YASKAWA

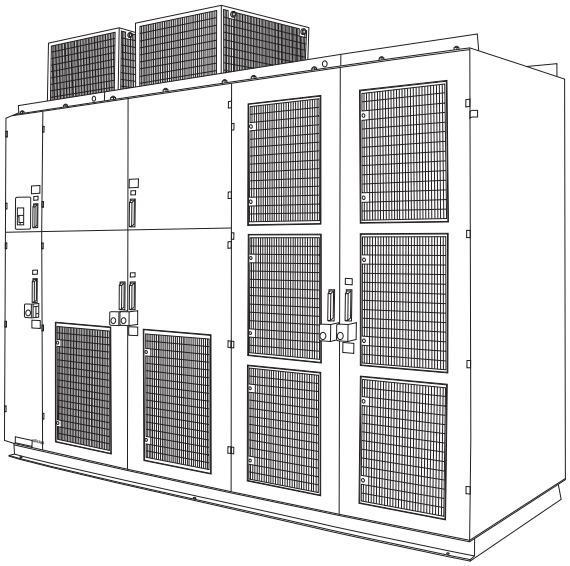
Super Energy-saving Medium-voltage Matrix Converter

FSDrive-MX1S

Instructions

4.16 kV Class

To properly use the product, read this manual thoroughly and retain for easy reference, inspection, and maintenance. Ensure the end user receives this manual.



MANUAL NO. EZZ010917

Table of Contents

Preface & General Safety

i.1 General Safety

◆ Supplemental Safety Information

General Precautions
• The diagrams in this manual may be indicated without covers or safety shields to show details. Be sure to restore covers or shields before operating the Units and run the Units according to the instructions described in this manual. • Any illustrations, photographs, or examples used in this manual are provided as examples only and may not apply to all products to which this manual is applicable. • The products and specifications described in this manual or the content and presentation of the manual may be changed without notice to improve the product and/or the manual. • When ordering a new copy of the manual due to damage or loss, contact your Yaskawa representative or the nearest Yaskawa sales office and provide the manual number shown on the front cover. • If nameplates become warn or damaged, order new ones from your Yaskawa representative or the nearest Yaskawa sales office.

⚠ WARNING
Read and understand this manual before installing, operating or servicing the Matrix converter. The Matrix converter must be installed according to this manual and local codes. The following conventions are used to indicate safety messages in this manual. Failure to heed these messages could result in serious or possibly even fatal injury, or damage to the products or to related equipment and systems.

⚠ DANGER
Indicates a hazardous situation, which, if not avoided, will result in death or serious injury.

⚠ WARNING
Indicates a hazardous situation, which, if not avoided, could result in death or serious injury.

WARNING! *will also be indicated by a bold key word embedded in the text followed by an italicized safety message.*

⚠ CAUTION
Indicates a hazardous situation, which, if not avoided, could result in minor or moderate injury, damage to the product, or faulty operation.

CAUTION! *will also be indicated by a bold key word embedded in the text followed by an italicized safety message.*

NOTICE
Indicates a property damage message.

NOTICE: *will also be indicated by a bold key word embedded in the text followed by an italicized safety message.*

◆ Safety Messages

⚠ DANGER

Heed the safety messages in this manual.

Failure to comply will result in death or serious injury.

The operating company is responsible for any injuries or equipment damage resulting from failure to heed the warnings in this manual.

Disconnect all main power before servicing.

Failure to comply may result in serious injury or death from electric shock.

To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc.

⚠ WARNING

Sudden Movement Hazard

System may start unexpectedly upon application of power, resulting in death or serious injury.

Clear all personnel from the Matrix converter before applying power.

The diagrams in this section may show Matrix converters without covers or safety shields to show details. Be sure to reinstall covers or shields before operating the Matrix converters and run the Matrix converters according to the instructions described in this manual.

Electrical Shock Hazard

Do not operate equipment with covers removed.

Failure to comply could result in death or serious injury.

The diagrams in this section may show Matrix converters without covers or safety shields to show details. Be sure to reinstall covers or shields before operating the Matrix converters and run the Matrix converters according to the instructions described in this manual.

Always ground the motor-side grounding terminal.

Improper equipment grounding could result in death or serious injury by contacting the motor case.

Do not perform work on the Matrix converter while wearing loose clothing, jewelry or without eye protection.

Failure to comply could result in death or serious injury.

Remove all metal objects such as watches and rings, secure loose clothing, and wear eye protection before beginning work on the Matrix converter.

Do not remove covers or touch circuit boards while the power is on.

Failure to comply could result in death or serious injury.

Do not allow unqualified personnel to perform work on the Matrix converter.

Failure to comply could result in death or serious injury.

Installation, maintenance, inspection, and servicing must be performed only by authorized personnel familiar with installation, adjustment, and maintenance of Medium Voltage AC Matrix converters.

⚠ WARNING

Fire Hazard

Tighten all terminal screws to the specified tightening torque.

Loose electrical connections could result in death or serious injury by fire due to overheating of electrical connections.

Do not use improper combustible materials.

Failure to comply could result in death or serious injury by fire.

Attach the Matrix converter to metal or other noncombustible material.

Do not use an improper voltage source.

Failure to comply could result in death or serious injury by fire.

Verify that the rated voltage of the Matrix converter matches the voltage of the incoming power supply before applying power.

⚠ CAUTION

Never install a Matrix converter that is damaged or missing components.

Doing so can result in injury.

NOTICE

Observe proper electrostatic discharge procedures (ESD) when handling the Matrix converter and circuit boards.

Failure to comply may result in ESD damage to the Matrix converter circuitry.

Never connect or disconnect the motor from the Matrix converter while the Matrix converter is outputting voltage.

Improper equipment sequencing could result in damage to the Matrix converter.

Do not use unshielded cable for control wiring.

Failure to comply may cause electrical interference resulting in poor system performance. Use shielded, twisted-pair wires and ground the shield to the ground terminal of the Matrix converter.

Check all wiring to ensure that all connections are correct after installing the Matrix converter and connecting any other devices.

Failure to comply may cause electrical interference resulting in poor system performance. Use shielded, twisted-pair wires and ground the shield to the ground terminal of the Matrix converter.

Failure to comply could result in damage to the Matrix converter.

Do not modify the Matrix converter circuitry.

Failure to comply could result in damage to the Matrix converter and will void warranty.

Yaskawa is not responsible for any modification of the product made by the user. This product must not be modified.

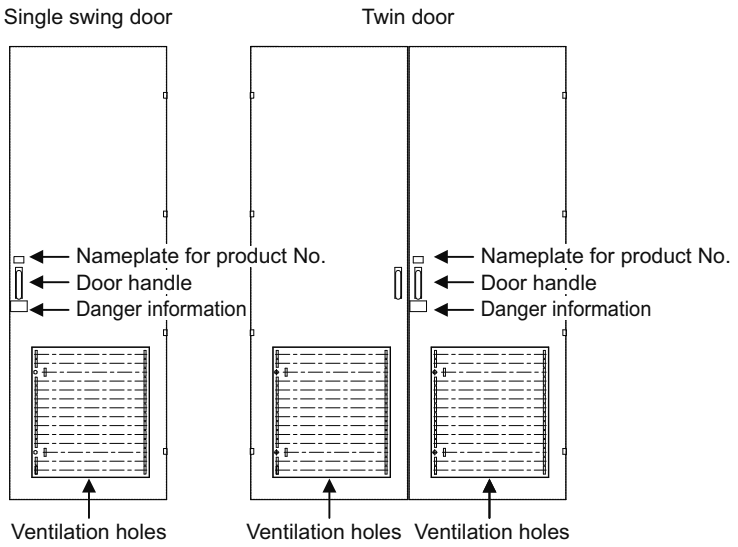
i.2 Preface

This manual is designed to ensure correct and suitable application of the Yaskawa MX1S Medium voltage Matrix converter (hereinafter referred to as Matrix converter). Read this manual before attempting to install, operate, maintain, or inspect a Matrix converter. Be sure to understand all precautions and safety information before attempting application.

This manual is necessary for maintenance management of the Matrix converter including daily maintenance/checking and troubleshooting. Keep this manual in a safe place for future reference.

i.3 Danger Information and Position

There is danger information provided on the Matrix converter in the locations shown in the following illustration. Always heed the danger sign.



◆ Danger Information

i.4 Mechanical Interlock

To use a mechanical interlock, install the same mechanical interlock on the incoming circuit breaker panel as that used with the Matrix converter.

To open the panel door for the high voltage section of the Matrix converter, use the following procedure.

1. Turn off the incoming circuit breaker and remove the key of the mechanical interlock.
2. Use the key to unlock the mechanical lock of the Matrix converter.

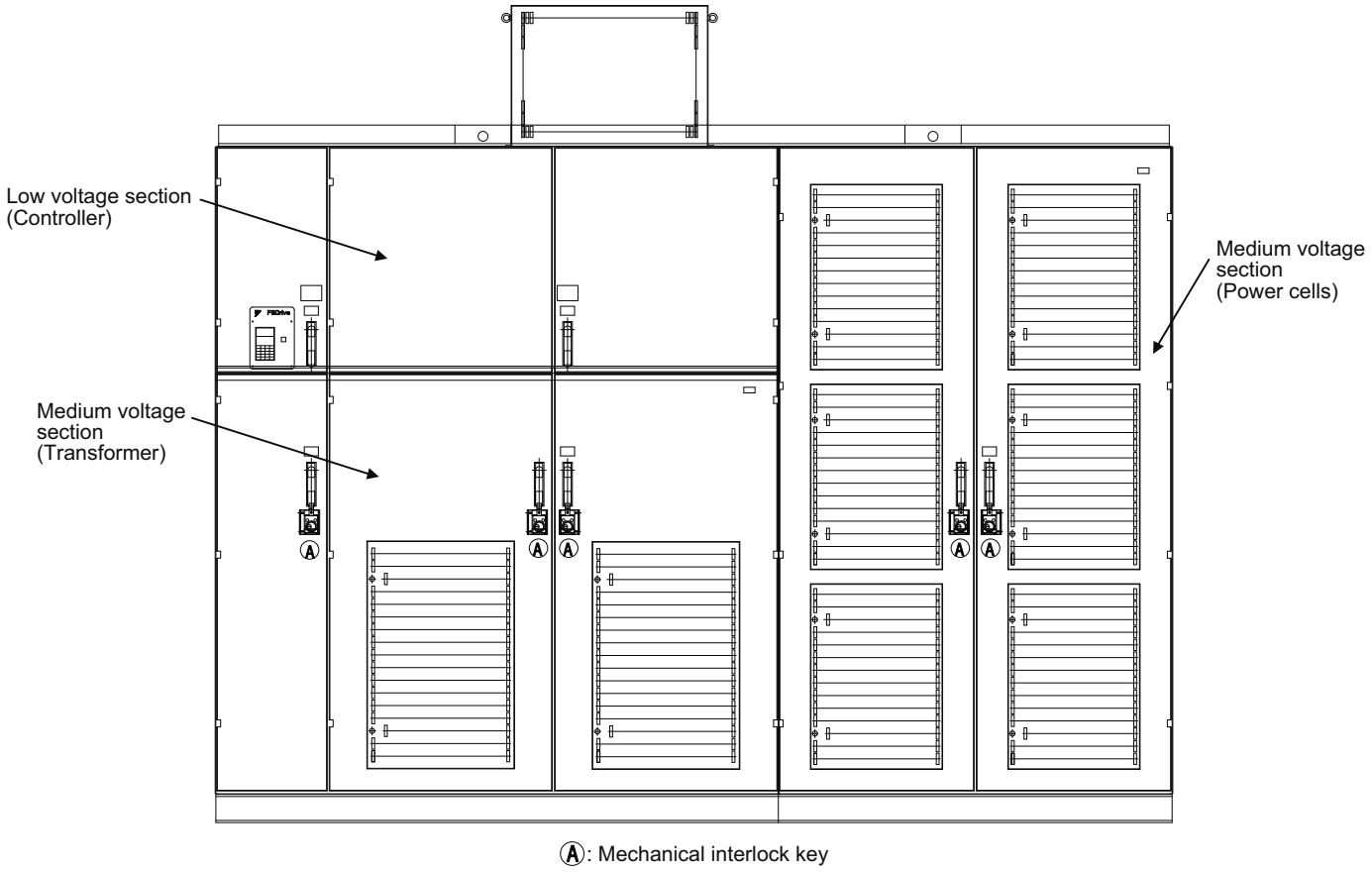


Figure i.1 Specification of Interlock Key (Kirk Key type F-Flat mounted)

i.5 Warranty Information

◆ Warranty Period

This drive is warranted for 12 months from the date of delivery to the customer or 18 months from the date of shipment from the Yaskawa factory, whichever comes first.

◆ Scope of Warranty

■ Inspections

Customers are responsible for periodic inspections of the drive. Upon request, a Yaskawa representative will inspect the drive for a fee. If the Yaskawa representative finds the drive to be defective due to Yaskawa workmanship or materials and the defect occurs during the warranty period, this inspection fee will be waived and the problem remedied free of charge.

■ Repairs

If a Yaskawa product is found to be defective due to Yaskawa workmanship or materials and the defect occurs during the warranty period, Yaskawa will provide a replacement or repair the defective product, and provide shipping to and from the site free of charge.

However, if the Yaskawa Authorized Service Center or representative determines that the problem with the drive is not due to defective workmanship or materials, the customer will be responsible for the cost of any necessary repairs. Some problems that are outside the scope of this warranty are:

- Problems due to improper maintenance or handling, carelessness, or other reasons where the customer is determined to be responsible.
- Problems due to additions or modifications made to a Yaskawa product without Yaskawa's understanding.
- Problems due to the use of a Yaskawa product under conditions that do not meet the recommended specifications.
- Problems caused by natural disaster or fire.
- After the free warranty period elapses.
- Replenishment or replacement of consumables or expendables.
- Defective products due to packaging or fumigation.
- Other problems not due to defects in Yaskawa workmanship or materials.

Warranty service is only applicable within the country where the product was purchased. However, after-sales service is available for customers outside of the country where the product was purchased for a reasonable fee.

Contact your local Yaskawa representative for more information.

■ Exceptions

Any inconvenience to the customer or damage to non-Yaskawa products due to Yaskawa's defective products whether within or outside of the warranty period are NOT covered by warranty.

◆ Restrictions

- The Matrix converter was not designed or manufactured for use in devices or systems that may directly affect or threaten human lives or health.
- Customers who intend to use the product described in this manual for devices or systems relating to transportation, health care, space aviation, atomic or electric power, or underwater use must contact their Yaskawa representatives or the nearest Yaskawa sales office.

WARNING! *This product has been manufactured under strict quality-control guidelines. However, if this product is to be installed in any location where failure of this product could involve or result in a life-and-death situation or loss of human life, or in a facility where failure may cause a serious accident or physical injury, safety devices must be installed to minimize the likelihood of any accident.*

i.6 Before Reading This Manual

There are places in this manual where the constants (parameter settings) and explanations depend on the version and capacity of the Matrix converter. Be sure to confirm the version and capacity on the Matrix converter's nameplate.

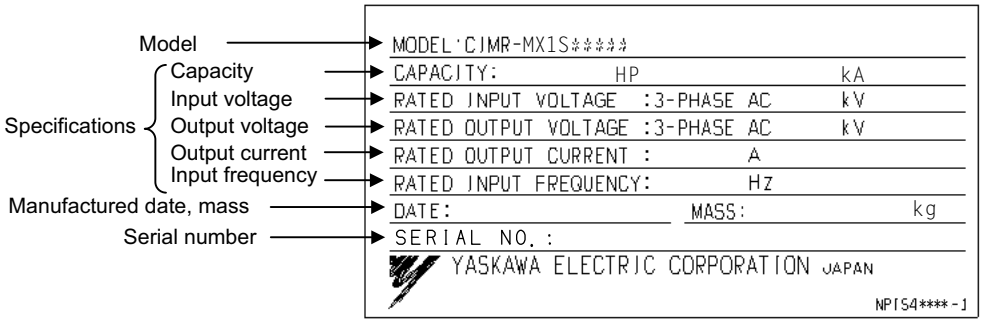


Figure i.2 Example of the Matrix converter's Nameplate

1

Handling Matrix converters

This chapter describes the checks required upon receiving or installing an MX1S Matrix converter.

1.1 Section Safety

⚠ WARNING

Crush Hazard

Use the fixtures provided on the enclosure sections for lifting.

When moving the MX1S using a crane, the crane must be operated by a qualified and trained crane operator.

Failure to observe this precaution may result in injury or in dropping the Matrix converter.

To lift the Transformer Panel on the large capacity (3500 to 4000 HP) Matrix converter, use the lifting tool provided as an accessory.

NOTICE

Observe proper electrostatic discharge (ESD) procedures when handling the Matrix converter and circuit boards.

Failure to comply may result in ESD damage to the Matrix converter circuitry.

