 Vibration

Since the FR-A500, FR-E500 series inverters use a high-carrier frequency sine-wave PWM control system, the vibration of the motor is small. As compared to that of the motor driven with the commercial power supply, however, the vibration of the motor installed to a machine may be slightly larger. Motor oscillation may occur for the following reasons:

1) Imbalance of the rotator itself including the mating machine.
2) Resonance with the natural frequency of the mechanical system. Care must be taken especially when a machine operated at constant speed is switched to variable speed. The transmission of oscillation can be reduced by, for example, using a flexible coupling or providing rubber vibration insulators under the motor base. Note that resonance areas can be avoided during operation by using the frequency jump function. When a two-pole motor is run at high speed beyond 60Hz, abnormal oscillation may occur.

Any of the following measures may be taken to remedy motor oscillation:

1) Use of low-vibration motor
   Identical in size to a general-purpose motor, a low-vibration motor dedicated to inverter use is designed to be high in machining accuracy and low in magnetic noise to ensure lower oscillation and lower noise than a general-purpose motor. (See Section 2.3.3 "Low-Vibration Motor".)
2) Connect the noise reducing reactor (FR-BOL) in the inverter output circuit.
3) Oscillation at low frequency can be remedied by setting a lower excitation value to the torque boost (Pr. 0).

2.3 Motor Operation

A variety of motors are available; various types of motors classified according to protection types and structure, those provided with equipment such as brakes and speed reducers, and special-purpose motors. When identical to a general-purpose three-phase motor in electrical characteristics, any motor can be run by the inverter without fault.

For motors which are different in electrical characteristics, adjustment may be required by the torque boost function (Pr. 0) and V/F pattern (see Section 2.1.4 Starting Torque Boost) or a dedicated inverter matching the motor characteristics may be needed.

When a motor designed for use with the commercial power supply (50Hz or 60Hz) is operated by the inverter, set the base frequency (Pr. 3) of the inverter to 50Hz or 60Hz.

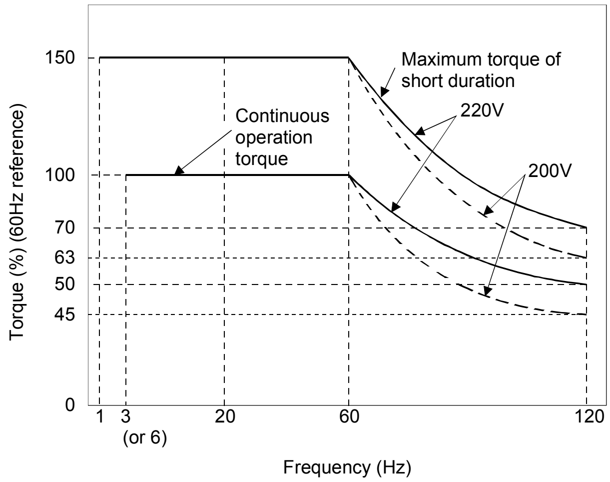
2.3.1 Motor Types Classified according to Protection Structure

Motor Protection Structure

Type	Mitsubishi Motor Catalog Code	International Protection Code	Remarks
Drip-proof type	SB-J(R)	JP 22	May be used with the inverter as standard. (Vertical or flange type may also be used.)
Totally-enclosed type	SE-J(R)	JP 44	
Totally-enclosed	SF-J(R)	JP 44	
Outdoor type	SF-J(R)	JPW44	
Water-proof type	SF-J(R)	JP 46	
Corrosion-proof type	SF-J(R),CF-NE	JPC44	
Explosion–protected type	XF-E XF-NE	JPE44	Motor and inverter combination requires explosion-proof official approval (safety approval). For more information, see Section 2.3.7.

2.3.2 Constant-Torque Motor

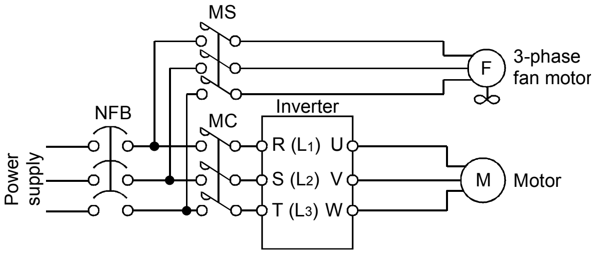
A constant-torque motor is a motor dedicated to inverter operation which can be run continuously without reducing the load torque even in the low speed range. It provides a 100% constant torque at 3 to 60Hz under advanced magnetic flux vector control (at 6 to 60Hz for 75kW or more).



Continuous Rating Range(Motor dedicated to magnetic flux vector control)

When a constant torque characteristic is necessary at 6 to 60Hz under V/F control, please contact your local Mitsubishi sales representative.

The FR-A500 and FR-E500 series are equipped with an electronic thermal relay dedicated to the Mitsubishi constant-torque motor and can therefore be used without providing an external thermal relay.



Note: Wire the fan motor carefully so that it is in the correct phase sequence. While the motor is operating, the contactor (breake) MS must be kept on and the fan motor should also be run.

Fan Motor Connection Example
(200V 30kW or up)

Standard Specifications of Constant-Torque Motor (Motor dedicated to magnetic flux vector control)

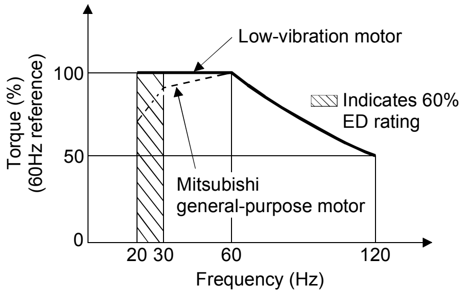
Output (kW)	Number of Poles	Mitsubishi Catalog Code	Frame Number	Continuos operation torque		Insulation	Power Supply	Frequency Range (Hz)	Applicable Inverter
				(Nm)	(kgm)				
0.4	4	Totally-enclosed fan-cooled type SF-JRCA	71M	2.12	0.22	Class B	200V/50Hz 200V/60Hz 220V/60Hz	3 to 120Hz	FR-A520-0.4K
0.75			80M	3.98	0.41				FR-A520-0.75K
1.5			90L	7.96	0.81				FR-A520-1.5K
2.2			100L	11.7	1.2	Class F			FR-A520-2.2K
3.7			112M	19.6	2.0				FR-A520-3.7K
5.5			132S	29.2	3.0				FR-A520-5.5K
7.5			132M	39.8	4.1				FR-A520-7.5K
11			160M	58.4	6.0			3 to 100Hz	FR-A520-11K
15			160L	79.6	8.1				FR-A520-15K
18.5			180M	98.2	10.0				FR-A520-18.5K
22			180L	117	12.0				FR-A520-22K
30			200L	159	16.2			3 to 65Hz	FR-A520-30K
37			200L	196	20.0				FR-A520-37K
45			225S	239	24.4				FR-A520-45K
55		Totally-enclosed fan-cooled type (Note) SE-JRCA-FV	225S	292	29.8				FR-A520-55K
75		Totally-enclosed fan-cooled type SF-LHCA	250M	398	40.6		400V/50Hz 400V/60Hz 440V/60Hz	6 to 60Hz	FR-A540L-75K
90			280S	478	45.7				FR-A540L-90K
110			280M	584	59.5				FR-A540L-110K
132			315M	700	71.4				FR-A540L-132K
150			315M	796	81.2				FR-A540L-160K
160			315M	849	86.6				FR-A540L-160K
185			315L	982	100				FR-A540L-220K
200			315L	1061	108				FR-A540L-220K
220			315L	1167	119				FR-A540L-220K
250			355L	1326	135				FR-A540L-280K
280			355L	1486	152				FR-A540L-280K

Note: The power supply of the motor mounted fan is three-phase 200V

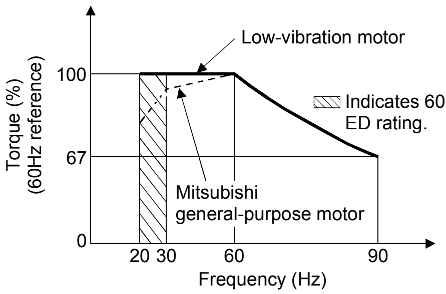
2.3.3 Low-Vibration Motor

When compared to a general-purpose motor, a low-oscillation motor is designed to be insusceptible to time harmonics and space harmonics and is improved in machining accuracy to minimize gap imbalance. Hence, this type of motor has achieved low oscillation of a maximum. 5μm full-amplitude and a maximum. 1.5G oscillatory acceleration. It is also wider in continuous output range than a general-purpose motor.

- 4-pole motor



- 2-pole motor



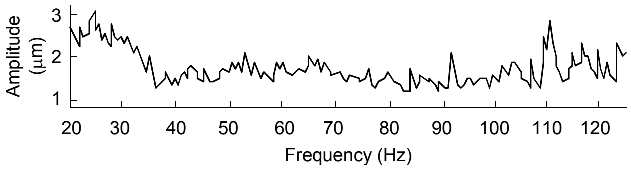
Continuous Rating Range

Standard Specifications of Low-Vibration Motor

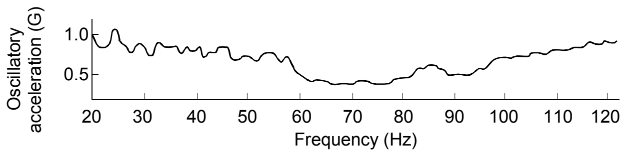
Mitsubishi Catalog Code	Frame Number	Output (kW)	Number of Poles	Insulation	Power Supply	Frequency Range (Hz)
Totally-enclosed fan-cooled type SF-JRL SF-JRLF(V)	80M	0.75	2	Class F	200V/50Hz 200V/60Hz 220V/60Hz or 400V/50Hz 400V/60Hz 440V/60Hz	20 to 90 Base frequency 60Hz
	90L	1.5				
	100L	2.2				
	112M	3.7				
Totally-enclosed fan-cooled type SF-JRL SF-JRLF(V)	80M	0.75	4			20 to 120 Base frequency 60Hz
	90L	1.5				
	100L	2.2				
	112M	3.7				

Note: 1. Set the manual torque boost (Pr. 0) of the inverter to the minimum value.
2. Set "0" in Pr. 9 (electronic thermal O/L relay) and install an external thermal relay.

- Amplitude (Full amplitude)



- Oscillatory acceleration



Oscillation Characteristics (Example of 3.7kW 4P)

2.3.4 Brake Motor

When a motor with magnetic brake is operated by the inverter, the power for the brake must be supplied from the primary of the inverter. (Modifications must be made to a motor with brake where the motor terminals are connected with the brake terminals inside the motor, e.g. a current type brake which operates the brake using a large starting current.)

To stop the motor with the magnetic brake, connect the output stop terminal MRS and SD of the inverter, and at the same time, switch off the start input signal (across terminals STF or STR and SD). If terminal MRS is not used, the braking force will reduce at the time of braking and/or a lock current will flow in the motor, causing the electronic thermal relay to be actuated by the current limit function which has been activated for a long time.

Other instructions

1) The brake should be used at a speed of 60Hz or less. If the motor running at high speed is brought to a sudden stop, the braking capacity of the electromagnetic brake may be insufficient depending on the value of load GD^2.
2) When the motor is provided with the NB brake, continuous low-speed operation below 900rpm may cause noise to be generated due to the looseness of the brake disc, which does not offer a functional problem. This type of motor can be used without fault if operated at low speed for a short duration, e.g. positioning to a stop.
   A four-pole motor with NB brake can be operated in the operating frequency range from 30 to 60Hz, and a six-pole from 45 to 90Hz.

2.3.5 Pole-Change Motor

Since a pole-change motor is different in rated current from a general-purpose motor, the inverter should be selected after checking the rated motor current. The number of poles must be changed after stopping the motor. If it is changed during rotation, the inverter is brought to an alarm stop as indicated in the table on the right and proper operation cannot be performed.

Switching from high-speed operation to low-speed operation	Overcurrent (OC3) or regenerative overvoltage (OV3) is activated to coast the motor to a stop.
Switching from low-speed operation to high-speed operation	Overcurrent (OC1) is activated to coast the motor to a stop.

2.3.6 Submersible Motor

Since its rotor and other parts rotate under water, a water seal type submersible motor is larger in mechanical loss and rated current than a general-purpose motor. Select the inverter capacity so that its rated output current is more than 1.1 times greater than the rated current of the submersible motor. (An inverter of one rank higher capacity may be required for the motor.)
When large torque is required due to lodged sand etc., an inverter of one rank higher capacity may be selected to raise its overload capacity and the motor capacity may also be increased.
Alternatively, the torque boost (Pr. 0) set value may be increased. Examples of submersible motors used with the inverters are indicated in the table on the right.

Other instructions

1) As compared to the one driven from a commercial power supply, the submersible motor driven by an inverter is slightly higher in motor temperature rise. Particularly in a canned system, the increase in can loss causes the submersible motor driven by the inverter to be about 15% higher in temperature than the one driven from a commercial power supply.
   For further details, refer to the Mitsubishi inverter-driven submersible motor technical manual.
2) Protection of submersible motor.
   Since the submersible motor may be installed deep in a well, it is difficult to detect its fault from the ground and its permissible lock time is short. Hence, an appropriate protection relay must be selected to protect the submersible motor. Ideally, the installation of a thermal detector, e.g. thermistor, on the motor for the detection of coil temperature ensures safety, allowing faults occurring in a low-speed range (ambient water temperature rise, overload operation) to be detected. Generally, provide a thermal relay between the inverter and motor and set zero in Pr. 9 (electronic thermal O/L relay) of the inverter. Set the overload protection of the thermal relay to the rated motor current and set the lock protection to within 5 seconds (3 seconds if desired).

Submersible Motor and Inverter Combinations

Submersible Motor			Applicable Inverter
Frame number	Output (kW)	Rated current (A) (Note) 200V/50Hz	Type
M4	0.75	4.2	FR-A520-0.75K
	1.1	6.0	FR-A520-1.5K
	1.5	8.0	FR-A520-2.2K
	2.2	12.0	FR-A520-3.7K
	3.7	19.0	FR-A520-5.5K
M6	3.7	17.8	FR-A520-5.5K
	5.5	25.5	FR-A520-7.5K
	7.5	33	FR-A520-11K
	11	48	FR-A520-15K
	15	65	FR-A520-18.5K
	18.5	79	FR-A520-22K
	22	97	FR-A520-30K
M8	18.5	78	FR-A520-22K
	22	93	FR-A520-30K
	30	122	FR-A520-37K
	37	150	FR-A520-45K
	45	182	FR-A520-55K

Note: When compared to a motor driven from a commercial power supply, a larger current flows when the motor is driven from the inverter under the same load because the full load characteristics reduce slightly (efficiency × 0.9, power factor × 0.95).

3) Operable frequency range.
The operable frequency ranges of the Mitsubishi submersible motors are as indicated below.

Operable Frequency Ranges of Submersible Motors

Motor Output (kW)	Motor Frame Number	Type of Submersible Motor	Operable Frequency Range (Hz)
			2P
0.75 1.1 1.5 2.2 3.7	M4	Canned type	25 to 60
3.7 5.5 7.5 11 15 18.5 22	M6		25 to 60
18.5 22 30 37 45	M8	Water resistant insulation type(polyethlene covered)	25 to 60

Note : The above table applies to the range given in the Mitsubishi submersible motor catalog (catalog No. K-C2936).

4) When the cable length between the motor and inverter is long, use a large-diameter cable to prevent the motor torque from decreasing due to the voltage drop over the cable.

5) Using an existing submersible motor.
The inverter power supply generates a surge voltage, causing the voltage to rise sharply (dV/dt is large). Therefor when using a submersible motor which has already been installed, a high voltage developed by the inverter may burn out the motor if insulation is lower than 10MΩ. Check that the insulation of the submersible motor has not deteriorated.

6) Installation of leakage current relay.
The installation of a leakage current relay informs of an alarm or an insulation fault of the submersible motor and cable, allowing measures to be taken in advance. Larger in normal leakage current and longer in cable length than a land motor, the submersible motor should be selected with consideration given to a large leakage current.
The leakage current of the submersible motor operated from a commercial power supply is as indicated in below.

Leakage Current of Submersible Motor

Output (kW)	Operating Condition	Leakage Current (mA)	
		Canned type	Polyethlene covered
0.75	Operation	0.4	—
	Locked	1	—
1.1	Operation	0.4	—
	Locked	1	—
1.5	Operation	0.5	—
	Locked	1	—
2.2	Operation	0.6	—
	Locked	2	—
3.7	Operation	0.7	—
	Locked	3	—
5.5	Operation	0.8	—
	Locked	4	—
7.5	Operation	0.8	—
	Locked	5	—
11	Operation	0.9	—
	Locked	6	—
15	Operation	1	—
	Locked	7	—
18.5	Operation	1.1	6
	Locked	8	73
22	Operation	1.2	6
	Locked	9	74
30	Operation	—	6
	Locked	—	79
37	Operation	—	7
	Locked	—	80
45	Operation	—	11
	Locked	—	117

2.3.7 Explosion-Proof Motor

Any existing commercial power supply-driven pressure-resistant explosion-proof motor or any safety-increased explosion-proof motor cannot be operated by the standard inverter.
To run such a motor by the inverter, approvals may be required according to the country of destination.
The table below indicates the standard specifications of the pressure-resistant explosion-proof motors dedicated to inverter drive. The inverter used with this motor must be the Mitsubishi FR-B series inverter dedicated to explosion-proof motor (equivalent to the FR-A200) and must be installed in non-hazardous locations.

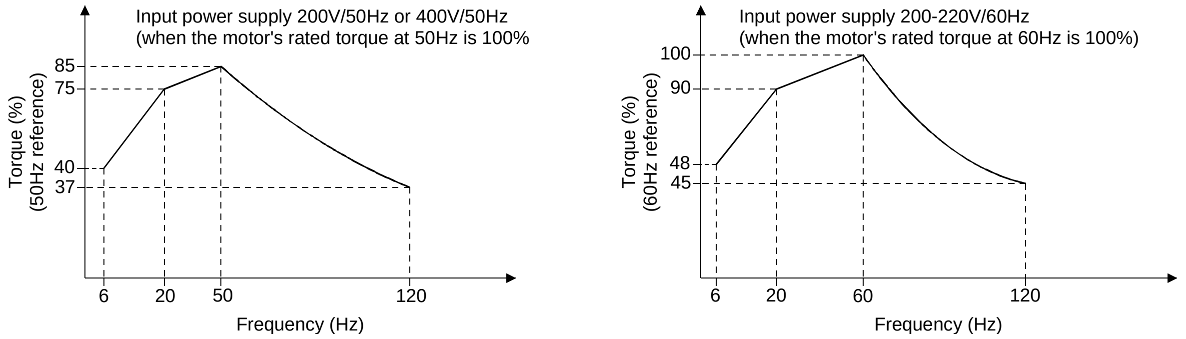
Standard Specification Example for the Explosion-Proof Motor

Type	Frame No.	Output (kW)	Number of Poles	Insulation	Power Supply	Explosion Proof Structure	Applied Inverter
XE-NE	71M	0.4	4	Class B	200V/50Hz 200V/60Hz 220V/60Hz	d2G4	FR-B-750
	80M	0.75					
	90L	1.5					FR-B-1500
	100L	2.2					FR-B-3700
	112M	3.7					
	132S	5.5					FR-B-5.5K
	132M	7.5					FR-B-7.5K
XF-E	160M	11					FR-B-11K
	160L	15					FR-B-15K
	180M	22					FR-B-22K
	200L	30		Class B or class F			FR-B-30K
	225S	37					FR-B-37K
	225M	45					FR-B-45K

Note : For data other than the above specifications, contact your nearest sales representative. Models of 400V class, outdoor type and corrosion-proof type are also available. For the 400V class, the applied inverters are different from those listed above. Please contact your nearest Mitsubishi sales representative.

Other instructions

1) The optional brake unit or power supply regenerating unit cannot be used with the inverter. In principle, the motor is operated only at the constant speed. For frequent starts and stops, the safety approval may be required again.
2) When a 18.5kW motor output is required, use a 22kW motor with the FR-B-22K inverter.
3) We can also manufacture pressure-resistant, explosion-proof motors of constant-torque motor specifications. For the motors of constant-torque motor specifications, their motor frame numbers and applied inverters are different from those listed in the table. Please contact your sales representative.



Continuous Duty Operation Rnge

Note : The usable operation range is between 6Hz and 120Hz (90Hz or less for the 15kW 4P, 90Hz or less for the 22kW 4P (indoors), and 60Hz or less for the 22kW 4P (outdoors) and 30kW 4P or more).

2.3.8 Geared Motors

Geared motors differ in the continuous-duty speed range according to the lubrication system and manufacturer. Particularly with oil lubrication, continuous operation only in the low speed range can cause gear seizure. When performing high-speed operation beyond 60Hz, please consult the manufacturer.

(1) Mitsubishi standard geared motors

The grease-lubricated GM-LJ and H may be used between low speed and high speed of 70 to 120Hz. The oil-lubricated GM-LJ and AJ are four-pole motors and may be used between 25Hz and high speed of 65 to 120Hz.

When the motor is inverter-driven, there is no restriction on the permissible number of start times as starting impact is lessened.

$N \geq 2 \times 10^6$ times

Note : Independent of the magnitude of load inertia, provided that the inverter capacity is equal to the motor capacity at the standard setting of the torque boost.

Operable Frequency Range

Motor Capacity 4P (kW)	Frequency Range (Hz)	
	Grease lubricated	Oil lubricated
0.1	0 to 120	—
0.2		
0.3		
0.4		
0.75		
1.5		
2.2		
3.7	0 to 85	25 to 120
5.5	0 to 75	25 to 120
7.5	0 to 70	25 to 115
11	—	25 to 105
15		25 to 95
22		25 to 90
30		25 to 70
37		
45		25 to 65
55		
75		

Note : The above table applies to the range given in the Mitsubishi geared motor catalog (catalog No. K-178-7-C0613-F).

(2) Built-in brake type geared motor
Refer to Section 2.3.4 "Motor with Brake". When the brake is used, this type of motor should be used at less than 60Hz because there is restriction on the braking capacity. When a four-pole motor is continuously operated at less than 30Hz, it will generate noise at the brake disc, which gives no problem regarding function.

(3) Geared motor dedicated to inverter operation
Being a totally-enclosed non-ventilated type, this motor has achieved 100% constant torque even in the low-speed range and runs without the sound of the cooling fan, ensuring low noise at high speed.(except 0.75kW).

Standard Specifications of Geared Motor Dedicated to Inverter Drive

Type	Output (kW)	Number of Poles	Power Supply	Insula-tion	Reduction Ratio
GM-H2	0.1	4	200V/50Hz 200V/60Hz 220V/60Hz	Class E	Parallel axis series 1/5 to 1/1200 Cartesian series 1/10 to 1/100
	0.2				
	0.3				
	0.4				
	0.75				

(4) Cyclo speed reducer directly coupled with motor
When the speed reducer is specified as inverter-driven in the purchase order, the motor may be different from the standard one. If overcurrent shut-off (OC1) occurs immediately after a start, adjust the torque boost (Pr. 0).

1) An 1:10 speed range is standard. Consult the manufacturer when the speed reducer is used at more than 60Hz.

2) Lubricant:
Frame numbers #208 to #211 are grease-lubricated. Frame numbers #84 to #89 of horizontal mounting type are oil-lubricated like the standard ones. For this type, oil used should be of low viscosity within the VG range. For frame numbers #84 to #89 of vertical type, the lubrication system must be considered according to the working speed range.

3) Note the starting characteristic at low temperature.
The loss of the cyclo speed reducer depends on the ambient temperature, input speed, load factor and lubricant. The starting characteristic must be noted under hostile conditions where sudden acceleration is made from the start to 1800rpm under load at a low temperature. The loss in torque of the oil-lubricated model at the ambient temperature of 0°C is 15 to 30% of the rated value at 60Hz.

2.3.9 Synchronous Motor

Since a synchronous motor is larger in starting and rated current than a standard three-phase motor, a larger inverter should be selected compared to the motor capacity. In addition, it is necessary to check whether the pull-in torque is sufficient and the rotation after pulling-in is stable on the actual machine. Particularly at 30Hz or less, the stability may deteriorate.

Note that when many synchronous motors are switched on/off individually in group control, they may be out of synchronization.

2.3.10 Single-Phase Motor

It is not recommended to use a single-phase motor with an inverter. The small capacity of the single-phase motor is often rated at 100V and does not match the inverter. The SC, SL, SCL and other motors with capacitors cause an excessive current to flow in the capacitor, resulting in capacitor breakage. A split-phase-start or repulsion-start motor cannot be used because they will cause the centrifugal switch to be deactuated. (The starting winding will be burned out in a short time.) When a single-phase 200V power supply is only available, refer to Section 1.8 “Use of the Inverter with Single-Phase Power Supply“ and use a standard three-phase motor.

2.3.11 Permissible Maximum Frequency of General- Purpose Motor

(1) Standard models

Drip-proof protection motor: SB-JR(F, V)

Totally-enclosed fan-cooled motor: SF-JR(F, V)

Number of Poles / Frame Number	2	4	6
63	120HzNote 2 (7200r/min)	120Hz (3600r/min)	120Hz (2400r/min)
71			
80			
90			
100			
112	90Hz (5400r/min)		
132			
160	75Hz (4500r/min)	100Hz (3000r/min)	
180	65Hz (3900r/min)		
200	60Hz (3600r/min)	65Hz (1950r/min)	65Hz (1300r/min)
225			

Note: 1. The value in the parentheses indicates synchronous speed.

2. When a two-pole motor of frame number 90 or 100 is run at 120Hz, noise will exceed 90dB (A).

(2) Other models

Number of Poles / Frame Number		2	4	6
With NB brake		No correspon-ding model	30 to 65Hz (except vertical type)	45 to 90Hz (except vertical type)
Outdoor type Water-proof type	63 to 132	65Hz	120Hz	120Hz
	160		100Hz	
	180		65Hz	90Hz
	200	60Hz		65Hz
	225			

2.3.12 Inverter-driven 400V motor

When a 400V class motor is driven by an inverter, a surge voltage attributable to the wiring constants is produced at the motor terminals. This voltage is influenced by the inverter-to-motor wiring length as shown on the right. Since this voltage may deteriorate the motor insulation, the following actions are needed:

(1) How to enhance motor insulation

For a 400V class motor, use an insulation-enhanced motor. Specifically:

1) Specify the "400V class inverter-driven, insulation-enhanced motor".

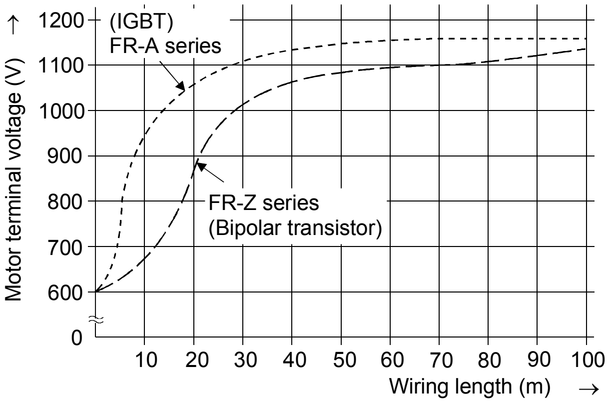
2) As a dedicated motor such as a constant-torque motor or low-vibration motor, use a "motor dedicated to inverter operation".

(2) How to suppress surge voltage on the inverter side

In the secondary side of the inverter, connect a surge voltage suppressing filter which will make the motor terminal voltage less than 850V.

When the motor is driven by the Mitsubishi inverter, connect the optional surge voltage suppression filter (FR-ASF-H) in the secondary side of the inverter.

In this case, the voltage reduces by about 6% and care must therefore be taken to avoid a torque shortage.

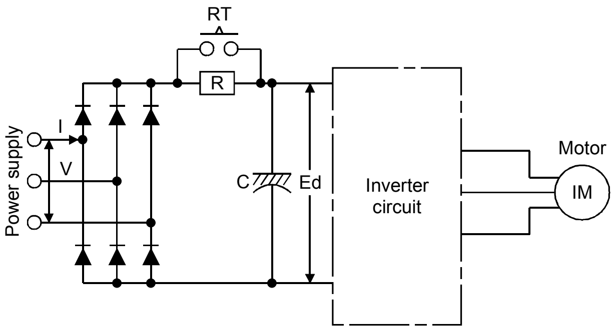


Wiring Length vs. Motor Terminal Voltage
(Measurement example)

2.4 Power Supply of the Inverter

2.4.1 Inverter Input Current and Power Factor

The converter circuit of the transistorized inverter consists of three-phase bridged diodes and capacitor-input smoothing circuit as shown in below.



Converter Circuit Structure

The static capacity of the DC smoothing capacitor is very large and the input current (I) from the power supply flows only when the voltage (V) of the power supply is higher than the terminal voltage (Ed) of the smoothing capacitor. Hence, the conduction width of the converter circuit is very narrow and the peak (crest) value of the input current is large. The input power factors given in the table on the right assume that the DC voltage does not vary. As shown in the table on the right, if the DC voltage (Ed) is greater than 1.35 times of the input voltage (V) under a light load, two pulse currents flow in a half cycle as shown in the input current waveform (see the diagrams on the next page) and the power factor falls to 58.7% or less.

Ordinarily, the power factor is represented by a phase difference between voltage and current. When a current having a distorted waveform flows in the inverter input, the power factor is calculated from an apparent power and a three-phase input power found through the three-wattmeter method. The power factor thus calculated is called an overall power factor.

AC Power Supply Current and Power Factor of Converter Circuit in Inverter

Ed	Power Factor	Form Factor	Crest (peak) Factor
Ed > 1.35V	58.7% or less	1.99 or more	2.16 or more
Ed = 1.35V	58.7%	1.99	2.16
1.35V > Ed > 1.225V	58.7 to 83.5%	1.99 to 1.27	2.16 to 1.71
Ed = 1.225V	83.5%	1.27	1.71
1.225V>Ed	83.5 to 95.3%	1.27 to 1.23	1.71 to 1.28

$$\text{Input current (I) Of inverter} = \frac{\text{Power supply capacity [KVA]} \underset{}{\text{(Note)}}}{\sqrt{3} \times V} \text{ [A]}$$

Note: Refer to Section 1.1.1.

$$\text{Overall power factor of Inverter} = \frac{\text{effective power}}{\text{apparent power}}$$

$$= \frac{\text{3-pahse input power found by 3-wattmeter method}}{3 \times V \text{ (Power supply voltage)} \times I \text{ (Input current effective value)}}$$

(The power factor value measured through three-phase power factor meter which indicates a phase difference between voltage and current is different from the above overall power factor because the current flowing in the inverter is not a sine-wave current.)

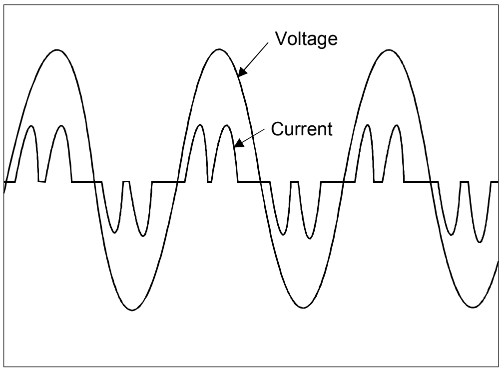
Since the input current has a distorted waveform and the form factor is high (the form factor of a sine wave is 1.11) as described above, the overall input power factor of the inverter may become extremely low depending on the power supply voltage and load factor, usually about 75 to 80% for transistorized inverters. Accordingly, the input current (effective value) increases.

2.4.2 Improvement of Power Factor

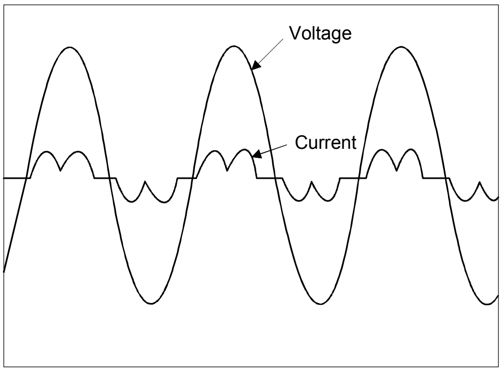
A widespread method of improving the power factor is to insert a reactor in the AC or DC side of the converter in order to smooth the current. (The inverter input power factor is not improved if a power-factor correcting power capacitor is inserted in the input circuit. A capacitor must not be inserted in the output circuit. If inserted, the capacitor will be damaged by the harmonic current of the inverter.)

By connecting the optional FR-BAL or FR-BEL power-factor correcting reactor to the inverter, the current waveform is improved and the power factor corrected as shown in Fig(b). In addition, the effective value of the input current is reduced.

The inverter input current is influenced by the reactance of the power supply line and that of the input transformer. When the reactance of the power supply line is larger, the power factor is higher and the input current is smaller.



a) Without power-factor correcting reactor



b) With power-factor correcting reactor

Inverter Input Current Waveforms

2.4.3 Inrush Current

In a PWM inverter which comprises of a capacitor-input filter circuit, an inrush current flows into the smoothing electrolytic capacitor when the input NFB is switched on. This inrush current, which flows only for the capacitor charging time, is extremely large despite its short duration. Since the inrush current is inversely proportional to the impedance of the power supply, the inrush current increases in proportion to the rise in power supply capacity.

To suppress the inrush current, an inrush current suppressing resistor of short-duration rating is provided in the converter circuit of the all models of (A500) and 2.2K to 7.5K models of (E500). Avoid switching the inverter power supply on/off frequently. The inrush current occurring frequently at power-on may deteriorate or short the inrush current suppressing circuit or damage the rectifier circuit, for example.

Especially when the power supply capacity is large, use the optional power factor improving reactor (FR-BAL or FR-BEL) in accordance with the selection conditions.

2.4.4 Instantaneous Power Failure

If an instantaneous power failure has occurred (15ms or longer), the inverter protective circuit is activated to coast the motor to a stop. (See Section 1.4.1.(2) (3))

When the power is restored in less than about 50 to 100ms, the instantaneous power failure protective circuit is kept activated and the motor does not restart. When the instantaneous power failure time is approximately 50 to 100ms or longer, the inverter is initial-reset at the time of power restoration and the inverter restarts if the start signal remains on. If the motor is coasting at this time, a large current may flow in the inverter and activate the current limit function. In this case, the motor is suddenly decelerated, then reaccelerated. To ensure smooth restart of the coasting motor at the time of power restoration, use the automatic restart function after instantaneous power failure.

2.4.5 Power Supply Voltage Variation

The permissible voltage variation range should be within the range from +10% to -15% of the rated voltage. If the power supply voltage rises sharply, the semiconductor devices and electrolytic capacitor may be damaged, adversely affecting the control transformer, magnetic contactor for shorting the inrush current preventing resistor, and the like. In addition, the regenerative brake capability will be reduced, more often resulting in OV1 to OV3 (regenerative overvoltage).

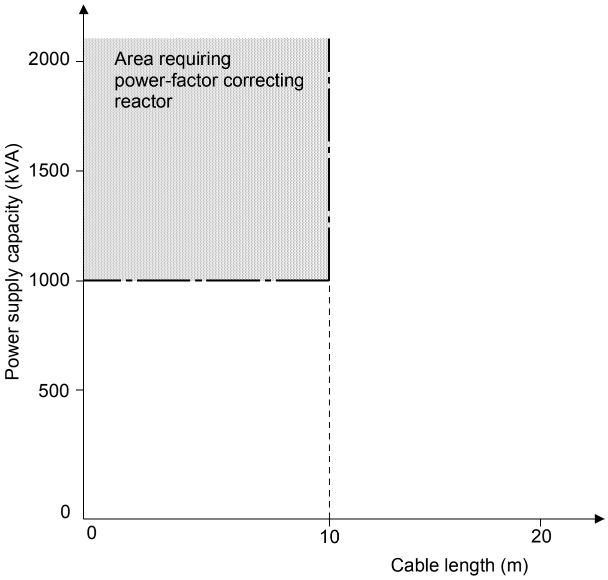
Conversely, if the voltage is reduced greatly, undervoltage protection (UVT) is activated and operation may not be performed properly. Particularly when the power supply is shared between the inverter and a large-capacity motor requiring a long starting time, the power supply voltage may drop sharply at when starting the motor. For more information on power supply undervoltage, refer to Section 1.7.6.

2.4.6 Imbalanced Power Supply Voltage

If a small imbalance occurs in the power supply voltage of the inverter, the inverter input current may be unbalanced greatly. In the worst case, the current may flow only in two phases. This takes place when the motor is operated by the inverter under a light load or at low speed. When the current flowing in the load is small, the terminal voltage of the smoothing capacitor only falls slowly, causing the input current not to flow in the phase lowest in AC power supply voltage. This is not a fault and the current is balanced when the load increases or when the motor reaches the high-speed range and the input current increases. To find the input current, average the currents measured at all the three phases.

2.4.7 Coordination with Commercial Supply

When the overall impedance of the power supply line is small or when there is a power capacitor switching device in the same power supply line, the peak value of the inverter input current may increase, damaging the converter circuit. To prevent this, the power-factor correcting reactor must be used to reduce the current peak value by the current limiting action of the reactor. Especially when the inverter is installed near a power transformer, insert the power factor improving reactor (DC or AC) according to the selection conditions shown below.

