MITSUBISHI ELECTRIC

Changes for the Better

FATEC

INVERTER SCHOOL TEXT

INVERTER TROUBLE SHOOTING COURSE (FR-A800)

● SAFETY PRECAUTIONS ●

(Read these precautions before using this product.)

When designing a system, always read the relevant manuals and give due consideration to safety.
In addition, pay careful attention to the following points for proper handling during training.

[Precautions during training]

⚠WARNING

- To prevent electric shock, do not touch the terminal block while the power is supplied.
- Before opening the safety cover, turn OFF the power, or check that it is sufficiently safe.
- Do not touch moving parts.

⚠CAUTION

- Follow the instructor's directions during training.
- Do not remove the units of a demonstration machine or change the wiring without permission. Doing so may cause a failure, malfunction, injury and/or fire.
- If the demonstration machine emits an abnormal odor or sound, stop it by operating the Power supply MCCB switch or Emergency stop button.
- If any trouble occurs, notify the instructor immediately.

<Notes on descriptions in this school text>

- Connection diagrams in this school text appear with the control logic of the input terminals as the sink logic, unless otherwise specified.

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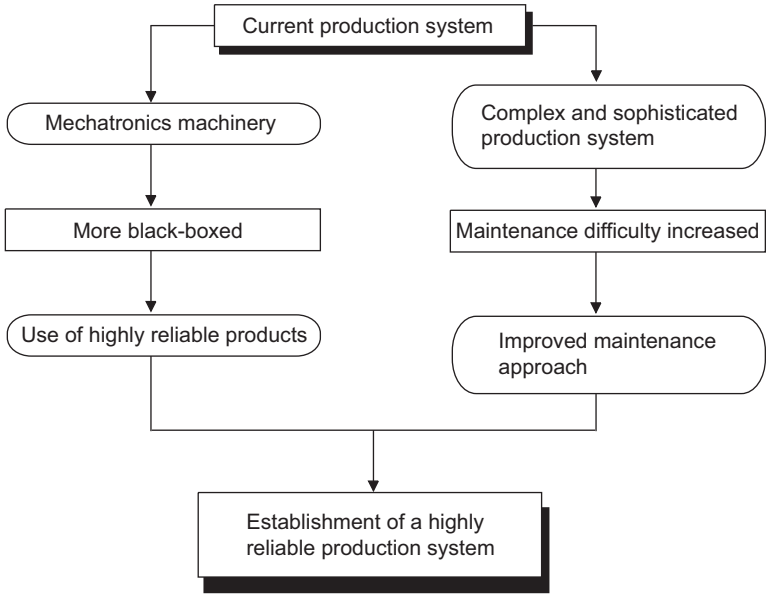
CHAPTER 1 IMPORTANCE OF PRODUCTIVE MAINTENANCE

When a production system stops due to a failure or power failure, downtime causes a loss proportional to the duration of the downtime.
Therefore, it is necessary to design a system that is not stopped by a failure or power failure.
In case the production system stops, quick recovery is an important issue. To improve the operating rate of the production system, each factory must have a team of maintenance personnel.

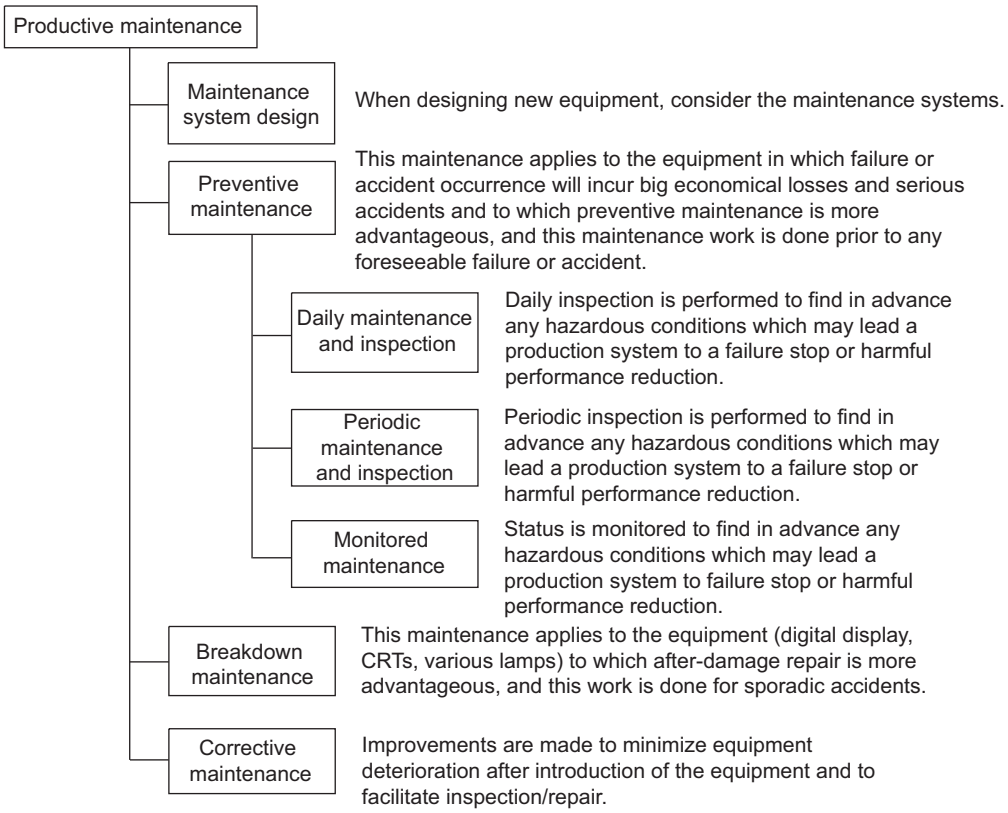
1.1 Importance of maintenance

With remarkable progress of mechatronics machinery and more complexity and sophistication, recent production systems have become more black-boxed with increasing difficulty in maintenance, making it difficult to improve the operating rate.
Therefore, highly reliable products and improved maintenance approach are strongly demanded.



1.2 Maintenance system

To establish a highly reliable production system, it is important to a well-organized maintenance system.
The following chart outlines a maintenance system.



1.3 Maintenance plan

Consider the maintenance for the production system after failures occur.
For the efficient maintenance, build a maintenance plan at the introduction of the production system.
In case of failure, perform the following maintenance systematically to repair the system in a short time.

Table 1.1 Inverter system maintenance plan

Category	Description	
Maintenance education	Knowledge about inverter	•Fundamental knowledge of inverter such as mechanism, function, performance, etc. •Characteristics of inverter •Position of inverter •Introduction status of inverter (usage condition in one's department) •Details of introduced (adopted) model (the model, function, performance, and characteristics of the inverter used)
	Maintenance range and maintenance technique	•Maintenance knowledge about inverter (maintenance characteristics and maintenance item of the inverter) •Precautions for inverter at maintenance (handling method, key points, and others)
	Training	•Functions related to inverter maintenance •Functions related to peripheral device maintenance (such as the troubleshooting function) •Practice of troubleshooting (peripheral device operation, hardware replacement, etc.)
Maintenance timing	Distinguish clearly between the preventive maintenance target and breakdown maintenance target, and determine the maintenance period.	
Maintenance tool	Prepare the spares, members, instruments, and measuring tools for the maintenance.	
Maintenance procedure	Prepare manuals and define the maintenance methods and details.	
Maintenance personnel	Secure personnel and determine the positions and tasks.	
Improvement of maintenance method	Examine improvement of maintenance methods.	
Understanding of customer service/support system of the inverter manufacturer	After-sales service	•Service station (location, contact information, persons in charge, etc.) •Service range (applicable models, handling range, etc.) •Service time (start/end time, time required for arrival, emergency service, etc.) •Service period (warranty period, support service on commercial basis, etc.) •Service parts supply period (such as repair after production stop, supply period) •Actions for production stop (such as stop declaration, repair period) •Period for repair (such as standard, shortest and longest delivery times)
	Technical support	•Support station (location, contact information, persons in charge, etc.) •Support range (applicable models, hardware/software, and system) •Support method (telephone, FAX, visit, teaching, and machine operation) •Manual (effective manual for maintenance)

1.4 Management of maintenance document

To repair a failure in a short time, the documents as listed below must be arranged and managed.

Table 1.2 Management of maintenance document

Category	Name	Description
System-specific documents	System/control specification	The functions and operations of the corresponding system/control are described. (Operation sequence/timing, operational conditions, and operation procedure)
	Electric wiring diagrams	Schematic diagrams (Power supply circuit, motor circuit, control circuit, operation circuit, display circuit, and others) Inter-device/inter-board connection diagrams (Cabling diagram and earthing (grounding) cable diagram)
	Equipment layout diagrams	In-panel electrical equipment layout diagram, terminal block wire number layout diagram, and connector pin connection assignment table (Diagrams which identify various instrument models name, wire numbers, and others)
	List of the used hardware	List of electrical equipment used in a system (Model names and specifications of all electrical equipment such as modules which comprise inverter system, peripheral devices, electrical parts in enclosure, I/O devices, software packages, and others)
	Instruction manual of the control target and Maintenance inspection manual	For handling (operating) the control target and maintenance/ inspection
General documents	Catalog of the used hardware	Provide model configurations, manufacturers, and others
	Instruction manual and technical information of the used hardware	For troubleshooting of hardware and software

1.5 Maintenance record

After repairing, the maintenance record below must be managed to refer to a maintenance.

Table 1.3 Maintenance record to manage

Record item	Description
Status of errors and failures	Status of apparatus/equipment name, phenomenon, and circumstances
Stop period of the system	Occurrence time and stop period
Effect of the accident	Effect of amount of loss, loss time, and influence
Cause	Method to find cause and cause including estimation
Repair method	Method of replacement, repair, and others
Recurrence prevention	Recurrence prevention method of similar failure and lessons
Failure record	Record of cause, measure, and others
Person in charge	

1.6 Failure stage

Generally, complicated system failure is categorized into three stages, initial failure, random failure, and wear-out failure as shown in Fig. 1.1. Initial failures are considered to be removed in manufacturing and inspection processes by a manufacturer. Because random failures are unforeseen and occur suddenly at any time within the useful life of equipment before it is worn, it is difficult to take the technical measure. At present, the measure only based on the statistical treatment can be taken.

Wear-out failures occur at nearly the end of useful life in the course of deterioration or as a result of wear, and increase suddenly as time proceeds. At Point tb in Fig. 1.1 which means the replacement years, preventive maintenance will be made proper by changing specific parts for new ones.

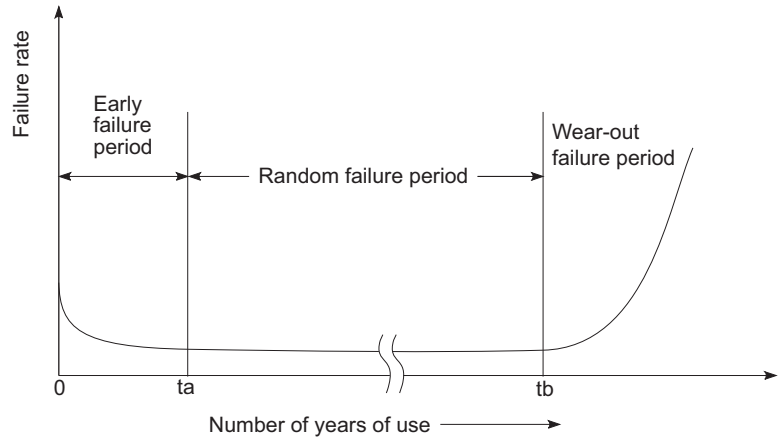


Fig. 1.1 Bath-tub curve

CHAPTER 2 UNDERSTANDING INVERTER SYSTEM

2.1 Demonstration machine configuration

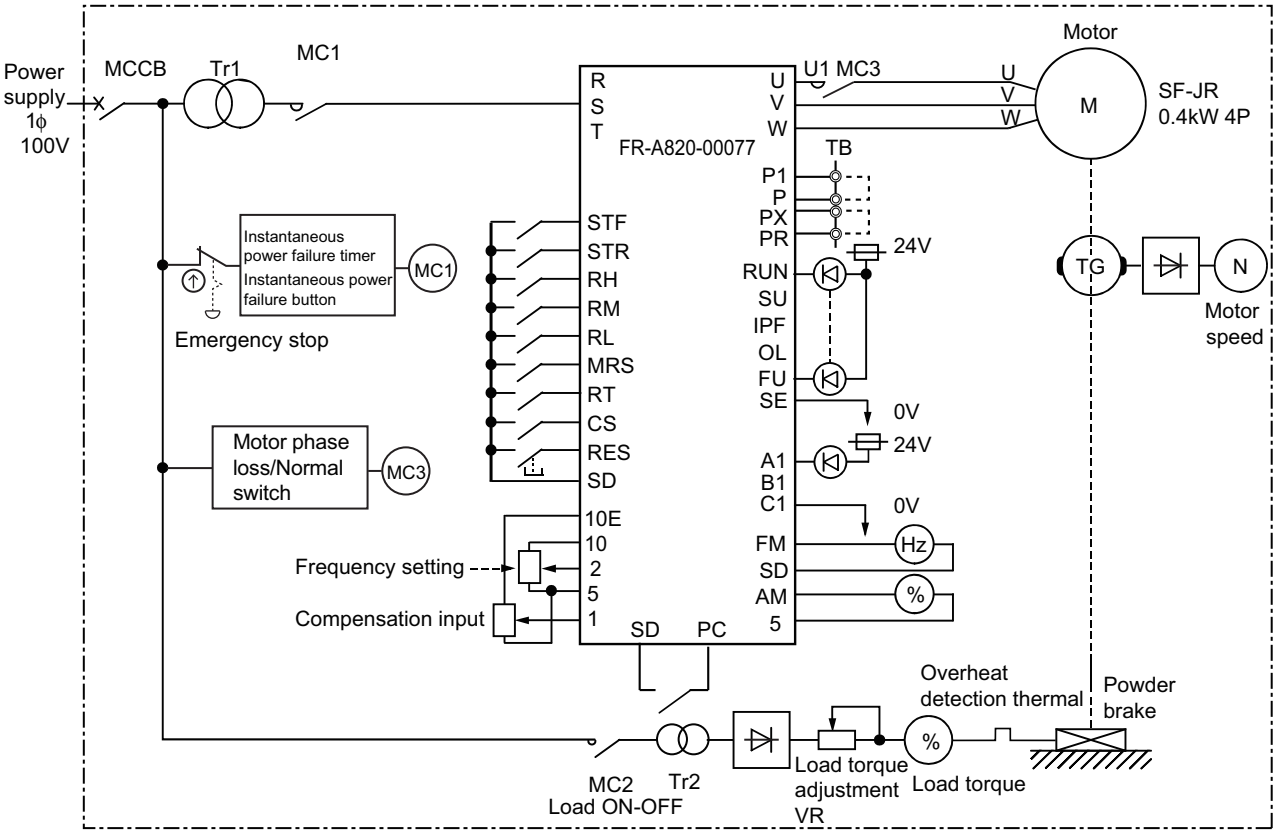


Fig. 2.1 Elementary wiring diagram of inverter demonstration machine

2.2 Appearance and item name of demonstration machine

The following figure shows the configuration of the inverter demonstration machine.

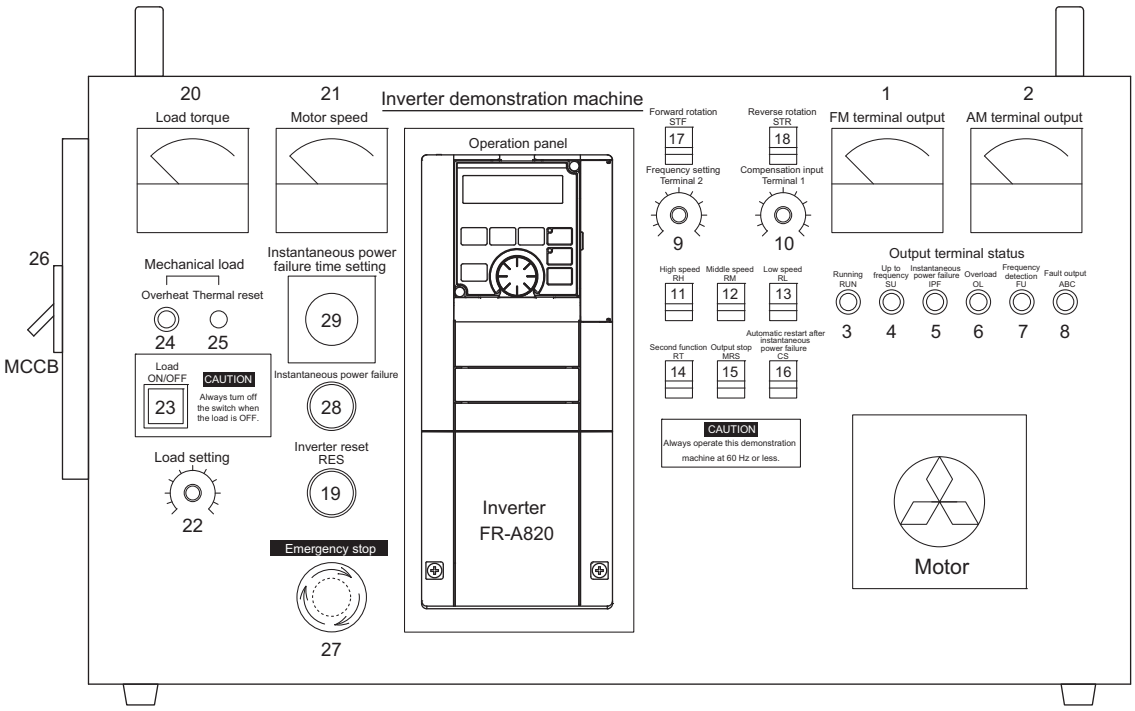


Fig. 2.2 Appearance of the inverter demonstration machine

1) FM terminal output ..... Displays the output frequency (pulse output) from the inverter.
2) AM terminal output ..... Displays the output frequency (analog output) from the inverter.
3) Running RUN ..... Turns ON when the output frequency is equal to or higher than the starting frequency, indicating that the inverter is in operation.
4) Up to frequency SU ..... Turns ON when the output frequency enters in the range of ±10% of the set frequency, indicating that the frequency is reached.
5) Instantaneous power failure IPF ..... Turns ON when the instantaneous power failure or under voltage protective function is activated, indicating that an instantaneous power failure has occurred.
6) Overload OL..... Turns ON when the stall prevention operation function is activated, indicating overload warning.
7) Frequency detection FU... Turns ON when the output frequency is equal to or higher than the set detection frequency, indicating frequency detection.
8) Fault output ABC..... Turns ON when the protective function of the inverter is activated and the output is stopped.
9) Frequency setting terminal 2..... Outputs the set frequency with analog voltage.
10) Compensation input terminal 1 ..... Outputs extra voltage to be added to the analog voltage of the frequency setting.

11) High speed RH…… Selects "High speed" from the multi-speed setting. Note that up to seven different speeds can be selected with a combination of "Middle speed" and "Low speed".

12) Middle speed RM…… Selects "Middle speed" from the multi-speed setting. Note that up to seven different speeds can be selected with a combination of "High speed" and "Low speed".

13) Low speed RL …… Selects "Low speed" from the multi-speed setting. Note that up to seven different speeds can be selected with a combination of "High speed" and "Middle speed".

14) Second acceleration/ deceleration RT …… Selects the second acceleration/deceleration time.

15) Output stop MRS …… Stops the inverter output.

16) Selection of automatic restart after instantaneous power failure CS …… When the CS signal is selected, the inverter restarts automatically at power restoration. (The parameter setting is required for the automatic restart after instantaneous power failure.)

17) Forward STF …… Forward rotation start signal

18) Reverse STR …… Reverse rotation start signal

19) Inverter reset RES …… Resets the fault output when the protective function is activated.

20) Load torque …… Indicates the load torque applied to the motor.

21) Motor speed …… Indicates the motor rotation speed.

22) Load setting …… Sets the load applied to the motor.

23) Load ON/OFF …… Turns ON or OFF the load applied to the motor.

24) Overheat …… Turns ON when the mechanical load applied to the motor (powder brake) is overheated.

25) Thermal reset …… Resets the thermal sensor when the mechanical load applied to the motor (powder brake) is overheated.

26) Power supply MCCB … Molded case circuit breaker for powering ON the demonstration machine.

27) Emergency stop …… Shuts OFF the power in case of emergency.

28) Instantaneous power failure…… Shuts OFF the power supply for the inverter.

29) Instantaneous power failure time setting …… Sets the instantaneous power failure time of when the instantaneous power failure button is pressed.

2.3 Precautions for use

(1) Set **the maximum frequency to 60 Hz.**

(2) Set **the acceleration/deceleration time to one second or longer.**

Technically, frequency can be set to a value higher than 60 Hz and acceleration time can be set to a value shorter than one second. However, setting those values may damage the machine due to the use of the powder brake, tachogenerator (TG), and timing belt.

(3) **Do not leave the demonstration machine for a long time with the Load ON/OFF switch set to ON and the Load setting VR high.**

2.4 Operation method

2.4.1 Types of operation methods

The inverter can be operated with various signals. This section explains the operations (start, stop, and speed variation) that can be operated with the inverter demonstration machine.

(1) External operation using external signals (D000 (Pr.79) = "0, 2")
Operate an inverter with a frequency setting potentiometer or start switch connected to the control circuit terminals of the inverter.

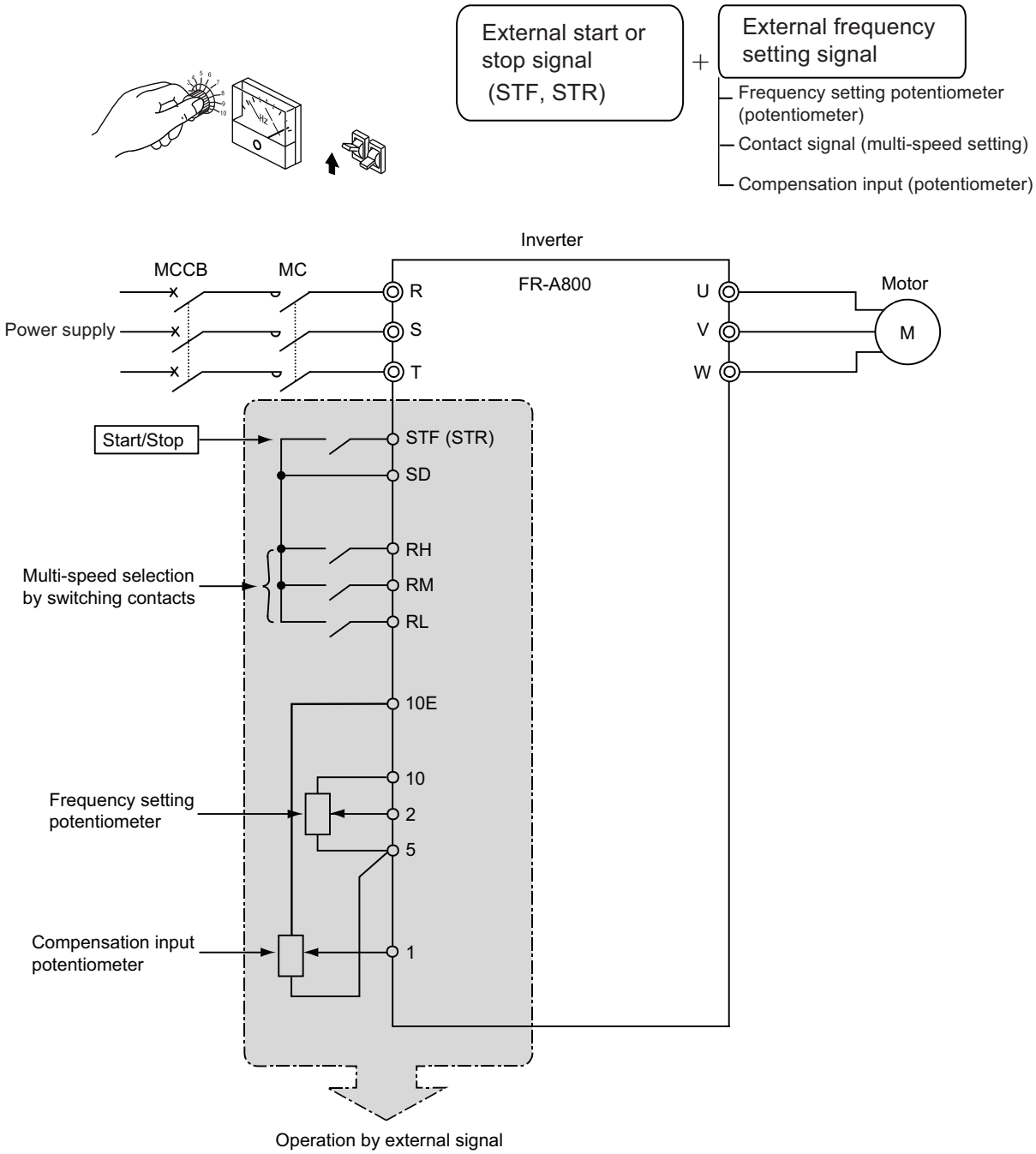


Fig. 2.3 External operation method

(2) PU operation using the operation panel or parameter unit (D000 (Pr.79) = "0, 1")

This operation is performed only with the keys of the operation panel or parameter unit.

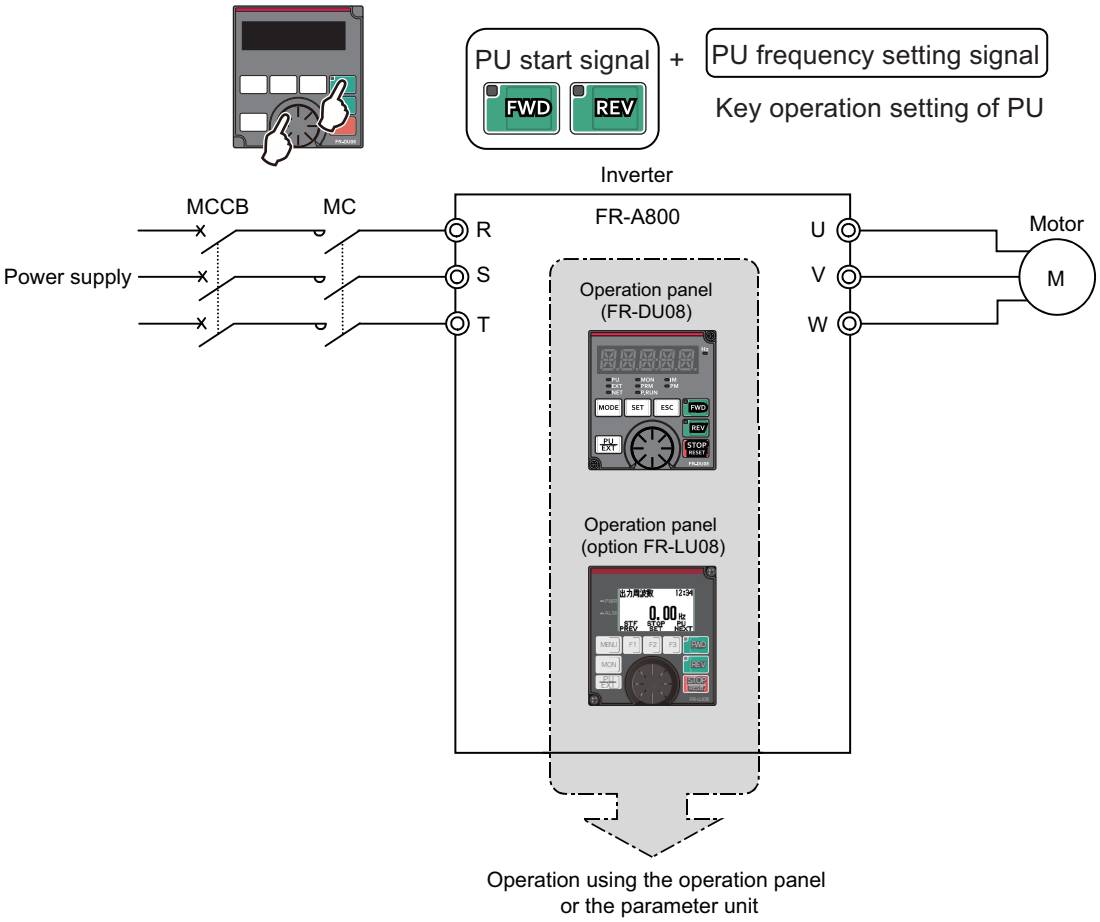


Fig. 2.4 PU operation method

(3) PU/External combined operation (D000 (Pr.79) = "3 or 4")

When D000 (Pr.79) is set to "3", set frequency using the operation panel or parameter unit, and input a start command using external start switches.

When D000 (Pr.79) is set to "4", set frequency using an external potentiometer or multi-speed setting, and input the start command using the keys of the operation panel or parameter unit.

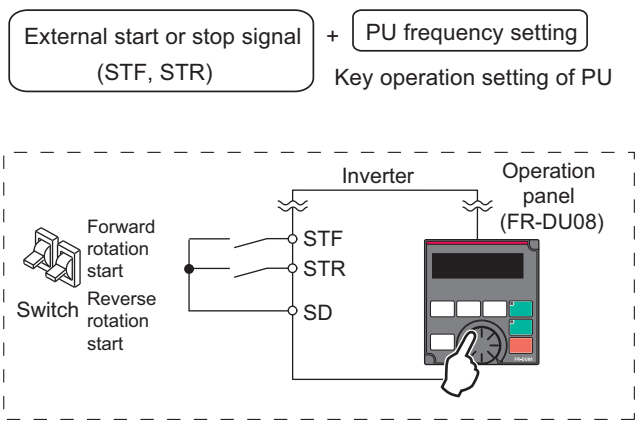


Fig. 2.5 PU/External combined operation (When D000 (Pr.79) = "3")

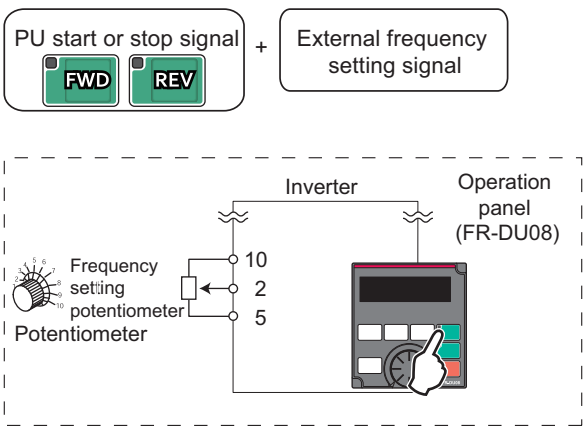
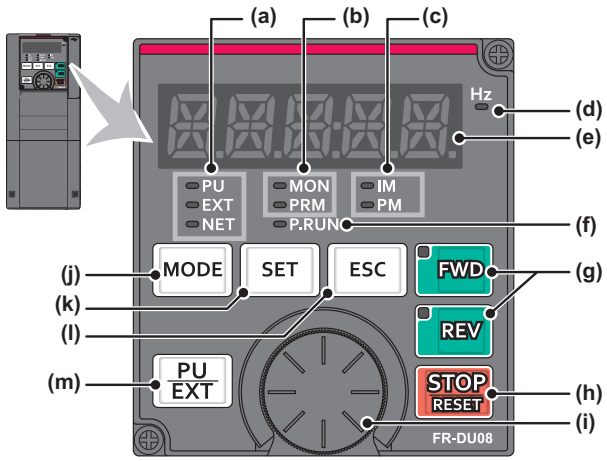


Fig. 2.6 PU/External combined operation (When D000 (Pr.79) = "4")

2.5 How to use the operation panel FR-DU08

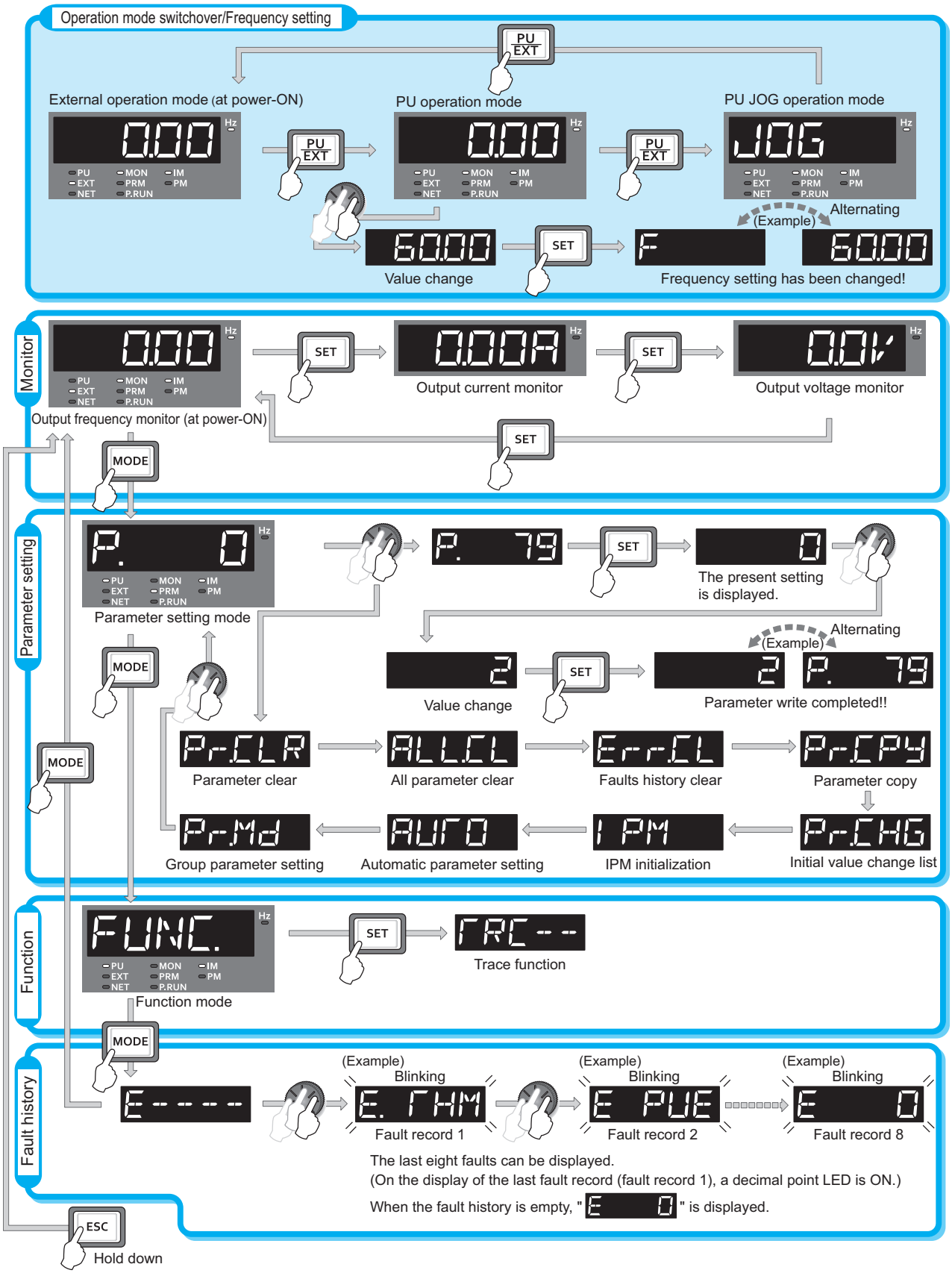
2.5.1 Component names of the operation panel (FR-DU08)



No.	Component	Name	Description
(a)	PU EXT NET	Operation mode indicator	PU: ON to indicate the PU operation mode. EXT: ON to indicate the External operation mode. (ON at power-ON in the initial setting.) NET: ON to indicate the Network operation mode. PU and EXT: ON to indicate the External/PU combined operation mode 1 and 2.
(b)	MON PRM	Operation panel mode LED indicator	MON: ON when the operation panel is in the monitor mode. Quickly blinks twice intermittently while the protective function is activated. Slowly blinks when the display-off function of the operation panel is valid. PRM: ON when the operation panel is in the parameter setting mode.
(c)	IM PM	Control motor indicator	IM: ON when the inverter is set to the induction motor control. PM: ON when the inverter is set to the PM sensorless vector control. The indicator blinks when test operation is selected.
(d)	Hz	Frequency unit indicator	ON when the actual frequency is monitored. (Blinks when the set frequency is displayed in the monitor.)
(e)	88.88.88	Monitor (5-digit LED)	Shows the frequency, parameter number, etc.
(f)	P.RUN	PLC function indicator	ON when the PLC function is activated.
(g)	FWD REV	FWD key, REV key	FWD key: Starts the forward rotation operation. The LED is ON during forward operation. REV key: Starts the reverse rotation operation. The LED is ON during reverse operation. The LEDs blink under the following conditions. • When the frequency command is not given even if the forward/reverse rotation command is given • When the frequency command is equal to the starting frequency or lower • When the MRS signal is being input
(h)	STOP RESET	STOP/RESET key	Used to stop operation commands. Used to reset the inverter when the protective function is activated.
(i)		Setting dial	The setting dial of the Mitsubishi inverters. Turn the setting dial to change the setting of frequency or parameter. Press the setting dial to perform the following operations: • To display a set frequency in the monitor mode • To display the present setting during calibration • To display a fault record number in the faults history mode.
(j)	MODE	MODE key	Switches the operation panel to a different mode. Switches to the easy setting mode by pressing simultaneously with PU/EXT.
(k)	SET	SET key	Used to confirm each selection. Switches the monitor screen during the operation. When the initial setting is set Output frequency → Output current → Output voltage
(l)	ESC	ESC key	Goes back to the previous display. Holding this key for a longer time changes the display back to the monitor mode.
(m)	PU/EXT	PU/EXT key	Switches between the PU operation mode and the External operation mode. Switches to the easy setting mode by pressing simultaneously with MODE. It also cancels the PU stop.

2.5.2 Basic operation of the operation panel

(1) Basic operation



(2) Parameter setting mode

In the parameter setting mode, inverter functions (parameters) are set.

The following table explains the indications in the parameter setting mode.

Operation panel display/ indicator	Function name	Description
P.	Parameter setting mode	Reads or changes the set value of the displayed parameter number.
Pr.CLR	Parameter clear	Clears and resets parameter settings to the initial values. Calibration parameters and offline auto tuning parameters are not cleared.
ALL.CL	All parameter clear	Clears and resets parameter settings to the initial values. Calibration parameters and offline auto tuning parameters are also cleared.
Err.CL	Fault history clear	Deletes the fault history.
Pr.CPY	Parameter copy	Copies the parameter settings saved in the inverter to the operation panel. The parameters copied to the operation panel can also be copied to other inverters.
Pr.CHG	Initial value change list	Identifies the parameters that have been changed from their initial values.
1 PM	IPM parameter initialization	Changes the parameters to the settings required to drive an IPM motor (MM-CF) in a batch. The parameter settings required to drive an IPM motor can be returned to parameter settings required to drive an induction motor.
AUTO	Automatic parameter setting	Changes parameter settings as a batch. The target parameters include communication parameters for the Mitsubishi Electric human machine interface (GOT) connection and the parameters for the rated frequency settings of 50 Hz/60 Hz.
Pr.Md	Group parameter setting	Displays parameter numbers by function groups.

(3) Digital characters and their corresponding printed equivalents

Digital characters displayed on the operation panel display are as follows.

0	1	2	3	4	5	6	7	8	9	A	B(b)	C	c	D(d)
0	1	2	3	4	5	6	7	8	9	A	b	C	c	d
E(e)	F(f)	G(g)	H	h	I(i)	J(j)	K(k)	L(l)	M(m)	N	n	O	o	P(p)
E	F	G	H	h	I	J	K	L	M	N	n	O	o	P
Q(q)	R	r	S(s)	T(t)	U	u	V	v	W	w	X(x)	Y(y)	Z(z)	
Q	R	r	S	T	U	u	V	v	W	w	X	Y	Z	

2.5.3 Parameter setting procedures (parameter display in numerical order)

This section explains how to change the setting value of Pr.1 Maximum frequency from "120 Hz" to "60 Hz".

Operation

1.	Turning ON the power of the inverter The operation panel is in the monitor mode.
2.	Changing the operation mode Press PU/EXT to choose the PU operation mode. The [PU] indicator turns ON.
3.	Parameter setting mode Press MODE to choose the parameter setting mode. (The parameter number read previously appears.)
4.	Selecting the parameter Turn the setting dial until "P. 1" (Pr.1) appears. Press SET to read the present set value. "120.00" (initial value) appears.
5.	Changing the setting value Turn the setting dial to change the setting value to "60.00". Press SET to enter the setting. "60.00" and "P. 1" are displayed alternately. • Turn the setting dial to read another parameter. • Press SET to display the setting again. • Press SET twice to display the next parameter. • Press MODE three times to return to the indication of the frequency.

☒ Good to know for checking an inverter

Press the setting dial () in the monitor mode when the PU operation mode or External/PU combined operation mode (Pr.79 Operation mode selection = "3") is selected to display the present set frequency.

2.5.4 Parameter display by function group

Parameter numbers can be displayed by function group.
Since the parameter numbers are grouped by function, related parameters can be set easily.

(1) Changing to parameter numbers grouped by function

Pr.MD setting	Description
0	Default parameter display
1	Parameter display in numerical order
2	Parameter display by function group

Operation

1. Turning ON the power of the inverter
   The operation panel is in the monitor mode.
2. Parameter setting mode
   Press MODE to choose the parameter setting mode. (The parameter number read previously appears.)
3. Selecting the parameter
   Turn the dial until "PrMd" (Group parameter setting) appears.
   Press SET to confirm the selection. The setting "0" (initial value) will appear.
4. Changing to the group parameter display
   Turn the dial to change the set value to "2" (group parameter display). Press SET to confirm the group parameter setting. "2" and "PrMd" are displayed alternately after the setting is completed.

(2) Changing the parameter setting value with group parameter display

The following explains how to change the setting value of H400 (Pr.1) Maximum frequency from "120 Hz" to "60 Hz".

Operation

1. Turning ON the power of the inverter
   The operation panel is in the monitor mode.
2. Changing the operation mode
   Press PU/EXT to choose the PU operation mode. The [PU] indicator turns ON.
3. Parameter setting mode
   Press MODE to choose the parameter setting mode. (The parameter number read previously appears.)
4. Selecting the parameter group
   Press ESC several times until "PAO . ." appears. The parameter group can be selected.
5. Selecting the parameter group
   Turn the dial until "PH4 . ." (Protective function parameter 4) appears. Press SET to confirm the selection. "PH4-- --" will appear, and the parameters in the function group of protective function parameter 4 can be selected.
6. Selecting the parameter
   Turn the dial until "PH400" (P.H400 Maximum frequency) appears. Press SET to read the present set value. "120.00" (initial value) appears.
7. Changing the setting value
   Turn the dial to change the set value to "60.00". Press SET to enter the setting. "60.00" and "PH400" are displayed alternately after the setting is completed.

2.5.5 Parameter clear / all parameter clear

Set Pr.CLR Parameter clear or ALL.CL All parameter clear to "1" to initialize parameters.
(Parameters cannot be cleared when E400 (Pr.77) Parameter write selection = "1".)

Operation

1. Turning ON the power of the inverter
   The operation panel is in the monitor mode.
2. Changing the operation mode
   Press PU/EXT to choose the PU operation mode. The [PU] indicator turns ON.
3. Parameter setting mode
   Press MODE to choose the parameter setting mode. (The parameter number read previously appears.)
4. Selecting the parameter
   Turn  to "Pr.CLR" for parameter clear or to "ALLCL" for all parameter clear, and press SET.
   "0" (initial value) appears.
5. Parameter clear
   Turn  to change the set value to "1". Press SET to enter the setting. "1" and "Pr.CLR" ("ALLCL") are displayed alternately after parameters are cleared.
   - Turn  to read another parameter.
   - Press SET to display the setting value again.
   - Press SET twice to display the next parameter.

Setting	Description	
	Pr.CLR Parameter clear	ALL.CL All parameter clear
0	Initial display (parameters are not cleared.)	
1	The settings of parameters except for calibration parameters and terminal function selection parameters are initialized.	The settings of all the parameters, including calibration parameters and terminal function selection parameters, are initialized.

2.5.6 Parameter copy

The parameter setting values for one inverter can be copied to multiple inverters.

Pr.CPY setting	Description
0.---	Initial display
1.RD	Copy the source parameters to the operation panel.
2.WR	Write the parameters stored in the operation panel to the target inverter.
3.VFY	Verify the parameters in the inverter and operation panel.

(1) Reading the parameter settings of the inverter to the operation panel

Operation

1. Connect the operation panel to the source inverter.
2. Parameter setting mode
   Press [MODE] to choose the parameter setting mode. (The parameter number read previously appears.)
3. Selecting the parameter
   Turn the dial to "Pr.CPY" (Parameter copy), and press [SET].
   "0.-- -- " appears.
4. Reading the setting to the operation panel
   Turn the dial to change the set value to " 1Rd ". Press [SET] to start reading the parameter settings by the operation panel. (It takes approximately 30 seconds to read all the settings. During reading, " 1Rd " blinks.)
5. End reading
   " 1Rd " and "Pr.CPY" are displayed alternately after settings are read.

(2) Copying parameter settings read to the operation panel to the inverter

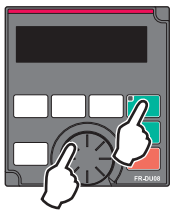
Operation

1. Connect the operation panel to the target inverter.
2. Parameter setting mode
   Press [MODE] to choose the parameter setting mode. (The parameter number read previously appears.)
3. Selecting the parameter
   Turn the dial to "Pr.CPY" (Parameter copy), and press [SET].
   "0.-- -- " appears.
4. Selecting the parameter copy
   Turn the dial to change the set value to "2WR", then press [SET].
   "2. ALL " appears.
5. Copying the settings to the inverter
   Press [SET] to start copying the settings to the inverter. (It takes approximately 60 seconds to copy all the settings. During copying, "2. ALL " blinks.)
   ● Perform this step when the inverter is stopped. (Parameter settings cannot be copied during operation.)
6. Ending copying
   "2WR" and "Pr.CPY" are displayed alternately after settings are copied.
7. After parameters are written to the destination inverter, always reset the inverter before operation by, for example, turning OFF the power.

2.5.7 Operation using the operation panel (PU operation)

Use the operation panel (FR-DU08) to give a start command and a frequency command. (PU operation)

Operation panel (FR-DU08)



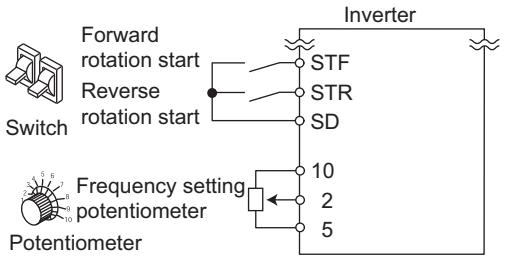
Operation example **Operate at 30 Hz.**

Operation

1.	Turning ON the power of the inverter The operation panel is in the monitor mode.
2.	Changing the operation mode Press PU EXT to choose the PU operation mode. The [PU] indicator turns ON.
3.	Setting the frequency Turn the dial until the target frequency "30.00" (30.00 Hz) appears. The indication blinks for approximately five seconds. While the indication is blinking, press SET to confirm the selection for the frequency. "F" and "30.00" are displayed alternately. The value blinks for approximately three seconds and the indication goes back to "0.00" (monitor display). (If SET is not pressed, the indication of the value goes back to "0.00" (0.00 Hz) after about 5 s of blinking. In that case, turn the dial again and set the frequency.)
4.	Start → acceleration → constant speed Press FWD or REV to start running. The frequency value on the monitor increases according to the setting of F010 (Pr.7) Acceleration time, and "30.00" (30.00 Hz) appears on the monitor. (To change the set frequency, perform the operation in above step 3. The previously set frequency appears.)
5.	Deceleration → stop Press STOP RESET to stop the motor. The frequency value on the monitor decreases according to the setting of F011 (Pr.8) Deceleration time, and "0.00" (0.00 Hz) appears. Then, the motor stops rotating.

2.5.8 Operation using external switches (External operation)

Turn ON the STF/STR signal to give a start command.
Use the potentiometer (frequency setting potentiometer) to give a frequency command. (by connecting it across terminals 2 and 5 (voltage input)).
[Connection diagram]
(The inverter supplies 5 V power to the frequency setting potentiometer (Terminal 10))



Operation example **Operate at 60 Hz.**

Operation

1.	Turning ON the power of the inverter The operation panel is in the monitor mode.
2.	Start Turn ON the start switch (STF/STR signal). [FWD] or [REV] indicator blinks as no frequency command is given.
3.	Acceleration → constant speed Turn the potentiometer (frequency setting potentiometer) clockwise slowly to full. The frequency value on the monitor increases according to the setting of F010 (Pr.7) Acceleration time, and "60.00" (60.00 Hz) appears on the monitor. [FWD] indicator is ON during the forward rotation, and [REV] indicator is ON during the reverse rotation.
4.	Deceleration Turn the potentiometer (frequency setting potentiometer) counterclockwise slowly to full. The frequency value on the monitor decreases according to the setting of F011 (Pr.8) Deceleration time, and "0.00" (0.00 Hz) appears. Then, the motor stops rotating. [FWD] or [REV] indicator blinks.
5.	Stop Turn OFF the start switch (STF/STR signal). [FWD] or [REV] indicator turns OFF.

POINT

When both the forward rotation switch (STF) and the reverse rotation switch (STR) are ON, the motor cannot be started. If both are turned ON while the inverter is running, the inverter decelerates the motor to a stop.

2.5.9 Monitoring of output current and output voltage

Press SET on the operation panel in the monitor mode to switch the monitor item between output frequency, output current, and output voltage.

Operation

1. Press MODE during operation to monitor the output frequency. [Hz] indicator turns ON.
2. Press SET to monitor the output current. This operation is valid during running or stopping under any operation mode. [A] appears.
3. Press SET to monitor the output voltage. [V] appears.