A motor connected to a Pulse Width Modulated (PWM) drive may operate at a higher temperature than a utility-fed motor and the operating speed range may reduce motor cooling capacity.

Ensure that the motor is suitable for drive duty and/or the motor service factor is adequate to accommodate the additional heating with the intended operating conditions.

1.2 Introduction to MX1S Matrix converters

◆ MX1S Models

The MX1S Matrix converters are classified 4.16 kV. The Matrix converters are suitable for power supply frequency of 60 Hz.

Applicable to motor capacities are 550 HP to 4000 HP (15 models).

Table 1.1 MX1S Models

Voltage Class [V]	Power Supply Frequency [Hz]	Max.Applicable Capacity [HP]	Cell Rated Current [A]	Basic Model Number	Product Code No.	Nominal Capacity [kVA] <Reference>
4160	60	550	70	CIMR-MX1SKB070	71686-MX1SKB070	505
		700	90	CIMR-MX1SKB090	71686-MX1SKB090	650
		800	102	CIMR-MX1SKB102	71686-MX1SKB102	735
		900	115	CIMR-MX1SKB115	71686-MX1SKB115	830
		1000	123	CIMR-MX1SKB123	71686-MX1SKB123	890
		1250	154	CIMR-MX1SKB154	71686-MX1SKB154	1110
		1500	185	CIMR-MX1SKB185	71686-MX1SKB185	1330
		1750	215	CIMR-MX1SKB215	71686-MX1SKB215	1550
		2000	245	CIMR-MX1SKB245	71686-MX1SKB245	1765
		2250	281	CIMR-MX1SKB281	71686-MX1SKB281	2025
		2500	311	CIMR-MX1SKB311	71686-MX1SKB311	2240
		2750	336	CIMR-MX1SKB336	71686-MX1SKB336	2420
		3000	372	CIMR-MX1SKB372	71686-MX1SKB372	2680
		3500	436	CIMR-MX1SKB436	71686-MX1SKB436	3140
		4000	520	CIMR-MX1SKB520	71686-MX1SKB520	3750

1.3 Confirmation upon Delivery

◆ Checks

Check the following items as soon as the Matrix converter has been delivered.

Table 1.2 Checks

Item	Method
Has the correct Matrix converter model been delivered?	Check the model number on the nameplate on the inside of the Matrix converter panel door.
Is the Matrix converter damaged in any way?	Inspect the entire exterior of the Matrix converter to see if there are any scratches or other damage resulting from shipping. Open the panel doors, and inspect the interior of the Matrix converter to see if there is any damage or displacement, and to confirm that there are no missing parts.
Are any screws or other components loose?	Use a screwdriver or other tool to check for tightness. In particular, check the tightening torque of all terminal screws on the electrical connections.

If there are any irregularities in the above items, contact your Matrix converter supplier or Yaskawa representative immediately.

◆ Nameplate Information

The nameplate is attached on the inside of the Control Panel door of the Matrix converter.

The nameplate contains information including the model number, specifications, date of manufacture, and serial number.

■ Nameplate Sample

An example of a nameplate on a Matrix converter with standard specifications is shown below.

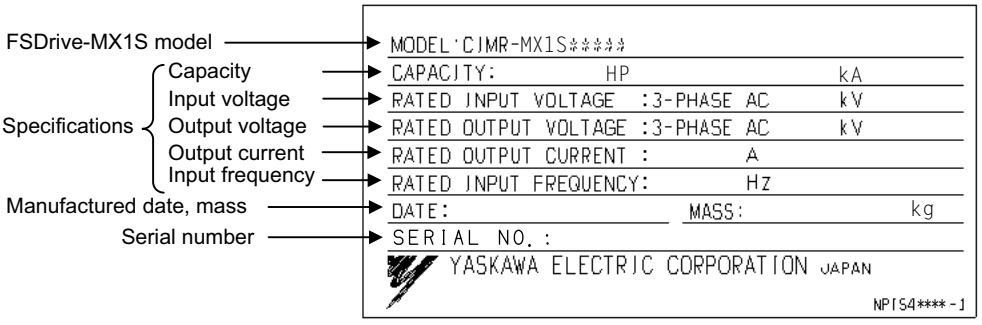


Figure 1.1 Nameplate Example

■ Matrix converter Model Descriptions

The Matrix converter model number on the nameplate indicates the specification, voltage class, and maximum capacity of the Matrix converter in alphanumeric code.

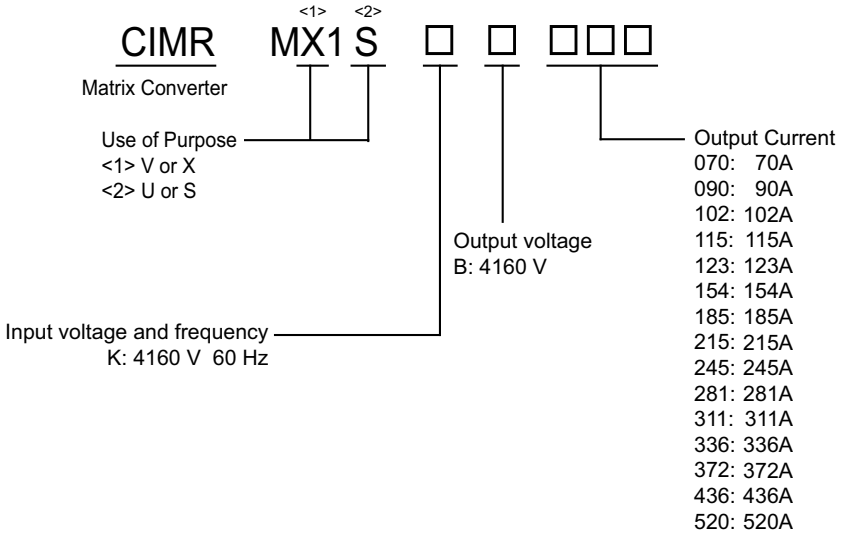


Figure 1.2 Matrix converter Model Descriptions

1.4 Product Description

◆ MX1S Matrix converter

The MX1S Matrix converter is a Pulse Width Modulated (PWM) type medium voltage inverter unit. This unit offers the following features:

- A power supply regeneration function which allows dynamic acceleration/deceleration operation.
- Enables a clean power supply with minimum harmonics.
  The Matrix converter creates minimal input voltage and current distortion.
- Achieves high efficiency and high power factor.
  Matrix converter efficiency: approximately 98 %, power factor: 0.95 or more (at rated speed and 100 % load)
- Output voltage and current waveforms are nearly sinusoidal.
  Since the Matrix converter unit generates minimal surge voltage, existing motors or cables can be used without modification.
- Torque ripple is minimized.

◆ Configuration

Figure 1.4 shows typical configurations of MX1S Matrix converters.

As shown in ***Figure 1.4***, the MX1S Matrix converter is composed of three panels:

- Transformer Panel
- Power Cell Panel
- Control Panel (Some smaller models have one panel used for both the Control and Transformer Panel.)

■ Transformer Panel

The Transformer Panel houses a dry-type transformer, 4.16 kV/590 V with multiple output windings. The secondary of the transformer is composed of four steps (12 windings) for 4.16 kV class, each of which is connected to the 3-phase input of a Power Cell.

Several cooling fan packages are mounted on the top of the enclosure, each containing pressurized ventilation fans. Cool ambient air (brought through the filters on the Transformer Panel and Power Cell Panel front faces) passes through the transformer section and Power Cell fin section, flows into the air duct in the panel rear, and is exhausted through the fans after cooling the main circuit components.

■ Power Cell Panel

In the Power Cell Panel, a total of 12 Power Cells, 4 steps for each phase of A (U), B (V) and C (W) output for the 4.16 kV class are mounted. These Power Cells have exactly the same configurations and electric ratings; each Power Cell is a single-phase matrix converter with 3-phase 590 Vac input.

The power section and the Cell Control Board (CCB) are incorporated into the Power Cell. Each CCB is connected to the controller in the Control Panel by a fiber optic cable. The CCB controls PWM output of the cell according to the references sent from the controller through the fiber optic cable. The CCB has protective functions against overvoltage, undervoltage, IGBT overheat, etc. and sends an answerback to the controller through the fiber optic cable.

■ Control Panel

The Control Panel houses a controller and a control power supply, used to control the Matrix converter and peripheral devices such as the MCCB (Molded-case Circuit Breaker), sequence I/O relays, and analog I/O isolation amplifiers.

The control circuit terminal block is mounted in the Control Panel for connection of all external cables except the medium voltage input cable and motor main circuit wiring.

A 460/480-Vac, 3 phase power supply (by others) is required for the cooling fans and control power.

The controller is composed of a CPU board, modulator board, current detection resistor board, and fiber optic interface board. The current detection resistor board model differs depending on the Matrix converter capacity. ***Refer to Current Detection Resistor Board Models on page 215*** for more information. The power supplies are 5 V, ±15 V, and 24 Vdc and are used as a control power supply, an analog I/O power supply, and a sequence I/O power supply respectively. ***Refer to List of Recommended Spare Parts on page 214*** for the power supply model.

A Digital Operator including the functions of writing/reading of constants and status/fault monitoring, and a modular jack for connection to a personal computer are provided on the panel face.

Typical Configurations

4.16 kV, 800 HP MX1S

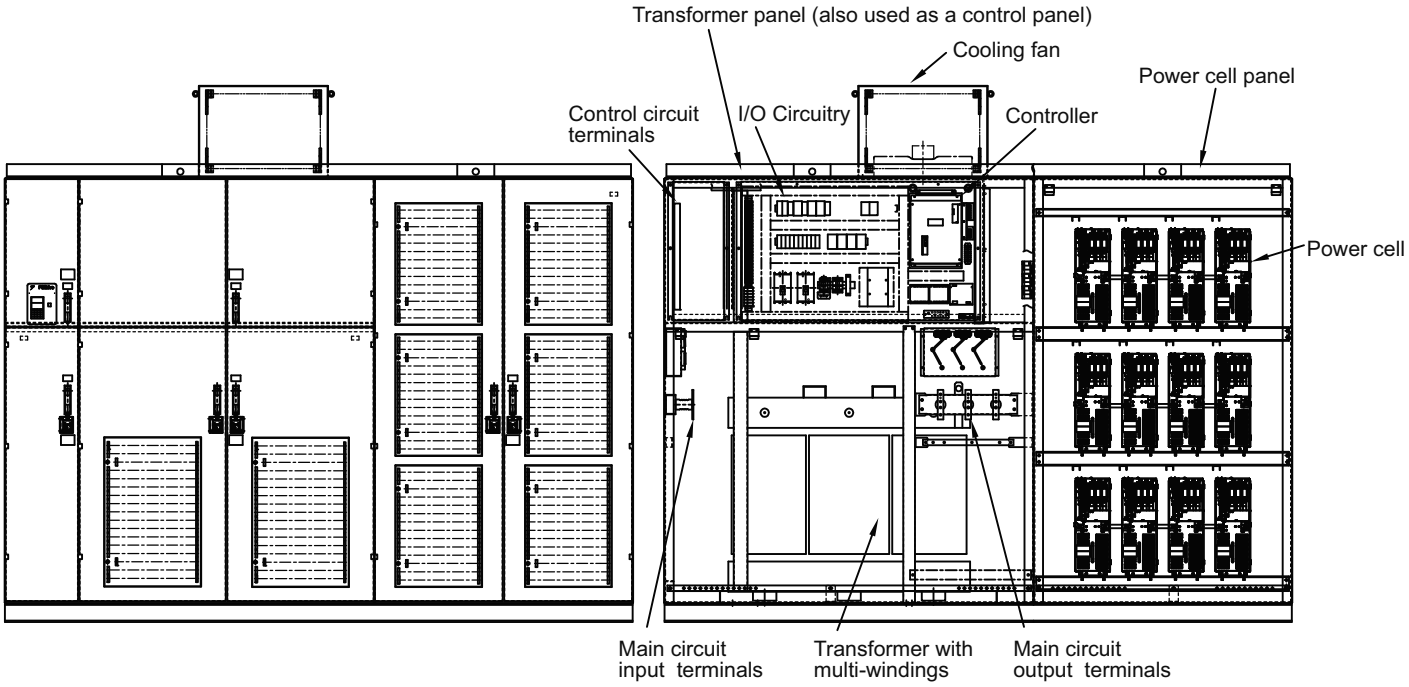


Figure 1.3 MX1S Appearance and Internal Diagram (4.16 kV Class 800 HP MX1S)

4.16 kV, 3000 HP MX1S

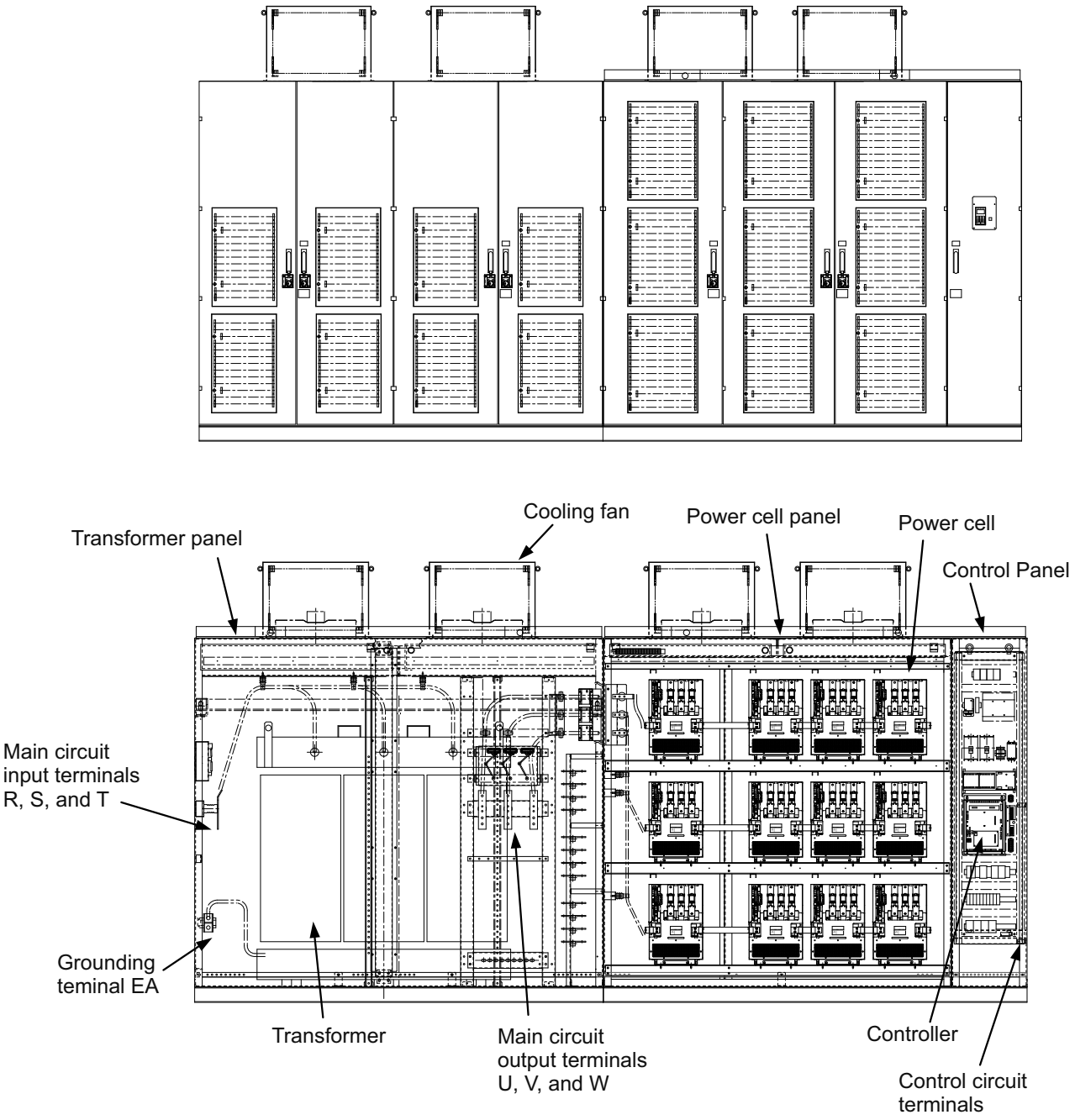


Figure 1.4 MX1S Appearance and Internal Diagram (4.16 kV Class 3000 HP MX1S)

1.5 Dimensions and Weight

The MX1S Matrix converter dimensions and weight are shown in the table below.