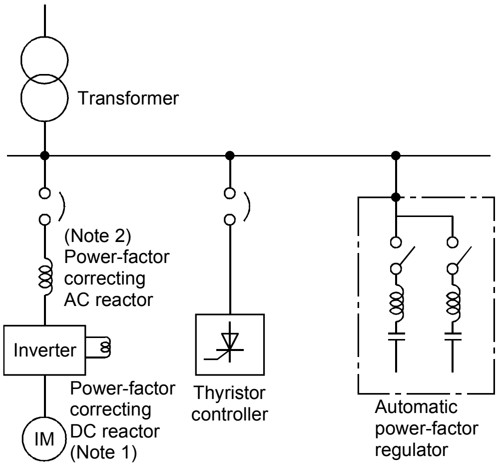


Inverter Power Supply Side Cable Length vs. Permissible Power Supply Capacity Value

Note: The cable size should be as indicated in Section 2.6 "Selecting Peripheral Equipment".

●When an automatic power-factor regulator or a thyristor type controller is connected to the power supply line where the inverter is connected (see below).

If the power supply voltage is distorted by running the above devices, the peak value of the inverter input current may increase, damaging the inverter. When such a condition is expected to occur, insert the power-factor correcting reactor in the input circuit (Note 1) as when installing the inverter close to the power supply transformer as described above.



Automatic power-factor regulator or a thyristor type controller is connected to the power supply line

Note: 1. The FR-BEL power-factor correcting DC reactor (option) for connection with the DC side of the inverter also produces an identical effect.

2. Note that using an AC reactor will cause the voltage to drop about 6% under rated inverter load, reducing the torque.

2.5 Inverter-Generated Harmonics, Noise and Leakage Current

2.5.1 Differences between noise and harmonics

Among adverse effects given by an inverter to a power supply and peripheral devices, peripheral device malfunctions and others whose causes cannot be identified are often mistaken for harmonics or noise and often obstruct reduction techniques. For example, electromagnetic interference, noise and other malfunctions produced by a personal computer are distinctly different in their sources, adverse effects etc. from harmonics in a power circuit and their reduction techniques differ greatly.

Their differences will be described below.

Harmonics are defined to have a frequency that is an integral multiple of the fundamental wave and is differentiated from high frequencies. The composition of a single fundamental wave and several harmonics is called a distorted wave.

A distorted wave generally includes harmonics in a high-frequency region (kHz to MHz order), but a distorted wave handled as harmonics in a power distribution system is usually of up to about 40th to 50th degrees (to several kHz), and a distorted wave above that value generally assumes an irregular form and must therefore be handled as noise.

Differences between Noise and Harmonics of an Inverter and Leakage Current

Item	Noise	Harmonic	Leakage Current
Frequency band	High frequency (several 10kHz to MHz order)	Normally 40th to 50th degrees (to several kHz)	(Several Hz to MHz order)
Source	Inverter circuit	Converter circuit	Inverter circuit
Cause	Transistor switching	Rectifying circuit commutation	Transistor switching
Generated amount	Depends on voltage variation ratio and switching frequency	Depends on current capacity	Depends on switching frequency and voltage
Propagation path	Electric channel, space, induction	Electric channel	Insulating material
Transmission amount	Distance, wiring route	Line impedance	Capacitance
Affected equipment and influence	Sensor, etc.: Mis-detection Radio, wireless equipment: Noise	Power capacitor: Heat generation Non-utility generator: Heat generation	Earth leakage circuit breaker: Unnecessary operation Thermal relay: Unnecessary operation Output side devices (e.g. CT, meter): Heat generation
Main remedy examples	Change the wiring route. Install a noise filter.	Install a reactor.	Change detection sensitivity. Change switching frequency.

2.5.2 Power harmonics and their reduction techniques

Constituted by a power rectifier, the converter circuit of the transistorized inverter generates harmonics, distorting the voltage and current waveforms of the input power supply. In addition, since the inverter circuit contains power switch devices such as transistors, harmonics are included in the voltage and current of the motor, resulting in distorted waveforms. These harmonics do not pose a problem in a small-capacity transistorized inverter. However, it is necessary to have a correct understanding of harmonics and take appropriate measures against them when using equipment having a converter circuit in the power supply circuit, e.g. a large-capacity inverter, many inverters, thyristor leonard, thyristor motor or CVCF.

The Japanese harmonic suppression guidelines issued by the Ministry of International Trade and Industry in September 1994 require that the following two main points should be considered as harmonic suppression techniques:

1) Actions taken for faults due to power harmonics (overheating of power capacitors, non-utility generators, etc.)
2) Clearing of the Japanese harmonic suppression guidelines

The actions taken to achieve the above two points are not always the same, so specific actions must be taken after clarifying their purposes.

(1) Influence on and actions taken for the power supply line

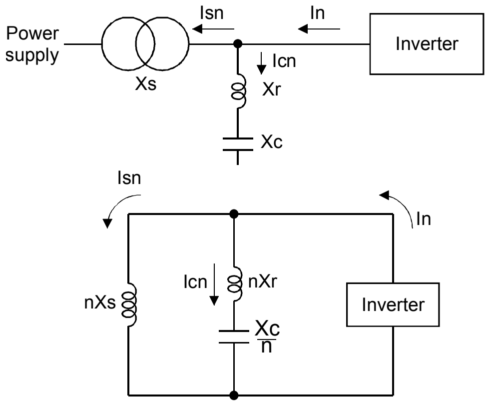
The power supply line to which the inverter is connected is connected with parallel loads such as a power capacitor and a generator, and a harmonic current generated in the inverter is divided into the power supply line and parallel loads according to their impedances. The influence of the harmonic current on the electrical devices and actions taken against that current will be described below.

1) Power capacitor

For the maximum working voltages and maximum working currents of power capacitors, JIS-C4902 (High-voltage power capacitors) and JIS-C4901 (Low-voltage power capacitors) stipulate their harmonic immunities. When parallel resonance is produced by harmonics, an excessive current entering the power capacitor may overheat the capacitor and cause dielectric breakdown.

Ordinarily, the power supply impedance is often small enough (the power supply capacity is large) and the power capacitor rarely results in a failure. When a low-voltage power capacitor susceptible to harmonics is used, it is recommended to use the one with a 6% series reactor.

As indicated below in the single-wire diagram and its equivalent circuit where the power capacitor is connected in parallel with the inverter. The harmonic current (In) generated by the inverter is divided into a harmonic current (Isn) which flows into the power supply and a harmonic current (Icn) which flows into the capacitor. Icn is found by the following expression:



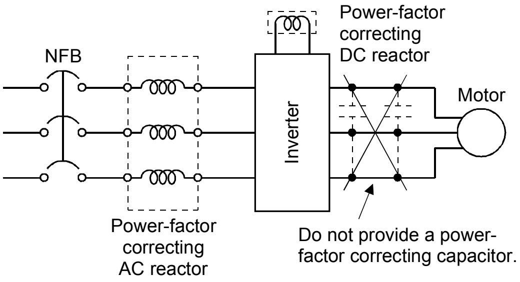
Equivalent Circuit Regarding the Inverter as a Harmonic Voltage Source

$$Icn = \left(\frac{nXs}{nXs + nXr - Xc/n} \right) \times In$$

Icn : Harmonic current flowing into the capacitor
Xs : Power supply impedance
Xr : Impedance of series reactor
Xc : Impedance of power capacitor
n : Harmonic order

If nXs + nXr − Xc/n = 0 in the above expression, resonance occurs and a very large current flows in the power capacitor, burning the capacitor. To prevent this, suppress the capacitor current using the series reactor, or insert the power-factor correcting reactor in the inverter input circuit or DC circuit, thereby reducing the harmonic current from the inverter.

Note: The power-factor correcting capacitor or surge suppressor in the inverter output circuit may be overheated or damaged by the harmonic components of the inverter output. Also, overcurrent protection is activated by overcurrent flowing in the inverter. Therefore, when the motor is driven from the inverter, do not provide the capacitor or surge suppressor in the inverter output circuit. To correct the power factor, insert the power-factor correcting reactor in the inverter primary or DC circuit.



Correction of Inverter Power Factor

The harmonic immunity of the capacitor is specified in the JIS Standards, e.g. the effective current including the harmonic current found by the above expression shall be within 130% of the rated capacitor current, and within 120% for the one with the series reactor.

(For further information, refer to the Technical Note No. 3.)

2) Synchronous generator

When the power is supplied to the inverter by an engine generator or when the inverter is connected to a line where a synchronous generator is running in parallel with the commercial power supply, a harmonic current generated by the inverter is divided between the synchronous generator and commercial power supply line and an induction current develops in the braking winding and field winding of the synchronous generator. If the induction current is too large, heat generated may lead to increased loss (reduced output), overheat, shorter life etc.

Assuming that the loss caused by the harmonic current is equal to that caused by a negative phase-sequence current, the influence resulting from the harmonics of the synchronous generator should be such that the equivalent negative phase-sequence current caused by harmonics is the 15% or less permissible negative phase-sequence current provided for in JEM1354 (Diesel Engine Driving Land Synchronous Generators).

Equivalent negative phase-sequence current (I_2).

$$I_2 = \sqrt{\sum \left(\sqrt[4]{\frac{n}{2}}\, In \right)^2}$$

In : Harmonic current

n : Harmonic order

When a synchronous generator is used, loss due to the harmonic current is large. If it exceeds the permissible value of the damper winding, a rated product several ranks higher must be selected or the one with large negative phase-sequence immunity must be designed. Alternatively, insertion of a reactor in the inverter input circuit or DC circuit is effective to reduce the harmonic current.

(For more information, see Technical Note No. 4.)

(2) Japanese harmonic suppression guidelines and their suppression techniques

1) Application to the guidelines.

There are the following two harmonic suppression guidelines:

A) <u>Harmonic suppression guideline for household appliances and general-purpose products</u>

The upper limit of the outgoing harmonic current is determined per unit.

This guideline applies to 200V class inverters of 3.7kW and less models and they can comply with the guideline when used with a DC or AC power factor improving reactor.

B) <u>Harmonic suppression guideline for consumers receiving power of high voltage or specially high voltage</u>

The upper limit of the outgoing harmonic current per 1kW contract power is determined for the power receiving point of a consumer who receives power of high voltage or specially high voltage.

This guideline applies to 200V class inverters of 5.5kW and more models and 400V class models.

Note that whether the suppression technique is required or not depends on whether the sum of outgoing harmonic current values of a consumer exceeds the upper limit of the permissible outgoing current determined by the contract power.

2) How to judge whether harmonic suppression technique is required or not at the consumer who receives power of high voltage or especially high voltage.

When updating the contract power, a consumer is requested to present a calculation sheet in the format as shown in page 224.

Calculation using the predetermined procedure clarifies whether the suppression technique is required or not. A specific procedure will be described below.

(a) Calculation of rated capacity [kVA]

Used to calculate the 6-pulse equivalent capacity to judge whether the inverter is covered by the <harmonic suppression guideline for consumers receiving power of high voltage or specially high voltage>.

Independently of whether the inverter has a reactor or not, the rated capacity [kVA] is standardized according to the motor capacity and found by the following formula:

● Rated capacity

= $3 \times V \times$ fundamental wave current $\times$ coefficient $\times 10^{-3}$ [kVA]

V: 200V or 400V (input voltage)

Fundamental wave current:
See the table on the following page.

Coefficient: 1.0228

Refer to the table for specific calculation results.

★ The above rated capacity is a value used to judge whether the inverter is covered by the harmonic guideline. Therefore, note that they are different from capacities of power supply equipment (such as power transformers) required for use of actual inverters.
The power supply equipment capacity. required is 1.3 to 1.6 times greater than the above rated capacity (for specific values, refer to the inverter catalog).

(b) Calculation of 6-pulse equivalent capacity

● 6-pulse equivalent capacity
= rated capacity × conversion coefficient (Ki) [kVA]

where, conversion coefficient (Ki) is as follows:

• Without reactor	: 3.4
• With AC reactor	: 1.8
• With DC reactor	: 1.8
• With AC and DC reactors	: 1.4

If the equivalent capacity is less than 50[kVA] (Note) at the received power of 6.6kV, the inverter is not covered by the guideline and the calculation of the outgoing harmonic current (harmonic suppression technique) is not required. (Note: Depending on the received power voltage.)

(c) Conversion of received power voltage into rated current.

- Rated current converted from received power voltage
  = fundamental wave current symbol 180 \f "Symbol" \s 10× (200V or 400V/received power voltage) [A]

(d) Calculation of outgoing harmonic current of each degree.

- Outgoing harmonic current
  = rated current converted from received power voltage × operation ratio × harmonic content [A]

  Note that the harmonic content is as listed below.

Fundamental Wave Currents and Rated Capacities of Inverters

Motor Capacity [kW]	Fundamental Wave Current [A]		Rated Capacity [kVA]
	200V	400V	
0.4	1.61	0.81	0.57
0.75	2.74	1.37	0.97
1.5	5.50	2.75	1.95
2.2	7.93	3.96	2.81
3.7	13.0	6.5	4.61
5.5	19.1	9.55	6.77
7.5	25.6	12.8	9.07
11	36.9	18.5	13.1
15	49.8	24.9	17.6
18.5	61.4	30.7	21.8
22	73.1	36.6	25.9
30	98.0	49.0	34.7
37	121	60.4	42.8
45	147	73.5	52.1
55	180	89.9	63.7

Harmonic Current Generating Amount with Individual Devices (Excerpt of appended document to the guideline)

(Unit: %)

Circuit components	Degree	5th	7th	11th	13th	17th	19th	23rd	25th
Three-phase bridge (capacitor smoothed)	Without reactor	65	41	8.5	7.7	4.3	3.1	2.6	1.8
	With reactor (AC side)	38	14.5	7.4	3.4	3.2	1.9	1.7	1.3
	With reactor (DC side)	30	13	8.4	5.0	4.7	3.2	3.0	2.2
	With reactor (AC, DC sides)	28	9.1	7.2	4.1	3.2	2.4	1.6	1.4

3) Specific calculation example.

When a 30kW 400V motor is driven by the FR-A540-30K inverter

- Fundamental wave current of the motor is 49.0A.
- Rated capacity
  = 3 × V × fundamental wave current × conversion coefficient × 10^{-3}
  = 3 × 400 × 49.0 × 1.0228 × 10^{-3} = 34.7 [kVA]
- 6-pulse equivalent capacity
  = rated capacity × conversion coefficient (Ki)
  = 34.7 × 3.4 = 118 [kVA]

  Since this value exceeds 50 [kVA], the inverter is covered by the guideline.

  Hence, find the outgoing harmonic current in the following procedure:
- Rated current converted from received power voltage
  = fundamental wave current × (400V/received power voltage)
  = 49.0 × 400/6600 = 2.97 [A]
- Outgoing harmonic current
  = rated current converted from received power voltage × operation ratio × harmonic content [A]

  It is derived from the following table.
  Assume that the operation ratio is 50%.

Degree	5th	7th	11th	13th	17th	19th	23rd	25th
Outgoing current [mA]	965	609	126	114	63.9	46.0	38.6	26.7
Maximum outgoing current value [mA/kW]	3.5	2.5	1.6	1.3	1.0	0.9	0.76	0.70

If the contract power is less than 982/3.5 = 276kW, harmonic suppression techniques are required.

4) Harmonic suppression techniques

(a) Reactors for inverter (ACL, DCL)

Connect an AC reactor (ACL) in the power supply side of the inverter or a DC reactor (DCL) in its DC side or both to suppress harmonic currents.

Generally, installation of the reactor in only one side of the inverter often produces an insufficient suppression effect.

(b) Power factor improving capacitor

When used with a series reactor, the power factor improving capacitor has an effect of absorbing harmonic currents.

This capacitor may be installed in either a high or low voltage side.

(c) Transformer multi-phase operation

When two transformers are used, connecting them with a phase angle difference of 30° as in 人- Δ, Δ- Δ combination will produce an effect corresponding to 12 pulses.

In this case, it is ideal that the harmonic generating equipment of the load of each transformer is the same in model and capacity. If the capacity differs, however, a 12-pulse effect for smaller-capacity equipment can be expected. Therefore, the conversion coefficient for 6-pulse reference is halved.

(d) AC filter

A capacitor and a reactor are used together to reduce impedance for a specific frequency, producing a great effect of absorbing harmonic currents.

The AC filter exhibits an effect on a specific frequency. When there is more than one harmonic current degree, the AC filter must be installed for each degree.

(e) Active filter

This filter detects the current of a circuit generating a harmonic current and generates a harmonic current equivalent to the difference between that current and the fundamental wave current to suppress the harmonic current at the detection point.

As this filter compensates for a whole waveform, a single filter can provide effects on more than one degree of harmonic.

The filter has a protective function. Therefore, if there is an incoming excessive harmonic current, the filter may be short of the harmonic current absorbing effect (i. e. not perform as good) but will not overheat or burn out.

To utilize the performance of the active filter effectively, circuit conditions and others must be examined before installing the active filter.

Overview of the Guideline (Excerpt)

HARMONIC SUPPRESSION GUIDELINE FOR CONSUMERS RECEIVING POWER OF HIGH VOLTAGE OR SPECIALLY HIGH VOLTAGE

1. PURPOSE

   This guideline sets forth technological requirements to suppress harmonic currents generated when electric equipment are used by consumers who receive power of high voltage or specially high voltage (hereinafter referred to as the "specific consumers") from commercial power systems (hereinafter referred to as the "systems"), after observing the technological standards in accordance with the Electricity Enterprises Act and taking into account the harmonic environment target levels of the systems.

2. SCOPE

   (1) This guideline applies to the specific consumers whose sum of "equivalent capacities" of harmonic generating equipment falls within either of the following:

   1) Consumers who receive power from high voltage systems

   6.6kV system : 50kVA or more

   2) Consumers who receive power from specially high voltage systems

   22kV or 33kV : 300kVA or more

   66kV or more system : 2000kVA or more

   (2) Equipment covered by (1) shall be all harmonic generating equipment with the exception of the equipment covered by the "harmonic suppression guideline for household appliances and general-purpose products".

   (3) Any new harmonic generating equipment installed or added/renewed is covered by this guideline when the sum of equivalent capacities fall within the value indicated above in (1) after installation, addition or renewal.

3. SUPPRESSION OF HARMONIC CURRENTS

   The maximum outgoing harmonic current values at a specific consumer's receiving point shall be values found by multiplying the maximum outgoing harmonic current values per 1kW of contract power indicated in Table 3.1 by the contract power of the corresponding consumer. If any of these values is exceeded, the necessary step must be taken.

4. CALCULATION OF OUTGOING HARMONIC CURRENTS

   Outgoing harmonic currents at a receiving point shall be as follows:

   (1) Only the magnitude of an outgoing harmonic current is calculated and the 40th or less degrees shall be covered by this guideline.

   (2) An outgoing harmonic current at a receiving point is found by summing up harmonic currents generated in the rated operating status of individual harmonic generating equipment and multiplying the sum by the maximum operation ratio of the harmonic generating equipment.

   If the consumer has a facility to reduce harmonic currents, its effect may be taken into consideration.

5. OTHER REFERENCES

   (1) Contract power

   If the "contract power" is not determined at the point of a consumption contract between an electric power company and a consumer or more than one consumer and will be determined later, the contract power shall be as defined below:

   1) The contract facility power applies to consumers to whom the "real amount system" of the industrial power of high-voltage power A or less than 500W contact power is applied.

   2) When there are more than one contract power such as time zone-based regulation contract, the largest contract power applies among the contract powers.

   (2) Maximum operation ratio of harmonic generating equipment

   The "maximum operation ratio of harmonic generating equipment" indicates the ratio of the maximum actual operation capacity (average during 30 minutes) to the sum of capacities of the harmonic generating equipment.

Maximum Outgoing Harmonic Current Values per 1kW Contract Power

(Unit: mA/kW)

Received Power Voltage	5th	7th	11th	13th	17th	19th	23rd	Over 23rd
6.6kV	3.5	2.5	1.6	1.3	1.0	0.9	0.76	0.70
22	1.8	1.3	0.82	0.69	0.53	0.47	0.39	0.36
33	1.2	0.86	0.55	0.46	0.35	0.32	0.26	0.24
66	0.59	0.42	0.27	0.23	0.17	0.16	0.13	0.12
77	0.50	0.36	0.23	0.19	0.15	0.13	0.11	0.10
110	0.35	0.25	0.16	0.13	0.10	0.09	0.07	0.07
154	0.25	0.18	0.11	0.09	0.07	0.06	0.05	0.05
220	0.17	0.12	0.08	0.06	0.05	0.04	0.03	0.03
275	0.14	0.10	0.06	0.05	0.04	0.03	0.03	0.02

Calculation sheet for outgoing harmonic currents from harmonic generating equipment (Part 1)

<Format 1>

Date of Application	
Application No.	
Date of Acceptance	

Customer Name		Business Category		Received Power Voltage	kV	Contract Power	kV

STEP 1 HARMONIC GENERATING EQUIPMENT PARTICULARS										STEP 2 GENERATED HARMONIC CURRENT CALCULATION									
	Harmonic Generating Equipment			Rated Capacity (kVA)	Qty	Total Capacity Pi (kVA)	Circuit Class No.	6-Pulse Conversion Factor Ki	6-Pulse Equivalent Capacity [Ki×Pi] (kVA)	Rated Current Value Converted from Received Power Voltage [a×Pi] (mA)	Max. Equipment Operation Ratio (%)	Outgoing Harmonic Current by Degrees (mA)							
No.	Equipment name	Manufacturer	Model									5th	7th	11th	13th	17th	19th	23th	25th
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
					Sum of 6-pulse equivalent capacities Po					Total									
										Judgment of technique requirement									

<Entry Method>

Step 1

☐ Complete the harmonic generating equipment particulars. Enter the circuit class number, etc. according to data.

☐ For the equipment whose circuit class number is 10, complete the application <Format 3>.

☐ If Po > 50kVA (6kV power received), 300kVA (22, 33kV power received) or 2000kVA (66kV or more power received), proceed to Step 2. (If not, Step 2 need not be completed.)

Maximum Outgoing Harmonic Current Value
(Maximum outgoing harmonic value per kW contract × contract power)

Degree	5th	7th	11th	13th	17th	19th	23th	25th
Maximum current value (mA)								

Step 2

☐ When outgoing current > maximum outgoing current value for each degree:
- ○ If there is in-plant harmonic reduction equipment or suppression technique has been carried out, proceed to Calculation Sheet (Part 2).
- ○ If not, separate suppression technique will be required.

Calculation sheet for outgoing harmonic currents from harmonic generating equipment (Part 2)

<Format 2>

Date of Application	
Application No.	
Date of Acceptance	

Customer Name		Business Category		Received Power Voltage	kV	Contract Power	kV

In-Plant Single-Wire Connection Diagram

Specify the installation position, specifications, electrical constants, etc. of harmonic generating equipment, power receiving transformers, and equipment and the like which reduce (branch) harmonic currents.

Detailed Calculation of Outgoing Harmonic Currents

In consideration of equipment for harmonic current reduction and a suppression effect by branching, specifically describe the process of calculating outgoing harmonic currents at the power receiving point.

Degree	5th	7th	11th	13th	17th	19th	23th	25th
Outgoing harmonic current in calculation sheet (part 1) (mA)								
Outgoing harmonic current after consideration of reduction effect (mA)								
Maximum outgoing harmonic current value (mA)								
Judgment of suppression technique requirement								

*Note: When it is difficult to complete the in-plant single-wire connection diagram and the detailed calculation of outgoing harmonic currents in this format, separate data may be appended as explanatory information.

<Judgment of suppression technique requirement>

☐ If (outgoing harmonic current after consideration of reduction effect) > (maximum outgoing harmonic current value) for each degree, an additional suppression technique will be required.

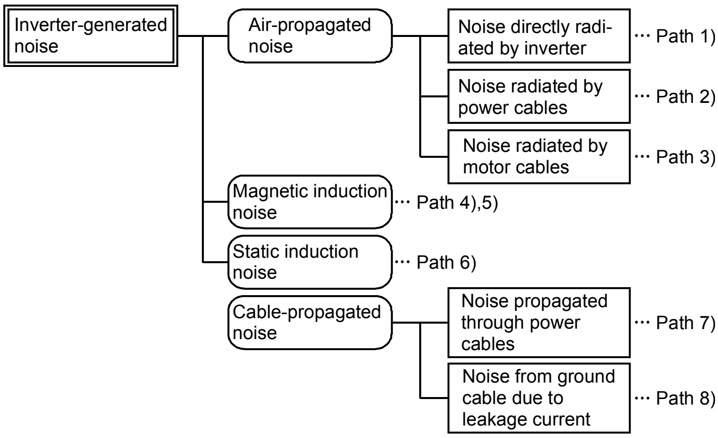
2.5.3 Inverter-generated noise and measures against noise

Noise generated by the inverter is largely classified into noise radiated by cables connected to the inverter and its main circuit (input, output), magnetic and static induction noise affecting peripheral device signal lines routed near the main circuit cable and electric path propagation noise transmitted over the power supply path line.

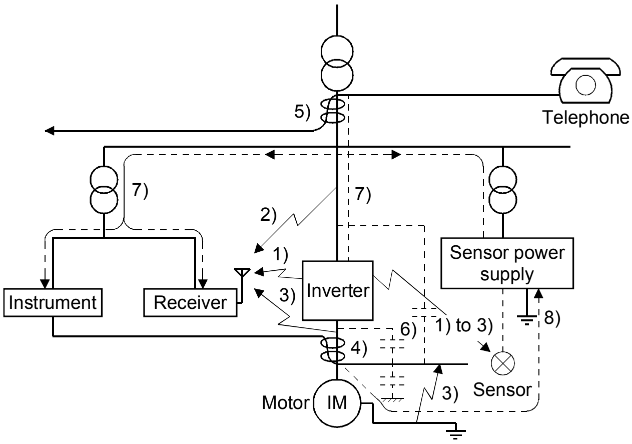
The noise types and their paths are shown below.

Influences given to the peripheral devices by high-frequency noise of the inverter include the malfunctions of computers instrumentation equipment, electronic equipment etc. mainly caused by induction noise and the malfunctions of radios and proximity switches chiefly caused by radiation noise.

For details of noise reduction techniques, refer to the Technical Note No. 21 <Noise and leakage currents>.



Types of Noises Generated



Noise Paths

(1) Noise to electronic equipment

Noise to electronic devices include those transmitted directly over the power supply line and ground cable of the inverter (paths 7 and 8 in the figure on the preceding page) and those transmitted where the inverter power line and electronic equipment signal line are coupled by electromagnetic induction (paths 4 and 5 in the figure on the preceding page) or electrostatic induction (path 6 in the figure on the preceding page).

The power supply line of the electronic devices should be different from the power line where the inverter is connected, protected from noise incoming from the power supply line by a constant-voltage power supply, insulating transformer, filters etc. and separated from the wiring route. The I/O cables to and from the electronic devices should be separated from the inverter power cables. Basically, keep the electronic equipment I/O cables as far away as possible from cables which must not be subjected to noise, or run them in separate iron shields (ordinarily, iron ducts or metal pipes which should be grounded) to minimize electromagnetic induction and prevent a failure. The best way of grounding the devices is independent grounding and the inverter and electronic equipment must not be grounded jointly.

Especially as a countermeasure against noise, run the cables in the shortest distance and twist them. Also, grounding should be carried out securely using a large-diameter cable over the shortest distance.

(2) Radio noise

When the motor is driven from the inverter, high-frequency noise is radiated to the air from the inverter. Like radio-wave noise, this noise has a great influence on the frequency band of less than 10MHz and may generate noise when entering into a radio receiver. The radio noise suppressing methods, radio noise propagation paths and measurement methods are given below.

1) Noise propagation paths

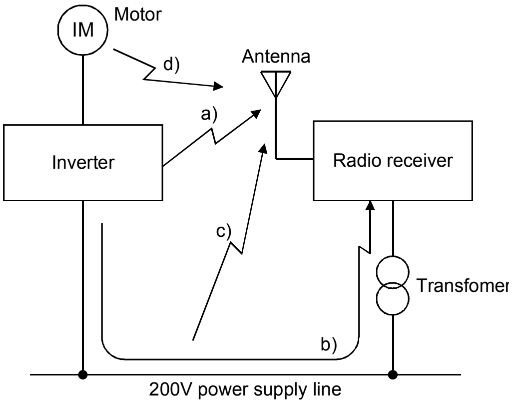
Major propagation paths of the radio-wave noise from the source of noise to a receiver affected may be as indicated below:

(a) Direct radiation noise radiated directly from the noise source as an airborne wave and entering the antenna and circuit of the receiver.

(b) Direct transmission noise of which current is transmitted through the power supply line and enters the receiver.

(c) Radiation from the power supply line noise which leaks to the power supply line, is radiated from the distribution line and enters the receiver.

(d) Radiation from the power line noise which is radiated from the wiring between the inverter and motor and enters the receiver.



Radio Noise Propagation Paths

2) Noise measuring methods

(a) Measurement of noise terminal voltage
Disturbance wave strength flowing into the power cord of the disturbing device is measured as a disturbance wave voltage on the distribution line where that device is connected.
The measured value is indicated in dB (1μV =0dB).

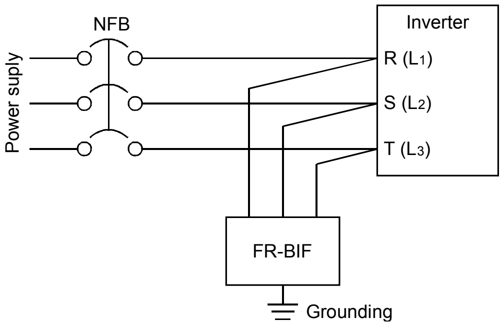
(b) Measurement of noise field strength
The strength of the electric field radiated by the disturbing device to the air is measured with an antenna. The distance of measurement between the device and antenna is specified as 10m or 3m. The measured value is indicated in dB (1μV/m =0dB).

(c) Also, disturbing power or the discontinuous noise (click noise) of a contact device is measured depending on the noise type.

As described above, the evaluation of disturbance wave noise depends greatly on the difference of its propagation path and the type of noise measuring method. The most appropriate method for comparing actual harm to the radio receiver by the disturbance wave is to measure the propagation noise field strength because the receiver is mostly influenced by the propagation paths a), c) or d).

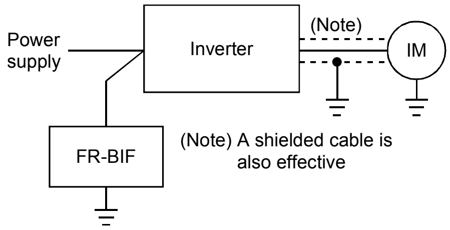
3) Countermeasures against radio noise
Radio noise can be reduced by any of the following methods:

(a) Connect the radio noise filter (FR-BIF) dedicated to FR series inverters across the inverter input power supply terminals (phases R, S, T (L_1, L_2, L_3)) and securely ground it with the ground cable. This is effective when the wiring distance between the inverter and motor is short.
Note: In this case, one FR-BIF causes an approximate. 4mA leakage current to flow.



Radio Noise Filter

(b) When the wiring distance between the inverter and motor is long, run the cable between the inverter and motor in a grounding conduit.

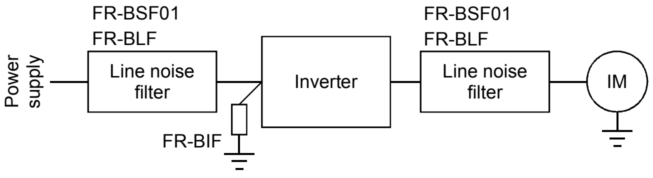


(Note) A shielded cable is also effective

Grounding Conduit

(c) House the inverter in an iron cubicle (without any instrument windows and indicator light windows) and ground the cubicle.

(d) Connect the line noise filter(s) (FR-BLF) across either or both the input terminals and output terminals of the inverter and house the inverter and cables in a grounding conduit. Use the line noise filter(s) together with the radio noise filter to produce a greater effect.



Line Noise Filters

Reference:
For example, a radio used in an urban area does not suffer from noise if it is used more than about 30m away from the inverter and the main circuit wiring to the inverter.

(3) Specific technique examples

1) Techniques and effects

The following levels (estimated values) of effects are expected for the technique examples (on the next page). Use this data for reference when determining the priority of actual techniques.

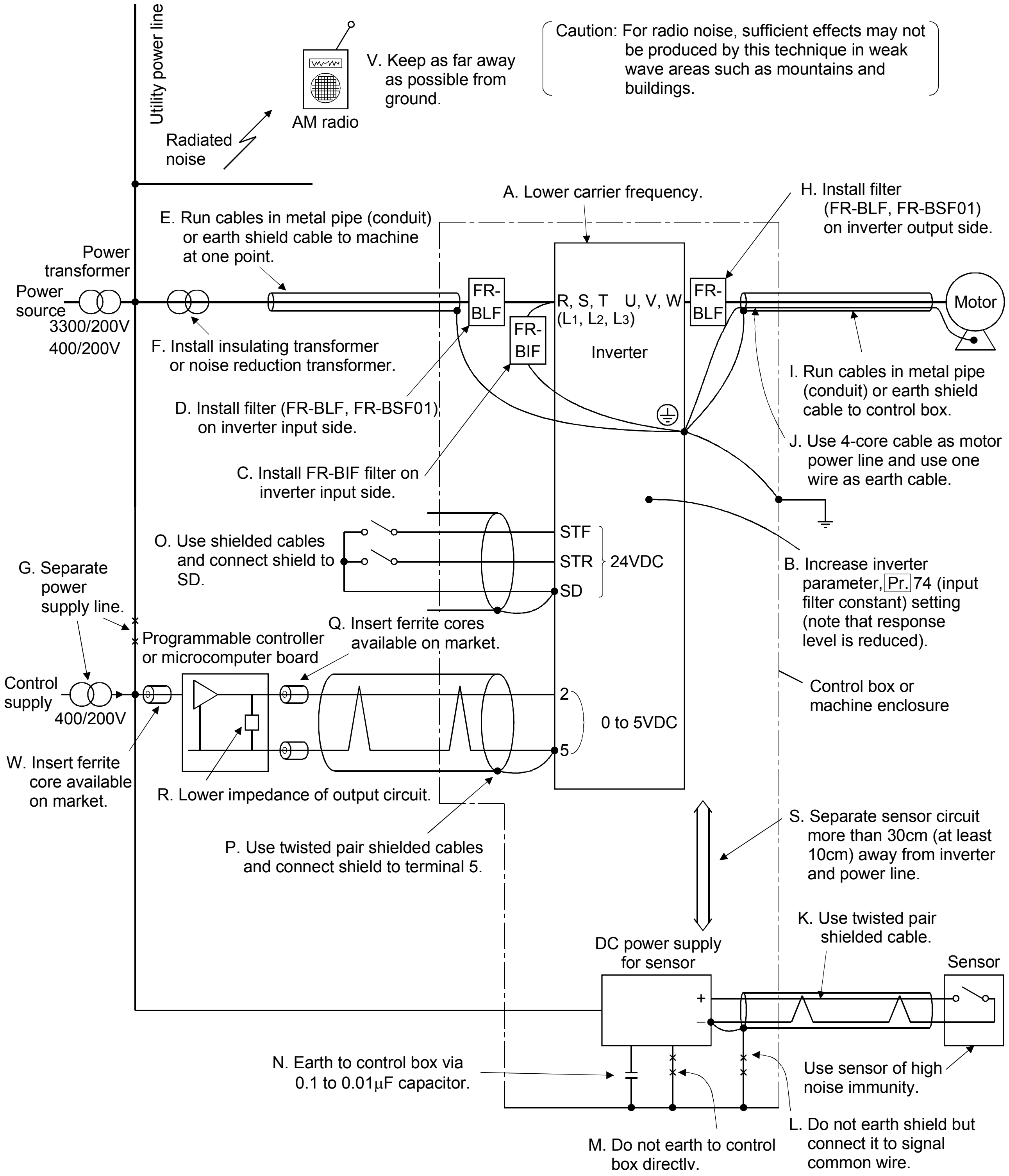
Symbol meanings
⊙ : Large effect
○ : Effect produced
Δ : Small effect
– : No effect

Effects of Noise Reduction Techniques

Location	Symbol	Technique	Noise Propagation						
			Air-propagated noise			Magnetic induction noise	Static induction noise	Cable-propagated noise	
			Radiation from inverter	Radiation from power cables	Radiation from motor cables			Power cables	Leakage current of ground cable
Inverter	A	Reduce carrier frequency (Pr. 72).	⊙	⊙	⊙	⊙	⊙	⊙	⊙
	B	Increase input switch filter constant (Pr. 74).	Δ	Δ	Δ	○	Δ	—	—
Input side	C	Install FR-BIF(-H) radio noise filter.	—	⊙	—	—	—	⊙	—
	D	Install FR-BSF01 or FR-BLF line noise filter.	—	⊙	—	—	—	⊙	Δ
	E	Run power supply cables in metal conduit or use shielded cables as power supply cables.	—	⊙	—	—	—	⊙	—
	F	Install insulating transformer or noise reduction transformer.	—	—	—	—	—	⊙	—
	G	Separate power supply line.	—	—	—	—	—	⊙	⊙
Output side	H	Install FR-BSF01 or FR-BLF line noise filter.	—	—	⊙	Δ	Δ	—	⊙
	I	Run output cables in metal conduit or use shielded cables as output cables.	—	—	⊙	○	○	—	—
	J	Use 4-core cable as motor power line and use one wire as ground cable.	—	—	Δ	Δ	Δ	—	⊙
Connected equipment	K	Use twisted pair shielded cable as sensor signal line.	○	○	○	⊙	⊙	—	—
	L	Connect shield to common of sensor signal.	—	—	—	⊙	⊙	—	⊙
	M	Do not earth sensor power unit to control box etc. directly.	—	—	—	—	—	Δ	⊙
	N	Earth sensor power unit via capacitor.	—	—	—	—	—	Δ	○
	O	Use shielded cables for signal inputs and connect shield to common (input terminal) SD.	Δ	Δ	Δ	○	⊙	—	Δ
	P	Use twisted pair shielded cables for speed inputs and connect shield to terminal 5.	○	○	○	⊙	⊙	—	Δ
	Q	Insert ferrite cores (available commercially) into speed input cables (output side of mating equipment).	Δ	Δ	Δ	○	—	—	—
	R	Lower impedance of output circuit of mating equipment.	Δ	Δ	Δ	○	—	—	—
	S	Separate more than 30cm from inverter and power line.	⊙	⊙	⊙	⊙	⊙	—	—
	T	Do not run cables in parallel or together.	Δ	Δ	Δ	⊙	⊙	—	8—
	U	Provide masking shield.	○	Δ	Δ	Δ	Δ	—	—
	V	Keep away from ground.	Δ	○	○	Δ	Δ	—	—
	W	Insert ferrite core available on market in input side of mating equipment.	—	—	—	—	—	○	Δ

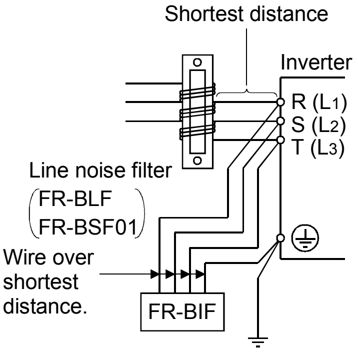
2) Technique examples

The following methods will produce some effects with regard to inverter noise reduction. For effects, see the preceding page.