2.5.10 First monitored item

The first monitored item to be displayed in the monitor mode is selectable.

To set a monitored item as the first monitored item, display a monitored item, and press SET for a while.

Changing example | Set the output current as the first monitored item.

Operation

1. Select the monitor mode, and select the output current.
2. Press SET for a while (one second). The output current is set as the first monitored item.
3. When the monitor mode is selected next time, the output current is monitored first.

2.5.11 Calibration procedure for terminal FM when using the operation panel (FR-DU08)

Operation

1.	Turning ON the power of the inverter The operation panel is in the monitor mode.
2.	Changing the operation mode Press [PU/EXT] to choose the PU operation mode. The [PU] indicator turns ON. Calibration is also possible in the External operation mode.
3.	Parameter setting mode Press [MODE] to choose the parameter setting mode. (The parameter number read previously appears.)
4.	Selecting the calibration parameter Turn  until "PM3 . ." appears. Press [SET] to display "PM3 - - ".
5.	Selecting the parameter Turn  until "PM3 10 "(M310 (Pr.900) FM/CA terminal calibration) appears. Press [SET] to enable the parameter setting. The monitored value of the item (initially the output frequency) selected by M300 (Pr.54) FM/CA terminal function selection will appear.
6.	Pulse output from terminal FM If the inverter is stopped, press [FWD] or [REV] to start the inverter operation. (To monitor the output frequency, motor connection is not required.) Calibration is also possible in a stop status.
7.	Scale adjustment Turn  to move the meter needle to a desired position.
8.	Setting completed Press [SET] to enter the setting. The monitored value and " PM3 10 " are displayed alternately. • Turn  to read another parameter. • Press [ESC] to return to the " PM3 10 " display. • Press [SET] to return to the monitored value of step 5.

2.6 Inverter setup software

FR Configurator2 (SW1DND-FRC2-E)
Inverter setup software provides a comfortable environment for operating the inverter as a support tool for the inverter operations from startup to maintenance.
Parameter setting and monitoring can be effectively performed on the screen of the Windows personal computer.

2.6.1 Function

Function	Description
Parameter list	Displays parameters in a list or by function group and the initial value change list, and allows editing and setting the parameters.
Convert	Copies the A700 series parameter settings to the A800 series parameter settings.
Diagnosis	Displays the fault history.
Graph	Displays the monitored values in a graph with the high speed sampling, monitor sampling, or USB trace file reading.
Batch monitor	Displays the monitored items of the inverter in a batch.
Test operation	Displays the frequency of the selected inverter, switches and displays the operation modes, sends commands of the forward or reverse operations, and writes the set frequency.
Developer	Creates a sequence program, writes it to the inverter, and enables the PLC function of the inverter.
USB memory parameter copy file edit	Edits the parameter setting value read from the inverter to the USB memory (USB memory parameter copy file).
Help	Displays the contents of the instruction manuals of the inverter and software.

2.6.2 Screen examples

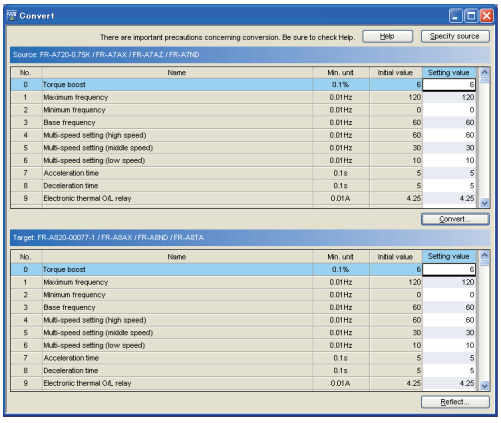


Fig. 2.7 Screen example of the convert function

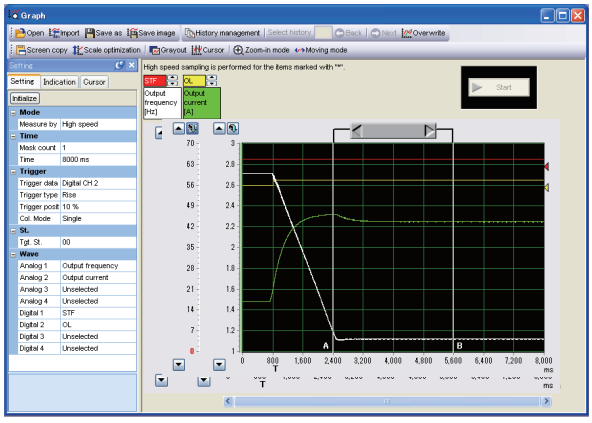
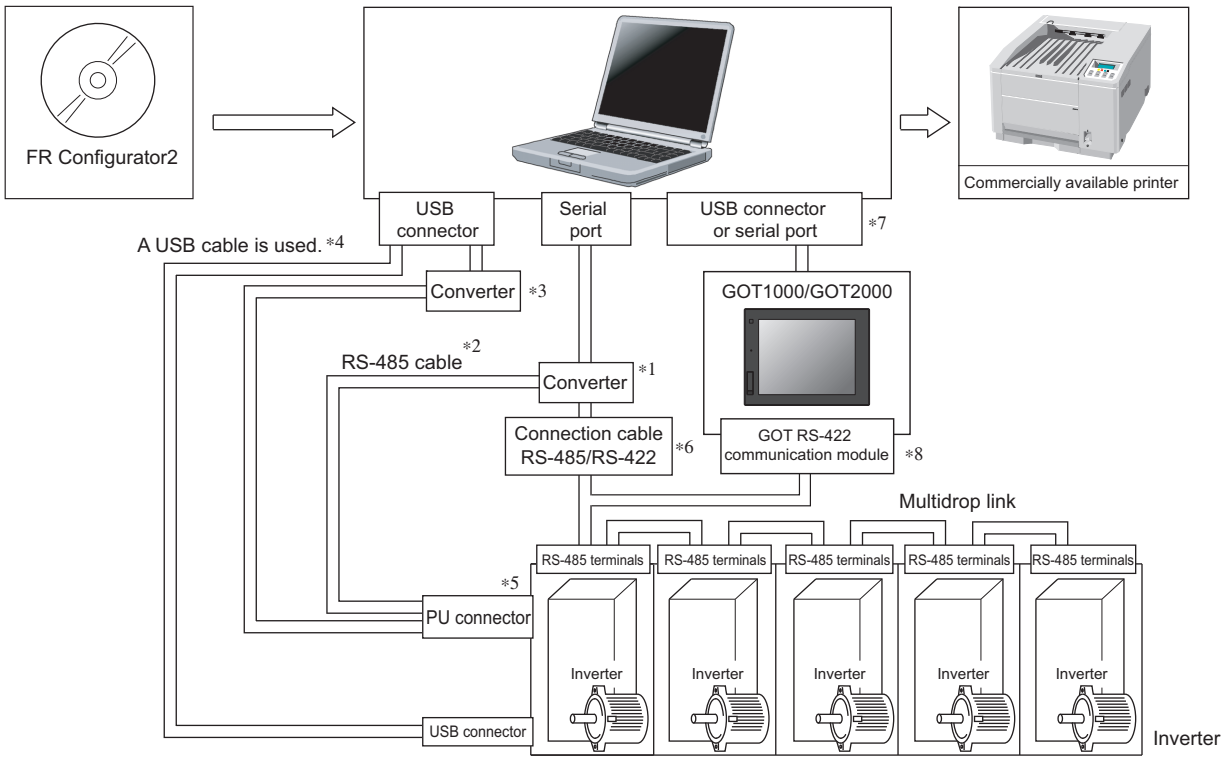


Fig. 2.8 Screen example of the graph display

2.6.3 System configuration

The following devices are required to use FR Configurator2. Configure the system in accordance with the instruction manuals of each device.



*1 For the serial port of the personal computer, a commercially available converter is required.
<Examples of commercially available products> (as of February 2012)
Model: DINV-CABV (with a connector and cable)
Diatrend Corp.
The conversion cable cannot connect multiple inverters. (The computer and inverter are connected in a 1:1 pair.) The above product is an RS-232C to RS-485 conversion cable that has a built-in converter. No additional cable or connector is required. For the product details, contact the manufacturer.

*2 Connection cable
<Examples of commercially available products> (as of February 2012)
Connector: RJ-45 connector
Example: Tyco Electronics
5-554720-3
Cable: A cable compliant with EIA 568 (such as the 10BASE-T cable)
Example: Mitsubishi Cable Industries, Ltd.
SGLPEV-T (Cat5e/300 m) 24AWG × 4P

*3 USB/RS-485 conversion cable
<Examples of commercially available products> (as of February 2012)
Model: DINV-U4
Diatrend Corp.
(For the communication setting with the DINV-U4, refer to page 26.)
When using the USB/RS-485 conversion cable, use the latest driver software.
For the product details or the latest driver software, contact the cable manufacturer.

*4 Recommended USB cable for the connection between the personal computer and the inverter
MR-J3USBCBL3M cable length: 3 m

*5 Any of the PU connector, RS-485 terminals, or USB connector can be used for the communication.

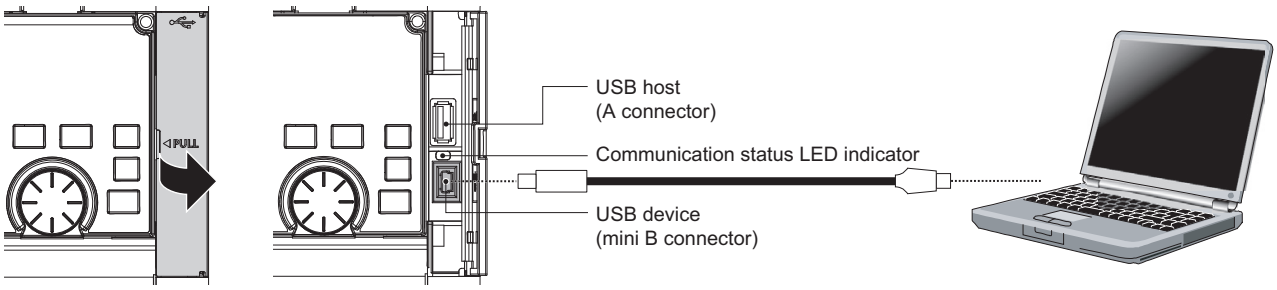
*6 The total connection cable length is 500 m.

*7 The available communication port is the USB or serial port (one of the port 1 to 63). Set it in the communication window of FR Configurator2. (Multiple ports cannot be used simultaneously.) One personal computer is connected to one GOT. When connecting the GOT to the personal computer with the USB connector, use the dedicated cable GT09-C30USB-5P or GT09-C20USB-5P. To connect the GOT2000 series to the personal computer, only the USB connection is possible.

*8 For the GOT1000 series, the RS-422 communication unit (GT15-RS4-9S) is required. For the supported versions of the GOT and details on the RS-422/485 connection, refer to the connection manual of the GOT1000 series or GOT2000 series.

Product name	Model	Manufacturer
Communication cable	SGLPEV-T (Cat5e/300 m) 24AWG × 4P	Mitsubishi Cable Industries, Ltd.
RJ-45 connector	5-554720-3	Tyco Electronics Japan G.K.

[Connection example of USB cable and USB connector]
For the inverter, connect the USB cable to the USB device (mini B connector).



Connecting the demonstration machine

For the demonstration machine, use a USB cable. Connect the inverter to the personal computer by using the USB cable.

2.6.4 Setup

(1) Operation mode setting

To operate the inverter with FR Configurator2 (operation such as the parameter setting and test operation), setting the operation mode of the inverter is required. The operation mode can be selected on the "Test operation" or "Parameter list" window.

Connection method		operation Mode ∗1	Parameter setting ∗2 (For the FR-A800 series)	
Directly connecting the inverter to FR Configurator2	PU connector (RS-485 connector)	PU	N026 (Pr.122) PU communication check time interval = "9999 (initial value)" N027 (Pr.123) PU communication waiting time setting = "9999 (initial value)" D013 (Pr.551) PU mode operation command source selection = "2"	
	RS-485 terminal	PU	D013 (Pr.551) PU mode operation command source selection = "1"	N036 (Pr.336) RS-485 communication check time interval ≠ "0" N037 (Pr.337) RS-485 communication waiting time setting = "9999 (initial value)"
		NET	D013 (Pr.551) PU mode operation command source selection = "9999 (initial value)" D012 (Pr.550) NET mode operation command source selection = "1"	
	USB connector	PU	N041 (Pr.548) USB communication check time interval = "9999 (initial value)" D013 (Pr.551) PU mode operation command source selection = "9999 (initial value)"	
Connecting the inverter via GOT	PU connector (RS-485 connector)	PU	N027 (Pr.123) PU communication waiting time setting = "0" D013 (Pr.551) PU mode operation command source selection = "2"	
	RS-485 terminal	PU	D013 (Pr.551) PU mode operation command source selection = "1"	N036 (Pr.336) RS-485 communication check time interval ≠ "0" N037 (Pr.337) RS-485 communication waiting time setting = "0"
		NET	D013 (Pr.551) PU mode operation command source selection = "9999 (initial value)"	

∗1 When using FR Configurator2 to write parameters and input operation commands, set the mode in the above list.

∗2 The changed values of D012 (Pr.550) and D013 (Pr.551) are applied at the next power-ON or inverter reset.

Setting the demonstration machine

Since the demonstration machine is connected with the USB cable, set the parameters as shown in ☐ of the above table.

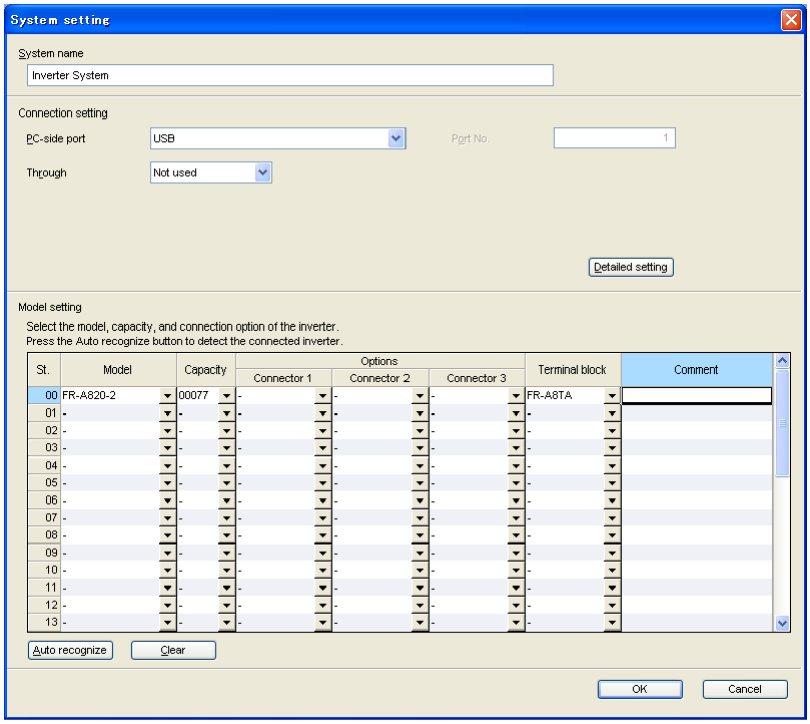
1) Set the inverter in the PU operation mode.
2) Check that D013 (Pr.551) = "9999 (initial value)" and N041 (Pr.548) = "9999 (initial value)".
3) After changing the setting, turn OFF and ON the power.

●●●After the demonstration●●●

Perform all parameter clear.

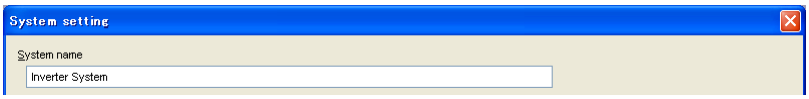
(2) Creating a project

Start up FR Configurator2, select [New] in the [Project] menu or select on the toolbar to display the "System setting" window.



(a) Enter the information required for creating a project.

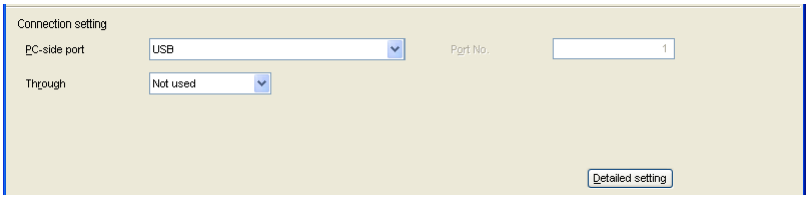
Enter the system name to be set (up to 32 characters) for the System name in the "System setting" window.



(b) Configure the settings for the communication between the personal computer and the inverter.

When using a USB port of the personal computer to communicate with the inverter, select "USB" in "PC-side Port".

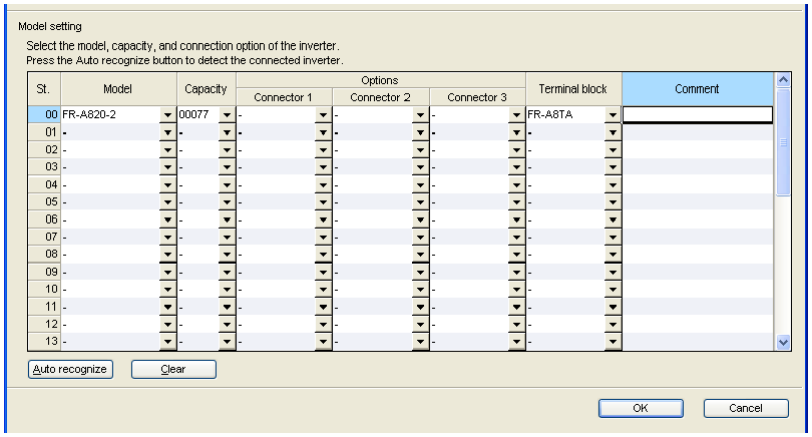
When using a serial port of the personal computer to communicate with the inverter, select "Specify the port number" in "PC-side Port".



Setting the demonstration machine

For the PC-side port, set USB. Other setting items can be used without any change.

(c) The inverter information can be reflected to the system setting by detecting the connected inverters automatically or selecting the inverters manually.



Automatic detection

Click [Auto recognize] to start detecting the communicable inverters.
When automatic inverter detection is finished, the inverter information is reflected to the system window.

Manual model setting

Select the station number of the connected inverter, and set the model, capacity, and plug-in options.

Setting the demonstration machine

For the station "00", set the model "FR-A820-1", capacity "00077", option connectors 1 to 3 "-", terminal block "FR-A8TA", and comment "None".

(d) Click [OK] to finish the system setting. The screen shifts to the main frame.
Creating the project is completed.

2.6.5 Graph (monitor area)

Data such as output frequency and current of the inverter can be sampled, and the results can be displayed in a waveform graph. The sampled data can be saved in a file (the *.jpg, *.emf, *.gp4, or *.csv file) to be read and displayed (import the *.gp4 or *.st1 file).

To display the "Graph" window, select [graph (G)] in the [monitor (M)] menu, or select  on the toolbar.
There are two sampling methods.

- **High speed sampling**
  The data can be collected at a shortest interval of 0.125 [ms]. Only one station can be set as the sampling target. The high speed sampling is available only when the USB is connected.

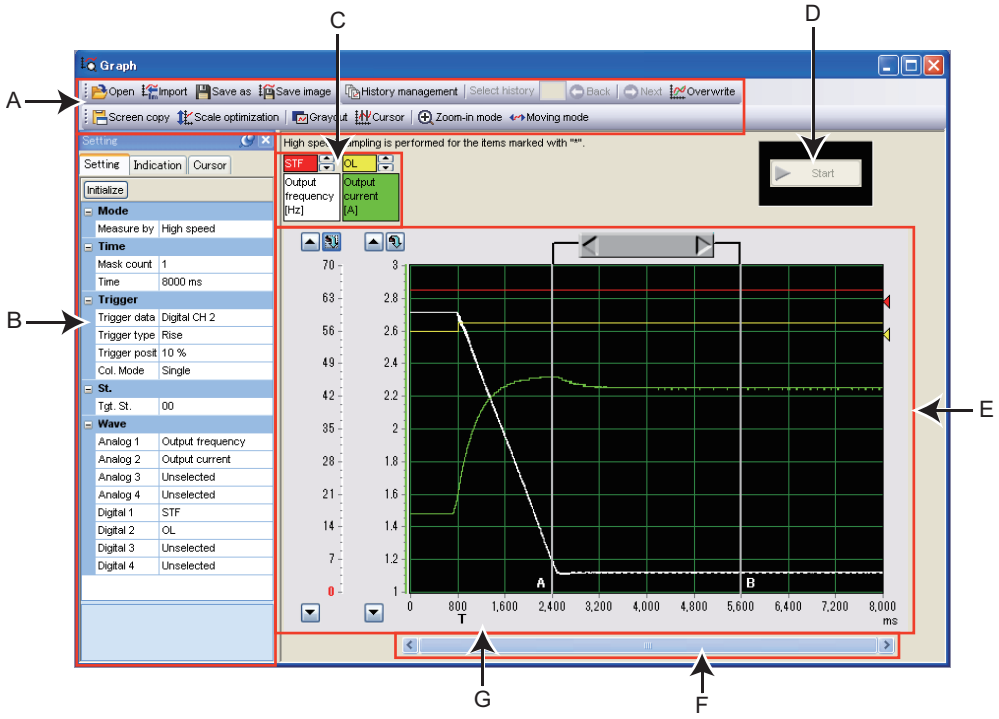
- **Monitor sampling**
  The sampling interval changes according to the communication settings (communication speed or communication port) or the number of sampling items.

Item	Specification
Sampling interval	High speed sampling: From 0.125 [ms] (mask count: 1) to 20 [ms] (mask count: 30) can be set. Monitor sampling: From 50 [ms] to 60000 [ms] can be set (depending on the communication speed, communication port, or the number of sampling items).
Sampling time [ms]	High speed sampling: Maximum (Mask count +1) × 4000 Monitor sampling: Maximum Sampling interval × 4000
Analog data	Analog data of 4 channels can be sampled.
Digital data	Digital data of 4 channels can be sampled.

☒ POINTS for understanding !

Running other applications during high speed sampling, or performing personal computer file operations during high speed sampling, etc., will cause communication errors (error code 0x80020007 or 0x80020008) or buffer overflow errors to occur, and data will not be able to be displayed correctly. In this case, take countermeasures such as closing other applications, refraining from FR Configurator2 operations, or setting a larger value for the mask counter of the sampling interval.

(1) Explanation of window



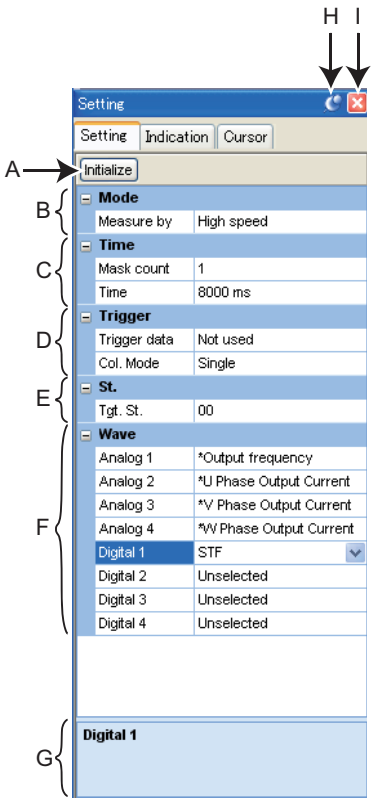
Symbol	Name	Function and description	
A	Toolbar	Provides file operations, history management, and graph display settings.	
B	Property window	Used to set the measurement conditions, display conditions, and cursor.	
C	Sampling item column	Displays the contents of the analog CH and digital CH set in the [Waveform] setting tab of the property window.	
D	Measurement start/ stop button	Start	Starts measurement (sampling).
		Stop	Stops measurement (sampling). This button only appears during measurement.
E	Graph display area	Displays the sampled data in a graph.	
F	Horizontal axis scroll bar	Used to scroll the displayed section in the graph display area.	
G	Trigger position	Shows the position in which the trigger completes. "T" on the graph horizontal axis denotes measuring time period.	

POINTS for understanding !

- If a normal communication with the inverter is not maintained (communication error, etc.), the sampling stops.
- If a fault occurs during sampling, the sampling continues.
- During sampling, other communication tasks such as parameter reading are unavailable.

(2) Sampling settings

Select the [Setting] tab in the property window to display the sampling settings column. The time, trigger, station, and waveform of the analog CH can be set as analog data, and that of the digital CH can be set as digital data.



Symbol	Name	Function and description	
A	Initialize	Initializes the sampling settings.	
B	Mode	Sets the measurement mode for sampling.	
C	Time	Mask count	Sets the interval for data sampling measurement.
		Measurement time (ms)	Displays the maximum time for data sampling measurement. For the details, refer to page 31.
D	Trigger	Used to set the start conditions of the sampling measurement. For the details, refer to page 33.	
E	Station	Used to select the station to be set for sampling.	
F	Wave	Used to select the items to be sampled. For analog data, 4 CHs (8 CHs of trace data) can be selected, and for digital data, 4 CHs (8 CHs of trace data) can be selected. For the sampling items, refer to page 32.	
G	Help area	Shows a description of the currently selected item.	
H	Show/hide switching button	Shows/hides the property window by pressing this button.	
I	Close	Closes the currently-selected tab ([Setting], [Indication], or [Cursor]) of the property window. The closed tab can be opened again from [Property window] in [Graph (Z)] of the menu bar.	

• **Setting range and setting unit of sampling interval and sampling time**

The setting range of the sampling interval and the sampling time are different for high speed sampling and monitor sampling.

(a) High speed sampling (only for USB connections)

The sampling interval can be about 0.125 [ms] (mask count: 1) to about 20 [ms] (mask count: 30). The sampling time can be set up to "(mask count +1) × 4000". The sampling interval varies depending on the control mode.

(b) Monitor sampling

The sampling interval and the sampling time change according to the communication settings. The lower limit of the sampling interval is "number of sampling items × lower limit of the sampling interval". Refer to the following table for the lower limit of the sampling interval.

Communication port	Communication speed [bps]	Lower limit of the sampling interval [ms] ∗1
Serial port	4800	250
	9600	150
	19200	100
	38400	100
	57600	50
	115200	50
USB	-	50

For the maximum values, minimum values, and setting units of the sampling interval and sampling time set under actual measurement conditions, refer to the following table.

	Maximum value	Minimum value	Setting increments
Sampling interval [ms]	60000	Lower limit of the sampling interval (table above) × number of the sampling items ∗1	1
Sampling time [ms]	Sampling interval × 4000	Sampling interval × 50 ∗2	1

∗1 If a fault trigger is set, the fault trigger is also counted as a sampling item.

∗2 Even if a sampling time shorter than 3000 [ms] is set, the minimum sampling time of 3000 [ms] applies.

Example: When connecting to the serial port with a communication speed of 19200 bps, and monitoring the output frequency, output current, and output voltage as the data items to be displayed in a graph.

Lower limit of the sampling interval = 100 [ms]

Maximum value of the sampling interval = 60000 [ms] (60 [s])
Minimum value of the sampling interval = 100 × 3 = 300 [ms]

Maximum value of the sampling interval = 60000 × 4000 = 240000000 [ms] (about 66.67 [h])
Minimum value of the sampling time = 300 × 50 = 15000 [ms] (15 [s])

・Sampling item list

For details on the monitor items, refer to the Instruction Manual (Detailed) of the inverter.
For sampling items of the digital data, refer to the Instruction Manual (Detailed) of the inverter.
High speed sampling is applicable to the items whose name contains an asterisk (∗) at the beginning. For details on the monitor items, refer to the Instruction Manual (Detailed) of the inverter.

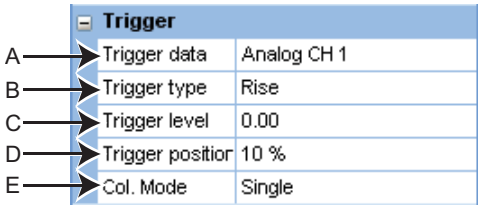
Model name	Sampling mode	Sampling item
FR-A800	Monitor/High speed	Output frequency, Output current, Output voltage, Frequency setting value, Speed/machine speed, Motor Torque, Converter output voltage, Regenerative brake duty, Electronic thermal O/L relay function load factor, Output current peak value, Converter output voltage peak value, Input power, Output power, Load meter, Motor excitation current, Position pulse, Cumulative energization time, Orientation status, Actual operation time, Motor load factor, Torque command, Torque current command, Motor output, Feedback pulse, PLC function user monitor 1, PLC function user monitor 2, PLC function user monitor 3, PID set point, PID measured value, PID deviation, Motor thermal load factor, Inverter thermal load factor, PTC thermistor resistance, PID measured value 2, Remote output value 1, Remote output value 2, Remote output value 3, Remote output value 4, PID manipulated amount, Second PID set point, Second PID measured value, Second PID deviation, Second PID measured value 2, Second PID manipulated amount, Dancer main speed setting, Control circuit temperature
	High speed	∗Output frequency, ∗U-phase output current, ∗V-phase output current, ∗W-phase output current, ∗Converter output voltage, ∗Output current (all three phases), ∗Excitation current (A), ∗Torque current (A), Terminal 2, Terminal 4, Terminal 1, ∗Excitation current (%), ∗Torque current (%), Position command, Current position, Droop pulse, ∗Output frequency (with sign), ∗Motor rotations per minute, ∗Speed command, ∗Torque command, ∗Motor torque, ∗Excitation current command, ∗Torque current command

☒ POINTS for understanding !

- When changing the sampling setting mode (monitor/high speed), change the sampling items before setting. Because the monitor contents change if the mode is changed, unshared sampling items are cleared. (Refer to (2) in this section)
- When setting the sampling items, the analog data (CH1 to CH4) is required to set from CH1, the digital data (CH5 to CH8) is required to set from CH5 in order.

(3) Trigger settings

Setting a trigger allows sampling to start when a fault occurs or sampling item conditions are met.



Symbol	Name	Function and description
A	Trigger data	Select the signal that triggers the start of sampling. The trigger signals are as follows. • Not used • Analog CH, digital CH (Sampling starts if the sampling items meet the conditions.) • Fault trigger (Sampling starts if a fault occurs.)
B	Trigger type	Select the conditions to determine trigger condition satisfaction from rise or fall. (Only appears when trigger data is analog CH or digital CH.) • Rise Analog CH: When the value specified by the trigger level is exceeded Digital CH: When the signal changes from OFF to ON • Fall Analog CH: When the value drops to a level lower than the trigger level Digital CH: When the signal changes from ON to OFF
C	Trigger level	Set the threshold to determine trigger condition satisfaction by the analog signal. (Only appears when trigger data is analog CH.)
D	Trigger position	Set the ratio of the sampling data to collect before the trigger conditions are met. (Only appears when trigger data is the analog CH, digital CH, or fault trigger.)
E	Collection mode	Set whether the sampling should be continuously operated. Single: Sampling is performed only once. Continuous: Sampling is performed continuously.

Remark

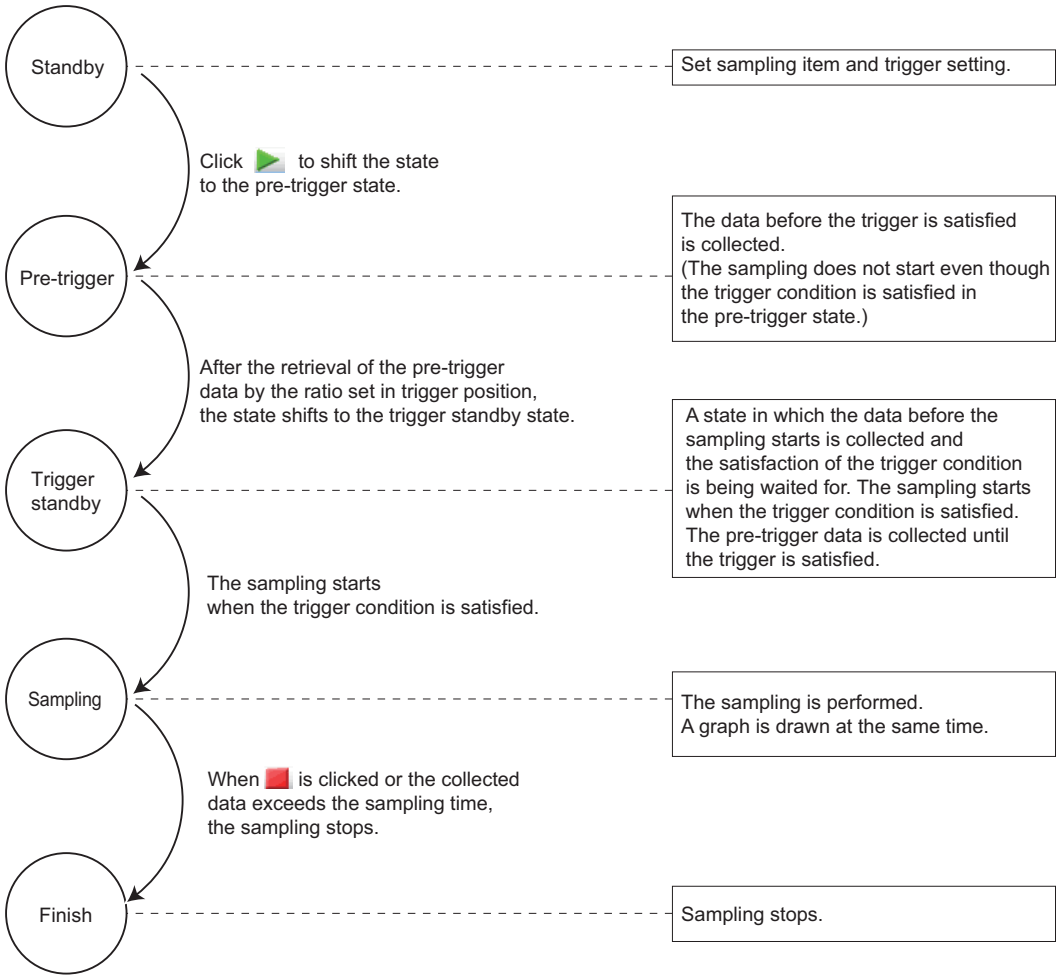
- Activation of analog data

  The trigger will not start if the trigger conditions have already been met when  is selected. If "Rise" is selected, the trigger occurs when the set value in "level" is exceeded, and with "Fall", the trigger occurs when the set value drops to a level lower than "level".

  Example: If trigger start condition is "Rise" and the level is set to "3"
  If the level is 4 when sampling starts, the trigger will not start. When changed from less than 3 to 3 or more, the trigger conditions are met and sampling will start.

- If the machine speed is displayed by setting M000 (Pr.37) Speed display to a value other than 0
  To set "Output frequency" or "Frequency" as the trigger data, enter the trigger activation machine speed as is to the "level" column.
  For example, if M000 (Pr.37) Speed display is set to 1800 with "Output frequency" as the sampling item, and the trigger is to be activated at "900", input "900" as is to the "level" column.

•Trigger standby state

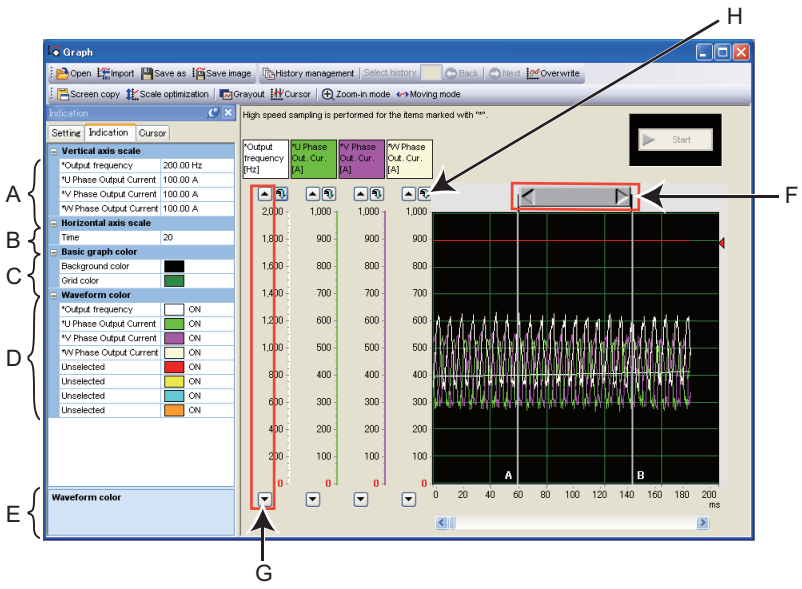


(4) Changing the scale and graph display

The scale and waveform data on the displayed graph can be changed. Graph area is divided into vertical 10 grids and horizontal 10 grids. The vertical scale and horizontal scale can be changed by setting the value for each grid.

The selected graph can be moved up and down with 0 position calibration.

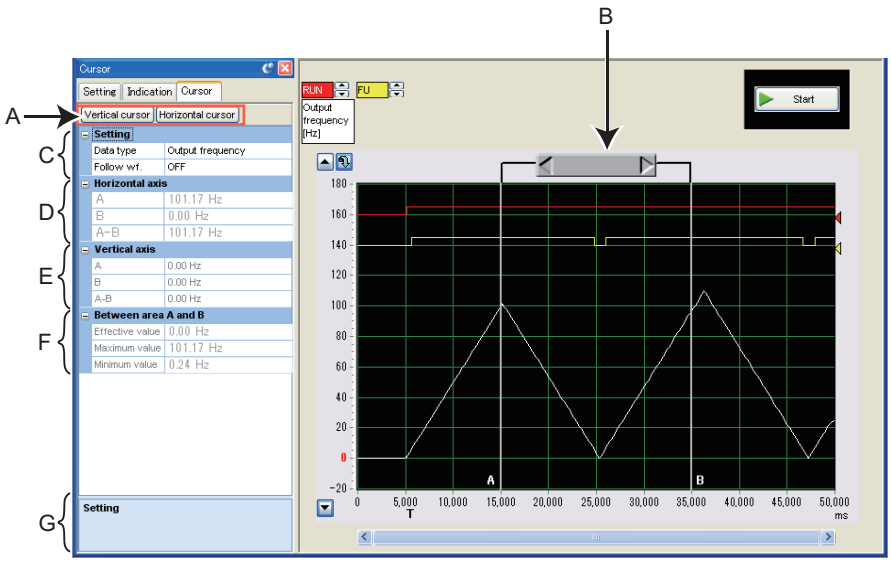
The displayed values of the vertical scale will change according to the vertical axis scale setting.



Symbol	Name	Function and description
A	Vertical axis scale	Used to change the vertical axis scale intervals for the analog CHs set as sampling items.
B	Horizontal axis scale	Used to change the horizontal axis scale interval based on the set measurement time.
C	Basic graph color	Used to change the background color of the graph and color of the grid lines.
D	Waveform color	Used to change the color of the measured waveform data.
E	Help area	Shows a description of the currently selected item.
F	Cursor bar	Used to adjust the cursor position.
G	Scroll button for each analog CH	Used to moves up/down the waveform data on the graph for each analog CH.
H	Scroll target setting button	Used to input a numerical value for the traveling target of the waveform data.

(5) Cursor function

The numeric value of the waveform at the cursor, effective value, maximum value, and minimum value between any 2 points can be displayed.

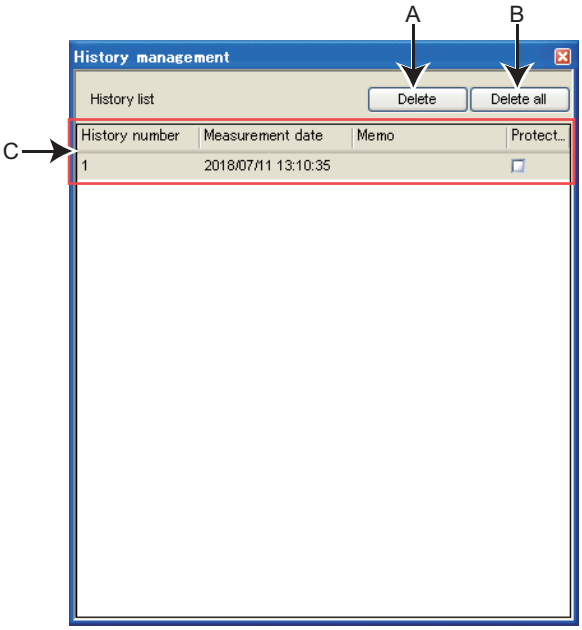


Symbol	Name	Function and description	
A	Vertical/horizontal cursor	Used to specify cursor A and cursor B as the vertical axis or horizontal axis.	
B	Cursor bar	Used to specify the position between cursor A and cursor B.	
C	Setting	Data type	Used to select the analog CH subject to the cursor measurement.
		Follow waveform	ON: Moves the cursor so as not to change the value of the vertical scale or horizontal scale. OFF: Moves the cursor so as not to change the position of the graph display area.
D	Horizontal axis	A	Shows the time (ms) at cursor point A.
		B	Shows the time (ms) at cursor point B.
		A - B	Shows the time (ms) between cursor points A and B.
E	Vertical axis	A	Shows the measured value at cursor point A.
		B	Shows the measured value at cursor point B.
		A - B	Shows the values between cursor points A and B.
F	A - B	Effective value	Calculates and displays the effective value between cursor A and cursor B.
		Maximum value	Shows the maximum value between cursor A and cursor B.
		Minimum value	Shows the minimum value between cursor A and cursor B.
G	Help area	Shows a description of the currently selected item.	

(6) History display

Data of the past 20 samplings (including the current data) can be saved and displayed. The graph data at the time of sampling is stopped is saved. When the number of records exceeds 20, the oldest set of data will be deleted for every new data sampled.

To display the "History management" window, select [History management] from the [Graph (Z)] menu while the graph window is displayed, or menu or  on the toolbar.



Symbol	Name	Function and description	
A	Delete	Deletes the selected history.	
B	Delete all	Deletes all records. However, protected records will not be deleted.	
C	History list	History number	Records are displayed in ascending order by number from the newest to the oldest. Up to 20 records can be saved.
		Measurement date and time	Displays the date and time when sampling was executed.
		Memo	A field for comments.
		Protection	Prevents the checked records from being deleted by the delete button or by continuous sampling. Up to 10 records can be protected.

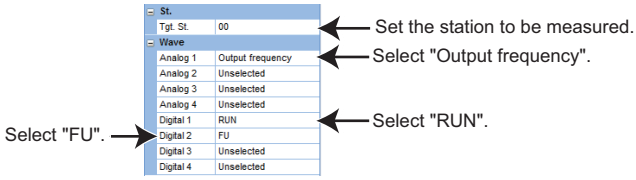
Remark

- When continuously sampling, all acquired data will be added sequentially to the history, and the next sampling will be performed.
- When graphs are displayed overlapped each other, cursor functions are available only for the currently displayed graph.

(7) Example of graph measuring procedure (monitoring output frequency, terminal RUN, and terminal FU)

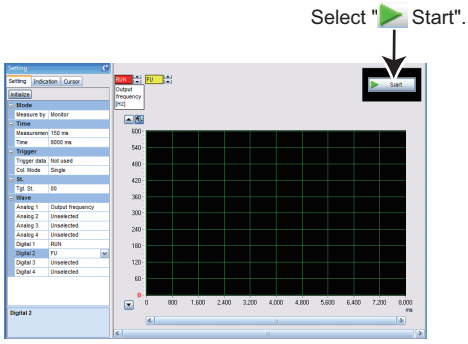
- **Measurement without a trigger**

(a) Specify the station number to be measured as "Tgt. St." (Target station).
Next, select "Output frequency" for the "Analog 1" column of "Wave", "RUN" for "Digital 1", and "FU" for "Digital 2".

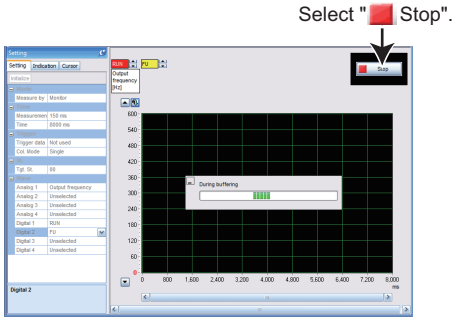


(b) The sampling interval can be set for "measurement interval", and the sampling time can be set for "Time".

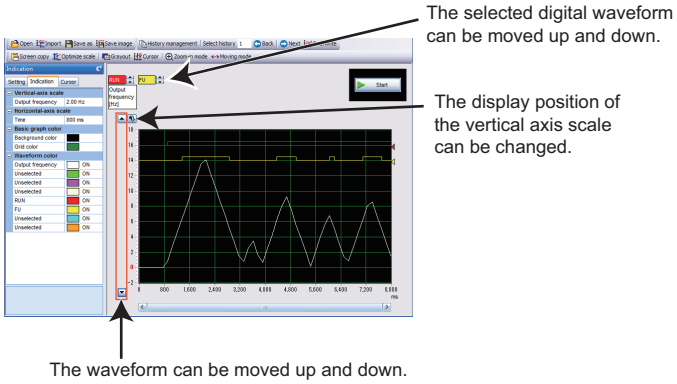
(c) Measurement will start by clicking " Start".



(d) Measurement is finished by clicking " Stop", or when the set sampling time is elapsed.

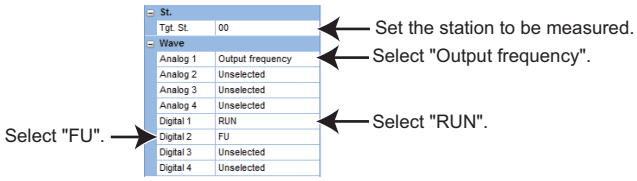


(e) The graph display can be adjusted.

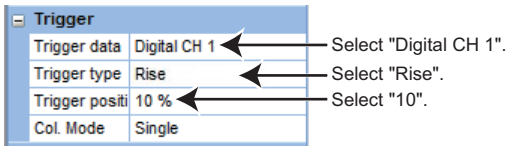


- **Measurement including the data sampled before the trigger occurs for 10% of the sampling time (sampling is started at the rise of the terminal RUN signal)**

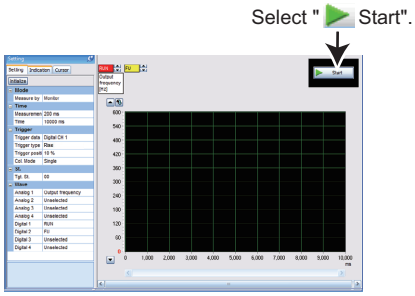
(a) Specify the station number to be measured as "Tgt. St." (Target station).
Next, select "Output frequency" for the "Analog 1" column of "Wave", "RUN" for "Digital 1", and "FU" for "Digital 2".



(b) Trigger setting:
- Select "Digital CH1" for the "Trigger data" column.
- Select "Rise" for the "Trigger type" column.
- Select "10%" for the "Trigger position" column.

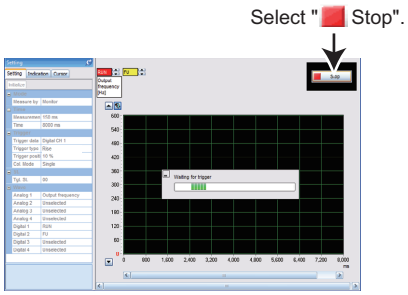


(c) By clicking [Start], trigger standby state is entered.

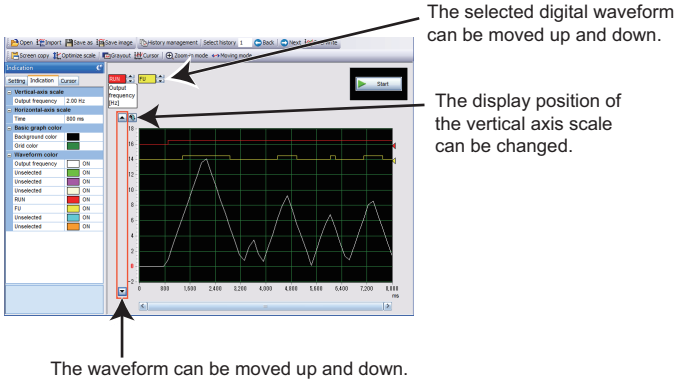


(d) When the trigger conditions are met (rise of the terminal RUN signal), measurement automatically starts including the data sampled before the trigger occurs for 10% of the sampling time.

(e) Measurement is finished by clicking [Stop], or when the set sampling time is elapsed.



(f) The graph display can be adjusted.

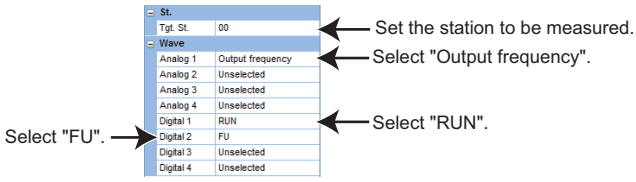


Remark

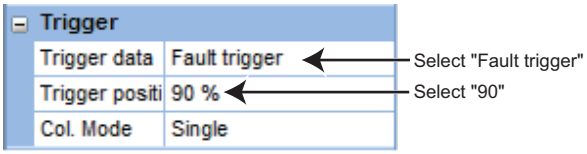
In this example, "Trigger position" is set to "10%". After clicking [Start], the rise of terminal RUN signal within 10% of the sampling time will be ignored, and measurement will not start.

- **Measurement including the data sampled before the trigger occurs for 90% of the sampling time (sampling is started at the occurrence of a fault)**

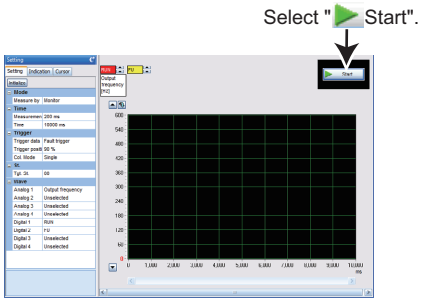
(a) Specify the station number to be measured as "Tgt. St." (Target station).
Next, select "Output frequency" for the "Analog 1" column of "Wave", "RUN" for "Digital 1", and "FU" for "Digital 2".