Table 1.3 Matrix Converter Dimensions

Voltage Class	Frequency [Hz]	Model CIMR-MX1S■■□□□	Dimensional Drawing No.	Dimensions mm (in)					Approx. Weight kg (lb) <1>
				Width W	Height H1	Height H2	Depth D1	D2 (with the door open to the max. extent)	
4.16 kV	60	070	1	3400 (133.86)	2300 (90.55)	500 (19.69)	1200 (47.24)	785 (30.91)	3900 (8580)
		090	1	3400 (133.86)	2300 (90.55)	500 (19.69)	1200 (47.24)	785 (30.91)	4500 (9900)
		102	1	3400 (133.86)	2300 (90.55)	500 (19.69)	1200 (47.24)	785 (30.91)	4500 (9900)
		115	1	3400 (133.86)	2300 (90.55)	500 (19.69)	1200 (47.24)	785 (30.91)	5400 (11880)
		123	1	3400 (133.86)	2300 (90.55)	500 (19.69)	1200 (47.24)	785 (30.91)	5400 (11880)
		154	1	3400 (133.86)	2300 (90.55)	500 (19.69)	1200 (47.24)	785 (30.91)	5400 (11880)
		185	2	4900 (192.91)	2300 (90.55)	500 (19.69)	1400 (55.12)	785 (30.91)	7900 (17380)
		215	2	4900 (192.91)	2300 (90.55)	500 (19.69)	1400 (55.12)	785 (30.91)	7900 (17380)
		245	2	4900 (192.91)	2300 (90.55)	500 (19.69)	1400 (55.12)	785 (30.91)	8700 (19140)
		281	2	4900 (192.91)	2300 (90.55)	500 (19.69)	1400 (55.12)	785 (30.91)	8700 (19140)
		311	3	5500 (216.54)	2300 (90.55)	500 (19.69)	1600 (62.99)	785 (30.91)	11300 (24860)
		336	3	5500 (216.54)	2300 (90.55)	500 (19.69)	1600 (62.99)	785 (30.91)	11300 (24860)
		372	3	5500 (216.54)	2300 (90.55)	500 (19.69)	1600 (62.99)	785 (30.91)	11300 (24860)
		436	4	6100 (240.16)	2300 (90.55)	500 (19.69)	1600 (62.99)	735 (28.94)	13100 (28820)
		520	4	6100 (240.16)	2300 (90.55)	500 (19.69)	1600 (62.99)	735 (28.94)	13100 (28820)

<1> Maximum value.

Table 1.4 Matrix Converter Weights

Voltage Class	Frequency Hz	Model CIMR-MX1S■■□□□	Dimension Drawing No.	TR Panel kg (lb)	Cell Panel kg (lb)	Weight TR + Cell kg (lb)
4.16 kV	60	070	1	3900 (8580)		3900 (8580)
		090	1	4500 (9900)		4500 (9900)
		102				
		115	1	5400 (11880)		5400 (11880)
		123				
		154				
		185	2	5800 (12760)	2100 (4620)	7900 (17380)
		215				
		245	2	6300 (13860)	2100 (4620)	8400 (18480)
		281				
		311	3	8100 (17820)	2700 (5940)	10800 (23760)
		336				
		372				
		436	4	9100 (20020)	3300 (7260)	12400 (27280)
		520				

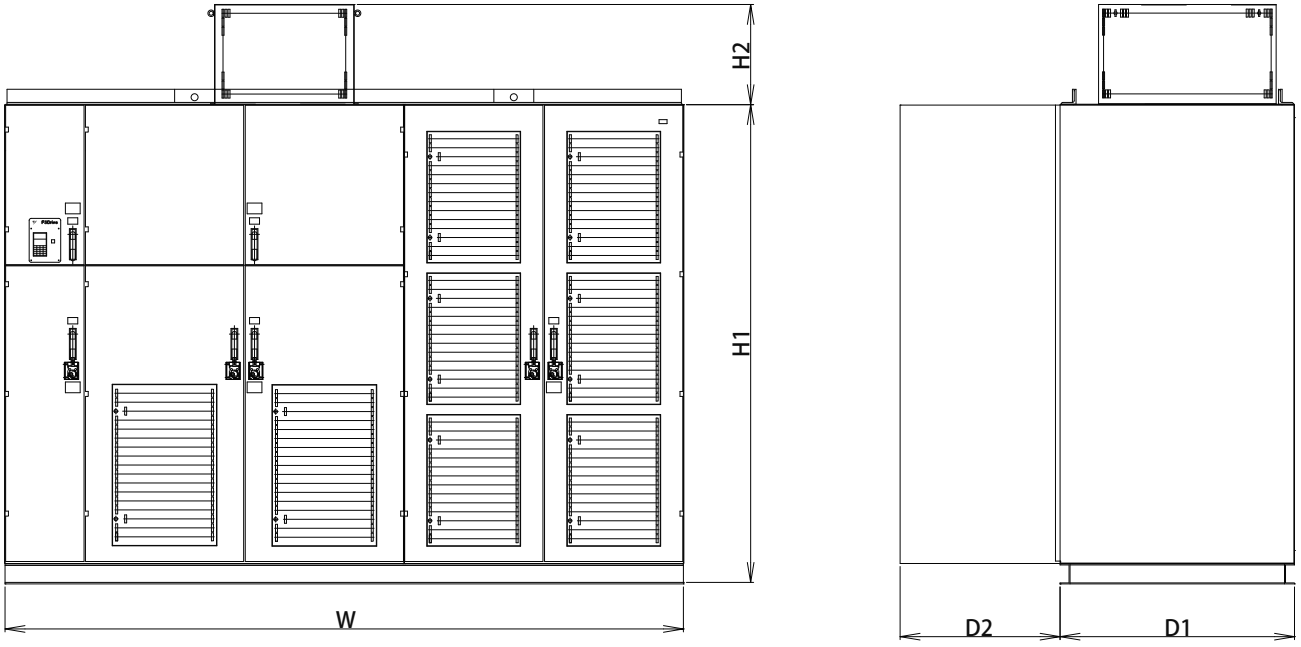


Figure 1.5 Dimension Drawing 1

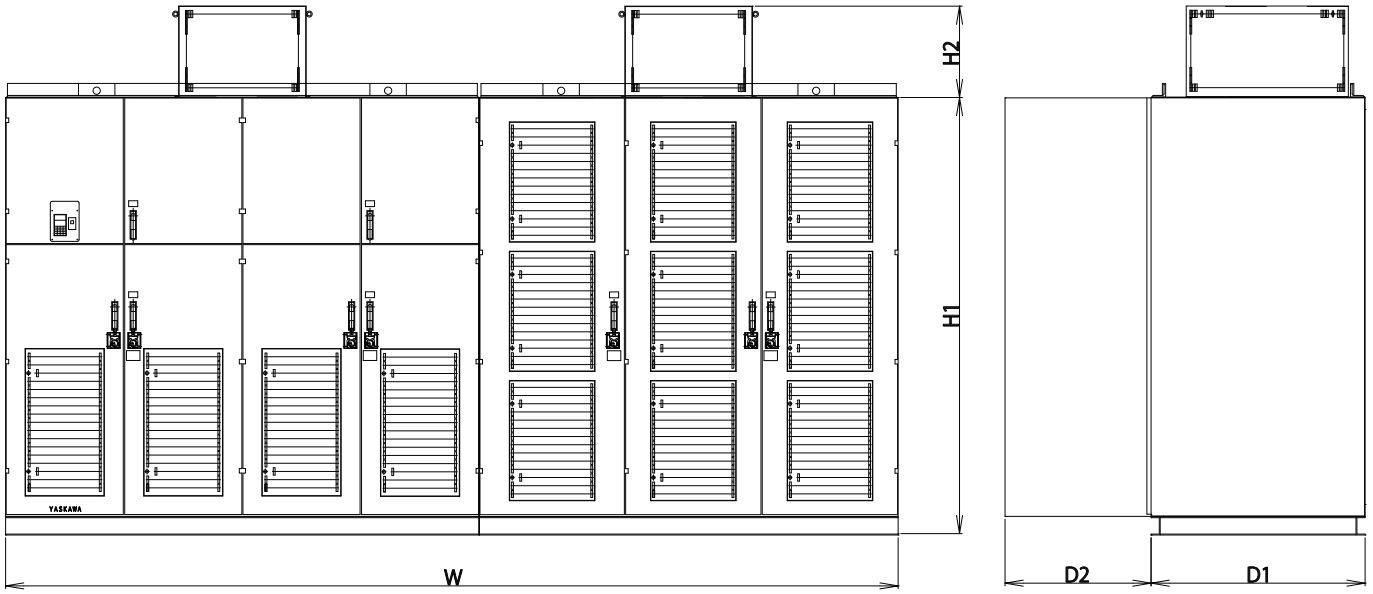


Figure 1.6 Dimension Drawing 2

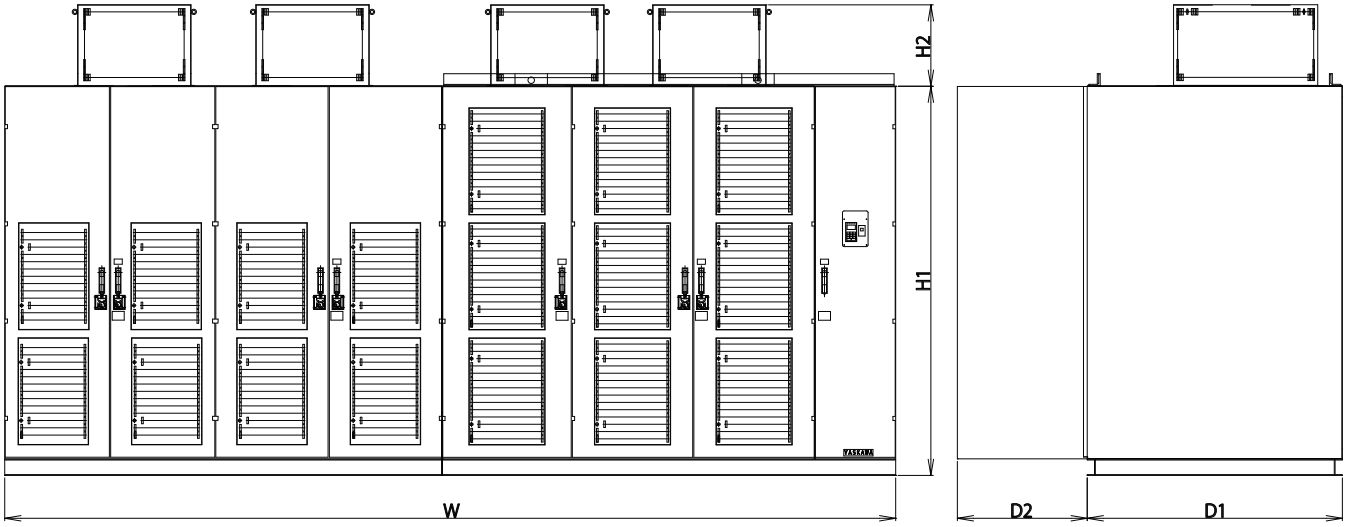


Figure 1.7 Dimension Drawing 3

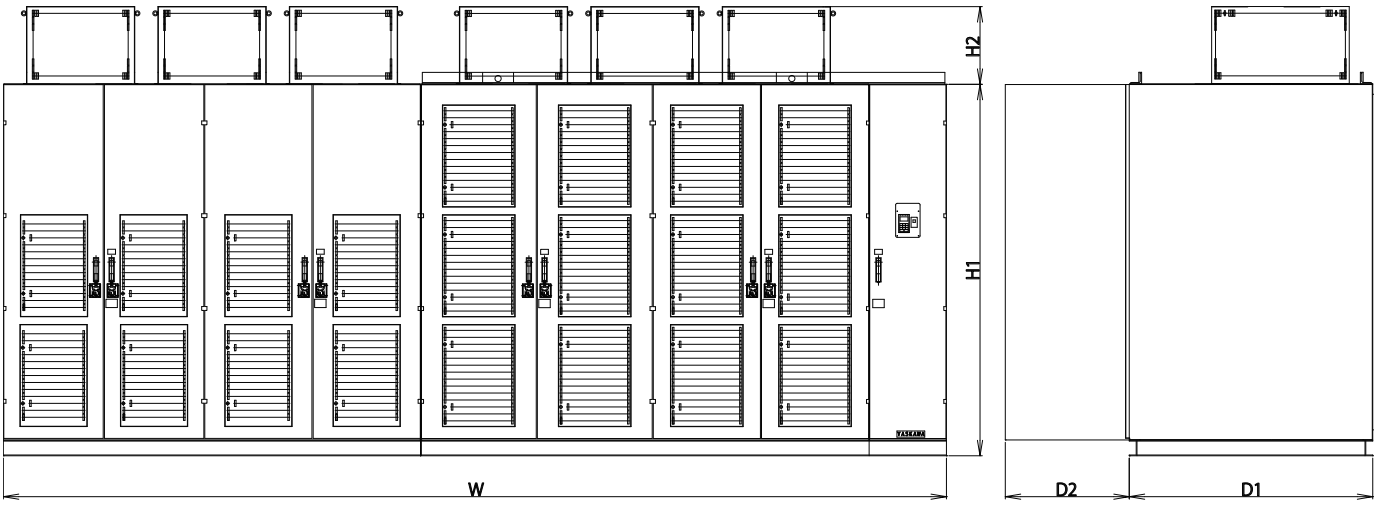


Figure 1.8 Dimension Drawing 4

1.6 Checking and Controlling the Installation Site

Install the Matrix converter at the installation site as described below and maintain optimum conditions.

◆ Installation Site

Install the Matrix converter at a location that satisfies the following requirements.

- Ambient temperature: -5 to +40°C (+23 to +104°F)
- Relative humidity: 95 % Relative Humidity (RH) maximum without condensation
- Free from water drops
- Free from corrosive liquid or gas
- Not subject to excessive dust and iron powder
- Not subject to excessive vibration
- Never install a duct on the air exhausting system.
  Modifications on the air exhausting system (cooling fan) on the top of the Matrix converter, such as installing air exhaust ducts, may lower the cooling effect, resulting in abnormal temperature rise and Matrix converter failure. If any additional ventilation system such as ductwork is required, consult your Yaskawa representative in advance.

Refer to the dimension drawings of each Matrix converter model for the space required for installation. If the Matrix converter must be installed in a location subject to excessive vibration, contact your Yaskawa representative. The Matrix converter generates audio and radio noise to some extent. This should be considered when selecting the installation location.

■ Required Space Around Panels

Keep space as described below around the panels to maintain sufficient cooling of the Matrix converter.

If the installation space is so limited that the described space cannot be reserved around the panels, contact your Yaskawa representative.

1. Space Above the Panels
   Keep a distance of 1000 mm (40 in) or more between the panel top and the room ceiling.
   A cooling fan assembly is provided on the top of each panel. If the room ceiling is too low, cooling air flow may be limited.
   Additionally, sufficient space for removing the cooling fan from the panel top is required for replacement.
2. Space in Front of the Panels
   Keep a space of 2000 mm (80 in) or more in front of each panel to allow for maintenance.
   Space for a lifter to draw out the cells in the Power Cell Panel is required.
3. Space Behind the Panels
   Keep a space of 600 mm (24 in) or more behind each panel to allow for maintenance.
   This space is required when leading the cable into the primary switch gear and installing anchors on the back of the Power Cell Panel.

◆ Controlling the Ambient Temperature

To optimize reliability, the Matrix converter should be installed in an environment free from extreme temperature variations. The ambient temperature and the temperature of incoming air to the panels must be 40°C (104°F) or below.

If the Matrix converter is installed in a room of limited space, such as a small electric room, where the room temperature may easily increase, use a cooling fan or air conditioner to maintain the room temperature at 40°C (104°F) or below.

◆ Protecting the Matrix converter from Foreign Matter

Take measures to prevent foreign matter such as metal chips or powder from entering the Matrix converter during installation.

Make sure that tools and unused parts are not left in or around the panels after installing the Matrix converter. Carefully check the power flow sections, their surroundings, the air filter section, and the exhaust fan assemblies to confirm that there are no foreign objects or obstacles.

1.7 Transportation and Installation

◆ Transporting the MX1S Matrix converter

- To lift the small/middle capacity (550 to 3000 HP) Matrix converter, use the fixtures indicated on the panels.
- To lift the Transformer Panel on the large capacity (3500 to 4000 HP) Matrix converter, use the lifting tool provided as an accessory.
- Never climb on the panel top.

WARNING! *When moving the MX1S using a crane, the crane must be operated by a qualified and trained crane operator. Failure to observe this precaution may result in injury or in dropping the Matrix converter.*

◆ Side-by-Side Installation

For 4.16 kV Matrix converters 1500 HP and larger, the packages are separated into two parts for shipment. The panels are designed to be installed side-by-side.

For these models, eight (8) holes are provided on each of the Transformer Panel frame and Power Cell Panel frame as shown in ***Figure 1.9***.

Use M10×30L bolts, washers, and S washers to join the panels.