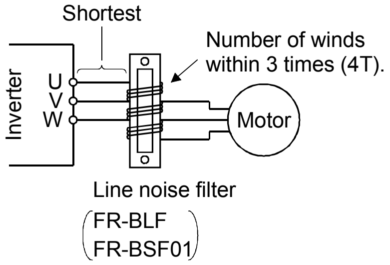


Instructions for Installation of Noise Filters

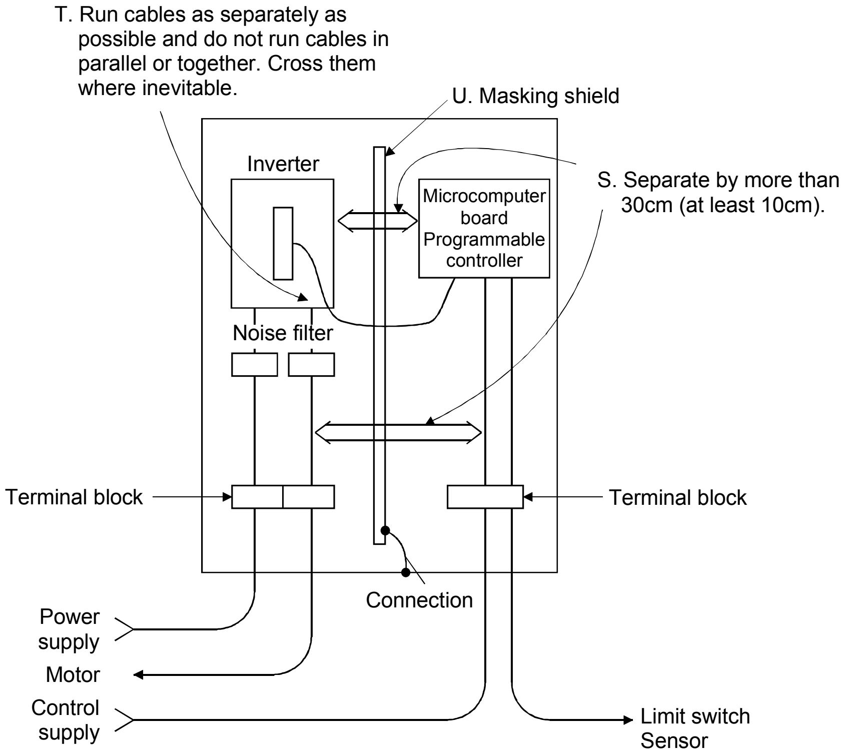
<Installation in inverter input side>



<Installation in inverter output side>



Cable Routing in Control Box


T. Run cables as separately as possible and do not run cables in parallel or together. Cross them where inevitable.

U. Masking shield

S. Separate by more than 30cm (at least 10cm).

2.5.4 Leakage currents and countermeasures

Due to capacitances existing in the inverter I/O lines and ground, leakage currents flow through them, in addition to the motor current.

These leakage currents are determined by the magnitudes of switching frequency (fc) (carrier frequency) and line-to-line and to-ground capacitances:

1) When the carrier frequency increases, the leakage current of the inverter increases.

2) If the wiring length is large, the line-to-line and to-ground capacitances increase, increasing the leakage current.

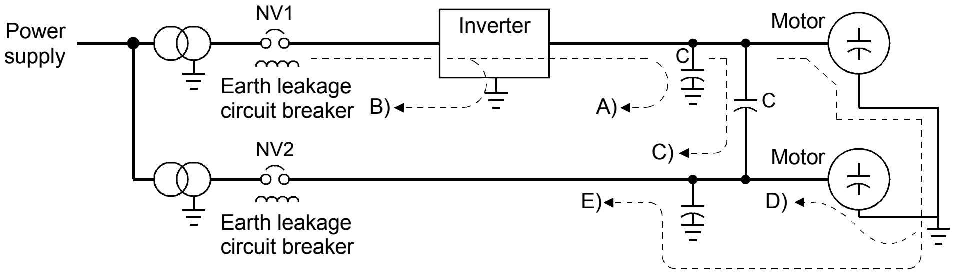
Therefore, independent of the manufacturer and inverter type, a low acoustic noise inverter using high-carrier frequency PWM control tends to increase leakage current.

(1) Influence of leakage currents

1) An earth leakage circuit breaker is actuated by to-ground leakage currents.
Compared to a case where a motor is driven by a commercial power supply, leakage current produced by inverter operation includes more high-frequency components and to-ground leakage current in this high frequency band are higher than the operating current of the earth leakage circuit breaker, actuating the earth leakage circuit breaker.

(a) The earth leakage circuit breaker (NV1) is actuated when leakage current flows through to-ground capacitances (C) in paths A) and B) indicated by dotted lines and exceed the setting of the earth leakage circuit breaker in the same line.

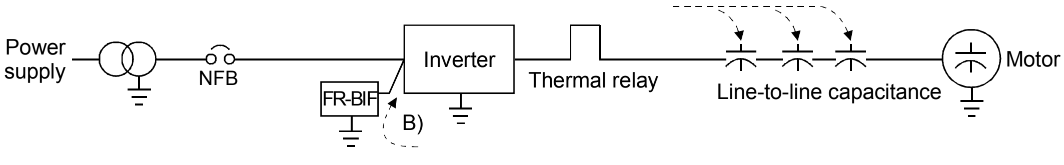
(b) The earth leakage circuit breaker NV2 or NV1 in the other line is actuated when leakage current flows in paths C), D), E), etc. indicated by dotted lines.



To-Ground Leakage Current Paths

2) External thermal relay is tripped by line-to-line leakage currents.
If the wiring distance on the inverter output side is long, line-to-line leakage currents (A) may increase the effective value of the current flowing in the thermal relay, operating the thermal relay.

A smaller-capacity model whose rated current is less than several amperes is more liable to be affected by leakage currents.
A leakage current B) may produce a several volts potential at the terminal of the radio noise filter (FR-BIF) but it is not a fault.



Line-to-Line Leakage Current Paths

(2) Leakage current data

To-Ground Leakage Current Example

Condition	Carrier Frequency	Leakage Current Value (mA)
FR-Z240	1.27kHz	60
FR-A540	2kHz	90
	14.5kHz	210

(Running frequency: 60Hz, wiring length: 20m)
(Motor capacity: 3.7kW 4-pole)

Note: Leakage currents in commercial power supply operation are approximately 1mA.

Line-to-Line Leakage Current Examples

Motor Capacity (kW)	200V Class			400V Class		
	Rated current (A)	Leakage current value (A)		Rated current (A)	Leakage current value (A)	
		Wiring length 50m	Wiring length 100m		Wiring length 50m	Wiring length 100m
0.4	1.8	0.31	0.50	1.1	0.62	1.00
0.75	3.2	0.34	0.53	1.9	0.67	1.05
1.5	5.8	0.37	0.56	3.5	0.74	1.12
2.2	8.2	0.40	0.59	4.1	0.80	1.18

(FR-A500 carrier frequency 14.5kHz)
(Wire used: 3.5mm dia., 4-core type cable)

(3) Actions to be taken for unnecessary operation of earth leakage circuit breaker and thermal relay due to leakage current.

1) Actions to be taken for unnecessary operation of earth leakage circuit breaker.

(a) Use an earth leakage circuit breaker (or earth leakage relay) for which high frequency components have been considered.
Use the earth leakage circuit breaker developed for use with an inverter, e.g. Mitsubishi's New Super NV series or set a large sensitivity current to prevent unnecessary operation.

(b) Provide dedicated ground cable.
Provide the motor with a dedicated ground cable to divide current, thereby reducing to-ground leakage current.

2) Actions to be taken for thermal relay malfunction.

(c) Install the reactor (FR-BOL) in the inverter output side.
Increase the impedance in the high frequency region to decrease line-to-line leakage currents.

(d) Use the electronic thermal relay built into the inverter.
The electronic thermal relay detects high frequency components after cutting them, and is rarely affected by leakage currents.

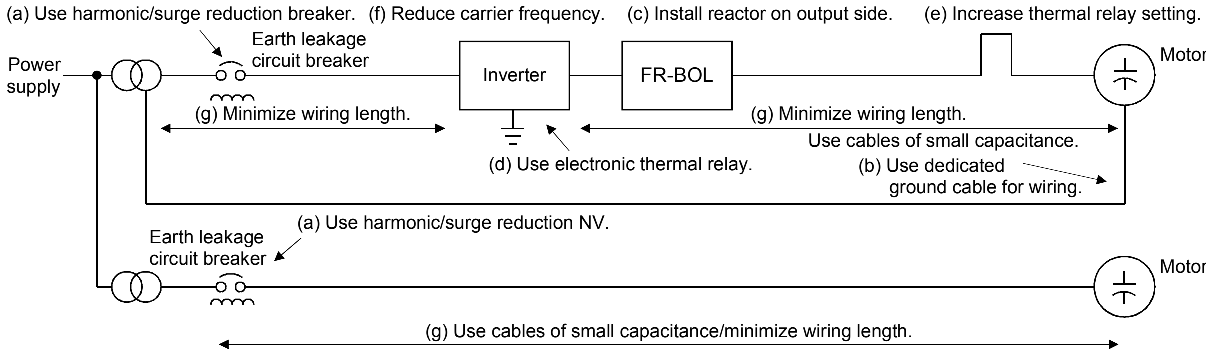
(e) Increase the setting of the external thermal relay.
When the electronic thermal relay cannot be used, e.g. when two or more motors are connected to one inverter and thermal relays are installed individually, increase the setting of each external thermal relay by the equivalence of the leakage current to make them difficult to be actuated.
Motors of 11kW or more capacity rarely have leakage current problems since their rated current is large.

3) Actions to be taken for unnecessary operation of earth leakage circuit breaker and thermal relay.

(f) Set the carrier frequency of the inverter to a low value.
Decrease leakage current by setting the carrier frequency of the inverter to a low value using the relevart parameter.
However, it should be noted that the decrease in carrier frequency increases noise during motor running.
The selection of Soft-PWM can eliminate this low frequency “metalic“ noise.

(g) Decrease the to-ground and line-to-line capacitances.
Wire cables of smaller capacitances between the inverter power supply side and motor side to minimize the wiring length.

Examples of actions to be taken to prevent unnecessary operation



Effects of actions

Actions marked ⊙ are recommended for phenomena occurring due to the influence of leakage current.

No.		Phenomenon	(a) Harmonic/ surge reduction breaker	(b) Dedicated ground cable	(c) Installation of reactor on output side	(d) Use of electronic thermal relay	(e) Thermal relay setting change	(f) Carrier frequency change	(g) Reduction of capacitance
1)	I	Operation of circuit breaker in the same line	⊙	○	×	×	×	⊙	○
	II	Operation of circuit breaker in the other line	⊙	○	×	×	×	⊙	○
2)		Thermal relay operation	×	×	○	○	○	⊙	○

Symbol meaning------ ⊙: Adequate effect, ○: Effect produced, Δ: Small effect, ×: No effect

2.6 Selecting peripheral Equipment

The no-fuse breakers, magnetic contactors and cables differ with the inverter models. For specific selection, refer to the corresponding model catalog or manual.

Peripheral Device Selection List (A500)

Voltage	Motor Output (kW)	Applicable Inverter Type	No-Fuse Breaker (NF) or Earth Leakage Circuit Breaker (NV)		Magnetic Contactor (MC)	Cables (mm^2)	
			Standard	With power factor improving reactor		R, S, T	U, V, W
200V class	0.4	FR-A520-0.4K	Type NF30, Type NV30 5A	Type NF30, Type NV30 5A	S-N10	2	2
	0.75	FR-A520-0.75K	Type NF30, Type NV30 10A	Type NF30, Type NV30 10A	S-N10	2	2
	1.5	FR-A520-1.5K	Type NF30, Type NV30 15A	Type NF30, Type NV30 15A	S-N10	2	2
	2.2	FR-A520-2.2K	Type NF30, Type NV30 20A	Type NF30, Type NV30 15A	S-N11,N12	2	2
	3.7	FR-A520-3.7K	Type NF30, Type NV30 30A	Type NF30, Type NV30 30A	S-N20	3.5	3.5
	5.5	FR-A520-5.5K	Type NF50, Type NV50 50A	Type NF50, Type NV50 40A	S-N25	5.5	5.5
	7.5	FR-A520-7.5K	Type NF100, Type NV100 60A	Type NF50, Type NV50 50A	S-N35	14	8
	11	FR-A520-11K	Type NF100, Type NV100 75A	Type NF100, Type NV100 75A	S-K50	14	14
	15	FR-A520-15K	Type NF225, Type NV225 125A	Type NF100, Type NV100 100A	S-K65	22	22
	18.5	FR-A520-18.5K	Type NF225, Type NV225 150A	Type NF225, Type NV225 125A	S-K80	38	38
	22	FR-A520-22K	Type NF225, Type NV225 175A	Type NF225, Type NV225 150A	S-K95	38	38
	30	FR-A520-30K	Type NF225, Type NV225 225A	Type NF225, Type NV225 175A	S-K125	60	60
	37	FR-A520-37K	Type NF400, Type NV400 250A	Type NF225, Type NV225 225A	S-K150	100	100
	45	FR-A520-45K	Type NF400, Type NV400 300A	Type NF400, Type NV400 300A	S-K180	100	100
	55	FR-A520-55K	Type NF400, Type NV400 400A	Type NF400, Type NV400 350A	S-K220	150	150
400V class	0.4	FR-A540-0.4K	Type NF30, Type NV30 5A	Type NF30, Type NV30 5A	S-N10	2	2
	0.75	FR-A540-0.75K	Type NF30, Type NV30 5A	Type NF30, Type NV30 5A	S-N10	2	2
	1.5	FR-A540-1.5K	Type NF30, Type NV30 10A	Type NF30, Type NV30 10A	S-N10	2	2
	2.2	FR-A540-2.2K	Type NF30, Type NV30 15A	Type NF30, Type NV30 10A	S-N20	2	2
	3.7	FR-A540-3.7K	Type NF30, Type NV30 20A	Type NF30, Type NV30 15A	S-N20	2	2
	5.5	FR-A540-5.5K	Type NF30, Type NV30 30A	Type NF30, Type NV30 20A	S-N20	3.5	2
	7.5	FR-A540-7.5K	Type NF30, Type NV30 30A	Type NF30, Type NV30 30A	S-N20	3.5	3.5
	11	FR-A540-11K	Type NF50, Type NV50 50A	Type NF30, Type NV50 40A	S-N20	5.5	5.5
	15	FR-A540-15K	Type NF100, Type NV100 60A	Type NF50, Type NV50 50A	S-N25	14	8
	18.5	FR-A540-18.5K	Type NF100, Type NV100 75A	Type NF100, Type NV100 60A	S-N35	14	8
	22	FR-A540-22K	Type NF100, Type NV100 100A	Type NF100, Type NV100 75A	S-K50	22	14
	30	FR-A540-30K	Type NF225, Type NV225 125A	Type NF100, Type NV100 100A	S-K65	22	22
	37	FR-A540-37K	Type NF225, Type NV225 150A	Type NF225, Type NV225 125A	S-K80	38	22
	45	FR-A540-45K	Type NF225, Type NV225 175A	Type NF225, Type NV225 150A	S-K80	38	38
	55	FR-A540-55K	Type NF225, Type NV225 200A	Type NF225, Type NV225 175A	S-K100	60	60

Note: 1. The cable sizes indicated are those for the wiring length of 20m.

2. When the inverter is larger in capacity than the motor in their combination, the breaker and magnetic contactor should be selected according to the inverter type, and the cables and power factor improving reactor selected according to the motor output.

2.6.1 No-Fuse Breaker

(1) Protective coordination (Breaking capacity)

The NFB is used to protect the wiring from damage caused by on overload or short-circuit currents. Install the NFB to shut off any accidental current passing through the inverter input circuit, such as overload or short-circuit thereby minimizing the influence of the accident.

Select the NFB of which breaking capacity is appropriate for the estimated short-circuit current in the circuit according to the overall impedance of the power supply. (For full information, refer to the Mitsubishi no-fuse breaker technical information.)

The master NFB and inverter NFB must be fully coordinated for protection. Should a low-impedance short circuit occur, for example, if the transistors in the inverter circuit of the inverter are damaged or the diodes in the converter circuit are broken, the master NFB may be tripped. Hence, it is necessary to make a pre-check using the operational characteristic curve.

When the overall impedance of the power supply line is small, the peak value of the inverter input power supply increases. Therefore, the current peak value must be reduced by the current limiting action of the power-factor correcting reactor.

The power-factor reactor must be inserted in the input or DC circuit when the power transformer is large.

(2) Setting the rated current of inverter primary NFB

The NFB in the inverter primary circuit is used to protect the inverter primary wiring from overload and short circuit.

Since the inverter has a converter circuit and a large-capacity smoothing electrolytic capacitor, it serves as a capacitor-input rectifier with respect to the power supply and a pulse-shaped current flows in the inverter input circuit to charge the capacitor.

The effective value of the inverter input current varies according to its form factor which is under the influence of the power supply impedance. Hence, the input current is not determined only by the load capacity of the motor and changes under the influence of the reactances of the power supply and wiring. The rated currents of the NFBs (listed on the previous page) have been selected in relation to the effective value of the inverter input power supply found by using the power supply impedance value on the assumption that the power supply capacity is about 200kVA to 500kVA, with the influence of the temperature rise and other factors such as harmonic components taken into consideration. Select a larger current rating version when an electro-magnetic type NFB is used because its operational characteristic may change due to harmonic current. By inserting the power-factor correcting reactor, the form factor of the primary current is improved and the current effective value is reduced.

2.6.2 Magnetic Contactor (MC)

(1) Inverter primary magnetic contactor (MC)

The inverter primary circuit can be directly connected with a NFB. In some cases, the MC may be provided for any of the following purposes. See section 1.4.1.

1) To disconnect the inverter from the power supply when the inverter protective function is activated or when a fault occurs in the drive unit (e.g. emergency stop operation).
2) To prevent an accident caused by automatic restart when the power is restored after the inverter has been stopped by a power failure. (For the (A500), when an instantaneous power failure is 15ms or longer, instantaneous power failure protection is activated to prevent the inverter from automatically restarting when power is restored. When a power failure is longer than about 100ms, the inverter is automatically reset when power is restored and is therefore restarted automatically if the run signal is on.)
3) To keep the inverter stopped for a long time. The inverter control power supply and cooling fan are always running, consuming little power. (Actually depends on intelligent fan control selection.)

   When the inverter is kept stopped for a long time, power can be economized slightly by switching the inverter power supply off.
4) To separate the inverter from the power supply to ensure safety during maintenance and inspection.

   Since the inverter primary MC is used for the above purposes, the number of on/off times is extremely small. Select the MC which conforms to JEM1038-AC Class 3 in relation to the inverter input current.

   Note: The inverter may be run and stopped by switching the MC on and off. However, frequent starting and stopping of the inverter using the MC must be avoided because an inrush current repeated at power-on reduces the life of the converter circuit (switching life is about 200,000 times). Run and stop the inverter by switching on and off the inverter start control terminal (STF, STR).

(2) Inverter secondary magnetic contactor

Refer to Section 1.4.3 for details of the turn-on condition of a magnetic contactor provided between the inverter and motor.

1) To run the motor by switching between a commercial power supply and inverter operation.

   In this case, the commercial power supply MC and inverter output circuit MC must be magnetic contactors with electrical and mechanical interlocks and the two MCs must be designed not to turn on at the same time. The transistors will be damaged if the commercial power is applied to the inverter output terminals. Select the MC which has a sufficient capacity for the inverter output current. (JEM1038-AC Class 3 or higher.) Take special care so that the inverter is not connected with the commercial power supply by an arc generated when the current is shut off.
2) To use one inverter with several motors by switching the inverter-driven motors from one to another.

   The MC may be switched off during operation. Select the MC which meets JEM1038-AC Class 3 or higher in consideration of the switching life.

2.6.3 Thermal Relay

A thermal relay is generally used to protect a general-purpose motor. The current flowing in the general-purpose motor driven from an inverter is about 10% larger than that flowing in the motor driven when from a commercial power supply.

For this reason, set the thermal relay to 1.1 times greater than the current value for use with the commercial power supply. Note that since the general-purpose motor is designed for use at any of the three ratings of 200V 50Hz, 200V 60Hz and 220V 60Hz, the temperature rise of the motor may exceed the permissible value even when the load current is within the rated value when the motor is continuously run at the rated torque of 50Hz or at low speed. Therefore, select the motor capacity so that the load torque is less than the nominal motor torque as indicated in Section 2.2.3.

The FR-A500 and FR-E500 series inverters are incorporated with an electronic thermal relay to protect the motor from overload in the low speed range. Therefore, a thermal relay need not be provided unless:

- Two or more motors are run by one inverter; or
- A special motor is run. In this case, provide a heat-operated thermal relay.

2.6.4 Cable Size and Wiring Distance

(1) Main circuit cables

Like that of a general power cable, determine the size of the main circuit cables after examining its current capacity, short circuit protection and cable voltage drop.

The effective value of the inverter primary current must be noted because a current larger than the motor current may flow depending on the inverter input power factor (see Section 2.4.1). If the wiring distance of the cable between the inverter and motor is long, the voltage drop increases, causing a reduction in motor torque and the current to increase. In an extreme case, the motor may overheat. Note that especially when the output frequency is low, the output voltage of the inverter is also low and the rate of voltage drop increases.

Select the cable size so that the voltage drop between the inverter and motor is 2% or less of the rated voltage.

Voltage Drop over Wiring Distance of 30m

(220V Supplied) Reference Values

General - Purpose Motor 4P(kW)	Applicable Inverter		Inverter Output Voltage		Standard Applicable Cable over 30m		Line Voltage Drop over 30m		
	Type	Current(A)	60Hz (V)	6Hz (V)	Cable diameter (mm^2)	Conductor resistance20°C (mΩ/m)	Voltage drop (V)	60Hz (%)	6Hz (%)
0.4	FR-A520-0.4K	3	220	34	2	9.24	1.44	0.65	4.2
0.75	FR-A520-0.75K	5	220	34	2	9.24	2.40	1.09	7.1
1.5	FR-A520-1.5K	8	220	30	2	9.24	3.84	1.75	12.8
2.2	FR-A520-2.2K	11	220	30	3.5	5.20	2.97	1.35	9.9
3.7	FR-A520-3.7K	17	220	30	5.5	3.33	2.94	1.34	9.8
5.5	FR-A520-5.5K	24	220	28	8	2.31	2.88	1.31	10.3
7.5	FR-A520-7.5K	33	220	28	8	2.31	3.96	1.80	14.1
11	FR-A520-11K	46	220	26	14	1.30	3.1	1.41	11.9
15	FR-A520-15K	61	220	26	22	0.824	2.33	1.06	9.0
18.5	FR-A520-18.5K	76	220	26	30	0.624	2.91	1.32	11.2
22	FR-A520-22K	90	220	26	30	0.624	2.91	1.32	11.2
30	FR-A520-30K	115	220	26	50	0.378	2.26	1.03	8.7
37	FR-A520-37K	145	220	26	80	0.229	1.73	0.78	6.7
45	FR-A520-45K	175	220	26	80	0.229	2.08	0.95	8.0
55	FR-A520-55K	215	220	26	125	0.144	1.61	0.73	6.2

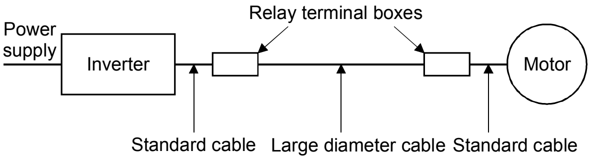
The line voltage drop can be calculated by the following expression:

Line voltage drop [V]

$$= \frac{\sqrt{3} \times \text{cable resistance}[\text{m}\Omega/\text{m}] \times \text{wiring distance}[\text{m}] \times \text{current}[\text{A}]}{1{,}000}$$

Use a larger diameter cable when the wiring distance is long or it is desired to decrease the voltage drop (torque reduction) in the low speed range.

Note: When it is desired to use a larger-diameter cable but it cannot be connected directly with the motor and inverter terminals, provide relay terminal boxes as shown below:



- Wiring length to the motor
  When the wiring distance between the inverter and motor is long, overcurrent protection may be activated by the influence of the charging current (leakage current) due to the stray capacity of the wiring in addition to the aforementioned voltage drop. Hence, the wiring length should be 500m (maximum). (When several motors are connected, the overall length should be within 500m)
  When magnetic flux vector control has been selected, the cable length should be within 30m. A longer cable length may cause instable rotation at low speed, in addition to reduced torque.

(2) Control circuit cables
The cable size of 0.75mm^2 or larger is enough for use with cable other than the main circuit cables, e.g. operation and signal circuits.

2.6.5 Ground Fault Breaker (NV)

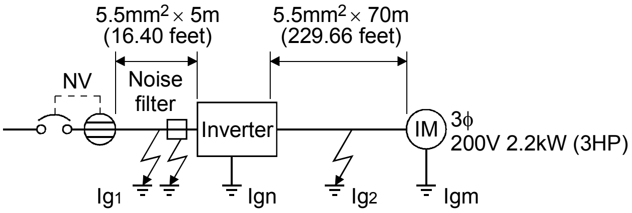
Since harmonic components are included in the output voltage of an inverter which drives a motor, an earth leakage current flows due to the earth capacity of the electrical path from the inverter to the motor and the stray capacity between the motor winding and iron core. For this reason, the rated sensitivity current of the ground fault breaker installed in the power supply side of the inverter should be selected as described below:

- New Super NV series (Type SF, CF)
  Rated sensitivity current
  $I \Delta n \geq 10 \times (Ig_1 + Ign + Ig_2 + Igm)$
- Conventional NV series (Type CA, CS, SS)
  Rated sensitivity current

$I \Delta n \geq 10 \times \{Ig + Ign + 3 \times (Ig_2 + Igm)\}$

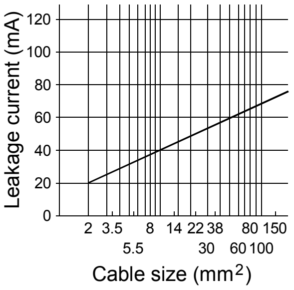
Ig1, Ig: leakage currents in cable path during commercial power supply operation
Ign : leakage current of noise filter on inverter input side
Igm : leakage current of motor during commercial power supply operation

[Example]

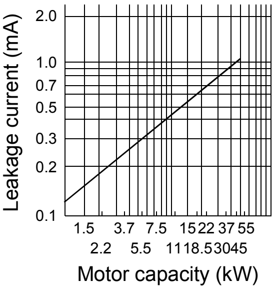


Note: 1. The NV should be installed on the primary (power supply) side of the inverter.
2. Ground fault in the secondary side of the inverter can be detected at the running frequency of 120Hz or lower.
3. In the star-connection neutral point grounding system, the sensitivity current is purified against a ground fault in the inverter secondary side. Therefore, the protective ground resistance of the load equipment should be 10Ω or less.

Example of leakage current in cable path during commercial power supply operation when the CV cable is routed in metal conduit (200V 60Hz)



Leakage current example of 3-phase induction motor during commercial power supply operation (200V 60Hz)



Selection Example (for the left figure)

(Unit: mA)

	Progressive Super Series (Type SP, CP)	Conventional NV (Type CA, CS, SS)
Leakage current (Ig1)	$33 \times \frac{5m\ (16.40\ feet)}{1000m\ (3280.80\ feet)} = 0.17$	
Leakage current (Ign)	0 (without noise filter)	
Leakage current (Ig2)	$33 \times \frac{70m\ (229.66\ feet)}{1000m\ (3280.80\ feet)} = 2.31$	
Motor leakage current (Igm)	0.18	
Total leakage current	2.66	7.64
Rated sensitivity current (≥ Ig × 10)	30	100

(1) Calculating the continuous leakage current

The value of the leakage current depends on the cable type, cable diameter, cable length from ground fault breaker to inverter, cable length from inverter to motor, and inverter output frequency. It is roughly calculated from a value for the commercial power supply (50Hz, 60Hz).

1) Leakage current from cables (Ig1,Ig2)

Measure the electrical path length from ground fault interrupter to inverter input terminals and the types and sizes of cables and calculate the leakage current according to the information. (Apply the value for the commercial power supply. Harmonic components can be ignored.)

Measure the electrical path length from inverter output terminals to the motor and the types and sizes of cables, calculate the leakage current according to this information and multiply the calculated value several times in consideration of the harmonic components (about three times on average, though it depends on the inverter output frequency).

2) Leakage current form the motor (Igm)

Determine the capacities and the number of motors, calculate the total leakage current using the in-operation leakage current value in the information and multiply the total value several times in consideration of the harmonic components (about three times on average, though it depends on the inverter output frequency).

3) Leakage current of noise filter in inverter input side (Ign).

When using the inverter-dedicated radio noise filter (FR-BIF), add approximately 4mA per filter.

(For the calculation of the continuous leakage current, refer to the "Mitsubishi Ground Fault Breaker Technical Information.")

(2) Selecting the rated sensitivity current

The rated sensitivity current, protective ground resistance value and continuous leakage current of an electrical path are interrelated. From the standpoint of protection from electric shock, the relationship between the rated sensitivity current and protective ground resistance value is important. From the standpoint of unnecessary operation prevention, the relationship between the rated sensitivity current and leakage current cannot be ignored.

Which factor is given priority depends on the circumstances. Generally, establish the relationship between the rated sensitivity current and protective ground and check for potential unnecessary operation caused by continuous leakage current.

1) Selecting the rated sensitivity current.

Find the continuous leakage current using the method described in paragraph (1) and use the rated sensitivity current of more than 10 times greater than the continuous leakage current, considering a transient inrush current. Note that when the Mitsubishi New Super NV Series (type SF, CF) is used with the inverter circuit, the harmonic components are cut. In this case, use the value 10 times greater than the continuous leakage current generated when a commercial power supply is used.

2) Application to legally restricted areas.

In some areas, the rated sensitivity current is specified by the electrical facility standard, occupational safety and health rules and indoor wiring regulations. When installing the ground fault breaker in such places, select the rated sensitivity current in accordance with these rules and regulations. If the rated sensitivity current selected for a large continuous leakage current cannot satisfy the rules and regulations, take either of the following measures:

a) When there are several loads, install a ground fault breaker for each motor and inverter.

b) Reduce the length of the cable or increase the distance from the ground.

3) Examination from the standpoint of electric shock prevention.

Electric shock is divided into direct shock and indirect shock. In Japan, protection is generally provided against indirect electric shock. The determination of the rated sensitivity current is related to the contact voltage and the resistance value of class 3 equipment grounding (protective grounding) and generally there are no restrictions on the rated sensitivity current. Hence, select the rated sensitivity current from among 15, 30, 100, 200 and 500mA, and conduct protective grounding so that the permissible contact voltage is not exceeded.

- 200V class------ Class 3 grounding (grounding resistance 100Ω maximum)
- 400V class------ Special class 3 grounding (grounding resistance 10Ω maximum)
- When the power transformer is of 人-connection neutral point ground type, use special class 3 grounding (10Ω or less) because the sensitivity current is blunted with respect to a ground fault on the secondary side of the inverter.

(3) Characteristics and operational instructions for the ground fault interrupter

1) When the FR-A200 series inverter is used, the leakage current increases in harmonic current component as compared to a conventional inverter, resulting in a larger continuous leakage current. When a recent ground fault interrupter provided with a harmonic eliminating circuit to prevent malfunction (e.g. Mitsubishi Super Scrum Series) is used, selection can be made in the same way as in the conventional inverter (see section 2.6.5).

   When the FR-A200 series is used with the ground fault interrupter which is not provided with the harmonic eliminating circuit, a malfunction may occur. Therefore, it is recommended to use the ground fault interrupter provided with the malfunction preventing circuit.

2) Install the ground fault interrupter in the power supply side of the inverter. (Proper operation is not performed if it is installed in the load side.)

3) If a ground fault occurs in the power supply side of the inverter, the ground fault interrupter operates properly, posing no problem. If a ground fault occurs in the load side of the inverter, the sensitivity current of the ground fault interrupter may change depending on the operating status (output frequency) of the inverter. This is mainly because the waveform of the ground fault current is not a sinusoidal wave but an AC non-sinusoidal wave including harmonic and DC components.

4) In Japan installation of an earth leakage circuit breaker is mandated by the "Technological Baseline Related to Electrical Equipment, Article 41" and "Occupational Safety and Health Rules, Articles 333, 334". For full information, refer to the corresponding ordinances.

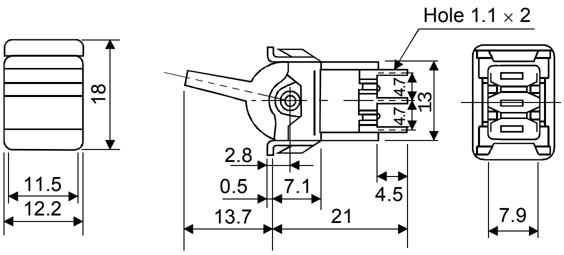
2.6.6 Relays

Relays used in the control circuit, e.g. inputs STF, STR, 10, 2, 5 etc.	Use small-signal relays (twin contact) to prevent a contact fault. Omron: Type G2A, Fuji: Type No. 473, 474
Relays used with outputs RUN, SU etc.	Use small relays of 12VDC or 24VDC, 100mA or less.

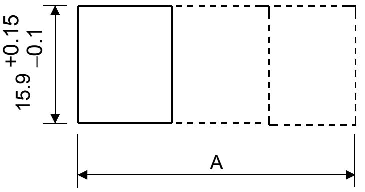
2.6.7 Start/stop switch

Use a low-current switch to prevent a contact fault.

Switch example (Nippon Kaiheiki)
Single-pole, double-throw switch (M-2012J-G-WIW)



Panel drilling diagram



Dimension A (Unit: mm)

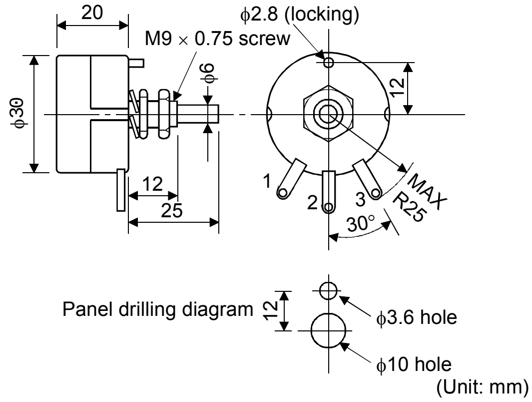
Without bezel $=12.5 \times n^{+0.3}_{0}$

With bezel $=12.5+15.6(n-1)^{+0.3}_{0}$

2.6.8 Frequency setting potentiometer

Type: WA2WYA2SEBK1kΩ (Japan Resistor) Wire-wound variable resistor 2W1kΩ, B characteristic.

When frequency setting is not changed frequently, a variable resistor of 1/2W1kΩ may be used.



(Unit: mm)

2.6.9 Frequency Meter and Calibration Resistor

A manual controller with frequency meter (such as the FR-AX) is available. When only a frequency meter is installed separately, use an instrument of the following specifications:

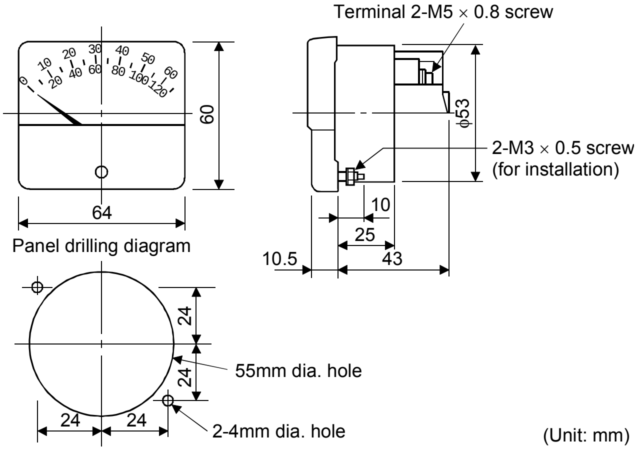
Moving-coil DC ammeter
Full scale 1mA (internal resistance 300Ω max.)
Graduations: 60, 120, 240Hz in full scale.
Alternatively, graduate in rpm according to the number of poles of the motor used.

Since the frequency meter terminal FM on the inverter develops about 5VDC at the maximum frequency, calibrate the frequency meter using the variable resistor having the following specifications. The variable resistor is not required when calibration is made with the parameter unit.