(b) Trigger setting:
- Select "Fault trigger" from the "Trigger data" column.
- Select "90%" for the "Trigger position" column.

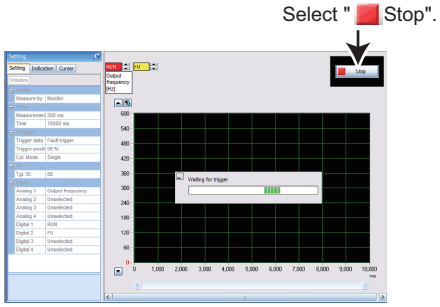


(c) Data before trigger occurrence will be acquired by clicking [Start].

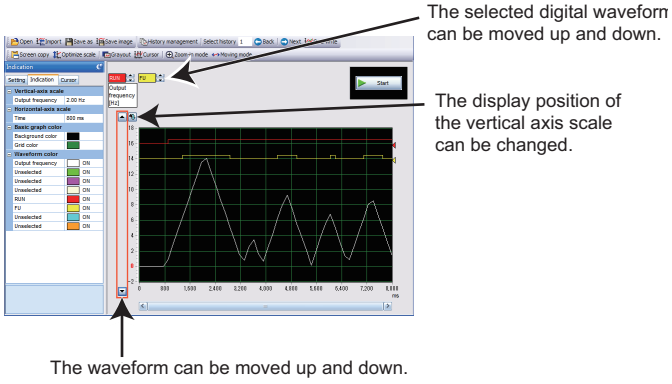


(d) Measurement automatically starts when an inverter fault occurs.

(e) Measurement is finished by clicking [Stop], or when the set sampling time is elapsed.



(f) The graph display can be adjusted.



Remark

In this example, "Trigger position" is set to "90%". After clicking [Start], the occurrence of a fault will be ignored and measurement will not start until 90% of the sampling time elapses.

Chapter 3 MAINTENANCE SYSTEM DESIGN

It is necessary to design a system for maintenance to prevent failures and accidents with a maintenance-friendly design.

3.1 Preparation for Maintenance

(1) Using products unlikely to fail

In simple terms, this means using highly reliable products. It is recommended to consider the following points.

1) Is the manufacturer of the product reliable?
2) Does it conform to recognized local and/or international standards?
3) Is the design simple?
4) Does it have low failure rate based on performance?
5) Does it have a good reputation in industry?

(2) Good system manufacturing for the maintainability

For a maintenance-friendly system, it is recommended to consider the following points.

1) Use an inverter with easily available parts and products.
2) Use an inverter that has high maintainability with functions such as self-diagnostics.
3) Use an inverter that allows easy program reading, modification, and storage.
4) Design the system so that failures are automatically displayed.
5) Design the system having space for maintenance inspection and repair work.
6) Design the system that allows easy replacement of parts and products, and change of wiring.

3.2 Failsafe system which uses the inverter

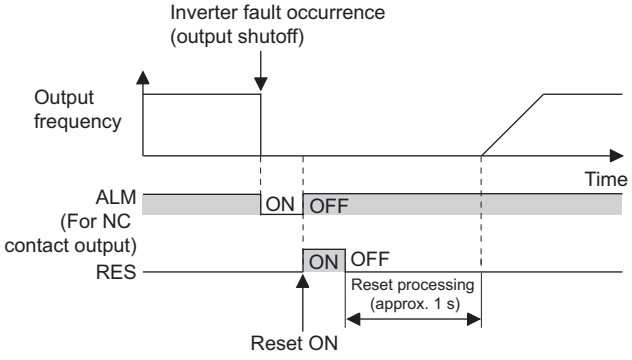
When a fault is detected by the protective function, the protective function activates and outputs a fault output signal. However, a fault output signal may not be output at an inverter's fault occurrence when the detection circuit or output circuit fails, etc. Although Mitsubishi assures the best quality products, provide an interlock which uses inverter status output signals to prevent accidents such as damage to the machine when the inverter fails for some reason. Also at the same time consider the system configuration where a failsafe from outside the inverter, without using the inverter, is enabled even if the inverter fails.

(1) Interlock method which uses the inverter status output signals

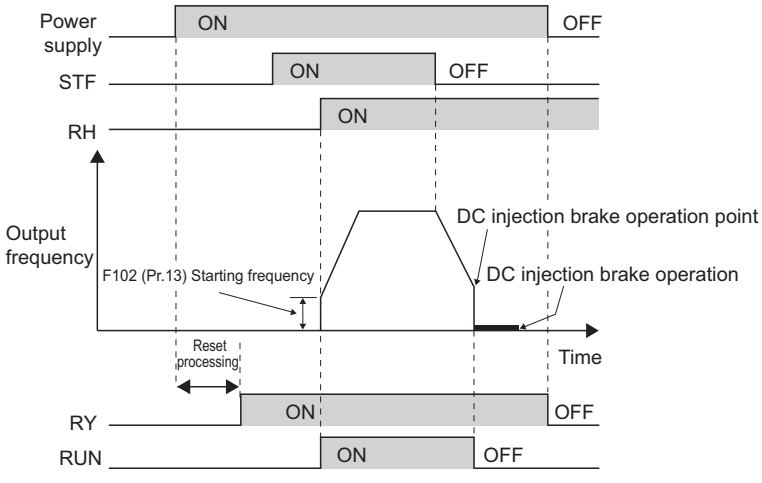
By combining the inverter output signals to provide an interlock as shown below, an inverter failure can be detected.

No.	Interlock method	Check method	Used signals
1)	Inverter protective function operation	Operation check of an alarm contact. Circuit error detection by negative logic.	Fault output signal (ALM signal)
2)	Inverter operating status	Operation ready signal check.	Operation ready signal (RY signal)
3)	Inverter running status	Logic check of the start signal and running signal.	Start signal (STF signal, STR signal) Running signal (RUN signal)
4)	Inverter running status	Logic check of the start signal and output current.	Start signal (STF signal, STR signal) Output current detection signal (Y12 signal)

1) Checking with the inverter fault output signal
When the inverter's protective function is activated and the inverter trips, the fault output signal (ALM signal) is output. (ALM signal is assigned to terminal A1B1C1 in the initial setting).
With this signal, check that the inverter operates properly.
In addition, negative logic can be set. (ON when the inverter is normal, OFF when the fault occurs.)



2) Checking the inverter operating status by the inverter operation ready completion signal
Operation ready signal (RY signal) is output when the inverter power is ON and the inverter becomes operative.
Check if the RY signal is output after powering ON the inverter.



3) Checking the inverter operating status by the start signal input to the inverter and inverter running signal
The inverter running signal (RUN signal) is output when the inverter is running. (RUN signal is assigned to terminal RUN in the initial setting.)
Check if Y12 signal is being output while inputting a start signal to the inverter. (STF signal is a forward rotation signal, and STR is a reverse rotation signal.) Even after the start signal is turned OFF, the RUN signal is kept output until the inverter makes the motor to decelerate and to stop. For the logic check, configure a sequence considering the inverter's deceleration time.

4) Checking the motor operating status by the start signal input to the inverter and inverter output current detection signal
The output current detection signal (Y12 signal) is output when the inverter operates and current flows into the motor.
Check if Y12 signal is being output while inputting a start signal to the inverter. (STF signal is a forward rotation signal, and STR is a reverse rotation signal.) Adjust the current level that outputs the Y12 signal to around 20% using no load current of the motor as reference with M460 (Pr.150) Output current detection level.
As well as the inverter running signal (RUN signal), the Y12 signal is kept output until the inverter decelerates and stops the output to the motor even after the start signal is turned OFF. For the logic check, configure a sequence considering the inverter's deceleration time.

Output signal	Output terminal function selection parameter setting value	
	Positive logic	Negative logic
ALM	99	199
RY	11	111
RUN	0	100
Y12	12	112

- When using each signal, refer to the left table and assign the functions to the output terminals.

☒ POINTS for understanding !

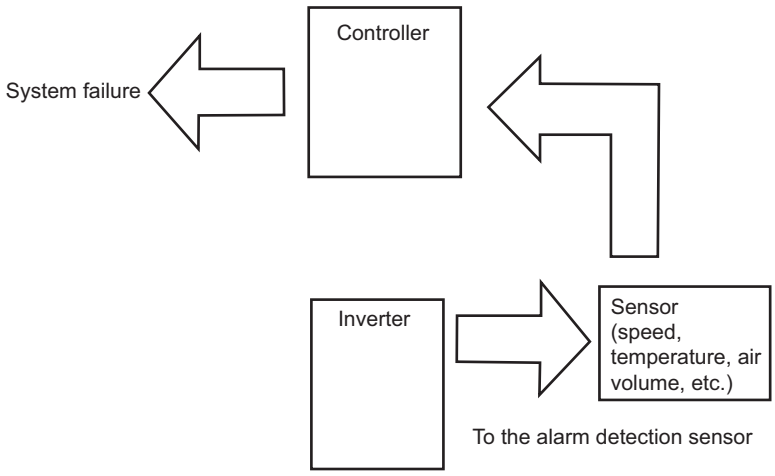
- Changing the terminal assignment using output terminal function selection may affect the other functions. Set parameters after confirming the function of each terminal.

(2) Backup method outside the inverter

Even if the interlock is provided by the inverter status signal, enough failsafe is not ensured depending on the failure status of the inverter itself. For example, if an inverter CPU fails in a system interlocked with the inverter's fault, start, and RUN signals, no fault output signal will be output and the RUN signal will be kept ON because the inverter CPU is down.
Provide a speed detector to detect the motor speed and current detector to detect the motor current and consider the backup system such as performing a check as below according to the level of importance of the system.

1) Start signal and actual operation check
Check the motor running and motor current while the start signal is input to the inverter by comparing the start signal to the inverter and detected speed of the speed detector or detected current of the current detector. Note that the current is flowing through the motor while the motor coasts to stop, even after the inverter's start signal is turned OFF. For the logic check, configure a sequence considering the inverter's deceleration time. In addition, it is recommended to check the three-phase current when using the current detector.

2) Command speed and actual operation check
Check for a gap between the actual speed and commanded speed by comparing the inverter's speed command and the speed detected by the speed detector.



CHAPTER 4 PREVENTIVE MAINTENANCE

Preventive maintenance consists of daily maintenance and periodic maintenance.

4.1 Necessity of preventive maintenance

It is inefficient to repair the production system after failures occur.
The primary goal is to avoid failures and equipment suspension. Preventive maintenance prevents critical failures, as well as leading to fast repair in case of failure.

4.2 Maintenance and inspection

The inverter is a static unit mainly consisting of semiconductor devices. Daily inspection must be performed to prevent any fault from occurring due to the adverse effects of the operating environment, such as temperature, humidity, dust, dirt and vibration, changes in the parts with time, service life, and other factors.

4.2.1 Precautions for maintenance and inspection

When accessing the inverter for inspection, the smoothing capacitor voltage remains high for a while after the power supply has been switched OFF. Therefore, wait until the charge lamp turns off and then make sure that the voltage across the main circuit terminals P/+ and N/- of the inverter is not more than 30 VDC using a tester.

4.2.2 Inspection items

(1) Daily inspection

- Basically, check for the following faults during operation.
  1) Motor operation fault
  2) Improper installation environment
  3) Cooling system fault
  4) Unusual vibration and noise
  5) Abnormal overheat and discoloration

(2) Periodic inspection

- Check the areas inaccessible during operation and requiring periodic inspection.
  1) Check for cooling system fault. ..... Clean the air filter, etc.
  2) Check the tightening and retighten the screws. .... The screws and bolts may become loose due to vibration, temperature changes, etc. Check and tighten them.
  3) Check the conductors and insulating materials for corrosion and damage.
  4) Measure the insulation resistance.
  5) Check and change the cooling fan and relay.

(Note) Understand the contents of the power supply display indicating that the inverter is running and error (fault) display indicating a trouble on general inverter. Also check the electronic thermal O/L relay and the acceleration/deceleration time from the parameter unit, and record the normal setting value.

Refer to the table on the next page for items and judgement criteria of daily and periodic inspections.

Daily and periodic inspection

Inspection area	Inspection item	Description	Inspection interval		Corrective action at fault occurrence	Customer's check
			Daily	Periodic *3		
General	Surrounding environment	Check the surrounding air temperature, humidity, dirt, corrosive gas, oil mist, etc.	○		Improve the environment.	
	Overall unit	Check for unusual vibration and noise.	○		Check fault location and retighten the screws.	
		Check for dirt, oil, and other foreign material.*1	○		Clean.	
	Power supply voltage	Check that the main circuit voltages and control voltages are normal.*2	○		Inspect the power supply.	
Main circuit	General	(1) Check with megger (across main circuit terminals and earth (ground) terminal).		○	Contact the manufacturer.	
		(2) Check for loose screws and bolts.		○	Retighten.	
		(3) Check for overheat traces on the parts.		○	Contact the manufacturer.	
		(4) Check for stain.		○	Clean.	
	Conductors, cables	(1) Check conductors for distortion.		○	Contact the manufacturer.	
		(2) Check cable sheaths for breakage and deterioration (crack, discoloration, etc.).		○	Contact the manufacturer.	
	Transformer/ Reactor	Check for unusual odor and abnormal increase of whining sound.	○		Stop the equipment and contact the manufacturer.	
	Terminal block	Check for a damage.		○	Stop the equipment and contact the manufacturer.	
	Smoothing aluminum electrolytic capacitor	(1) Check for liquid leakage.		○	Contact the manufacturer.	
		(2) Check for safety valve projection and bulge.		○	Contact the manufacturer.	
		(3) Visual check and judge by the life diagnosis of the main circuit capacitor.		○		
	Relay/contactor	Check that the operation is normal and no chattering sound is heard.		○	Contact the manufacturer.	
	Resistor	(1) Check for crack in resistor insulation.		○	Contact the manufacturer.	
		(2) Check for a break in the cable.		○	Contact the manufacturer.	

Daily and periodic inspection

Inspection area	Inspection item		Description	Inspection interval		Corrective action at fault occurrence	Customer's check
				Daily	Periodic *3		
Control circuit Protection circuit	Operation check		(1) Check that the output voltages across phases are balanced while operating the inverter alone.		○	Contact the manufacturer.	
			(2) Check that no fault is found in protective and display circuits in a sequence protective operation test.		○	Contact the manufacturer.	
	Parts check	Overall	(1) Check for unusual odor and discoloration.		○	Stop the equipment and contact the manufacturer.	
			(2) Check for serious rust development.		○	Contact the manufacturer.	
		Aluminum electrolytic Capacitor	(1) Check for liquid leakage in a capacitor and deformation trace.		○	Contact the manufacturer.	
			(2) Visual check and judge by the life diagnosis of the control circuit capacitor.		○		
Cooling system	Cooling fan		(1) Check for unusual vibration and noise.	○		Replace the fan.	
			(2) Check for loose screws and bolts.		○	Fix with the fan cover fixing screws	
			(3) Check for stain.		○	Clean.	
	Heat sink		(1) Check for clogging.		○	Clean.	
			(2) Check for stain.		○	Clean.	
Indication	Indication		(1) Check that display is normal.	○		Contact the manufacturer.	
			(2) Check for stain.		○	Clean.	
	Meter		Check that reading is normal.	○		Stop the equipment and contact the manufacturer.	
Load Motor	Operation check		Check for vibration and abnormal increase in operation noise.	○		Stop the equipment and contact the manufacturer.	

*1 Oil component of the heat dissipation grease used inside the inverter may leak out. The oil component, however, is not flammable, corrosive, nor conductive and is not harmful to humans. Wipe off such oil component.

*2 It is recommended to install a voltage monitoring device for checking the power supply voltage to the inverter.

*3 One to two years of periodic inspection cycle is recommended. However, it differs according to the installation environment. For periodic inspection, consult the nearest Mitsubishi FA Center.

Remark

Continuous use of a leaked, deformed, or degraded smoothing aluminum electrolytic capacitor (as shown in the table above) may lead to a burst, breakage, or fire. Replace such capacitor without delay.

4.2.3 Measurement of main circuit voltage, current, and power

● How to measure the voltage and current of each part

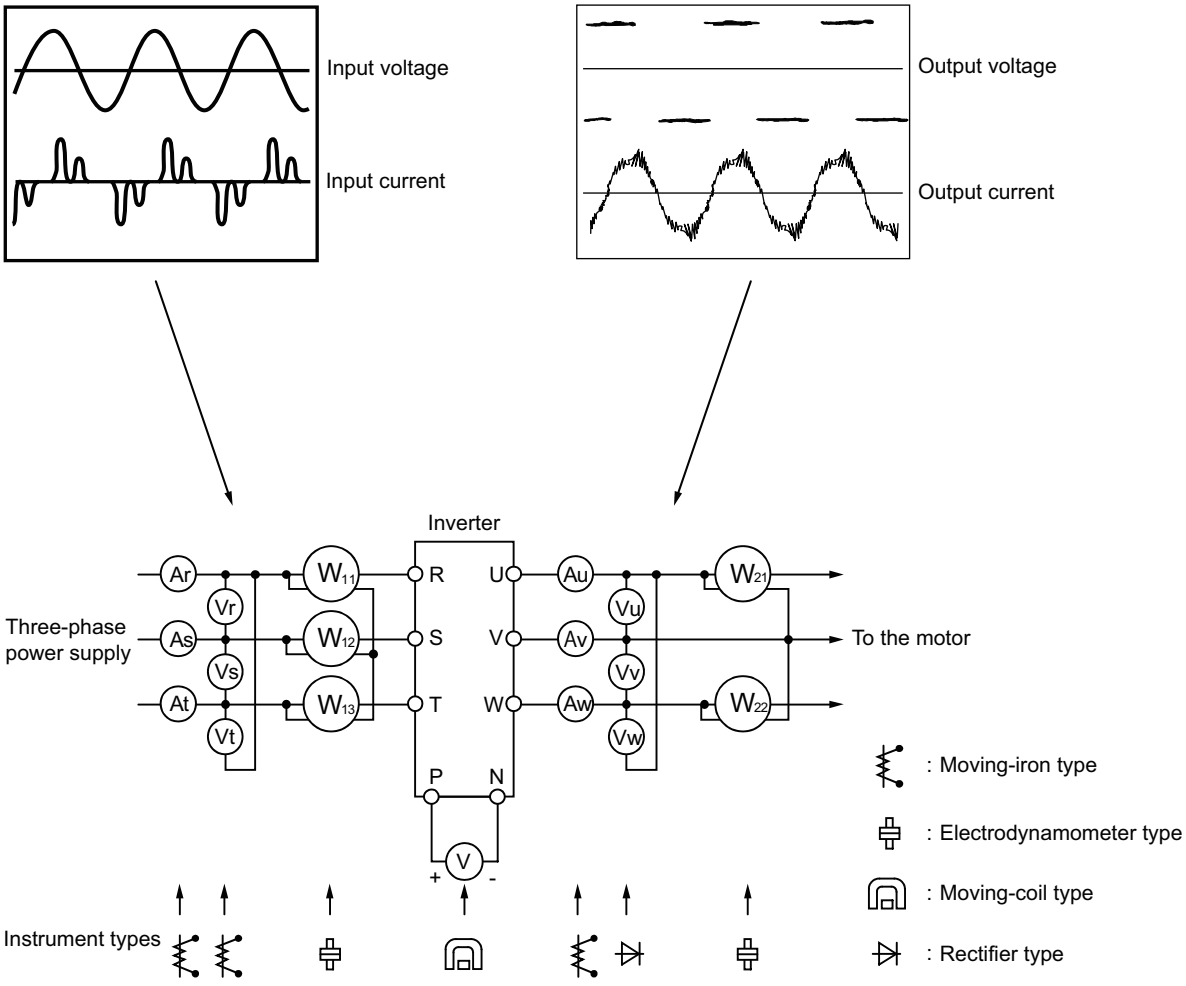
Since the voltages and currents on the inverter power supply and output sides include harmonics, measurement data depends on the circuits measured.

When instruments for commercial frequency are used for measurement, measure the following circuits with the instruments given on the next page.

● When installing meters etc. on the inverter output side

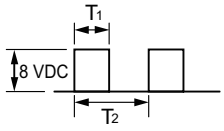
When the inverter-to-motor wiring length is large, especially in the 400 V class, small-capacity models, the meters and CTs may generate heat due to line-to-line leakage current. Therefore, choose the equipment which has enough allowance for the current rating.

When measuring and indicating the output voltage and output current of the inverter, it is recommended to utilize the terminals AM and FM output function of the inverter.



Examples of measuring points and instruments

Measuring points and instruments

Item	Measuring point	Measuring instrument	Remarks (reference measured value)	
Power supply voltage V_1	Across R and S, S and T, T and R	Moving-iron type AC voltmeter *4	Commercial power supply Within permissible AC voltage fluctuation (Refer to the Instruction Manual of the inverter.)	
Power supply side current I_1	R, S, and T line currents	Moving-iron type AC ammeter *4		
Power supply side power P_1	R, S, T and R and S, S and T, T and R	Digital power meter (for inverter) or electrodynamic type single-phase wattmeter	$P_1=W_{11}+W_{12}+W_{13}$ 3-wattmeter method	
Power supply side power factor Pf_1	Calculate after measuring power supply voltage, power supply side current and power supply side power. $Pf_1 = \frac{P_1}{\sqrt{3}V_1 \cdot I_1} \times 100\%$			
Output side voltage V_2	Across U and V, V and W, W and U	Rectifier type AC voltmeter (*1*4) (moving-iron type cannot measure.)	Difference between the phases is within ±1% of the maximum output voltage.	
Output side current I_2	U, V, and W line currents	Moving-iron type AC ammeter (*2*4)	Inverter rated current or lower Difference between the phases is 10% or lower	
Output side power P_2	U, V, W and U and V, V and W	Digital power meter (for inverter) or electrodynamic type single-phase wattmeter	$P_2=W_{21}+W_{22}$ 2-wattmeter method (or 3-wattmeter method)	
Output side power factor Pf_2	Calculate in similar manner to power supply side power factor. $Pf_2 = \frac{P_2}{\sqrt{3}V_2 \cdot I_2} \times 100\ \%$			
Converter output	Across P and N	Moving-coil type (such as tester)	Inverter LED indication ON $1.35 \times V_1$	
Frequency setting signal	Across 2(+) and -5	Moving-coil type (tester and such may be used.) (internal resistance 50 kΩ or more)	0 to 5 VDC / 0 to 10 VDC	"5" is common
	Across 1(+) and -5		0 to ±5 VDC / 0 to ±10 VDC	
	Across 4(+) and -5		4 to 20 mADC	
Frequency setting power supply	Across 10(+) and -5		5 VDC	
	Across 10E(+) and -5		10 VDC	
Frequency meter signal	Across AM(+) and 5		Approximately 10 VDC at maximum frequency (without frequency meter)	
	Across FM(+) and SD		Approximately 5 VDC at maximum frequency (without frequency meter)  Pulse width T1: Adjust M310 (Pr.900) Pulse cycle T2: Set with M040 (Pr.55) (frequency monitor only)	SD is common
Start signal Select signal	Across SD and the following: STF, STR, RH, RM, RL, JOG, RT, AU, STOP, CS (+)		When open 20 to 30 VDC ON voltage: 1 V or less	
Reset signal	Across RES (+) and SD			
Output stop signal	Across MRS (+) and SD			

Measuring points and instruments

Item	Measuring point	Measuring instrument	Remarks (reference measured value)
Alarm signal	Across A and C Across B and C	Moving-coil type (such as tester)	Conduction check (∗3) Across A and C: <Normal> No conduction, <Abnormal> Conduction Across B and C: <Normal> Conduction, <Abnormal> No conduction

∗1 Use an FFT to measure the output voltage accurately. A tester or general measuring instrument cannot measure accurately.

∗2 When the carrier frequency exceeds 5 kHz, do not use this instrument since using it may increase eddy current losses produced in metal parts inside the instrument, leading to burnout. In this case, use an approximate-effective value type.

∗3 When the setting of M405 (Pr.195) ABC1 terminal function selection is the positive logic

∗4 A digital power meter (designed for inverter) can also be used to measure.

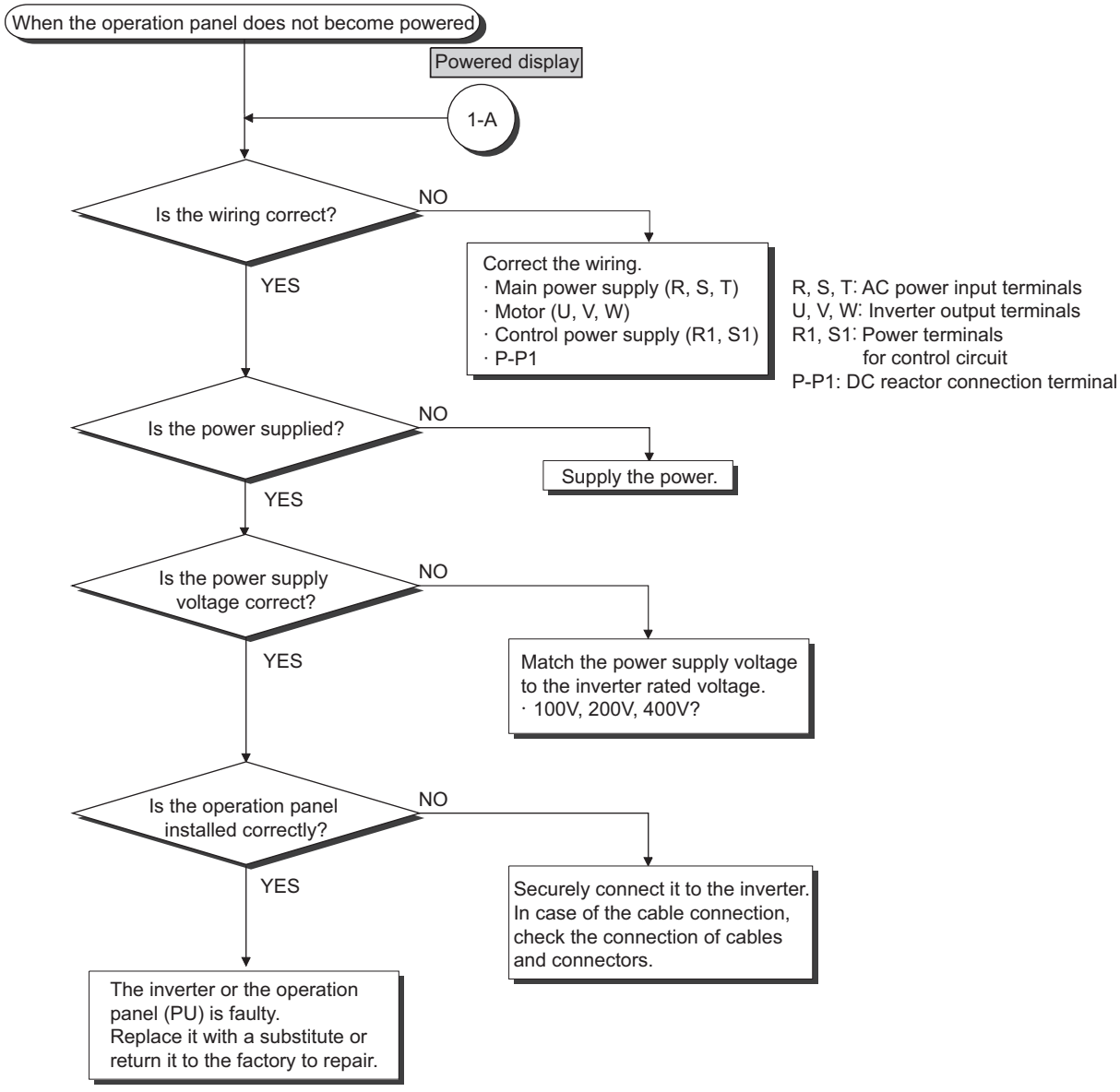
CHAPTER 5 BREAKDOWN MAINTENANCE

Troubles can be caused by failures or accidents even though preventive maintenance is performed. If the inverter becomes faulty by any unexpected reason and the production system stops, breakdown maintenance is required.

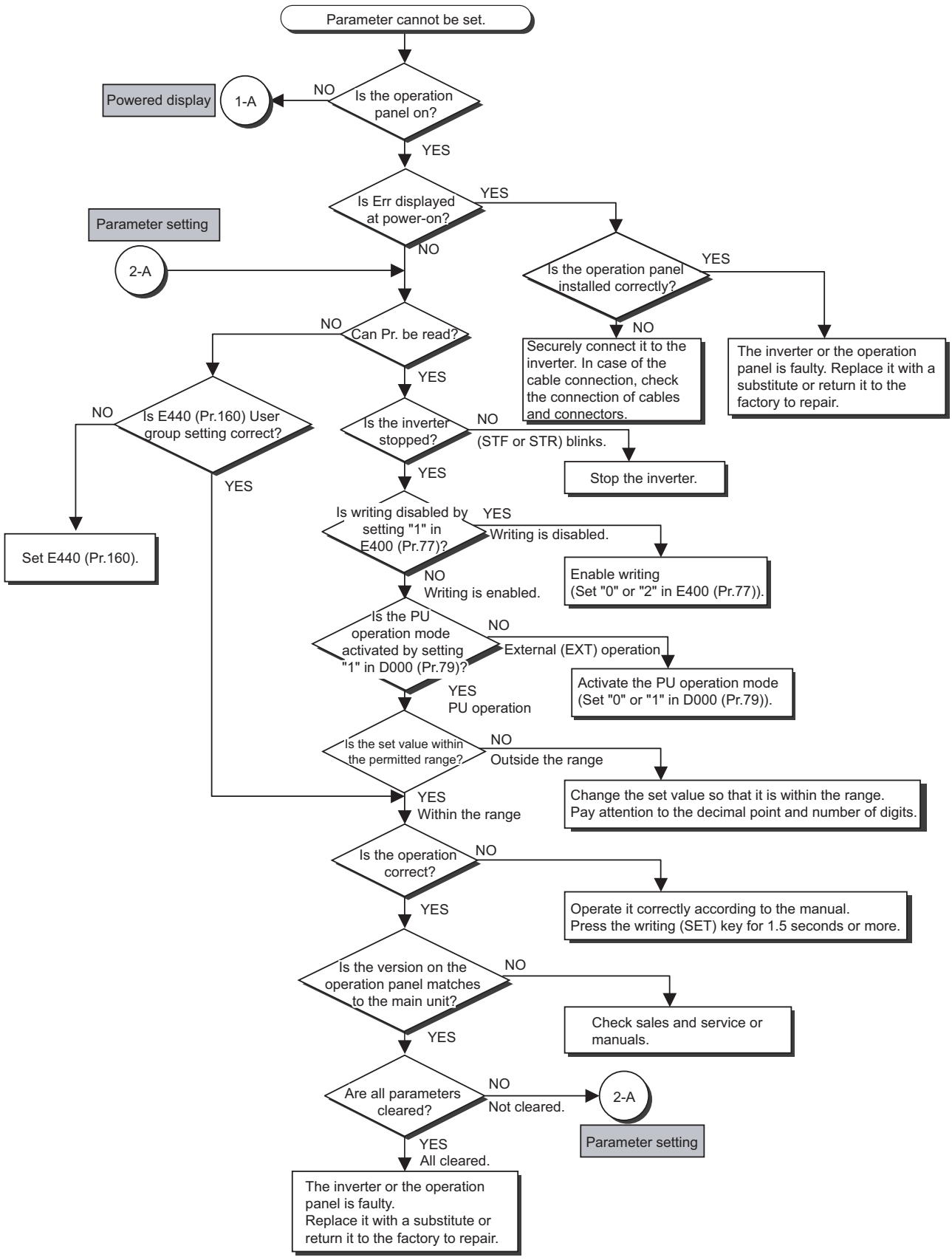
5.1 Troubleshooting

The troubleshooting flowcharts for each phenomenon are shown below. Perform an appropriate troubleshooting depending on the trouble. "Pr." in the troubleshooting flowcharts indicates the parameter. For example, "Pr.0" indicates the parameter No. 0. A four-digit value starting with an alphabet indicates the functional group parameter number.

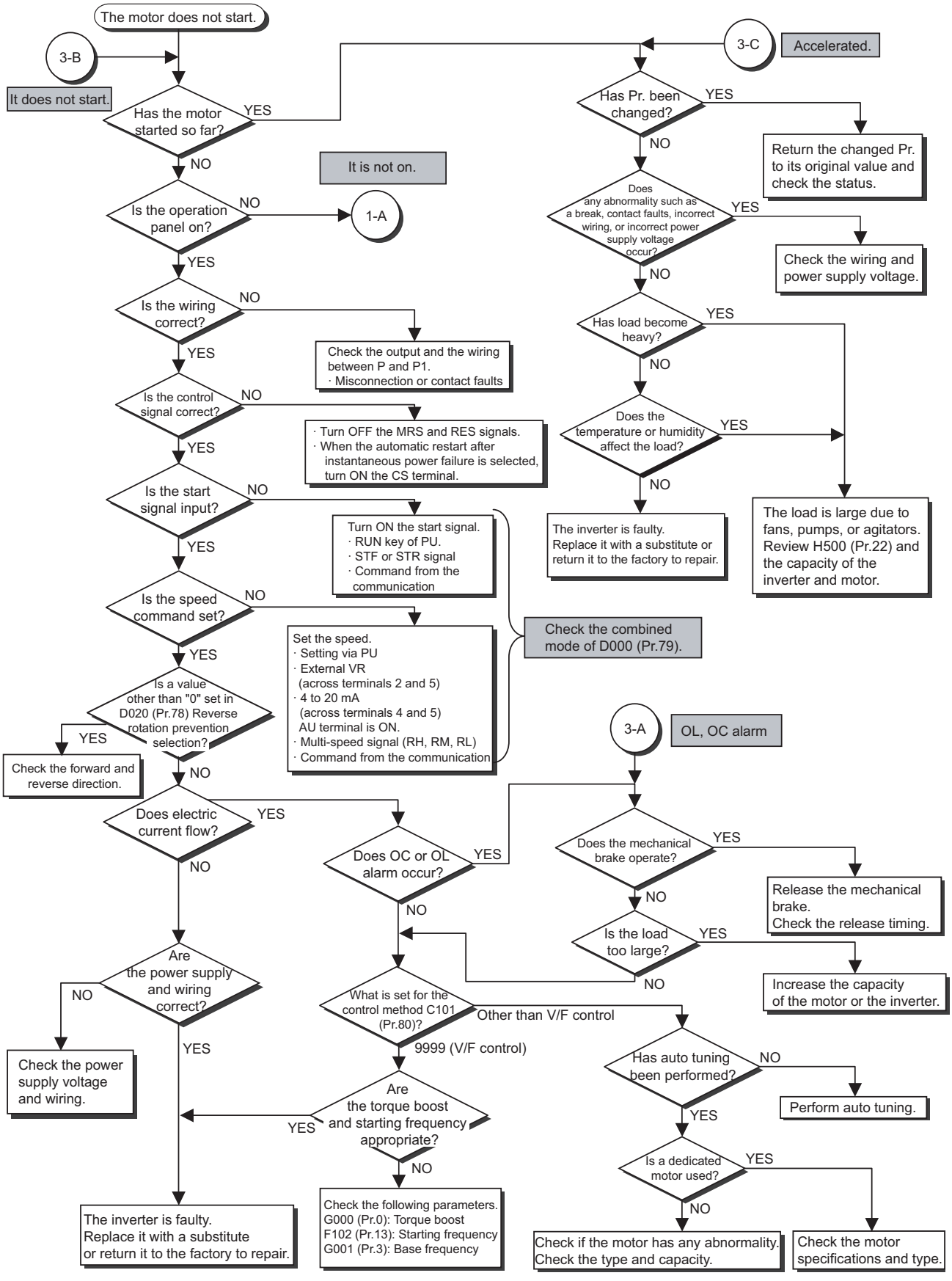
5.1.1 When the operation panel does not display the energization



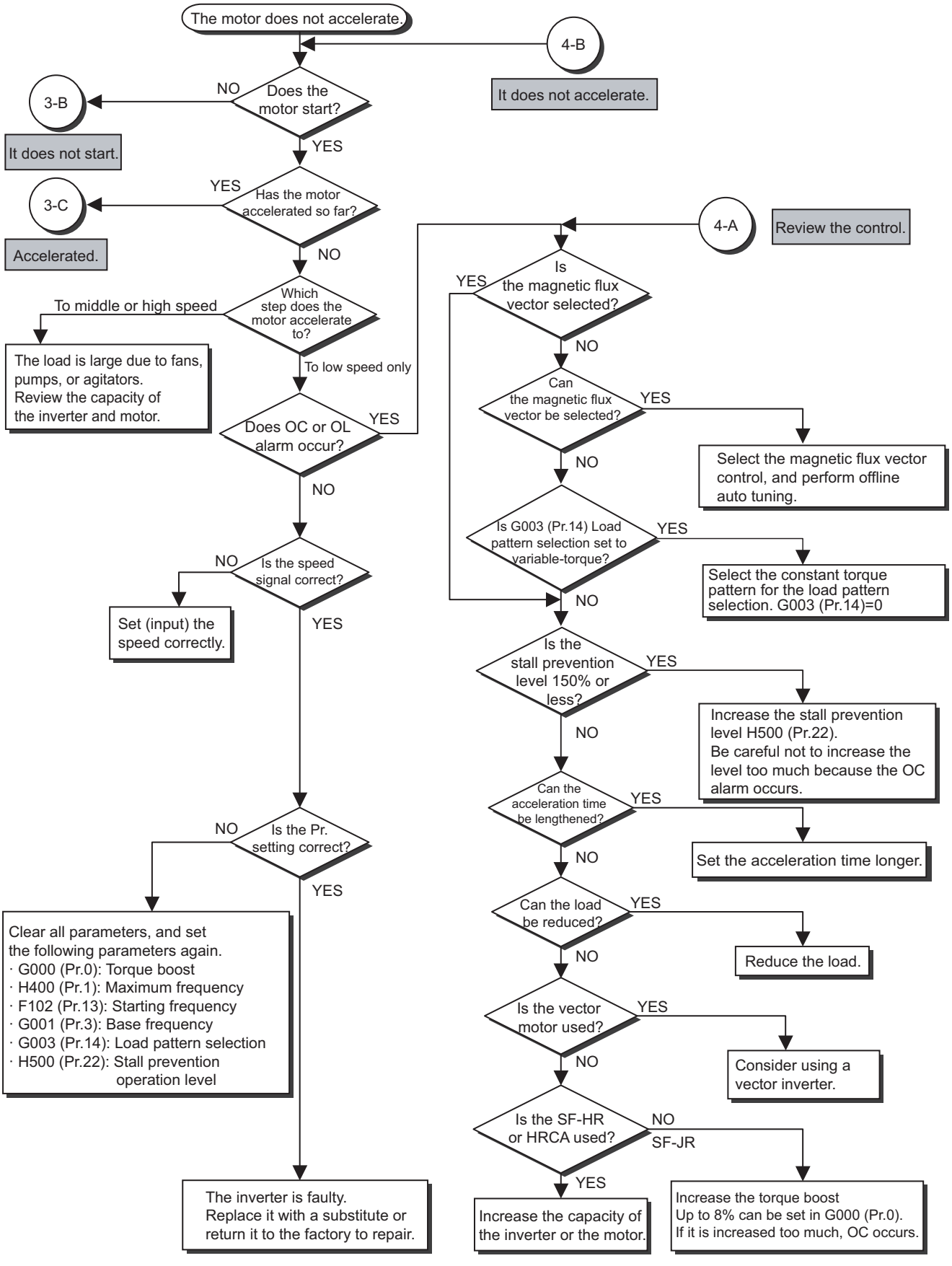
5.1.2 When parameters cannot be set



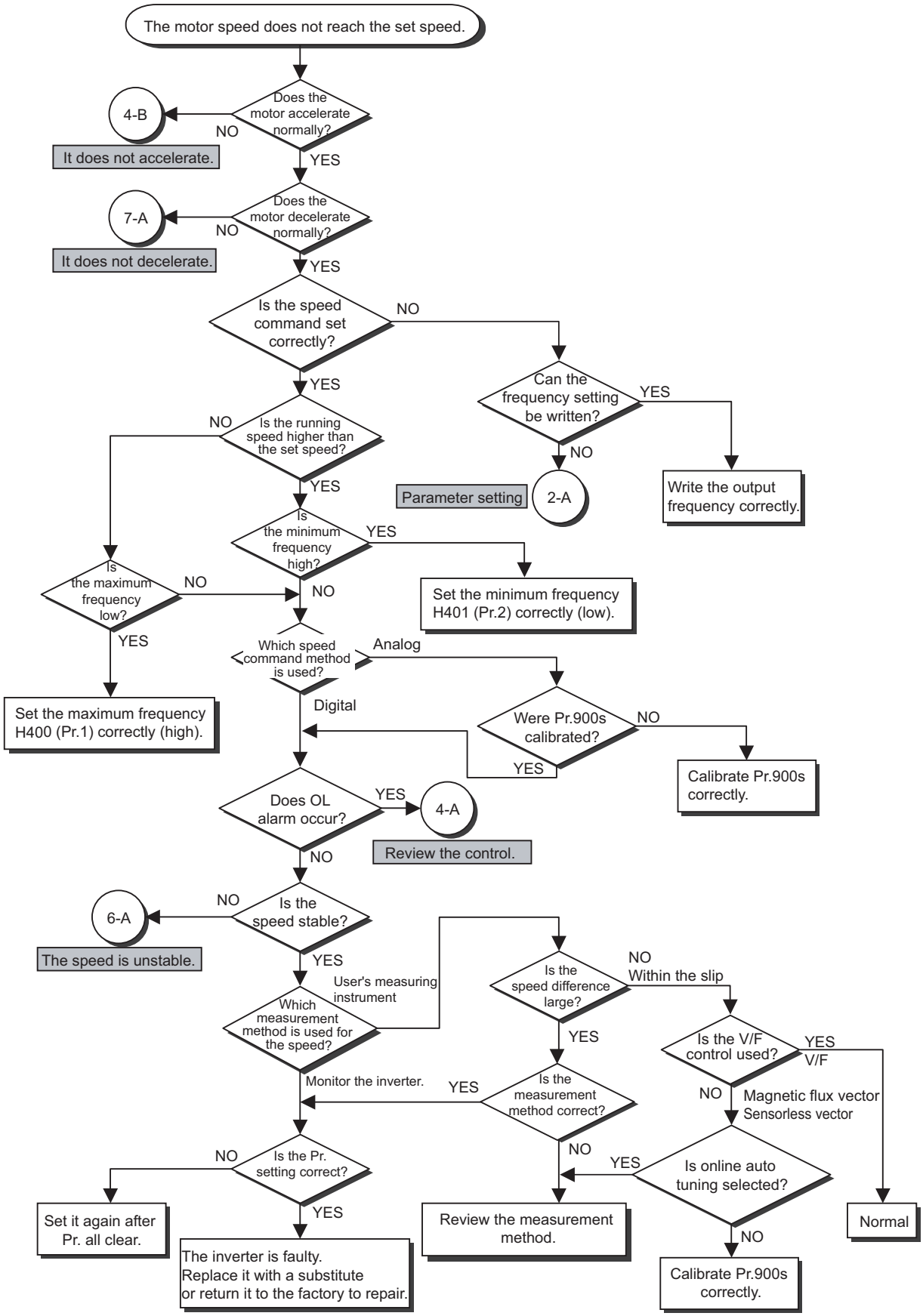
5.1.3 When the motor does not start



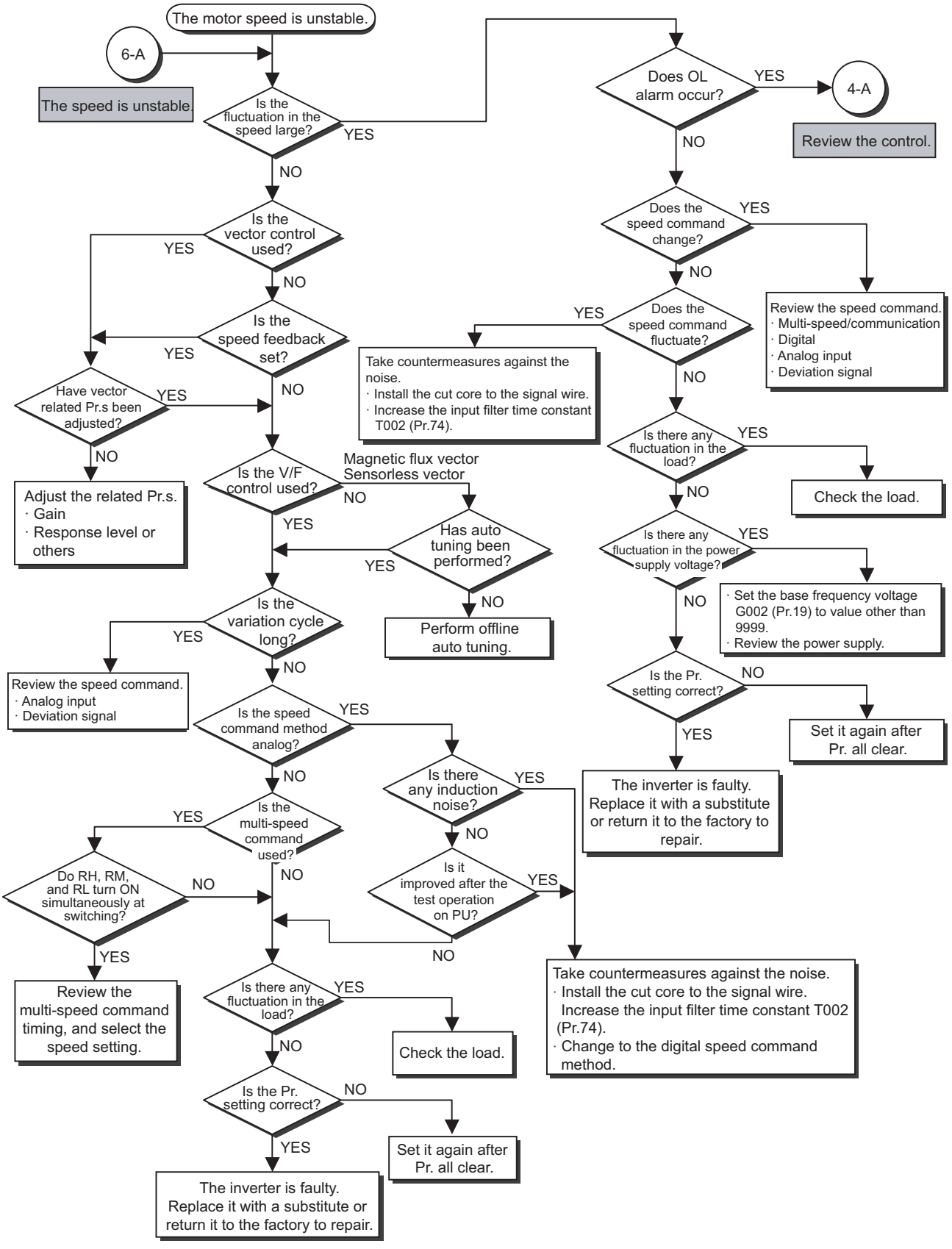
5.1.4 When the motor does not accelerate



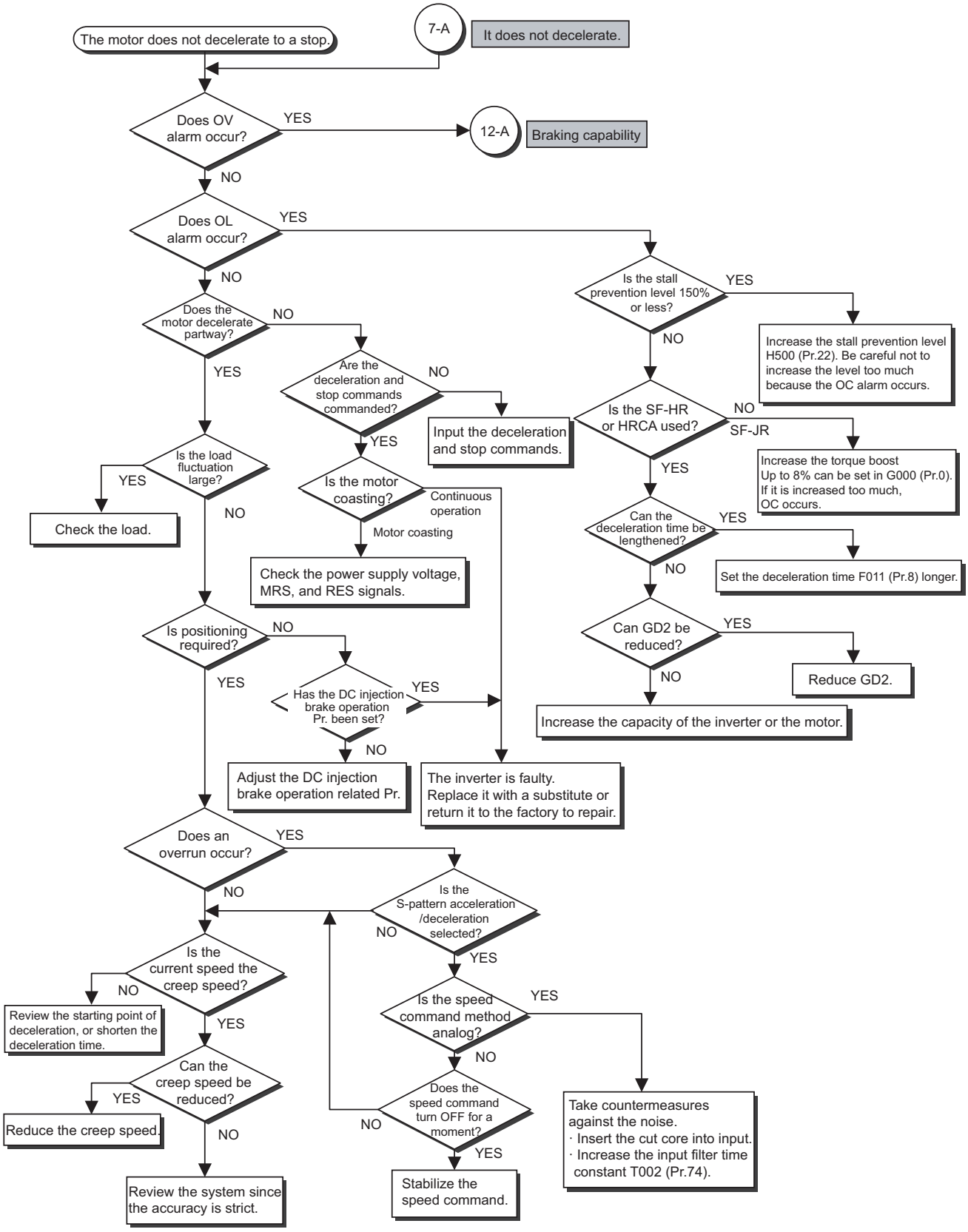
5.1.5 When the motor speed does not become the set speed