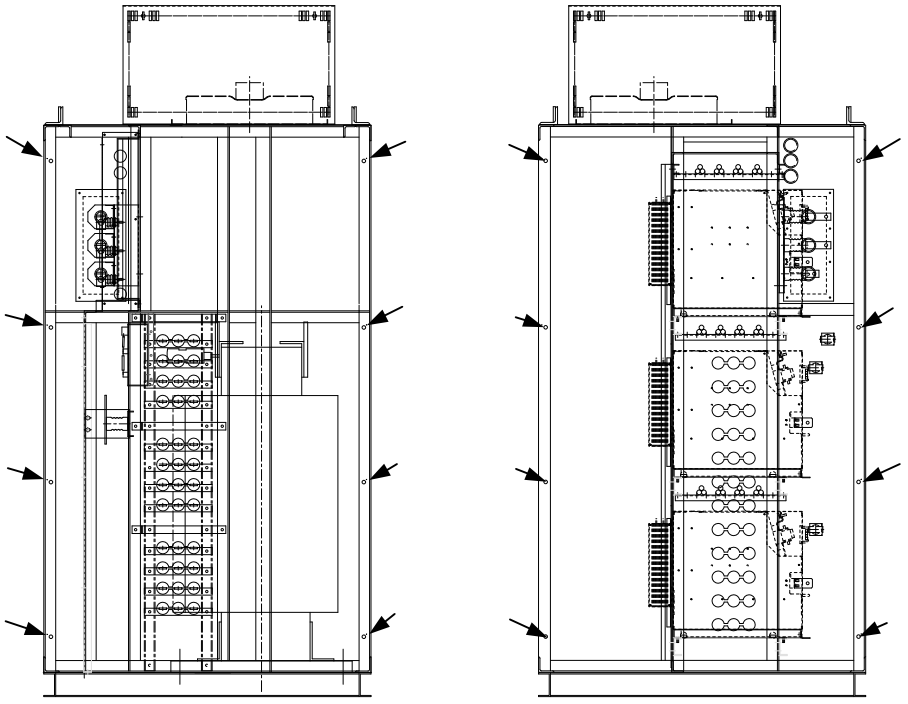


Figure 1.9 Mounting Holes for Side-by-Side Installation (Example of 4.16 kV 1750 HP Matrix converter)

After installing the panels, perform the following wiring procedures.

- Main circuits (between the transformer secondaries and the power cell primaries; and also between the power cell secondary and the output terminals.)
- Earth bus
- Cooling fans
- Cell control boards (between the power cells and the main controller, via fiber optic cables)

◆ Installing a Matrix converter on a Floor

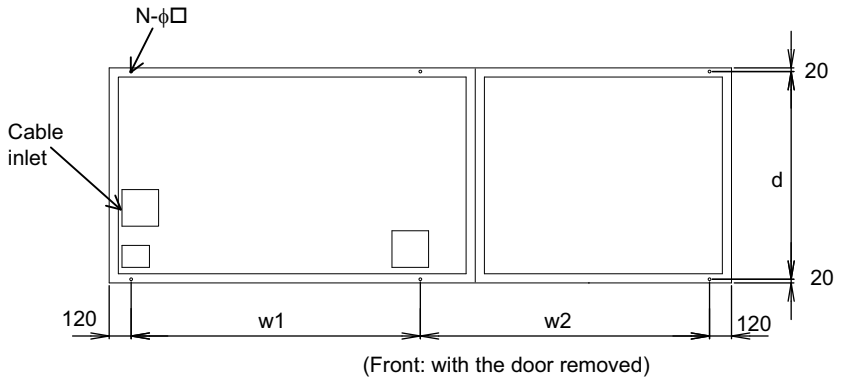
The table below shows the mounting holes and dimensions when installing a Matrix converter on a floor.

Use mounting screws of diameter M12 to fix the Matrix converter.

Attach and fasten M12 screws at all the mounting holes to secure the Matrix converter in any installation conditions, whether there is vibration or not.

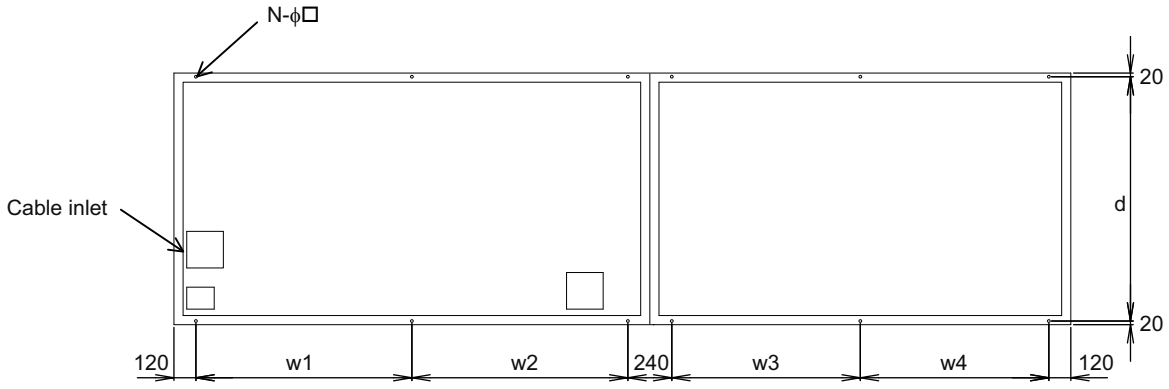
Table 1.5 MX1S Installation Dimensions

Voltage Class	Frequency Hz	MX1S Model CIMR-MX1S■■□□□	Panel Bottom Dimensional Drawing	Dimensions mm (in)					Mounting Hole N-f mm (in)
				w1	w2	w3	w4	d	
4.16 kV	60	070	1	1580 (62.20)	1580 (62.20)	–	–	1135 (44.68)	6-f17 (0.67)
		090	1	1580 (62.20)	1580 (62.20)	–	–	1135 (44.68)	6-f17 (0.67)
		102	1	1580 (62.20)	1580 (62.20)	–	–	1135 (44.68)	6-f17 (0.67)
		115	1	1580 (62.20)	1580 (62.20)	–	–	1135 (44.68)	6-f17 (0.67)
		123	1	1580 (62.20)	1580 (62.20)	–	–	1135 (44.68)	6-f17 (0.67)
		154	1	1580 (62.20)	1580 (62.20)	–	–	1135 (44.68)	6-f17 (0.67)
		185	2	1180 (46.46)	1180 (46.46)	1030 (40.55)	1030 (40.55)	1335 (52.56)	12-f17 (0.67)
		215	2	1180 (46.46)	1180 (46.46)	1030 (40.55)	1030 (40.55)	1335 (52.56)	12-f17 (0.67)
		245	2	1180 (46.46)	1180 (46.46)	1030 (40.55)	1030 (40.55)	1335 (52.56)	12-f17 (0.67)
		281	2	1180 (46.46)	1180 (46.46)	1030 (40.55)	1030 (40.55)	1335 (52.56)	12-f17 (0.67)
		311	3	1230 (48.43)	1230 (48.43)	1280 (50.39)	1280 (50.39)	1535 (60.43)	12-f17 (0.67)
		336	3	1230 (48.43)	1230 (48.43)	1280 (50.39)	1280 (50.39)	1535 (60.43)	12-f17 (0.67)
		372	3	1230 (48.43)	1230 (48.43)	1280 (50.39)	1280 (50.39)	1535 (60.43)	12-f17 (0.67)
		436	4	1230 (48.43)	1230 (48.43)	1580 (62.20)	1580 (62.20)	1535 (60.43)	12-f17 (0.67)
		520	4	1230 (48.43)	1230 (48.43)	1580 (62.20)	1580 (62.20)	1535 (60.43)	12-f17 (0.67)



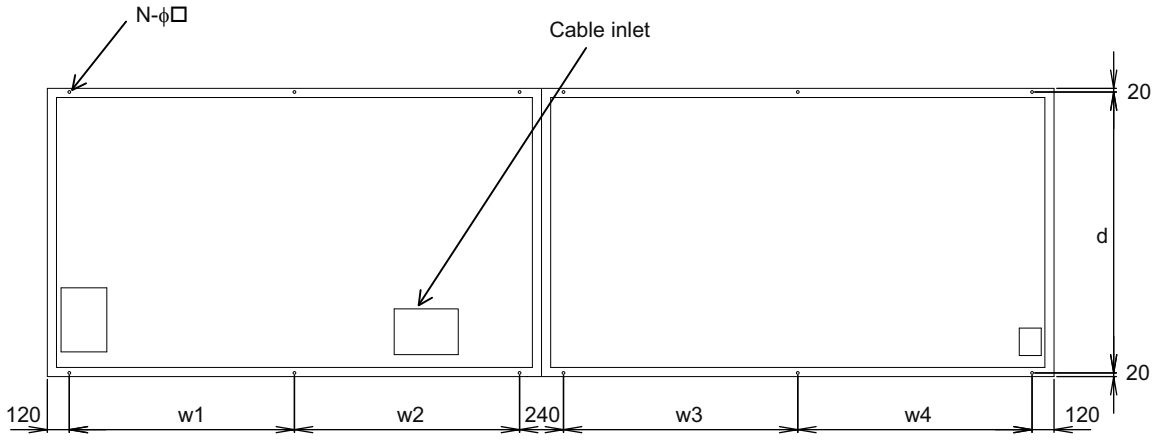
(Front: with the door removed)

Figure 1.10 Panel Bottom Dimensional Drawing 1



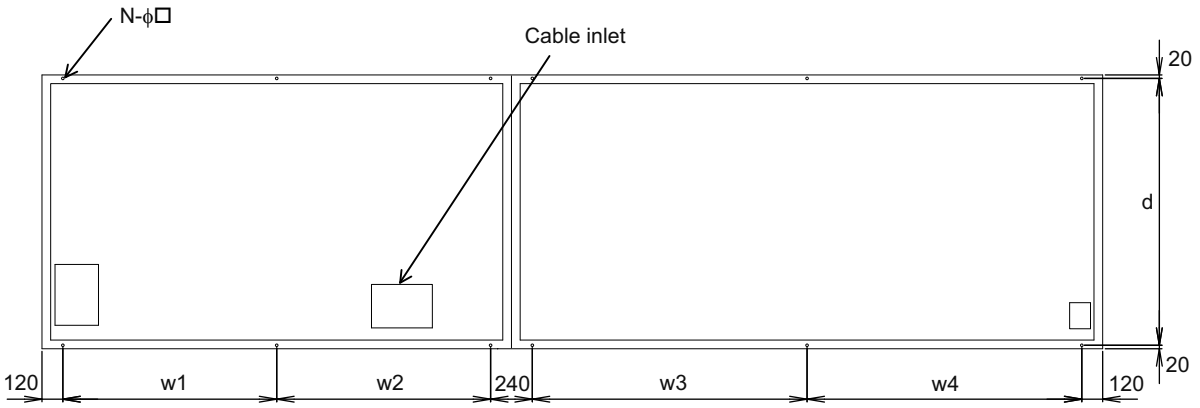
(Front: with the door removed)

Figure 1.11 Panel Bottom Dimensional Drawing 2



(Front: with the door removed)

Figure 1.12 Panel Bottom Dimensional Drawing 3



(Front: with the door removed)

Figure 1.13 Panel Bottom Dimensional Drawing 4

2

Wiring

This chapter describes terminal wiring, main circuit terminal connections and specifications, and control circuit terminal connections and specifications.

2.1 Section Safety

⚠ DANGER

Electrical Shock Hazard

Disconnect all main power before servicing.

Failure to comply may result in serious injury or death from electric shock.

To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc.

⚠ WARNING

Electrical Shock Hazard

Do not operate equipment with covers removed.

Failure to comply could result in death or serious injury.

The diagrams in this section may show Matrix converters without covers or safety shields to show details. Be sure to reinstall covers or shields before operating the Matrix converters and run the Matrix converters according to the instructions described in this manual.

Always ground the motor-side grounding terminal.

Improper equipment grounding could result in death or serious injury by contacting the motor case.

Do not perform work on the Matrix converter while wearing loose clothing, jewelry or without eye protection.

Failure to comply could result in death or serious injury.

Remove all metal objects such as watches and rings, secure loose clothing, and wear eye protection before beginning work on the Matrix converter.

Do not remove covers or touch circuit boards while the power is on.

Failure to comply could result in death or serious injury.

Do not allow unqualified personnel to perform work on the Matrix converter.

Failure to comply could result in death or serious injury.

Installation, maintenance, inspection, and servicing must be performed only by authorized personnel familiar with installation, adjustment, and maintenance of Medium Voltage AC Matrix converters.

Fire Hazard

Tighten all terminal screws to the specified tightening torque.

Loose electrical connections could result in death or serious injury by fire due to overheating of electrical connections.

Do not use improper combustible materials.

Failure to comply could result in death or serious injury by fire.

Attach the Matrix converter to metal or other noncombustible material.

Do not use an improper voltage source.

Failure to comply could result in death or serious injury by fire.

Verify that the rated voltage of the Matrix converter matches the voltage of the incoming power supply before applying power.

NOTICE

Observe proper electrostatic discharge procedures (ESD) when handling the Matrix converter and circuit boards.

Failure to comply may result in ESD damage to the Matrix converter circuitry.

Never connect or disconnect the motor from the Matrix converter while the Matrix converter is outputting voltage.

Improper equipment sequencing could result in damage to the Matrix converter.

Do not use unshielded cable for control wiring.

Failure to comply may cause electrical interference resulting in poor system performance. Use shielded, twisted-pair wires and ground the shield to the ground terminal of the Matrix converter.

Check all wiring to ensure that all connections are correct after installing the Matrix converter and connecting any other devices.

Failure to comply may cause electrical interference resulting in poor system performance. Use shielded, twisted-pair wires and ground the shield to the ground terminal of the Matrix converter.

Failure to comply could result in damage to the Matrix converter.

Do not modify the Matrix converter circuitry.

Failure to comply could result in damage to the Matrix converter and will void warranty.

Yaskawa is not responsible for any modification of the product made by the user. This product must not be modified.

2.2 Standard Wiring

Figure 2.1 shows the standard connection diagram of the MX1S Matrix converter.

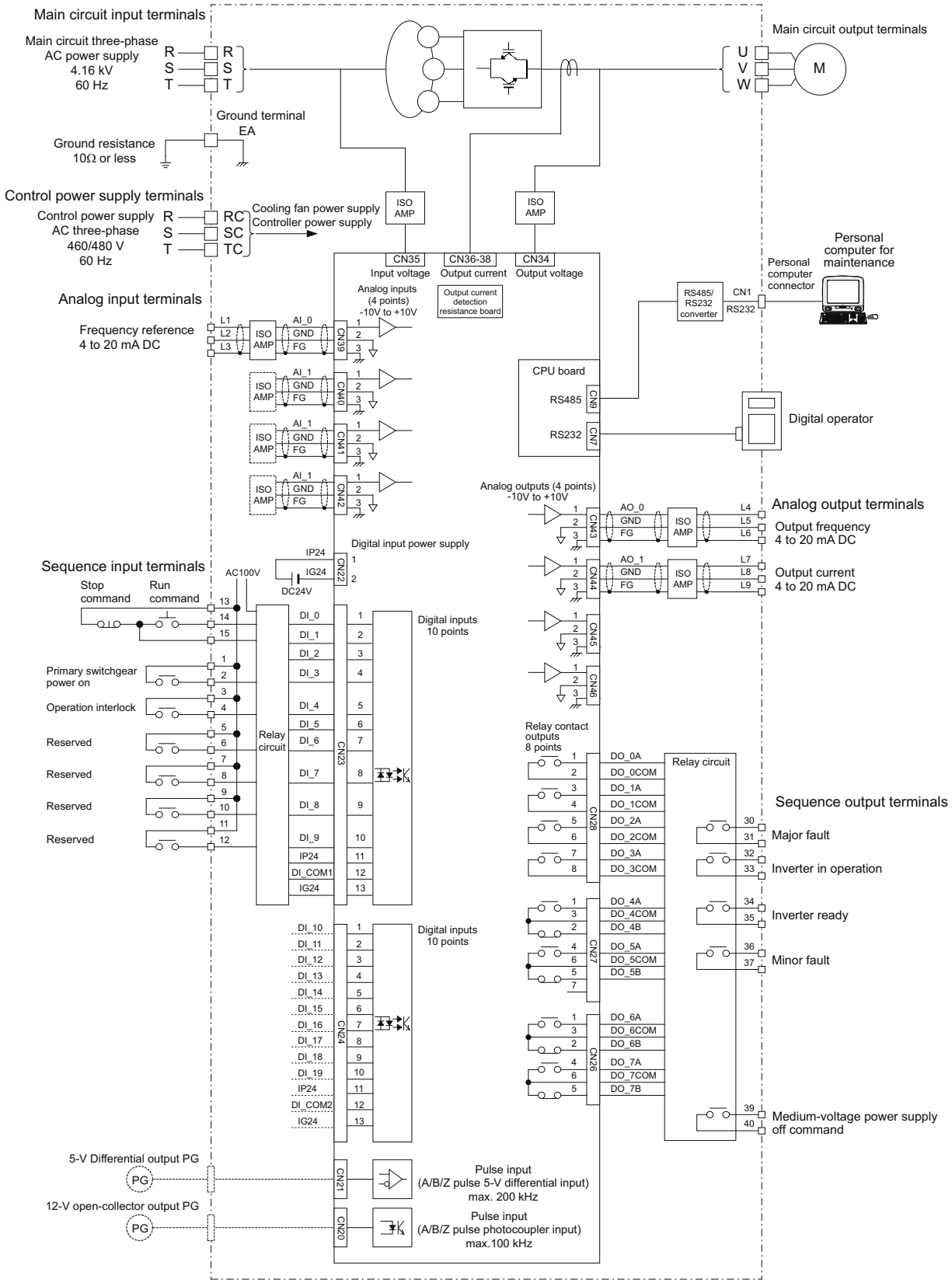


Figure 2.1 Standard Wiring

Note:
1. The external connection terminals include main circuit input terminals (R, S, and T), main circuit output terminals (U, V, and W), a grounding terminal (EA), and control circuit terminals. The control circuit terminals include control power supply input terminals (RC, SC, and TC), analog I/O terminals (L1 to L15), and sequence I/O output terminals (1 to 40).
2. The analog input terminals (frequency reference) require a 4 to 20 mA input signal.
3. The analog outputs, monitoring output frequency and current, are 4 to 20 mA. They are not used for control such as feedback control. Be careful not to short circuit these terminals. Doing so will cause malfunction or fault of the Matrix converter.
4. The sequence input terminals 1 through 12 are for contact closures, not an external voltage source. The sequence output terminals are contact closures. Refer to ***Table 2.5*** for the sequence I/O terminal specifications.
5. Do not use terminals other than grounding terminals for grounding. Doing so may cause malfunction or fault.
6. For flux vector control, PG circuit wiring is required in addition to the standard wiring. Contact your Yaskawa representative if wiring other than the standard connections are required.