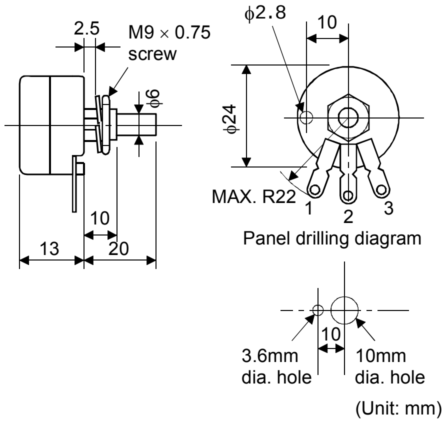
Calibration resistor 1/3W or more, 10kΩ

The following frequency meter and calibration resistor are available for use.

- Frequency meter
  Type: YM206RI 1mA
  Graduations: 0 to 65, 130Hz, double graduations



- Calibration resistor
  Type: RV24YN 20SB10kΩ - K (Tokyo Cosmos)
  Deposited carbon variable resistor 1/3W, 10kΩB characteristic



2.6.10 Twisted and Shielded Cables

Example: Twisted cable

Type: KV-2C × 0.3SQ (Optec Dai-Ichi Denko)

Qty. × Size (mm^2)	Finish OD (mm)	Characteristics of a Single Cable				Color
		Structure (wires/mm)	Conductor resistance (8Ω /km)	Rated voltage (V)	Permissible temperature (°C)	
2 × 0.3	2 × 1.5	12 / 0.18	64.4 max.	300	60	Red/white

Example: Multi-core shielded cable

Type: VCT-S3C × 0.5SQ (Tokiwa Cable)

Qty. × Size (mm^2)	Finish OD (mm)	Characteristics of a Single Cable				Color
		Structure (wires/mm)	—	Rated voltage (V)	—	
3 × 0.3	8.3	20/0.18	—	600	—	Gray

2.7 Panel Design

In designing and manufacturing inverter panels, heat generated by equipment housed in the panel, the operating environment etc. must be fully considered to determine the structure, dimensions and device layout of the panel.

Many semiconductor devices are used in the inverter unit. To ensure high reliability and a long period of use the inverter should be operated in an ambient environment where the specifications of the equipment are fully satisfied.

2.7.1 Installation Environment of the Inverter

The standard specifications of the inverter installation environment are indicated below. If the inverter is used in a place beyond any of the indicated conditions, its performance and life will not only be deteriorated but also lead to a fault. To protect the inverter, take sufficient measures in accordance with the following precautions:

Standard Environmental Resistance Specifications of the Inverter

Item	Specifications
Ambient temperature	−10 to + 50°C (non-freezing)
Ambient humidity	90% maximum (non-condensing)
Ambience	No corrosive and explosive gases. No dust and dirt.
Altitude	1000m maximum
Vibration	$5.9m/s^2$ {0.6G} maximum (conforming to JIS C0911)

(1) Temperature

The inverter must be used within the permissible ambient temperature range from - 10 to + 50°C. If it is used outside this range, its semiconductors, parts, capacitor, etc. will be deteriorated considerably. Take the following measures so that the ambient temperature of the inverter falls within the specified value.

1) Measures against high temperature
   - a) Adopt a cooling method such as forced ventilation system. (See Section 2.7.4.)
   - b) Install the panel in an air-conditioned electrical room.
   - c) Block direct sunlight.
   - d) Provide a masking shield so that the panel is not exposed to the radiant heat and warm air of a heat source.
   - e) Improve ventilation around the panel.

2) Measures against low temperature
   - a) Provide a space heater inside the panel.
   - b) Do not switch off the inverter power. (The inverter start signal should be off.)

3) Sudden temperature changes
   - a) Install the panel in a place where sudden temperature changes do not occur.
   - b) Avoid areas by an air outlet of an air conditioner.
   - c) If temperature changes occur due to door opening, install the panel away from the door.

(2) Humidity

Use the inverter in the operating humidity range from 45 to 90%. If humidity is too high, insulation will be deteriorated and the metal area corroded. In contrast, if humidity is too low, through-air insulation breakdown may occur. The insulation distance stipulated in JEM1103 "Insulating Devices for Control Equipment" provides for the humidity of 45 to 85%.

1) Measures against high humidity
   - a) Use an enclosed panel with moisture absorber.
   - b) Blow dry air into the panel from outside.
   - c) Provide a space heater inside the panel.

2) Measures against low humidity

Blow properly humid air into the panel from the outside. In addition, when installing or checking the unit in this state, it is important to discharge the charge (static electricity) of the human body in advance and also important not to make contact with internal parts and devices.

3) Measures against condensation

Condensation may occur if temperature in the panel changes suddenly due to frequent power on/off switching or if atmospheric temperature changes suddenly.

Condensation will cause insulation to be deteriorated and corrosion to occur.

   - a) Take measures against high humidity as in (1).
   - b) Do not switch off inverter power. (The inverter start signal should be off.)

(3) Dust, dirt, oil mist

Dust and dirt will cause such faults as contact fault of contact areas, insulation deterioration due to moisture absorption by accumulated dust and dirt, cooling effect reduction and temperature rise in the panel due to a clogged filter. In an environment where conductive powders are floating, faults such as malfunction, insulation deterioration and short circuit will occur in a short time.

Since oil mist will cause similar circumstances, sufficient countermeasures must be taken.

Measures

a) House the inverter in an enclosed panel. If the temperature in the panel rises, take appropriate countermeasures. (See Sections 2.7.3 and 2.7.4.)

b) Conduct an air purge. Pump clean air from outside so that the inner pressure of the panel is made higher than the atmospheric air.

(4) Corrosive gas, sea breeze

When the panel is installed in places susceptible to corrosive gas or sea breeze, the printed circuit board patterns and parts will be corroded and/or contact faults of the relays and switches will occur.

In such places, take measures (a) and (b) in Paragraph (3).

(5) Explosive and flammable gases

Designed to be non-explosion-proof, the inverter must be housed in an explosion-proof panel. If used in any place where an explosion may occur due to explosive gases, dust and/or dirt, the panel must conform in structure to the basic guideline of the law and be officially approved, resulting in higher price. The best way is to avoid such a place and select a non-hazardous place. (See Section 2.3.7.)

(6) High altitude operation

Use the inverter at the altitude of not more than 1000m. If used at higher than 1000m, the cooling effect is liable to reduce due to thin air and the dielectric strength is liable to deteriorate due to reduced atmospheric pressure.

(7) Vibration, impact

The vibration resistance of the inverter is 5.9m/s^2 {0.6G} maximum at the vibration frequency of 10 to 55Hz and amplitude of 1mm, conforming to JIS C0911. If less than the specified value, vibration or impact applied for a long time may cause mechanism looseness, connector contact fault etc.

Care must be taken especially when impact is applied repeatedly, since part mounting pin breakage or other accidents are likely to occur.

Countermeasures

a) Provide rubber vibration insulators in the panel.

b) Strengthen the structure of the panel to prevent resonance.

c) Install the panel away from the source of vibration.

2.7.2 Heat generated by inverter and related devices

Heat Generated by Inverter and Related Devices

Motor Capacity [kW]	Inverter-Generated Heat [W]				Power Return Converter (Note 1) FR-RC [W]	High Power Factor Converter (Note 1)			Power Factor Improving DC Reactor (Note 2) FR-BEL [W]	Power Factor Improving AC Reactor (Note 2) FR-BAL [W]	Surge Suppression Filter FR-ASF-H [W]
	A500		E500			FR-HCL01 [W]	FR-HCL02 [W]	FR-HC [W]			
	200V class	400V class	100V, 200V class (Note 1)	400V class							
0.1	—	—	16	—	—	—	—	—	—	—	—
0.2	—	—	20	—	—	—	—	—	—	—	—
0.4	55	50	45	40	—	—	—	—	2	6	—
0.75	70	70	50	55	—	—	—	—	3	8	—
1.5	110	100	85	90	—	—	—	—	6	16	75
2.2	150	150	100	110	—	—	—	—	8	15	—
3.7	230	220	160	180	—	—	—	—	14	21	129
5.5	310	285	310	260	—	—	—	—	19	30	—
7.5	420	390	420	390	—	65	154	440	25	30	216
11	570	500	—	—	—	—	—	—	31	45	—
15	700	685	—	—	500	100	218	860	36	55	342
18.5	920	830	—	—	—	—	—	—	40	60	—
22	1120	955	—	—	—	—	—	—	52	65	450
30	1160	1200	—	—	1020	163	316	1750	60	90	—
37	1380	1590	—	—	—	—	—	—	67	110	670
45	1810	1920	—	—	—	—	—	—	95	140	—
55	2400	2450	—	—	1790	234	473	2700	100	170	1010

Note: 1. The values of heat generated by the single-phase 100V class, single-phase 200V class and three-phase 200V class are the same.

2. The heat generated by the 200V class is the same as that generated by the 400V class.

3. The inverter-generated heat indicated is that of the model having the same capacity as the motor.

4. The heat generated by the FR-A500 series 7.5K or less does not include the heat generated by the built-in brake resistor.

Heat generated by other equipment

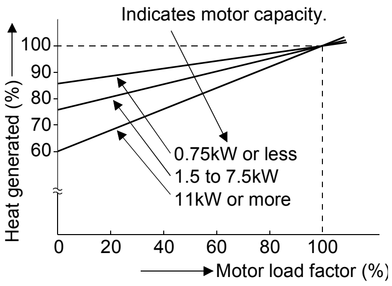
- Radio noise filter FR-BIF(-H) : 4W or less
- Line noise filter FR-BLF : 4W or less
- Line noise filter FR-BSF01 : 4W or less

(1) Inverter-generated heat

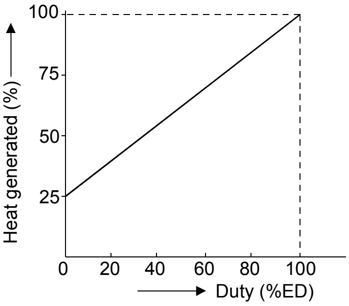
When the rated output current flows, the inverter generates heat as shown on the preceding page.

1) Reduction according to motor load factor. As indicated below the ratio of reduction in heat generated to the rated output current of the inverter which is used under light load is shown.

2) Reduction according to duty. As indicated below the ratio of reduction during intermittent operation in a cycle of within five minutes is shown.



Load Factor versus
Heat Generated
(when motor and inverter have the same rank)



Duty versus
Heat Generated

(2) Brake unit-generated heat

When a brake unit is used, heat is generated by the brake unit and the brake resistor.

1) Heat generated by the brake unit (excluding that of the brake resistor) is found according to the diagram as shown below.

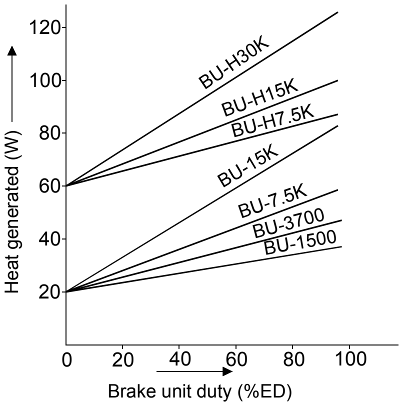
2) Heat loss of the brake resistor is calculated by the following expression:

$$P[W]=\frac{\Sigma GD^2 \times N^2 \times S}{54800}$$

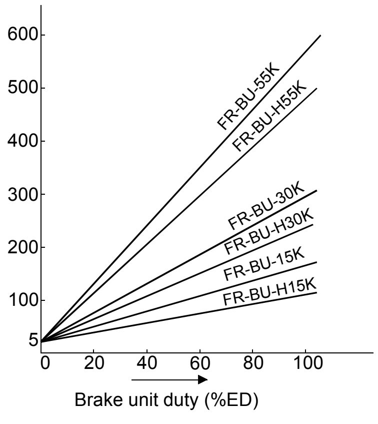
ΣGD^2 : Overall $GD^2{}_T$ reflected to motor shaft (including motor $GD^2{}_M$) [kg · m^2]

N : Motor speed [r/min{rpm}]

S : Number of decelerations [times/min.]



a) BU type



b) FR-BU type
Brake Unit-Generated Heat

2.7.3 Specification of enclosed panel

For the FR-A500 series, the installation of the semiconductor heat sink and brake resistor outside the panel allows heat generated in the panel to be greatly reduced to 30% and a compact enclosure to be designed. The following table lists the heat dissipation area and approximate dimensions of the enclosed dust-proof panel with respect to the loss (W).

Heat Dissipation Area of the
Enclosed Dust-Proof Control Panel
(Heat sink outside panel)

Inverter Capacity	Enclosed Dust-Proof Type (IP5X)		
	Loss (Rated) (W)	Area required for heat dissipation (m^2)	Approximate box dimensions (mm)
FR-A520-0.4K	Heat sink must not be placed outside		
FR-A520-0.75K			
FR-A520-1.5K	33	0.55	300W×500H×250D
FR-A520-2.2K	45	0.75	400W×500H×250D
FR-A520-3.7K	69	1.2	500W× 500H×400D
FR-A520-5.5K	93	1.6	500W×800H×400D
FR-A520-7.5K	126	2.1	600W×800H×600D
FR-A520-11K	171	2.9	800W×800H×600D
FR-A520-15K	210	3.5	800W×1000H×600D
FR-A520-18.5K	276	4.6	800W×1000H×1000D
FR-A520-22K	336	5.6	1000W×1000H×1000D
FR-A520-30K	348	5.8	1000W×1000H×1000D
FR-A520-37K	414	6.9	1000W×1500H×1000D
FR-A520-45K	543	9.1	1500W×1500H×1000D
FR-A520-55K	720	12.0	2000W×1500H×1000D
FR-A540-0.4K	15	0.3	300W×500H×150D
FR-A540-0.75K	21	0.4	300W×500H×150D
FR-A540-1.5K	30	0.5	300W×500H×250D
FR-A540-2.2K	45	0.8	400W×500H×250D
FR-A540-3.7K	66	1.1	500W×500H×400D
FR-A540-5.5K	85.5	1.5	500W×800H×400D
FR-A540-7.5K	117	2.0	500W×800H×600D
FR-A540-11K	150	2.5	600W×800H×600D
FR-A540-15K	205.5	3.5	800W×1000H×600D
FR-A540-18.5K	249	4.2	800W×1000H×800D
FR-A540-22K	286.5	4.8	1000W×1000H×800D
FR-A540-30K	360	6.0	1200W×1000H×1000D
FR-A540-37K	477	8.0	1200W×1500H×1000D
FR-A540-45K	576	9.6	1500W×1500H×1000D
FR-A540-55K	735	12.3	2000W×500H×1000D

Heat Dissipation Area of the
Enclosed Dust-Proof Control Panel
(All units contained in panel)

Inverter Capacity	Enclosed Dust-Proof Type (IP5X)		
	Loss (Rated) (W)	Area required for heat dissipation (m^2)	Approximate box dimensions (mm)
FR-A520-0.4K	55	0.92	400W×600H×250D
FR-A520-0.75K	70	1.2	550W×600H×250D
FR-A520-1.5K	110	1.9	550W×800H×400D
FR-A520-2.2K	150	2.5	800W×800H×400D
FR-A520-3.7K	230	3.9	900W×1000H×600D
FR-A520-5.5K	310	5.2	1200W×1200H×600D
FR-A520-7.5K	420	7.0	1400W×1500H×600D
FR-A520-11K	570	9.5	2000W×1500H×600D
FR-A520-15K	700	11.7	2000W×1500H×1000D
FR-A520-18.5K	920	15.4	2000W×2000H×1000D
FR-A520-22K	1120	18.7	2500W×2000H×1000D
FR-A520-30K	1160	19.4	3000W×2000H×1000D
FR-A520-37K	1380	23.0	3000W×2000H×1200D
FR-A520-45K	1810	30.2	4000W×2000H×1200D
FR-A520-55K	2400	40.0	5500W×2000H×1200D
FR-A540-0.4K	50	0.84	350W×600H×250D
FR-A540-0.75K	70	1.2	550W×600H×250D
FR-A540-1.5K	100	1.7	550W×800H×400D
FR-A540-2.2K	150	2.5	800W×800H 400D
FR-A540-3.7K	220	3.7	900W1000H×600D
FR-A540-5.5K	285	4.8	1200W×1000H×600D
FR-A540-7.5K	390	6.5	1200W×1500H×600D
FR-A540-11K	500	8.4	1600W×1500H×600D
FR-A540-15K	685	11.5	1800W×1500H×1000D
FR-A540-18.5K	830	13.9	1800W×2000H×1000D
FR-A540-22K	955	16.0	2000W×2000H×1000D
FR-A540-30K	1200	20.0	3000W×2000H×1000D
FR-A540-37K	1590	26.5	3500W×2000H×1200D
FR-A540-45K	1920	32.0	4500W×2000H×1200D
FR-A540-55K	2450	40.9	6000W×2000H×1200D

Note:
1. IP5X--------------Type classified by JEM1030
2. The built-in brake resistor loss is not included.
3. The values in the above table depend on the operating conditions and ambient temperature. (Heat generated by other equipment has not been taken into consideration.)
4. The values in the above table indicate areas effective for heat dissipation.
5. When the heat sink is installed outside the panel, the loss indicates the heat generated by the inverter unit in the panel.

2.7.4 Cooling of Inverter Panel

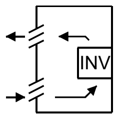
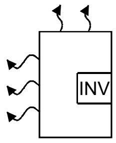
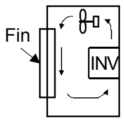
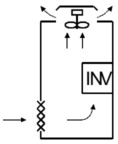
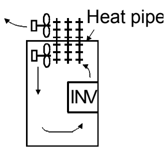
(1) Cooling method

The panel housing the inverter must efficiently dissipate heat generated by the inverter and other devices (transformer, lamps, resistors etc.) and heat entering from the outside, e.g. direct sunlight, to keep the temperature inside the panel less than the permissible temperature of the equipment in the panel including the inverter.

The cooling method is classified as follows according to the calculation method of cooling:

1) Cooling by natural heat dissipation from the panel surface (totally enclosed panel).
2) Cooling by heat sink (aluminum heat sink etc.).
3) Cooling by ventilation (forced draft, piping draft).
4) Cooling by heat exchanger or cooling equipment (heat pipe, cooler etc.).

Types of Inverter Panel Cooling

Cooling Method		Panel Structure	Remarks
Natural cooling	Natural ventilation (enclosed, open type)		Low in cost and generally used, but panel dimensions increase in proportion to inverter capacity. For relatively small capacity.
	Natural ventilation (totally enclosed type)		Most suitable for use in hostile environment having dust, dirt, oil mist etc. Panel dimensions may be large depending on inverter capacity.
Forced cooling	Fin cooling		There are restrictions on fin installation place and area. For relatively small capacity.
	Forced ventilation		For general indoor installation. Suitable for reduction in panel size and cost, often used.
	Heat pipe		Totally enclosed type allowing the panel to be compact.

(2) Cooling effect calculation

1) Calculation of heat dissipation energy by natural heat dissipation from panel surface:

$W1 = K1 \times A \times \Delta t$

W1 : Heat dissipation energy per second [W]

A : Effective heat dissipation area [m^2]

Δt : Temperature difference between inside and outside the panel [°C]

K1 : 6 [$W/m^2 \cdot °C$]

a) The effective heat dissipation area does not include constructions, such as a floor and walls, and any surface proximate to the other panels.
It does not include the installation areas of vents, heat sinks and heat exchangers either.
b) The temperature in the panel should be kept constant by an agitating fan.
c) Constant K1 is indicated as a reference value because it depends on the panel structure, parts layout in the panel, and ambient temperature.

2) Calculation of heat dissipation energy from heat sink:

$W2 = N \times K2 \times \Delta t$

W2 : Heat dissipation energy per second [W]

N : Number of heat sink units [pieces]

Δt : Temperature difference between inside and outside the panel [°C]

K2 : Heat dissipation capability of one heat sink unit [W/ °C]

3) Calculation of heat dissipation energy by ventilation:

$$W3 = K3 \times \frac{Q}{60} \times \Delta t$$

W3 : Heat dissipation energy per second [W]

Q : Air flow [m^3/min]

Δt : Temperature difference between inside and outside the panel [°C]

K3 : 1160[$J/m^3 \cdot °C$]

4) Calculation of heat dissipation energy by heat exchanger or cooler:

$W4 = K4 \times H$

W4 : Heat dissipation energy per second [W]

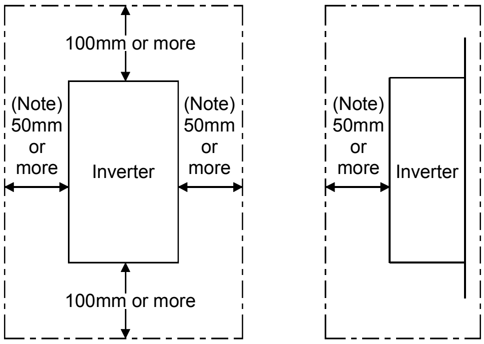
H : Cooling capability [kcal/h]

K4 : 1.16 [Wh/kcal]

2.7.5 Notes on Installation of Inverter in a Panel

(1) Position of inverter installation

1) Clearances around the inverter.
To ensure proper heat dissipation and easy access, leave at least the following distances between the inverter and other devices or panel walls. The following minimum distances must be left under the inverter as wiring space and above the inverter as dissipation space
Note: 10mm or more for an inverter of 3.7K or below.



Front face

Side face

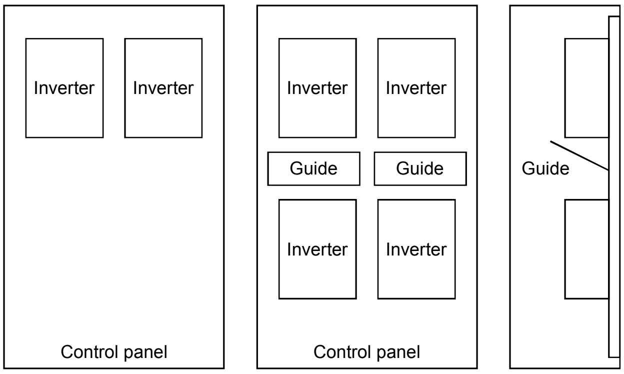
Clearances around the Inverter

2) Installation direction of the inverter.
Install the inverter on a wall surface as specified. Do not install it horizontally or in any other manner.

3) Top of the inverter.
Heat in the inverter goes up from the bottom to top by the built-in fan. Therefore, devices insusceptible to heat can be installed above the inverter.

The ambient temperature should be 50°C maximum at a position 50mm away from the bottom center of the inverter.

4) Positions of two or more inverters housed in one panel.
When several inverters are housed in the same panel, ordinarily arrange them as indicated below. If the inverters have to be lined vertically to minimize the panel space, the temperature in the top inverters rises due to the heat of the lower inverters, resulting in inverter failure.



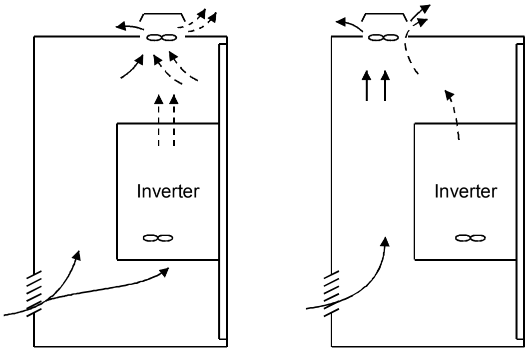
(a) Horizontal

(a) Vertical arrangement

Arrangement of Several Inverters in Panel

When several inverters are housed, take extreme care to increase the ventilation, draft and panel size so that the ambient temperature of the inverter does not exceed the permissible value.

5) Positions of ventilation fan and inverter.
The cooling fan causes the heat generated in the inverter to flow from the bottom to top of the unit as warm air. When a fan is installed to ventilate the heat, determine the installation place of the ventilating fan after full consideration of the air flow. (The air flows in a path where resistance is small. Make an airway and/or straightening vanes to expose the inverter to cold air.)



Good example

Bad example

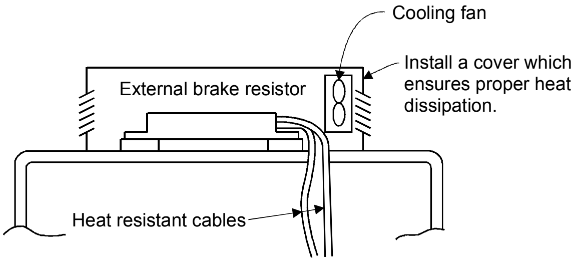
Positions of Ventilation Fan and Inverter

(2) External frequent-use brake resistor (Type FR-ABR)

1) Installation position.

a) When the inverter of 7.5K or below is operated in excess of the duty of the brake resistor, disconnect the built-in brake resistor supplied with the inverter and install an external brake resistor.

b) Since the external brake resistor generates much heat, its surface temperature is about 150 to 300°C. Hence, install the external brake resistor in consideration of heat dissipation. The inverter and other devices must not be placed above the resistor.

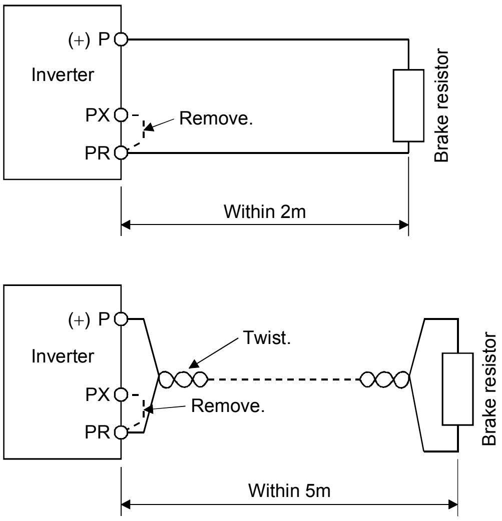


Example of Installing an External Brake Resistor on Top of the Panel

2) Wiring.

a) When wiring the brake resistor, note high DC voltage application and resistor-generated heat.

b) The wiring distance between the inverter and brake resistor should be as short as possible. If it exceeds 2m, twist the cables. (If twisted, the distance must not exceed 5m.)



Wiring the Brake Resistor

c) When wiring the brake resistor, the resistor-generated heat (maximum surface temperature is approximately 150 to 300°C) must be taken into consideration.

- Take measures to prevent the cables from making contact with the resistor.
- Use heat-resistant cables (such as glass-braided cables), or cover the cables with silicone tubes. Use cables of $2mm^2$ or larger size.

(3) BU brake unit and discharge resistor

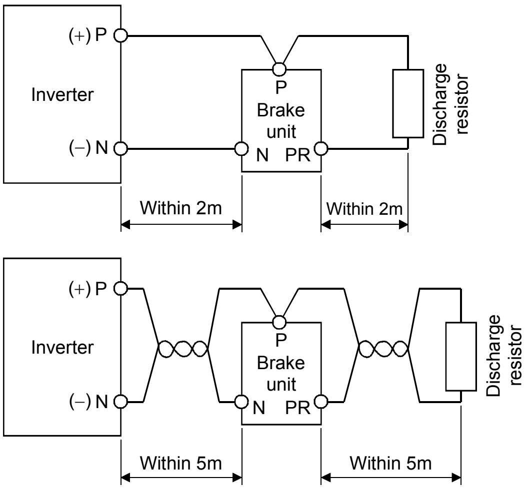
1) Installation position.

For the installation position of the discharge resistor, refer to Paragraph 2, part 1).

2) Wiring.

a) When wiring the brake unit (BU type) and discharge resistor, note high DC voltage application and discharge resistor-generated heat.

b) The wiring distances between the inverter and brake unit and between the brake unit and discharge resistor should be as short as possible. If the distance exceeds 2m, twist the cables. (If twisted, the distance must not exceed 5m.)



Wiring the Brake Unit

c) When wiring the discharge resistor, the resistor-generated heat (maximum surface temperature is approximately 150 to 300°C) must be taken into consideration.

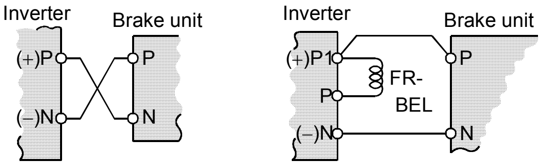
- Take measures to prevent the cables from making contact with the resistor.
- Use heat-resistant cables (such as glass-braided cables), or cover the cables with silicone tubes.

d) Use cables of the following sizes:

Cables Applicable to
the BU Brake Unit

BU Brake Unit Type		Cable Size
200V	BU-1500, 3700	$2mm^2$
	BU-7.5K, 15K	$3.5mm^2$
400V	BU-H7.5K	$2mm^2$
	BU-H15K, H30K	$3.5mm^2$

e) Connect the cables so that the terminal symbols of the brake unit match those of the inverter. When the FR-BEL power-factor correcting reactor has been connected, do not connect the brake unit to terminal P1 to protect the brake unit from damage.



Incorrect Connection Examples

(4) FR-BU brake unit and resistor unit

1) Installation position.

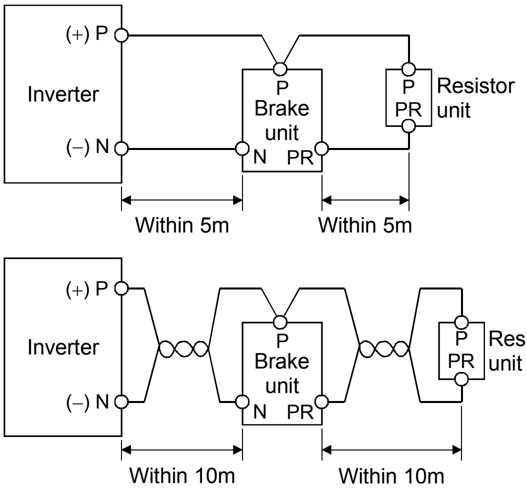
Always install the brake unit and resistor unit on a vertical surface in the vertical direction. Installing them in the horizontal direction or on a horizontal surface reduces the heat dissipation effect.

Since the case temperature of the resistor unit rises to or above 100°C, install the unit in a place where it will not make contact with cables and flammables.

2) Wiring.

a) Wire the brake unit (FR-BU) and resistor unit, noting high DC voltage application and resistor unit-generated heat.

b) The wiring distances between the inverter and brake unit and between the resistor unit and brake unit should be as short as possible. If the distance exceeds 5m, twist the cables. (If the cables are twisted, the distance must not exceed 10m).



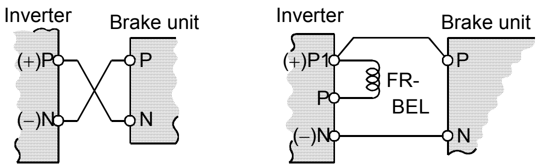
Wiring the FR-BU Brake Unit

c) Use cables of the following sizes:

Cables Applicable to
FR-BU Brake Unit

FR-BU Brake Unit Type		Cable Size
200V	FR-BU-15K	$3.5mm^2$
	FR-BU-30K	$5.5mm^2$
	FR-BU-55K	$14mm^2$
400V	FR-BU-H15K	$3.5mm^2$
	FR-BU-H30K	$3.5mm^2$
	FR-BU-H55K	$5.5mm^2$

d) Connect the brake unit and inverter so that their terminal symbols match. Note that the brake unit will be damaged if a cable is connected to terminal P1 which is connected with the FR-BEL power factor improving reactor.



Incorrect Connection Examples

3) Brake unit operation indications

Brake Unit Operation Indications

7-Segment LED Indication	Description
0 (0)	Indicates that the brake unit is switched on.
1 to A (1 to A)	Indicates %ED during brake operation.
E (E)	Indicates a brake transistor failure.
F (F)(Note 1)	Indicates that the brake is operated in excess of permissible %ED.

Note 1: When this operation indicator LED is lit to indicate the excess of the permissible %ED, the brake unit stops operating and therefore the "overcurrent", "overvoltage" or other protective function of the inverter is activated. To resume operation, find and remove its cause, then reset the inverter.

2: By switching off the brake unit and making a reset, the cumulative data of the brake duty is cleared. Note that repeating reset many times to perform operation will overheat the resistor unit.

(5) Noise filter

1) Installation position.

Since the noise filter produces a greater effect when it is located closer to the source of noise, determine its installation position in consideration of the following:

a) When used in the inverter power supply circuit, install the noise filter in a position where the wiring distance from the inverter input terminals is short.

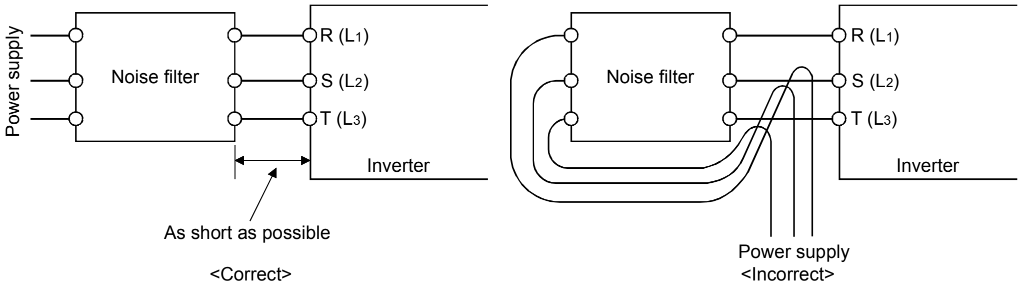
b) When used also in the inverter output circuit, install the noise filter in a position where the wiring distance from the inverter output terminals is the shortest. (The FR-BIF radio noise filter cannot be connected to the output circuit.)

2) Wiring

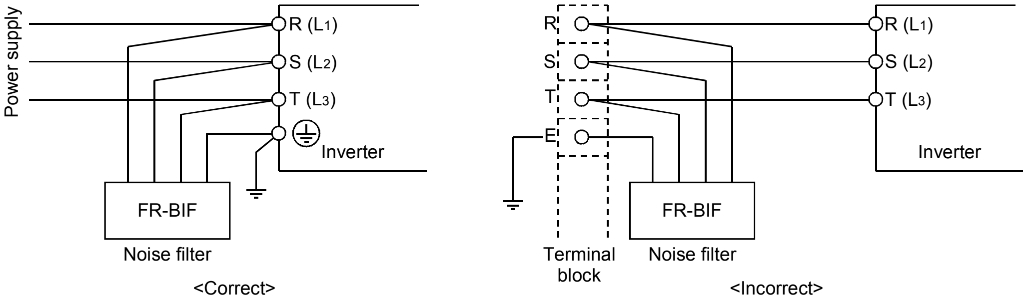
The noise filter cannot produce its effect unless it is wired as indicated below.

The noise filter must be installed as close as possible to the inverter and its wiring distance minimized. In addition, the primary and secondary wirings of the noise filter must not be close to each other or cross each other.

For the selection of the noise filter, see Section 2.5.3.



Wiring the Noise Filter



Wiring the FR-BIF

(6) Surge voltage suppression filter (FR-ASF-H)

When a 400V class motor is inverter-driven, a microsurge voltage attributable to wiring constants is generated at the motor terminals and may deteriorate the motor insulation. In such a case, the microsurge voltage can be suppressed to 850V or less by inserting the surge voltage suppression filter (FR-ASF-H) in the secondary side of the inverter.

1) Installation position.

When energized, the surge voltage suppression filter gets hot. Never install it near flammables or where it can easily make contact with a human body.

Because of heat dissipation, leave at least 100mm clearances around the filter as an installation space.

2) Wiring.

a) After checking the terminal symbols of the filter terminal block, connect the cables from the output terminals of the inverter to the filter input terminals (U, V, W) and the cables from the motor terminals to the output terminals (X, Y, Z) of the filter. Incorrect wiring may damage the equipment.

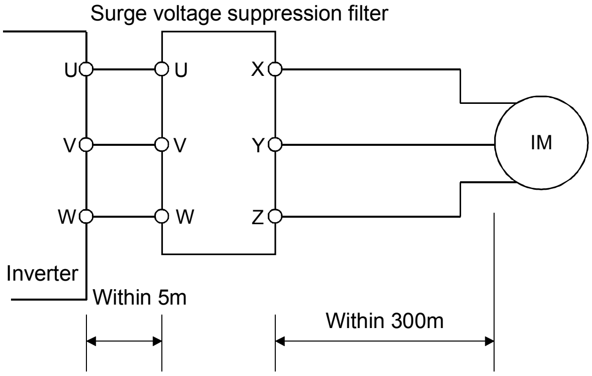
As the filter gets hot, avoid wiring the cables near the resistor.

b) The wiring length between the inverter output terminals and filter input terminals should be within 5m.

The wiring length between the filter output terminals and motor input terminals should be within 30m.

c) The cable size may be any size if it is as recommended for the inverter.

d) The cable type recommended for use is a heat-resistant cable. Note that the temperature of the resistor section of the filter rises about 70°C when the filter is switched on. Therefore, if the cables may make contact with the resistor, use heat-resistant, glass-braided cables.



Wiring of Surge Voltage Suppression Filter

3) Voltage drop.

A voltage drop caused by the filter is proportional to the inverter output frequency and output current.

The voltage drop is approximately 30V when the inverter output frequency is 60Hz and the filter is on at the rated current, independent of the capacity.

4) Leakage current.

By connecting the filter, the leakage current slightly increases. When using many filters at the same time, take this into consideration when selecting the earth leakage circuit breaker. (As a result of measurement in accordance with the measurement method specified in the New Electrical Appliances Control Rules, the leakage current of the H15K or less is approximately 1mA under the conditions of 60Hz inverter output frequency and 14.5kHz carrier frequency.)