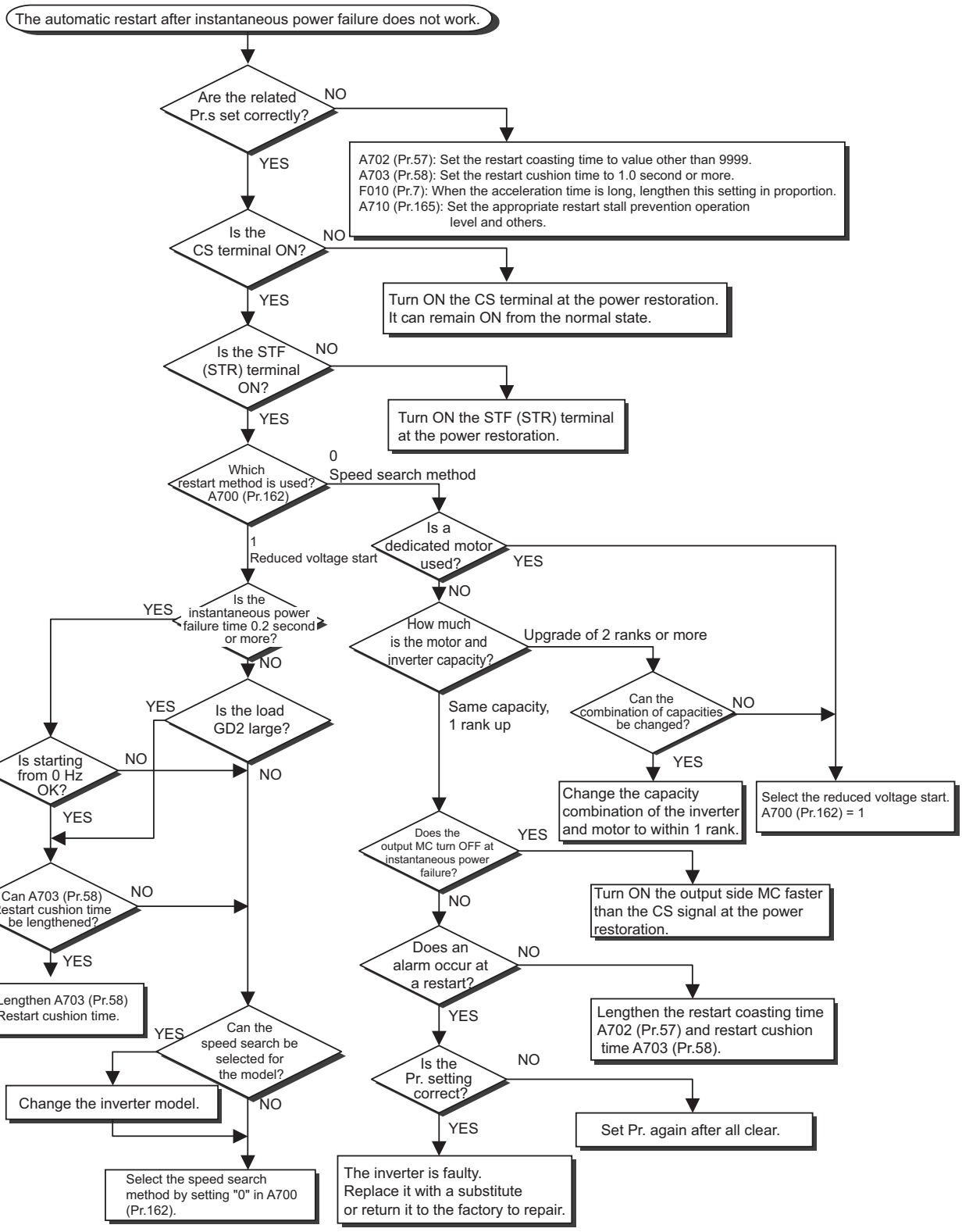
5.1.6 When the motor speed is unstable



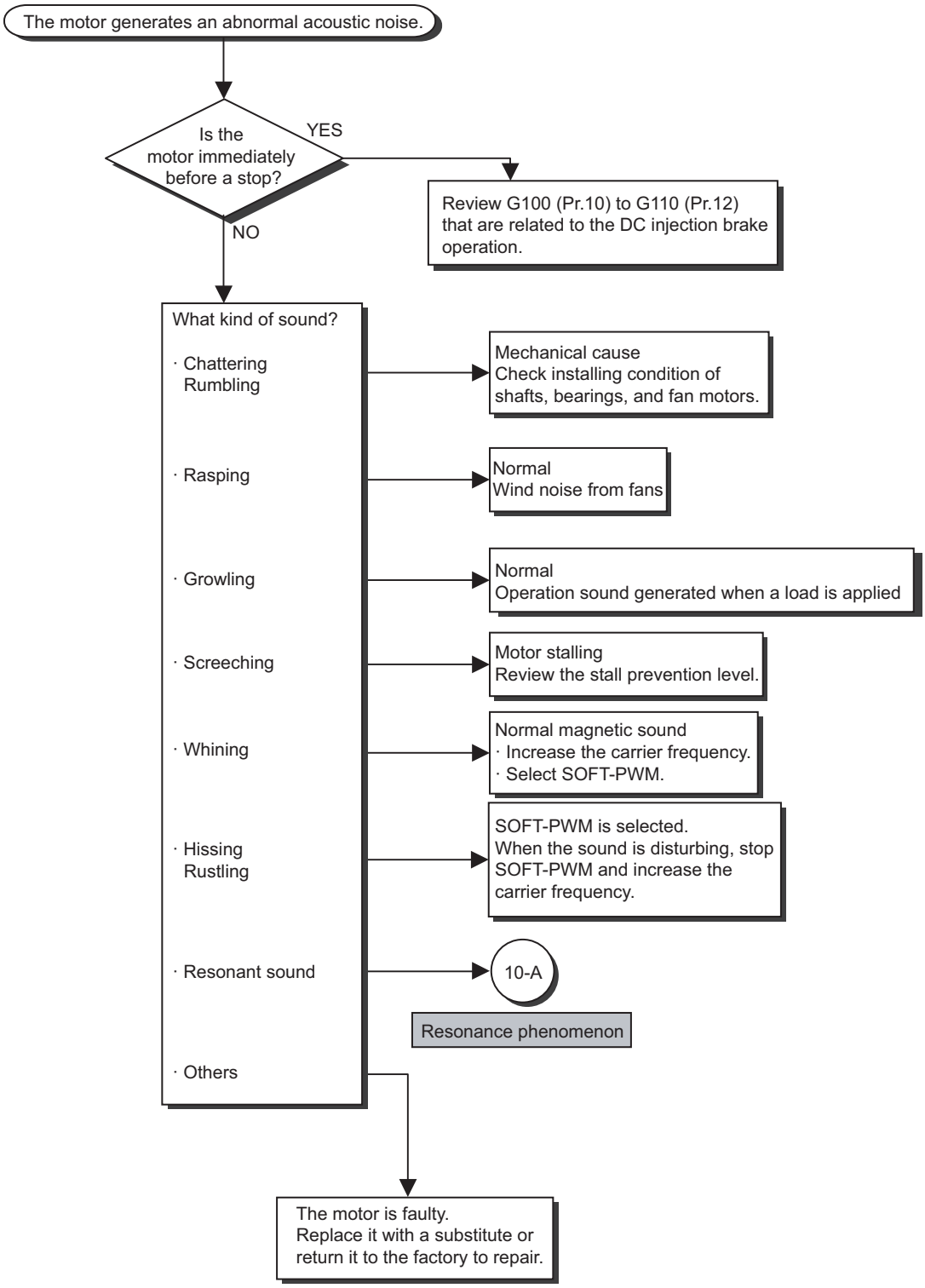
5.1.7 When the motor does not accelerate



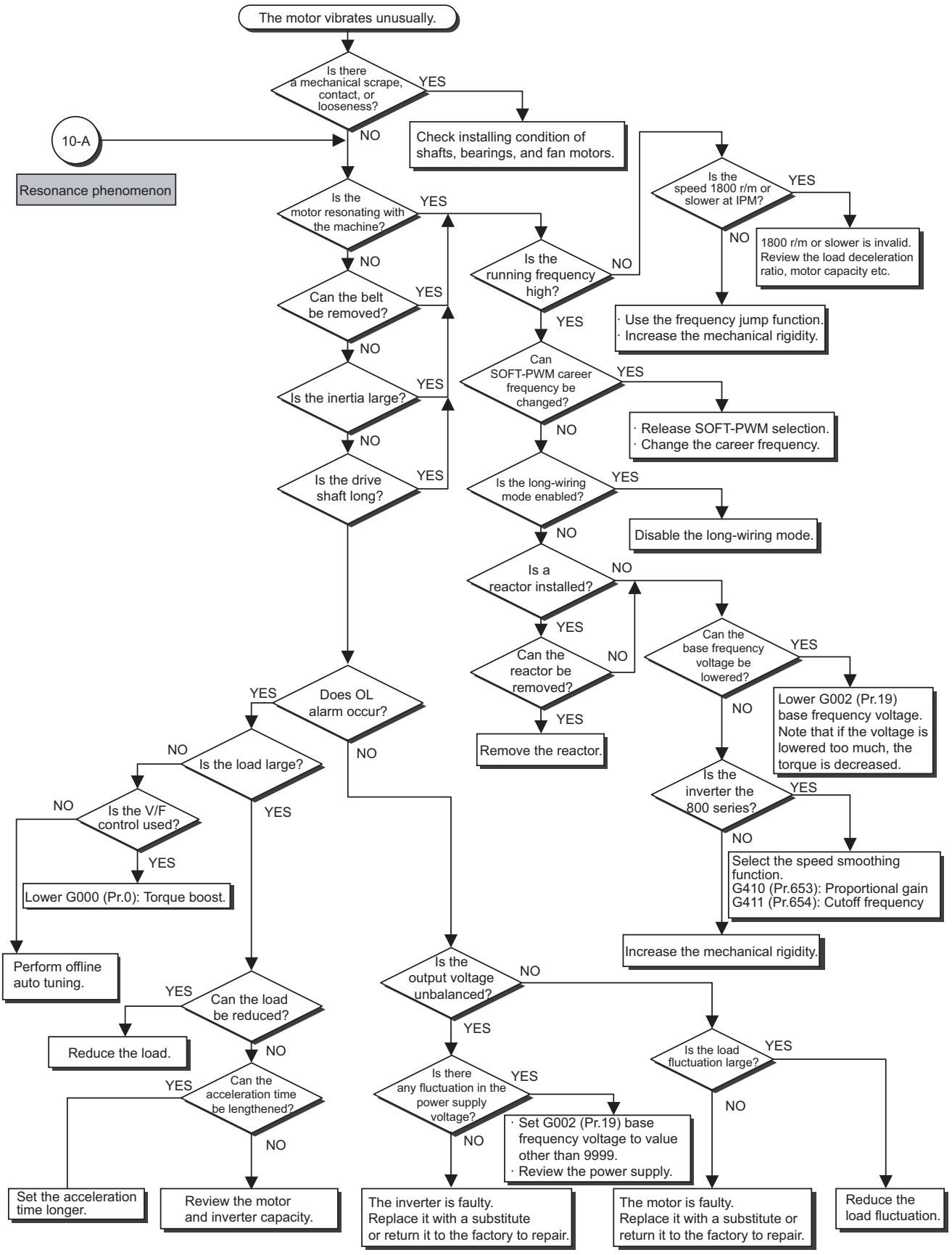
5.1.8 When automatic restart after instantaneous power failure does not work



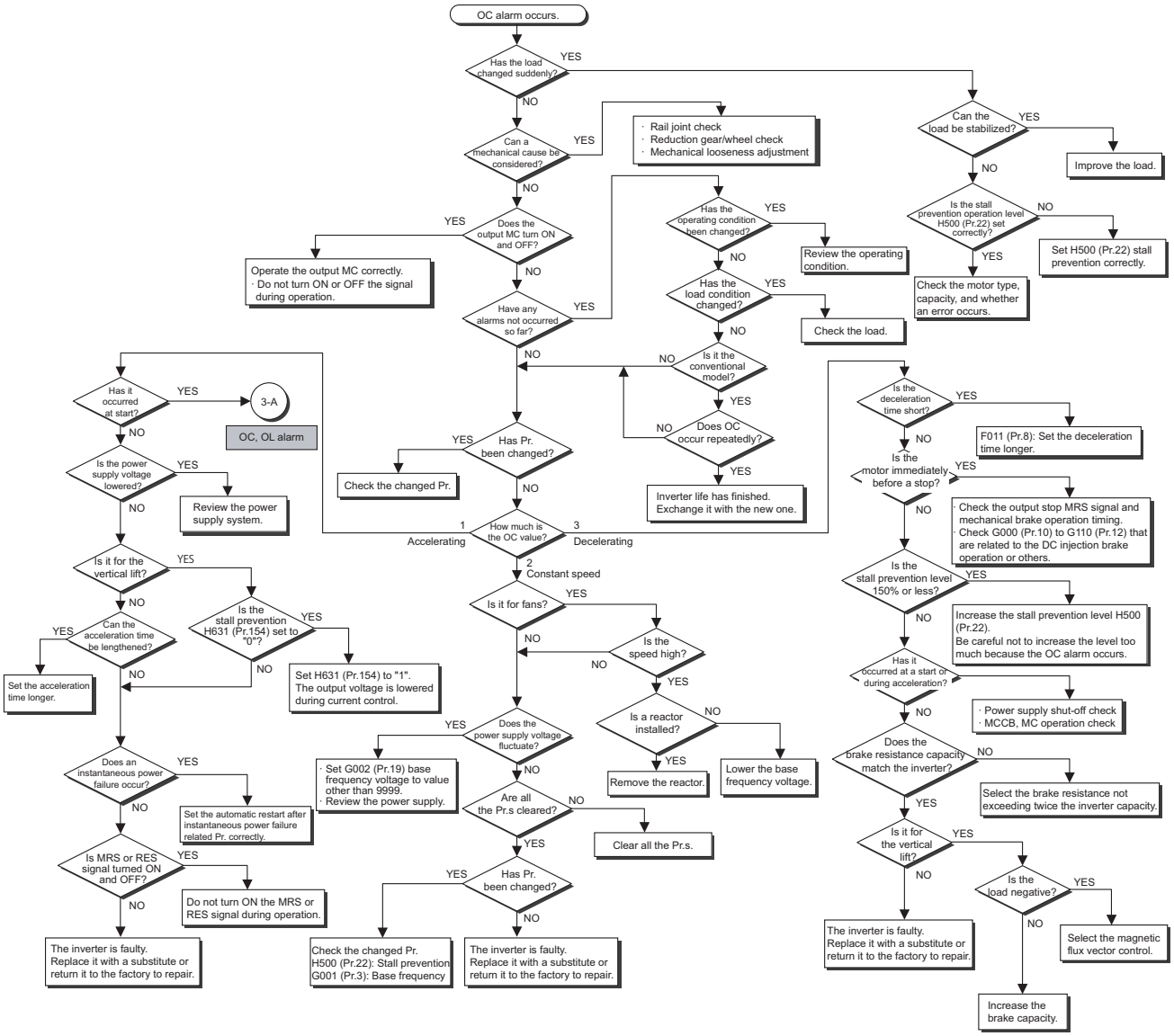
5.1.9 When abnormal noise is generated from the motor



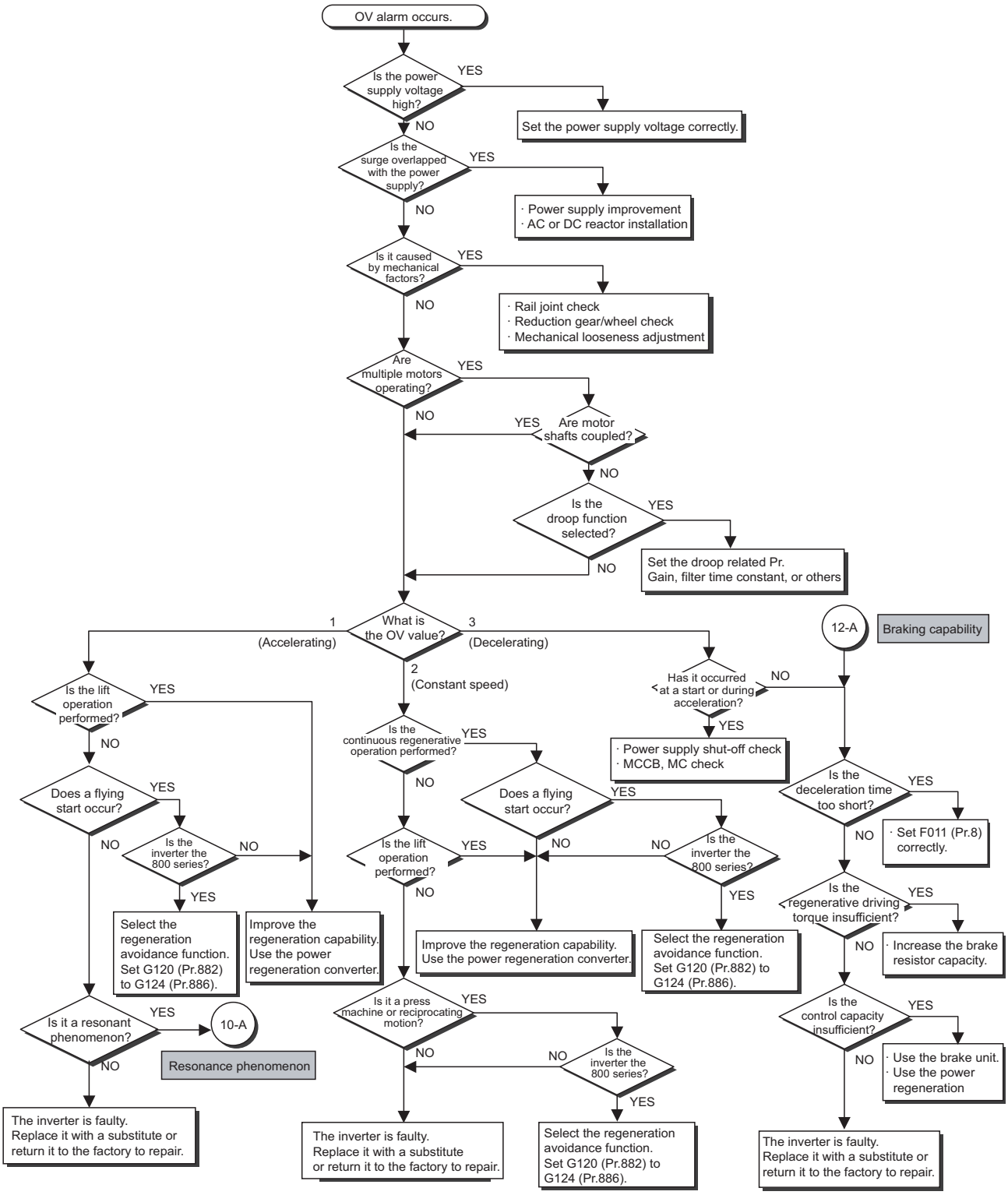
5.1.10 When the motor vibrates abnormally



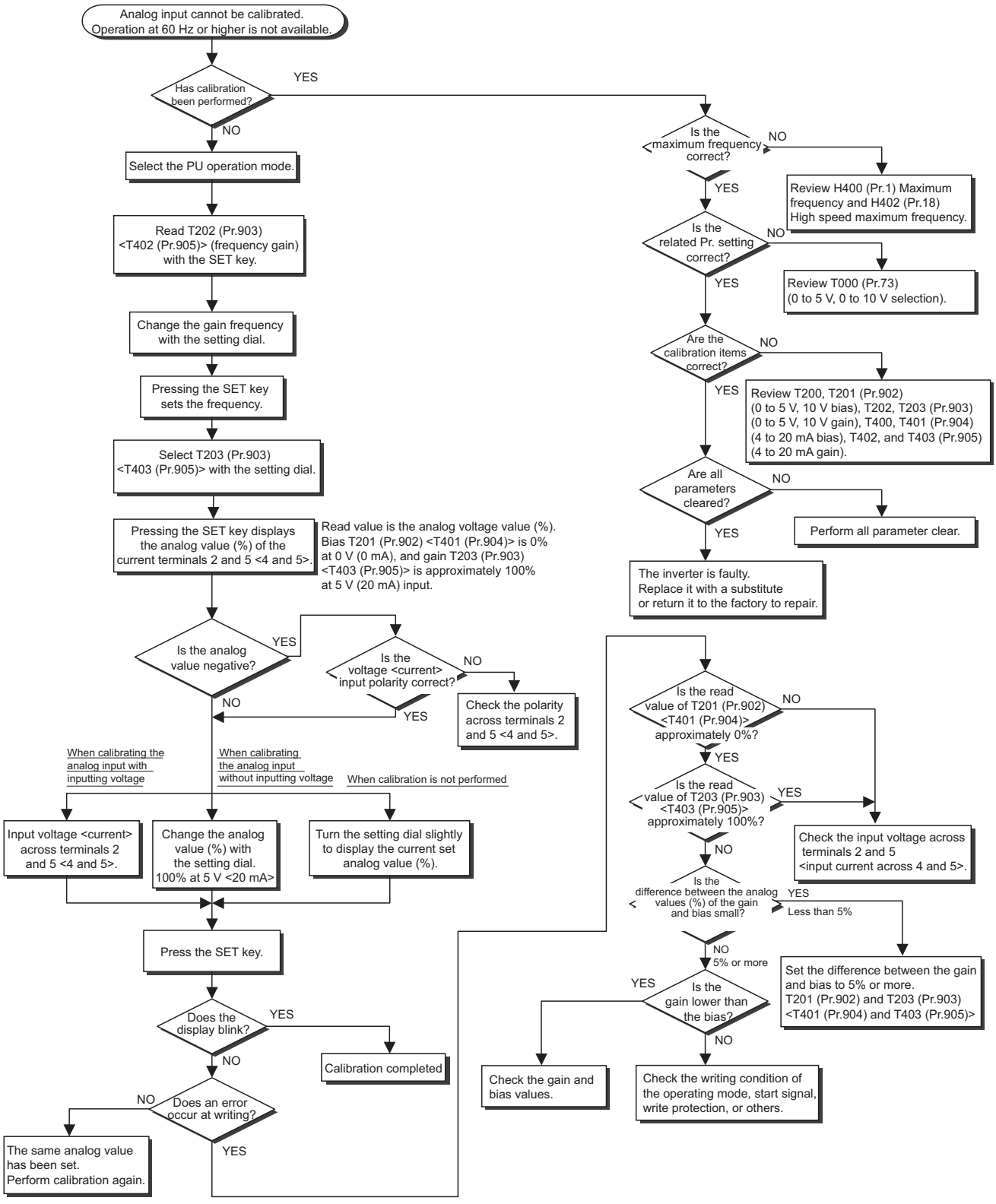
5.1.11 When OC alarm occurs



5.1.12 When OV alarm occurs



5.1.13 When analog input cannot be calibrated (When adjusting gains T203 (Pr.903) and T403 (Pr.905))



5.2 Troubleshooting by the demonstration machine

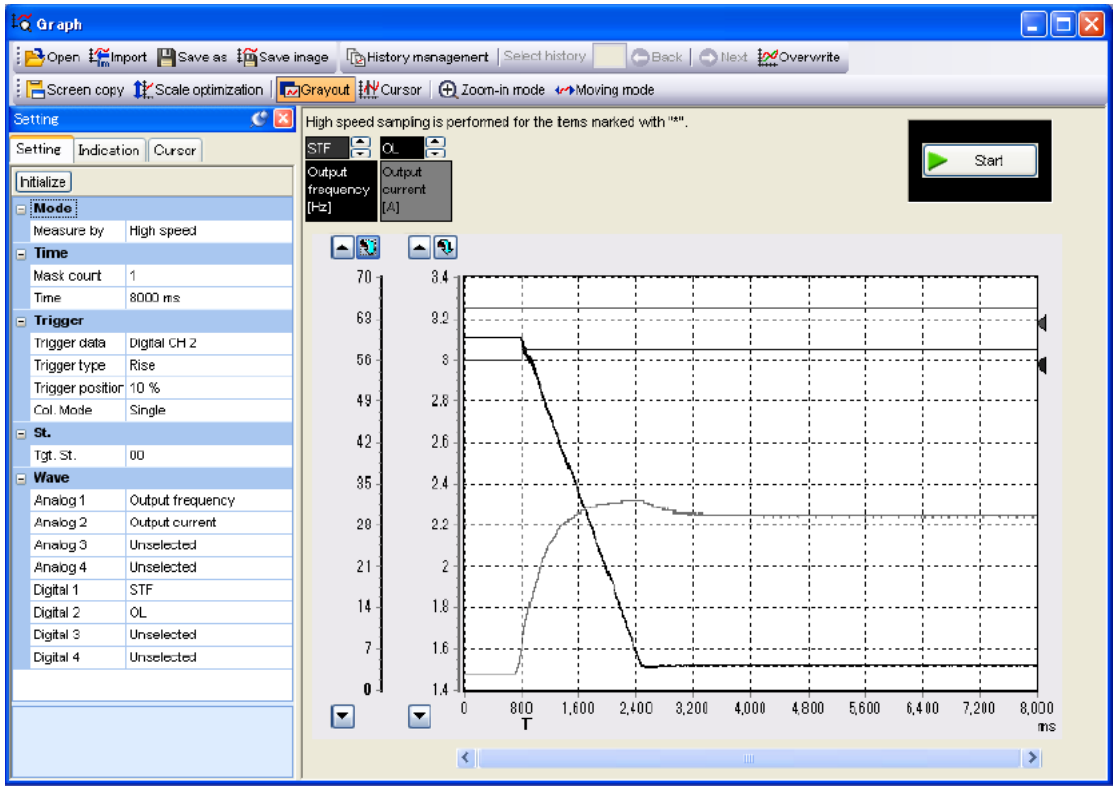
Perform troubleshooting using the demonstration machine.
Check the symptom and take measures following the described procedures for operation.

5.2.1 Stall prevention (overcurrent) (OL display) [Demonstration]

Change H500 (Pr.22) (Stall prevention operation level) from the initial value "150%" to "45%", and turn ON STF and high speed RH. Turn the potentiometer of the load setting to the right as far as it goes after 60 Hz is displayed. Run the inverter with the load ON at load torque 150%. Confirm that the OL display appears and the motor stops.

(1) Corrective action

1) Use FR Configurator2 to check the output current value.



2) Check that the stall prevention (overcurrent) (OL display) occurs when the value is higher than the current value that is set in H500 (P.22).
(Check that output current is equal to the rated current (5A) × stall prevention operation level that is set (%).)

Task 1 Change H500 (Pr.22) (Stall prevention operation level) and obtain the threshold for OL display.

Task 2 Adjust the potentiometer of the load setting, and obtain the setting value that triggers the stall prevention (overcurrent) (OL display).

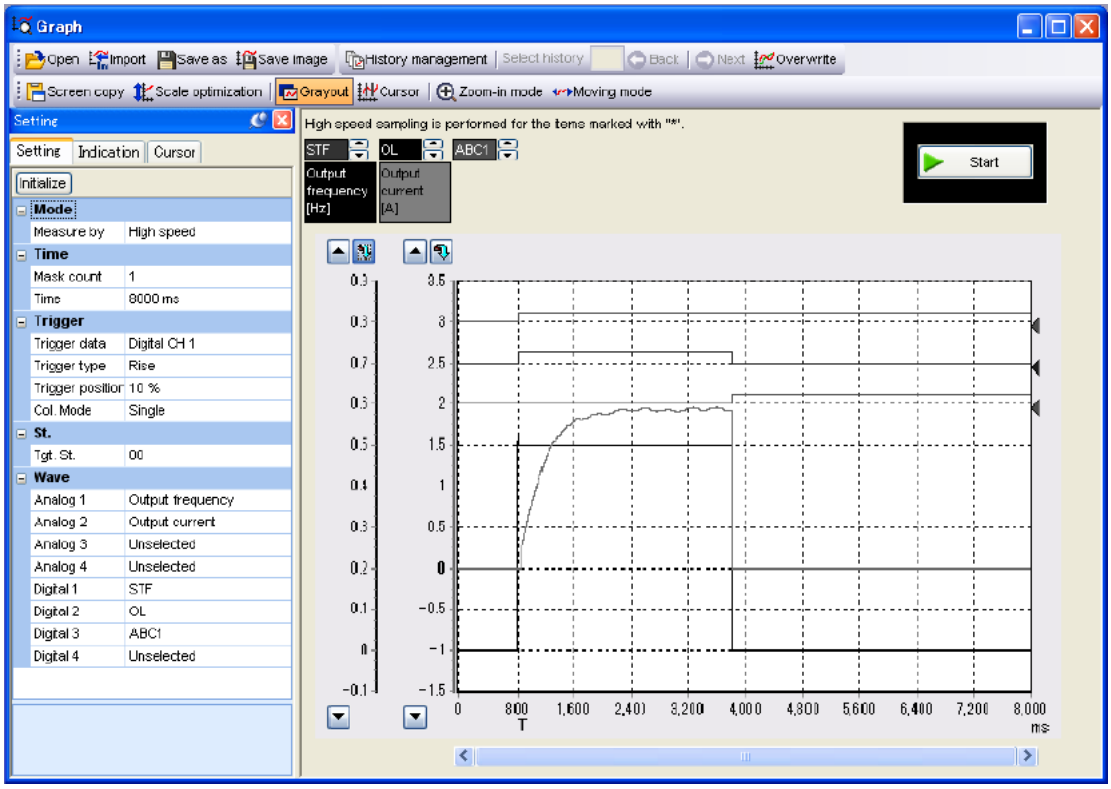
5.2.2 Stall prevention stop (E.OLT display) [Demonstration]

Check that the stall prevention stop (E.OLT display) occurs.

Change H500 (Pr.22) (Stall prevention operation level) from the initial value "150%" to "10%", and turn ON STF and high speed RH. Check that E.OLT is displayed in 3 or 4 seconds.

(1) Corrective action

1) Use FR Configurator2 to check the output current value.



2) Check that the stall prevention stop (E.OLT display) occurs at the output current value lower than usual.

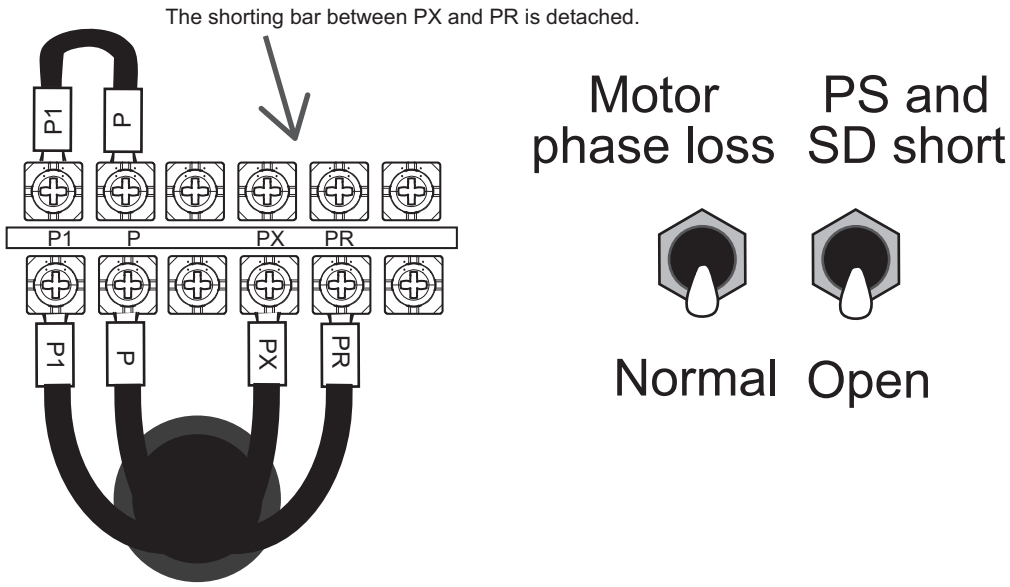
Task 1 Change H500 (Pr.22) (Stall prevention operation level) and obtain the setting value at which the stall prevention stop (overcurrent) (E.OLT display) occurs.

●●●After the demonstration●●●

Reset H500 (Pr.22) (Stall prevention operation level) to the initial value "150%".

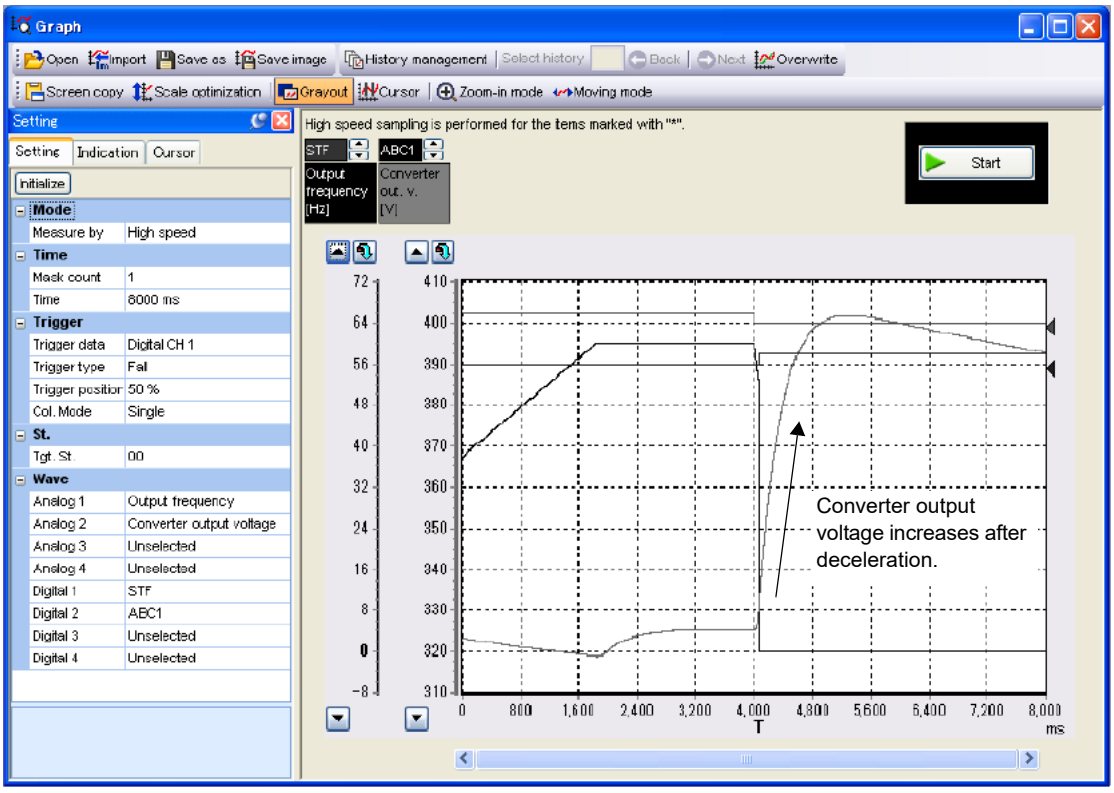
5.2.3 Regenerative overvoltage trip during deceleration (E.OV3 display) [Demonstration]

Change F011 (Pr.8) (Deceleration time) from the initial value "5" to "1" second and turn ON STF and high speed RH. Turn OFF STF after 60 Hz is displayed and check that E.OV3 is displayed.
The shorting bar between PX and PR on the terminal block on the rear side of the demonstration machine is removed.



(1) Corrective action

1) Use FR Configurator2 to measure the timing when regenerative overvoltage trip during deceleration (E.OV3 display) occurs, and the level of the converter output voltage.
Set the trigger position to 50%.



Task 1 Change F011 (Pr.8) (Deceleration time) and obtain the setting value at which E.OV3 is displayed, and the level of the converter output voltage.

Task 2 When F011 (Pr.8) (Deceleration time) is increased, the display changes from E.OV3 to OL warning. Obtain the setting value at which the display changes and the level of the converter output voltage.

Task 3 Turn the potentiometer to the right with the load setting ON, and compare the changes on the levels of tasks 1 and 2.

●●●**After the demonstration**●●●

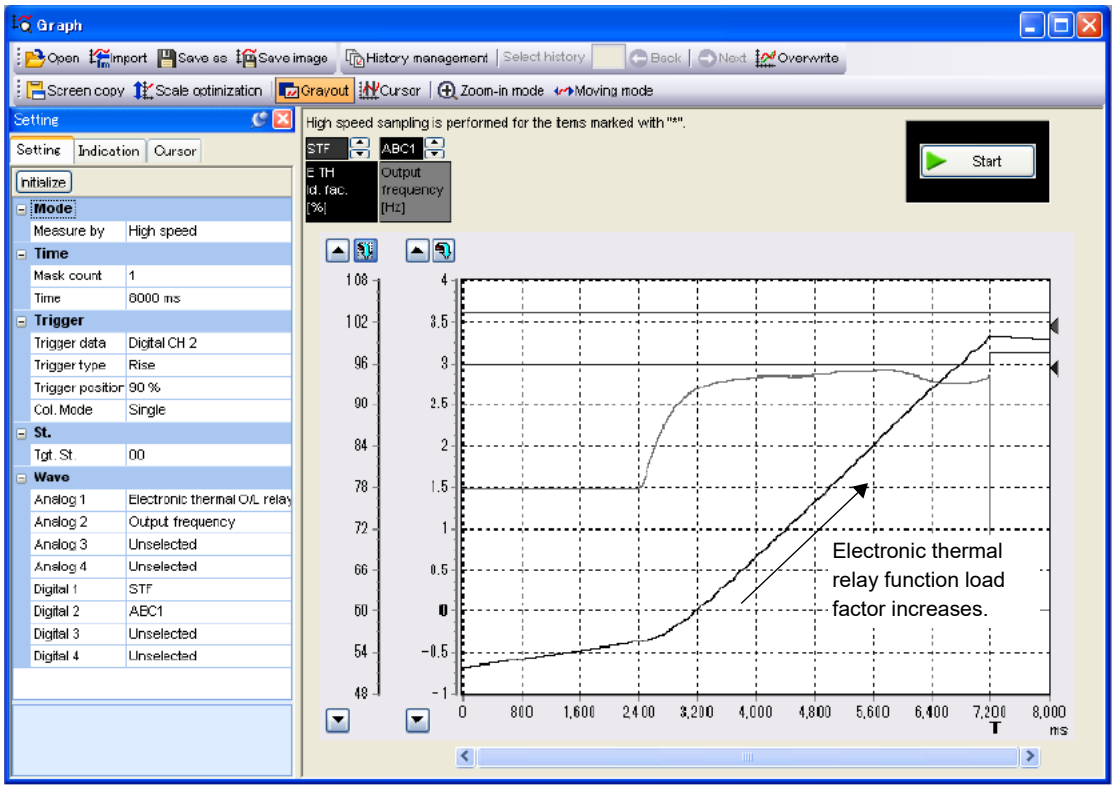
Reset F011 (Pr.8) (Deceleration time) so that no warning or error occurs.

5.2.4 Electronic thermal O/L relay pre-alarm (TH display) and motor overload trip (electronic thermal O/L relay) (E.THM display) [Demonstration]

Change H000 (Pr.9) (Electronic thermal O/L relay) from "2.0" (setting value of the electronic thermal O/L relay for the demonstration machine) to "1.00". Turn ON STF and high speed RH, and turn the potentiometer of the load setting to the right as far as it goes after 60 Hz is displayed. Run the inverter with the load ON at load torque 150%. Check that TH is displayed in approximately 30 seconds and E.THM is displayed in approximately 50 seconds, and that the motor is coasting.

(1) Corrective action

1) Use FR Configurator2 to measure the output current value when the electronic thermal O/L relay pre-alarm (TH display) and the motor overload trip (Electronic thermal O/L relay) (E.THM display) occurred.
Set the trigger position to 90%.



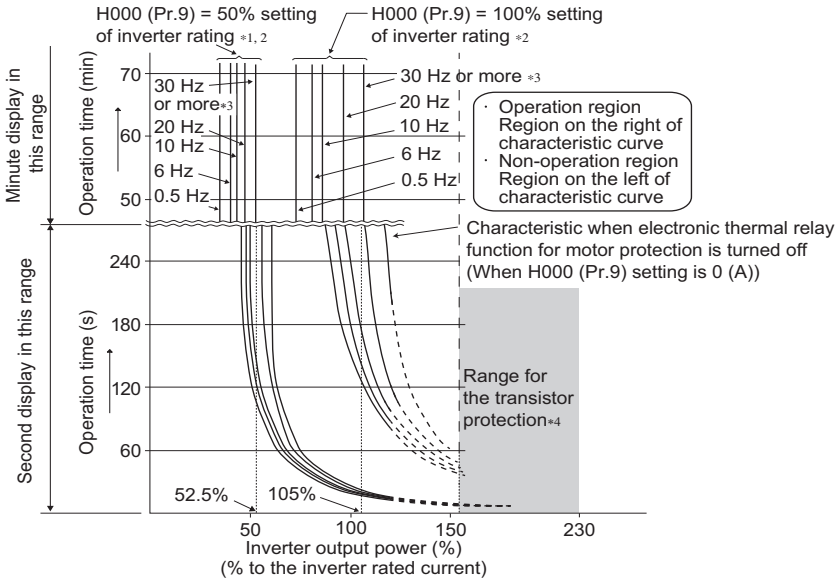
Task 1 Change H000 (Pr.9) (Electronic thermal O/L relay) and compare the output current values and timings when E.THM is displayed.

●●●After the demonstration●●●

Reset H000 (Pr.9) (Electronic thermal O/L relay) to "2.0" (setting value of the electronic thermal O/L relay for the demonstration machine).

POINT

Electronic thermal O/L relay operation characteristic (THM)



This function detects the overload (overheat) of the motor and stops the operation of the output transistor in the inverter to stop the output. (The operation characteristic is shown on the left.)

- Set the rated current value of the motor (A) in H000 (Pr.9).
  (If the motor has both 50 Hz and 60 Hz ratings and G001 (Pr.3) Base frequency is set to "60 Hz", set the 60 Hz rated motor current multiplied by 1.1 times.)
- Set "0" in H000 (Pr.9) to avoid activating the electronic thermal O/L relay; for example, when using an external thermal relay for the motor. (Note that the output transistor protection of the inverter is activated. (E.THT))

*1 When 50% of the inverter rated current (current value) is set in H000 (Pr.9.)

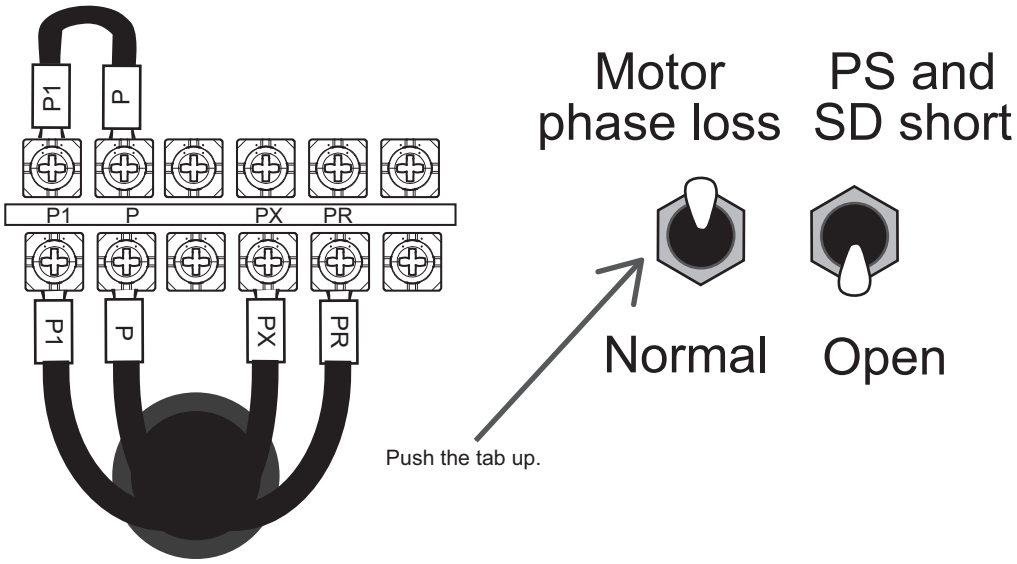
*2 The % value denotes the percentage to the inverter rated current. It is not the percentage to the rated motor current.

*3 When the electronic thermal O/L relay function dedicated to the Mitsubishi constant-torque motor is set, this characteristic curve applies to operation at 6 Hz or higher.

*4 Transistor protection is activated depending on the temperature of the heat sink. The protection may be activated even with less than 150% depending on the operating conditions.

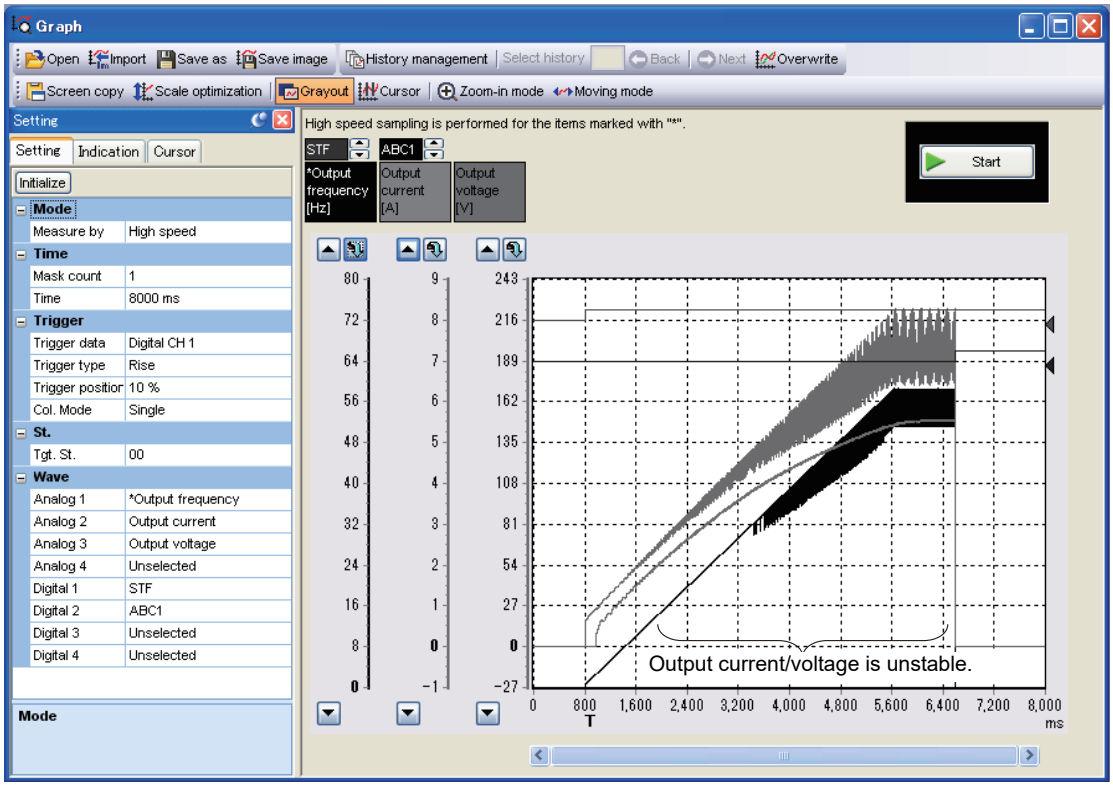
5.2.5 Output phase loss (E.LF display) [Demonstration]

Check that E.LF is displayed in a few minutes due to the U phase loss after switching the left switch on the rear side to the motor phase loss side and turning ON STF and high speed RH.



(1) Corrective action

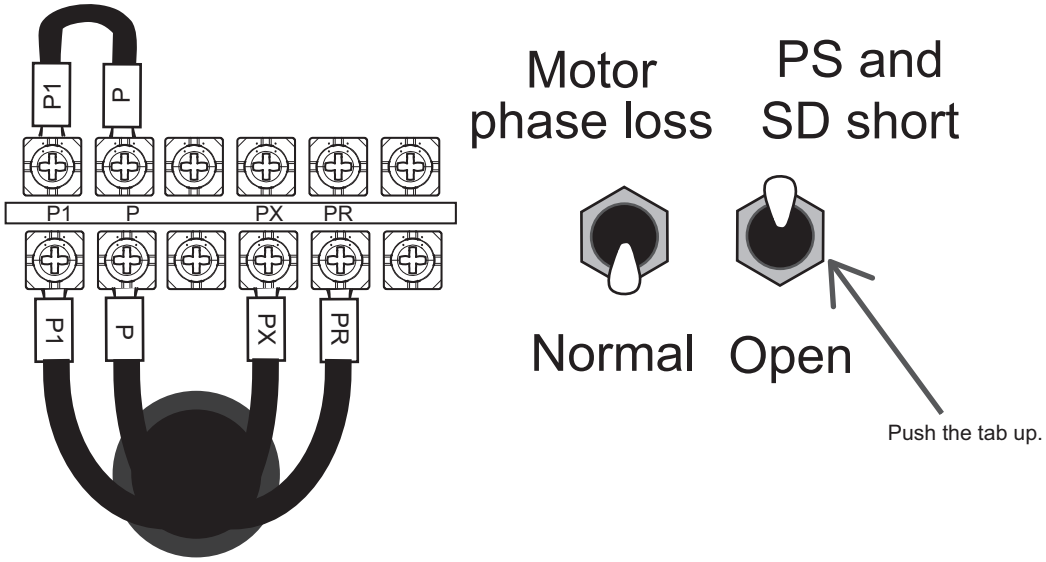
1) Use FR Configurator2 to check the output voltage and output current, and to compare them with the normal values.