◆ Precautions for Main Circuit Power Supply

The MX1S is intended to operate from the grid at 4160 V ±10 %, 60 Hz ±5 %, with maximum input waveform distortion of 5 % and maximum source impedance of 5 % (minimum short circuit ratio of 20:1). Consult your Yaskawa representative if higher distortion or source impedance is anticipated. Also, consult Yaskawa if operating from a private power generator or variable transformer.

2.3 Terminals

Figure 2.2 and ***Figure 2.3*** show the terminals provided on the MX1S Matrix converters.

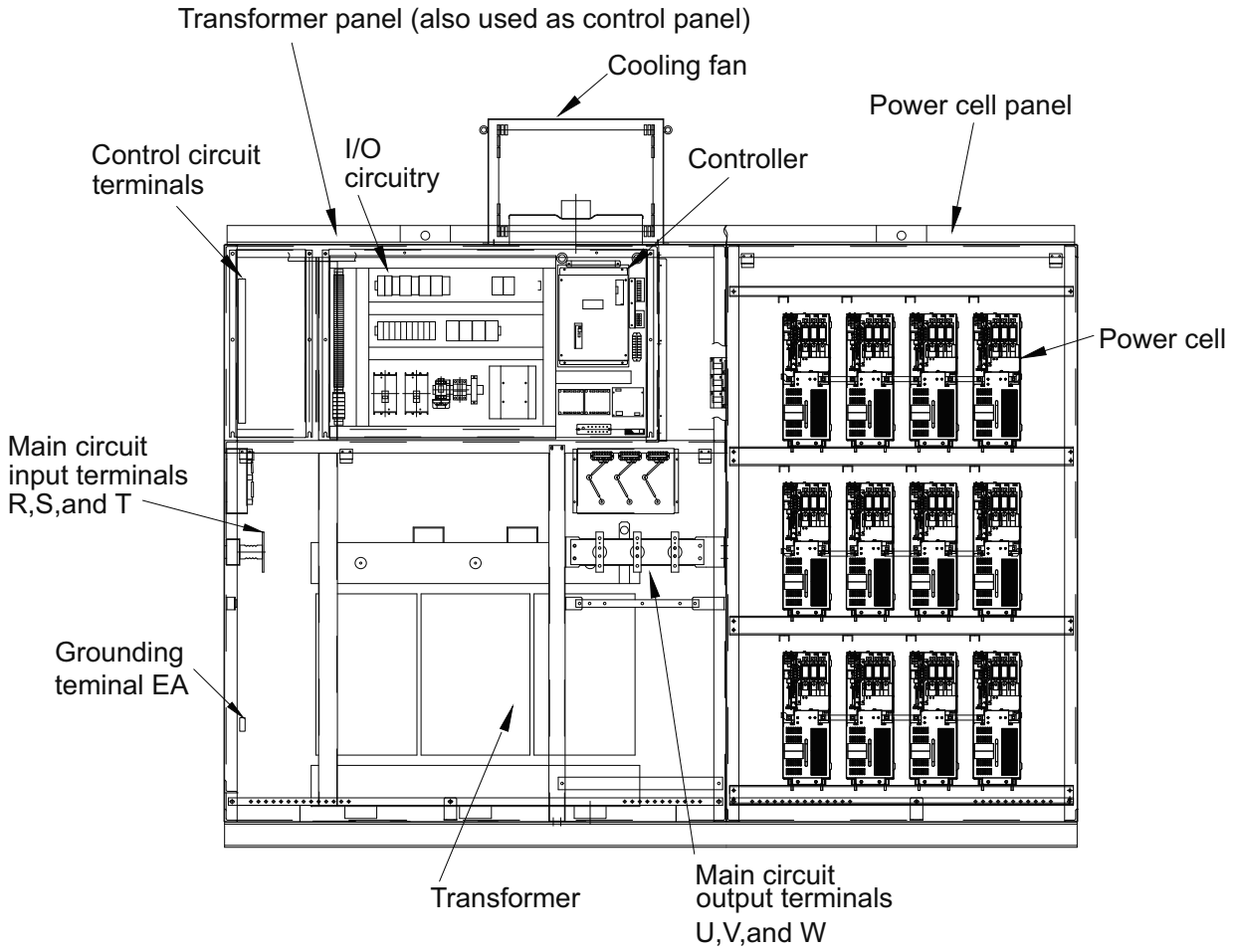


Figure 2.2 Terminal Locations (4.16 kV class, 800 HP MX1S)

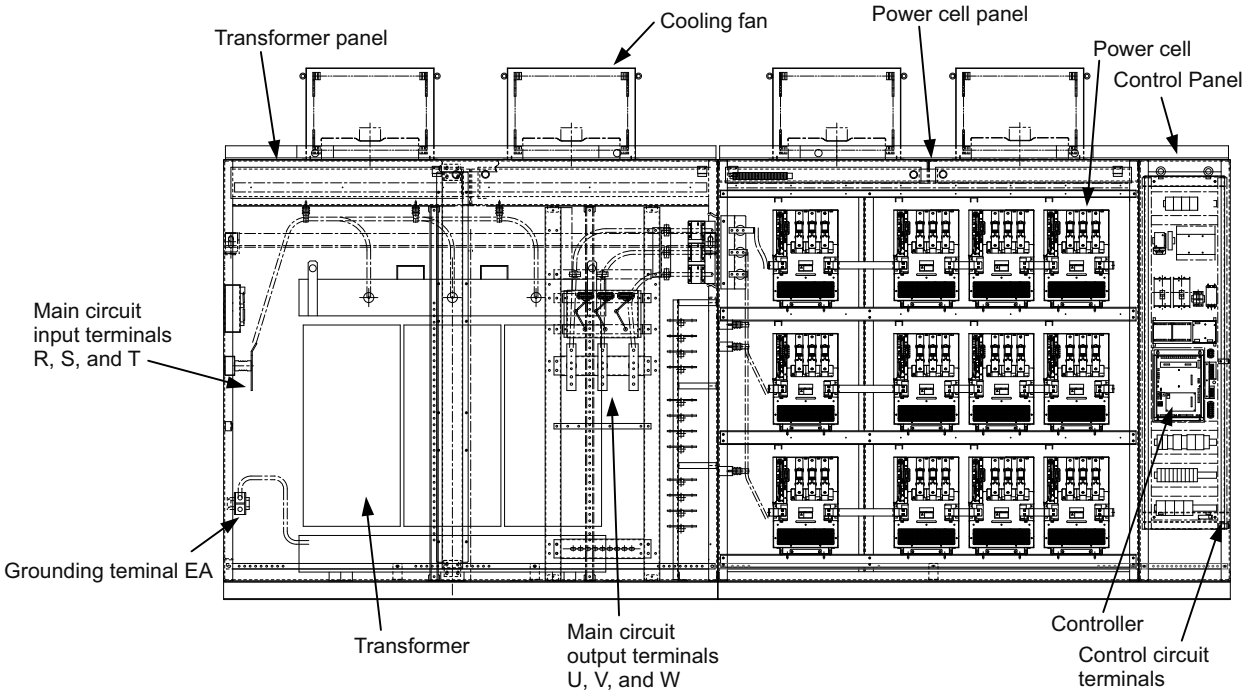


Figure 2.3 Terminal Locations (4.16 kV class, 3000 HP MX1S)

2.4 Wiring Main Circuit Terminals

◆ Main Circuit Terminals

■ Input Terminals

Table 2.1 Main Circuit Input Terminals

Terminal Code	Signal	Specifications
R	Main circuit phase-R input	Primary 3 phase input power 4.16 kV AC 60 Hz
S	Main circuit phase-S input	
T	Main circuit phase-T input	

■ Output Terminals

Table 2.2 Main Circuit Output Terminals

Terminal Code	Signal	Specifications
U	Main circuit phase-U output	3 phase output power to motor
V	Main circuit phase-V output	
W	Main circuit phase-W output	

◆ Applicable Wire Sizes and Crimp Terminals

Refer to ***Table 2.3*** to select appropriate wires and crimp terminals for main circuit wiring and grounding.

Table 2.3 Terminal Screw Size and Applicable Wire Sizes

Voltage Class	Frequency [Hz]	Model CIMR-MX1S ■■□□□	Rated Current [A]	Terminal		Terminal Screw Size	Tightening Torque N·m (lb-in)	Applicable Wire Size mm² (AWG)
				Function	Code			
4.16 kV	60	070	70	I/O	R, S, T, U, V, W	M10	18.0 to 23.0 (159 to 204)	22 to 100 (4 to 4/0)
			150	Ground	EA	M8	0.9 to 10.8 (8 to 96)	22 to 60 (4 to 1/0)
		090	90	I/O	R, S, T, U, V, W	M10	18.0 to 23.0 (159 to 204)	22 to 100 (4 to 4/0)
			150	Ground	EA	M8	0.9 to 10.8	22 to 60 (4 to 1/0)
		102	102	I/O	R, S, T, U, V, W	M10	18.0 to 23.0 (159 to 204)	38 to 100 (2 to 4/0)
			150	Ground	EA	M8	0.9 to 10.8 (8 to 96)	22 to 60 (4 to 1/0)
		115	115	I/O	R, S, T, U, V, W	M10	18.0 to 23.0 (159 to 204)	38 to 100 (2 to 4/0)
			150	Ground	EA	M8	0.9 to 10.8 (8 to 96)	22 to 60 (4 to 1/0)
		123	123	I/O	R, S, T, U, V, W	M10	18.0 to 23.0 (159 to 204)	38 to 100 (2 to 4/0)
			150	Ground	EA	M8	0.9 to 10.8 (8 to 96)	22 to 60 (4 to 1/0)
		154	154	I/O	R, S, T, U, V, W	M10	18.0 to 23.0 (159 to 204)	38 to 100 (2 to 4/0)
			150	Ground	EA	M8	0.9 to 10.8 (8 to 96)	22 to 60 (4 to 1/0)

Voltage Class	Frequency [Hz]	Model CIMR-MX1S ■■□□□	Rated Current [A]	Terminal		Terminal Screw Size	Tightening Torque N·m (lb-in)	Applicable Wire Size mm² (AWG)
				Function	Code			
4.16 kV	60	185	185	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	60 to 100 (1/0 to 4/0)
			310	Ground	EA	M10	18.0 to 23.0 (159 to 204)	22 to 100 (4 to 4/0)
		215	215	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	60 to 100 (1/0 to 4/0)
			310	Ground	EA	M10	18.0 to 23.0 (159 to 204)	22 to 100 (4 to 4/0)
		245	245	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	60 to 100 (1/0 to 4/0)
			310	Ground	EA	M10	18.0 to 23.0 (159 to 204)	22 to 100 (4 to 4/0)
		281	281	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	60 to 100 (1/0 to 4/0)
			310	Ground	EA	M10	18.0 to 23.0 (159 to 204)	22 to 100 (4 to 4/0)
		311	311	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	150 to 325 (300MCM to 600MCM)
			350	Ground	EA	M12	31.5 to 39.5 (279-350)	150 to 325 (300MCM to 600MCM)
		336	336	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	150 to 325 (300MCM to 600MCM)
			350	Ground	EA	M12	31.5 to 39.5 (279-350)	150 to 325 (300MCM to 600MCM)
		372	372	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	150 to 325 (300MCM to 600MCM)
			350	Ground	EA	M12	31.5 to 39.5 (279-350)	150 to 325 (300MCM to 600MCM)
		436	436	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	150 to 325 (300MCM to 600MCM)
			600	Ground	EA	M16	78.5 to 98.0 (695 to 867)	150 to 325 (300MCM to 600MCM)
		520	520	I/O	R, S, T, U, V, W	M12	31.5 to 39.5 (279-350)	150 to 325 (300MCM to 600MCM)
			600	Ground	EA	M16	78.5 to 98.0 (695 to 867)	150 to 325 (300MCM to 600MCM)

Note: Line voltage drop must be taken into consideration when selecting wire size.
Select the wire size for the main circuit so that the line voltage drop is < 2 % of the rated voltage.

◆ Wiring the Main Circuits

This section outlines the various steps, precautions, and checkpoints for wiring the main circuit terminals and motor terminals

WARNING! *Do not connect the incoming AC power lines to the output motor terminals of the Matrix converter. Failure to comply could result in death or serious injury by fire as a result of Matrix converter damage from line voltage application to output terminals.*

CAUTION! *Incorrect wiring of the power input and output terminals will damage the Matrix converter when the power supply is turned on, and may result in injury.*

NOTICE: *When connecting the motor to the Matrix converter output terminals U/T1, V/T2, and W/T3, the phase sequence for the Matrix converter and motor should match. If the phase sequence is backward, the motor will run in reverse when energized.*

NOTICE: *Do not connect power factor correction capacitors or LC/RC noise filters to the Matrix converter output. The components will be destroyed and the action could result in damage to the Matrix converter.*

■ Wiring the Main Circuit Input Terminals

Observe the following when wiring the main circuit input terminals.

Terminal Block Construction and Cable End Processing

Prepare appropriate cable terminations for the cable size and terminal block.

Connection to the Terminal Block

The input power supply can be connected to any of terminals R, S, or T. The phase sequence of the input power supply is irrelevant to the output phase sequence. It is recommended that input phase sequence be consistent for ease of future maintenance.

■ Wiring the Main Circuit Output Terminals

Observe the following precautions when wiring the main circuit output terminals.

Connecting a Motor to the Matrix converter

Connect the motor lead wires U, V, and W to the Matrix converter main circuit output terminals U, V, W respectively.

Confirm that the motor rotates in the forward direction under the forward run command during trial operation. If the motor rotates in reverse, check the output terminal codes and the motor lead wire codes, switch any two of the output terminals U, V, and W, and reconnect.

NOTICE: *Never connect a power supply to the output terminals U, V, and W. Applying voltage to the output terminals will destroy the Power Cells inside the panel.*

NOTICE: *Never Short Circuit or Ground the Output Terminals. Equipment damage may result when power is applied.*

■ Ground Wiring

Observe the following when wiring grounding lines.

WARNING! *Electrical Shock Hazard. Be sure to ground the Matrix converter ground terminals as follows. Improper equipment grounding could result in death or serious injury by contacting ungrounded electrical equipment.*

Grounding terminal EA	Ground resistance 10 ohms or less, wire size 5.5 mm^2 minimum (AWG 10 minimum).