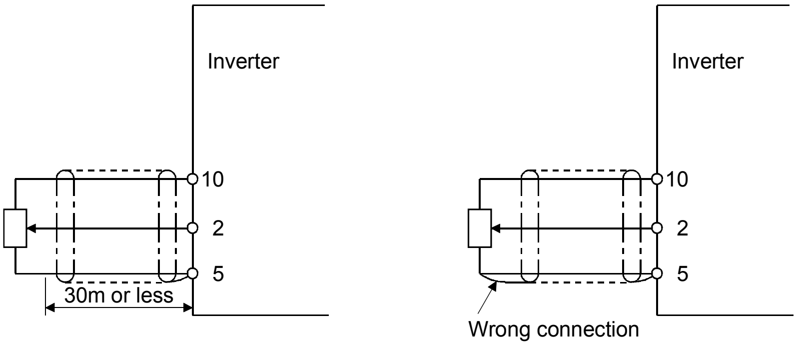
(7) Wiring the control circuit

1) Use twisted or shielded cables for connection with the control circuit terminals (10, 2, 5, 1, 4, AM). Do not ground the shield but connect it as indicated below. (Keep the other end of the shield open.)

2) Use twisted or shielded cables for connection with the display (frequency) meter terminals (FM, SD) over a wiring distance of 200m maximum. If the distance exceeds 200m, the display (frequency) meter reading may result in a larger error.

3) Run the control circuit cables away from the power line over the shortest distance.

Example 1 : Shielded cables



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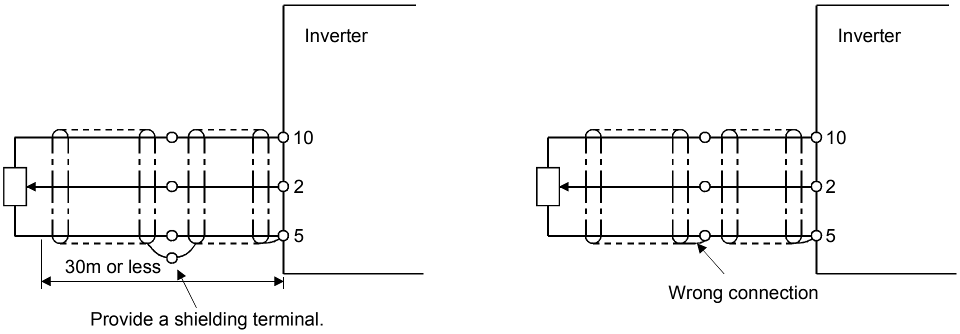
Connecting the Shielded Cables

Example 2 : Shielded cables joined



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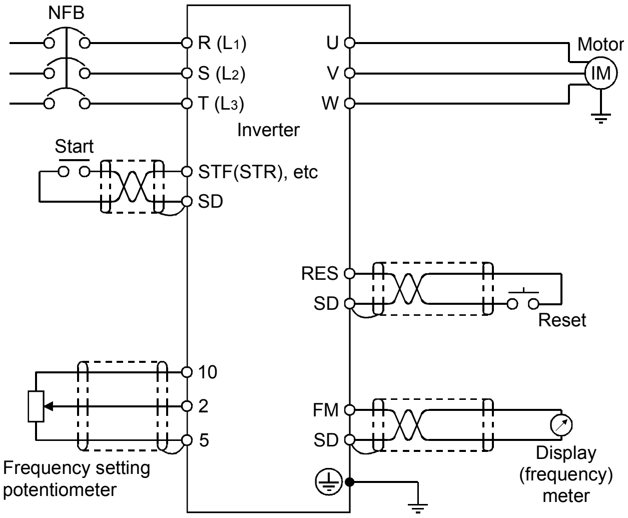
Connecting the Shielded Cables

(8) Countermeasures against external noise

1) Strengthening the countermeasures against noise. The FR series inverters are sufficiently protected from noise. However, extremely large external noise may cause the inverter to malfunction. When there is such external noise that cannot be eliminated, wire the inverter in accordance with the following figure.



Countermeasures Against Noise

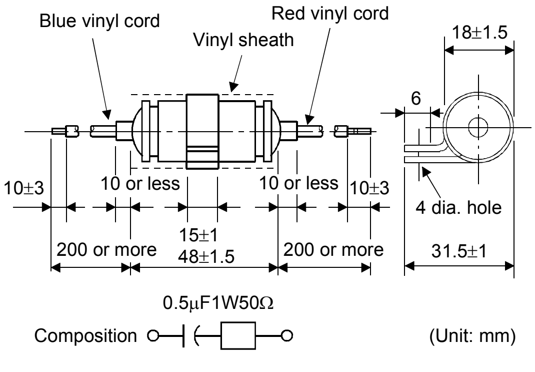
2) Remote control, etc.

Acting as an antenna, the single lines are susceptible to external noise. Therefore, run the signal lines as far away as possible from the power line.

If the inverter is controlled 30m or further away from its installation position, it is recommended to use any of the following:

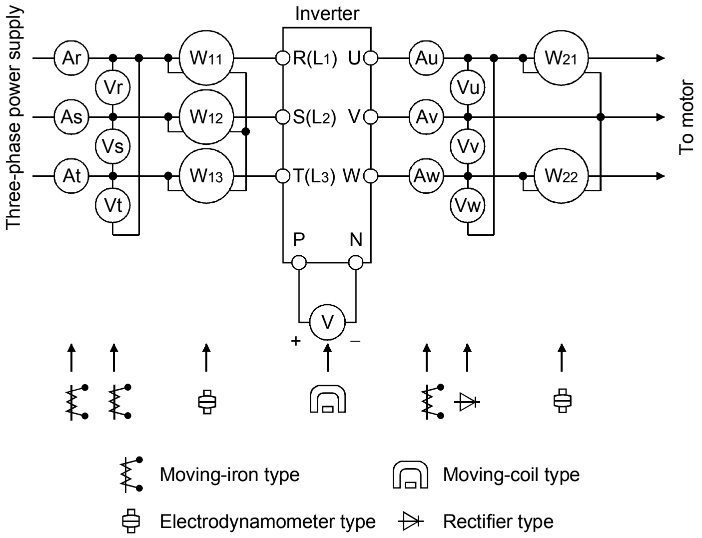
a) Speed setting device.
   Use the FR-FK motorized speed setter. (For the operation information, see the corresponding manual.)
b) External start/stop signal.
   Add a relay in the vicinity of the inverter.
c) Cables.
   Use twisted or twisted shielded cables.
d) Surge suppressors.
   Install surge suppressors to the coils of the relays, valves etc. around the inverter.

Example: 972A-2003 504 11
manufactured by Matsuo



2.8 Meters and Measurement Methods

Since voltages and currents in the primary and secondary side of the inverter include harmonics, different meters indicate different measurement values. When making measurement with the meters designed for commercial frequency, use the following measuring instruments and circuits:



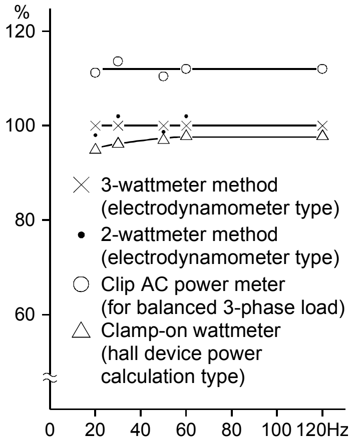
Examples of Measurement Points and Measuring Instruments

Note: When installing meters etc.on the inverter output side
When the inverter-to-motor wiring length is large, especially in the 400V class, small-capacity models, the meters and CTs may generate heat due to line-to-line leakage current. Therefore, choose the equipment which has enough allowance for the current rating.
When measuring and indicating the output voltage and output current of the inverter, it is recommended to utilize the AM-5 terminal output function of the inverter.

2.8.1 Measurement of powers

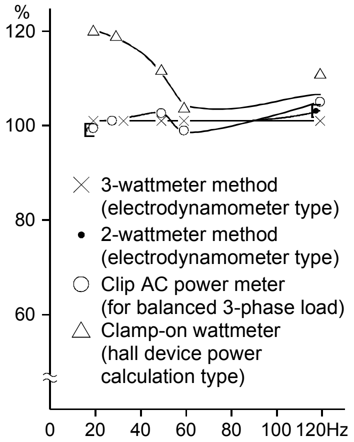
Using an electrodynamometer type meter, measure the power in both the input and output sides of the inverter using the two- or three-wattmeter method. As the current is liable to be imbalanced especially in the input side, it is recommended to use the three-wattmeter method.
Examples of measurement value differences produced by different measuring meters are shown below. An error will be produced by a difference between measuring instruments, e.g. power calculation type and two- or three-wattmeter type three-phase wattmeters. When a CT is used in the current measurement side or when the meter contains a PT on the voltage measurement side, an error will also be produced due to the frequency characteristics of the CT and PT.

[Measurement conditions]
Constant-torque (100%) load, constant-output at 60Hz or more.
3.7kW, 4-pole motor, value indicated in 3-wattmeter method is 100%.



Example of Measuring Inverter Input Power

[Measurement conditions]
Constant-torque (100%) load, constant-output at 60Hz or more.
3.7kW, 4-pole motor, value indicated in 3-wattmeter method is 100%.



Example of Measuring Inverter Output Power

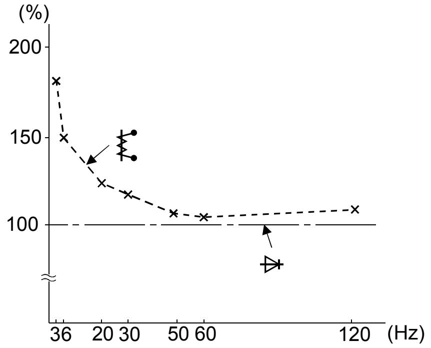
2.8.2 Measurement of voltages and use of PT

(1) Inverter input side
As the input side voltage has a sine wave and is extremely small in distortion factor, accurate measurement can be made with an ordinary AC meter.

(2) Inverter output side
Since the output side voltage has a PWM-controlled rectangular wave, always use a rectifier type voltmeter. A needle type tester cannot be used to measure the output side voltage as it indicates a value much greater than the actual value. A moving-iron type meter indicates an effective value which includes harmonics and therefore the value is larger than that of the fundamental wave. The value monitored on the operation panel (parameter unit) is the inverter-controlled voltage itself. Hence, that value is accurate and it is recommended to monitor values (provide analog output) using the operation panel (parameter unit). As a panel meter, use the Mitsubishi Type YR or LS. An example of a measurement value difference produced by different measuring meters is shown on the right.

(3) PT
No PT can be used in the output side of the inverter. Use a direct-reading meter. (A PT may be used in the input side of the inverter.)

[Measurement conditions]
3.7kW, 4-pole motor + FR-A520-3.7K inverter.
Value indicated by rectifier type voltmeter is 100%.



Example of Measuring Inverter Output Voltage

2.8.3 Measurement of currents

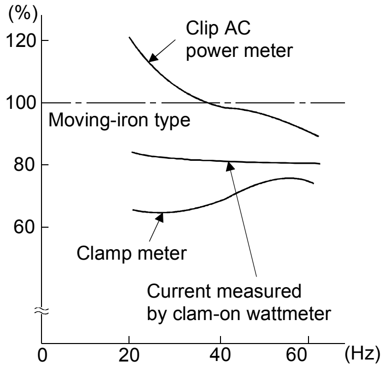
Use a moving-iron type meter on both the input and output sides of the inverter. However, if the carrier frequency exceeds 5kHz, do not use that meter since an overcurrent loss produced in the internal metal parts of the meter will increase and the meter may burn out. In this case, use an approximate-effective value type.

As the inverter input side current is easily imbalanced (see Section 2.4.6), measurement of currents in all three phases is recommended. Correct values cannot be measured in one or two phases. On the other hand, the phase imbalance ratio of the output side current must be within 10%.

When a clamp ammeter is used, always use an effective value detection type. A mean value detection type produces a large error and may indicate an extremely smaller value than the actual value. The value monitored on the operation panel (parameter unit) is accurate if the output frequency varies, and it is recommended to monitor values (provide analog output) using the operation panel (parameter unit).

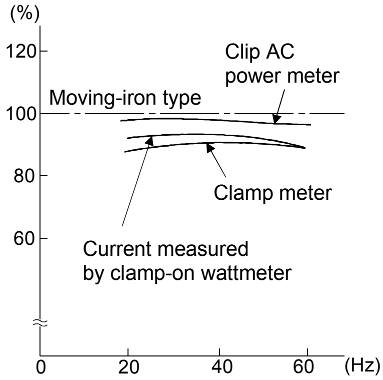
For a panel meter, use the Mitsubishi Type YS-12 (which is better than Type YS-8 or YS-10 in frequency characteristic). An example of the measurement value difference produced by different measuring meters is shown on the right.

[Measurement condition]
Value indicated by moving-iron type ammeter is 100%.



Example of Measuring Inverter Input Current

[Measurement condition]
Value indicated by moving-iron type ammeter is 100%.



Example of Measuring Inverter Output Current

2.8.4 Use of CT and transducer

A CT may be used in both the input and output sides of the inverter, but the one used should have the largest possible VA ability because an error will increase if the frequency gets lower.

When using a transducer, use the effective value calculation type (Mitsubishi S series) which is immune to harmonics.

2.8.5 Measurement of inverter input power factor

Use the effective power and apparent power to calculate the inverter input power factor (refer to Section 2.4.1). A power-factor meter cannot indicate an exact value.

2.8.6 Measurement of converter output voltage (across terminals P-N)

The output voltage of the converter is developed across terminals P-N (+, −) and can be measured with a moving-coil type meter (tester). Varying with the power supply voltage, the converter output voltage is approximately 270 to 300V (approximately 540 to 600V for the 400V class) under no load and lowers under load.

When regenerative energy is returned from the motor during deceleration, for example, the converter output voltage rises to nearly 400V (800V for the 400V class) maximum. (When the converter output voltage reaches approximately 400V for the 200V class or approximately 800V for the 400V class, the inverter results in OVT shut-off.)

2.8.7 Measurement of inverter output frequency

A pulse train proportional to the output frequency is output across the frequency meter signal output terminal FM-SD of the inverter. This pulse train output can be counted by a frequency counter, or a meter (moving-coil type voltmeter) can be used to read the mean value of the pulse train output voltage. When a meter is used to measure the output frequency, approximately 5VDC is indicated at the maximum frequency.

For detailed specifications of the frequency meter signal output terminal FM, refer to Section 1.4.17.

2.9 Compliance with Standards

The standard models of the FR-A500 and FR-E500 series inverters comply with the UL Standard, CSA Standard and EN Standard.

2.9.1 Compliance with the UL and CSA Standards

(1) About the UL and CSA (cUL) Standards

The UL (Underwriter's Laboratories Inc.) Standard is a safety standard in the U.S.A. UL is a non-profit testing institution established by the U.S. Fire Underwriters' Association and conducts approval tests on industrial products. UL has strictly prescribed the safety standard in an extremely wide range, assuming every possible situation during use of products. The UL mark has extremely high authority and reliability and is mandated by the state laws and city ordinances in many U.S. states.

Canada has a similar standard, the CSA Standard. The standard equivalent to Canada's CSA Standard has been stipulated by the U.S.A. as the cUL Standard, and products approved by this Standard are regarded as approved by the CSA Standard.

cUL and UL marks

The FR-E500 series carries the cULus mark which covers both the conventional UL and cUL marks.

cULus mark

(2) Installation

The following inverters have been approved as products for use in enclosures and approval tests were conducted under the following conditions. For enclosure design, refer to these conditions so that the ambient temperature of the inverter is 50°C or less.

Inverter Type	Cabinet Size (Unit: mm)		Vent Hole Area	Cooling Fan
FR-A520-0.75K	Control box having the size of the inverter size plus 100mm in W, 100mm in H and 50mm in D	W H D 210 × 360 × 175	W D 160 × 60 (top and bottom)	Not required
FR-A520-11K		W H D 320 × 400 × 240	W D 130 × 70 (bottom)	Install a cooling fan at top of the enclosure to suck internal air to the outside. (Fan air flow: 1.72m^3/min or more)
FR-A520-22K		W H D 350 × 600 × 240	W D 330 × 70 (bottom)	Install a cooling fan at top of the enclosure to suck internal air to the outside. (Fan air flow: 3.44m^3/min or more)
FR-A520-55K	Inverter size plus 100mm in W, 100mm in H and 50mm in D	W H D 580 × 815 × 300	W D 123 × 492 (bottom) 123 × 126 (bottom × 2) 123 × 30 (bottom × 2)	Install cooling fans at top of the enclosure to suck internal air to the outside. (Fan air flow: 3.24m^3/min or more)
FR-A540-5.5K		W H D 310 × 460 × 220	W D 100 × 210 (top) 60 × 48 (bottom)	Not required
FR-A540-22K		W H D 350 × 600 × 240	W D 330 × 70 (bottom)	Install cooling fans at top of the enclosure to suck internal air to the outside. (Fan air flow: 1.72m^3/min or more)
FR-A540-55K		W H D 550 × 665 × 300	W D 123 × 126 (bottom × 2)	Install cooling fans at top of the enclosure to suck internal air to the outside. (Fan air flow: 3.24m^3/min or more)

Inverter Type	Cabinet Size (Unit: mm)	Vent Hole Area	Cooling Fan
FR-E520-3.7K	W H D 255 × 192 × 218	• 55% of the control box side face • 1 slit width: 3.2mm • Located at top of both side faces.	Not required

(3) Wiring of the power supply and motor

Use the UL-approved power supply and round crimping terminals to wire the input (R, S, T (L1, L2, L3)) and output (U, V, W) terminals of the inverter. Crimp the terminals with the crimping tool recommended by the terminal manufacturer.

(4) Fuse

The fuse used on the input side should be any of the UL Class K5 fuses having the ratings as listed below:

Applicable Inverter Type	Rating (A)	Applicable Inverter Type	Rating (A)
FR-A520-0.4K	7.5 to 10	FR-A540-0.4K	5
FR-A520-0.75K	15 to 20	FR-A540-0.75K	8
FR-A520-1.5K	25 to 30	FR-A540-1.5K	10
FR-A520-2.2K	30 to 40	FR-A540-2.2K	20
FR-A520-3.7K	45 to 60	FR-A540-3.7K	35
FR-A520-5.5K	75 to 90	FR-A540-5.5K	45
FR-A520-7.5K	90 to 125	FR-A540-7.5K	60
FR-A520-11K	115 to 175	FR-A540-11K	90
FR-A520-15K	190 to 225	FR-A540-15K	110
FR-A520-18.5K	225 to 300	FR-A540-18.5K	125
FR-A520-22K	265 to 350	FR-A540-22K	150
FR-A520-30K	340 to 450	FR-A540-30K	225
FR-A520-37K	375 to 500	FR-A540-37K	250
FR-A520-45K	450 to 600	FR-A540-45K	300
FR-A520-55K	600	FR-A540-55K	350

Applicable Inverter Type	Rating (A)
FR-E520-0.1K	4
FR-E520-0.2K	6
FR-E520-0.4K	7.5 to 10
FR-E520-0.75K	15 to 20
FR-E520-1.5K	25 to 30
FR-E520-2.2K	30 to 40
FR-E520-3.7K	45 to 60

(5) Short-circuit rating

This inverter has been put to the short-circuit test of the UL in the AC circuit whose peak current and voltage are limited to _*_ A and 500V maximum respectively and conforms to this circuit.

Applicable Inverter Type	*
FR-A520-1.5K to 37K FR-A540-1.5K to 37K	5,000
FR-A520-45K, 55K FR-A540-45K, 55K	10,000

Applicable Inverter Type	*
FR-E520-1.5K to 3.7K	5,000

2.9.2 Compliance with the European Directives

(1) About the European Directives

For European unification, harmonized rules common to all countries for free movements and sales of people, things and services are being made. As one way of this rule making, the EC Committee has compiled 13 directives as the technological uniform standards on health and safety, and each country is legislating in accordance with these directives. Products covered by these directives are obliged to carry the CE mark, and the permission of export to and free movements and sales in the European district is only given to products carrying the CE mark. The following three directives are concerned with drive products:

1) Machinery Directive: Stipulates the safety of machinery, and fundamentally requires that any machine should not threaten the health and safety of living creatures and the safety of things when it is installed and maintained correctly and operated properly. Since inverters are components designed to control machines/apparatuses, we understand that they are not covered by this directive directly.

2) EMC Directive: Prescribes electromagnetic compatibility and fundamentally requires that any equipment should not affect other equipment adversely by electromagnetic interference and should have adequate noise immunity. Since inverters are components designed to control machines/apparatuses, we understand that they are not covered by this directive directly. However, we have made available the European Standard-compliant noise filter and our Technical Information/installation guide so that machines/apparatuses incorporating inverters may comply with the EMC Directive as easily as possible.

3) Low Voltage Directive: Sets forth the safety of electrical equipment and basically requires that any electrical equipment should not threaten the health and safety of living creatures and the safety of things when it is installed and maintained correctly and operated properly.

Since this directive applies to equipment operating at the power supply voltages of 50 to 1000VAC and 75 to 1500VDC, inverters are covered by this directive and the CE mark is placed on the inverters conforming to this directive.

CE mark

(2) EMC Directive

1) Our view of transistorized inverters for the EMC Directive

A transistorized inverter does not function independently. It is a component designed for installation in a control box and for use with the other equipment to control the equipment/device. Therefore, we understand that the EMC Directive does not apply directly to transistorized inverters. For this reason, we do not place the CE mark on the transistorized inverters themselves. (The CE mark is placed on inverters in accordance with the Low Voltage Directive.) The European power drive manufacturers' organization (CEMEP) also holds this point of view.

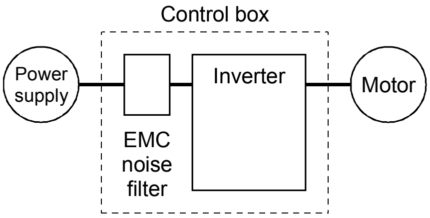
2) Compliance

We understand that the transistorized inverters themselves are not covered directly by the EMC Directive. However, the EMC Directive applies to machines/equipment into which transistorized inverters have been incorporated, and these machines and equipment must carry the CE marks. Hence, we prepared the technical information "EMC Installation Guidelines" (information number BCN-A21041-202) so that machines and equipment incorporating transistorized inverters may conform to the EMC Directive more easily.

3) Outline of installation method

Install an inverter in the following method:

- Use the inverter with an European Standard-compliant noise filter.
- For wiring between the inverter and motor, use shielded cables or run them in metal piping and ground the cables on the inverter and motor sides with the shortest possible distance.
- Insert a line noise filter and ferrite cores into the power and control lines as required. Full information including the European Standard-compliant noise filter specifications are written in the technical information "EMC Installation Guidelines" (information number BCN-A21041-202). Please contact your sales representative.



Noise Filter Wiring Diagram

(3) Low Voltage Directive

1) Our view of transistorized inverters for the Low Voltage Directive

Transistorized inverters are covered by the Low Voltage Directive.

2) Compliance

We have self-declared our inverters as products compliant to the Low Voltage Directive and place the CE mark on the inverters.

3) Outline of instructions

- In the 400V class inverters, the rated input voltage range is three-phase, 380V to 415V, 50/60Hz.
- Connect the equipment to the earth securely. Do not use an earth leakage circuit breaker as an electric shock protector without connecting the equipment to the earth.
- Wire the earth terminal independently. (Do not connect two or more cables.)
- Use the no-fuse breaker and magnetic contactor which conform to the EN or IEC Standard.
- Use the inverter under the conditions of overvoltage category II and contamination level 2 or less as set forth in IEC664.
  - (a) To meet the overvoltage category II, insert an EN or IEC Standard-compliant isolation transformer or surge suppressor in the input of the inverter.
  - (b) To meet the contamination level 2, install the inverter to a control box protected against ingress of water, oil, carbon, dust, etc. (IP54 or higher).
- On the input and output of the inverter, use cables of the type and size set forth in EN60204 Appendix C.
- The operating capacity of the relay outputs (terminal symbols A, B, C) should be 30VDC, 0.3A. (The relay outputs are basically isolated from the inverter's internal circuitry.)

Details are given in the technical information "Low Voltage Directive Conformance Guide" (information number BCN-A21041-203). Please contact your sales representative.

3

PRACTICAL CIRCUITS

3.1 How to Use the Parameters

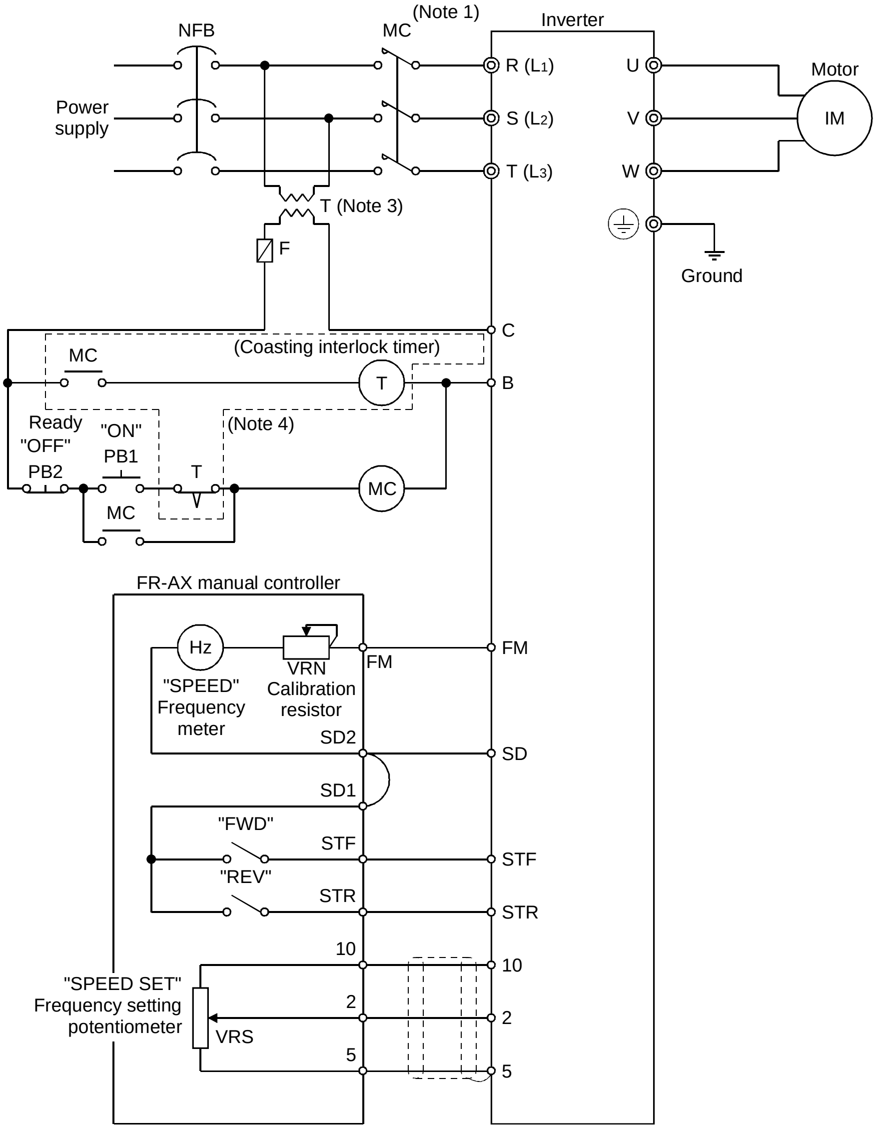
Set various functions according to the load specifications and operating conditions. The purposes of use and applied functions are listed below.
The parameter numbers indicated are those of the FR-A500. The parameter numbers of the other series are different from those listed below. Refer to the corresponding catalog or manual.

Purpose of Use	Parameter Numbers
	Parameter numbers which must be set
Adjustment of acceleration/deceleration time and pattern	Pr. 7, Pr. 8, Pr. 20, Pr. 21
Motor overheat protection	Pr. 9
Selection of optimum output characteristic for load characteristic	Pr. 3
Limit of output frequency	Pr. 1, Pr. 2, Pr. 18
Operation over 60Hz	Pr. 903, Pr. 905
Adjustment of frequency setting signal and output	Pr. 73, Pr. 902, Pr. 903, Pr. 904, Pr. 905
Calibration of frequency meter	Pr. 54, Pr. 55, Pr. 56, Pr. 158, Pr. 900
Adjustment of digital frequency meter	Pr. 54, Pr. 55, Pr. 56, Pr. 900
Adjustment of motor output torque	Pr. 0, Pr. 80, Pr. 81
Multi-speed operation	Pr. 4, Pr. 5, Pr. 6, Pr. 24, Pr. 25, Pr. 26, Pr. 27, Pr. 232, Pr. 233, Pr. 234, Pr. 235, Pr. 236, Pr. 237, Pr. 238, Pr. 239
Jog operation	Pr. 15, Pr. 16
Frequency jump operation	Pr. 31, Pr. 32, Pr. 33, Pr. 34, Pr. 35, Pr. 36
Reversible operation according to analog signal polarity	Pr. 28, Pr. 73
Automatic restart after instantaneous power failure	Pr. 57, Pr. 58
Adjustment of brake operation	Pr. 10, Pr. 11, Pr. 12
Timing of magnetic brake operation	Pr. 42
Display of speed etc.	Pr. 37, Pr. 52, Pr. 53
Function rewrite prevention	Pr. 77
Reverse rotation prevention	Pr. 78
Optimum acceleration/deceleration within continuous rating range	Pr. 60
Energy-saving operation	Pr. 60
Automatic restart after alarm stop	Pr. 65, Pr. 67, Pr. 68, Pr. 69
Sub-motor operation	Pr. 0, Pr. 3, Pr. 7, Pr. 8, Pr. 44, Pr. 45, Pr. 46, Pr. 47, Pr. 110, Pr. 111, Pr. 112, Pr. 113
To make desired output characteristics (V/F pattern)	Pr. 100 to Pr. 109
Operation via communication with personal computer	Pr. 117 to Pr. 124
Operation under PID control	Pr. 128 to Pr. 134
To perform commercial power supply-inverter switch-over operation	Pr. 135 to Pr. 139
To make backlash compensation	Pr. 140 to Pr. 143
To detect current	Pr. 150 to Pr. 153
Assignment of input terminal functions	Pr. 180 to Pr. 186
Assignment of output terminal functions	Pr. 190 to Pr. 195
To suppress noise	Pr. 72, Pr. 240
To group parameters	Pr. 160, Pr. 173 to Pr. 176
To set initial values for parameters	Pr. 199
Clearing of inverter's actual operation time	Pr. 171
High-speed frequency control operation	Pr. 271 to Pr. 274
To exercise stop-on-contact control	Pr. 275, Pr. 276
To increase cooling fan life	Pr. 244
To decelerate inverter to a stop at power failure	Pr. 261 to Pr. 266
Advanced magnetic flux vector control operation	Pr. 80, Pr. 81
Programmed operation	Pr. 200 to Pr. 231
Selection of key beep	Pr. 990

3.2 Standard connection Diagrams COMMON

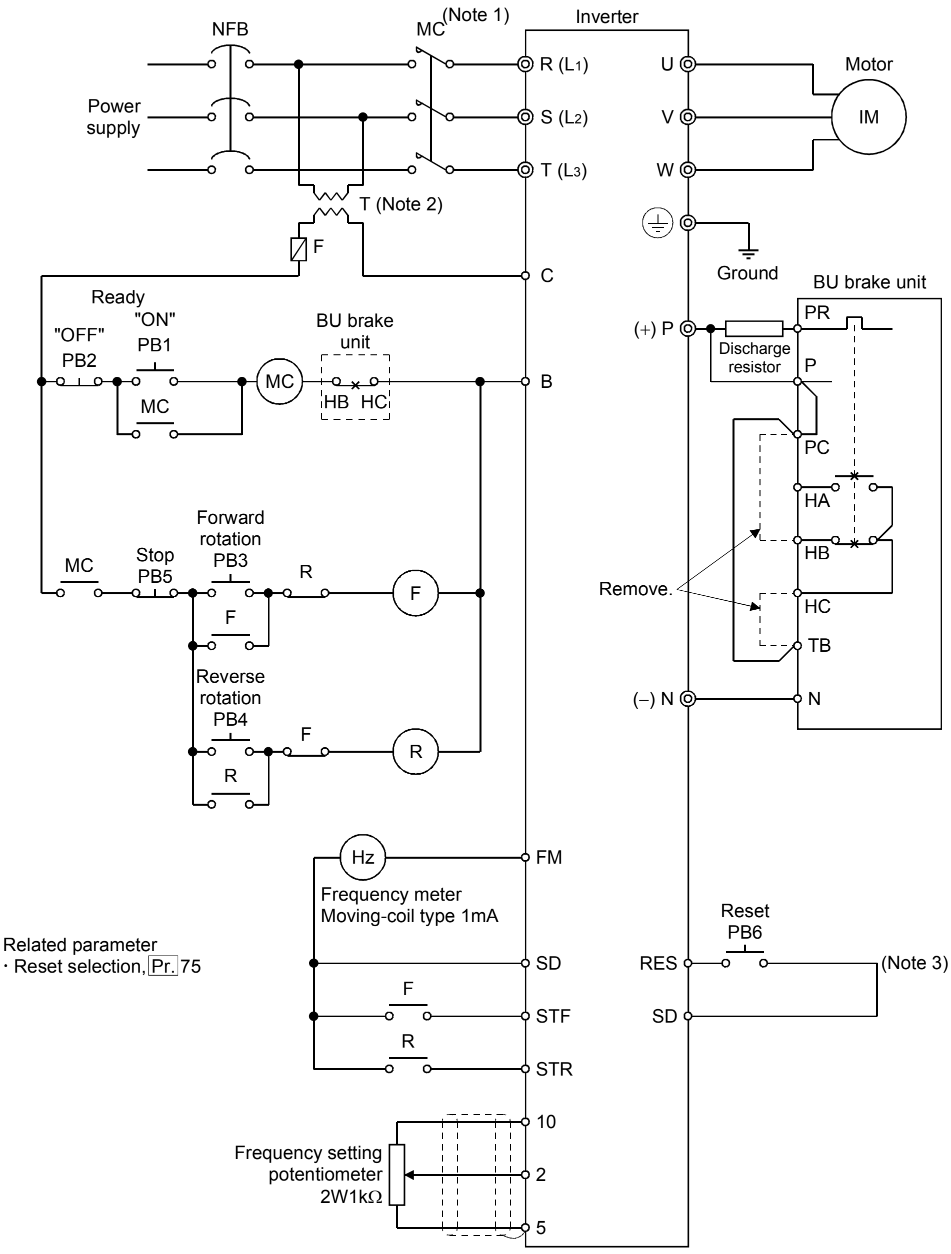
The circuit diagrams shown in this chapter are reference circuit diagrams used to activate functions.
When designing actual circuits, examine the operations of the machine and system and the rating, safety interlocks and others devices such as the contactors, relays and other equipment used.

3.2.1 Standard connection diagram of the inverter equipped with magnetic contactor on primary side (FR-AX manual controller used) COMMON



Note:
1. This magnetic contactor is provided to prevent an automatic restart when power is restored after a power failure. Use the start signal (ON-OFF across terminals STF-SD, STR-SD) to make a start and stop.
2. The inverter stops when both signals of the STF and STR terminals turn off.
3. Provide a control transformer when the power supply is 400V class.
4. When the motor shaft inertia is small, for example, this circuit may be omitted by utilizing the current limit function of the inverter.

3.2.2 Standard connection diagram of the inverter equipped with magnetic contactor on primary side (with Type BU brake unit) COMMON



Related parameter
· Reset selection, Pr. 75

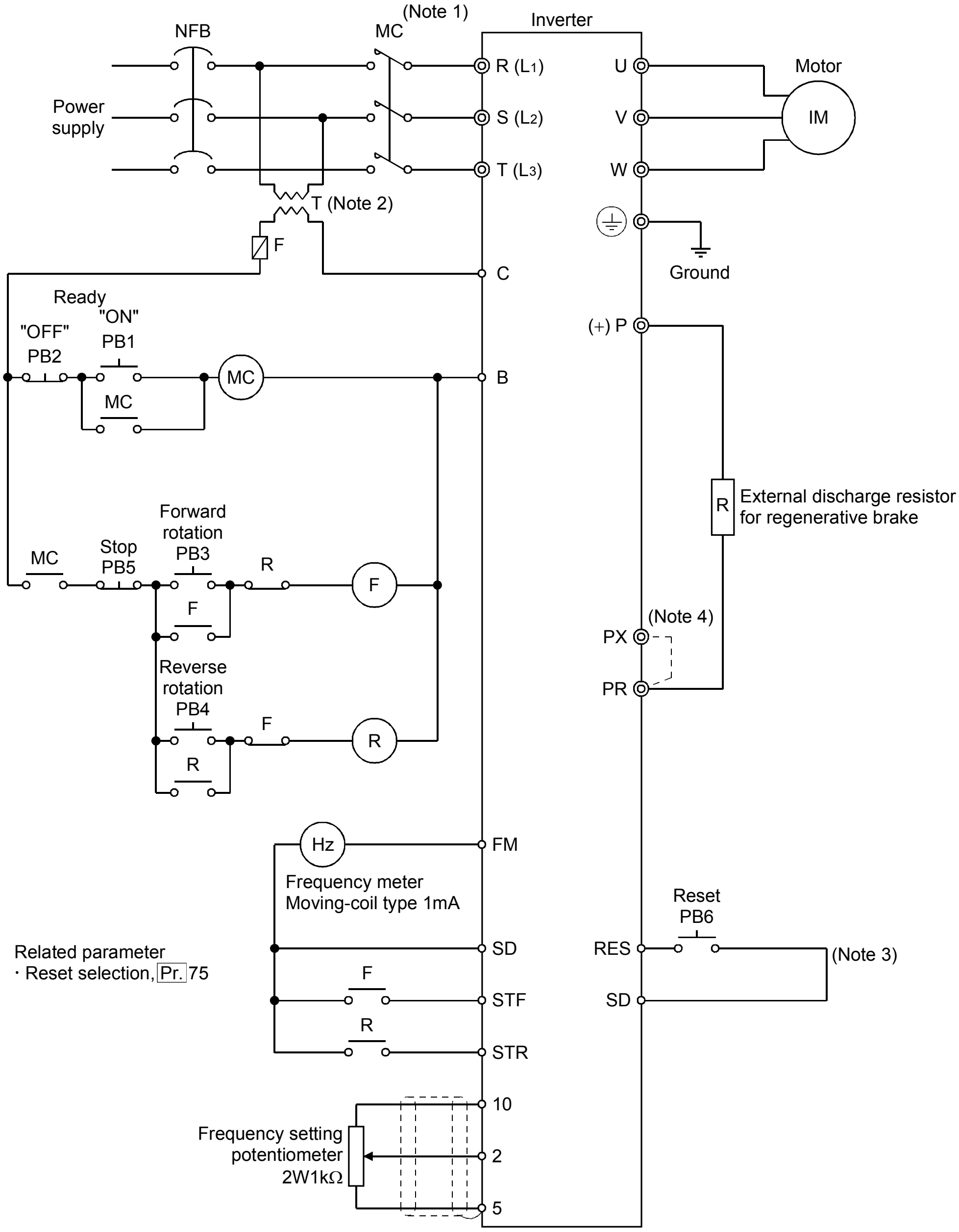
Note: 1. This magnetic contactor is provided to prevent an automatic restart when power is restored after a power failure. Use the start signal (ON-OFF across terminals STF-SD, STR-SD) to make a start and stop.