2) Switch the Motor phase loss/Normal switch on the rear side of the demonstration machine to Normal.

5.2.6 24 VDC power output short circuit (E.P24 display) [Demonstration]

Switch the right switch on the rear side to PC-SD short circuit, and check that E.P24 is displayed immediately.



(1) Corrective action

1) Switch the PC-SD short circuit/Release switch on the rear side of the demonstration machine to Release.
2) Turn OFF/ON the power supply MCCB of the demonstration machine and check that the display of the 24 VDC power output short circuit (E.P24 display) is cleared.

5.2.7 Error (Err. display) [Demonstration]

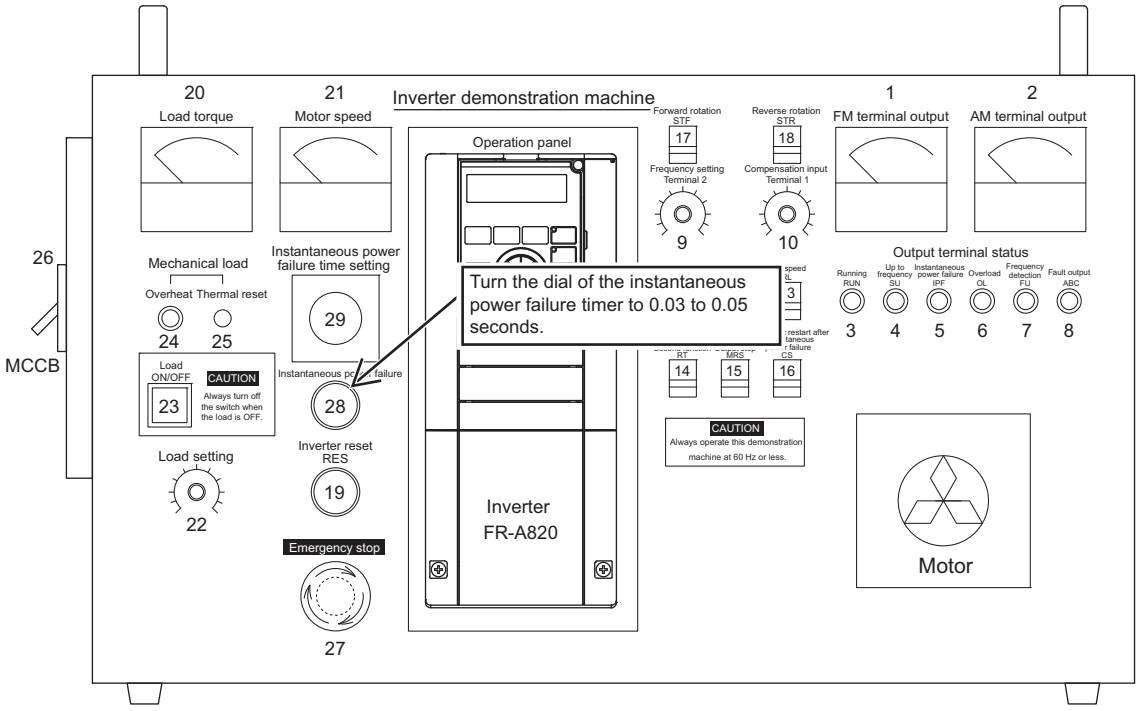
Press and hold the RESET button while ON, and check that Err. display blinks.

(1) Corrective action

1) Use FR Configurator2 to check that the error signal is ON.
2) Press the inverter reset RES button of the demonstration machine, and release the RESET button to turn OFF the error signal.

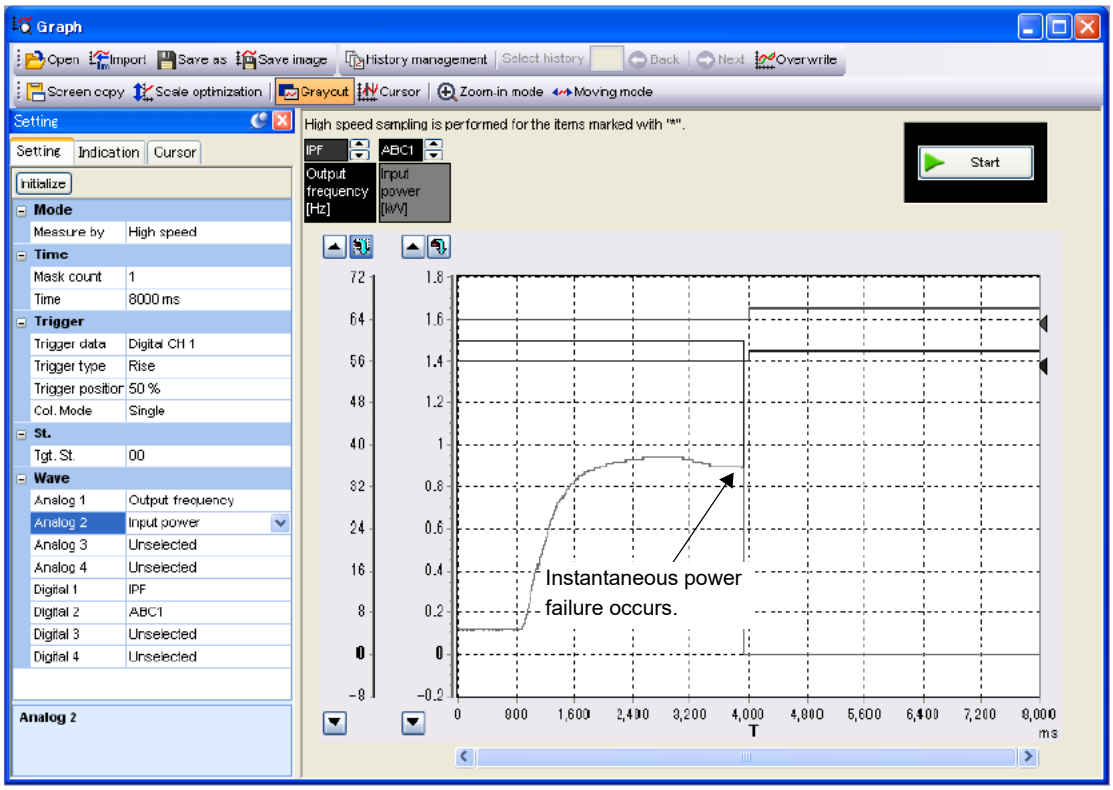
5.2.8 Instantaneous power failure (E.IPF display), automatic restart after instantaneous power failure [Demonstration]

Turn ON STF and high speed RH to display 60 Hz. Turn ON the load button and turn the potentiometer of the load setting to the right as far as it goes. Set the load torque to 150%. Set the timer of the instantaneous power failure to 0.03 to 0.05 seconds, and press the instantaneous power failure button. Check that E.IPF is displayed.



(1) Procedure on the instantaneous power failure

1) Use FR Configurator2 to check the graph when E.IPF is displayed.
Set the trigger position to 50%.



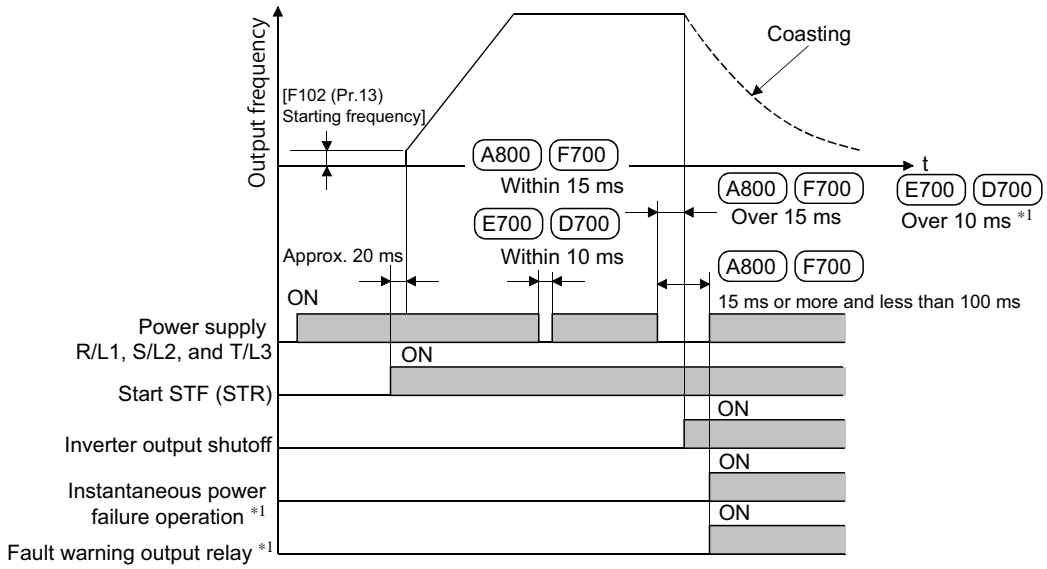
2) Check that the operation continues when setting the instantaneous power failure time setting timer to 0 second and pressing the instantaneous power failure button.

3) Use FR Configurator2 to check the period of time that Err. display continues after restarting, when setting the instantaneous power failure time setting timer to 0.1 seconds or more and pressing the instantaneous power failure button.

4) To prevent instantaneous power failure, a stable power supply is required (such as installing UPS and switching to DC auxiliary power supply).

POINT

The time chart when an instantaneous power failure occurs to the inverter



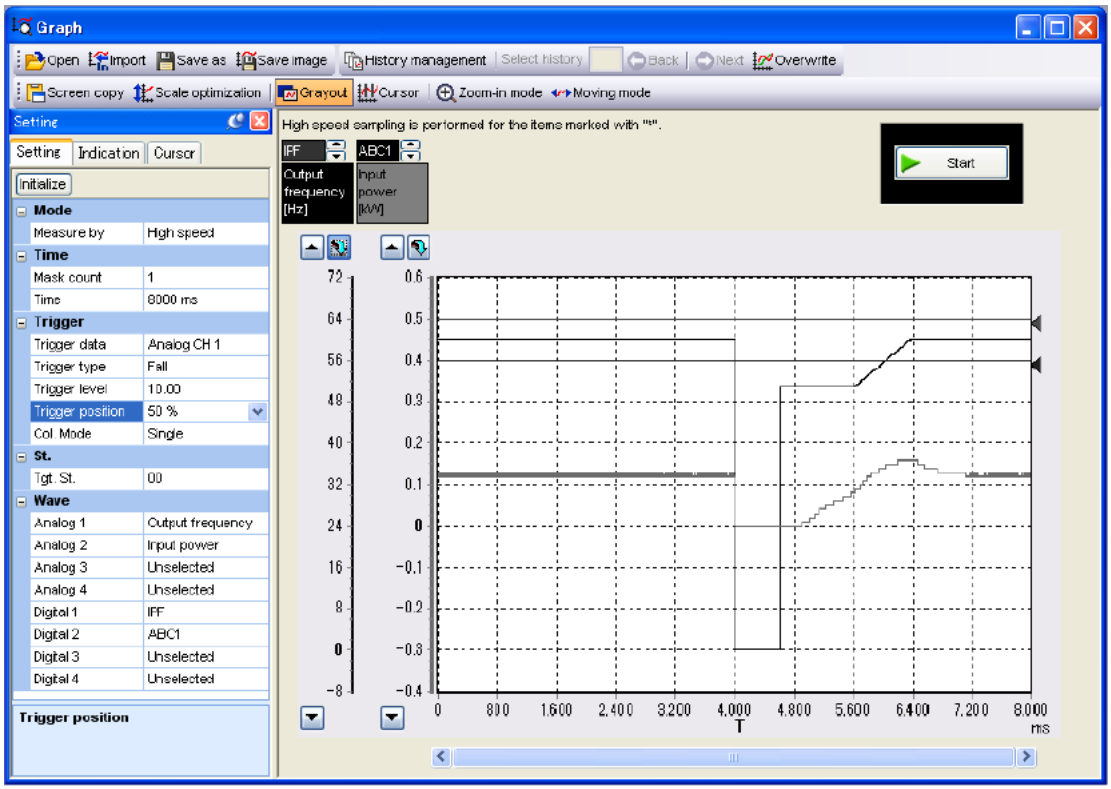
*1 A800 and F700 are activated when the power is restored within 15 to 100 ms. However, the fault output signal is not activated due to the automatic restart after instantaneous power failure function when the automatic restart after instantaneous power failure function [A702 (Pr.57)] is set as follows: 0 or 0.1 to 5 seconds for a capacity 55K or less; 0 or 0.1 to 30 seconds for a capacity 75K or more.
E700 and D700 restart operation from the starting frequency without fault output even if the power is restored after the inverter output shutoff.
However, when the automatic restart after instantaneous power failure function [A702 (Pr.57)] is set to 0 or 0.1 to 5 seconds, the automatic restart after instantaneous power failure is activated.

*2 An instantaneous power failure for 100 ms or longer is equivalent to a long time power failure. If the start signal is on, the inverter restarts when at the power is restored.

(2) Setting the automatic restart after instantaneous power failure

When the automatic restart after instantaneous power failure function is set, the motor restarts when the power is restored after the instantaneous power failure. (E.IPF is not activated.) Change A702 (Pr.57) (Restart coasting time) from the initial value "9999" to "0", set the automatic restart after turning ON instantaneous power failure CS, and press the instantaneous power failure button. Check that the motor restarts after the instantaneous power failure.

1) Use FR Configurator2 to check the graph when the motor is restarted after the instantaneous power failure.
   Set the trigger position to 50%.



After the demonstration

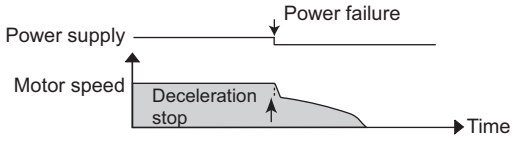
Reset A702 (Pr.57) (Restart coasting time) to the initial value "9999".

(3) Setting the power failure time deceleration-to-stop function (A730 (Pr.261) to A735 (Pr.266), A785 (Pr.294))

Change A730 (Pr.261) (Power failure stop selection) from the initial value "0" to "2" (without UV avoidance, re-accelerate if power is restored) to restart the motor without E.IPF display.

The power failure time deceleration-to-stop function decelerates and stops the motor to prevent motor coasting when power failure or undervoltage occurs.

This setting is effective to stop the motor when power failure occurs for safety of the machine tool.



Parameter number	Name	Initial value FM	Initial value CA	Setting range	Description	
A730 (261)	Power failure stop selection	0		0	Coasts to stop When undervoltage or a power failure occurs, the inverter output is shut off.	
				1	Without undervoltage avoidance	When undervoltage or a power failure occurs, the inverter can be decelerated to a stop.
				11	With undervoltage avoidance	
				21	Without undervoltage avoidance	When undervoltage or a power failure occurs, the deceleration time is automatically adjusted for a deceleration stop.
				2	Without undervoltage avoidance	When undervoltage or a power failure occurs, the inverter can be decelerated to a stop. The motor re-accelerates if the power is restored during the deceleration to stop.
				12	With undervoltage avoidance	
				22	Without undervoltage avoidance	When undervoltage or a power failure occurs, the deceleration time is automatically adjusted for a deceleration stop. The motor re-accelerates if the power is restored during the deceleration to stop.
A731 (262)	Subtracted frequency at deceleration start	3 Hz		0 to 20 Hz	Normally, the motor runs at the initial value as it is. However, adjust the value according to the size of the load specification (moment of inertia and torque).	
A732 (263)	Subtraction starting frequency	60 Hz	50 Hz	0 to590 Hz	When output frequency ≥ A732 (Pr.263) Output frequency - deceleration from A731 (Pr.262) When output frequency < A732 (Pr.263) Deceleration from the output frequency	
				9999	Output frequency - deceleration from A731 (Pr.262)	
A733 (264)	Power failure deceleration time 1	5s		0 to 3600/ 360 s*	Set the slope applicable from the deceleration start to A735 (Pr.266) set frequency.	
A734 (265)	Power failure deceleration time 2	9999		0 to 3600/ 360 s*	Set the slope applicable for the frequency range starting at A735 (Pr.266) and downward.	
				9999	Same as A733 (Pr.264)	
A735 (266)	Power failure deceleration time switchover frequency	60 Hz	50 Hz	0 to590 Hz	Set the frequency at which the slope during deceleration switches from the A733 (Pr.264) setting value to the A734 (Pr.265) setting value.	
A785 (294)	UV avoidance voltage gain	100%		0 to 200%	Adjust the response at undervoltage avoidance operation. Setting a large value improves the response to changes in the bus voltage.	

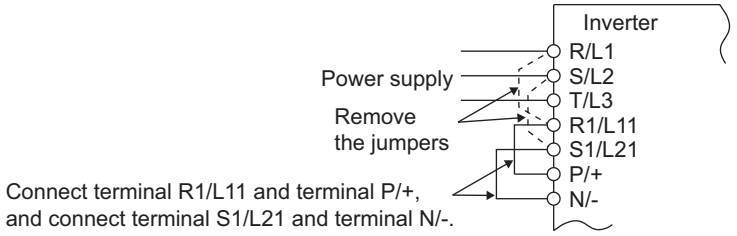
Parameter number	Name	Initial value FM	Initial value CA	Setting range	Description
A786 (668)	Power failure stop frequency gain	100%		0 to 200%	Adjust the response during operation of the deceleration time automatic adjustment function.

∗ When the setting value of F001 (Pr.21) Acceleration/deceleration time increments is "0" (initial value), the setting range is "0 to 3600 s" and the setting increments are "0.1 s", and when the setting is "1", the setting range is "0 to 360 s" and the setting increments are "0.01 s".

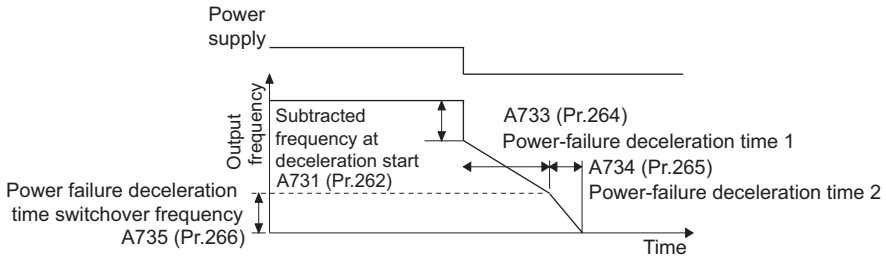
(a) Connection and parameter setting

- Remove the jumpers between terminals R/L1 and R1/L11 and terminals S/L2 and S1/L21, and connect terminals R1/L11 and P/+, and terminals S1/L21 and N/-.
- If an undervoltage, power failure or input phase loss (H201 (Pr.872) = "1" (with input phase loss protection)) occurs when A730 (Pr.261) ≠ "0", the motor decelerates to a stop.

(b) Outline of operation of deceleration stop at a power failure

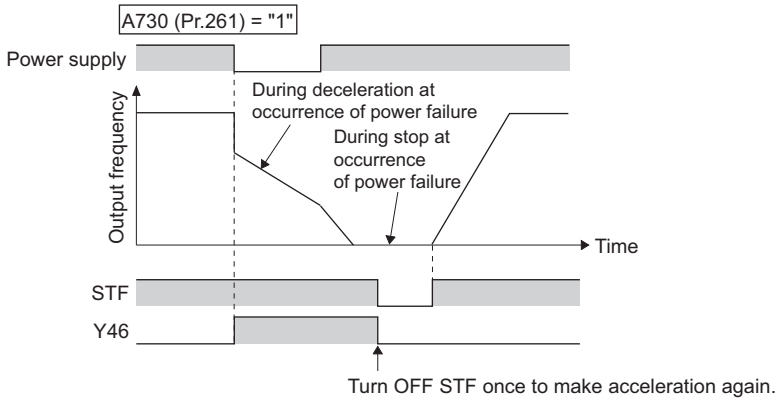


- If an undervoltage or power failure occurs, the output frequency is turned OFF only for the frequency set in A731 (Pr.262).
- The motor decelerates for the time set in A733 (Pr.264). (The deceleration time setting is the time it takes for the motor to stop from F000 (Pr.20) Acceleration/deceleration reference frequency.)
- Change the deceleration time (slope) to the stop using A734 (Pr.265) when the frequency is too low to obtain the regenerative power or in other instances.

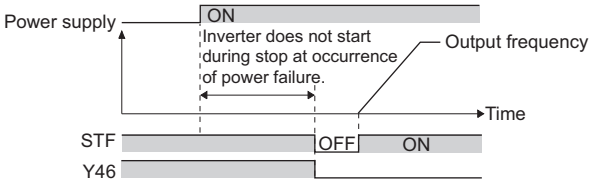


(c) Power failure stop function (A730 (Pr.261) = "1, 11, 21")

- Even if power is restored during deceleration triggered by a power failure, deceleration stop is continued after which the inverter stays stopped. To restart operation, turn the start signal OFF then ON again.



Remark



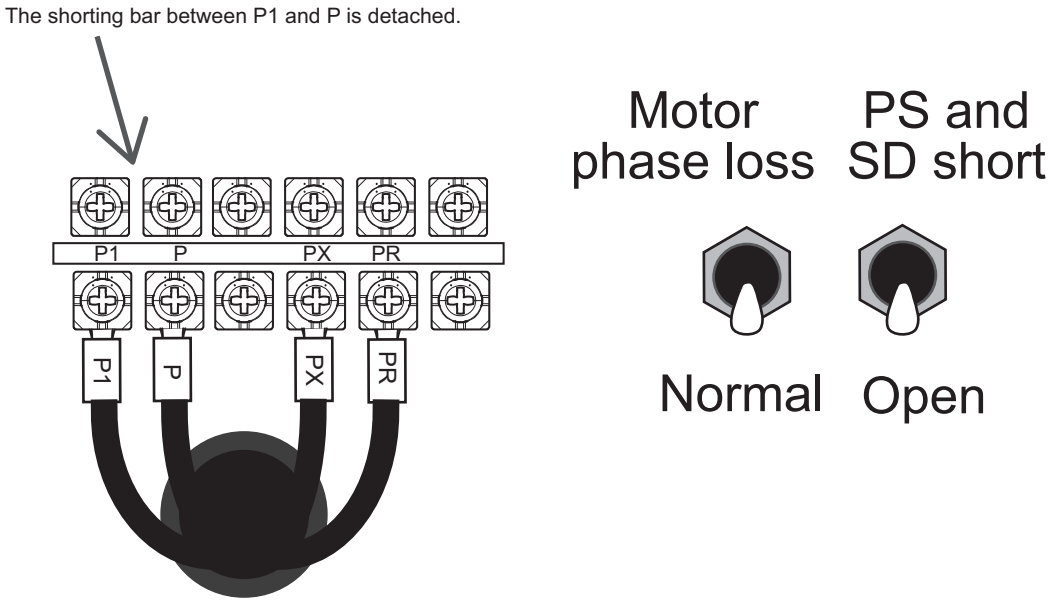
- If the automatic restart after instantaneous power failure is selected (A702 (Pr.57) ≠ "9999"), the power failure time deceleration stop function is disabled and an automatic restart after instantaneous power failure is performed.
- After the power failure stop, the inverter will not start even if the power is turned ON with the start signal (STF/STR) input. After switching ON the power, turn OFF the start signal once and then ON again to make a start.

After the demonstration

Reset A730 (Pr.261) (Power failure stop selection) to the initial value "0".

5.2.9 Undervoltage (E.UVT display) [Demonstration]

The shorting bar between P and P1 on the terminal block on the rear side of the demonstration machine is removed.
Check that E.UVT is displayed right after the inverter is powered ON due to the decreased bus power voltage.



5.3 Appendices for demonstration (Confirmation of error descriptions and others)

Following the 5.2 Troubleshooting by the demonstration machine in the previous section, this section provides the simple errors descriptions.
Check the error details by following "Error setting", "Error description", and "Error handling procedure" in this order.

5.3.1 Error setting

(1) Prevention of reverse rotation <When the prevention of reverse rotation is valid>
Change D020 (Pr.78) (Prevention of reverse rotation of the motor) from the initial value "0" to "1" (reverse rotation disabled), and turn ON STR. Check that the REV of the parameter unit blinks and the motor does not rotate in the reverse direction.

(2) Maximum frequency setting
Change H400 (Pr.1) (Maximum frequency) from "120 Hz" to "55 Hz", and turn ON STF and high speed RH. Then, check that 55 Hz is displayed although the high speed RH is set to 60 Hz, and that the frequency cannot exceed 55 Hz.

(3) E.OHT display <External thermal relay operation>
Change T708 (Pr.186) (CS terminal function selection) from "6" (automatic restart after instantaneous power failure selection) to "7" (external thermal relay input) and make CS - SD terminal open. Check that E.OHT is displayed.

(4) E.OPT display <Option fault>
Change E300 (Pr.30) (Regenerative function selection) from "0" (built-in brake) to "2" (high efficiency converter or power supply regeneration common converter connection), and check that E.OPT is displayed.

(5) E.PUE display <PU disconnection>
Change E101 (Pr.75) (PU disconnection detection) from "14" (operation continues even when PU disconnected) to "2" (inverter output shut off when PU disconnected), and turn ON STF and high speed RH. Disconnect PU after 60 Hz is displayed and stop the inverter output. Check that E.PUE is displayed.

(6) E.CDO display <Output current detection value exceeded>
Change M464 (Pr.167) (Output current detection operation selection) from "0" to "1", M460 (Pr.150) (Output current detection level) from "150" to "40", and turn ON STF and high speed RH. Check that E.CDO is displayed at the start up.

(7) E.USB display <USB communication fault>
Change N041 (Pr.548) (USB communication check time interval) from "9999" to "1", and check that E.USB is displayed when disconnecting USB cable with FR Configurator2 being online.

(8) E.RET display <Retry count excess>

Change H302 (Pr.68) (Retry waiting time) from "1" to "5" seconds and change H301 (Pr.67) (Number of retries at fault occurrence) from "0" to "3" times. Change H000 (Pr.9) (Electronic thermal O/L relay) to "1".

Check that E.THM is displayed in 1 second when STF and high speed RH are turned ON and that E.RET is displayed by performing three retries after the automatic reset without fault output.

(9) MT1 display <Maintenance signal output>

Change E711 (Pr.504) (Maintenance timer warning output set time) from "9999" to "0" and check that MT1 is displayed.

(10) PS display <PU stop>

During operation in the external operation mode EXT, press the STOP/RESET button on the operation panel and check that PS is displayed.

5.3.2 Error description

(1) The motor does not rotate.
The motor does not rotate when STR is turned ON.

(2) The frequency does not reach the set value.
When STF and high speed RH are ON, 55 Hz is displayed. ∗High speed RH of 60 Hz is required.

(3) E.OHT display <External thermal relay operation>
E.OHT is displayed.

(4) E.OPT display <Option fault>
E.OPT is displayed.

(5) E.PUE display <PU disconnection>
E.PUE is displayed.

(6) E.CDO display <Output current detection value exceeded>
When STF and high speed RH are ON, E.CDO is displayed at the startup.

(7) E.USB display <USB communication fault>
E.USB is displayed.

(8) E.RET display <Retry count excess>
When STF and high speed RH are turned ON, E.THM is displayed. However, E.RET is displayed when three retries are performed after the automatic reset without fault output.

(9) MT1 display <Maintenance signal output>
MT1 is displayed.

(10) PS display <PU stop>
PS is displayed.

5.3.3 Error handling procedure

(1) Prevention of reverse rotation <When the prevention of reverse rotation is valid>

Follow the flowchart on 5.1.3 When the motor does not start to check that ON signals of STR and high speed RH are input using FR Configurator2. Change D020 (Pr.78) (Reverse rotation prevention selection) to the initial value "0".

(2) Maximum frequency setting

Follow the flowchart on 5.1.5 When the motor speed does not become the set speed to check that the output frequency does not match with the command using FR Configurator2. Change H400 (Pr.1) (Maximum frequency setting) to "120 Hz".

(3) E.OHT display <External thermal relay operation>

Change T708 (Pr.186) (CS terminal function selection) to "6" (automatic restart after instantaneous power failure selection) and close the CS - SD terminal.

(4) E.OPT display <Option fault>

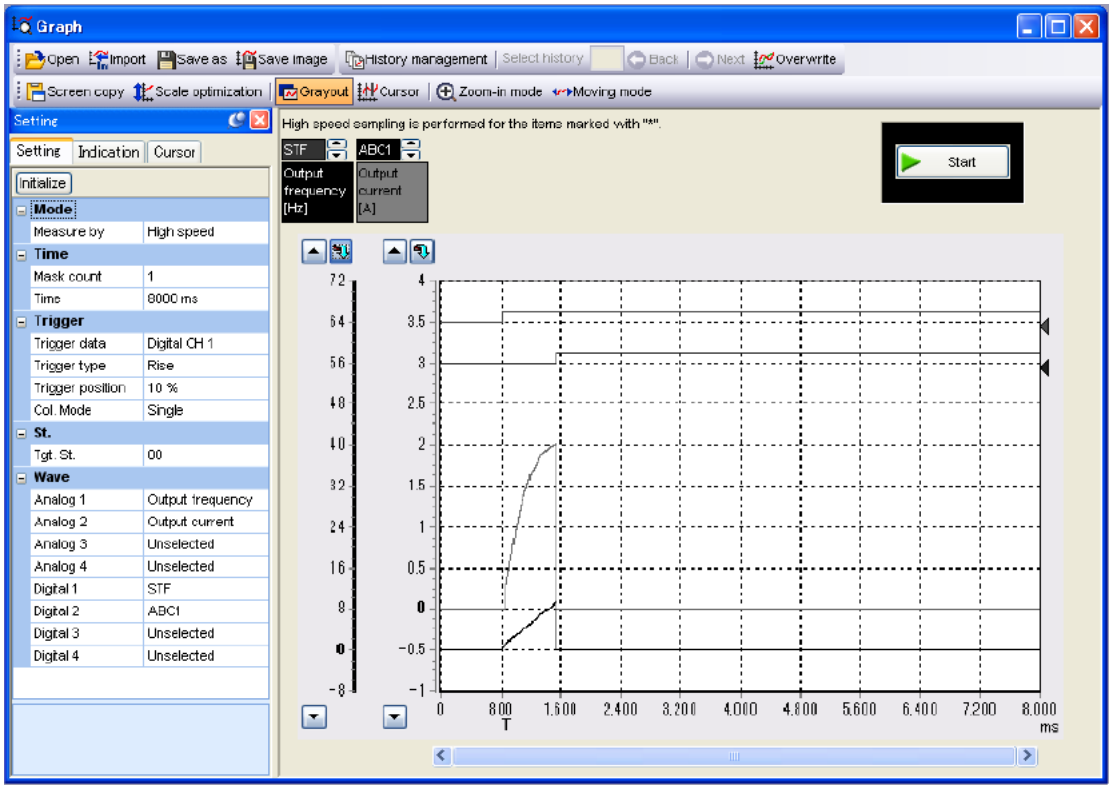
Change E300 (Pr.30) (Regenerative function selection) to "0" (built-in brake).

(5) E.PUE display <PU disconnection>

Return PU to the original position.

(6) E.CDO display <Output current detection value exceeded>

1) Use FR Configurator2 to check the output current when the output current detection value is exceeded.



2) Change M464 (Pr.167) (Output current detection operation selection) to the initial value "0" (continuous operation when output current detection value exceeded).

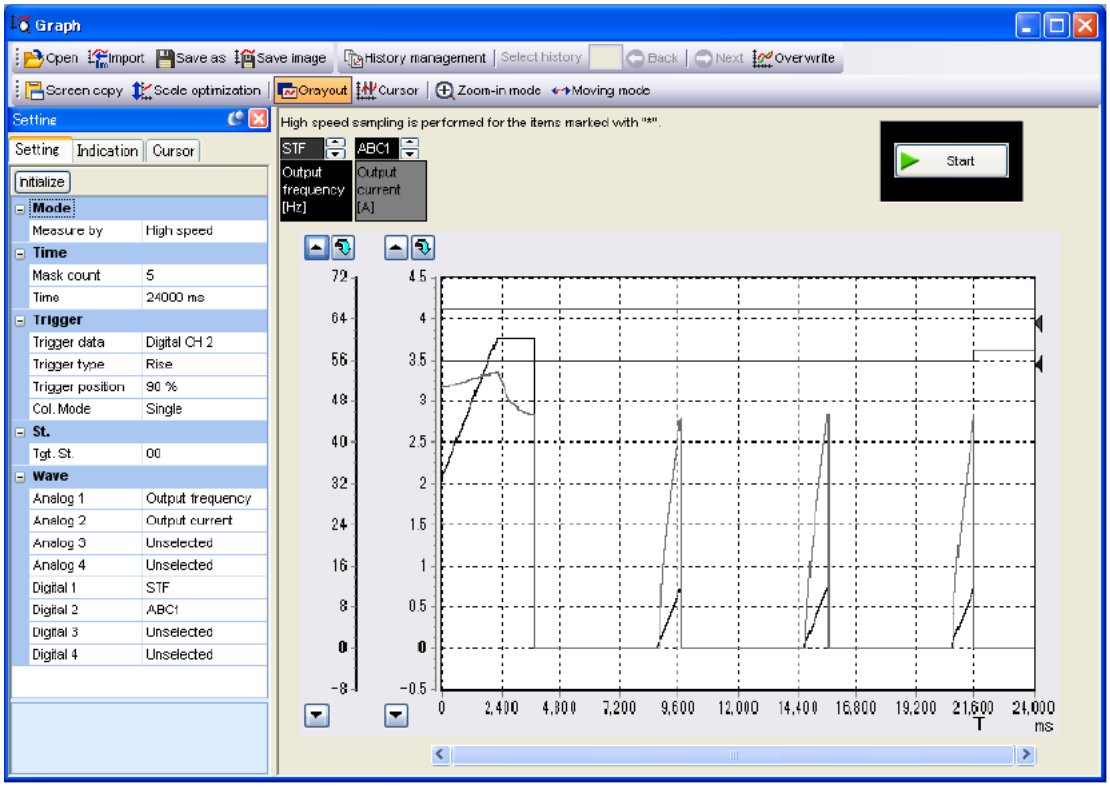
3) Change M460 (Pr.150) (Output current detection level) to the initial value "150%".

(7) E.USB display <USB communication fault>

Change N041 (Pr.548) (USB communication check time interval) to "9999", and put the USB cable back.

(8) E.RET display <Retry count excess>

1) Use FR Configurator2 to measure the graph from when the electronic thermal O/L relay (E.THM display) occurs to when retries are performed for three times in five seconds. Set the trigger position to 90%.



2) Check that the graph that is measured on 1), H302 (Pr.68) (Retry waiting time), and H301 (Pr.67) (Number of retries at fault occurrence) are consistent.

3) Change H301 (Pr.67) (Number of retries at fault occurrence) to the initial value "0", H302 (Pr.68) (Retry waiting time) to "1s", and H000 (Pr.9) (Electronic thermal O/L relay) to "2A" (The electronic thermal O/L relay setting value for the demonstration machine).

(9) MT display <Maintenance signal output>

On simultaneous monitoring of FR Configurator2, check the actual operation time of No.19. Change E711 (Pr.504) (Maintenance timer warning output set time) to "9999".

(10) PS display <PU stop>

Turn OFF the start signal, and then press the PU/EXT button to clear the error.

CHAPTER 6 CORRECTIVE MAINTENANCE

Reduce the deterioration of equipment and facilitate maintenance work to increase maintainability of the production system.

6.1 Improving the maintainability of equipment

(1) Improvement to reduce deterioration of equipment

1) Review the surrounding environment and install an air conditioning system or a ventilation system as necessary to prevent abnormal deterioration of equipment.
2) Take countermeasures against dust, moisture, and vibration to prevent abnormal deterioration of equipment.
3) Replace the device that may deteriorate rapidly with the durable one.

(2) Improvement to facilitate repair

1) Improve the configuration of equipment.
2) Provide space for repair.
3) Use products that can be easily repaired.

(3) Using products unlikely to fail

1) Use products with low failure rate and high reliability.

CHAPTER 7 REVIEW OF INSTALLATION ENVIRONMENT

7.1 Power supply of inverter (harmonics and instantaneous power failure)

This section explains the influence of harmonics generated from the inverter on the power supply and its system to which an inverter is connected. Determine the level of influence on the peripheral devices according to the amount of harmonics generated from the inverter to consider concrete countermeasures against harmonics.
This section also explains the influence of voltage fluctuations such as an instantaneous power failure and voltage drop on the inverter is explained. It is important to understand the operation of the inverter and motor well.

POINT

1. Differences between harmonics and noise
2. Inflow path and the size of harmonic current
3. Harmonic suppression guidelines and handling methods
4. Operation of the inverter and motor at an instantaneous power failure (including an instantaneous voltage drop)

7.1.1 Harmonics

A harmonic has a frequency that is an integral multiple of the fundamental wave (generally the power supply frequency). The composition of a single fundamental wave and multiple harmonics is called a distorted wave. (Refer to Fig. 7.2.)
A distorted wave typically includes harmonics in a high-frequency range (kHz to MHz order). However, in a power distribution system, harmonics are usually up to 40th to 50th degrees (to 3 kHz). Harmonics have different problems from those of high-frequency that usually assume an irregular form. For example, noise and electromagnetic interference from the computer (refer to Section 7.2) are local problems which are closely related to hard devices, and the influences and measures are different from those of harmonics in electrical power network. This must be defined first.

$$i = i_o + \sum_{n=1}^{\infty} i_n \cdot \sin(2\pi f n t + \psi n) \cdots\cdots (7.1)$$

n=1, 2, 3, ……
f=Fundamental frequency

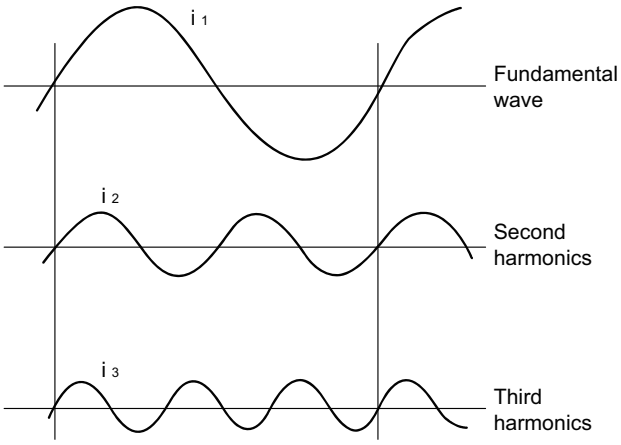


Fig. 7.1 Fundamental wave and harmonics

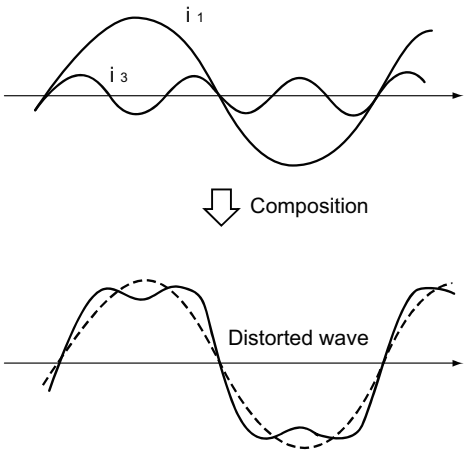


Fig. 7.2 Distorted wave

Table 7.1 Differences between harmonics and noise

Item	Harmonics	Noise
Frequency	Normally 40th to 50th degrees or less (3 kHz or less).	High frequency (several 10 kHz to MHz order)
Source	Converter section	Inverter section
Cause	Rectifier circuit commutation	Transistor switching
Environment	To-electric channel, power impedance	To-space, distance, wiring path
Quantitative understanding	Theoretical calculation is possible.	Due to random occurrence, quantitative grasping is difficult.
Generated amount	Nearly proportional to the load capacity	Changes with the current variation ratio. (Gets larger as switching speed increases.)
Affected equipment immunity	Specified by standards per equipment.	Different depending on maker's equipment specifications.
Countermeasure	Provide a reactor (L).	Increase distance (ℓ).

7.1.2 Characteristics of rectifier circuit and generated harmonics

Harmonics are generated by a rectifier, an AC power adjuster, etc. The converter circuit of a general-purpose inverter consists of a rectifier circuit, and generates a large amount of harmonic current. There are various types of rectifier circuits depending on the main circuit method. The three-phase bridge method is most widely adopted in the general-purpose inverter.
The ordinal number "n" of the generated harmonic current is theoretically equal to PK ± 1 (P = number of pulses, K = 1, 2, 3.....). The general-purpose inverter using the three-phase bridge method (P = 6, as 6-pulse converter is used) generates harmonic current of 6K ± 1st (5, 7, 11, 13th.....). The magnitude of the harmonic current (harmonic content) is 1/n, and as the ordinal number of harmonic current increases, the generated amount decreases. The inverter using the single-phase power supply input generates harmonic current of 4K ± 1st (3, 5, 7, 9th.....).

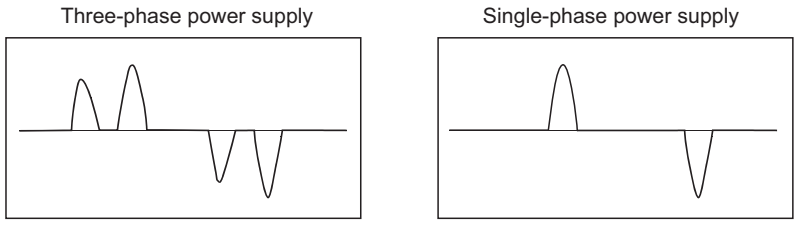


Fig. 7.3 Inverter input current waveform (harmonic current)

7.1.3 Split-flow path of harmonic current

When harmonic current is used in the power distribution system, the power supply of the harmonic current is not a general commercial power supply but the source of harmonics (the converter section for the general-purpose inverter). The commercial power supply (low and high voltage power transformer) becomes a load on harmonics. Therefore, as shown in the example of Fig. 7.4, the harmonic current "In" generated from the inverter ($I_n = I_2 + I_3 + I_4 + ...$ (n stands for the ordinal number)) splits and flows in proportion to the impedance of power transformer ($\dot{Z}_L = RL + jnXL$) and the devices connected in parallel with it (in the example of Fig. 7.4, the motor B and the capacitor), in other words the reciprocal ratio 1/Z between the impedance of the motor B ($\dot{Z}_M = R_M + jnX_M$) and the impedance of the capacitor ($\dot{Z}_C = jnX_r - jX_C / n$).
Since the frequency of harmonics is higher than that of the power supply, the impedance of the capacitor decreases and thus the harmonic current tends to flow into the capacitor.
As a result, the capacitor may be overheated or damaged.

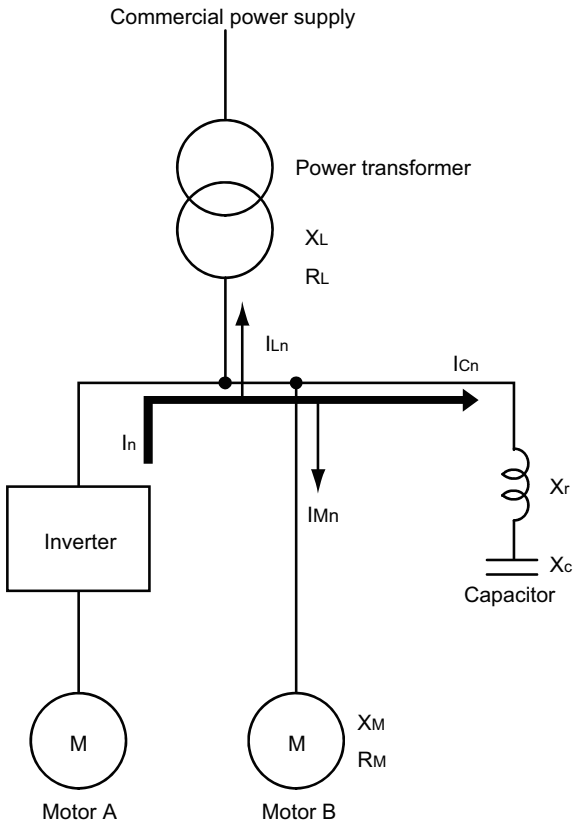


Fig. 7.4 Power distribution system

Good to know for checking an inverter

- Current tends to flow into the smaller impedance, and the harmonics may increase when there are capacitive impedance elements (such as a power factor correction capacitor). Therefore, in harmonic problems,

  1) Since the impedance at the power supply side $\dot{Z}_S$ is represented by the short-circuit capacity of the power supply system, the larger the power supply capacity is, the less the influence of other elements is. 2) Inductive loads can be ignored since it is high impedance for harmonics. 3) Only capacitive loads such as a power factor correction capacitor should be considered.

7.1.4 Harmonic suppression guidelines

The harmonic current flows from the inverter to a power receiving point via a power transformer. The Harmonic Suppression Guidelines was established to protect other consumers from this outgoing harmonic current.
The three-phase 200 V input specifications 3.7 kW or lower were previously covered by the "Harmonic Suppression Guidelines for Household Appliances and General-purpose Products" and other models were covered by the "Harmonic Suppression Guidelines for Consumers Who Receive High Voltage or Special High Voltage". However, the general-purpose inverter has been excluded from the target products covered by the "Harmonic Suppression Guidelines for Household Appliances and General-purpose Products" in January 2004 and the "Harmonic Suppression Guideline for Household Appliances and General-purpose Products" was repealed on September 6, 2004.
All capacities and all models of general-purpose inverters used by specific consumers (consumers who receive high voltage) are covered by the "Harmonic suppression guideline for consumers who receive high voltage or special high voltage".

"Harmonic Suppression Guidelines for Consumers Who Receive High Voltage or Special High Voltage"

This guideline defines the maximum harmonic current outgoing from a high-voltage or especially high-voltage receiving consumer who will install, add, or renew harmonic generating equipment. If any of the maximum values is exceeded, this guideline requires that consumer to take certain suppression countermeasures.

However, we ask the users who are not covered by the guideline to connect a DC reactor or an AC reactor as usual.

For compliance with the "Harmonic Suppression Guidelines for Consumers Who Receive High Voltage or Special High Voltage"

Input power supply	Applicable capacity	Countermeasures
Three-phase 200 V	All capacities	Make a judgment based on the "Harmonic Suppression Guidelines for Consumers Who Receive High Voltage or Special High Voltage" issued by the Japanese Ministry of Economy, Trade and Industry (formerly Ministry of International Trade and Industry) in September 1994 and take countermeasures if necessary. For how to calculate the power supply harmonics, refer to the following. References • "Harmonic Suppression Measures of the General-purpose Inverter" January 2004 JEMA The Japan Electrical Manufacturers' Association • "Calculation Method of Harmonic Current of the General-purpose Inverter Used by Specific Consumers" JEM-TR201 (Revised in December 2003): The Japan Electrical Manufacturers' Association
Three-phase 400 V		

For compliance with the "Harmonic Suppression Guideline of the General-purpose Inverter (Input Current of 20A or Less) for Consumers Other Than Specific Consumers" published by JEMA

Input power supply	Applicable capacity	Countermeasures
Three-phase 200 V	3.7 kW or lower	Connect the AC reactor or DC reactor recommended in the catalog or instruction manual. References • "Harmonic Suppression Guideline of the General-purpose Inverter (Input Current of 20A or Less)" JEM-TR226 (Established in December 2003): The Japan Electrical Manufacturers' Association

Follow the procedure below to examine the necessity of the harmonic suppression techniques along the "Harmonic Suppression Guidelines for Consumers Who Receive High Voltage or Special High Voltage".

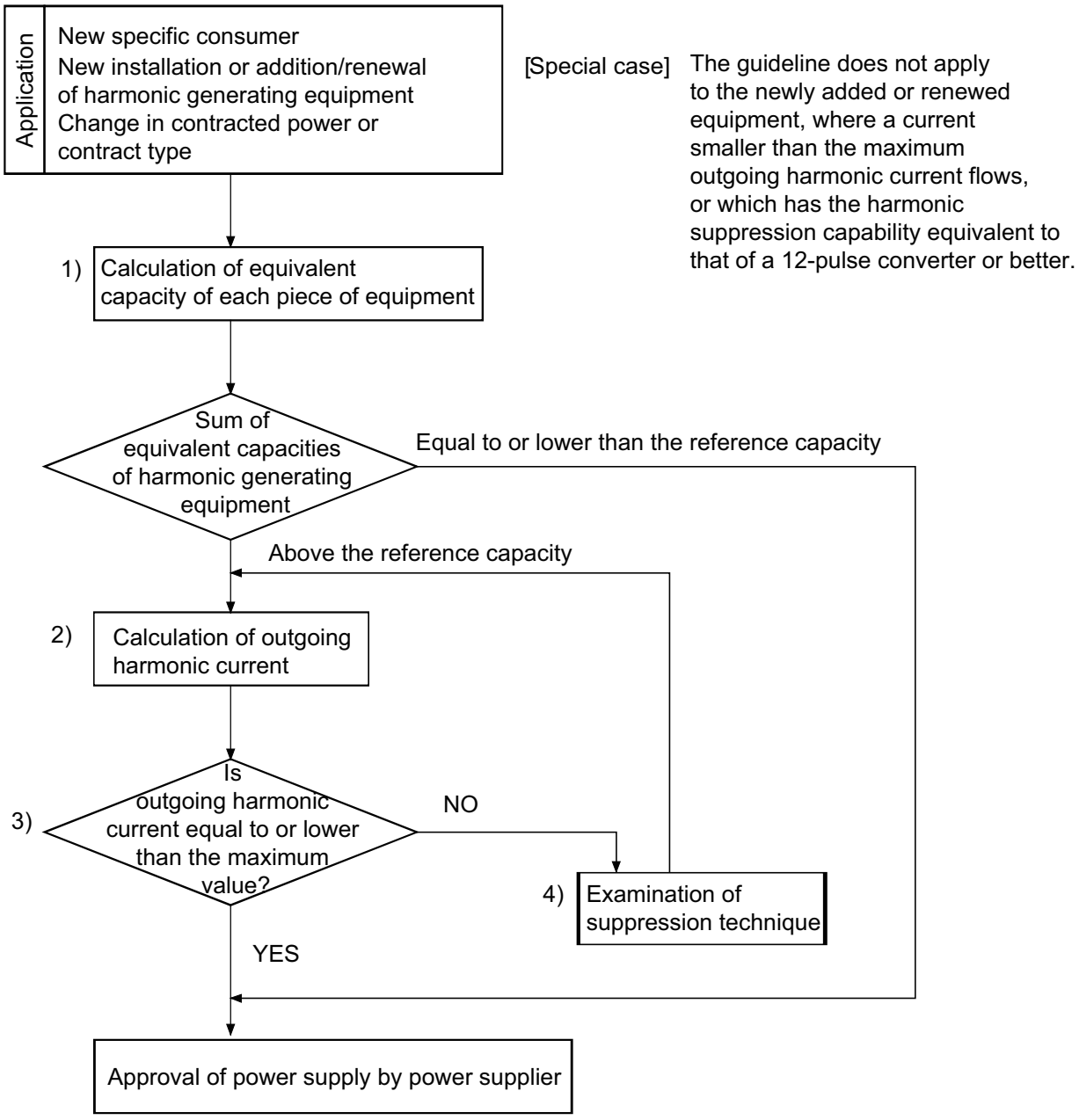


Fig. 7.5 Harmonics examination flowchart

7.1.5 Overview of harmonic suppression measures

The following table lists the basis and characteristics overview of the methods to suppress and absorb harmonics.