WARNING! *Electrical Shock Hazard. Always use a ground wire that complies with technical standards on electrical equipment and minimize the length of the ground wire. Improper equipment grounding may cause dangerous electrical potentials on equipment chassis, which could result in death or serious injury.*

NOTICE: *Do not share the ground wire with other devices such as welding machines or large-current electrical equipment. Improper equipment grounding could result in Matrix converter or equipment malfunction due to electrical interference.*

NOTICE: *When using more than one Matrix converter, ground multiple Matrix converters according to instructions. Improper equipment grounding could result in abnormal operation of Matrix converter or equipment.*

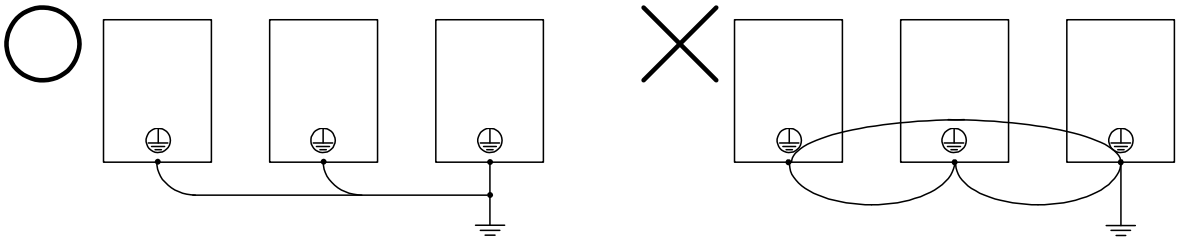


Figure 2.4 Ground Wiring

O = Correct. X = Incorrect.

2.5 Wiring Control Circuit Terminals

◆ Control Circuit Terminal Layout and Specifications

Figure 2.5 shows the control circuit terminal layout and ***Table 2.4***, ***Table 2.5***, and ***Table 2.6*** show each terminal function. Use appropriate terminals according to the application.

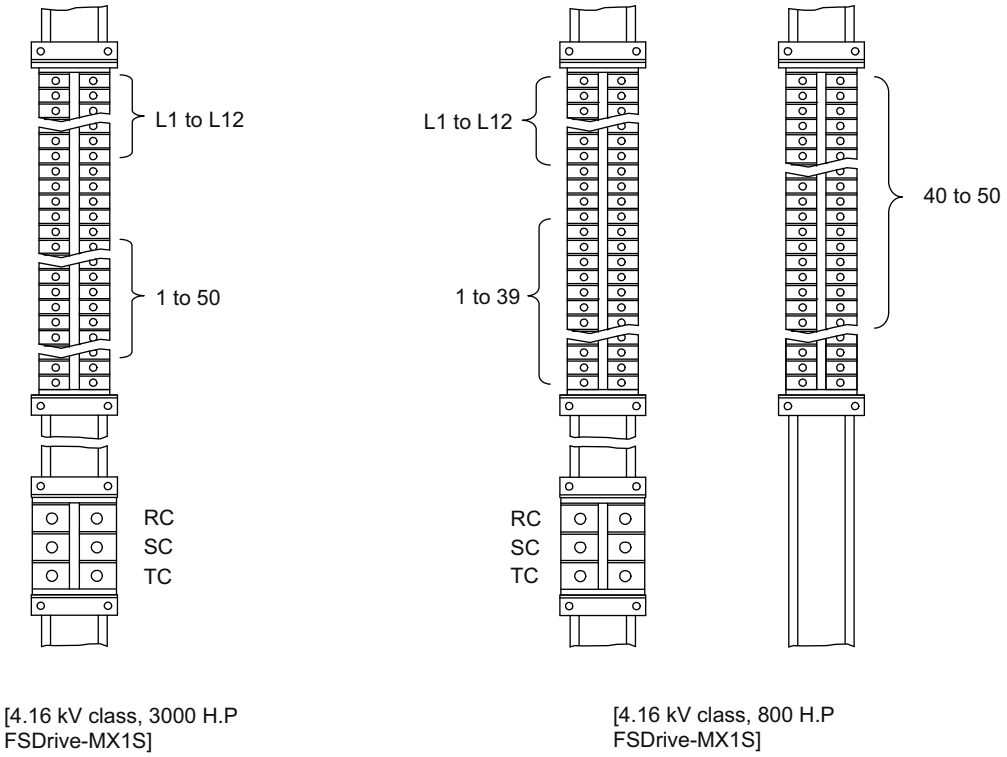


Figure 2.5 Control Circuit Terminal Layout

■ Analog I/O Terminals

Table 2.4 Analog I/O Terminals

Type	Signal Name	Signal Level	Terminal Code	Terminal Function
Analog input terminals	Frequency reference	4 to 20 mADC, range 0 to Maximum frequency command	L1	Frequency reference input signal
			L2	Ground
			L3	Shield ground
Analog output terminals	Output frequency	4 to 20 mADC, range 0 to Maximum frequency output	L4	Operating frequency output signal
			L5	Ground
			L6	Shield ground
	Output current	4 to 20 mADC, range 0 to 150 % output	L7	Operating current output signal
			L8	Ground
			L9	Shield ground
Reserved	–	–	–	–

■ Control Circuit Terminals

Table 2.5 Control I/O Signals

Type	Signal Name	Signal Level	Terminal Code	Terminal Function
Digital Input	Primary switchgear power on	Contact input 110 Vac, 15 mA	1 2	On when primary power is applied (Short-circuit at shipment)
	Operation interlock _1	Contact input 110 Vac, 15 mA	3 4	On when interlocked (Short-circuit at shipment)
	Run/Stop	Contact input 110 Vac, 15 mA	13 14 15	3 wire start-stop control. See ***Figure 2.1***
	Reserved	–	5 to 12, 16 to 29, and 38	–
Digital outputs	Major fault	N.O. (Normally Open) relay contact output LY4N 110 Vac (manufactured by OMRON Corporation) 110 Vac/7.5 A, 24 Vdc/5 A	30 31	Closed in normal operation. Opens in event of a major fault.
	In operation	N.O. relay contact output LY4N 110 Vac (manufactured by OMRON Corporation) 110 Vac/7.5 A, 24 Vdc/5 A	32 33	Closed during operation
	Ready	N.O. relay contact output LY4N 110 Vac (manufactured by OMRON Corporation) 110 Vac/7.5 A, 24 Vdc/5 A	34 35	Closed when Matrix converter is ready to run
	Minor fault	N.O. relay contact output LY4N 110 Vac (manufactured by OMRON Corporation) 110 Vac/7.5 A, 24 Vdc/5 A	36 37	Closes when a minor fault occurs
	Medium-voltage power supply off command	N.C. (Normally Closed) relay contact output LY2N 110 Vac (manufactured by OMRON Corporation) 110 Vac/7.5 A, 24 Vdc/5 A	39 40	Closes when the medium-voltage power supply must be shut off
	Reserved	–	–	–

■ Control Power Supply Input Terminals

Table 2.6 Control Power Supply Input Terminals

Type	Signal Name	Terminal Function	Terminal Code	Remarks
Control power supply input terminals	R	460/480 Vac, 60 Hz	RC	–
	S		SC	
	T		TC	

◆ Applicable Wire Sizes

Table 2.7 shows the wire size of each terminal. Select an appropriate wire size considering the current capacity.

Terminal Type	Terminal Code	Terminal Screw	Tightening Torque (N·m) (lb-in)	Applicable Wire Size mm2 (AWG)	Recommended Wire Size mm2 (AWG)	Wire Type (For reference)
Analog I/O terminals	L1 to L9	M3.5	0.8 to 1.0 (7 to 9)	0.5 to 2 (20 to 14)	1.25 (16)	Shielded twisted-pair wire <1>
Control I/O terminals	1 to 40	M3.5	0.8 to 1.0 (7 to 9)	0.5 to 2 (20 to 14)	1.25 (16)	Insulated vinyl sheathed cable (CVV) for control circuit
Control power supply input terminals	RC, SC, TC	M5	2 to 2.5 (18-22)	8 to 14 (8 to 6)	8 (8)	600-V vinyl insulated, vinyl sheathed cable (VV)

<1> Use shielded twisted-pair wires to input an external frequency reference.

◆ Control Circuit Wiring Precautions

Observe the following precautions when wiring control circuits.

WARNING! *Electrical Shock Hazard. Do not remove covers or touch the circuit boards while the power is on. Failure to comply could result in death or serious injury.*

NOTICE: *Separate control I/O wiring, analog I/O wiring and control power supply wiring from each other and from other high-power wiring. Improper wiring practices could result in Matrix converter malfunction due to electrical interference.*

NOTICE: *Use twisted pair shielded cables for analog I/O. Insulate shields with tape or shrink tubing to prevent contact with other signal lines and equipment. Improper wiring practices could result in Matrix converter or equipment malfunction due to short circuit.*

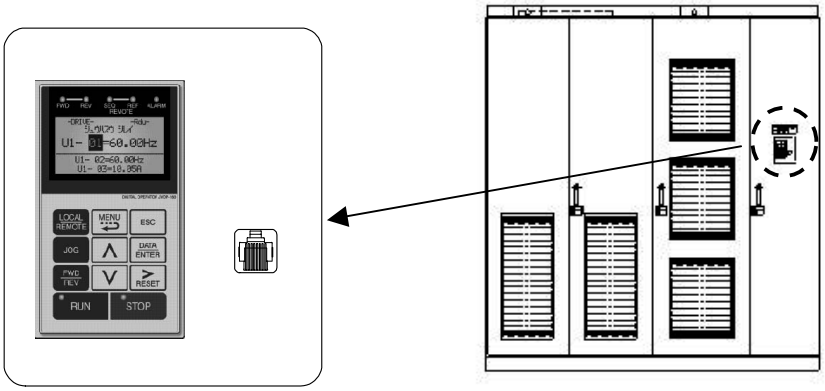
NOTICE: *Connect the shield of shielded cable to the appropriate ground terminal. Improper equipment grounding could result in Matrix converter or equipment malfunction or nuisance trips.*

2.6 Connector for Personal Computer

◆ Specifications

Table 2.7 Specifications of Connector for Personal Computer

Item	Specifications
Connector type	Modular jack
Number of poles	Eight

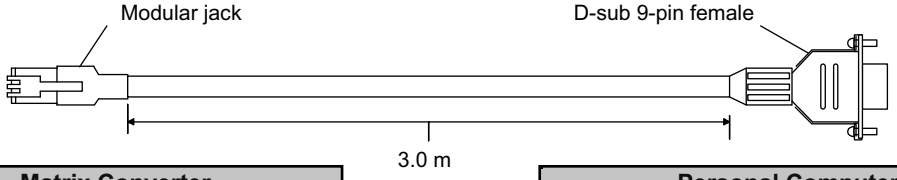


◆ Connection Cable

Use the following cable for connection to a personal computer.

Table 2.8 Personal Computer Connection Cable

Item	Specifications
Model	JZCP-751904
Length	3 m
Manufacturer	Yaskawa Electric Corporation



Matrix Converter		
No.	Signal Name	Description
1		
2	GND	Ground
3	GND	Ground
4		
5		
6	RS232RX	RS232 receive signal
7	RS232TX	RS232 send signal
8		

Personal Computer		
No.	Signal Name	Description
1	CD	
2	RD	RS232 receive signal
3	TD	RS232 send signal
4	DTR	
5	GND	Ground
6	DSR	
7	RTS	
8	CTS	
9	N.C.	

Figure 2.6 Personal Computer Connection Cable and Wiring

2.7 Cable Connections to Matrix converter Terminals

Figure 2.7 shows an example of cable connections to the terminals.

Correctly connect the cables to the Matrix converter terminals referring to the figures below.

Attach cable brackets (clamps) at the places shown in the figures.

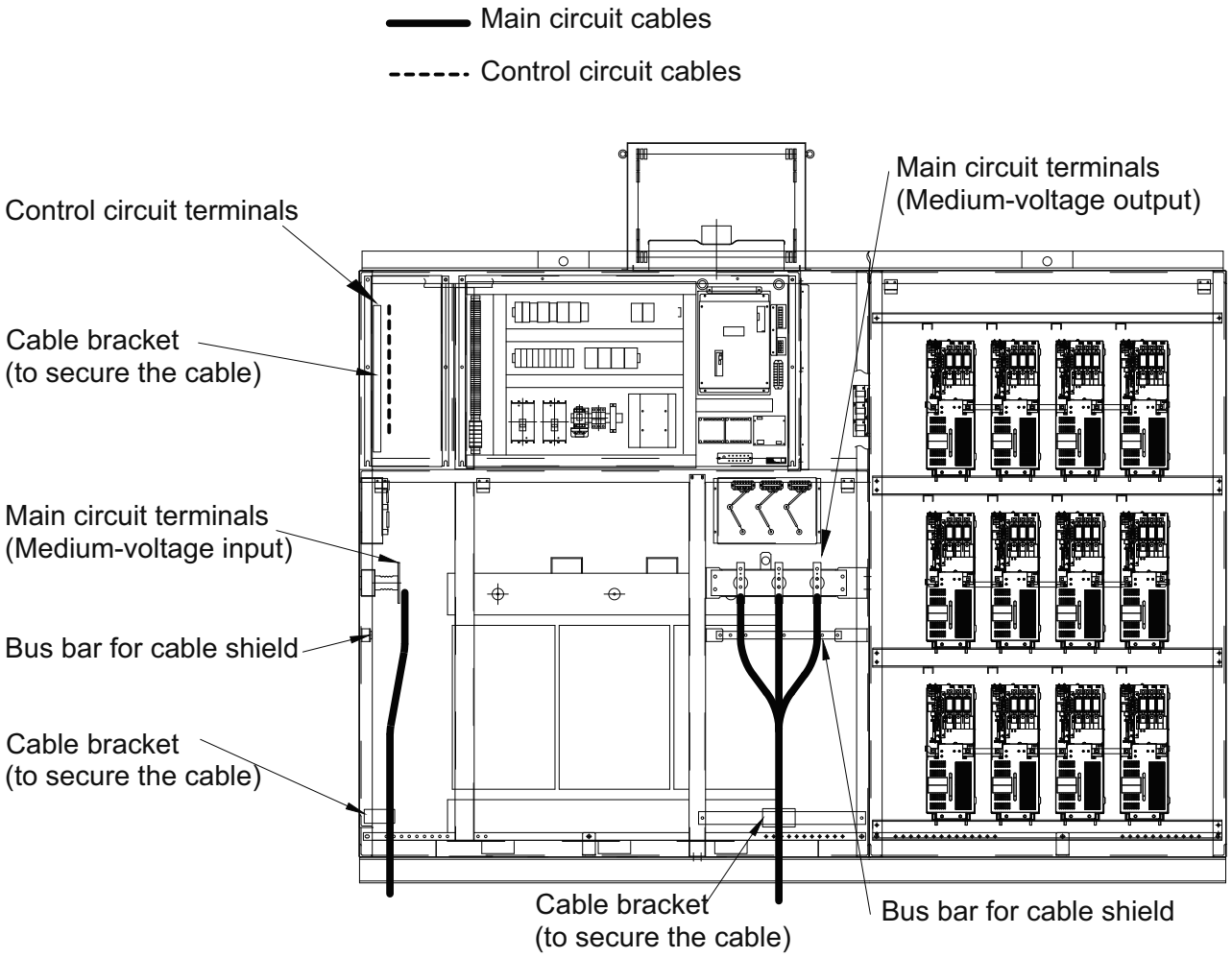


Figure 2.7 Cable Connection Example for 4.16 kV Class 800 HP MX1S

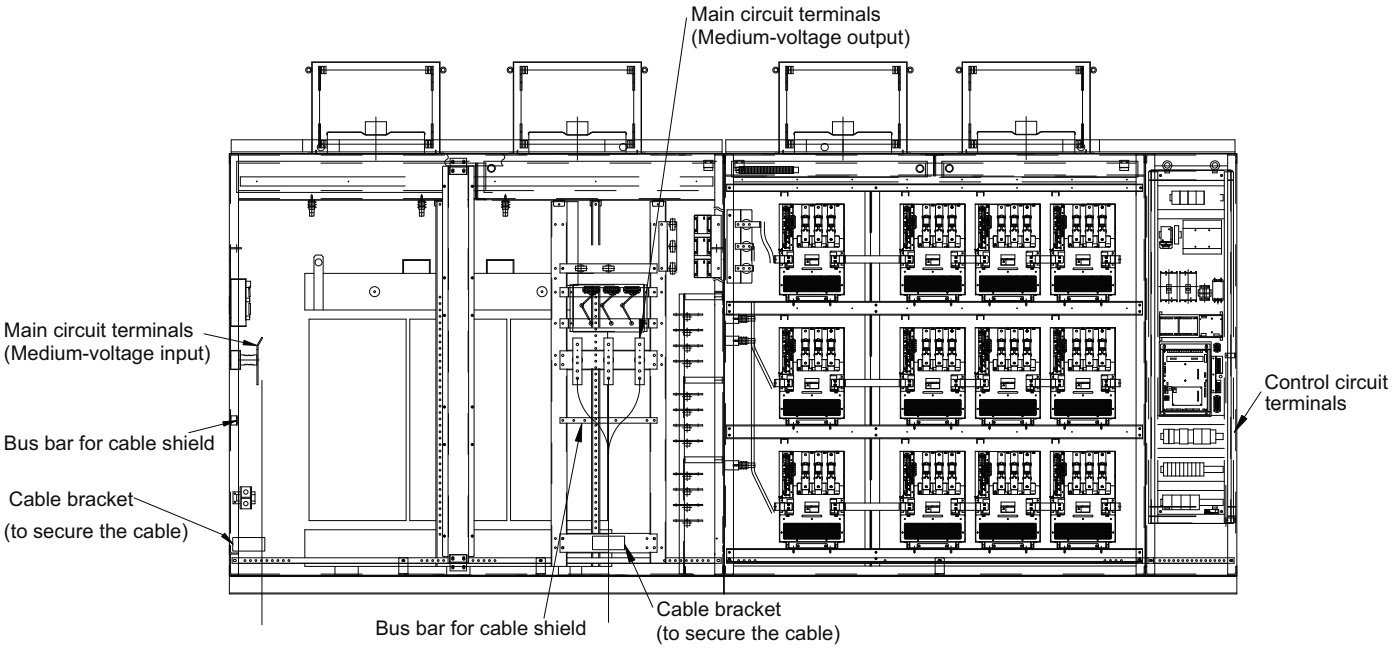


Figure 2.8 Cable Connection Example for 4.16 kV 3000 HP MX1S

2.8 Wiring Check

◆ Checks

Check all wiring after work has been completed. Do not use a buzzer to check out control circuits. Use a multimeter. Confirm the following items:

- All wiring is correct.
- No foreign matter such as drill chips, wire clippings, or unnecessary screws remain.
- All screws are securely tightened.
- No loose wire ends exist at the terminals.