2. Provide a control transformer when the power supply is 400V class.

3. Set "1" "reset enabled only when protective function is activated" in Pr. 75 to disable resetting the inverter during normal operation. (If the inverter is reset during normal operation, the motor coasts to a stop. This setting is made to prevent the inverter from resulting in an alarm if the motor is still coasting when the inverter has returned from the reset status.)

3.2.3 Standard connection diagram of the inverter equipped with magnetic contactor on primary side (when regenerative brake duty is large) COMMON

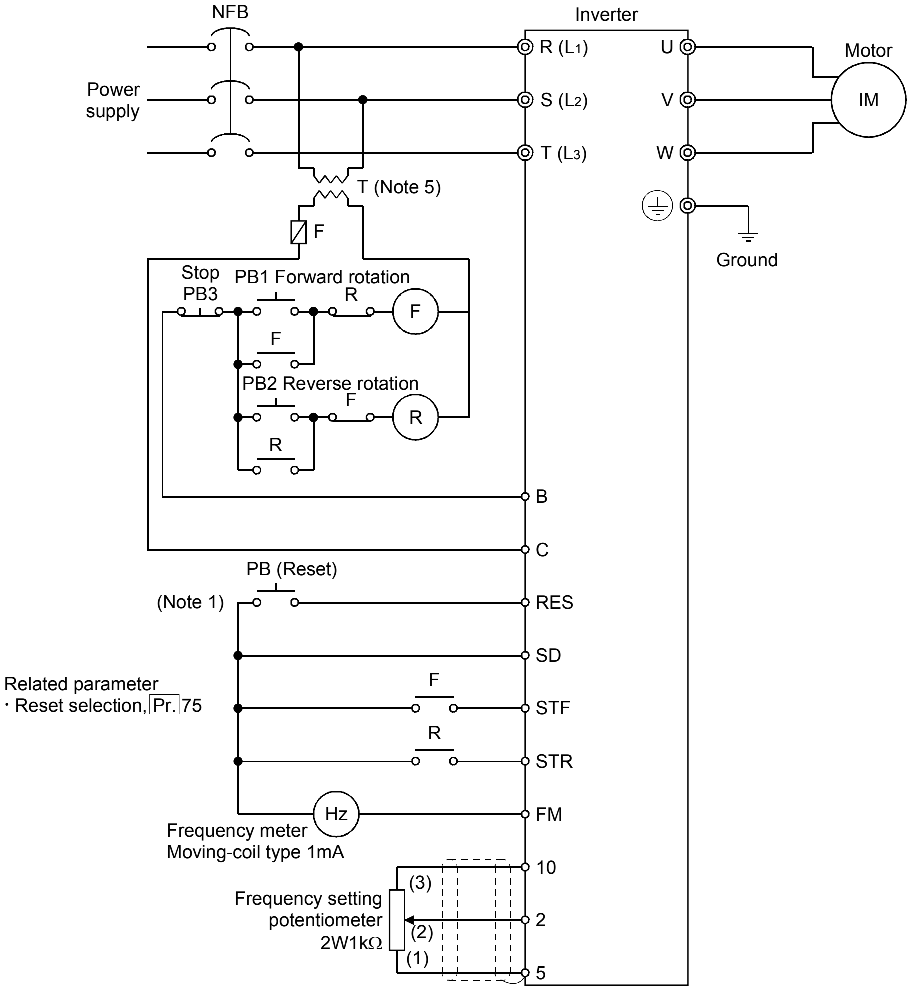
FR-A500 series 7.5K or less



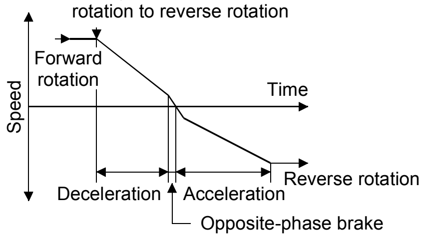
Related parameter
· Reset selection, Pr. 75

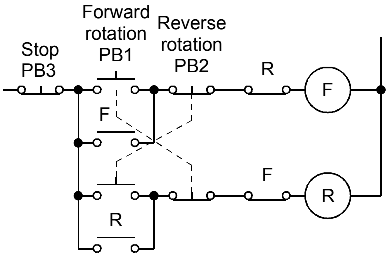
Note:
1. This magnetic contactor is provided to prevent an automatic restart when power is restored after a power failure. Use the start signal (ON-OFF across terminals STF-SD, STR-SD) to make a start and stop.
2. Provide a control transformer when the power supply is 400V class.
3. Set "1" "reset enabled only when protective function is activated" in Pr. 75 to disable resetting the inverter during normal operation. (If the inverter is reset during normal operation, the motor coasts to a stop. This setting is made to prevent the inverter from resulting in an alarm if the motor is still coasting when the inverter has returned from the reset status.)
4. When using an external brake resistor or brake unit, remove the jumper from across PR-PX.

3.2.4 Standard connection diagram of the inverter without magnetic contactor on primary side COMMON



Note:
1. Set "1" "reset enabled only when protective function is activated" in Pr. 75 to disable resetting the inverter during normal operation. (If the inverter is reset during normal operation, the motor coasts to a stop. This setting is made to prevent the inverter from resulting in an alarm if the motor is still coasting when the inverter has returned from the reset status.)
2. During operation, switch-over from "forward rotation" to "stop" to "reverse rotation" may be made. In this case, when the reverse rotation signal is turned on, the regenerative brake is applied down to the forward rotation frequency of 0.5Hz, the opposite-phase brake is applied at or less than the starting frequency, and acceleration in reverse rotation is started at that frequency. (DC dynamic brake is not applied.)

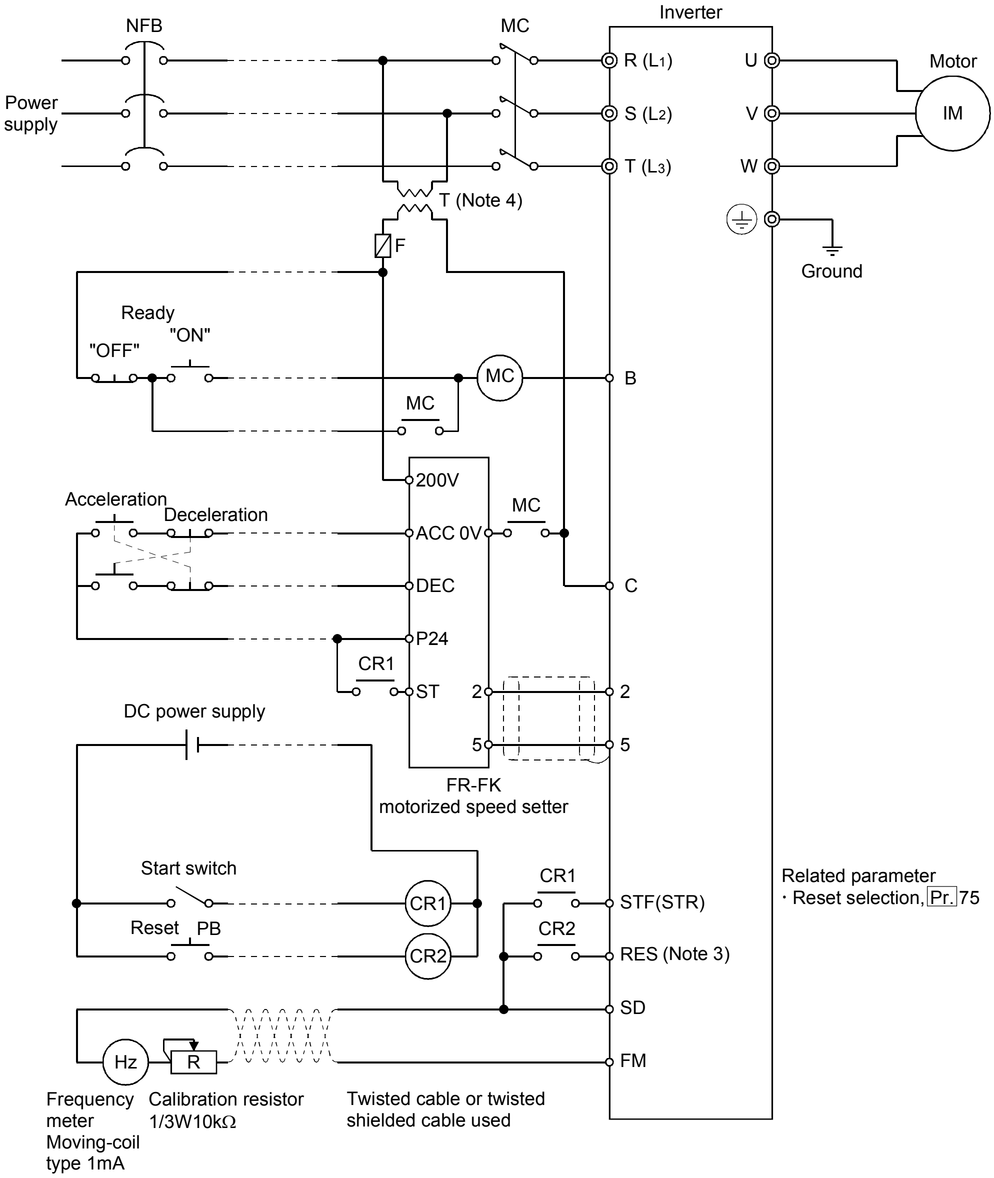




3. When making "forward rotation" to "reverse rotation" change-over during forward rotation in the above chart, change part of the connection diagram as shown on the right (above).
4. When the FR-A500 series 7.5K or less is used for cyclic or heavy duty operation, it is recommended to install a magnetic contactor in the primary side to prevent the brake discharge resistor from overheat/burnout if the regenerative brake transistor is damaged due to the thermal capacity shortage of the discharge resistor, an excessive regenerative brake duty etc.
5. Provide a control transformer when the power supply is 400V class.

3.3 Remote Operation

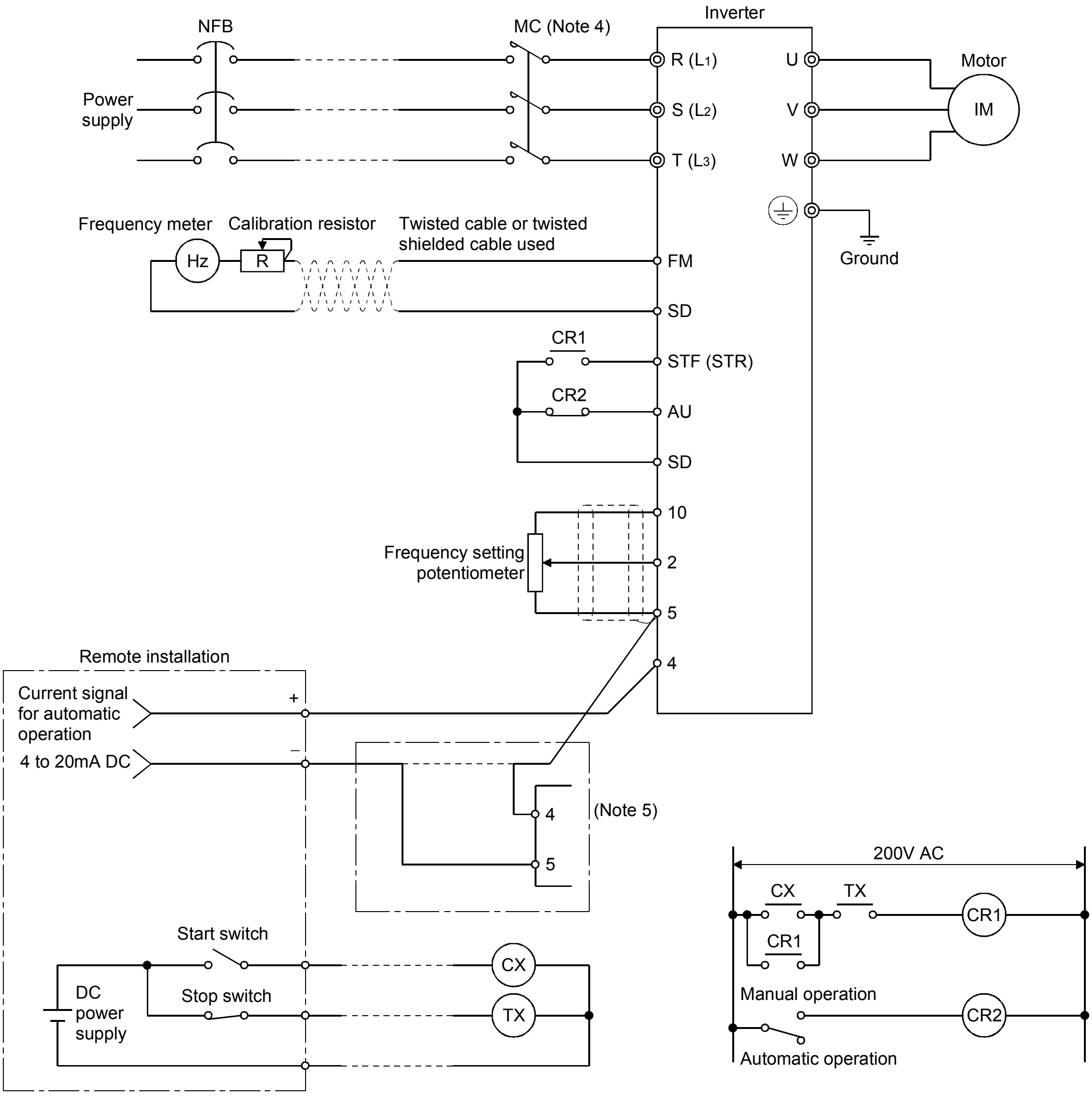
3.3.1 Use of the FR-FK motorized speed setter COMMON



Note: 1. Run the signal lines away from the power lines. Not doing so can cause the signal line to act as an antenna and be affected more easily by external noise.

2. The frequency meter connection cable may be increased up to 200m in length. (Install the calibration resistor near the frequency meter.)
3. Set "1" "reset enabled only when protective function is activated" in Pr. 75 to disable resetting the inverter during normal operation. (If the inverter is reset during normal operation, the motor coasts to a stop. This setting is made to prevent the inverter from resulting in an alarm if the motor is still coasting when the inverter has returned from the reset status.)
4. Provide a control transformer when the power supply is 400V class.
5. When the electric channel length between inverter and motor is large:
   1) As the output voltage of the inverter includes harmonics, continuous leakage current due to the to-ground capacitances in the inverter-to-motor electric channel increases and the earth leakage circuit breaker or earth leakage relay may operate unnecessarily.
      Wire the cables between the inverter and motor over the shortest distance and increase the electric channel-to-ground distance (i.e. distance between cables and ground).
   2) At a low frequency, the motor torque may reduce due to a voltage drop in the cables. (Refer to Section 2.6.4.)

3.3.2 Automatic operation using 4 to 20mADC current signal COMMON



Note: 1. Run the signal lines away from the power lines. Not doing so can cause the signal line to act as an antenna and be affected more easily by external noise.

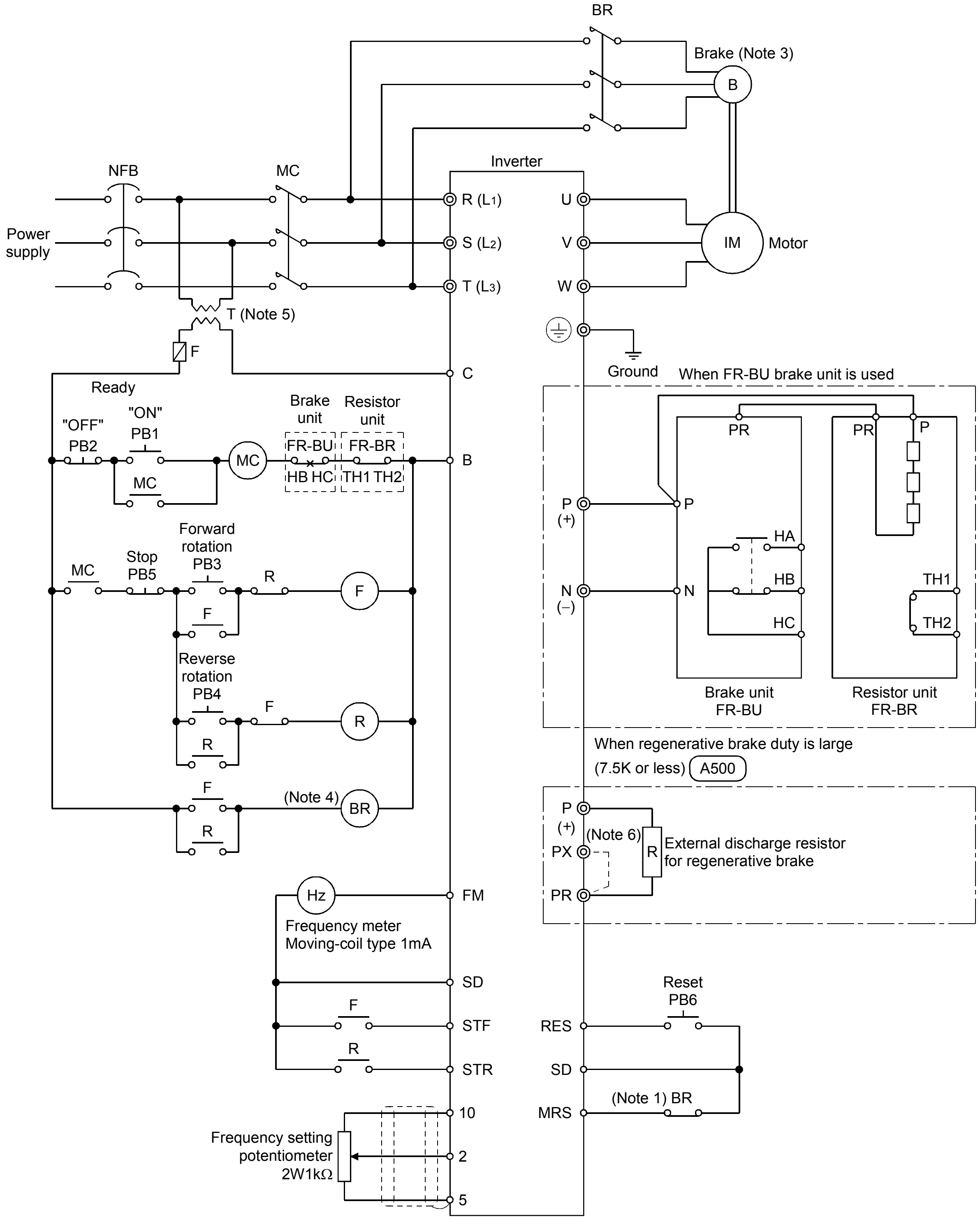
2. The frequency meter connection cable may be increased up to 200m in length. (Install the calibration resistor near the frequency meter.)

3. When the electric channel length between inverter and motor is large:
   1) As the output voltage of the inverter includes harmonics, continuous leakage current due to the to-ground capacitances in the inverter-to-motor electric channel increases and the earth leakage circuit breaker or earth leakage relay may operate unnecessarily.
   Wire the cables between the inverter and motor over the shortest distance and increase the electric channel-to-ground distance (i.e. distance between cables and ground).
   2) At a low frequency, the motor torque may reduce due to a voltage drop in the cables. (Refer to Section 2.6.4.)

4. When the FR-A500 series 7.5K or less is used for cyclic or heavy duty operation, it is recommended to install a magnetic contactor in the primary side to prevent the brake discharge resistor from overheat/burnout if the regenerative brake transistor is damaged due to the thermal capacity shortage of the discharge resistor, an excessive regenerative brake duty etc.

5. When running two inverters with a 4 to 20mADC current signal at the same time, connect terminals 4-5 in series. Note the power supply capacity of the 4 to 20mADC signal.

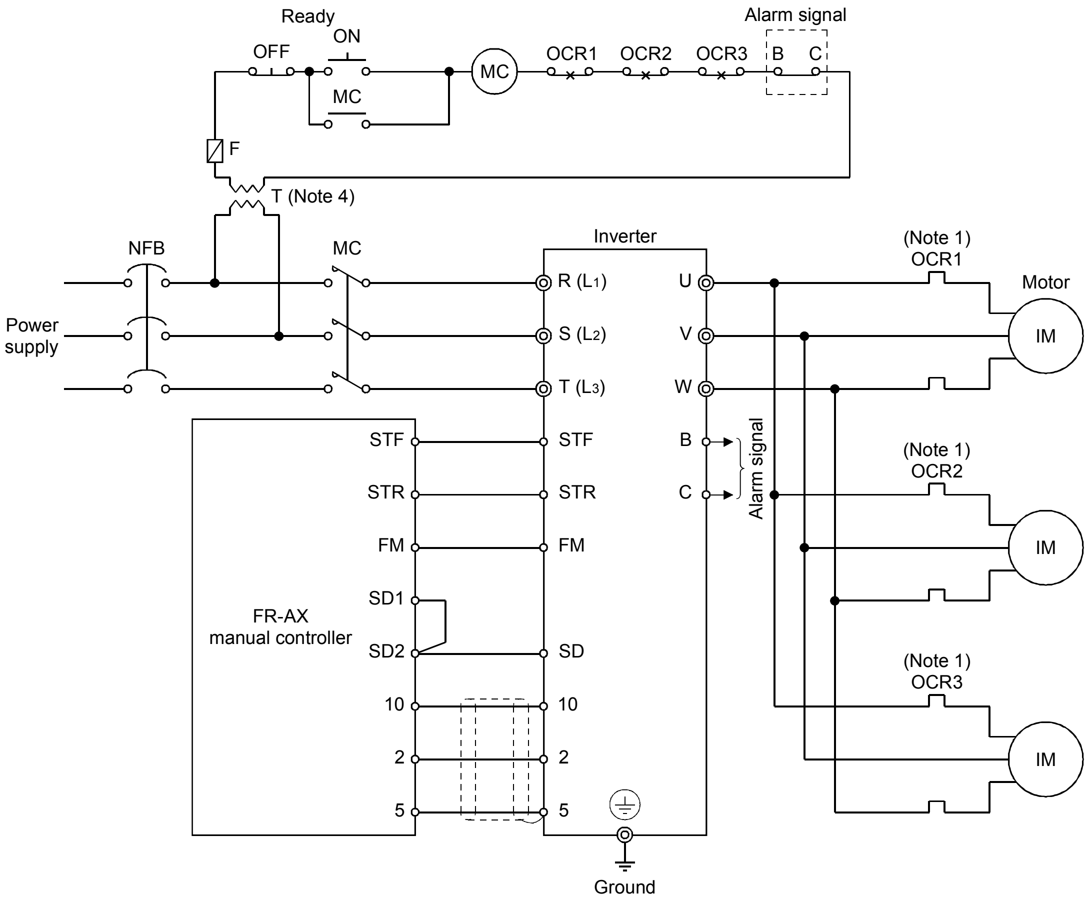
3.4 Motor Equipped with Brake



Note:
1. When stopping the motor equipped with electromagnetic brake, use the output stop terminal MRS-SD of the inverter. A failure to do so causes a lock current to flow in the motor when the brake is applied, and OCT may occur.
2. The above caution must also be taken when using any other mechanical brake.
3. When a motor equipped with a brake is run at or less than 30Hz continuously, the brake disc may rattle but the motor may be used without any problem if it is run at low speed for a short period, e.g. in orientation. Also, as there is a limit to the braking capacity, run the motor at no more than 60Hz.
4. In this circuit, pressing the stop button stops the motor with the electromagnetic brake. For operation of the electromagnetic brake after the motor is decelerated by the inverter, refer to Section 3.10.1.
5. Provide a control transformer when the power supply is 400V class.
6. When using an external brake resistor or brake unit, remove the jumper from across PR-PX.

3.5 Parallel Motor Operation COMMON

3.5.1 Motors driven by one inverter COMMON

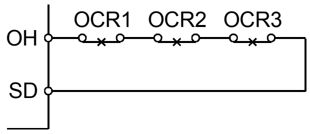


Note: 1. The electronic thermal relay built into the inverter cannot be used. Use an external thermal relay with each motor.

Note that when the capacity is small and the wiring length is large (50m or more), line-to-line leakage currents may operate the thermal relay. Refer to Section 2.5.4 and take adequate actions. Set “0“ (A) in the electronic thermal relay parameter to switch off the electronic thermal relay.

2. How to stop the inverter without switching off the magnetic contactor (MC) when the external thermal relay is actuated:

Use the external thermal relay input terminal (OH) to cause the inverter to stop the output. (For details, refer to Section 1.4.9.)

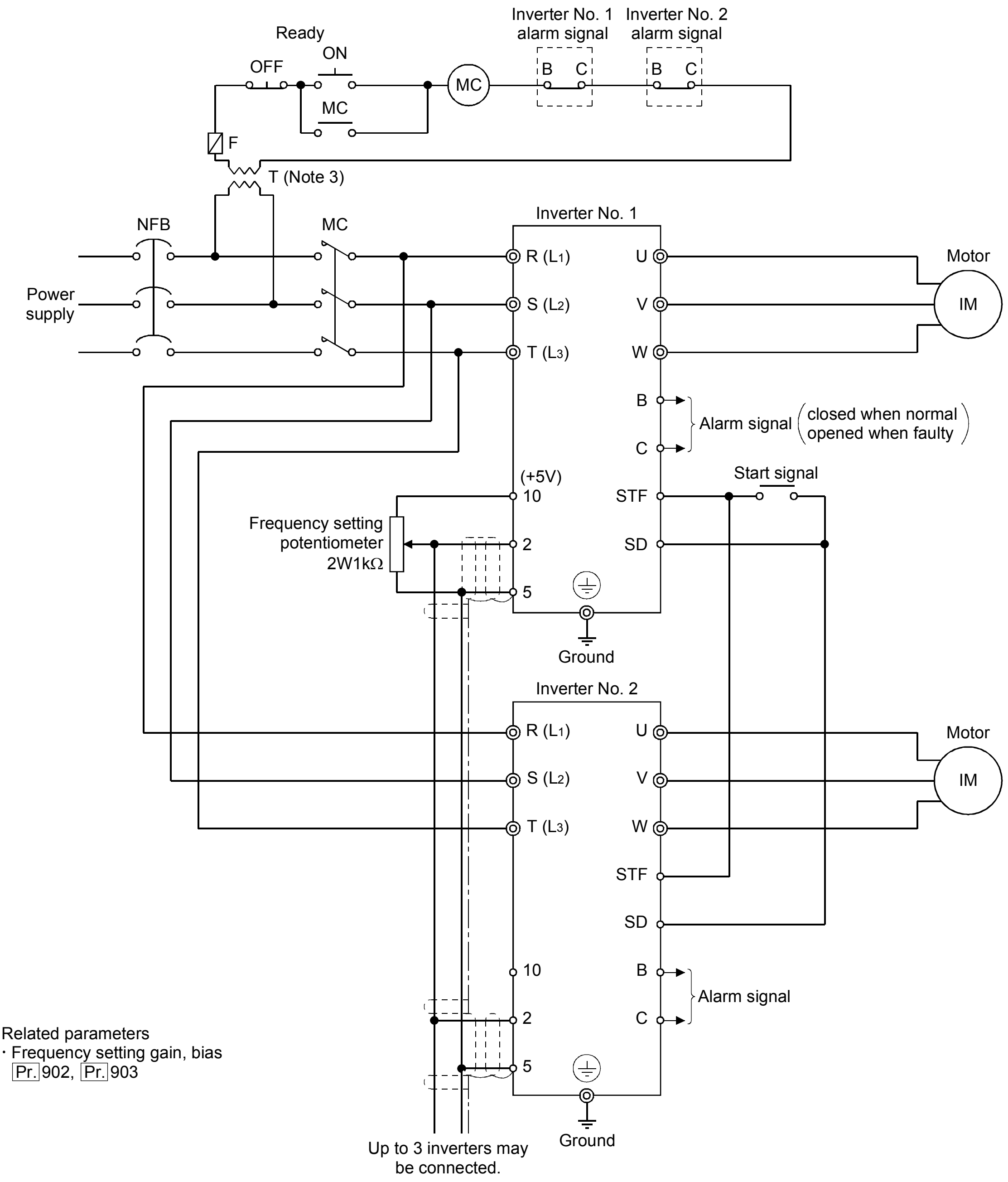


3. Motor selection.

No problem will arise when a specific motor is connected or selected while all motors are at a stop. However, if any of the motors during a stop is direct-on line started by the contactor etc. during inverter operation, the current limit function of the inverter may be activated by the starting current of that motor, leading to a sudden change of the output frequency. In this case, it is recommended to increase the inverter capacity.

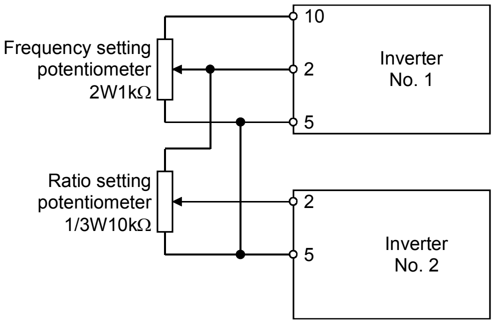
4. Provide a control transformer when the power supply is 400V class.

3.5.2 Inverters and motors are in pairs COMMON



Related parameters
· Frequency setting gain, bias
Pr. 902, Pr. 903

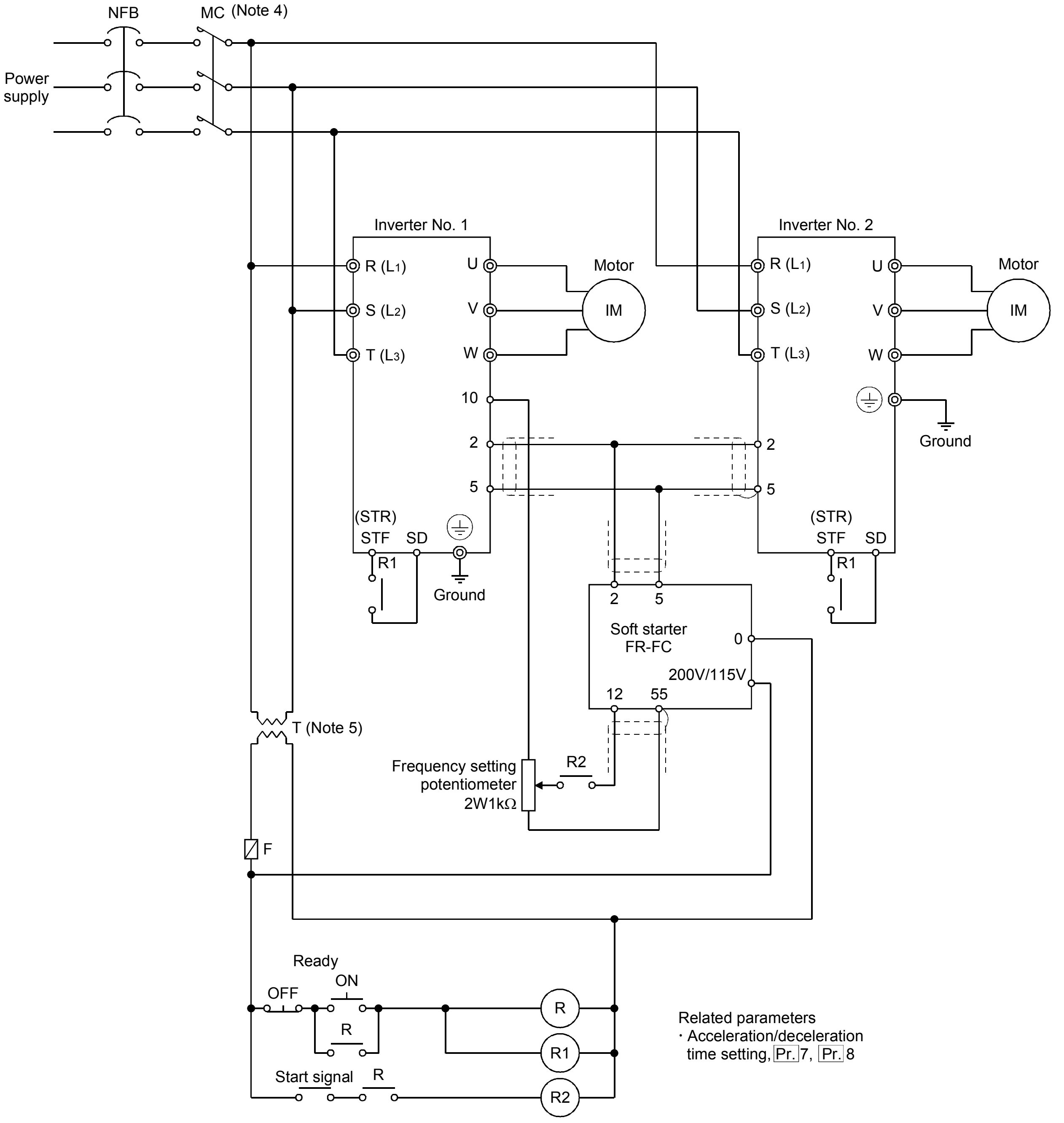
Ratio control operation



The ratio setting potentiometer may be omitted by setting the frequency setting gain/bias function of the operation panel (parameter unit).

Note:
1. By using the frequency setting gain/bias function of the operation panel (parameter unit), you can make adjustment to match the output frequencies of the three inverters corresponding to the common command voltage value from the frequency setting potentiometer.
2. When two or more motors are coupled mechanically, larger load may be applied to one motor, resulting in overload. Use the system described in Section 3.5.1.
3. Provide a control transformer when the power supply is 400V class.

3.5.3 Soft starter is used to soft-start/soft-stop two motors at the same time COMMON



Related parameters
· Acceleration/deceleration time setting, Pr. 7, Pr. 8

Note: 1. Use the signal of the relay R2 to make a soft start/soft stop. Turn off the relay R1 after the motor has stopped. If it is turned off during motor operation, the motor may decelerate at the acceleration/deceleration time in the inverter, resulting in an OVT trip.

2. The times of acceleration and deceleration made by the FR-FC soft starter are as indicated below at the maximum output voltage. (For the specifications of 90 seconds or longer, contact the manufacturer.)

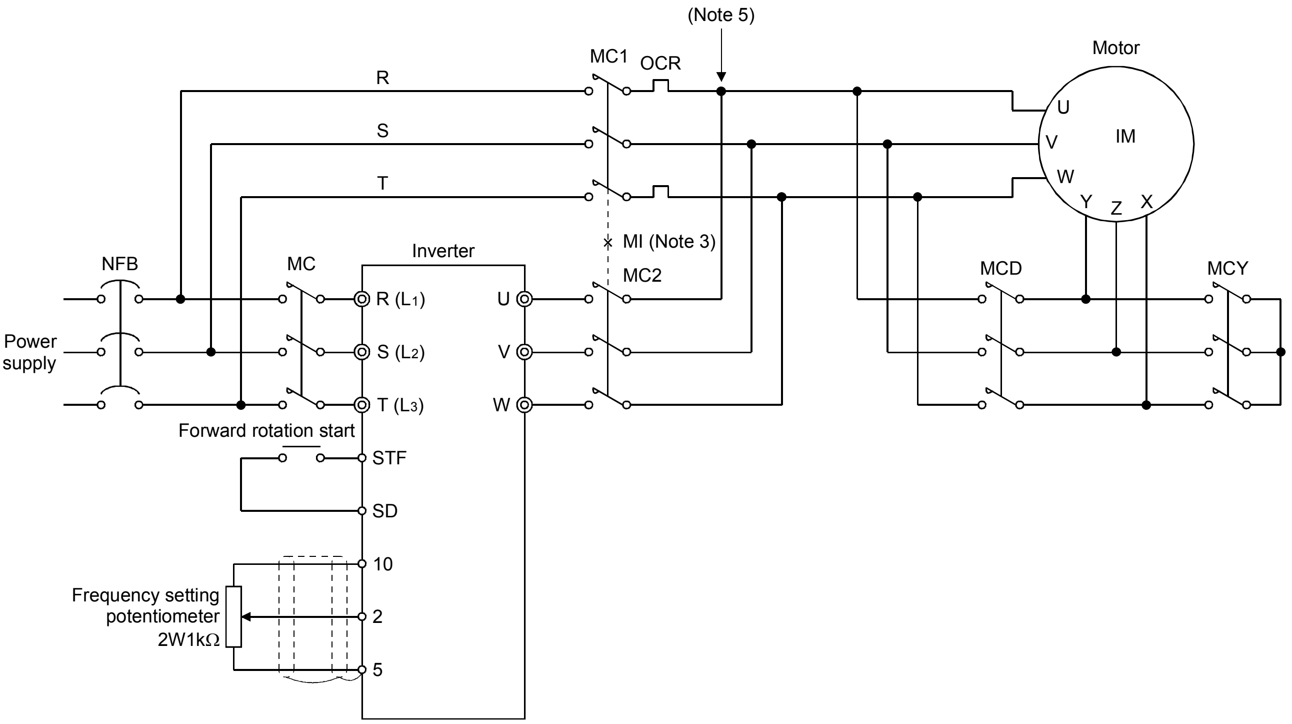
Standard:	0.15 to 1.3 s adjustable	C1-C2 shorted:	0.75 to 7.5 s. adjustable
C1-C2-C3 shorted:	5 to 50 s. adjustable	C1-C2-C3-C4 shorted:	10 to 90 s. adjustable

3. Set the acceleration/deceleration time of the inverter to the minimum value of 0 seconds.
4. When the FR-A500 series 7.5K or less is used for cyclic or heavy duty operation, it is recommended to install a magnetic contactor in the primary side to prevent the brake discharge resistor from overheat/burnout if the regenerative brake transistor is damaged due to the thermal capacity shortage of the discharge resistor, an excessive regenerative brake duty etc.
5. Provide a control transformer when the power supply is 400V class.