No.	Item	Description	Effect, etc.
1)	Reactor for inverter (FR-HAL, HEL)	Connect an AC reactor on the power supply side of the inverter or/and a DC reactor on the DC side of the inverter to increase the circuit impedance and suppress the harmonic current.	Harmonic current is suppressed to approximately half.
2)	High power factor converter (FR-HC2)	The converter switches the converter section ON/OFF to reshape an input current waveform into a sine wave, greatly suppressing harmonics. Connect it to the DC area of an inverter.	Harmonic current is suppressed to almost zero.
3)	Power factor improving static capacitor	The power factor improving capacitor has a small impedance for high frequency components and can absorb the harmonic current when used with a reactor connected in series. This capacitor can be installed in either of the high or low voltage side.	The absorbing effect is greater in the low voltage side.
4)	Transformer multi-phase operation	When two or more transformers are used, connecting them with a phase angle difference of 30° as in combinations of Y to Δ and Δ to Δ will cause a timing shift that suppresses peak current, resulting in an effect equivalent to 12 pulses.	Even if the capacities of the combinations of Y to Δ and Δ to Δ are different, the effect equivalent to 12 pulses is expected for the smaller one. Thus, harmonic current can be suppressed to approximately half.
5)	AC filter	As in a power factor improving capacitor, a capacitor and reactor connected in series are used together to reduce the impedance for a specific frequency (ordinal number). The harmonic current is absorbed greatly.	Current is greatly suppressed. (The requirements of the guideline can be satisfied.)
6)	Active filter	This filter detects the current in a circuit generating a harmonic current and generates a harmonic current equivalent to a difference between that current and a fundamental wave current to suppress the harmonic current at the detection point.	Current is greatly suppressed. (The requirements of the guideline can be satisfied.) Since this filter corrects the whole waveform, a power factor can be improved.

∗ The countermeasures above are effective in the following order:

- For suppression effect: 6) or 2) → 5) → 4) → 3) → 1)
- For cost: 1) → 2) → 3) → 4) → 5) → 6)

7.1.6 Influence to inverter at instantaneous power failure

When an instantaneous power failure occurs, the power supply voltage of the control circuit for the inverter is shut off. To prevent malfunction of control due to this power failure, activate the instantaneous power failure protection to stop the inverter output and keep the output stopped. The protective operation differs depending on the instantaneous power failure time. The FR-A800 series is used as an example here.

(1) Inverter operation depending on the instantaneous power failure time

(a) When the instantaneous power failure time is within 15 ms
Since the protective function is not activated, operation can continue normally.

(b) When the instantaneous power failure time is over 15 ms and under 100 ms
The protective function is activated and the inverter output is stopped. (The motor coasts to a stop.)

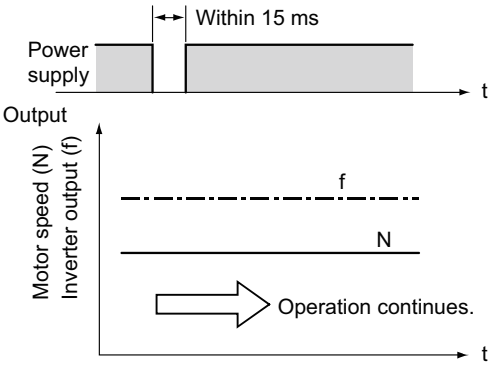


Fig. 7.6 Instantaneous power failure for 15 ms or less

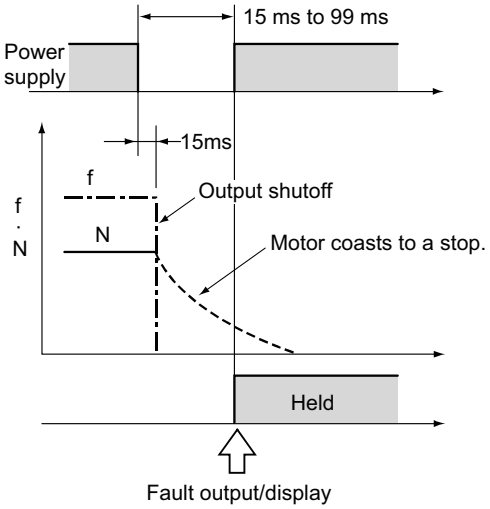


Fig. 7.7 Instantaneous power failure for more than 15 ms and less than 100 ms

(c) Power failure for 100 ms or more

The protective function is reset automatically at the power restoration and the inverter can be restarted.

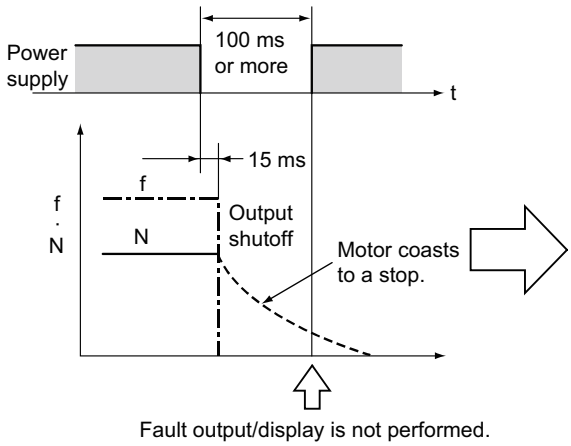


Fig. 7.8 Instantaneous power failure for 100 ms or more

[Note]

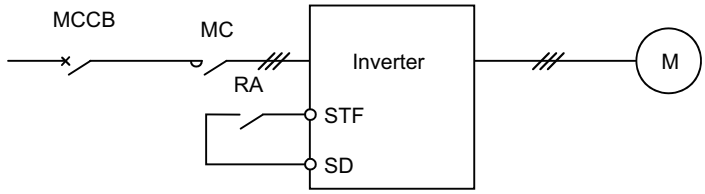
When the start signal (STF, STR) is ON, the inverter restarts at the power restoration. If the motor is coasting at this time, the overvoltage or overcurrent protection may be activated and thus the inverter may trip. To restart automatically at power restoration, use the automatic restart after instantaneous power failure function.

(The FR-A800 series inverters have this function as standard. However, the function is not selected at the factory shipment. Thus, set the parameter A702 (Pr.57) to "0".)

For details on the operation of the automatic restart after instantaneous power failure, refer to (3).

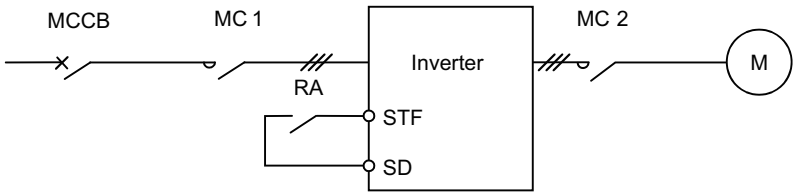
7.1.7 Inverter peripheral circuit and inverter operation at instantaneous power failure

(1) For a magnetic contactor (MC) at the inverter's input line



When the instantaneous power failure time is short and both the magnetic contactor MC and relay RA do not trip (start signal STF remains ON), the operation is as described in Subsection 7.1.6.
When only the magnetic contactor MC trips, the motor coasts to a stop. Therefore, when restarting the inverter after a power restoration, turn on MC again or use the instantaneous power failure function after the motor coasts to a stop (coasting interlock timer is necessary).

(2) For magnetic contactors (MC) at both the inverter's input line and the output line



When the instantaneous power failure time is short and both the magnetic contactor MC1 and relay RA do not trip (start signal STF remains ON), the operation is as described in Subsection 7.1.6.
When only the magnetic contactor MC1 trips, the motor coasts to a stop. Therefore, when restarting the inverter after a power restoration, turn on MC1 again or use the instantaneous power failure function after the motor coasts to a stop (coasting interlock timer is necessary).

When only the magnetic contactor MC2 trips, the motor coasts to a stop. However, the inverter continues to output depending on the instantaneous power failure time, or only the inverter restarts after resetting at the power restoration. Therefore, when MC2 is turned on again, the motor starts directly with the inverter output frequency, and this may cause an inverter trip due to overcurrent.

☒ Good to know for checking an inverter

1) Even though an instantaneous power failure occurs at the receiving end, an instantaneous power failure is unlikely to occur (completely) at the low voltage side inverter input terminal (R, S, T) and voltage drops instantaneously. (Undervoltage protection operations)
2) An inverter has the instantaneous power failure protective function and the undervoltage protection. The protective function is activated when the DC circuit voltage of the inverter is under a certain value for a certain time. Therefore, when the power supply drops instantaneously, the protective function may be activated for an inverter whose load output (kW) is large, and the operation may continue for an inverter whose load output is small.
3) On the other hand, the magnetic contactors or relays may not trip due to an instantaneous voltage drop, if once it is turned on. In general, it trips when the voltage is equal to or lower than 30% to 50% of coil rating.

(3) Automatic restart after instantaneous power failure control

(a) Electronic bypass and automatic restart after instantaneous power failure function

CAUTION These functions operate properly only when one motor is connected to the inverter. Using multiple motors disrupts proper operation of the functions.

- Electronic bypass.....When the commercial power supply operation is switched to the inverter operation, the inverter can be started in coasting without stopping the motor.
- Automatic restart after instantaneous power failure
.....When an instantaneous power failure occurs, the inverter continues to operate without stopping the motor at a power restoration.

(b) Operation of automatic restart after instantaneous power failure

1) When an instantaneous power failure occurs during operation, the motor starts coasting.
2) After a power restoration, applying the DC voltage from the inverter to the coasting motor carries the DC to the motor. (Refer to Fig. 7.9 Ⓐ .)
   This DC includes the ripple cycle proportional to the motor speed.
3) Input the signal from the current detector to the CPU and count the ripple cycle to determine the motor speed.
4) The inverter outputs with the frequency according to the motor speed. (Refer to Fig. 7.9 Ⓑ .) After that, restart the inverter operation while increasing the output voltage gradually to reduce the starting current of the motor.

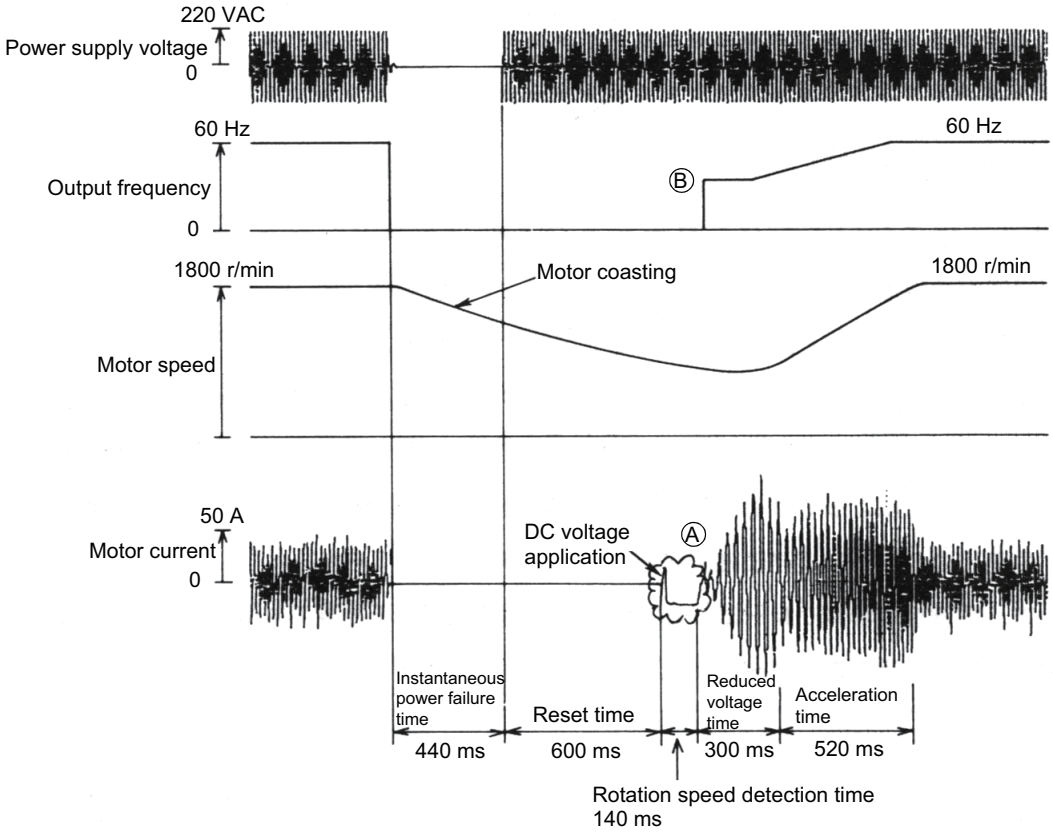


Fig. 7.9 Example of automatic restart after instantaneous power failure operation

When the automatic restart after instantaneous power failure function is supported (Example: FR-A800 series)
When using the automatic restart after instantaneous power failure function, short across terminals CS and SD.

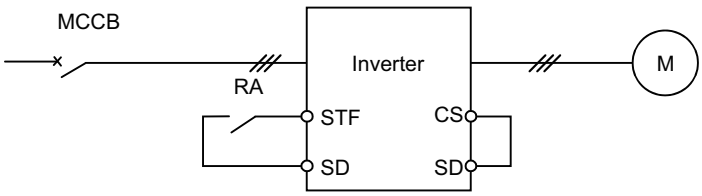
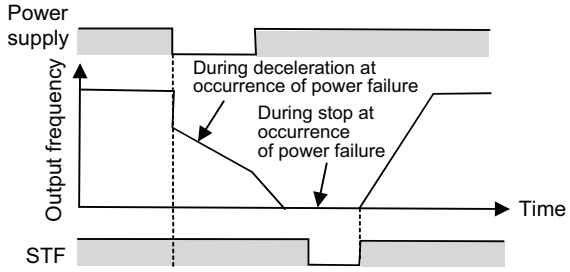


Fig. 7.10 Wiring for automatic restart after instantaneous power failure operation

☒ Good to know for checking an inverter

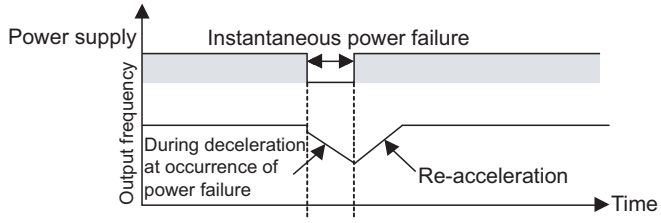
Power failure time deceleration-to-stop function

Usually, when a power failure occurs, the motor starts coasting. However, if the power failure time deceleration-to-stop function is used, the motor can be decelerated in a relatively short time by using the regenerative power. Even though the start signal is ON, it does not restart at a power restoration. The mode in which the motor re-accelerates at a power restoration during deceleration at occurrence of power failure can be selected as well.



Continuous operation function at instantaneous power failure

When an instantaneous power failure is detected, the operation is continued by using the regenerative power generated by decelerating the motor. After the power restoration, the motor is accelerated until it reaches the command frequency and continues to operate. When the load inertia is small, a trip may occur due to an undervoltage since the regenerative power from the motor is not provided.
In this case, use the automatic restart after instantaneous power failure.



7.2 Noise

As electronic devices is widely used, troubles due to the noise tend to increase.
Since an inverter generates the noise in accordance with the operating principle, it may affect adjacent devices.
The influence rate varies depending on circumstances such as the inverter control method, noise capacity of the adjacent device, wiring status, installation interval, and earthing (grounding) method.
However, when installing the following devices around the inverter, it is recommended to take the countermeasures described hereafter according to the circumstances.

[Devices for which considering countermeasures against noise is required]
Sensors (such as proximity switches), video cameras (such as ITVs and image scanners), wireless communications devices (including AM radios), sound equipment (such as microphones, videos, and audio equipment), CRT display devices, and medical devices

[Devices for which considering countermeasures against noise is recommended]
Instruments and internal telephones

7.2.1 Principles of noise generation

The inverter controls output voltage waveform by switching the DC voltage in a high speed.
Precipitous rising and falling of the output waveform contain many high frequency components.
These high frequency components are the source of the noise.
The noise generated in such a case and the harmonics described in Section 7.1 may be confused because both of them may affect other electronic devices. However, harmonics are typically 40th to 50th (2.4 to 3 kHz), and noise is several 10 kHz or more.

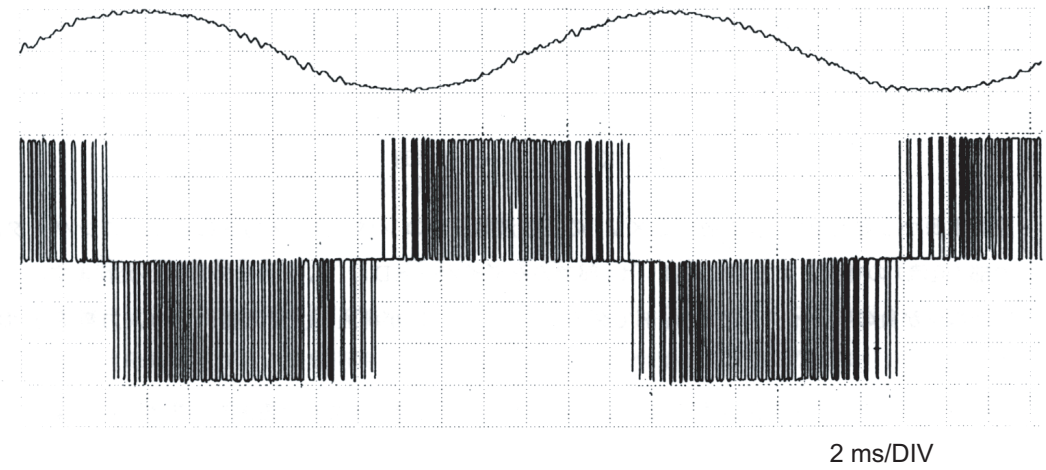


Fig. 7.11 Actual measurement example of output current and voltage waveform of the inverter FR-A800 series (When carrier frequency is 2 kHz)

7.2.2 Types of noise and propagation path

The inverter-generated noise is largely classified into those radiated by the cables connected to the inverter and inverter main circuits (I/O), those electromagnetically and electrostatically induced to the signal cables of the peripheral devices close to the main circuit power supply, and those transmitted through the power supply cables.
Fig. 7.12 shows the types of noise, and Fig. 7.13 shows the path of noise.

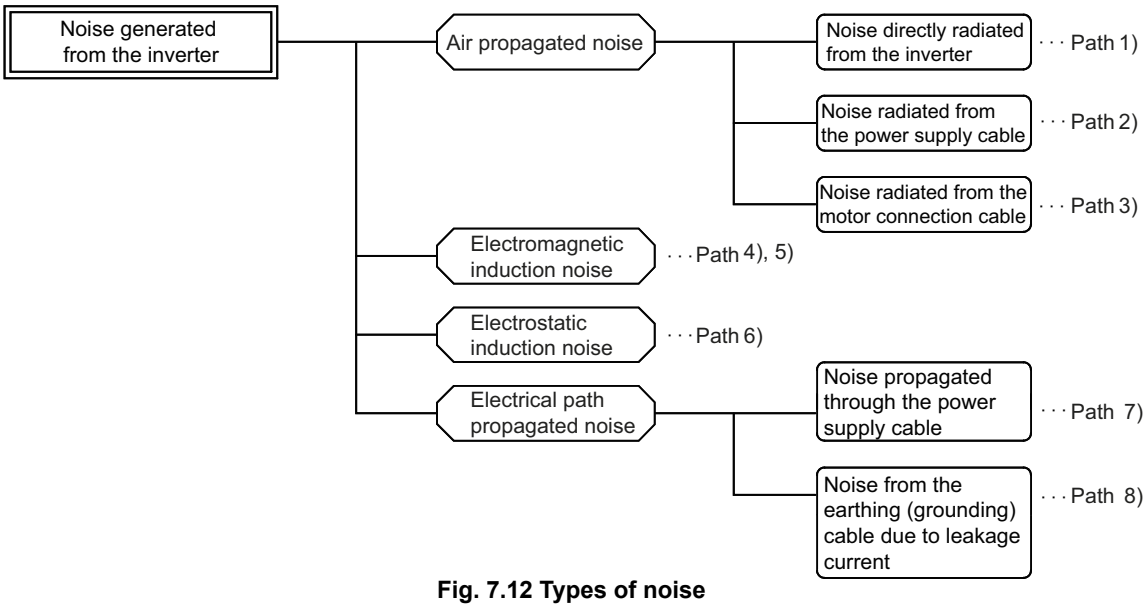


Fig. 7.12 Types of noise

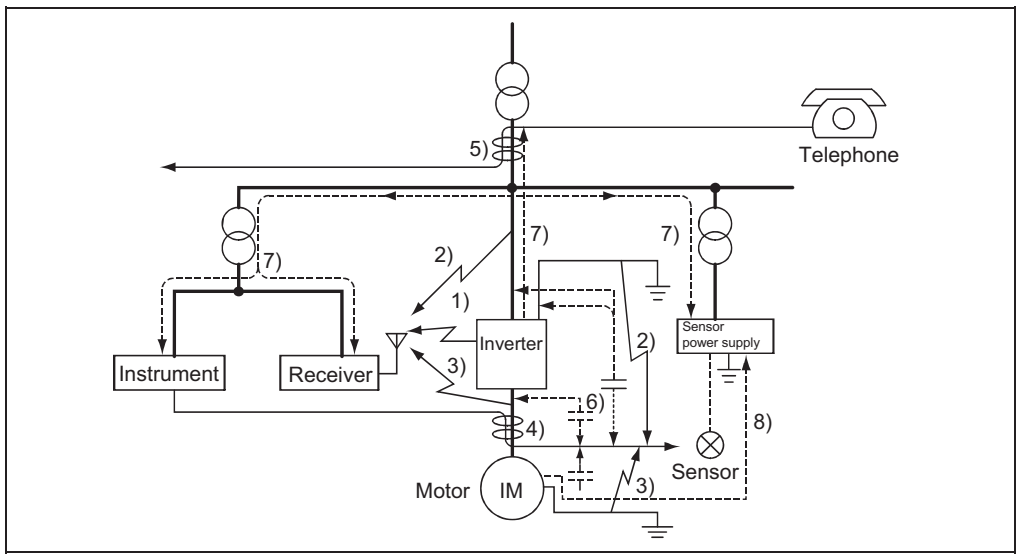


Fig. 7.13 Path of noise

Each noise level tends to be decreased as the frequency band rises. In general, it does not matter in the frequency band of 30 MHz or more.
Therefore, it does not affect much the televisions or FM radios that use frequency 30 MHz or more with some exceptions. However, it affects low frequency band (0.5 to 10 MHz) radios such as AM radios.
Accordingly, it is rational to consider the countermeasures with regard to the frequency band of the noise.

(1) Air propagated noise (Path 1) to 3))

The noise generated by an inverter is radiated and transmitted into the air following the three paths as shown in Fig. 7.14.

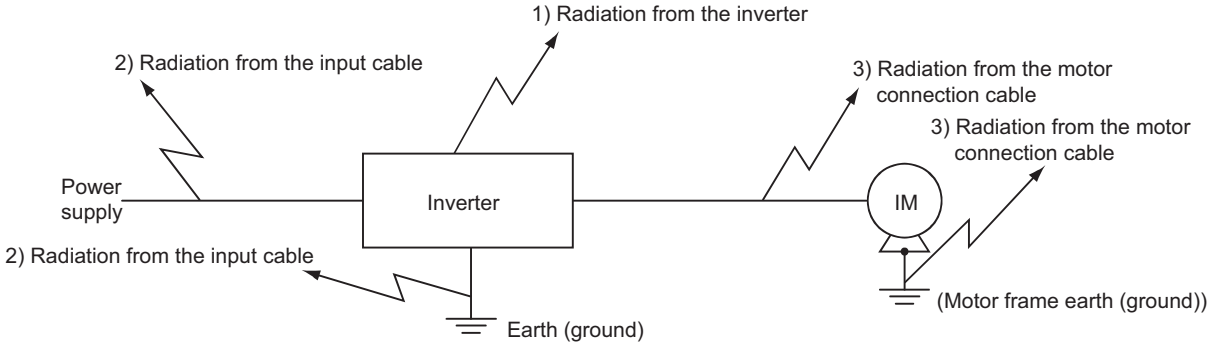


Fig. 7.14 Air propagated noise

(2) Electromagnetic induction noise (Path 4), 5))

The noise is transmitted by the interlinkage of the power supply cables and signal cables for the peripheral devices in the magnetic field that is generated by the I/O side current of the inverter. (Refer to Fig. 7.15.)
When both cables are close and parallel, or when the loop of each cable is large, the inducted noise increases.

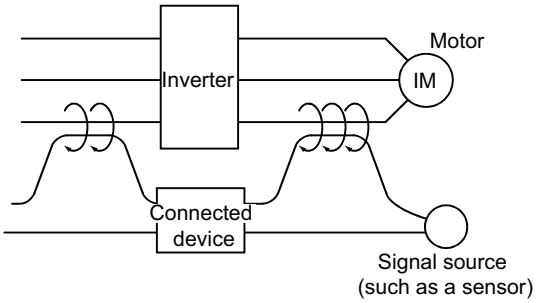


Fig. 7.15 Electromagnetic induction noise

(3) Electrostatic induction noise (Path 6)

The noise is transmitted when the electric field that is generated by the I/O cables of the inverter is coupled with the signal cables through the static capacitance. (Refer to Fig. 7.16.)

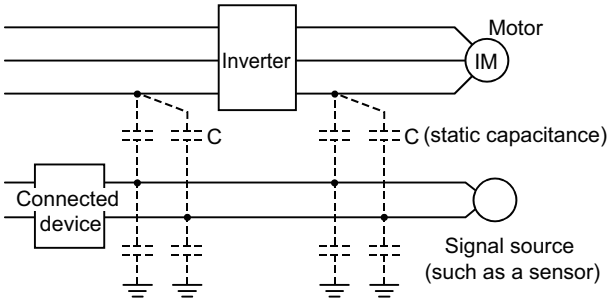


Fig. 7.16 Electrostatic induction noise

(4) Electrical path propagated noise (Path 7)

The high frequency noise generated in the inverter is transmitted to the peripheral devices through the cables at the power supply side. (Refer to Fig. 7.17.)

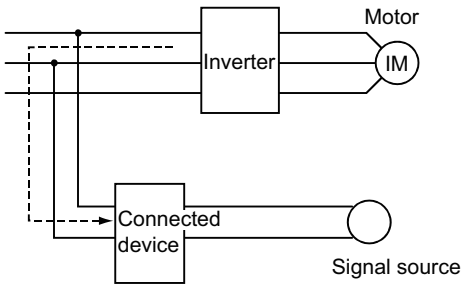


Fig. 7.17 Electrical path propagated noise

☒ POINT

Failure example: Noise

[Failure]

When using an inverter for the sprinkler in a golf course, an electric cart stopped while sprinkling water.

[Cause]

The noise of the inverter affected the power supply of the electric cart (supplied from the rail).

[Countermeasure]

Countermeasures against the noise were taken.

7.2.3 Countermeasures against noise

(1) Stance of countermeasures against noise

Although there are many noise propagation paths as described in Subsection 7.2.2, the noise source can be classified into the following three types, as shown in Fig. 7.12 and Fig. 7.13.

1) Conduction, induction, or radiation from the input power supply cable
2) Induction or radiation from the motor connection cable
3) Radiation from the inverter

Each noise level tends to be decreased as the frequency band rises. In general, it does not matter in the frequency band of 10 MHz or more.
Therefore, it does not affect televisions or FM radios that use frequency over 70 MHz. However, it affects low frequency band radios such as AM radios. Accordingly, it is rational to consider the countermeasures with regard to the frequency band of the noise.

(a) Reducing the noise that leaks into the power supply cables
Inserting a filter between an inverter and the power supply cable is effective.
There are several types of filters as described below.
The following explains the usage and effect.

1) Radio noise filter FR-BIF (200 V class), FR-BIF-H (400 V class)
This filter requires distinction between 200 V and 400 V, however, it is common to all capacities.
Connect the filter to the power supply input terminal of the inverter as shown in Fig. 7.18.
A long connection cable between the filter and inverter becomes the noise radiation antenna which is obstructive to the effect of the filter. Therefore, connect the cables including the earthing (grounding) cable directly to the inverter terminal so that they are as short as possible.
In addition, when the inverter earth (ground) terminal is far from the earth, the earthing (grounding) cable may be the antenna which is obstructive to the effect of the filter. Therefore, the earthing (grounding) cable should also be as short as possible.
This filter has large effect on several MHz or less and is effective to decrease the noise influence on AM radios.
Do not connect the filter to the inverter output side because it has a capacitor. Otherwise it will be damaged.

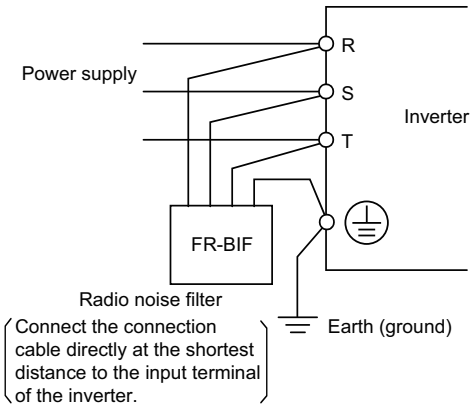


Fig. 7.18 Installation of the radio noise filter FR-BIF

2) Line noise filter FR-BSF01, FR-BLF

This filter consists of the core. Therefore, it can be used for all models regardless of the power supply voltage or capacity.

Wind the all three-phase cables around the filter in the same direction as shown in Fig. 7.19 and insert it to the inverter power input side. The more times it is wound, the more effect the filter has, Wind the cables as much as possible, at least three times (four turns). For the thick cable which cannot be wound three times (four turns) or more, use two filters so that the number of winding times is three times (four turns) or more in total. (Inverter input side)

Use either of the two types of the filter depending on the used cable gauge.

This filter has large effect on several 100 kHz or more. The filter can be used at the inverter output side as well. When it is inserted to the inverter output side, the number of winding times must be within three times (four turns).

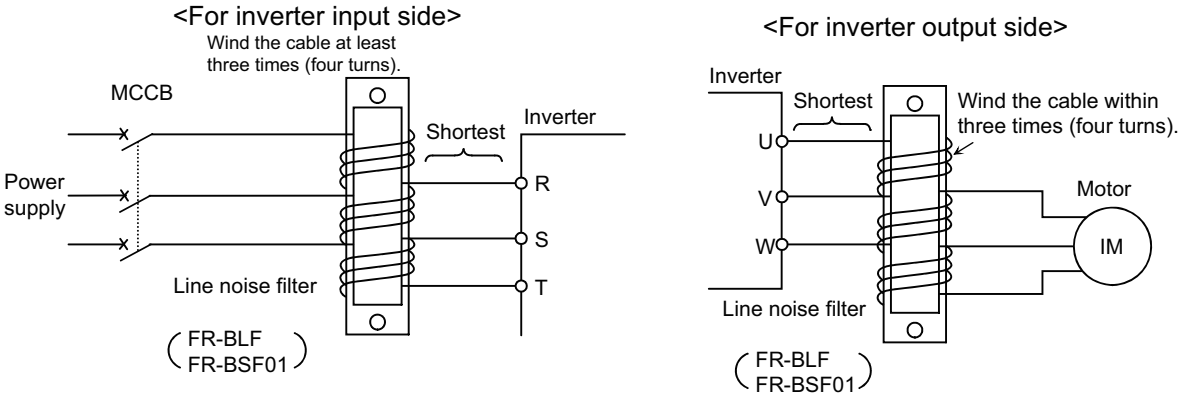
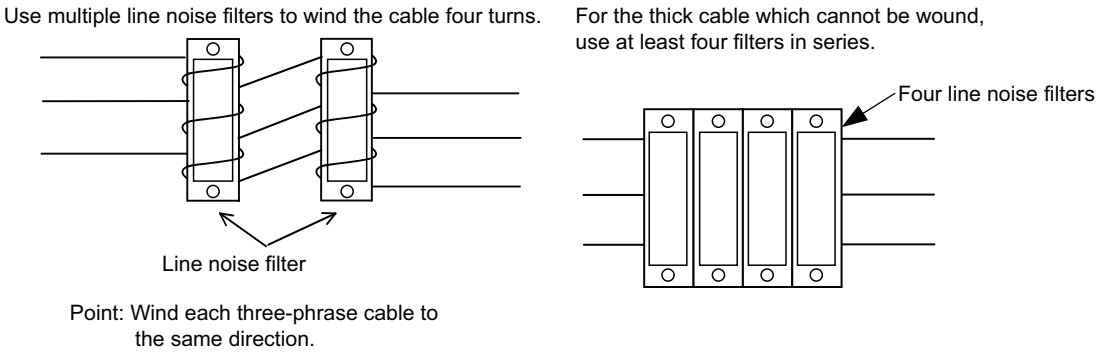
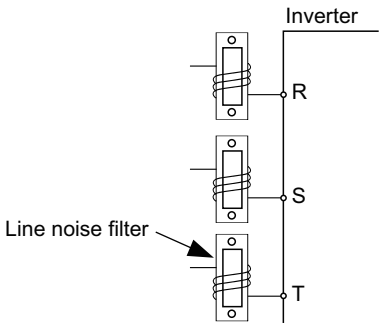


Fig. 7.19 Installation of the line noise filter FR-BSF01, FR-BLF



Point: Wind each three-phrase cable to the same direction.

Fig. 7.20 How to use multiple line noise filters



Point: Wind three-phrase cables to the same line noise filter.

Fig. 7.21 Incorrect usage of line noise filters

Table 7.2 Cable used and number of pass-through times

●FR-BSF01

Cable used (mm^2)	Number of pass-through times (T)
2	4
3.5	4
5.5	3
8	2
14	2
22	1
38 to 150	× Cannot be used.

When the cable is thick (5.5 mm^2 or more)

⇩

The cable cannot be wound four turns to one filter. It is recommended to use two or more filters to wind the cable four turns in total.

Use the above mentioned type or FR-BLF type line noise filter.

●FR-BLF

Cable used (mm^2)	Number of pass-through times (T)
2 to 22	4
30 to 60	3
80	2
100 to 150	1

When the cable is thick (30 mm^2 or more)

⇩

The cable cannot be wound four turns to one filter. It is recommended to use two or more filters to wind the cable four turns in total.

3) Using FR-BIF (-H) and FR-BLF or FR-BSF01 together

As described above, FR-BIF is effective for the noise with a relatively low frequency, and FR-BLF is effective for the noise with a high frequency. Therefore, the effect can be enhanced by using both filters together.

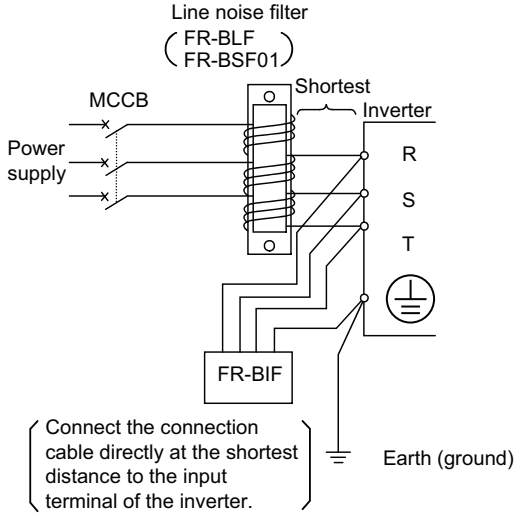


Fig. 7.22 Using FR-BIF and FR-BLF or FR-BSF01 together

☒ POINTS for understanding !

The FR-A800 and F700P series 55 kW or lower inverters have the filters equivalent to the line noise filter and radio noise filter on the input side.
The 75 kW or higher inverters have the filters equivalent to the radio noise filter only.

4) Noise suppression transformer

Noise suppression transformers are transformers having extremely small magnetic and electrostatic coupling of the primary and secondary coils and effective in noise reduction.

(b) Reducing the noise radiated from the wire between the inverter and the motor

Although the radiated noise can be reduced by inserting the line noise filter FR-BLF or FR-BSF01 to the inverter output side as described previously, it is usually reduced by using a metallic pipe or shielded cable as shown in Fig. 7.23. For effective earthing (grounding) of the motor, connect one cable of the 4-core cable on the inverter side and use a pipe whose thickness is 2 mm or more.

Wiring inside the concrete pit or room surrounded by concrete has an effect similar to the metallic pipe.

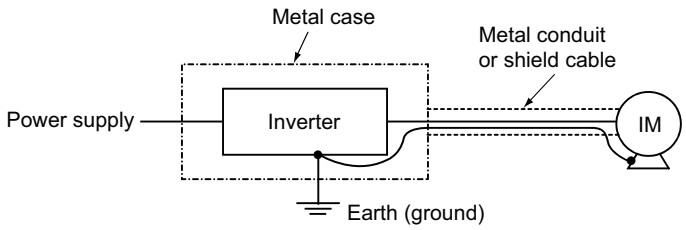


Fig. 7.23 Pipe arrangement for the motor connection cable

(c) Reducing the noise radiated from the inverter

Usually, the noise radiated from an inverter is relatively small and does not matter. However, when an inverter needs to be installed near a device susceptible to the noise described above, store the inverter in a metal case as shown in Fig. 7.24, install a noise filter at the power supply side, and connect a metallic pipe to the case at the output side.

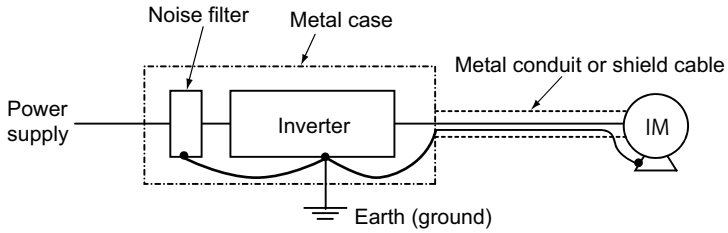


Fig. 7.24 Reducing the noise radiated from the inverter

(2) Specific examples of countermeasures

The following figure shows promising countermeasures against the inverter noise.

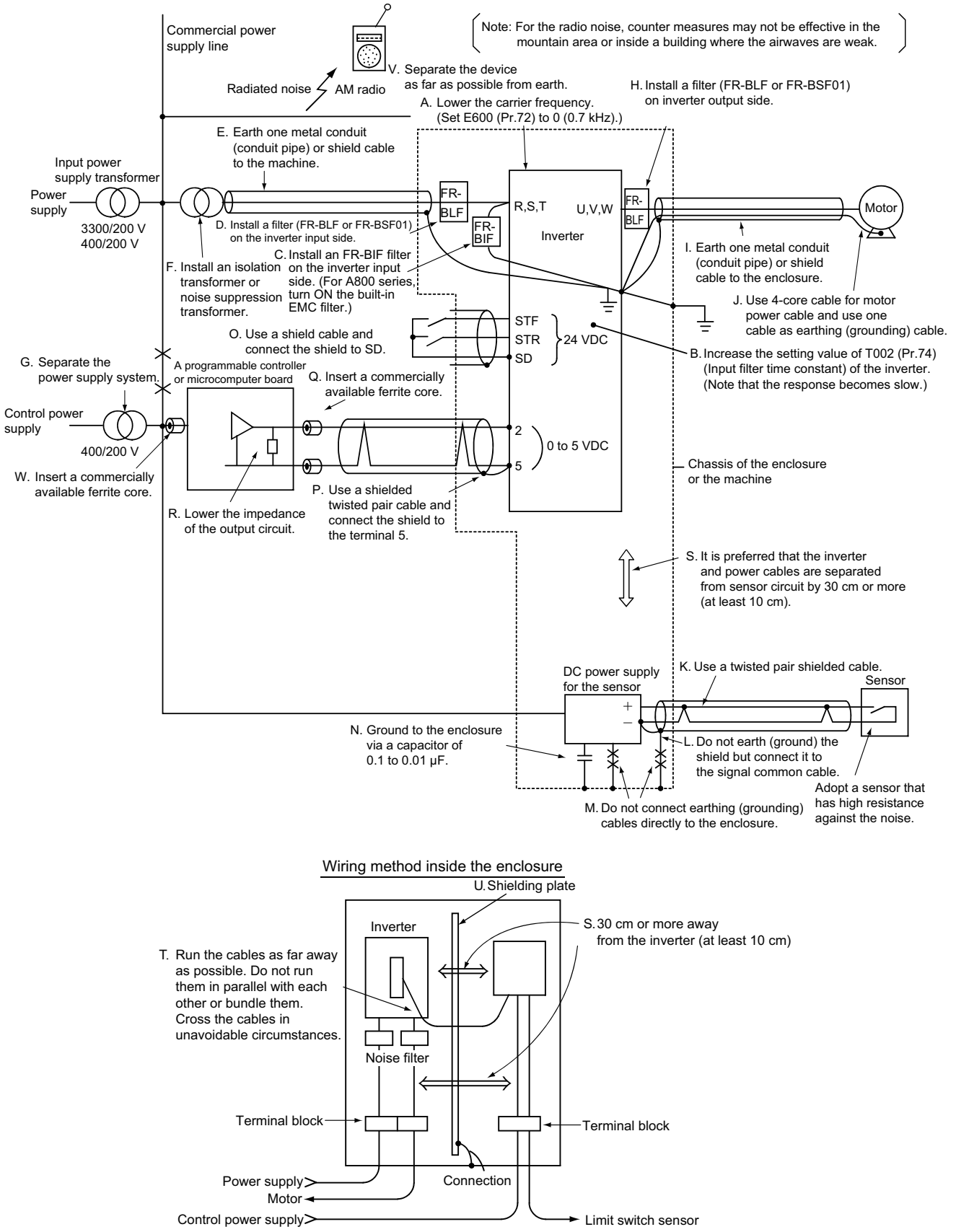


Fig. 7.25 Example of countermeasures against noise

The following table lists the promising effects (estimation) for each item of countermeasure examples (refer to the previous page). When taking actual countermeasures, refer to the list to determine the priorities.

Meaning of signs
⊙: Great effect
○: Effective
Δ: Small effect
—: No effect

Table 7.3 Effects of countermeasures against noise

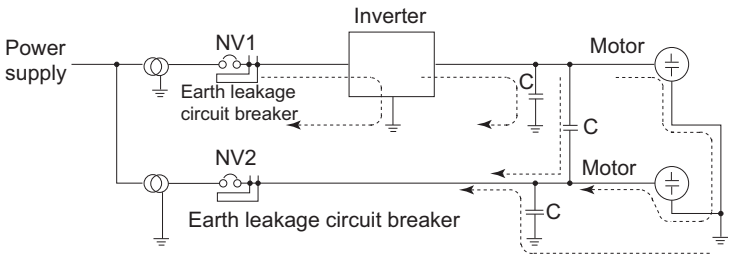
Location	Measure symbol	Countermeasure	Propagation method of noise						
			Air propagated noise			Electromagnetic induction noise	Electrostatic induction noise	Electrical path propagated noise	
			Radiation from inverter	Radiation from power supply cables	Radiation from motor cables			Power supply cable	Undesirable current of earthing (grounding) cable
Inverter	A	Decrease Carrier frequency E600 (Pr.72).	⊙	⊙	⊙	⊙	⊙	⊙	⊙
	B	Increase Input filter time constant T002 (Pr.74).	Δ	Δ	Δ	○	Δ	—	—
Input side	C	Install a radio noise filter FR-BIF(-H). (For FR-A800 series, turn ON the built-in EMC filter.)	—	⊙	-	-	-	⊙	-
	D	Install a line noise filter FR-BSF01 or FR-BLF.	—	⊙	—	—	—	⊙	Δ
	E	Wire the power supply cable with a metal conduit or shield cable.	—	⊙	—	—	—	⊙	—
	F	Install an isolation transformer or noise suppression transformer.	—	Δ	—	—	—	⊙	—
	G	Separate the power supply system.	—	—	—	—	—	⊙	⊙
Output side	H	Install a line noise filter FR-BSF01 or FR-BLF.	—	—	⊙	Δ	Δ	—	⊙
	I	Wire the output cable with a metal conduit or shield cable.	—	—	⊙	○	○	—	—
	J	Use 4-core cable for motor power cable and use one cable as earthing (grounding) cable.	—	—	Δ	Δ	Δ	—	⊙
Connected device	K	Use a twisted pair shielded cable for the signals from the sensor.	○	○	○	⊙	⊙	—	—
	L	Connect the shield to the sensor signal common cable.	—	—	—	⊙	⊙	—	⊙
	M	Do not earth (ground) the sensor power supply unit directly to the enclosure.	—	—	—	—	—	Δ	⊙
	N	Earth (ground) the sensor power supply unit using a capacitor.	—	—	—	—	—	Δ	○
	O	Use a shielded cable for input signals and connect the shield to common (input terminal) SD.	Δ	Δ	Δ	○	⊙	—	Δ
	P	Use a twisted pair shield cable for the speed input and connect the shield to the terminal 5.	○	○	○	⊙	⊙	—	Δ
	Q	Attach a commercially available ferrite core to the speed input cable (at the input side of the connected device).	Δ	Δ	Δ	○	—	—	—
	R	Reduce the output circuit impedance of the connected device.	Δ	Δ	Δ	○	—	—	—
	S	Keep a distance of 30 cm or more between the sensor circuit and the inverter or its power cable.	⊙	⊙	⊙	⊙	⊙	—	—
	T	Do not run cables in parallel with each other and do not bundle them.	Δ	Δ	Δ	⊙	⊙	—	—
	U	Install the shielding plate.	○	Δ	Δ	Δ	Δ	—	—
	V	Keep the device away from earth.	Δ	○	○	Δ	Δ	—	—
	W	Attach a commercially available ferrite core to the input side of the connected device.	—	—	—	—	—	○	Δ

7.2.4 Leakage current

The static capacitances exist between the inverter I/O cables and other cables or earth and in the motor, through which a leakage current flows. Since its value depends on the static capacitances or carrier frequency, the low acoustic noise operation at the increased carrier frequency of the inverter will increase the leakage current. Therefore, take the following countermeasures. Select the earth leakage circuit breaker according to its rated sensitivity current, independently of the carrier frequency setting.

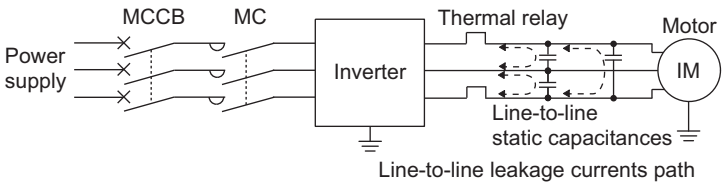
(1) To-earth (ground) leakage current

Table 7.4 Effects and countermeasures of to-earth (ground) leakage current

Type	Effect and countermeasure
Effect and counter-measure	• The leakage current may flow not only into the inverter's own line but also into the other lines through the earthing (grounding) cable or the like. This leakage current may cause an unnecessary operation of the earth leakage circuit breaker or earth leakage relay. ● Countermeasures • If the carrier frequency setting is high, decrease E600 (Pr.72) PWM frequency selection setting. Note that the motor noise increases. Selecting E601 (Pr.240) Soft-PWM operation selection makes the sound inoffensive. • By using earth leakage circuit breakers that support harmonic and surge suppression in the inverter's own line and other line, operation can be performed with a high carrier frequency (with low noise).
Undesirable current path	

(2) Line-to-line leakage current

Table 7.5 Effects and countermeasures of line-to-line leakage current

Type	Effect and countermeasure
Effect and countermeasure	• This leakage current flows via a static capacitance between the inverter output cables. • Harmonics of the leakage current may operate the external thermal relay unnecessarily. When the wiring length is long (50 m or more) for the 400 V class small-capacity models (7.5 kW or lower), the external thermal relay is likely to operate unnecessarily because the ratio of the leakage current to the rated motor current increases. ●Countermeasures • Use H000 (Pr.9) Electronic thermal O/L relay. • If the carrier frequency setting is high, decrease E600 (Pr.72) PWM frequency selection setting. Note that the motor noise increases. Selecting E601 (Pr.240) Soft-PWM operation selection makes the sound inoffensive. To ensure that the motor is protected against line-to-line leakage current, it is recommended to use a temperature sensor to directly detect motor temperature.
Undesirable current path	

7.2.5 Earth (ground)

Generally, an electrical apparatus has an earth (ground) terminal, which 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 that can shut off a leakage current completely, and actually, a slight current flows into the case.
The original purpose of the earth (ground) terminal is earthing (grounding) the case of an electrical apparatus to prevent operators from getting an electric shock from this leakage current when they touch it. To avoid the influence of external noises, earthing (grounding) is important to machines that handle low-level signals or operate in a significantly high speed such as audio equipment, sensors, and computers.
As described above, earthing (grounding) has two completely different types, and a problem occurs when these are earthed (grounded) together. Therefore, consider a dirty earth (ground) for electric shock prevention and a clean earth (ground) for noise prevention separately.
When an inverter is used, its output voltage has not a sine waveform but a precipitous waveform. Therefore, the charging/discharging current to the static capacitance in the isolated section flows as the leakage current.
Furthermore, the same charging/discharging leakage current flows into the motor where the output voltage of the inverter is applied. The leakage current contains more high frequency components and the current value is larger compared to the operation with a commercial power supply as shown in Fig. 7.27. The higher the carrier frequency of the inverter is, the stronger this tendency is.