3

Digital Operator and Modes

This chapter describes Digital Operator displays and functions, and provides an overview of operating modes and switching between modes.

3.1 Section Safety

⚠ DANGER

Electrical Shock Hazard

Disconnect all main power before servicing.

Failure to comply may result in serious injury or death from electric shock.

To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc.

⚠ WARNING

Electrical Shock Hazard

Do not operate equipment with covers removed.

Failure to comply could result in death or serious injury.

The diagrams in this section may show Matrix converters without covers or safety shields to show details. Be sure to reinstall covers or shields before operating the Matrix converters and run the Matrix converters according to the instructions described in this manual.

Always ground the motor-side grounding terminal.

Improper equipment grounding could result in death or serious injury by contacting the motor case.

Do not perform work on the Matrix converter while wearing loose clothing, jewelry or without eye protection.

Failure to comply could result in death or serious injury.

Remove all metal objects such as watches and rings, secure loose clothing, and wear eye protection before beginning work on the Matrix converter.

Do not remove covers or touch circuit boards while the power is on.

Failure to comply could result in death or serious injury.

Do not allow unqualified personnel to perform work on the Matrix converter.

Failure to comply could result in death or serious injury.

Installation, maintenance, inspection, and servicing must be performed only by authorized personnel familiar with installation, adjustment, and maintenance of Medium Voltage AC drives.

Fire Hazard

Tighten all terminal screws to the specified tightening torque.

Loose electrical connections could result in death or serious injury by fire due to overheating of electrical connections.

Do not use improper combustible materials.

Failure to comply could result in death or serious injury by fire.

Attach the Matrix converter to metal or other noncombustible material.

Do not use an improper voltage source.

Failure to comply could result in death or serious injury by fire.

Verify that the rated voltage of the Matrix converter matches the voltage of the incoming power supply before applying power.

NOTICE

Observe proper electrostatic discharge procedures (ESD) when handling the Matrix converter and circuit boards.

Failure to comply may result in ESD damage to the Matrix converter circuitry.

Never connect or disconnect the motor from the Matrix converter while the Matrix converter is outputting voltage.

Improper equipment sequencing could result in damage to the Matrix converter.

Do not use unshielded cable for control wiring.

Failure to comply may cause electrical interference resulting in poor system performance. Use shielded, twisted-pair wires and ground the shield to the ground terminal of the Matrix converter.

Check all the wiring to ensure that all connections are correct after installing the Matrix converter and connecting any other devices.

Failure to comply could result in damage to the Matrix converter.

Do not modify the Matrix converter circuitry.

Failure to comply could result in damage to the Matrix converter and will void warranty.

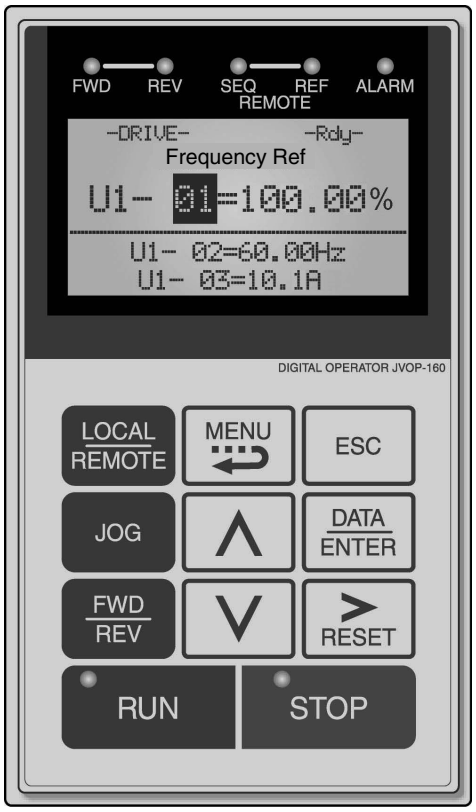
Yaskawa is not responsible for any modification of the product made by the user. This product must not be modified.

3.2 Digital Operator

This section describes the displays and functions of the Digital Operator.

◆ Digital Operator Display

The key names and functions of the Digital Operator are described below.



Drive Mode Indicators (LED)
FWD: Lit when there is a Forward Run Command input.
REV: Lit when there is a Reverse Run Command input.
SEQ: Lit when the Run Command from the control circuit terminal is enabled.
REF: Lit when the frequency reference from control circuit terminal is enabled.
ALARM: Lit when error activated.
Blinks when alarm activated.

Data Display
Displays monitor data, constant numbers, and settings.

Mode Display (Displayed at upper left of data display.)
DRIVE: Lit in Drive Mode.
QUICK: Lit in Quick Programming Mode.
ADV: Lit in Advanced Programming Mode.
A. TUNE: Lit in Autotuning Mode.
: Lit in Fault History Mode.

Keys

Execute operations such as setting user constants, monitoring, jogging, and autotuning.

Figure 3.1 Digital Operator Component Names and Functions

◆ Digital Operator Keys

The names and functions of the Digital Operator Keys are described in ***Table 3.1***.

Table 3.1 Key Functions

Key	Name	Function
LOCAL/REMOTE	LOCAL/REMOTE Key	Switches between operation via the Digital Operator (LOCAL) and control circuit terminal operation (REMOTE). This Key can be enabled or disabled by setting user constant o2-01.
MENU	MENU Key	Selects menu items (modes).
ESC	ESC Key	Returns to the status before the DATA/ENTER Key was pressed.
JOG	JOG Key	Enables jog operation when the Matrix converter is being operated from the Digital Operator.
FWD/REV	FWD/REV Key	Selects the rotation direction of the motor when the Matrix converter is being operated from the Digital Operator.
RESET	Shift/RESET Key	Sets the number of digits for user constant settings. Also acts as the Reset Key when a fault has occurred.
∧	Increment Key	Selects menu items, sets user constant numbers, and increments set values. Used to move to the next item or data.
∨	Decrement Key	Selects menu items, sets user constant numbers, and decrements set values. Used to move to the previous item or data.
DATA/ENTER	DATA/ENTER Key	Pressed to enter menu items, user constants, and set values. Also used to switch from one display to another.
RUN	RUN Key	Starts the Matrix converter operation when the Matrix converter is being controlled by the Digital Operator.
STOP	STOP Key	Stops Matrix converter operation. This Key can be enabled or disabled when operating from the control circuit terminal by setting user constant o2-02.

Note: Except in diagrams, Keys are referred to using the Key names listed in the above table.

There are indicators on the upper left of the RUN and STOP Keys on the Digital Operator. These indicators will light, flash, and turn off to indicate operating status.

3.3 Modes

This section describes the Matrix converter's modes and switching between modes.

◆ Matrix converter Modes

The Matrix converter's user constants and monitoring functions are organized in groups called “modes” that make it easier to read and set user constants. The Matrix converter is equipped with 5 modes.

The 5 modes and their primary functions are shown in the ***Table 3.2***.

Table 3.2 Modes

Mode	Primary Function(s)
Drive mode	The Matrix converter can be run in this mode. Use this mode when monitoring values such as frequency references or output current, displaying fault information, or displaying the fault history.
Quick programming mode	Use this mode to reference and set the minimum user constants to operate the Matrix converter (e.g., the operating environment of the Matrix converter and Digital Operator).
Advanced programming mode	Use this mode to reference and set all user constants.
Autotuning mode	Use this mode when running a motor with unknown motor constants in the vector control method. The motor constants are calculated and set automatically. This mode can also be used to measure only the motor line-to-line resistance. Always perform autotuning when there is no load connected to the motor, before operating with vector control.
Fault history mode	Use this mode to display the fault history of a maximum of 256 faults

◆ Switching Modes

The Mode Selection display will appear when the MENU key is depressed from a monitor or setting display.

Press the MENU key from the Mode Selection Display to sequence through the various modes.

While in a particular mode, press the DATA/ENTER key to monitor data and constants on the Monitor display and again to change the Monitor display to the Setting display.

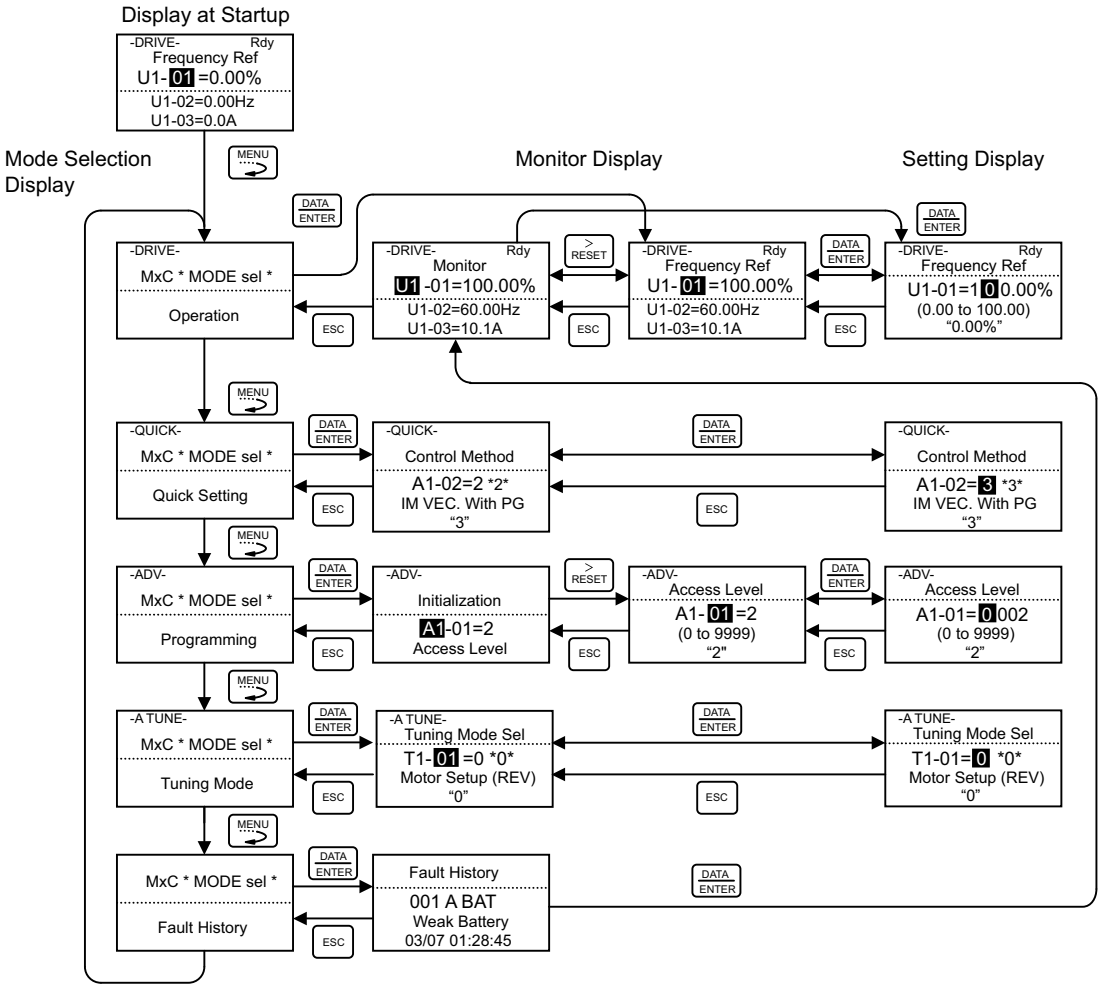


Figure 3.2 Mode Transitions

To operate the Matrix converter with the Digital Operator, after having used the Digital Operator for another propose, press the MENU key as needed to sequence to the Drive mode ("-DRIVE-" displayed on the LCD screen). Then press the DATA/ENTER key to sequence to the Monitor Display.

The Matrix converter will not accept run commands from the Digital Operator if any display other than the Monitor display in Drive mode is active. When power is turned on, the initial display is the Monitor display in Drive mode.

◆ Drive Mode

Drive Mode is the mode in which the Matrix converter can be operated. The following Monitor displays are available in Drive Mode: frequency reference, output frequency, output current, output voltage, and fault history.

If parameter b1-01 (Reference Selection) has been set to 0, the frequency command can be changed from the Frequency Setting Display. Use the Increment, Decrement, or SHIFT/RESET key to change the frequency. After the setting has been changed, press the DATA/ENTER key to save the change. The screen will return to the Monitor display.

■ Example Operations

Key operations in drive mode are shown in the following figure.

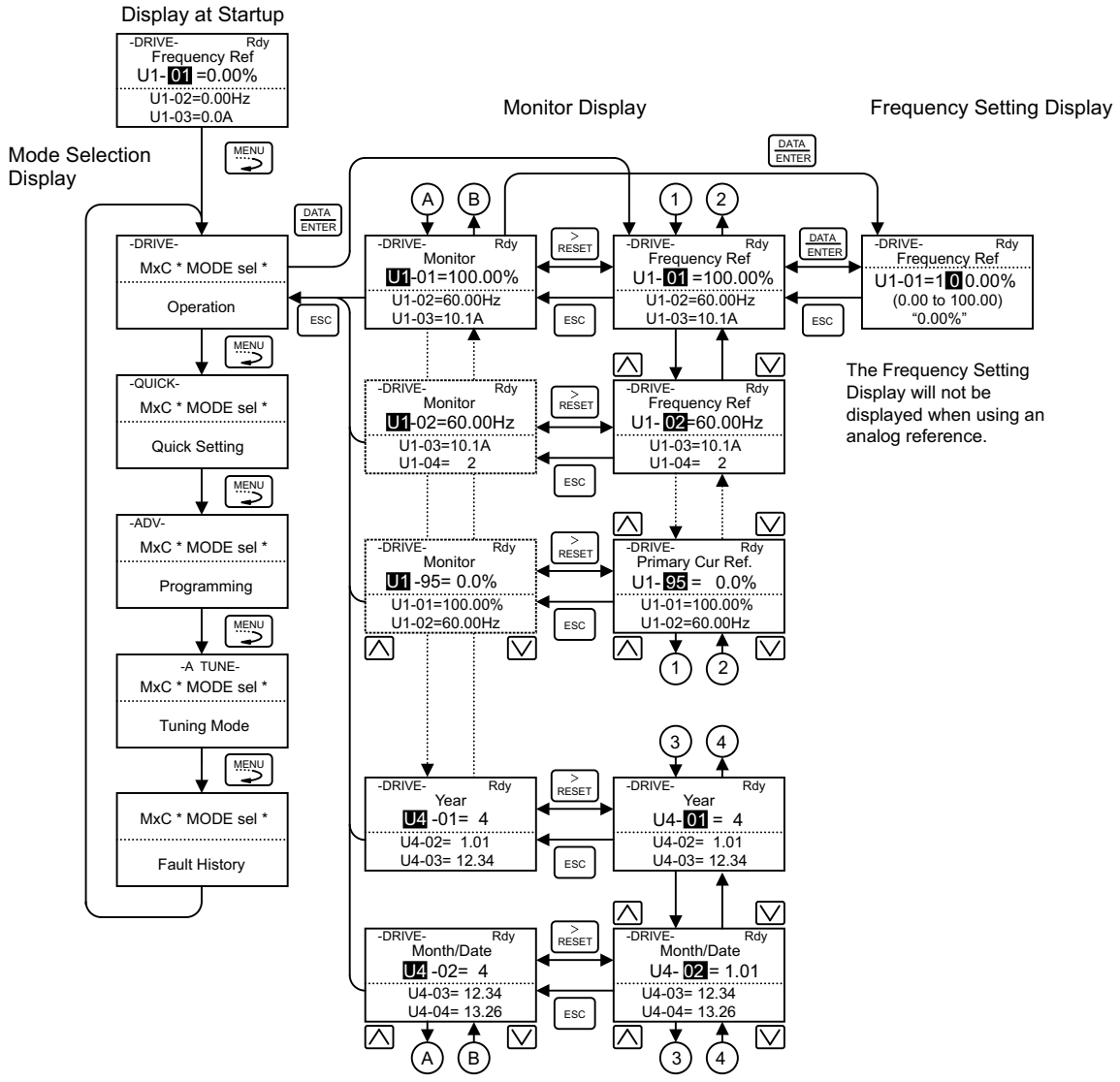


Figure 3.3 Operations in Drive Mode

Note: If using the Increment or Decrement key to change the constant number, pressing the Increment key when the final constant number is displayed will return to the constant starting number. Conversely, by pressing the Decrement key when the constant starting number is displayed, will return to the final constant number. This is indicated in the figures by the letters A and B, and the numbers 1 to 4. The display for the first monitor constant (frequency reference) will appear when power is turned on. Operation cannot be started from the mode selection display.