3.6 Inverter ↔ Commercial Power Supply Switch-Over Operation COMMON

3.6.1 ⅄-Start COMMON

When the motor is rotated at full speed at 60Hz (or 50Hz), commercial power supply operation is more efficient than inverter operation. Also, when the motor cannot be stopped long for maintenance/inspection of the inverter, it is recommended to provide a commercial power supply circuit.

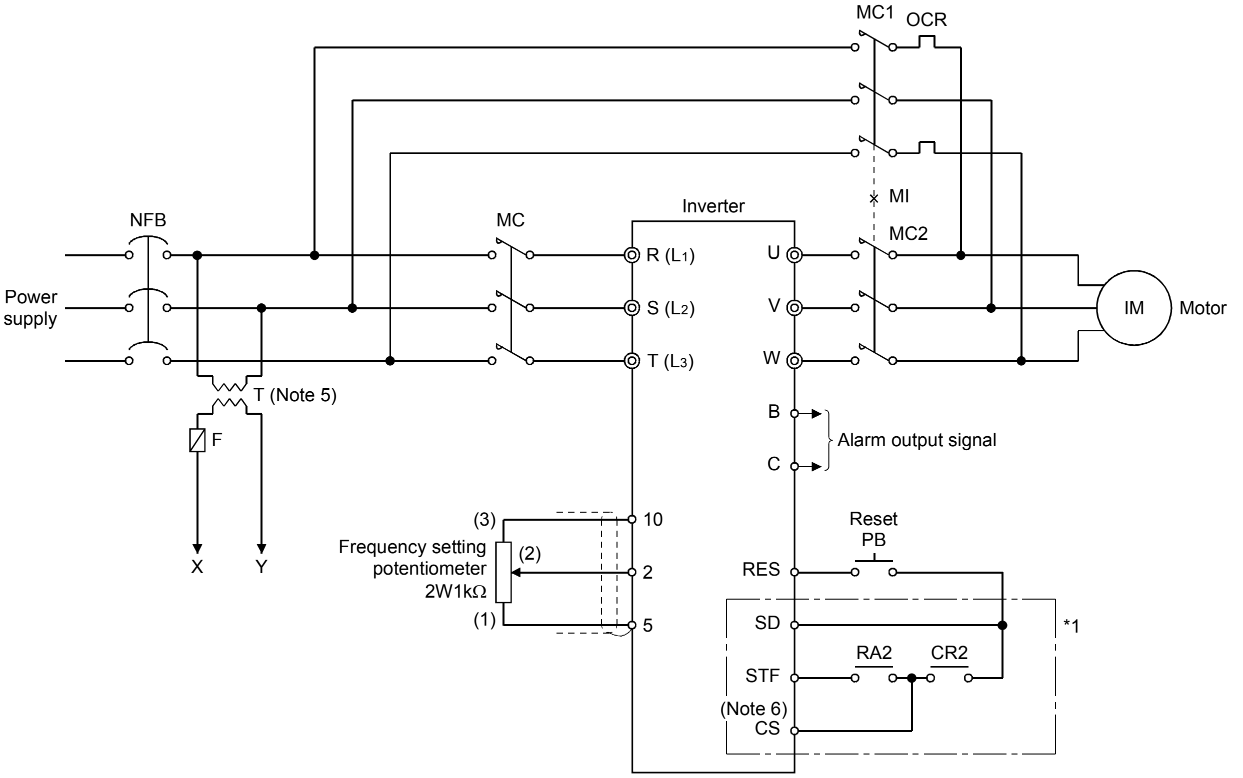


Note: 1. For the control circuit, refer to Section 3.6.2.

2. For inverter operation, turn on MC2 and MCD simultaneously. (start-connection operation cannot be performed.)
3. Provide electrical and mechanical interlocks to prevent the MC1 and MC2 from being turned on at the same time.
4. In principle, do not turn on the MC2 to start the inverter while the motor is rotating (coasting). Refer to Section 1.4.3 for details of the magnetic contactor (MC2) turn-on conditions.
5. Before making connection, ensure that the phase rotation of the commercial power supply is in R→ S→T sequence.

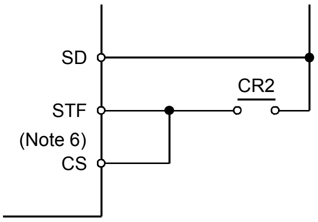
3.6.2 Commercial power supply ↔ inverter switch-over operation (COMMON)

Commercial power supply operation can be changed over to inverter operation without stopping the motor.



*1: When coasting the motor to a stop by pressing the stop pushbutton in the inverter mode, modify the circuit as shown below:

Related parameters
· Restart selection, Pr. 57, Pr. 58
· Reset selection, Pr. 75



Note: 1. By pressing the inverter operation pushbutton, commercial power supply operation can be changed over to inverter operation without stopping the motor.

2. When the inverter is tripped due to an instantaneous power failure (IPF), the motor restarts automatically when power is restored. (Note that when there is no Type RD instantaneous power failure relay, the motor is coasted to a stop when the relay or MS turns off, and does not restart automatically.)

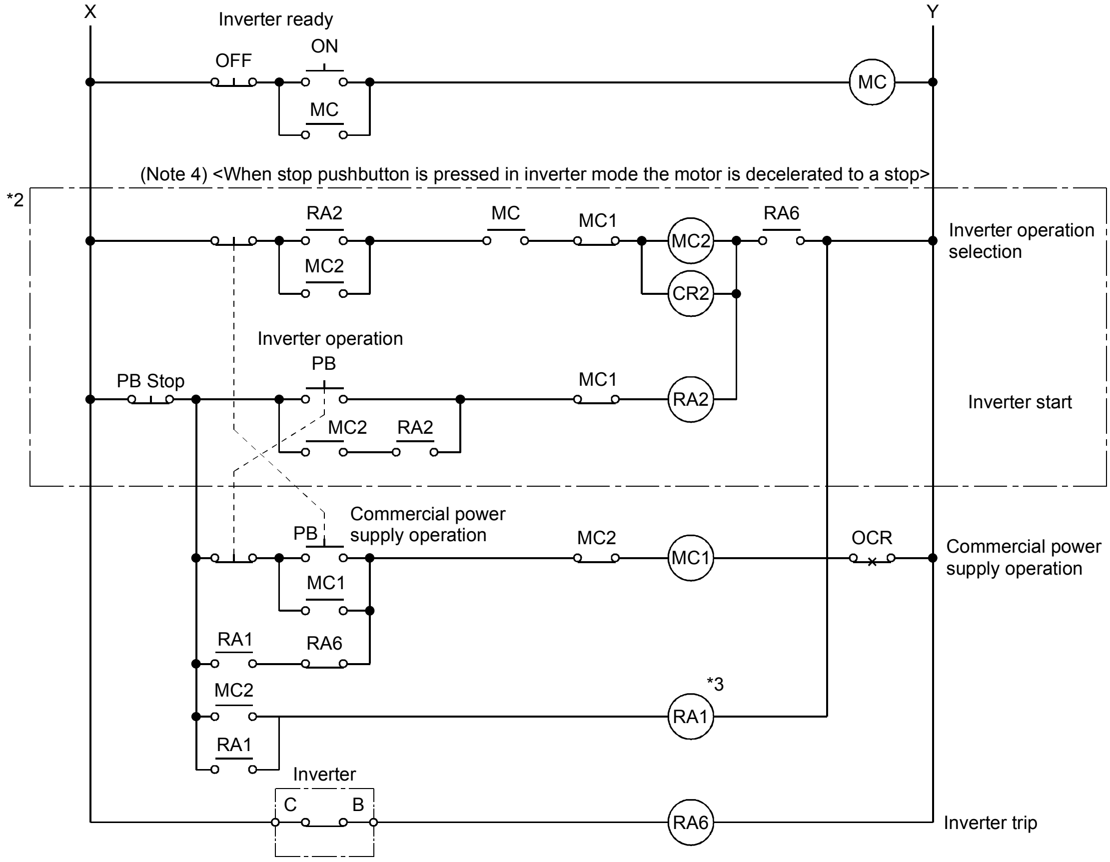
3. When an inverter trip occurs, inverter operation is changed over to commercial power supply operation. (When the RA1 marked *3 is removed, commercial power supply backup operation is not performed.)

4. When the stop pushbutton is pressed during inverter operation, the motor is inverter-controlled from deceleration to a stop. (When coasting the motor to a stop, modify the circuit portions marked *1, *2 and *4.)

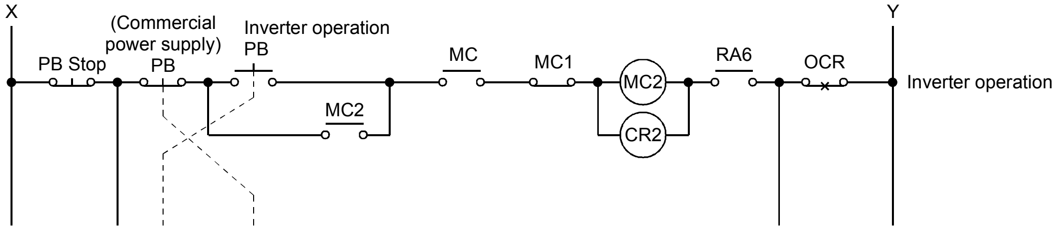
5. Provide a control transformer when the power supply is 400V class.

6. The (E500) is not provided with terminal CS. Set any value other than 9999 in Pr. 57 to select the function of automatic restart after instantaneous power failure. (Automatic restart is made if control power remains from occurrence of an instantaneous power failure to power restoration.)

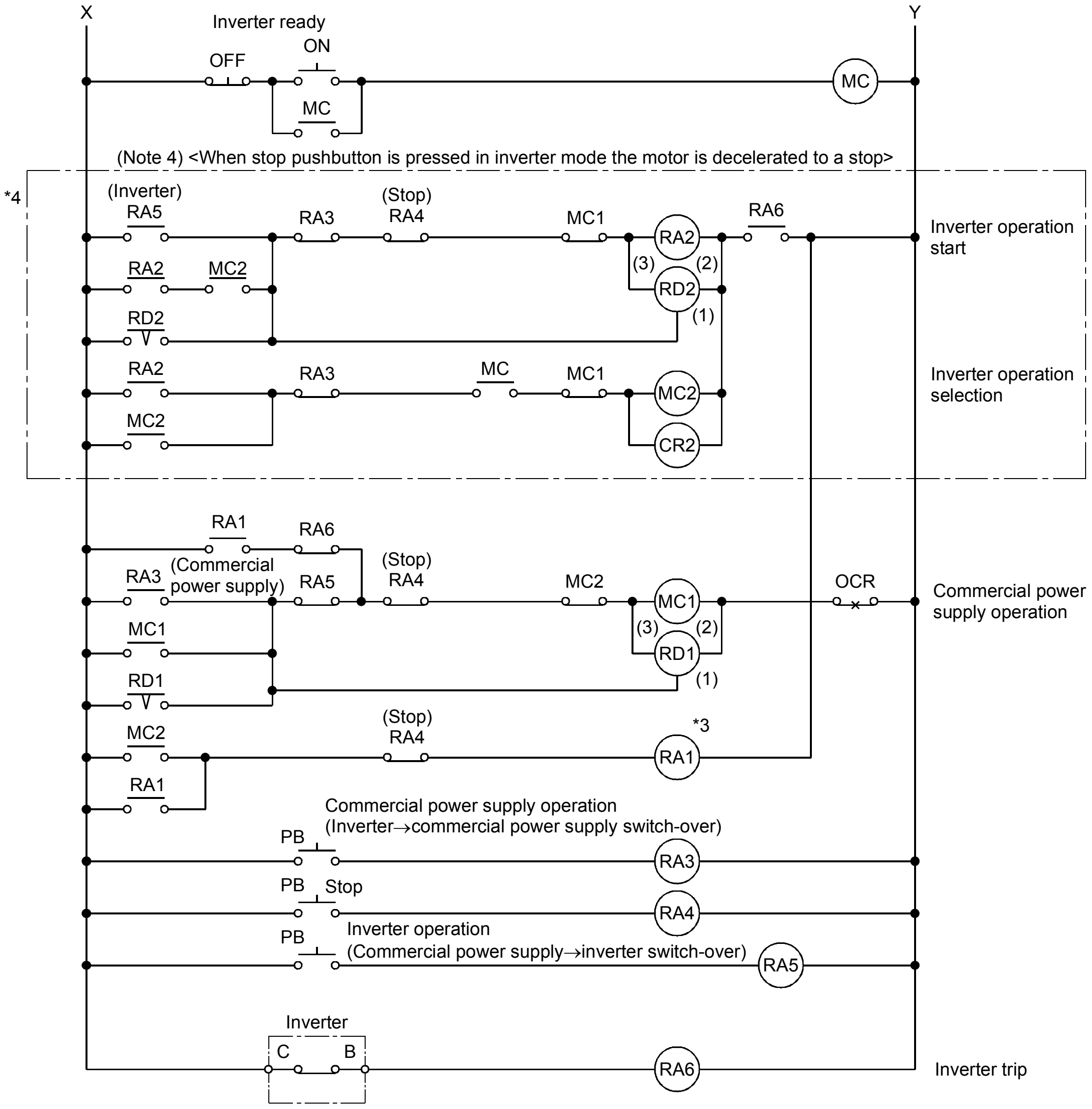
[For commercial power supply-inverter switch-over operation only]



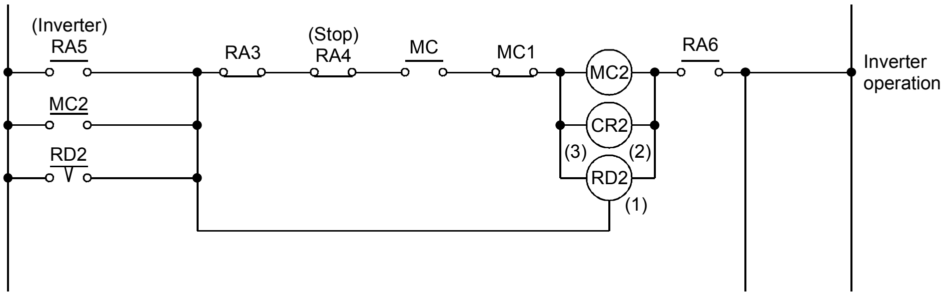
*2: Modify the circuit as shown below when pressing the stop pushbutton in the inverter mode to coast the motor to a stop:



[For commercial power supply-inverter switch-over operation and automatic restart after instantaneous power failure]

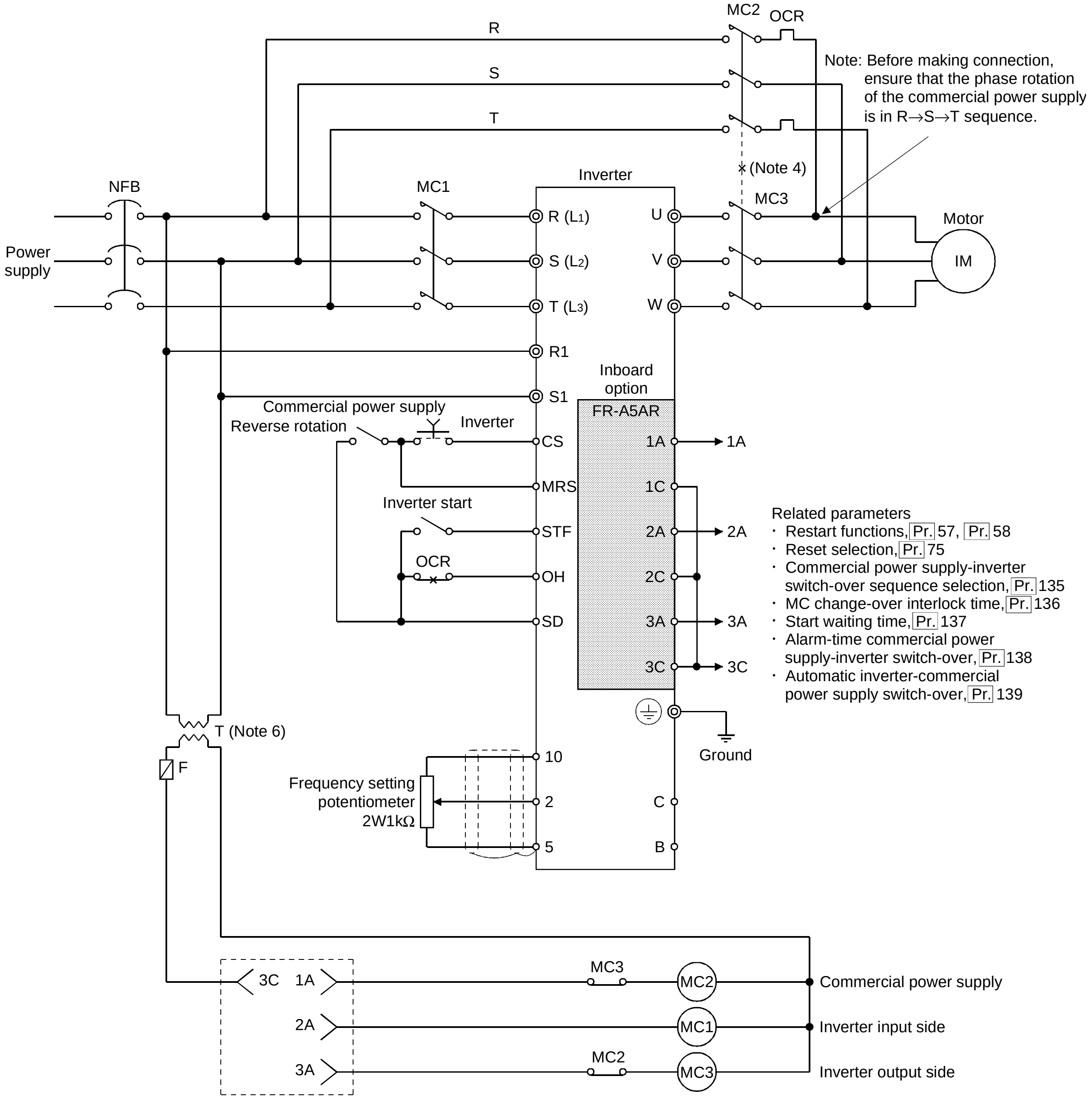


*4: Modify the circuit as shown below when pressing the stop pushbutton in the inverter mode to coast the motor to a stop:



3.6.3 Commercial power supply ↔ inverter switch-over operation [when commercial power supply ↔ inverter switch-over sequence is used] (A500)

Relay output inboard option is used (Note 2)



Note: Before making connection, ensure that the phase rotation of the commercial power supply is in R→S→T sequence.

Related parameters
- Restart functions, Pr. 57, Pr. 58
- Reset selection, Pr. 75
- Commercial power supply-inverter switch-over sequence selection, Pr. 135
- MC change-over interlock time, Pr. 136
- Start waiting time, Pr. 137
- Alarm-time commercial power supply-inverter switch-over, Pr. 138
- Automatic inverter-commercial power supply switch-over, Pr. 139

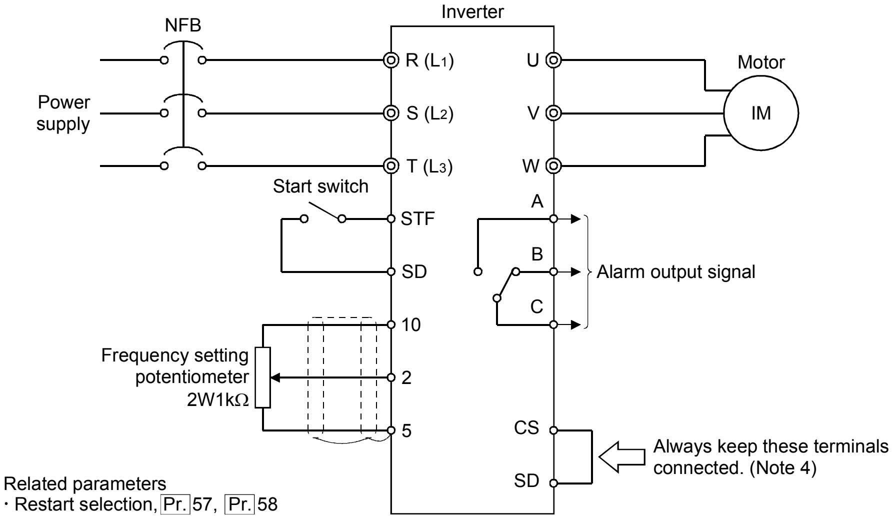
Commercial power supply

Inverter input side

Inverter output side

Note:
1. When the inverter protective function is activated, reset the inverter by turning off the main breaker once or shorting the inverter reset terminal (RES) and (SD).
2. Operation may be performed without the inboard option. In this case, however, a 24VDC power supply is required to drive the magnetic contactors.
3. For switch-over from commercial power supply operation to inverter operation, the motor coasting speed is automatically detected to continue operation without stopping the motor. In this case, note that a value other than 9999 should be set to the function of automatic restart after instantaneous power failure (Pr. 57, Pr. 58) of the inverter.
4. The MC1 and MC2 must be mechanically interlocked.
5. If an alarm occurs during inverter operation, inverter operation can be automatically changed over to commercial power supply operation. (Pr. 138)
6. Provide a control transformer when the power supply is 400V class.

3.7 Circuit for Automatic Restart after Instantaneous Power Failure



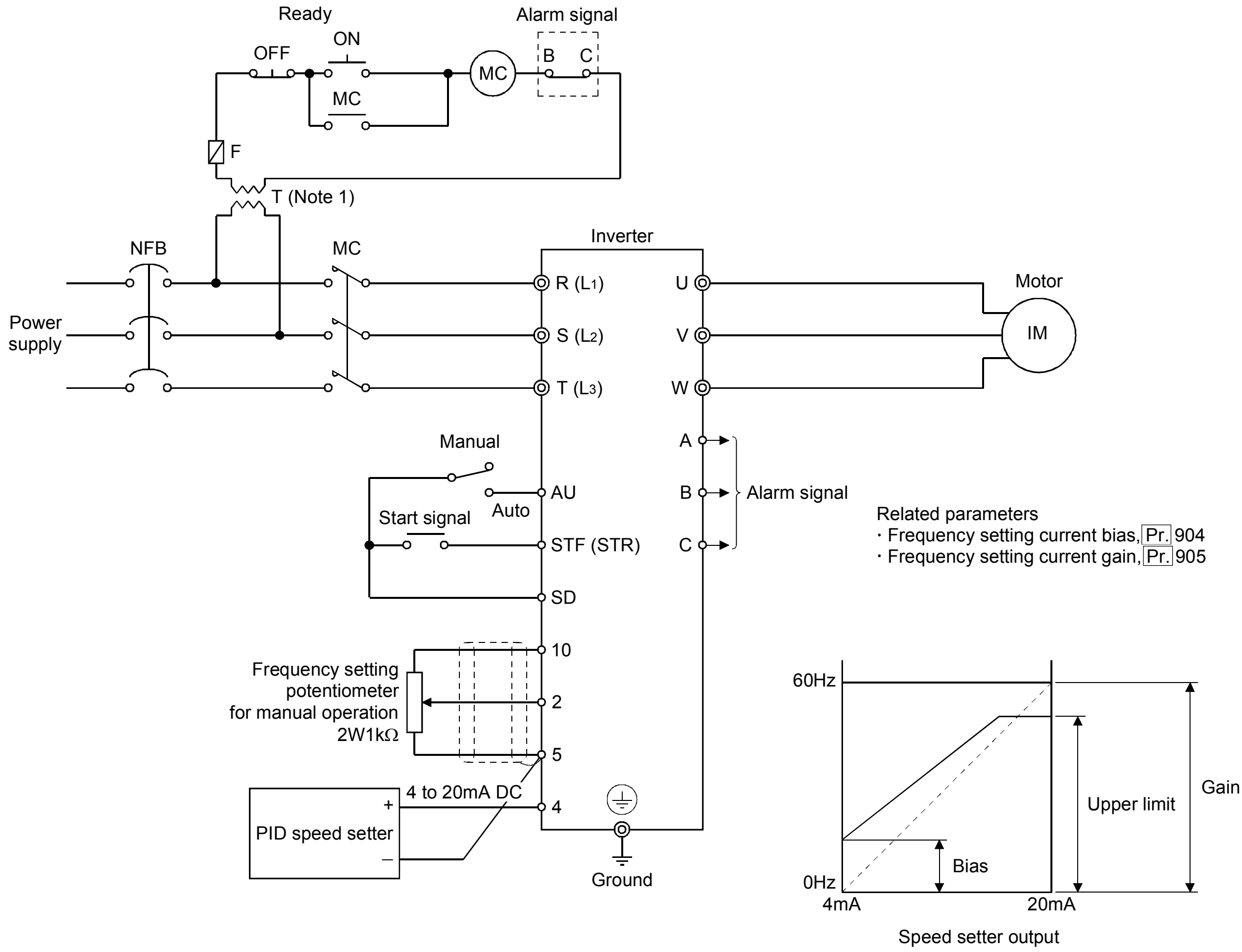
For the (A500), shorting terminals CS and SD allows the motor to automatically restarted by the inverter without the motor being stopped when power is restored if an instantaneous power failure of longer than 15ms occurs during inverter operation.

Note: 1. The start signal (STF) must be on when power is restored. Restart cannot be made if the start signal is turned off by the self-holding circuit due to a power failure.

2. Refer to the instruction manual for other operational details and application instructions.
3. When performing this operation, short the above terminals CS-SD and also set a value other than 9999 in Pr. 57.
4. The (E500) is not provided with terminal CS. Set any value other than 9999 in Pr. 57 to select the function of automatic restart after instantaneous power failure. (Automatic restart is made if control power remains from occurrence of an instantaneous power failure to power restoration.)

3.8 Automatic Operation of Fan, Pump or the Like Using Speed Setter

[Auto-manual switch-over operation]

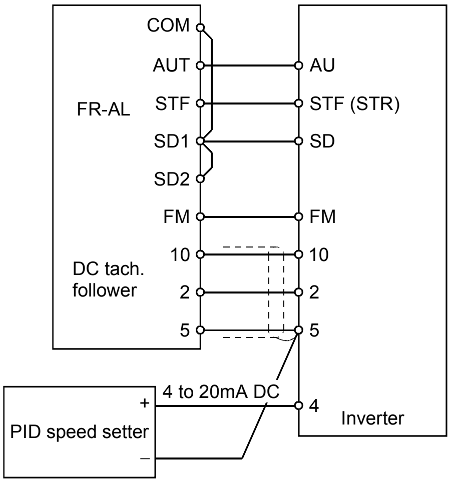


Related parameters
- Frequency setting current bias, Pr. 904
- Frequency setting current gain, Pr. 905

Note: 1. When the power supply is 400V class, provide a control transformer.

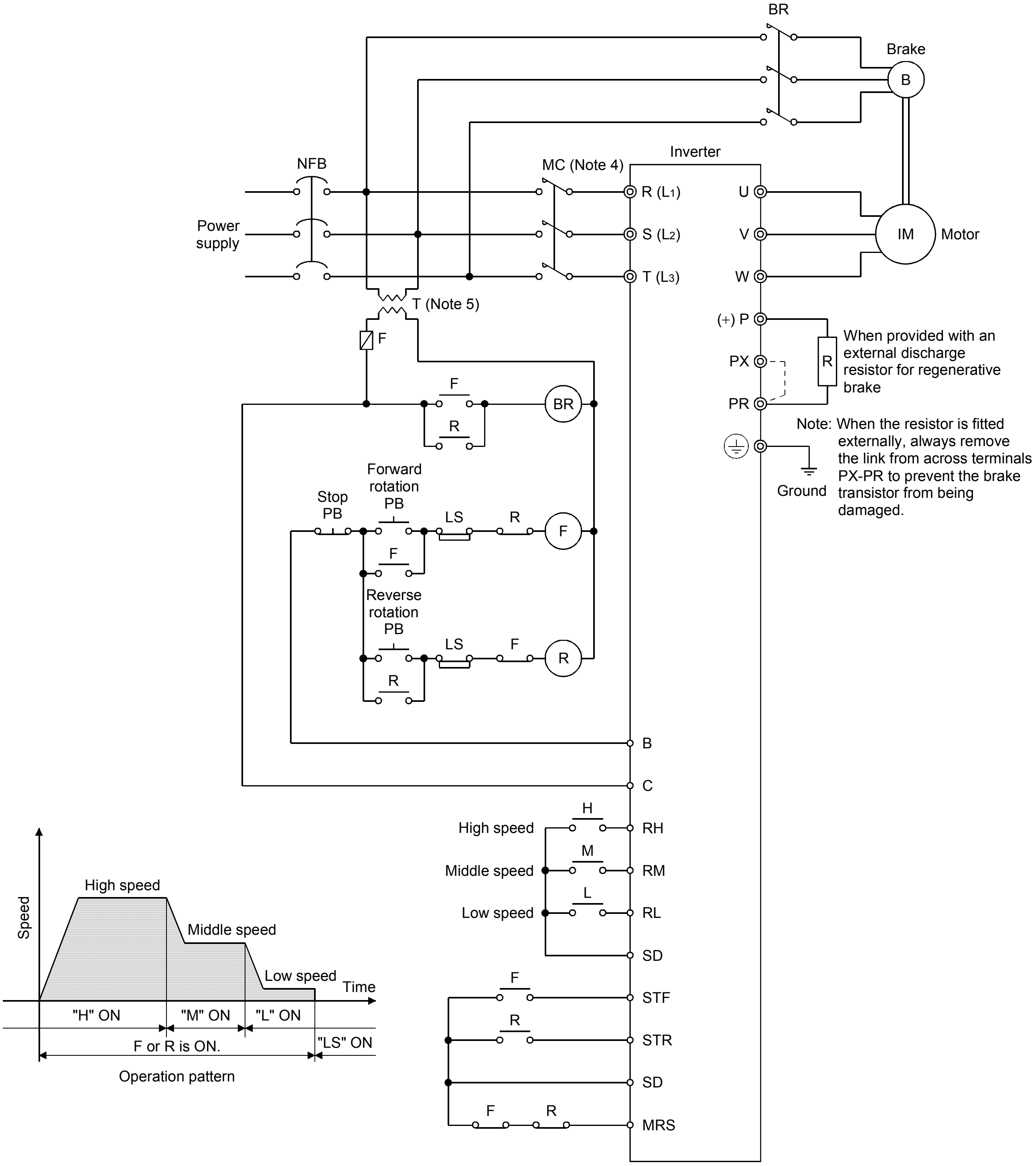
Using the setting function of the operation panel (parameter unit), you can set the relationship between speed setter output and output frequency as shown above.

FR-AL DC tachometer. follower



2. The FR-AL has the manual-auto change-over, start signal switch and frequency meter.

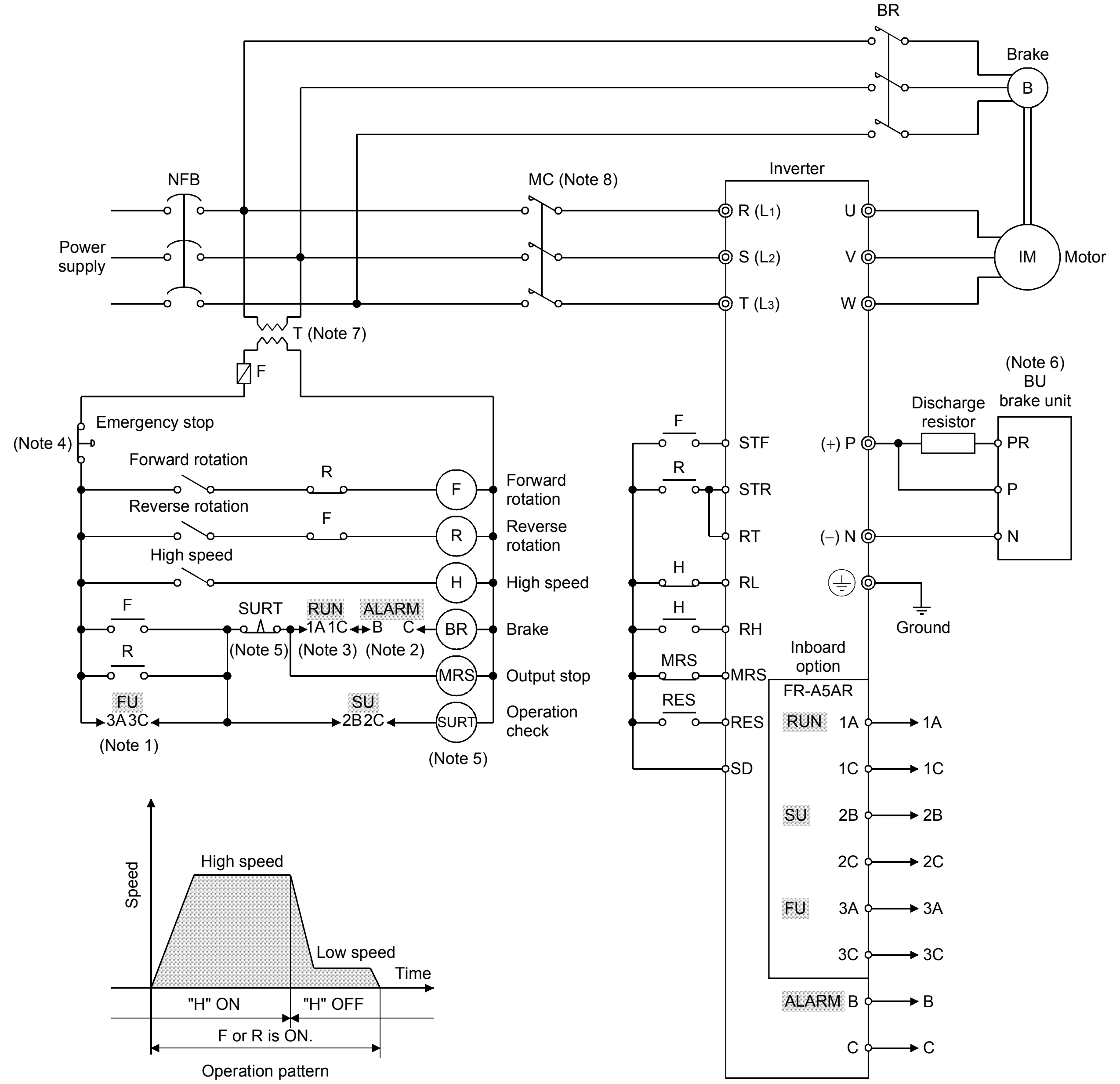
3.9 Positioning Operation Common COMMON



Note:
1. When the speed commands H, M and L are turned on simultaneously, the lower speed has precedence in operation.
   [Example] When the speed commands H and L are turned on simultaneously, the low speed command L is used in operation.
2. The FR-A500 series 7.5K or less has a built-in discharge resistor designed for regenerative braking, but in the above diagram it was replaced by an especially large-capacity external discharge resistor for regenerative braking.
3. Also refer to the circuit example of the motor equipped with brake. (Refer to Section 3.4.)
4. When the FR-A500 series 7.5K or less is used for cyclic or heavy duty operation, it is recommended to install a magnetic contactor in the primary side to prevent the brake discharge resistor from overheat/burnout if the regenerative brake transistor is damaged due to the thermal capacity shortage of the discharge resistor, an excessive regenerative brake duty etc.
5. Provide a control transformer when the power supply is 400V class.