(1) Earthing (grounding) methods and earthing (grounding) work

As described previously, earthing (grounding) is roughly classified into the electrical shock prevention type and noise-influenced malfunction prevention type. These two types should be clearly distinguished, and the following work must be done to prevent the leakage current having high frequency components from entering the malfunction prevention type earthing (grounding):

(a) Make the separate earth (ground) connection for the inverter. (Refer to Fig. 7.26.)
If separate earthing (grounding) (I) is not available, use (II) common earthing (grounding) where the inverter is connected with the other equipment at an earthing (grounding) point. Do not use the common earthing (grounding) in which one earthing (grounding) cable is shared between the inverter and the other devices as shown in (III).
Especially, the common earthing (grounding) with the high-power devices such as motors or transformers must be avoided. As leakage current containing many high frequency components flows into the earthing (grounding) cables of the inverter and the motor driven by the inverter, the inverter must also be earthed (grounded) separately from the noise-sensitive devices described above. In a high building, it may be effective to use its iron structure frames as earthing (grounding) electrode for EMI prevention in order to separate from the earth (ground) system for electric shock prevention.

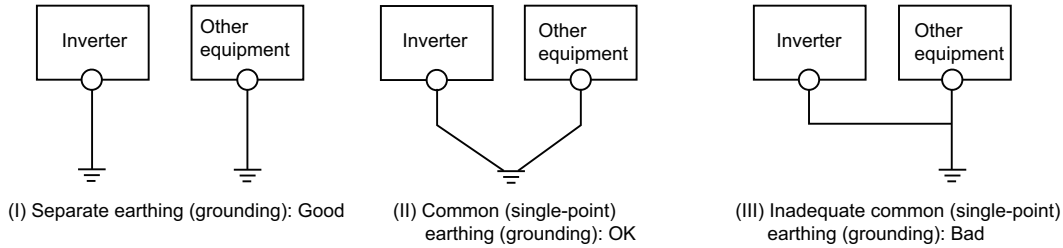


Fig. 7.26 Earthing (grounding) methods

(b) This inverter must be earthed (grounded). Earthing (grounding) must conform to the requirements of national and local safety regulations and electrical codes. (NEC section 250, IEC 61140 class 1 and other applicable standards).
A neutral-point earthed (grounded) power supply must be used for 400 V class inverter to be compliant with EN standard.

(c) Use the thickest possible earthing (grounding) cable. The earthing (grounding) cable should be no less than the size indicated in the Instruction Manual.

(d) The earthing (grounding) point should be as close to the inverter as possible, and the earth (ground) wire length should be as short as possible.

(e) Run the earthing (grounding) cable as far away as possible from the I/O wiring of the noise-sensitive devices, and run them in parallel in the minimum distance.

(f) For the earth (ground) terminal of the motor, use one cable of the 4-core cable and earth (ground) at the inverter side.

When earthing (grounding) of the inverter, motor driven by the inverter, and devices such as audio devices, sensors, and computers are connected together, the leakage current becomes the noise source and the noise that affects the devices.
To resolve this problem, separate the dirty earth (ground) for the inverter and the clean earth (ground) for devices such as audios, sensors, and computers.

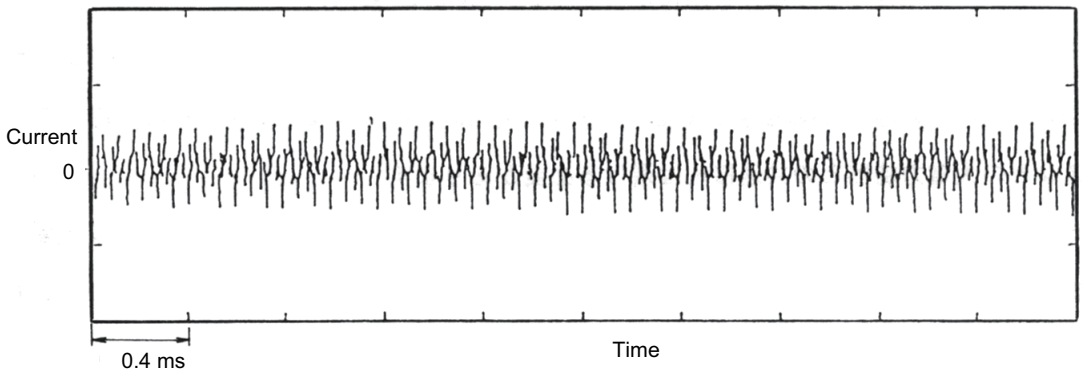


Fig. 7.27 Example of the earthing (grounding) cable current of the inverter-driven motor (Inverter: 200 V class 0.75 K, Motor: SF-JR 0.75 kW 4 P)

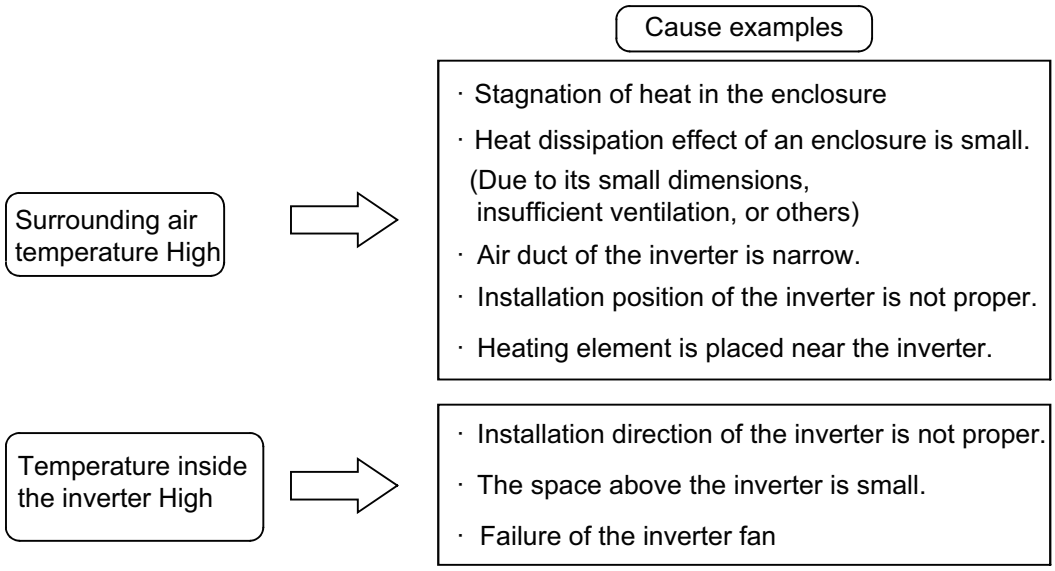
7.3 Problems and measures when using inverter

This section explains the reliability and life of the inverter and important precautions depending on the installation environment of the inverter and the operating condition.
In addition, the circuit design, precautions on wiring, and operating procedure for using an inverter are explained as well.

7.3.1 Environment and installation condition

(1) Reliability of the inverter and temperature

The reliability of the inverter is significantly influenced by the temperature. High surrounding air temperature or incorrect installation may cause unexpected troubles such as failures and damages due to the increased temperature inside the inverter which is installed in an undesired place or not installed correctly.
The possible causes are shown below.



(2) Surrounding air temperature

Surrounding air temperature of the inverter is the temperature at the immediate periphery of the position where the inverter is installed.

1) Measure the temperature at the position shown in Fig. 7.28.
2) The permissible temperature range is from -10°C to +50°C.
(Too high or low temperature causes a trouble.)
3) When the temperature inside the enclosure is +50°C or lower, consider that the surrounding air temperature of the enclosure is 40°C or lower.

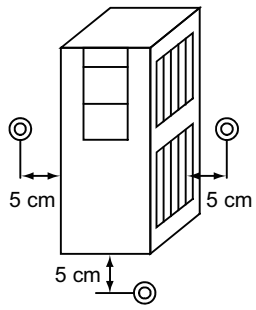
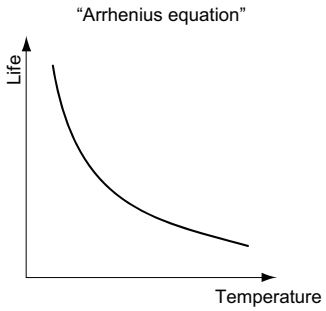


Fig. 7.28 Measuring the surrounding air temperature

☒ Good to know for checking an inverter

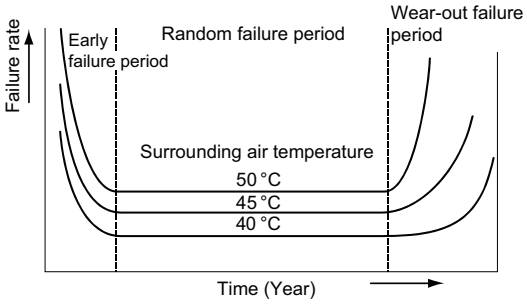
Life

The smoothing electrolytic capacitor used in the inverter is one of the components to which the "Arrhenius equation" is applied. It will shorten the life by half for every 10°C increase in surrounding air temperature (double for every 10°C decrease).
The life of other components is very much affected by the temperature as well.



Relation between failure occurrence rate and temperature

The inverter consists of many electronic parts such as semiconductor devices. For these components, the failure rate is closely related to the surrounding temperature. It is important to operate them at as lower temperature as possible to reduce the failure rate.



(3) Heat of an inverter

The amount of heat generated by the inverter depends on the inverter capacity or the motor load factor.
Options contained in the enclosure with the inverter such as an AC reactor, DC reactor, and brake unit (including the resistor) generate relatively large amount of heat. Consider this heat when designing the enclosure. Generated heat amount is shown in Table 7.6.

Table 7.6 Amount of heat generated by the inverter and reactor (at the rated output)

Motor capacity (kW)	FR-A800 Inverter heat amount (W)		Reactor heat amount (W)			
			FR-HEL		FR-HAL	
	200 V	400 V	200 V	400 V	200 V	400 V
0.4	50	50	6	6	10	16
0.75	70	65	7	7	14	23
1.5	110	75	8	8	20	30
2.2	140	100	11	11	24	43
3.7	190	150	13	13	33	46
5.5	260	200	17	17	40	52
7.5	360	250	19	19	46	52
11	520	300	23	23	60	60
15	670	400	26	26	75	60
18.5	770	550	29	29	74	76
22	940	650	34	34	82	74
30	1050	800	38	38	97	91
37	1270	1100	47	47	120	97
45	1610	1300	47	47	140	140
55	1880	1550	52	52	140	150
75	2530	1900	130	130	170	180
90	3110	2400	130	130		
110		2500	160	140	280	200
132		3000		140		
160		4000		170		
185		4200		230		400
220		5000		240		
250		5500		270		
280		6500		300		490
315		7000		360		
355		8000		360		530
400		9000		450		
450		10500		450		
500		11500		470		
560				500		1080

(Note) The heat amount of the 7.5 K or lower built-in brake resistor is not included.

(4) Interference of heat inside the enclosure and ventilation

The arrangement of the inverter and ventilation fan is one of the important points when they are installed in the enclosure.

When installing multiple inverter or a ventilation fan in the enclosure, note that the surrounding air temperature of the inverter increases or the ventilation becomes less effective depending on the installing position.

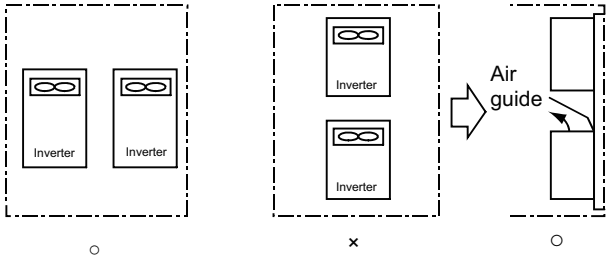


Fig. 7.29 When installing multiple inverters

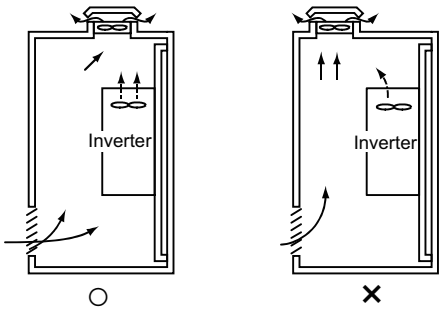


Fig. 7.30 Location of the ventilation fan

(5) Arrangement of the discharging resistor

When using a discharging resistor or externally installed high-duty brake resistor (FR-ABR), take necessary countermeasures against the heat generated from the resistor.

Consider the cooling system regarding the resistor as a heater.

It is recommended to install the discharging resistor outside the enclosure.

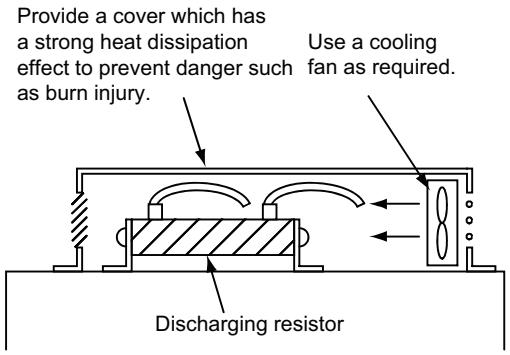


Fig. 7.31 Installing method of the resistor

Caution: The temperature of the resistor surface may increase up to approximately 300°C. Pay attention to the material of the installation side and the arrangement of multiple resistors.

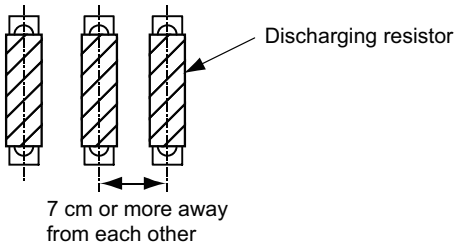


Fig. 7.32 Arrangement of the resistors

(6) Installation orientation of the inverter

If the installing orientation is not correct, the heat dissipation effect of the inverter is reduced significantly, and the generated heat remains inside the inverter. (The printed plate of the control circuit is not cooled by a cooling fan.)

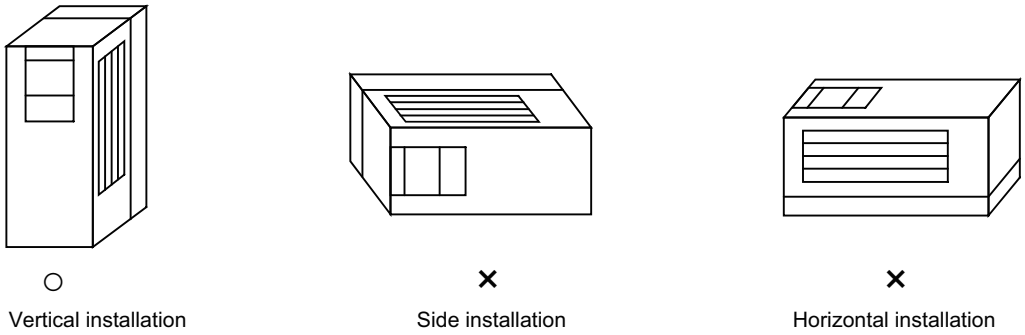


Fig. 7.33 Installation orientation of the inverter

(7) Standard specifications of the installation environment (for the FR-A800 series 200 V class)

Item		Description
Surrounding air temperature	LD, ND (initial setting), HD	-10°C to +50°C (non-freezing)
	SLD	-10°C to +40°C (non-freezing)
Ambient humidity		With circuit board coating: 95% RH or less (non-condensing) Without circuit board coating: 90% RH or less (non-condensing)
Atmosphere		Indoors (free from corrosive gas, flammable gas, oil mist, dust and dirt)
Altitude		Maximum 1000 m
Vibration		5.9 m/s^2 or less at 10 to 55 Hz (directions of X, Y, Z axes)
AC voltage/frequency		Three-phase 200 to 220 V 50 Hz, 200 to 240 V 60 Hz
Permissible voltage fluctuation		170 to 242 V 50 Hz, 170 to 264 V 60 Hz
Permissible frequency fluctuation		±5%

● Temperature

(a) Countermeasures against high temperature
1) Use a forced ventilation system or similar cooling system. (Refer to (4).)
2) Install the enclosure in an air-conditioned electric chamber.
3) Block direct sunlight.
4) Provide a shielding plate or similar plate to avoid direct exposure to the radiated heat and wind of a heat source.
5) Ventilate the area around the enclosure well.

(b) Countermeasures against low temperature
1) Provide a space heater in the enclosure.
2) Do not power OFF the inverter. (Keep the start signal of the inverter OFF.)

(c) Sudden temperature changes
1) Select an installation place where temperature does not change suddenly.
2) Avoid installing the inverter near the air outlet of an air conditioner.
3) If temperature changes are caused by opening/closing of a door, install the inverter away from the door.

● Humidity

Operate the inverter within the ambient air humidity range of 45 to 90% (up to 95% with circuit board coating). If the humidity is too high, problems such as the reduced insulation and metal corrosion occur. On the other hand, too low humidity may cause a spatial electrical breakdown. The humidity conditions for the insulation distance defined in JEM 1103 standard "Insulation Distance from Control Equipment" is 45 to 85%.

(a) Countermeasures against high humidity
1) Make the enclosure enclosed, and provide a hygroscopic agent.
2) Provide dry air into the enclosure from outside.
3) Provide a space heater in the enclosure.

(b) Countermeasures against low humidity
Air with proper humidity can be blown into the enclosure from outside. Also when installing or inspecting the unit, discharge your body (static electricity) beforehand, and keep your body away from the parts and patterns.

(c) Countermeasures against condensation
Condensation may occur if frequent operation stops change the in-enclosure temperature suddenly or if the outside air temperature changes suddenly.
Condensation causes faults such as reduced insulation and corrosion.
1) Take the countermeasures against high humidity described in (a).
2) Do not power OFF the inverter. (Keep the start signal of the inverter OFF.)

(8) When driving an explosion-proof motor with an inverter

An explosion-proof motor has an authorization system in combination with the driving inverters. Check the following points for installing them.

(a) For the existing explosion-proof motor for commercial power supply drive and a safety explosion-proof motor, the inverter operation is not available.
The motor must pass the explosion-proof test by Ministry of Health, Labor and Welfare in combination with the inverter. The Technology Institution of Industrial Safety organizes the test.
The combination of the explosion-proof motor and the inverter which has passed the test in advance can be used. However, only the inverters which have the same model (including the capacity) as the one passed the test can be used. Furthermore, operation range is limited within the certified terms.
The inverter-driven dedicated explosion-proof type motor and inverter are prepared by Mitsubishi. For the details, refer to the catalog.

(b) Take the test to use the rating out of the certified terms or model that has not been passed the test.

(c) When using the inverter option together, refer to the Instruction Manual.

(d) Using a safety explosion-proof motor in combination with an inverter is not economical not only because it costs the test fee but also the operation condition (such as reduction in incurred loss and improvement of cooling effect) is strictly restricted.
It is recommended to use the explosion-proof motor which has been passed the test.

(e) The inverter itself is a non-explosion proof structure. Always install it in a non-explosion location.

7.3.2 Connection of the inverter

(1) Terminal connection diagram

Connection statuses of various terminals to operate an inverter are described in the catalog. The following explains the specifications and usage notes of these terminals when using the FR-A800 series as an example.

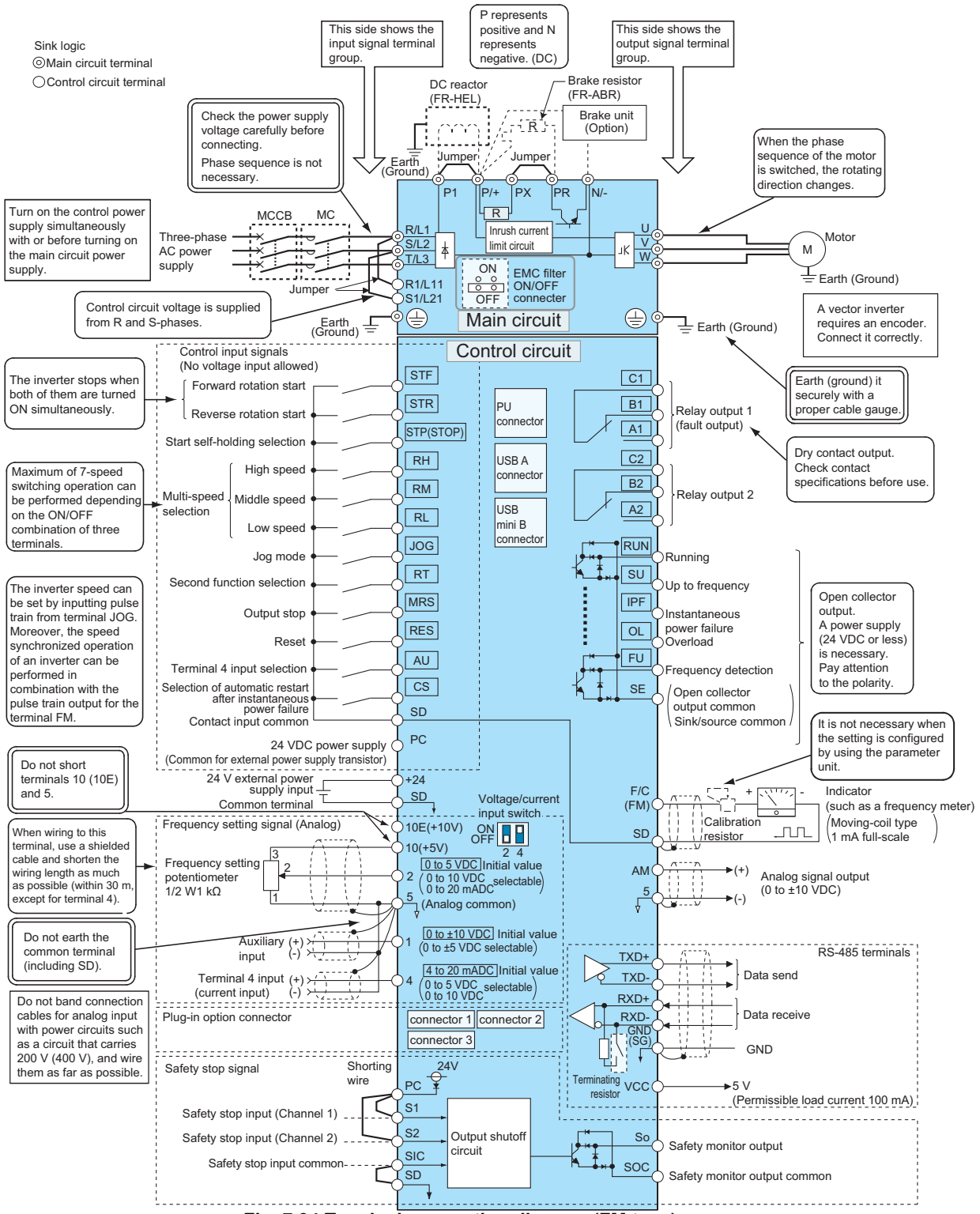


Fig. 7.34 Terminal connection diagram (FM type)

POINT

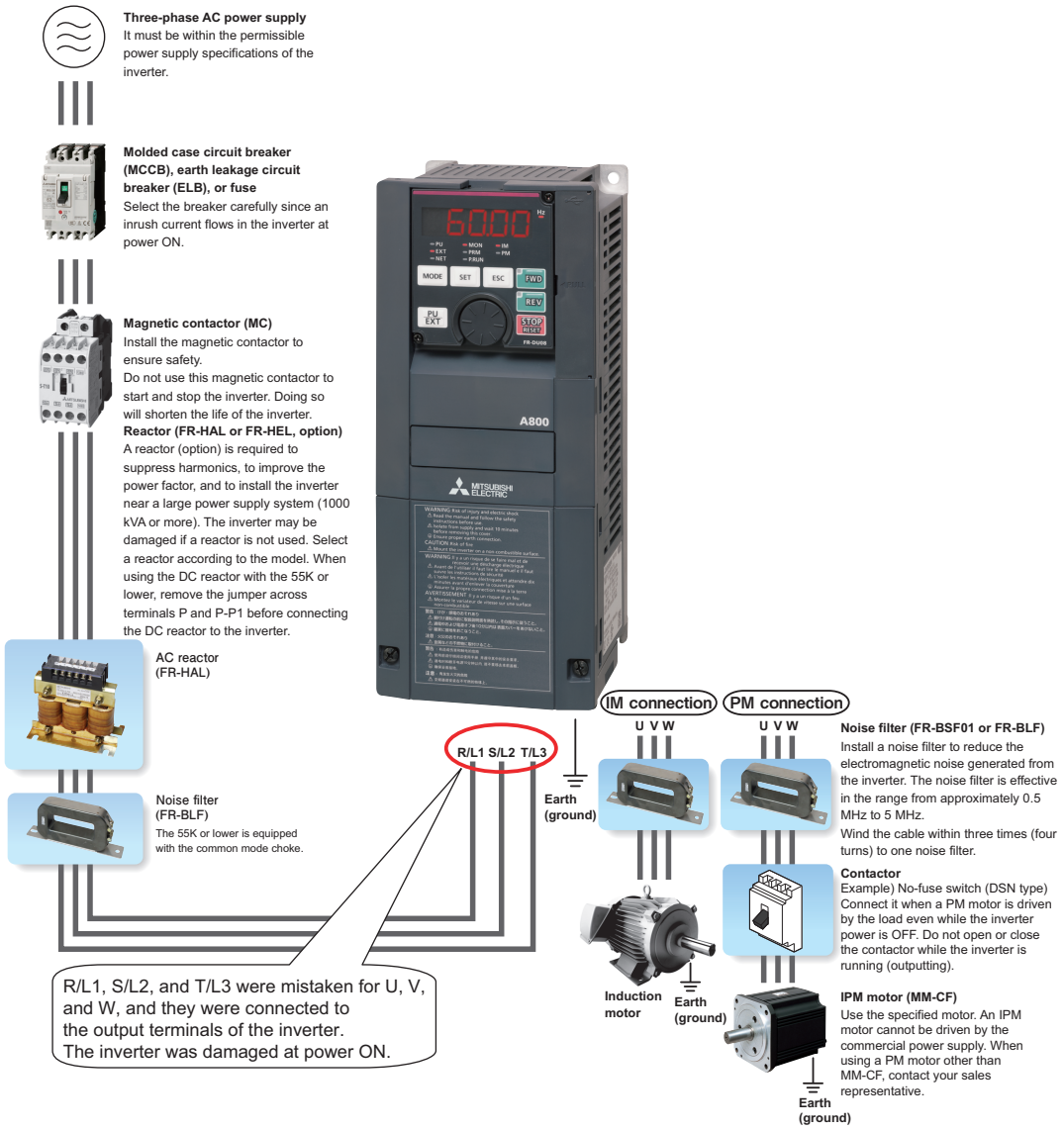
Failure example 1: Wiring for the power supply

[Failure]

Nothing was displayed on the monitor (LED display) when power of the inverter was turned on.

[Cause]

The commercial power supply inputs R/L1, S/L2, and T/L3 were connected to the output terminals of the inverter U, V, and W. The display of the power supply itself was incorrect.



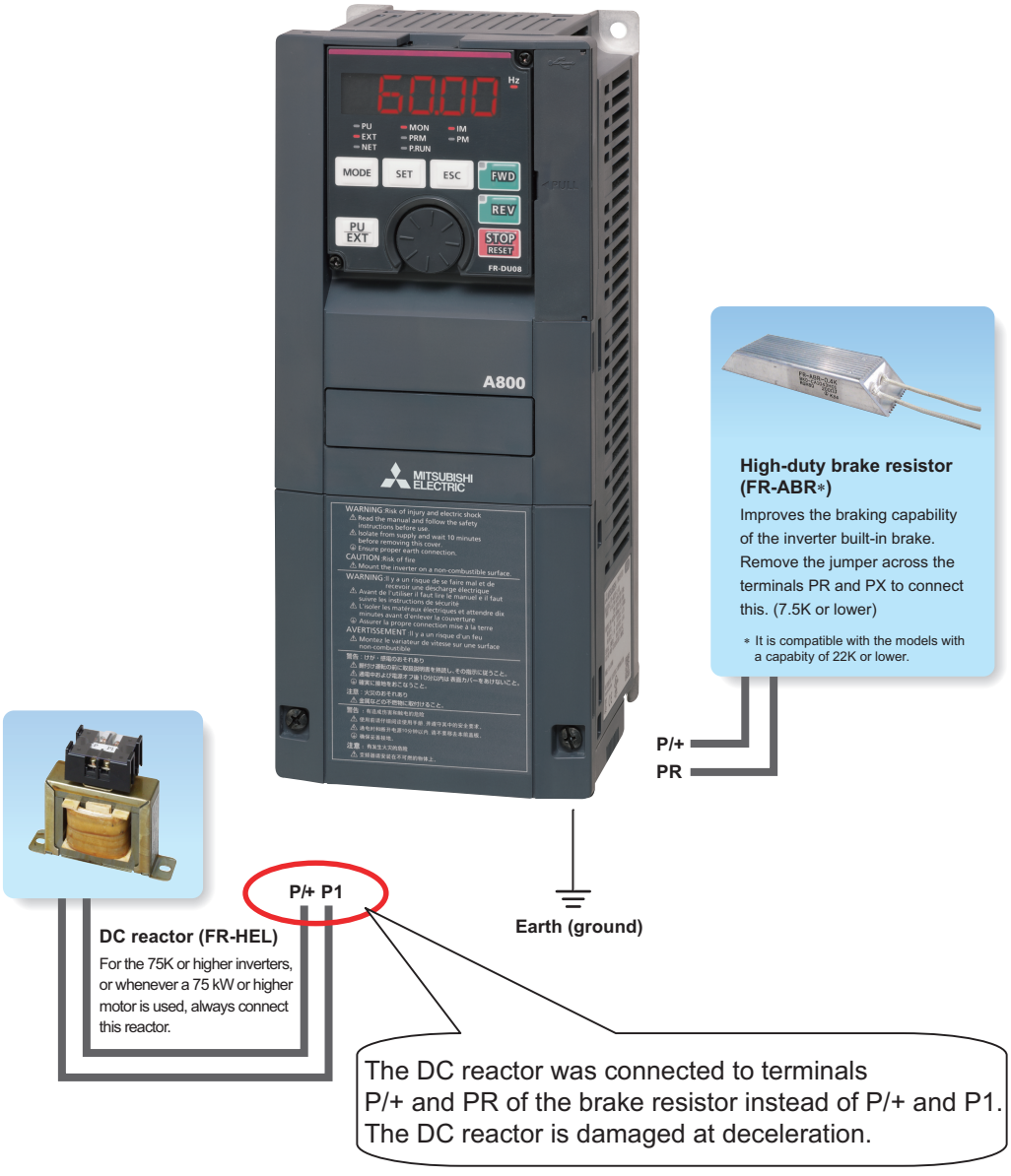
Failure example 2: Incorrect connection of the DC reactor

[Failure]

At a motor test drive, OV was displayed and the DC reactor was burned.

[Cause]

The DC reactor was connected to terminals P/+ and PR of the brake resistor instead of P/+ and P1.



(2) Connection of the main circuit

Since the main circuit is a power circuit, incorrect connection may not only damage the inverter but also pose a risk to operators. The following figure shows points likely to fail.

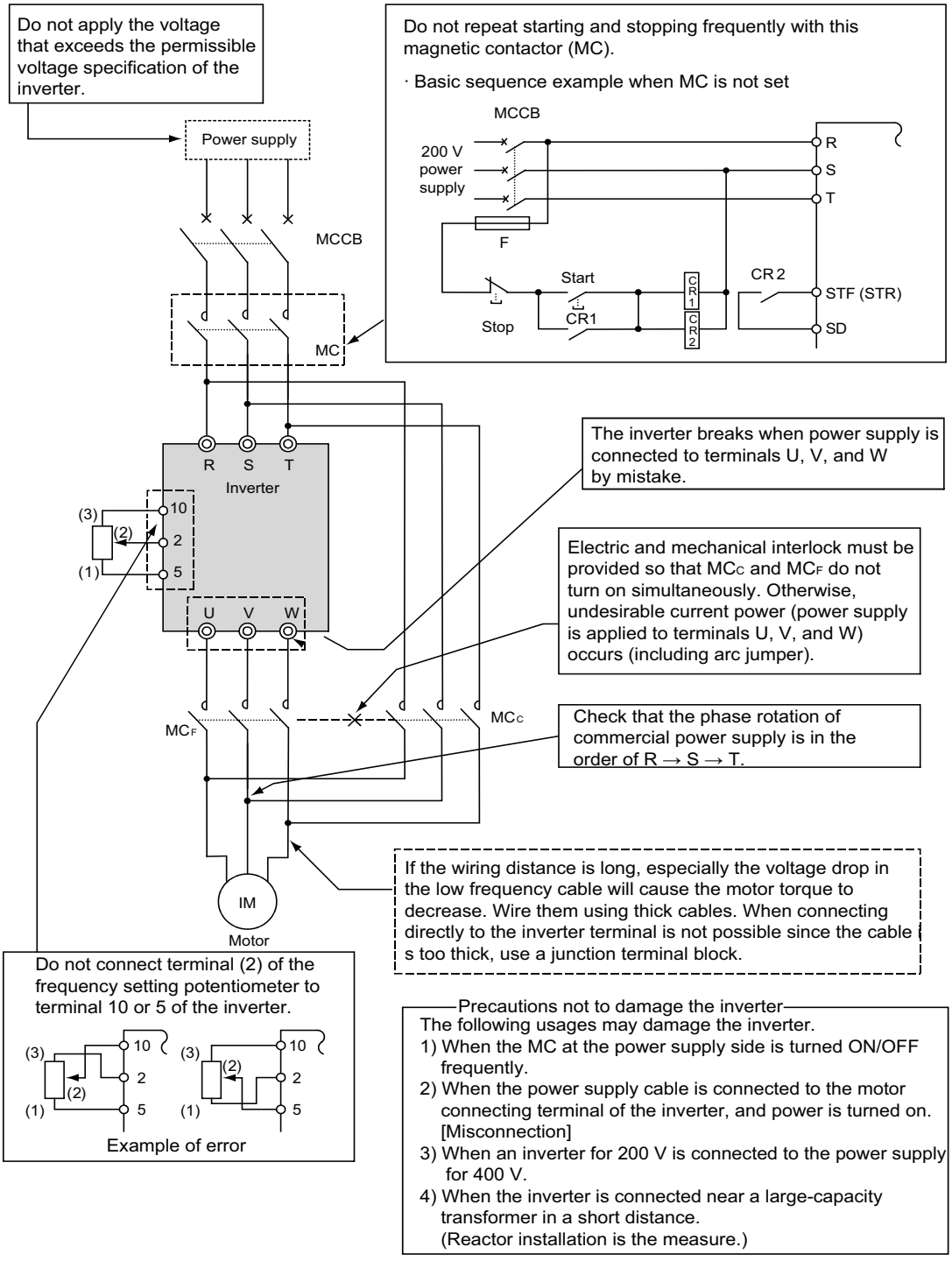


Fig. 7.35 Main circuit connection

(3) Connection of the control circuit

The following table lists the formats of the I/O terminals in the inverter and common terminals.

Terminal	Format	Example of terminal	Common terminal
Input terminal	Contact (or open collector)	Start signal (STF, STR) Selection signal (RH, RM, RL, AU, etc)	SD or PC (power supply ⊕ common)
	Analog	Frequency setting signal (such as 2, 1, and 4)	5
Output terminal	Contact	Fault output (A, B)	C
	Open collector	Running signal (RUN, SU, OL, IPF, FU)	SE
	Pulse train	For an indicator (frequency meter) (FM)	SD
	Analog	For analog voltage output (AM)	5

(a) Connection to input terminals

1) Contact or open collector input terminal (insulated from the inverter internal circuit)
Each terminal functions by short-circuiting with the common terminal SD. Since the power distribution current is the micro-current (4 to 6 mADC), use the micro-current (such as twin contacts) for switches or relays to prevent a contact faults.

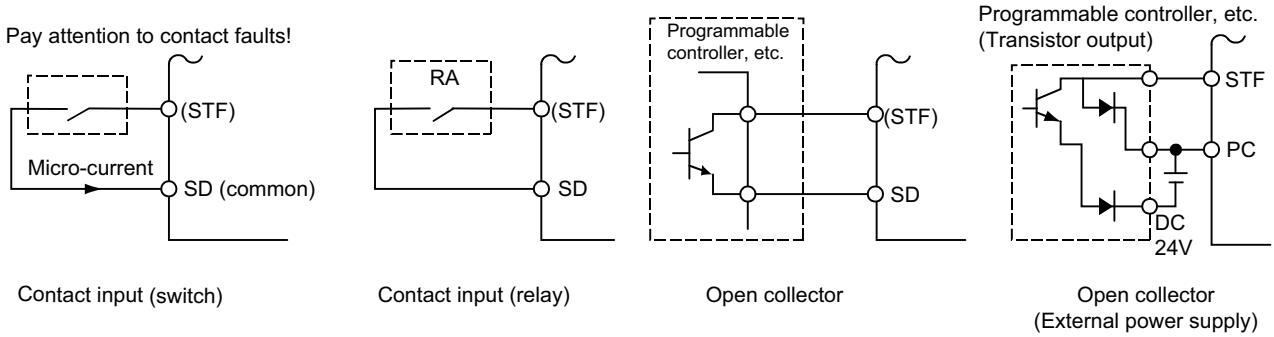


Fig. 7.36 Connection of input signals

2) Analog input terminal (It is not insulated from the inverter internal circuit.)
Separate the cables from the high-voltage circuit cables of 200 V (400 V) not to band them together.
Always use the shielded cable as a countermeasure against the external noise.

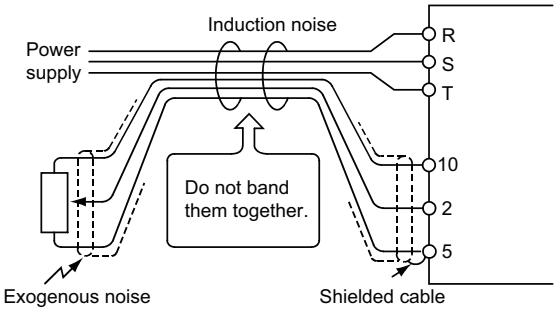


Fig. 7.37 Connection example of the frequency setting input terminal

3) How to connect the frequency setting potentiometer correctly
Each terminal of the frequency setting potentiometer has a terminal symbol. Incorrect connection causes an inverter failure.
The resistance is also important for selection.
<Specification> 2 W 1 kΩ Wire-wound variable resistor type B characteristic

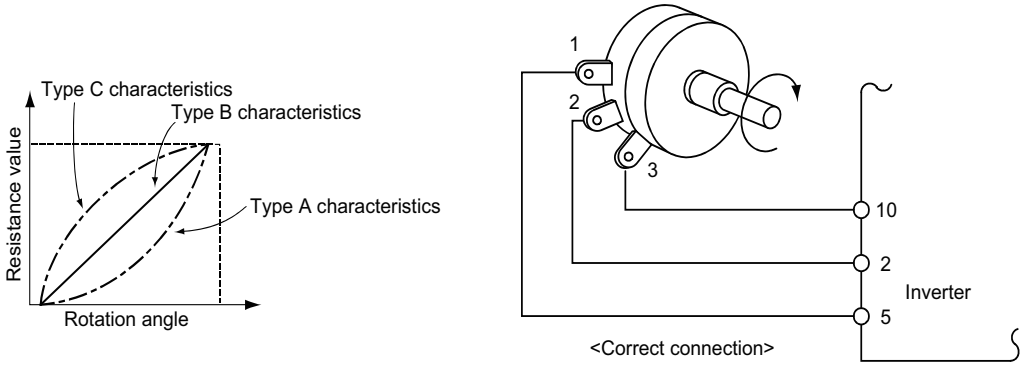
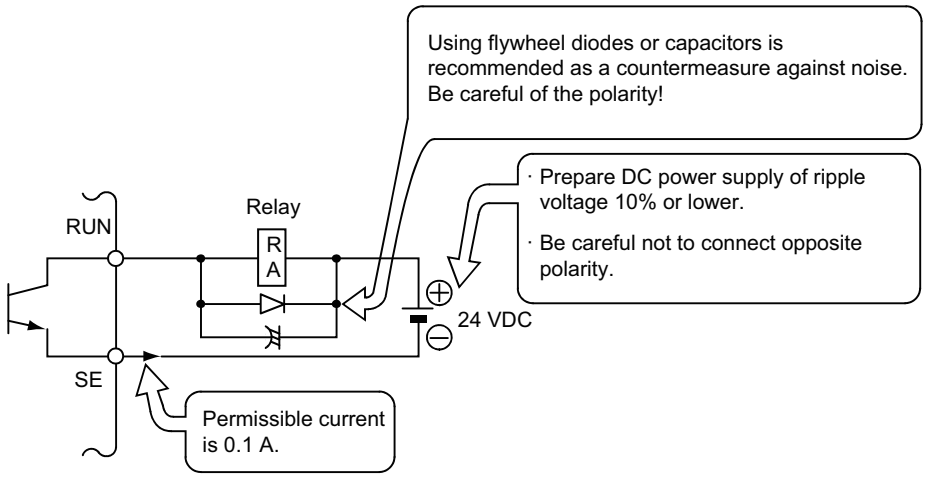


Fig. 7.38 Connection of the frequency setting potentiometer

(b) Connection to output terminals

1) Open collector output terminal



2) Pulse train output terminal

3) Analog voltage output (0 to 10 VDC)

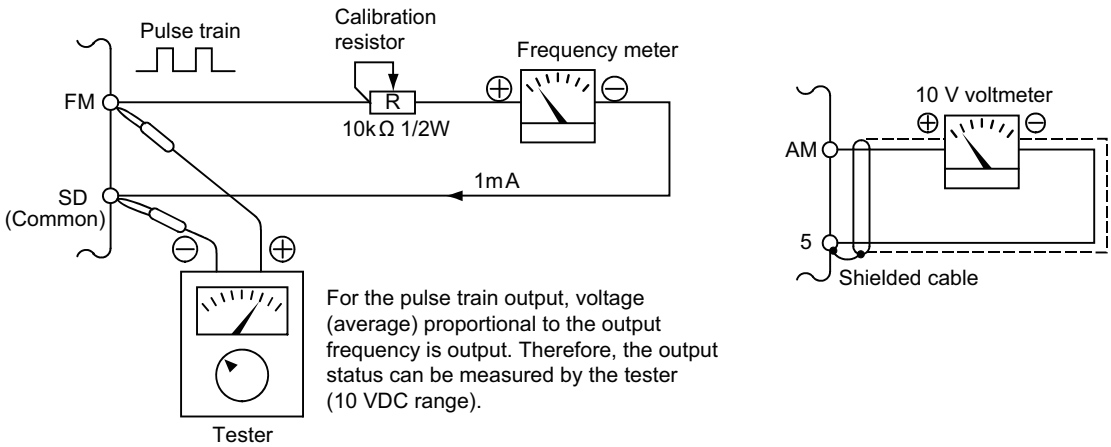


Fig. 7.39 Connection of output signal terminals

(4) Wiring distance of I/O cables

Restrictions differ depending on the I/O terminal. Although the control signals are isolated at the input by photocoupler to improve noise tolerance, they are not isolated for the analog input. Therefore, pay particular attention to the wiring of the frequency setting signal and shorten the wire length as much as possible or take other countermeasures against the external noise. A guide of the permissible wiring length for each signal and how to handle the length exceeding it are shown in Fig. 7.40.

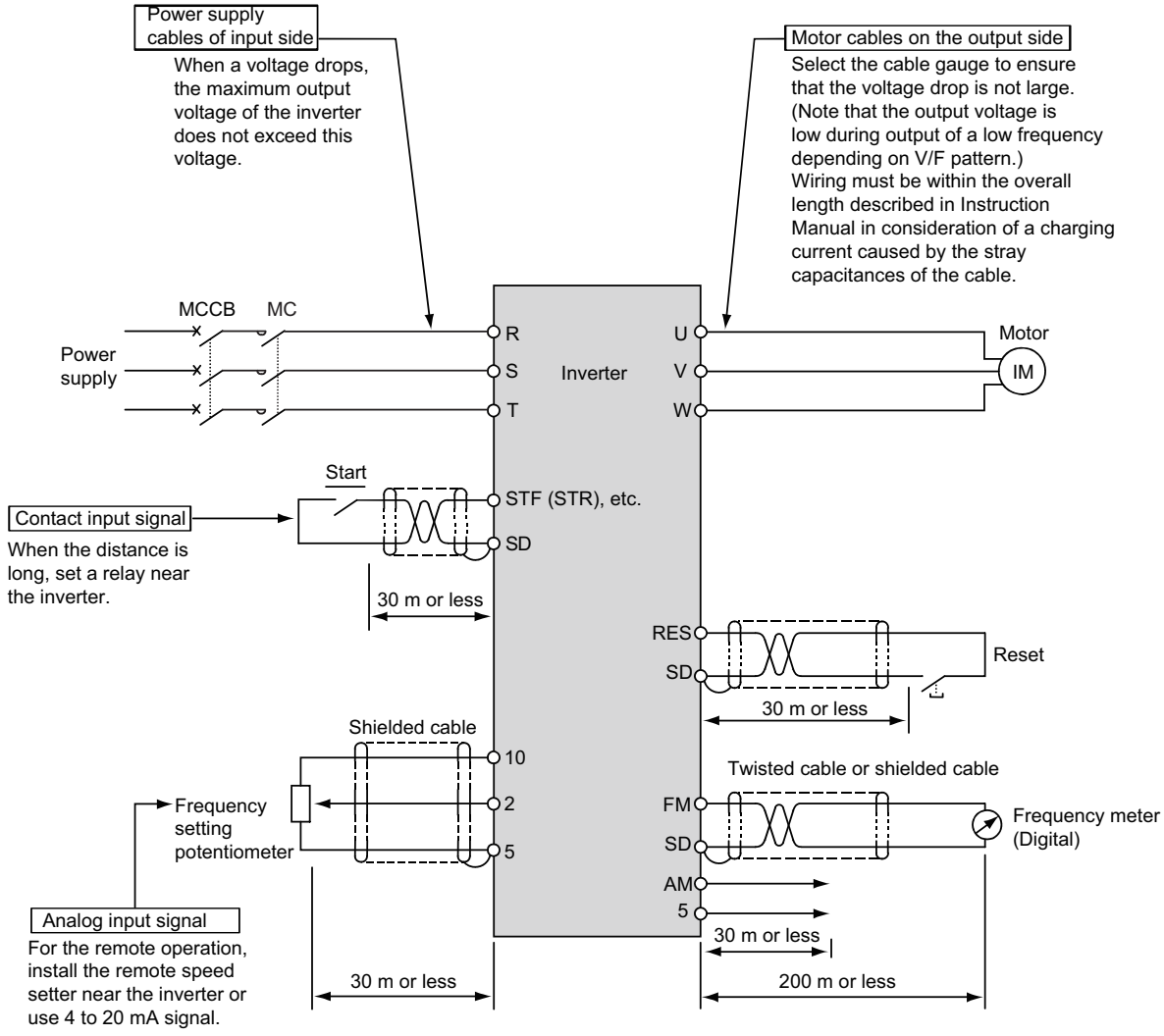
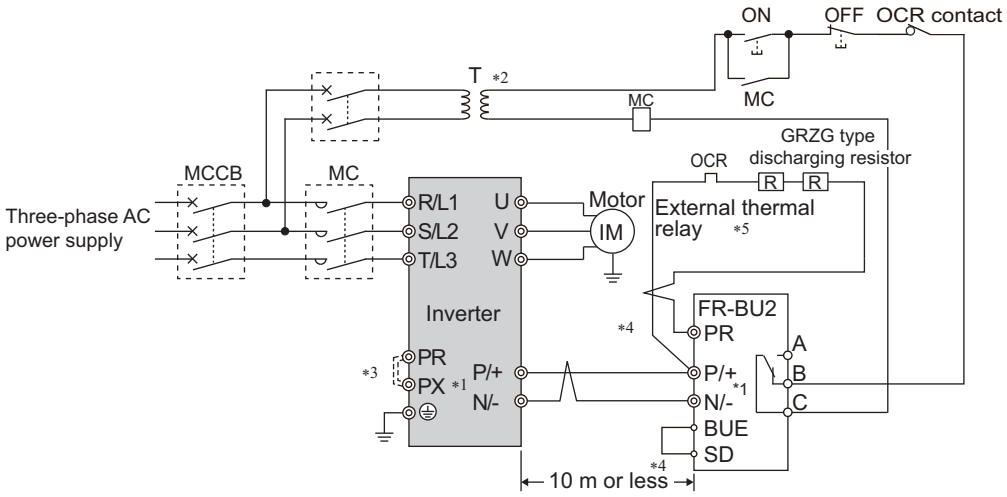


Fig. 7.40 Wiring lengths of I/O cables

(5) Wiring of the FR-BU2 brake unit

For the wiring, connect a pair of the FR-BU2 brake unit and discharging resistor or resistor unit to the inverter terminals P/+ and N/-.

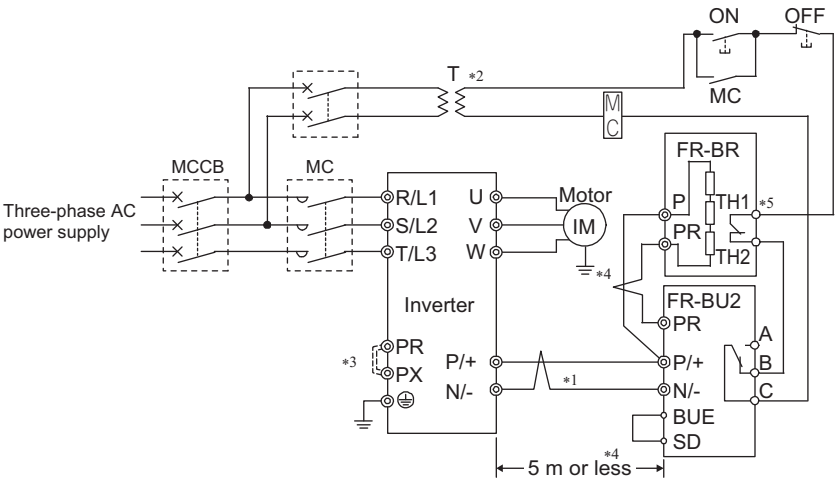
(a) The FR-BU2 brake unit and the discharging resistor



*1 When wiring, make sure to match the terminal symbol (P/+, N/-) at the inverter side and at the brake unit (FR-BU2) side. (Incorrect connection will damage the inverter and brake unit.)
*2 When the power supply is 400 V class, install a stepdown transformer.
*3 Remove the jumper across terminals PR and PX when using the FR-BU2 with the inverter of the FR-A800 series 7.5K or lower or the FR-V500 series 5.5K or lower.
*4 The wiring distance between the inverter, brake unit (FR-BU2), and discharging resistor must be within 5 m. Even when the cable is twisted, the wiring length must be within 10 m.
*5 It is recommended to install an external thermal relay to prevent overheat of the discharging resistor.

Fig. 7.41 Wiring method of the brake unit (GRZG type discharging resistor)

(b) The FR-BU2 brake unit and the FR-BR resistor unit



*1 When wiring, make sure to match the terminal symbol (P/+, N/-) at the inverter side and at the brake unit (FR-BU2) side. (Incorrect connection will damage the inverter and brake unit.)
*2 When the power supply is 400 V class, install a stepdown transformer.
*3 Remove the jumper across terminals PR and PX when using the FR-BU2 with the inverter of the FR-A800 series 7.5K or lower or the FR-V500 series 5.5K or lower.
*4 The wiring distance between the inverter, brake unit (FR-BU2), and resistor unit (FR-BR) must be within 5 m. Even when the cable is twisted, the wiring length must be within 10 m.
*5 The contact between TH1 and TH2 is closed in the normal status and is open at a fault.
*6 For details of MT-BR5 type resistor unit, refer to the optional catalog.

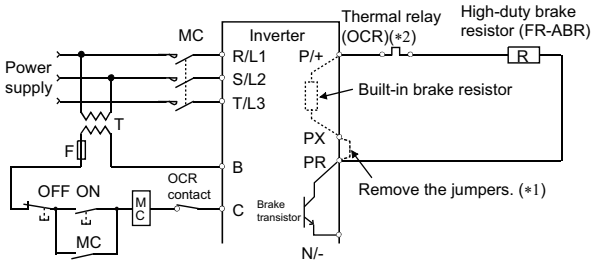
Fig. 7.42 Wiring method of the brake unit (FR-BR resistor unit)

(6) Wiring of the high-duty brake resistor (FR-ABR)

A built-in brake resistor is connected to terminals P and PX. When the operation is frequently performed, only if the built-in brake resistor has insufficient heat power, remove the jumper across the terminals PR and PX. Then, connect the high-duty brake resistor to the terminals P and PR.

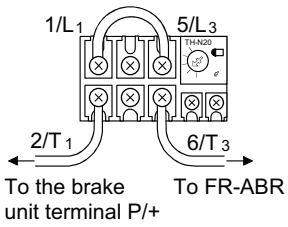
(Note) • Do not connect resistors other than the high-duty brake resistor.
• There is no terminal PX in models which do not have the brake resistor.
• High-duty brake resistors cannot be connected to models which do not have the brake transistor.

When the regenerative brake transistor is damaged, the following sequence is recommended to prevent overheat and burnout of the brake resistor.



∗1 Since the inverter without built-in brake resistor is not provided with the PX terminal, a jumper need not to be removed.
∗2 Refer to the table below for the thermal relay types for each capacity. Refer to the diagram below for the connection.
(Always install a thermal relay when using a brake resistor whose capacity is 11K or higher.)

Power supply voltage	High-duty brake resistor	Thermal relay type (Mitsubishi product)	Contact rating
200 V	FR-ABR-0.4K	TH-N20CXHZ-0.7A	110 VAC: 5 A, 220 VAC: 2 A (AC11 class) 110VDC: 0.5 A, 220 VDC: 0.25 A (DC11 class)
	FR-ABR-0.75K	TH-N20CXHZ-1.3A	
	FR-ABR-2.2K	TH-N20CXHZ-2.1A	
	FR-ABR-3.7K	TH-N20CXHZ-3.6A	
	FR-ABR-5.5K	TH-N20CXHZ-5A	
	FR-ABR-7.5K	TH-N20CXHZ-6.6A	
	FR-ABR-11K	TH-N20CXHZ-11A	
	FR-ABR-15K	TH-N20CXHZ-11A	
	FR-ABR-22K	TH-N60-22A	
400 V	FR-ABR-H0.4K	TH-N20CXHZ-0.24A	
	FR-ABR-H0.75K	TH-N20CXHZ-0.35A	
	FR-ABR-H1.5K	TH-N20CXHZ-0.9A	
	FR-ABR-H2.2K	TH-N20CXHZ-1.3A	
	FR-ABR-H3.7K	TH-N20CXHZ-2.1A	
	FR-ABR-H5.5K	TH-N20CXHZ-2.5A	
	FR-ABR-H7.5K	TH-N20CXHZ-3.6A	
	FR-ABR-H11K	TH-N20CXHZ-6.6A	
	FR-ABR-H15K	TH-N20CXHZ-6.6A	
	FR-ABR-H22K	TH-N20-9A	



7.4 Precautions for storing an inverter in the enclosure

Refer to Fig. 7.43 for precautions of enclosure storage.

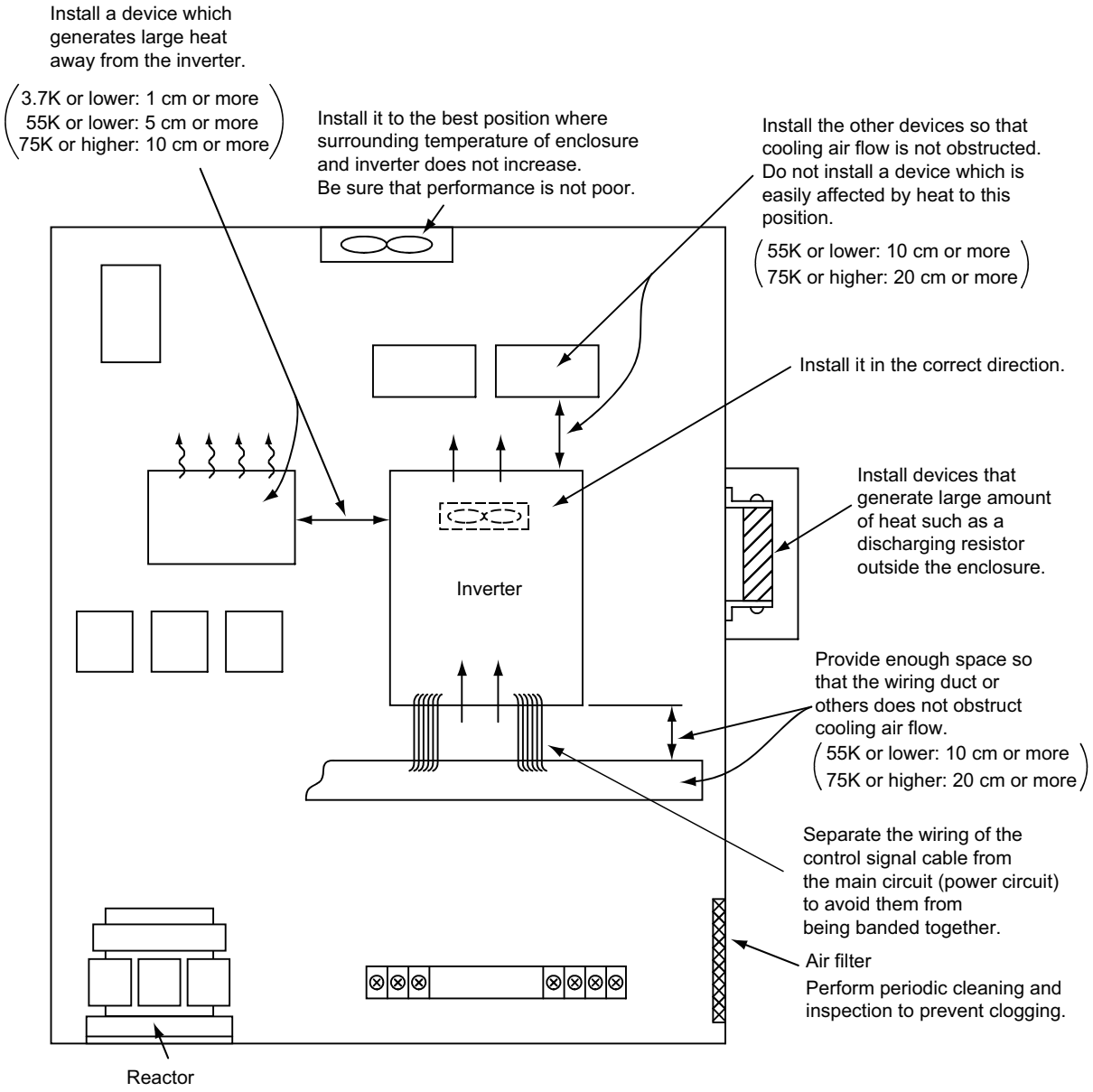


Fig. 7.43 Precautions of enclosure storage

POINT

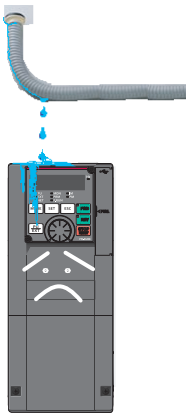
Failure example 1: Inverter failure due to leaking

[Failure]

An inverter in an enclosure installed outside stopped on a rainy day.

[Cause]

A short-circuit of the internal plate was found on the investigation of the inverter in the enclosure. A detailed examination inside the enclosure revealed that rain had been trickled from the accordion hose (for storing wires) to the inverter.



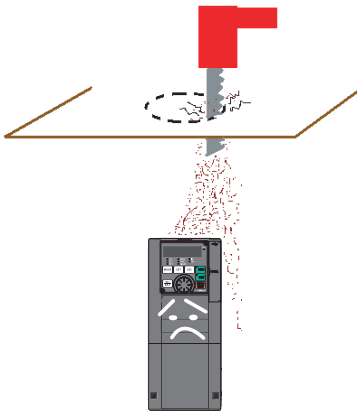
Failure example 2: Inverter failure due to foreign object

[Failure]

Nothing was displayed on the monitor (LED display) when power of the inverter in the enclosure was turned on.

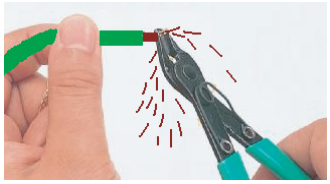
[Cause]

A short-circuit of the internal plate was found on the investigation of the inverter in the enclosure. According to the enclosure manufacturer, additional processing associated with the added upper pipe of the enclosure was performed after the inverter installation, producing considerable cutting chips.



[Similar failure]

After the cables are bared with the stripper during processing, the cut chip touches the inverter when the wire length is adjusted.



● Dust, dirt, oil mist

Dust and dirt will cause such faults as poor contacts, reduced insulation and cooling effect due to the moisture-absorbed accumulated dust and dirt, and in-enclosure temperature rise due to a clogged filter.

In an atmosphere where conductive powder floats, dust and dirt will cause such faults as malfunction, deteriorated insulation and short circuit in a short time.

Since oil mist will cause similar conditions, it is necessary to take adequate measures.

Countermeasures

(a) Place the inverter in a totally enclosed enclosure.
Take countermeasures if the in-enclosure temperature rises.

(b) Purge air.
Pump clean air from outside to make the in-enclosure air pressure higher than the outside air pressure.

● Corrosive gas, salt damage

If the inverter is exposed to corrosive gas or to salt near a beach, the printed board patterns and parts will corrode or the relays and switches will result in poor contact.

In such places, take the measures given in (a) and (b) of the previous paragraph.

● Explosive, flammable gases

As the inverter is non-explosion proof, it must be contained in an explosion-proof enclosure. In places where explosion may be caused by explosive gas, dust, or dirt, an enclosure cannot be used unless it structurally complies with the guidelines and has passed the specified tests. This makes the enclosure itself expensive (including the test charges).

The best way is to avoid installation in such places and install the inverter in a non-hazardous place.

● High altitude

Use the inverter at an altitude of within 1000 m. For use at an altitude above 1000 m (up to 2500 m), consider a 3% reduction in the rated current per 500 m increase in altitude.

If it is used at a higher place, it is likely that thin air will reduce the cooling effect and low air pressure will deteriorate dielectric strength.

● Vibration, impact

The vibration resistance of the inverter is up to 5.9 m/s^2* at 10 to 55 Hz frequency (directions of X, Y, Z axes).

Applying vibration and impacts for a long time may loosen the structures and cause poor contacts of connectors, even if those vibration and impacts are within the specified values. *2.9 m/s^2 depending on the capacity.

Especially, repeated impacts require attention because accidents including installation feet damage are likely to occur.

Countermeasures

(a) Provide the enclosure with rubber vibration isolators.

(b) Strengthen the structure to prevent the enclosure from resonance.

(c) Install the enclosure away from the sources of the vibration.

CHAPTER 8 LIFE OF INVERTER PARTS

8.1 Replacement of parts

The inverter consists of many electronic parts such as semiconductor devices.
The following parts may deteriorate with age because of their structures or physical characteristics, leading to reduced performance or fault of the inverter. For preventive maintenance, the parts must be replaced periodically.
For 800 series inverters, use the life check function as a guidance of parts replacement.

(1) Cooling fan

The estimated life of the bearing of the cooling fan used for cooling the heat-generating parts such as the main circuit semiconductor device is 87600 hours (for the 800 series inverters). Therefore, the parts including the cooling fan in continuous operation should usually be replaced once in every 10 years. However, if unusual noise or vibration is found during the inspection, the cooling fan must be replaced immediately.
The 800 series inverters have a function to set the ON/OFF control of the cooling fan. With the ON/OFF control setting, the cooling fan life can be longer. Also, a cassette type cooling fan can be replaced easily.

(2) Smoothing capacitors

A large-capacity aluminum electrolytic capacitor is used for smoothing in the main circuit DC section, and an aluminum electrolytic capacitor is used for stabilizing the control power in the control circuit. Note that their characteristics are deteriorated by the adverse effects of ripple currents, etc. The replacement intervals greatly vary with the surrounding air temperature and operating conditions. When the inverter is operated in air-conditioned, normal environment conditions, replace the capacitors about every 10 years (for the 800 series inverters).
The capacitors are deteriorated rapidly since a certain time period has passed. Therefore, perform the inspection at least once in every year (once in every half-year is recommended near the end of the capacitor's life).
The appearance criteria for inspection are as follows:

1) Case: Check the side and bottom faces for expansion.
2) Sealing plate: Check for a remarkable warp and extreme crack.
3) Explosion-proof valve: Check for remarkable expansion and operation.
4) Check for an external crack, discoloration, and liquid leakage etc. Judge that the capacitor has reached its life when the measured capacitance of the capacitor reduced below 85% of the rating.

(3) Relays

To prevent a contact fault, relays must be replaced according to the cumulative number of switching times (switching life).

The table below shows the replacement criteria of inverter parts. The other parts which have a short life, such as lamps, must be replaced with new ones when performing the periodic inspection.

Replacement of inverter parts (800 series inverters)

Part name	Estimated life*1	Description
Cooling fan	10 years	Replace (as required)
Main circuit smoothing capacitor	10 years *2	Replace (as required)
On-board smoothing capacitor	10 years *2	Replace the board (as required)
Relays	—	As required

*1 Estimated life for when the yearly average surrounding air temperature is 40°C. (without corrosive gas, flammable gas, oil mist, dust and dirt etc.)

*2 Output current: 80% of the inverter rating

8.2 Inverter parts life display

The degree of deterioration of the control circuit capacitor, main circuit capacitor, cooling fan, and inrush current limit circuit can be diagnosed on the monitor.
When a part approaches the end of its life, a warning can be output by self diagnosis to prevent a fault.
(Note that the life diagnosis of this function should be used as a guideline only, because with the exception of the main circuit capacitor, the life values are theoretical calculations.)
In the life diagnosis of the main circuit capacitor, the alarm signal (Y90) is not output unless the measurement method in (4) is performed.

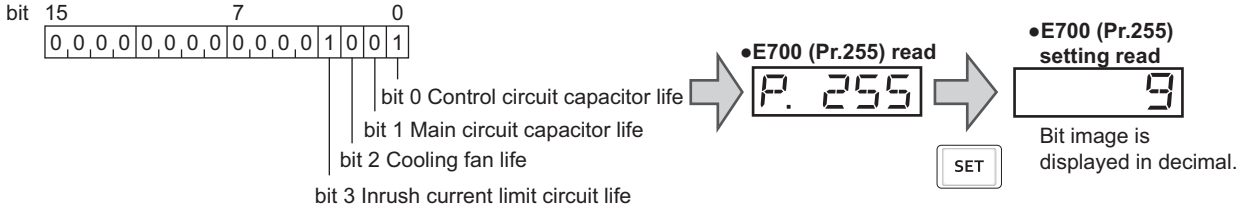
Parameter number	Name	Initial value	Setting range	Description
E700 (255)	Life warning status display	0	(0 to 15)	Displays whether or not the parts of the control circuit capacitor, main circuit capacitor, cooling fan, and inrush current limit circuit have reached the life warning output level. Read-only.
E701 (256)	Inrush current limit circuit life display	100%	(0 to 100%)	Displays the deterioration degree of the inrush current limit circuit. Read-only.
E702 (257)	Control circuit capacitor life display	100%	(0 to 100%)	Displays the deterioration degree of the control circuit capacitor. Read-only.
E703 (258)	Main circuit capacitor life display	100%	(0 to 100%)	Displays the deterioration degree of the main circuit capacitor. Read-only. The value measured by E704 (Pr.259) is displayed.
E704 (259)	Main circuit capacitor life measuring	0	0, 1 (2, 3, 8, 9)	Setting "1" and turning the power supply OFF starts the measurement of the main circuit capacitor life. If the setting value of E704 (Pr.259) becomes "3" after turning the power supply ON again, it means that the measurement is completed. The deterioration degree is read to E703 (Pr.258).

☒ POINTS for understanding !

Since repeated inrush currents at power ON will shorten the life of the converter circuit, frequent starts and stops of the magnetic contactor must be avoided.

(1) Life warning display and signal output (Y90 signal, Pr.255)

- Whether the parts of the control circuit capacitor, main circuit capacitor, cooling fan, and inrush current limit circuit have reached the life warning output level or not, can be checked with E700 (Pr.255) and the life alarm signal (Y90).



E700 (Pr.255) (decimal)	bit (binary)	Inrush current limit circuit life	Cooling fan life	Main circuit capacitor life	Control circuit capacitor life
15	1111	○	○	○	○
14	1110	○	○	○	×
13	1101	○	○	×	○
12	1100	○	○	×	×
11	1011	○	×	○	○
10	1010	○	×	○	×
9	1001	○	×	×	○
8	1000	○	×	×	×
7	0111	×	○	○	○
6	0110	×	○	○	×
5	0101	×	○	×	○
4	0100	×	○	×	×
3	0011	×	×	○	○
2	0010	×	×	○	×
1	0001	×	×	×	○
0	0000	×	×	×	×

○: With warnings, ×: Without warnings

- The life alarm signal (Y90) turns ON when any of the control circuit capacitor, main circuit capacitor, cooling fan, or inrush current limit circuit reaches the life warning output level.
- For the terminal used for the Y90 signal, set "90" (positive logic) or "190" (negative logic) in any of M400 to M406 (Pr.190 to Pr.196) (output terminal function selection).

Remark

When using an option (FR-A8AY, FR-A8AR, FR-A8NC), the life can be output separately to the Control circuit capacitor life (Y86) signal, Main circuit capacitor life (Y87) signal, Cooling fan life (Y88) signal, and Inrush current limit circuit life (Y89) signal.

☒ POINTS for understanding !

Changing the terminal assignment by using M400 to M406 (Pr.190 to Pr.196) (output terminal function selection) may affect the other functions. Set parameters after confirming the function of each terminal.

(2) Life display of the inrush current limit circuit (E701 (Pr.256))

- The life of the inrush current limit circuit (relay, contactor and inrush resistor) is displayed in E701 (Pr.256).
- The number of contact (relay, contactor, thyristor) ON times is counted, and it is counted down from 100% (0 time) every 1%/10,000 times.
  As soon as 10% (900,000 times) is reached, E700 (Pr.255) bit 3 is turned ON and also a warning is output to the Y90 signal.

(3) Life display of the control circuit capacitor (E702 (Pr.257))

- The deterioration degree of the control circuit capacitor is displayed in E702 (Pr.257).
- In the operating status, the control circuit capacitor life is calculated from the energization time and temperature, and is counted down from 100%.
  As soon as the control circuit capacitor life falls below 10%, E700 (Pr.255) bit 0 is turned ON and also a warning is output to the Y90 signal

(4) Life display of the main circuit capacitor (E703, E704 (Pr.258, Pr.259))

- The deterioration degree of the main circuit capacitor is displayed in E703 (Pr.258).
- With the main circuit capacitor capacity at factory shipment as 100%, the capacitor life is displayed in E703 (Pr.258) every time measurement is made.
  When the measured value falls to 85% or lower, E700 (Pr.255) bit 1 is turned ON and also a warning is output to the Y90 signal.
- Measure the capacitor capacity according to the following procedure and check the deterioration degree of the capacitor capacity.
  1) Check that the motor is connected to the inverter and stopped.
  2) Set "1" (measuring start) in E704 (Pr.259).
  3) Turn OFF the power of the inverter. The inverter applies DC voltage to the motor to measure the capacitor capacity while the inverter is OFF.
  4) After confirming that the power lamp is OFF, turn ON the power again.
  5) Check that "3" (measurement complete) is set in E704 (Pr.259), read E703 (Pr.258), and check the deterioration degree of the main circuit capacitor.

E704 (Pr.259)	Description	REMARKS
0	No measurement	Initial value
1	Start measurement	Measurement starts when the power supply is switched OFF.
2	During measurement	Only displayed and cannot be set.
3	Measurement complete	
8	Forced end	
9	Measurement error	

Remark

- When the main circuit capacitor life is measured under the following conditions, "forced end" (E704 (Pr.259) = "8"), or "measurement error" (E704 (Pr.259) = "9") may occur, or the status may remain in "measurement start" (E704 (Pr.259) = "1"). To perform measurement, first eliminate the following conditions. Under the following conditions, even if "measurement complete" (E704 (Pr.259) = "3") is reached, measurement cannot be performed correctly.
  (a) The FR-HC2, FR-CV, MT-RC, or a sine wave filter is connected.
  (b) Terminals R1/L11, S1/L21, or DC power supply is connected to terminals P/+ and N/-.
  (c) The power supply is switched ON during measurement.
  (d) The motor is not connected to the inverter.
  (e) The motor is running (coasting).
  (f) The motor capacity is smaller than the inverter capacity by two ranks or more.
  (g) The inverter is tripped or a fault occurred while the power was OFF.
  (h) The inverter output is shut off with the MRS signal.
  (i) The start command is given while measuring.
  (j) The applied motor setting is incorrect.
- Operation environment: Surrounding air temperature (annual average of 40°C (free from corrosive gas, flammable gas, oil mist, dust, and dirt)).
  Output current (80% of the inverter rating)
- Since repeated inrush currents at power ON will shorten the life of the converter circuit, frequent starts and stops of the magnetic contactor must be avoided.

☒ POINTS for understanding !

For accurate life measurement of the main circuit capacitor, wait three hours or longer after turning OFF because the temperature left in the main circuit capacitor affects measurement.

⚠ WARNING

⚠ When measuring the main circuit capacitor capacity (E704 (Pr.259) the main circuit capacitor life measurement = "1"), the DC voltage is applied to the motor for about 1 second at power OFF. Never touch the motor terminal, etc. right after powering OFF to prevent an electric shock.

(5) Life display of the cooling fan

The cooling fan speed of 50% or less is detected and "FN" is displayed on the operation panel (FR-DU08). As a warning display, E700 (Pr.255) bit 2 is turned ON and also a warning is output to the Y90 signal.

Remark

When the inverter is mounted with two or more cooling fans, "FN" is displayed with one or more fans.

☒ POINTS for understanding !

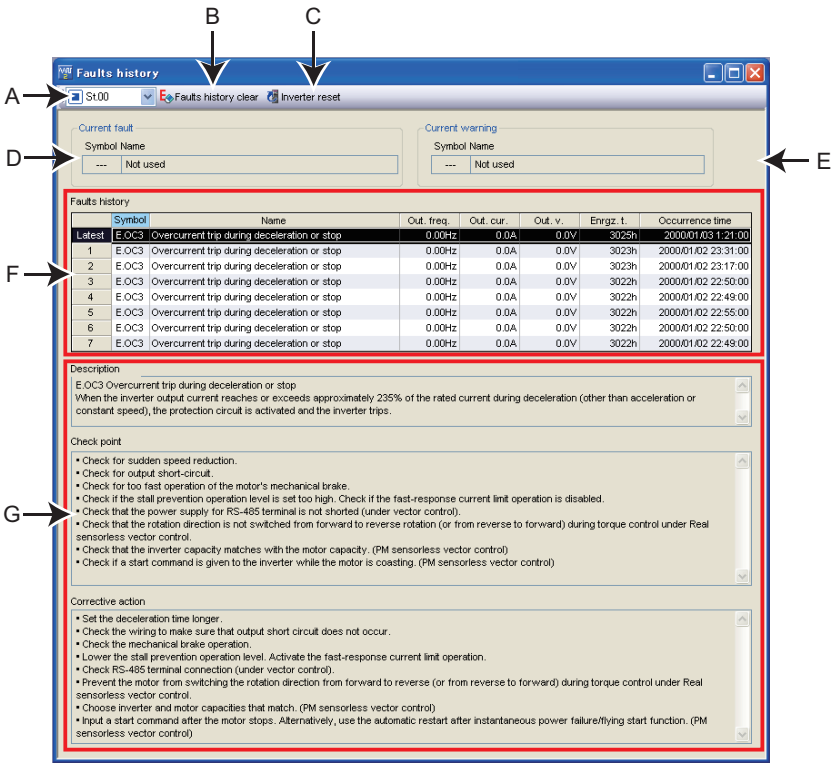
For replacement of each part, contact your local Mitsubishi Electric System & Service Co., Ltd.

8.3 Diagnosis using FR Configurator2

"Diagnosis" displays fault information of the inverter.

Select [Faults History (A)] in the [Diagnosis (D)] menu to display the "Faults History" window as a sub window.

8.3.1 Explanation of window



Symbol	Name	Function and Description
A	Station Select	Select a station for which faults history is to be displayed.
B	Faults History Clear	Clears the selected station's faults history.
C	Inverter Reset (INV.Reset)	Resets the inverter of the selected station.
D	Current Faults	Shows the current faults.
E	Current Warning	Shows the current warning.
F	Faults History	Shows a list of the faults history read from the inverter. The output frequency, output current, output voltage, energization time, and occurrence time at the faults are displayed together.
G	Faults details	Shows explanations of selected fault details, check points, and corrective actions.

CHAPTER 9 REPLACEMENT PROCEDURE

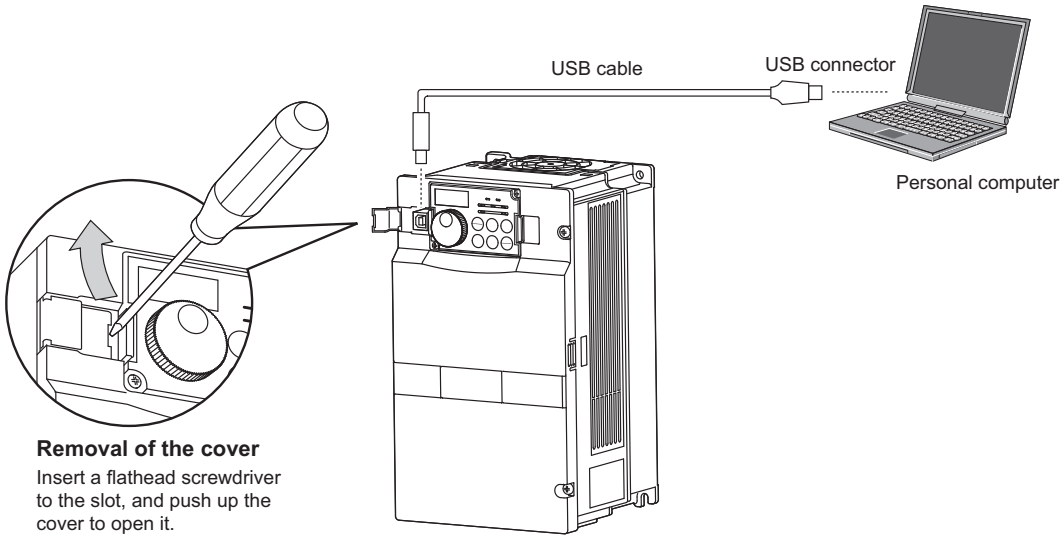
This chapter describes how to replace the Mitsubishi inverter FR-A700 series with FR-A800 series.

9.1 Saving FR-A700 parameters and replacing with FR-A800 parameters

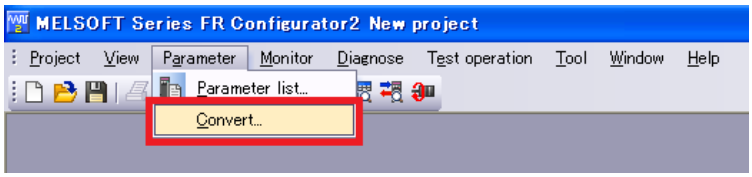
(1) Prepare a personal computer where FR Configurator2 (SW1DND-FRC2-E) is installed and a cable for inverter connection.

(2) Turn ON the FR-A700.

(3) Connect the personal computer with the FR-A700.

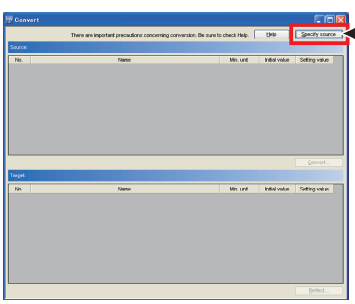


(4) Turn ON the computer and start up the FR Configurator2 (SW1DND-FRC2-E). To display the "Convert" window, select [Convert] in the [Parameter] menu.

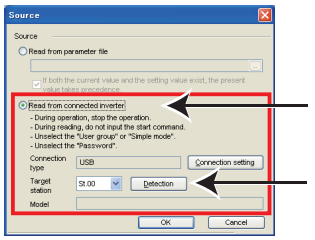


(5) Check that FR Configurator2 (SW1DND-FRC2-J) is online. (Select on the menu bar to switch the condition to ONLINE.)

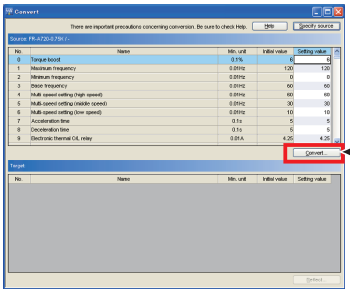
(6) Click [Specify source] in "Convert" window.



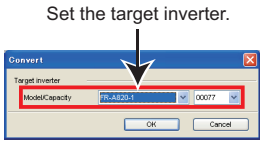
(7) Select [Read from connected inverter]. Check that [Connection type] is "USB", and specify the station number connected to the source inverter in [Target station]. After specifying the station number, click [Detection]. After detection, check the inverter model in the [Model] field, and click [OK] to convert the parameters and return to the "Convert" window.



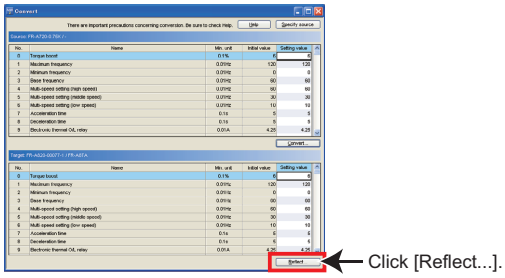
(8) The setting value can be changed for some parameters of the source. To change the parameter setting value, enter the desired value in the setting value field of the source parameter list. After the parameters of the source inverter are displayed in the list, the [Convert...] button in the "Convert" window will be active. Click [Convert...] to display the "Convert" window.



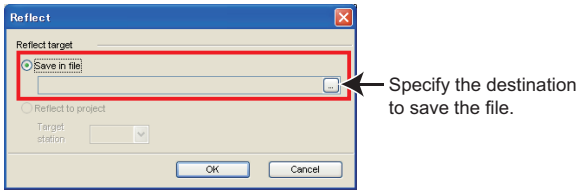
(9) Specify "Model/Capacity" of the [Target inverter] in the "Convert" window. Click [OK] to convert the parameters and return to the "Convert" window.



(10) The result of parameter converting is shown in the "Convert" window.



(11) Click [Reflect...] in the "Convert" window to display the "Reflect" window. Select [Save in file]. Specify the destination to save the file and click [OK]. The converted parameter setting is saved in the parameter file (*.pr4).



[Converting without a personal computer]

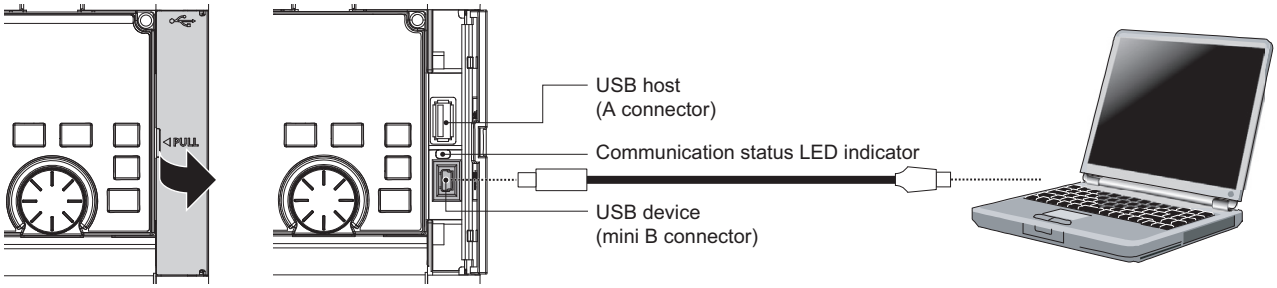
If a personal computer cannot be prepared, the parameter setting values for FR-A800 series must be created. The parameter numbers are almost the same as for FR-A700 series, but some of the setting values differ. Refer to the parameter section in "Information for Replacement of FR-A700 Series (BCN-C21002-162)" and create the parameter setting values for FR-A800 series.

9.2 Setting the parameter

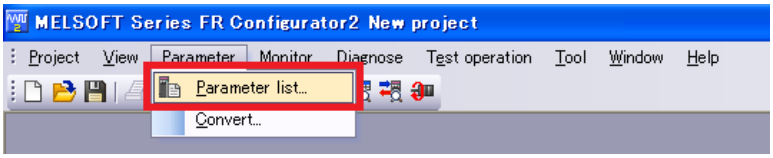
(1) Prepare a personal computer where FR Configurator2 (SW1DND-FRC2-E) is installed and a cable for inverter connection.

(2) Turn ON the FR-A800.

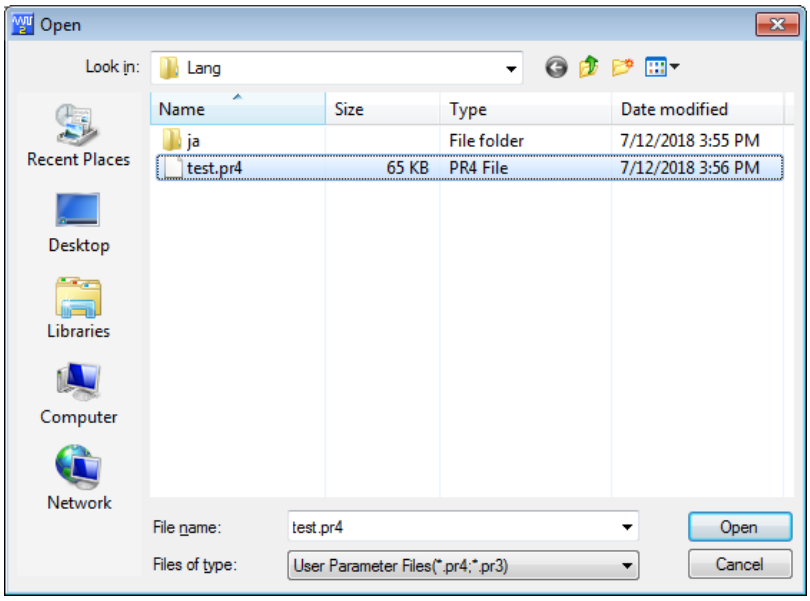
(3) Connect the personal computer with the FR-A800.



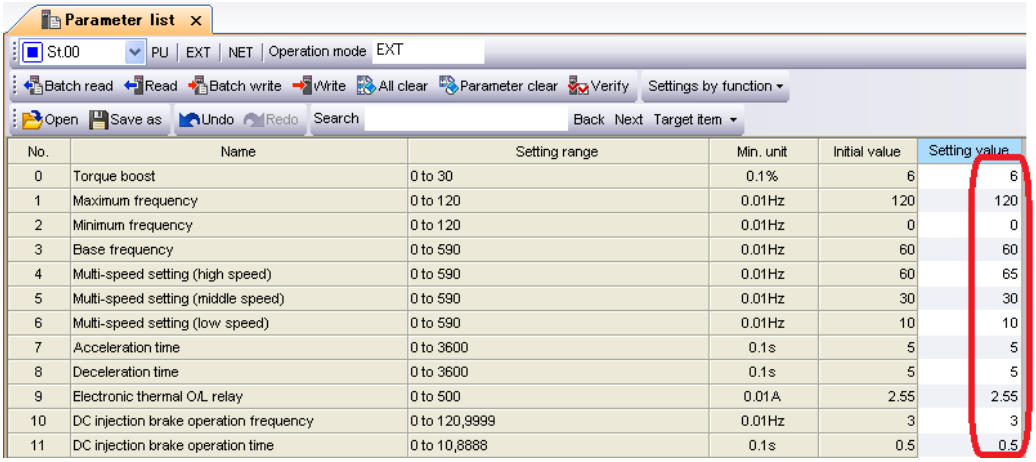
(4) Turn ON the computer and start up the FR Configurator2 (SW1DND-FRC2-E). Click the [Parameter List] in the [Parameter] menu, or click  on the toolbar to display "Parameter List".



(5) While displaying the parameter list window, select [Open] in the [File] menu, or select  in the tool menu of the parameter list window to open the parameter file to save in Section 9.1(11).

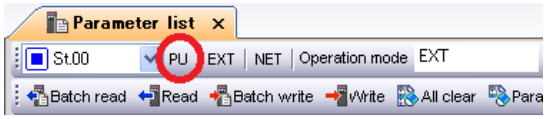


(6) Parameters converted for the FR-A800 are listed on the [Setting Value] column.



No.	Name	Setting range	Min. unit	Initial value	Setting value
0	Torque boost	0 to 30	0.1%	6	6
1	Maximum frequency	0 to 120	0.01Hz	120	120
2	Minimum frequency	0 to 120	0.01Hz	0	0
3	Base frequency	0 to 590	0.01Hz	60	60
4	Multi-speed setting (high speed)	0 to 590	0.01Hz	60	65
5	Multi-speed setting (middle speed)	0 to 590	0.01Hz	30	30
6	Multi-speed setting (low speed)	0 to 590	0.01Hz	10	10
7	Acceleration time	0 to 3600	0.1s	5	5
8	Deceleration time	0 to 3600	0.1s	5	5
9	Electronic thermal O/L relay	0 to 500	0.01A	2.55	2.55
10	DC injection brake operation frequency	0 to 120,9999	0.01Hz	3	3
11	DC injection brake operation time	0 to 10,8888	0.1s	0.5	0.5

(7) Click [PU] to change the operation mode to PU.



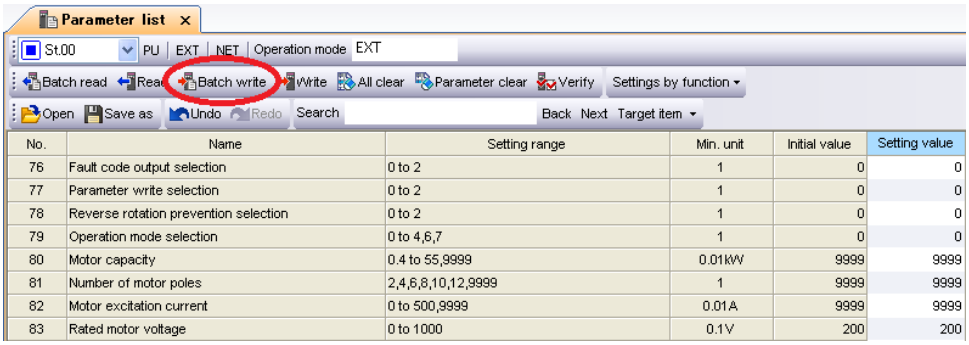
(8) Check and write down the setting values of E400 (Pr.77), D000 (Pr.79).
When E400 (Pr.77) is "1", change the setting values of E400 (Pr.77) to "0".
When D000 (Pr.79) is other than "0 or 1", change the setting values of D000 (Pr.79) to "0".
To change a setting value, click the target value on the [Setting Value] column.

76	Fault code output selection	0 to 2	1	0	0
77	Parameter write selection	0 to 2	1	0	1
78	Reverse rotation prevention selection	0 to 2	1	0	0
79	Operation mode selection	0 to 4,6,7	1	0	2
80	Motor capacity	0.4 to 55,9999	0.01kW	9999	9999
81	Number of motor poles	2,4,6,8,10,12,9999	1	9999	9999
82	Motor excitation current	0 to 500,9999	0.01A	9999	9999
83	Rated motor voltage	0 to 1000	0.1V	200	200

76	Fault code output selection	0 to 2	1	0	0
77	Parameter write selection	0 to 2	1	0	0
78	Reverse rotation prevention selection	0 to 2	1	0	0
79	Operation mode selection	0 to 4,6,7	1	0	0
80	Motor capacity	0.4 to 55,9999	0.01kW	9999	9999
81	Number of motor poles	2,4,6,8,10,12,9999	1	9999	9999
82	Motor excitation current	0 to 500,9999	0.01A	9999	9999
83	Rated motor voltage	0 to 1000	0.1V	200	200

(9) Check that the computer is online. (Click on the "tool menu bar" to switch the condition to ONLINE.)

(10) Click [Batch Write] to write the parameters on the FR-A800.



No.	Name	Setting range	Min. unit	Initial value	Setting value
76	Fault code output selection	0 to 2	1	0	0
77	Parameter write selection	0 to 2	1	0	0
78	Reverse rotation prevention selection	0 to 2	1	0	0
79	Operation mode selection	0 to 4,6,7	1	0	0
80	Motor capacity	0.4 to 55,9999	0.01kW	9999	9999
81	Number of motor poles	2,4,6,8,10,12,9999	1	9999	9999
82	Motor excitation current	0 to 500,9999	0.01A	9999	9999
83	Rated motor voltage	0 to 1000	0.1V	200	200

(11) Turn OFF the personal computer, and then turn OFF the inverter. (Note that some parameter setting values reflect the inverter after turning off or resetting the inverter.)
Mount the operation panel.

(12) If the setting values of E400 (Pr.77), D000 (Pr.79) are changed in step (8), turn ON the inverter and set the values of E400 (Pr.77), D000 (Pr.79) written down earlier, and then turn OFF the inverter.

[Precautions for converting]
There are adjustment parameters and parameters which cannot be converted. Read the instruction manual of FR Configurator2 [SW1DND-FRC2-E] carefully before converting parameters.

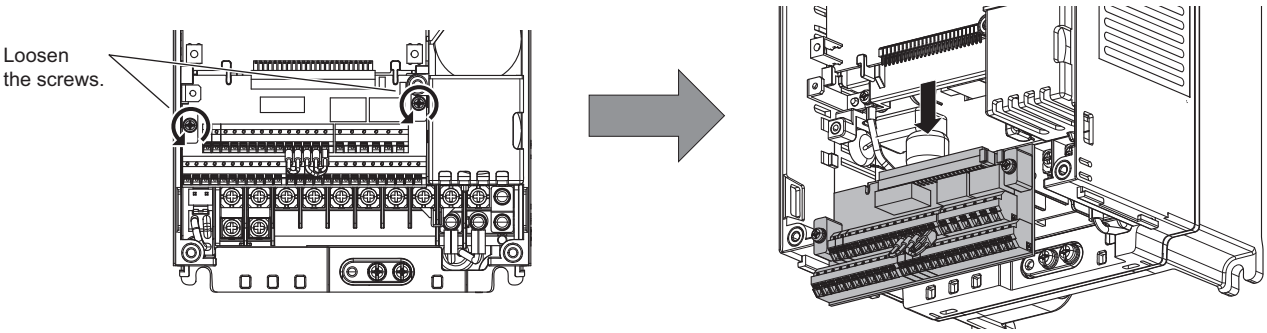
9.3 Installation of the FR-A800

(1) Install the FR-A800 to the enclosure.
Since the installation size of 280K model or lower of the FR-A800 inverter is the same as that of the FR-A700, the FR-A800 can be installed as it is in the mounting hole of the FR-A700.

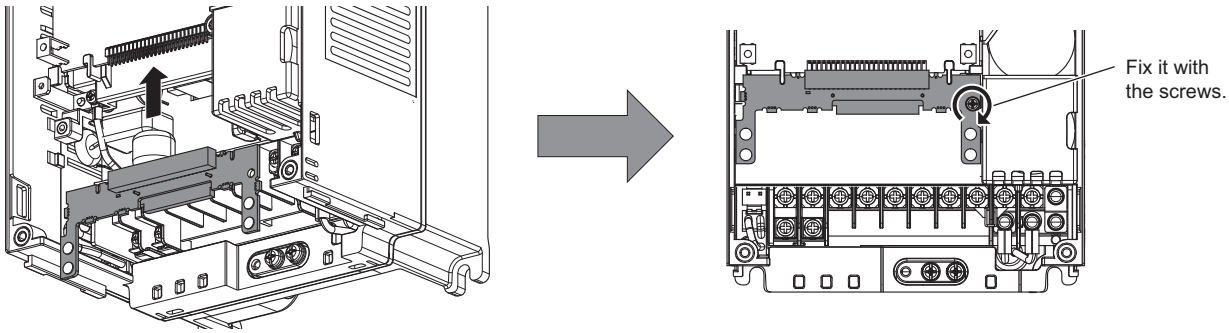
(2) Open the wiring cover and route the main circuit wires.

(3) Perform the control circuit wires.
By using the option FR-A8TAT, the control circuit terminal block of the FR-A700 series inverter (Leave the cables connected on the terminal block.) can be installed as it is in FR-A800.

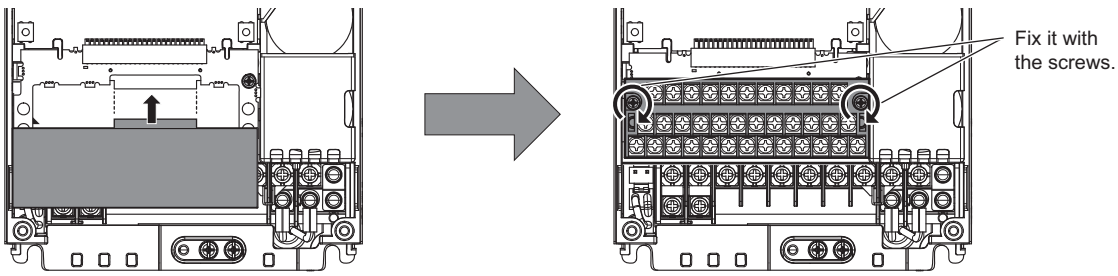
1) Loosen the two installation screws at the both sides of the control circuit terminal block of the 800 series inverter. (These screws cannot be removed.)
Slide down the control circuit terminal to remove it.



2) Install the control circuit terminal block attachment. Be careful not to bend the pins of the inverter control circuit connector, and fix it by the installation screws supplied with the product. (Tightening torque: 0.33 to 0.4 N m)



3) Install the control circuit terminal block of the 700 series inverter. Be careful not to bend the pins of A8TAT control circuit connector. Fix the control circuit terminal block by the installation screws of the control circuit terminal block. (Tightening torque: 0.33 to 0.4 N m)



Memo

INVERTER SCHOOL TEXT
INVERTER TROUBLE SHOOTING COURSE
(FR-A800)

MITSUBISHI ELECTRIC CORPORATION
HEAD OFFICE: TOKYO BUILDING 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN

MODEL	
MODEL CODE	

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