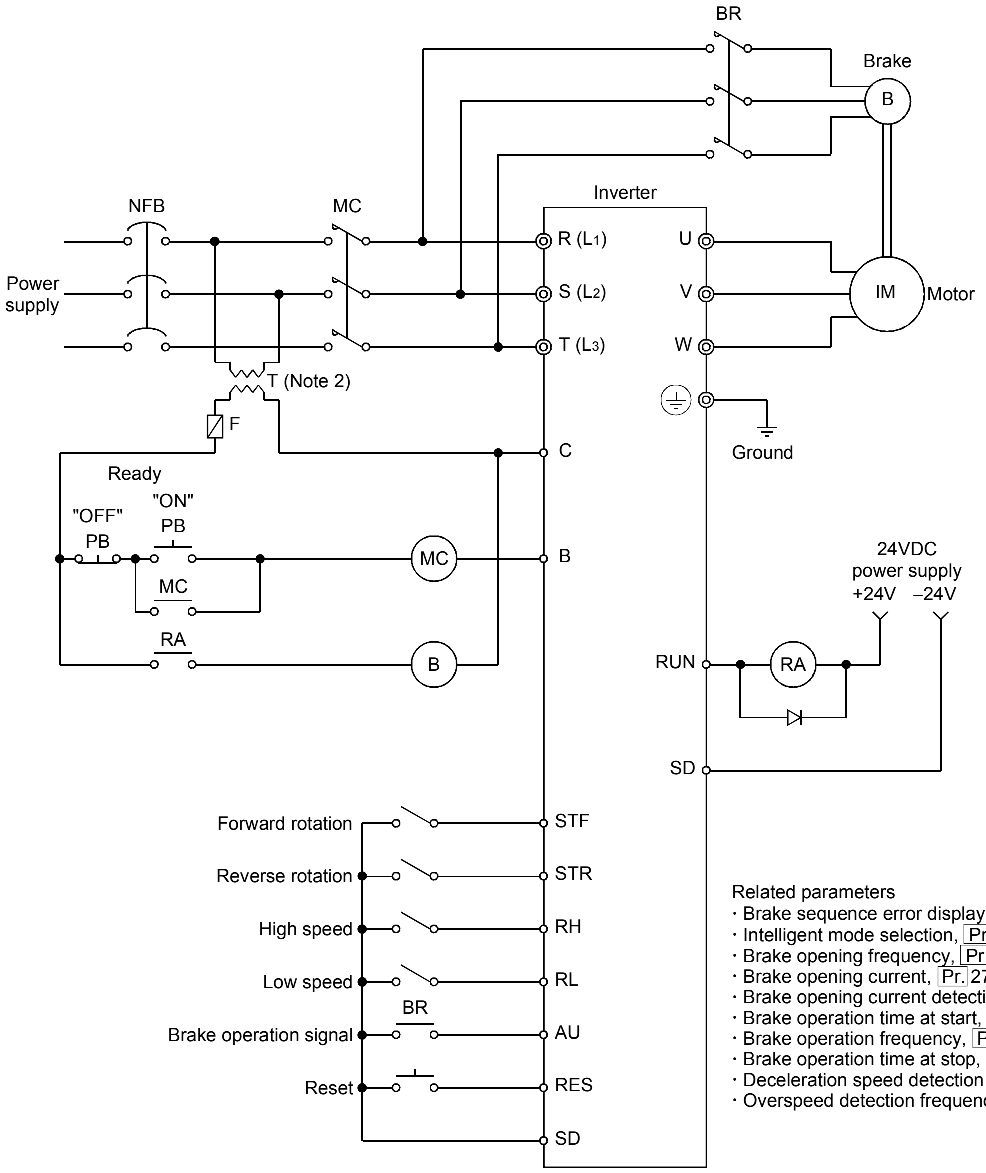
3.10 Vertical Winding, Lifter (A500)

3.10.1 Use of relay output option (A500)



Note:
1. The brake is opened after terminal MRS is turned off by the start signal and the FU signal is then output from the inverter. At a stop, the brake is designed to be closed as soon as the motor has fully decelerated (FU signal).
2. Connect terminals B-C to the brake circuit to always close the brake when an inverter alarm occurs.
3. The brake should not be opened except when the inverter provides normal output (RUN signal is ON).
4. Install an emergency stop switch as provision against a failure. In case of an emergency, do not rely on the electric braking of the inverter but use the mechanical brake to stop the motor.
5. Check whether acceleration/deceleration is completed within the given time. If not, judge that the inverter is faulty and close the brake.
6. The FR-A500 series 7.5K or less has a built-in brake resistor, but the above diagram shows a case where an external brake is required.
7. Provide a control transformer when the power supply is 400V class.
8. It is recommended to install a magnetic contactor in the primary side to prevent the brake discharge resistor from overheat/burnout if the regenerative brake transistor is damaged due to the thermal capacity shortage of the discharge resistor, an excessive regenerative brake duty etc.

3.10.2 Use of brake sequence circuit function A500 A500



Related parameters
- · Brake sequence error display erase, Pr. 30
- · Intelligent mode selection, Pr. 60
- · Brake opening frequency, Pr. 278
- · Brake opening current, Pr. 279
- · Brake opening current detection time, Pr. 280
- · Brake operation time at start, Pr. 281
- · Brake operation frequency, Pr. 282
- · Brake operation time at stop, Pr. 283
- · Deceleration speed detection function selection, Pr. 284
- · Overspeed detection frequency, Pr. 286

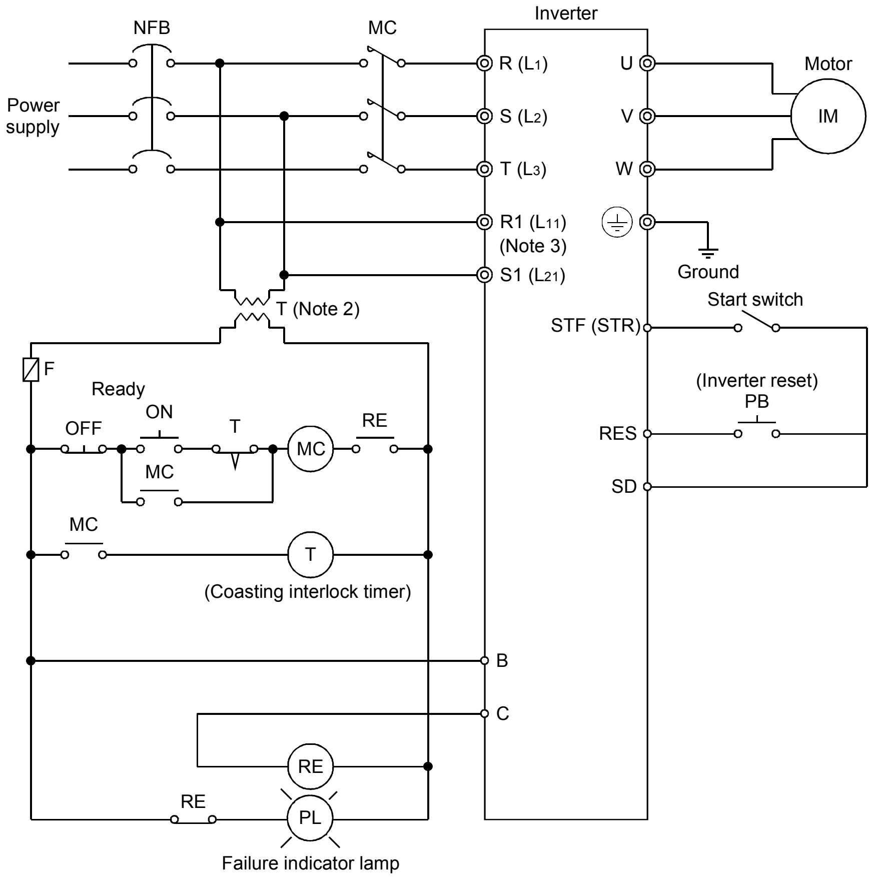
- At start: When the start signal is input to the inverter, the output is provided at the starting frequency, and when the given frequency (Pr. 278) is reached, the brake opening signal (RUN) is output. When the given time (Pr. 281) has elapsed after the brake operation completion signal (AU or STOP) has been input, the output frequency is raised to the preset speed.
- At stop: When the speed is reduced to the given frequency (Pr. 282), the brake opening signal (RUN) is turned off. When the given time (Pr. 283) has elapsed after the brake operation signal (AU or STOP) has been turned off, the inverter output is switched off.

Note: 1. When the motor equipped with a brake is run at or less than 30Hz continuously, the brake disc may rattle but the motor may be used without any problem if it is run at low speed for a short period, e.g. in orientation. Also, as there is a limit to the braking capacity, run the motor at no more than 60Hz.

2. Provide a control transformer when the power supply is 400V class.

3.11 Inverter Alarm Output Display and Failure Reset (A500)

When the overcurrent, overvoltage, instantaneous power failure or another protective function is activated, the inverter outputs the corresponding alarm signal. A relay contact is used to output the alarm signal and is actuated (turned on) when an alarm occurs. This relay can be deactuated by using the reset terminal (RES) of the inverter. It may also be reset by switching off the inverter power. For details, refer to Section 1.4.12. When the FR-A500 series 7.5K or less is used for cyclic or heavy duty operation, it is recommended to install a magnetic contactor in the primary side to prevent the brake discharge resistor from overheat/burnout if the regenerative brake transistor is damaged due to the thermal capacity shortage of the discharge resistor, an excessive regenerative brake duty etc.

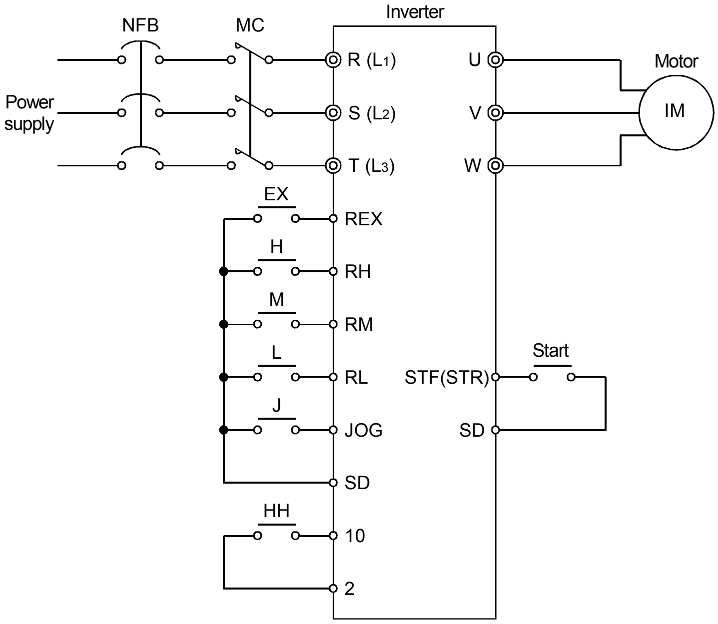


Note: 1. Set "1" "reset enabled only when protective function is activated" in Pr. 75 to disable resetting the inverter during normal operation. (If the inverter is reset during normal operation, the motor coasts to a stop. This setting is made to prevent the inverter from resulting in an alarm if the motor is still coasting when the inverter has returned from the reset status.)
Do not press the inverter reset pushbutton unless required. It is recommended to provide the failure reset pushbutton of the external device and the inverter reset pushbutton individually.

2. Provide a control transformer when the power supply is 400V class.
3. Indicates a case where an alarm indication is held for the (A500).
In this case, always remove the links or cables from across terminals R-R1 (L_1-L_{11}) and across S-S1 (L_2-L_{21}).

3.12 Multi-Speed Operation Application Example (COMMON)

The FR-A500 series allows 15-speed operation. The following application gives an example of operation performed at these speeds.

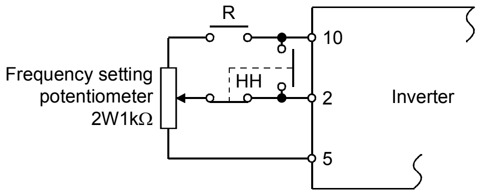


(1) (A500) (Maximum. 18-speed operation possible), (E500) (maximum. 17-speed operation possible)

Speed	Relay Contacts						Setting
	J	HH	EX	H	M	L	
Lowest speed	OFF	OFF	OFF	OFF	OFF	OFF	Pr. 2
JOG	ON	—	—	—	—	—	Pr. 15, Pr. 16
Speed 3 (low speed)	OFF	—	OFF	OFF	OFF	ON	Pr. 6
Speed 2 (middle speed)	OFF	—	OFF	OFF	ON	OFF	Pr. 5
Speed 1 (high speed)	OFF	—	OFF	ON	OFF	OFF	Pr. 4
Speed 4	OFF	—	OFF	OFF	ON	ON	Pr. 24
Speed 5	OFF	—	OFF	ON	OFF	ON	Pr. 25
Speed 6	OFF	—	OFF	ON	ON	OFF	Pr. 26
Speed 7	OFF	—	OFF	ON	ON	ON	Pr. 27
Speed 8	OFF	—	ON	OFF	OFF	OFF	Pr. 232
Speed 9	OFF	—	ON	OFF	OFF	ON	Pr. 233
Speed 10	OFF	—	ON	OFF	ON	OFF	Pr. 234
Speed 11	OFF	—	ON	OFF	ON	ON	Pr. 235
Speed 12	OFF	—	ON	ON	OFF	OFF	Pr. 236
Speed 13	OFF	—	ON	ON	OFF	ON	Pr. 237
Speed 14	OFF	—	ON	ON	ON	OFF	Pr. 238
Speed 15	OFF	—	ON	ON	ON	ON	Pr. 239
Highest speed	OFF	ON	OFF	OFF	OFF	OFF	Pr. 1, Pr. 903

Note: For the (E500), jog operation cannot be performed in the external operation mode. (It has no jog signal.)

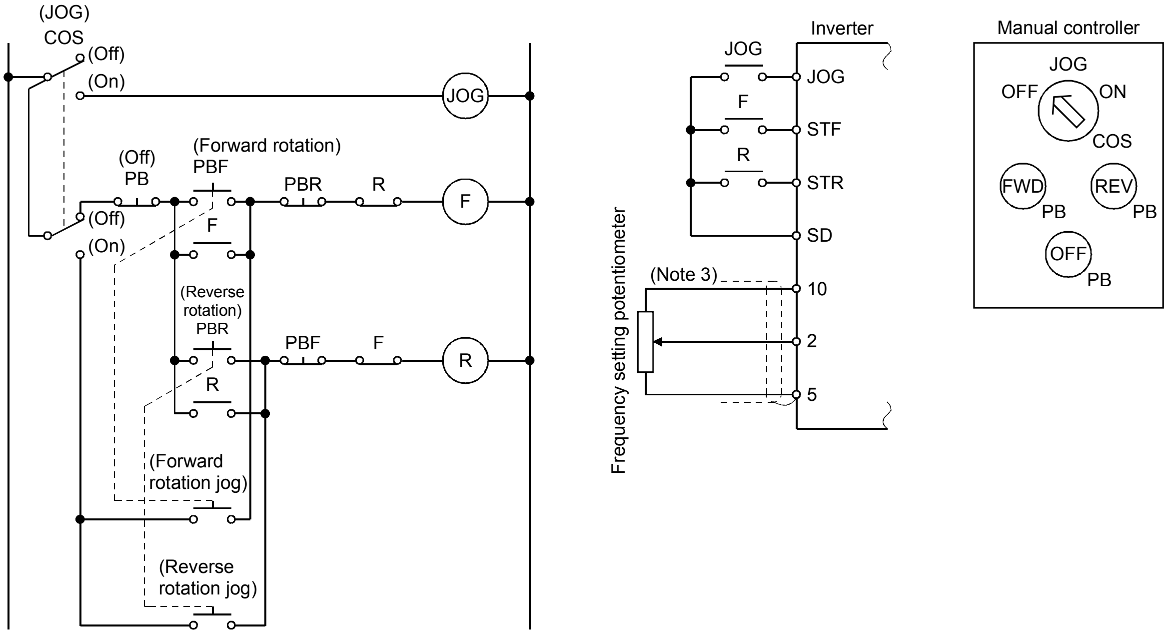
(2) To add an external potentiometer to further increase the number of speeds (COMMON)



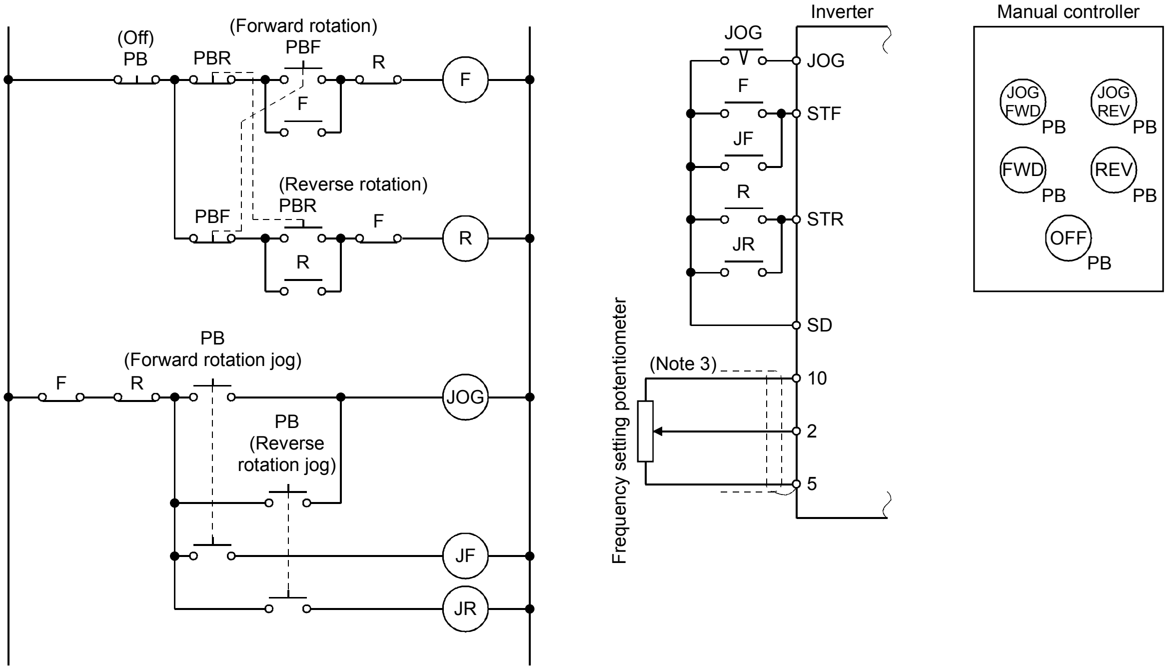
Note: When the relay R turns on, operation is performed at the frequency set by the frequency setting potentiometer (external potentiometer). In this case, the relays J, HH, EX, H, M and L should all be off.

3.13 Jog Operation in External Operation Mode (A500)

Part 1 [With jog mode selection switch]



Part 2 [With jog-dedicated pushbutton]



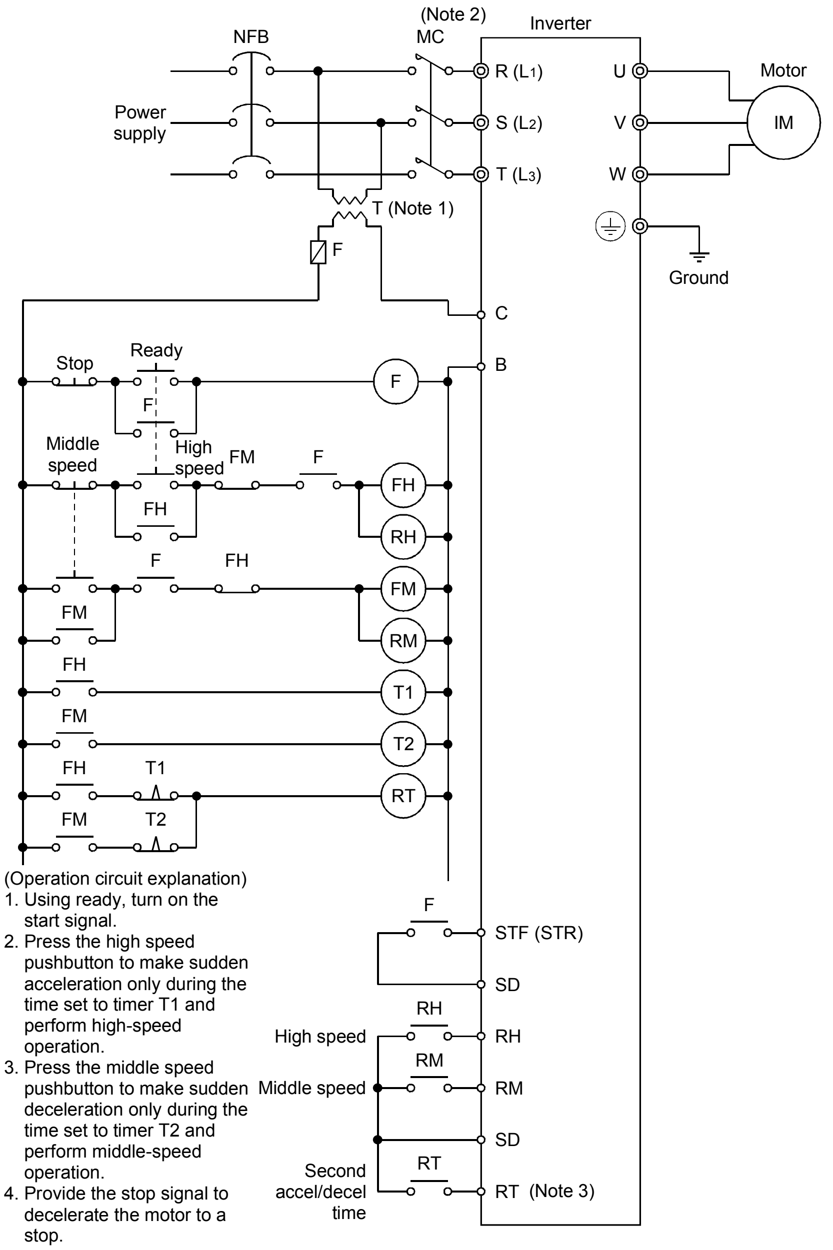
Note: 1. Jog speed setting, Pr. 15 (jog frequency).

2. Acceleration/deceleration time for jog operation, Pr. 16 (jog acceleration/deceleration time).

3. Potentiometer for constant-speed operation.

3.14 Operation Using the Second Acceleration/Deceleration Time COMMON

PRACTICAL CIRCUITS



(Operation circuit explanation)

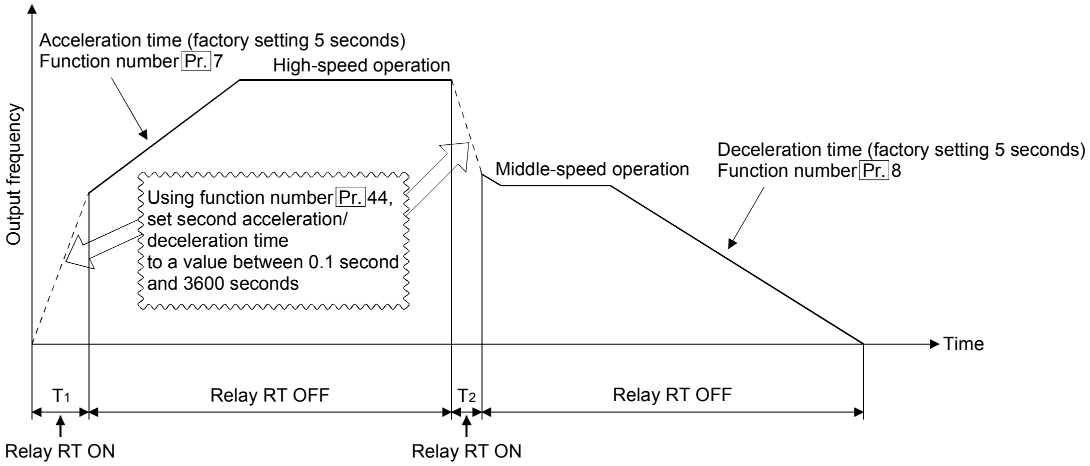
1. Using ready, turn on the start signal.
2. Press the high speed pushbutton to make sudden acceleration only during the time set to timer T1 and perform high-speed operation.
3. Press the middle speed pushbutton to make sudden deceleration only during the time set to timer T2 and perform middle-speed operation.
4. Provide the stop signal to decelerate the motor to a stop.

Note:1. Provide a control transformer when the power supply is 400V class.

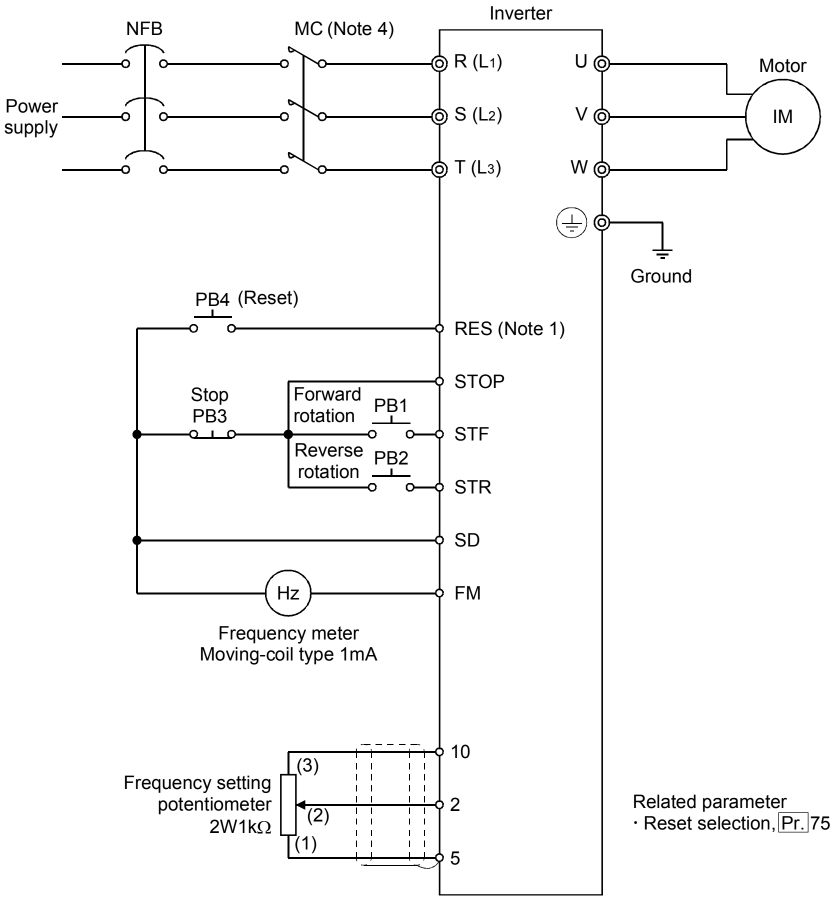
2. When the FR-A500 series 7.5K or less is used for cyclic or heavy duty operation, it is recommended to install a magnetic contactor in the primary side to prevent the brake discharge resistor from overheat/burnout if the regenerative brake transistor is damaged due to the thermal capacity shortage of the discharge resistor, an excessive regenerative brake duty etc.

3. Turning on-off the signal across terminals RT-SD changes the selected base frequency and torque boost, in addition to acceleration and deceleration, as listed below:

Function Name	Parameters Selected by Terminals RT-SD	
	OFF	ON
Acceleration time	Pr. 7	Pr. 44
Deceleration time	Pr. 8	Pr. 45
Manual torque boost	Pr. 0	Pr. 46
Base frequency	Pr. 3	Pr. 47

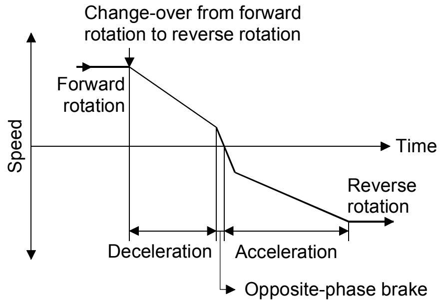


3.15 Start Signal (Three-Wire) Holding COMMON



Note: 1. Set "1" "reset enabled only when protective function is activated" in Pr. 75 to disable resetting the inverter during normal operation. (If the inverter is reset during normal operation, the motor coasts to a stop. This setting is made to prevent the inverter from resulting in an alarm if the motor is still coasting when the inverter has returned from the reset status.)

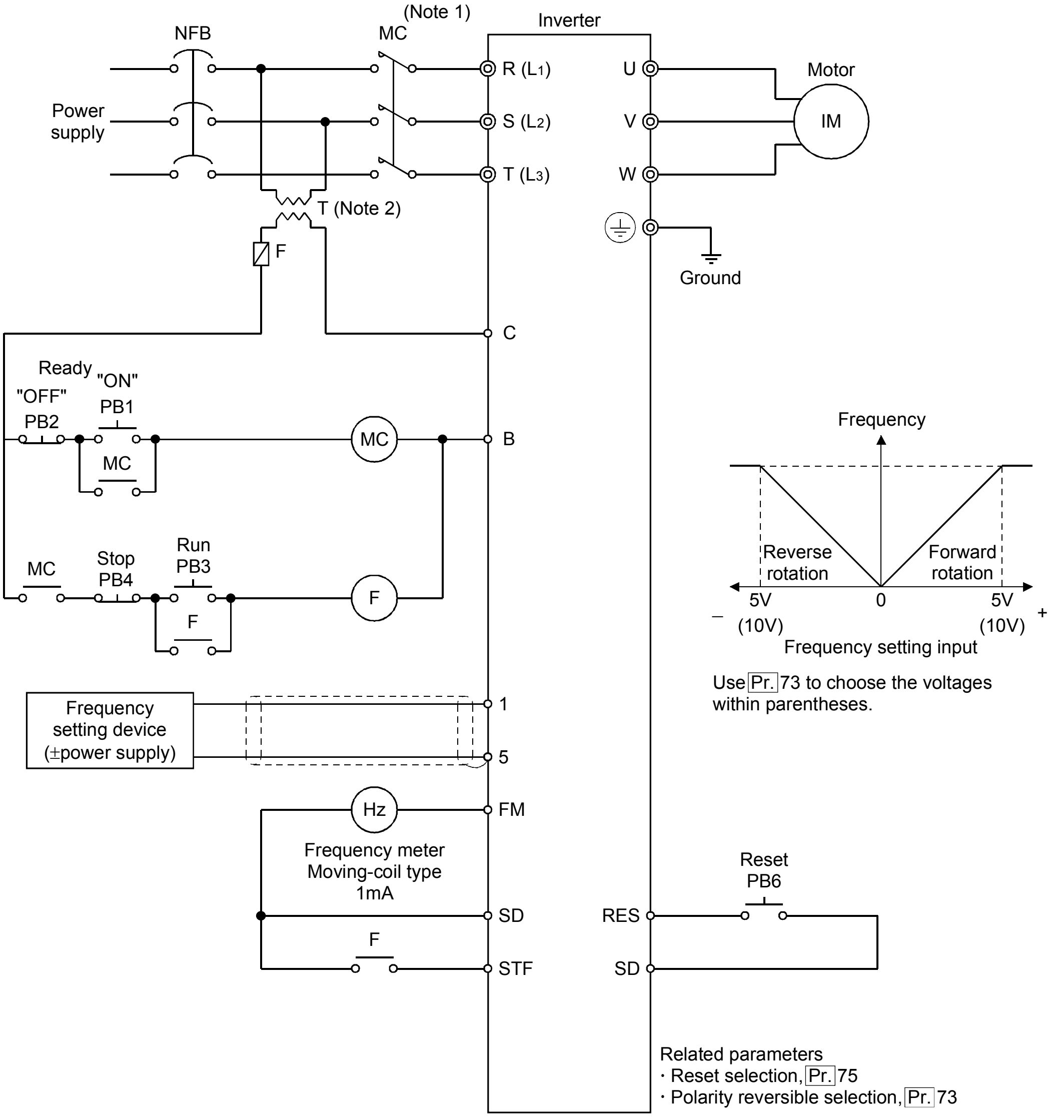
2. The inverter will stop when both terminals STF and STR are closed simultaneously.
3. During operation, switch-over from "forward rotation" to "reverse rotation" may be made. In this case, when the reverse rotation signal is turned on, the regenerative brake is applied down to the forward rotation frequency of 0.5Hz, the opposite-phase brake is applied at or less than the starting frequency and acceleration in reverse rotation is started at that frequency. (DC dynamic brake is not applied.)



4. When the FR-A500 series 7.5K or less is used for cyclic or heavy duty operation, it is recommended to install a magnetic contactor in the primary side to prevent the brake discharge resistor from overheat/burnout if the regenerative brake transistor is damaged due to the thermal capacity shortage of the discharge resistor, an excessive regenerative brake duty etc.

3.16 Reversible Operation by Analog Input (A500)

By changing the polarity of the analog input signal to terminal 1 between positive and negative, reversible operation can be performed between forward rotation and reverse rotation.



Use Pr. 73 to choose the voltages within parentheses.

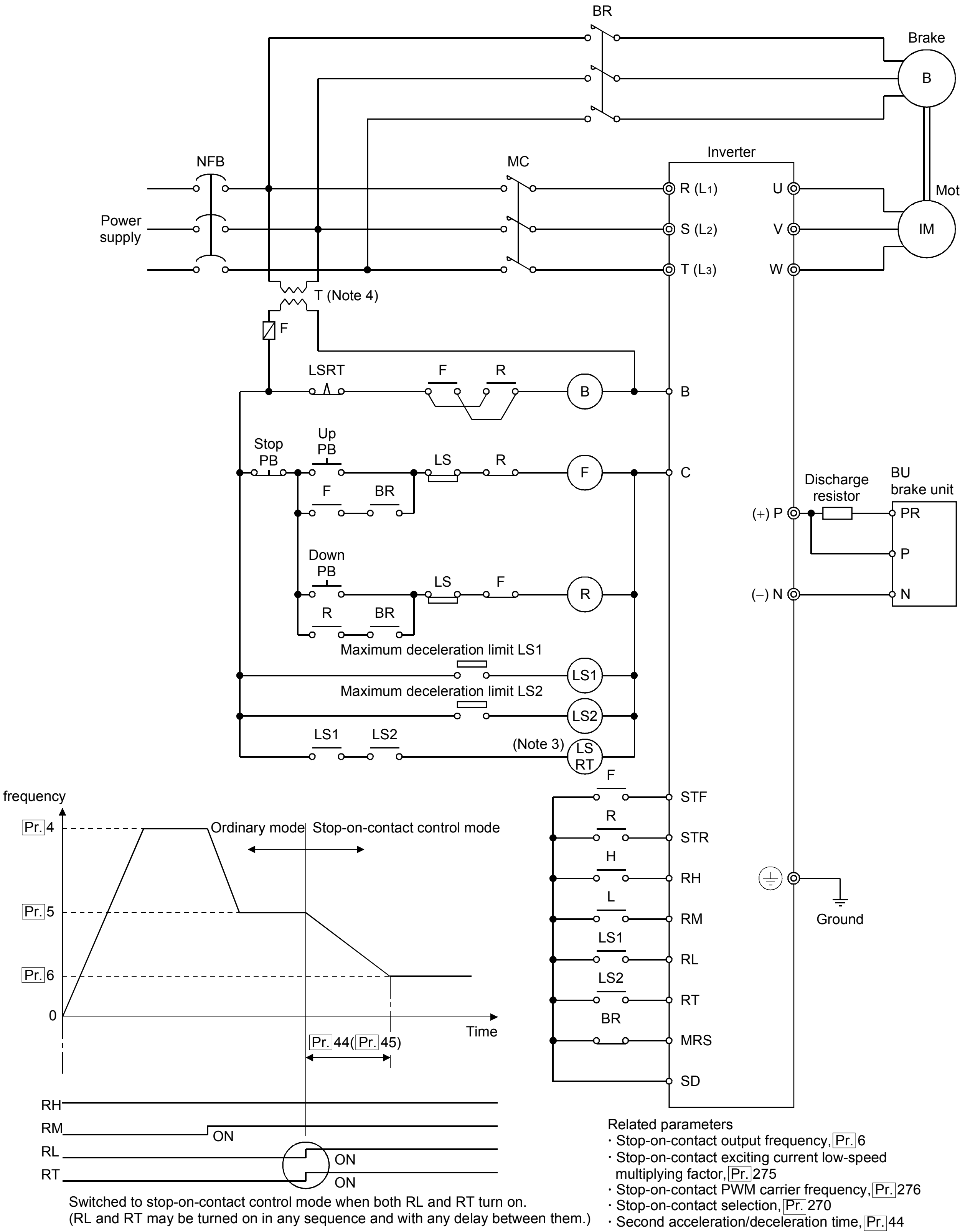
Related parameters
· Reset selection, Pr. 75
· Polarity reversible selection, Pr. 73

Note: 1. This magnetic contactor is provided to prevent an automatic restart when power is restored after a power failure. Use the start signal (ON-OFF across terminals STF, STR-SD) to make a start and stop.

2. Provide a control transformer when the power supply is 400V class.

3. Set "1" "reset enabled only when protective function is activated" in Pr. 75 to disable resetting the inverter during normal operation. (If the inverter is reset during normal operation, the motor coasts to a stop. This setting is made to prevent the inverter from resulting in an alarm if the motor is still coasting when the inverter has returned from the reset status.)

3.17 Operation using Stop-on-Contact Control Function (A500)



Switched to stop-on-contact control mode when both RL and RT turn on.
(RL and RT may be turned on in any sequence and with any delay between them.)

Related parameters
- Stop-on-contact output frequency, Pr.6
- Stop-on-contact exciting current low-speed multiplying factor, Pr.275
- Stop-on-contact PWM carrier frequency, Pr.276
- Stop-on-contact selection, Pr.270
- Second acceleration/deceleration time, Pr.44
- Second deceleration time, Pr.45

Note: 1. If the setting of the stop-on-contact exciting current low-speed multiplying factor is too large, an overcurrent (OCT) alarm is liable to occur.
2. If the setting of the exciting current low-speed multiplying factor is too large, the machine may oscillate in the stop-on-contact status.
3. Unlike the servo lock function, the stop-on-contact function cannot hold the load for a long time. Stop-on-contact operation continued for long time can cause the motor to overheat. Immediately after a stop, therefore, use the mechanical brake to hold the load.
4. Provide a control transformer when the power supply is 400V class.

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