◆ Quick Programming Mode

In quick programming mode, the constants required for Matrix converter trial operation can be monitored and set.

Constants can be changed from the setting displays. Use the Increment, Decrement, and Shift/RESET Keys to change the constant. After changing the setting, press the DATA/ENTER key to write the user constant to memory and return to the Monitor Display.

Refer to Description of User Constant Tables on page 84 for details on the constants displayed in quick programming mode.

■ Example Operations

Key operations in quick programming mode are shown in the following figure.

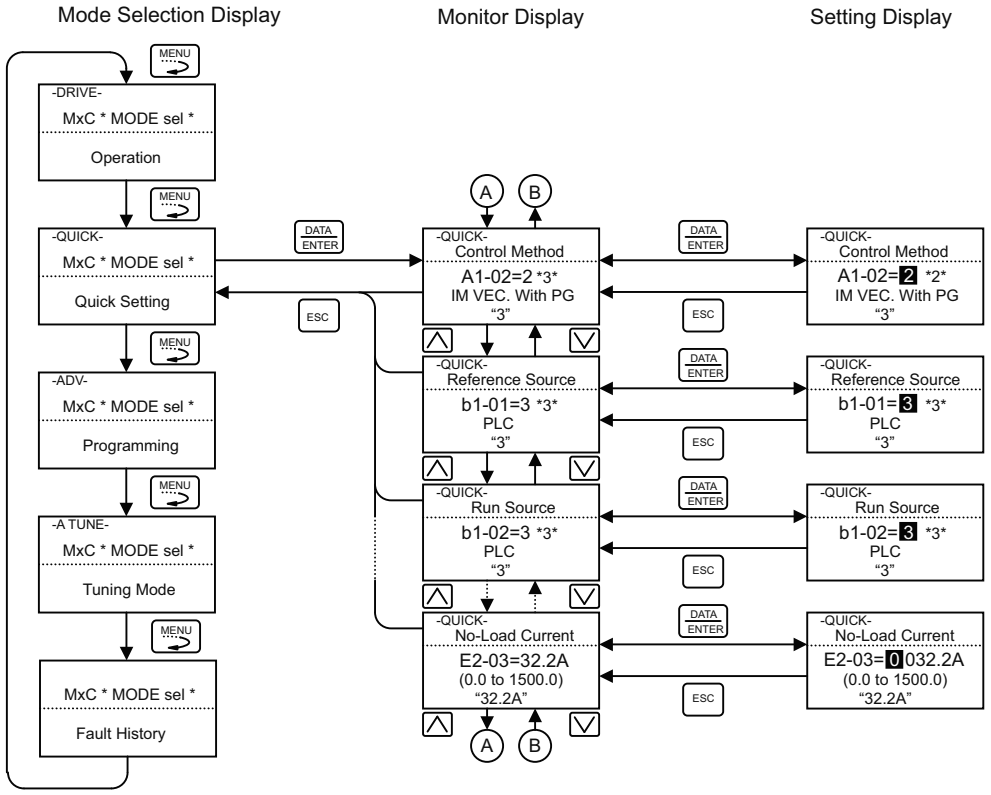


Figure 3.4 Operations in Quick Programming Mode

◆ Advanced Programming Mode

In advanced programming mode, all Matrix converter constants can be monitored and set.

Constants can be changed from the setting displays. Use the Increment, Decrement, and Shift/RESET Keys to change the constants. The user constant will be written and the monitor display will be returned to when the DATA/ENTER Key is pressed after changing the setting.

Refer to Description of User Constant Tables on page 84 for details on the constants.

■ Example Operations

Key operations in advanced programming mode are shown in the following figure.

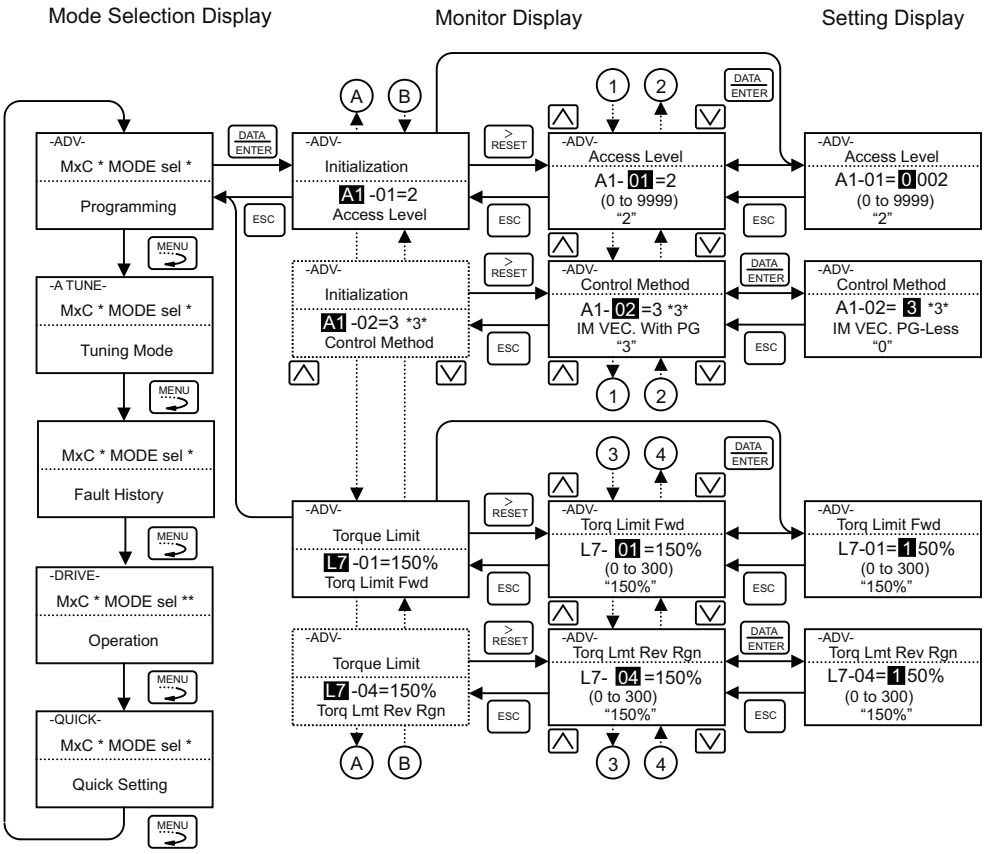


Figure 3.5 Operations in Advanced Programming Mode

■ Setting User Constants

The procedure to change the setting of C1-01 (Acceleration Time 1) from 60 s to 20 s is shown here.

Table 3.3 Setting User Constants in Advanced Programming Mode

Step No.	Digital Operator Display	Description
1	-DRIVE- Rdy Frequency Ref U1-01 =0.00% U1-02=0.00Hz U1-03=0.0A	Turn on the power supply.
2	-DRIVE- MxC * MODE sel * Operation	Press the MENU key to enter drive mode.
3	-QUICK- MxC * MODE sel * Quick Setting	Press the MENU key to enter quick programming mode.
4	-ADV- MxC * MODE sel * Programming	Press the MENU key to enter advanced programming mode.

Step No.	Digital Operator Display	Description
5	-ADV- Initialization A1 -01=2 Access Level	Press the DATA/ENTER Key to access monitor display.
6	-ADV- Accel Time 1 C 1- 01 =60.0sec (0.0 to 6000.0) "60.0sec"	Press the Increment or Decrement Key to display C1-01 (Acceleration Time 1).
7	-ADV- Accel Time 1 C1-01= 0 060.0sec (0.0 to 6000.0) "60.0sec"	Press the DATA/ENTER Key to access setting display. The setting of C1-01 (10.00) is displayed.
8	-ADV- Accel Time 1 C1-01=00 6 0.0sec (0.0 to 6000.0) "60.0sec"	Press the Shift/RESET Key to move the flashing digit to the right.
9	-ADV- Accel Time 1 C1-01=00 2 0.0sec (0.0 to 6000.0) "60.0sec"	Press the Increment Key to change set value to 20.00 s.
10	-ADV- Entry Accepted	Press the DATA/ENTER Key to enter the set data. "Entry Accepted" is displayed for 1.0 s after the data setting has been confirmed with the DATA/ENTER Key.
11	-ADV- Accel Time 1 C1- 01 =20.0sec (0.0 to 6000.0) "60.0sec"	Return to the monitor display for C1-01.

◆ Autotuning Mode

This section describes the Autotuning mode and keystroke sequencing. For the actual autotuning procedure, refer to ***Autotuning on page 76***.

CAUTION! *During autotuning, the motor must be disconnected from any load (machine, equipment).*
The motor may operate in an unexpected manner, possibly resulting in injury or damage to equipment. Also, motor constants cannot be correctly set with the motor attached to a load.

CAUTION! *Do not touch the motor during autotuning.*
The motor may suddenly restart from the stopped state, possibly leading to injury.

NOTICE: *Protect both exposed ends of any coupling detached for autotuning with tape or cloth.*
Otherwise, the coupling may be damaged or grease may splash.

Autotuning automatically tunes and sets the required motor constants when operating in either open loop or flux vector control. Always perform autotuning before starting operation.

Contact your Yaskawa representative to set motor constants by calculation.

The default setting of the Matrix converter is for flux vector control (A1-02 = 3).

■ Example of Operation

Set the motor output power (in kW) {kW=HP*0.746}, rated voltage, rated current, rated frequency, rated speed, and number of poles specified on the nameplate on the motor, and then press the RUN Key. The motor will run automatically. Motor constants will be calculated and set based on the data entered in this paragraph and the autotuning.

Always enter the data noted above and complete the keystroke sequence. Autotuning cannot be started otherwise. For example, it cannot be started from the motor rated voltage display.

Constants are changed using the Setting Display. Use the Increment, Decrement, and Shift/RESET Keys to change a constant. After changing the setting and pressing the DATA/ENTER Key, the user constant will be written and the display will transition from the Setting Display to the Monitor Display.

The following example shows autotuning for open-loop vector control while operating the motor.

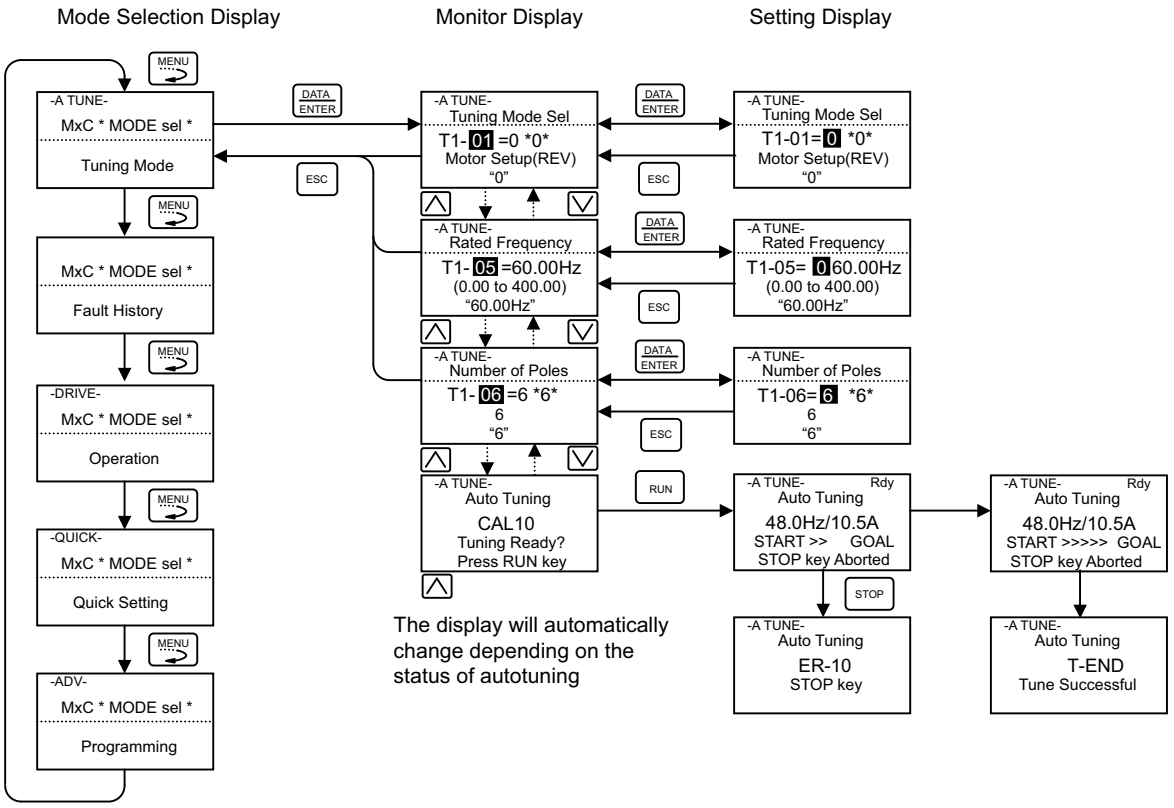


Figure 3.6 Operation in Autotuning Mode

◆ Fault History Mode

Fault history mode is used to display the fault history to a maximum of 256 faults.

The record number of the fault history is included with the data. The latest data is 001 and the oldest data is 256. The display data can be changed by the Increment Key and the Decrement Key. When a fault has occurred, the Shift/ RESET Key acts as a fault reset key. If the DATA/ENTER key is pressed, it will return to the drive mode.

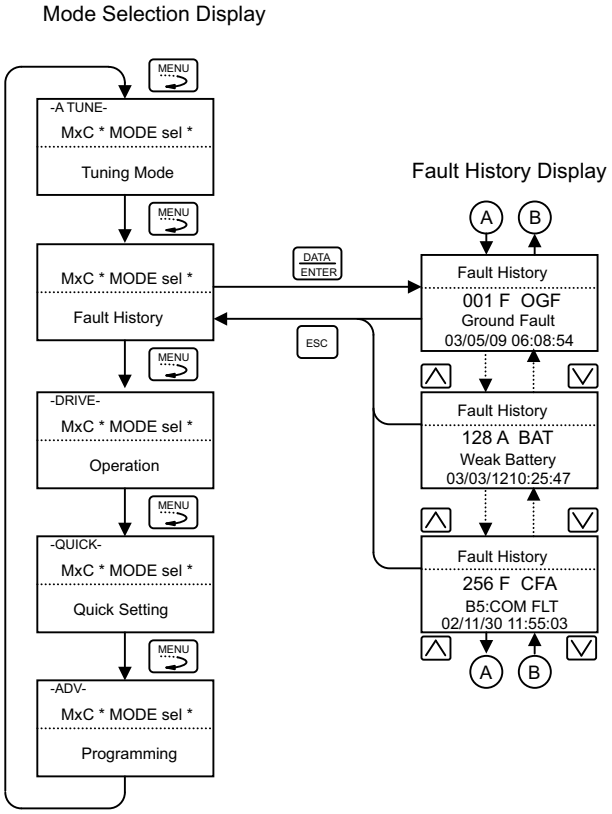


Figure 3.7 Operation in Fault History Mode

4

Trial Operation

This chapter describes the procedures for trial operation of the MX1S Matrix converter and provides an example of trial operation.

4.1 Section Safety

⚠ DANGER

Electrical Shock Hazard

Disconnect all main power before servicing.

Failure to comply may result in serious injury or death from electric shock.

To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc.

⚠ WARNING

Electrical Shock Hazard

Do not operate equipment with covers removed.

Failure to comply could result in death or serious injury.

The diagrams in this section may show Matrix converters without covers or safety shields to show details. Be sure to reinstall covers or shields before operating the Matrix converters and run the Matrix converters according to the instructions described in this manual.

Always ground the motor-side grounding terminal.

Improper equipment grounding could result in death or serious injury by contacting the motor case.

Do not perform work on the Matrix converter while wearing loose clothing, jewelry or without eye protection.

Failure to comply could result in death or serious injury.

Remove all metal objects such as watches and rings, secure loose clothing, and wear eye protection before beginning work on the Matrix converter.

Do not remove covers or touch circuit boards while the power is on.

Failure to comply could result in death or serious injury.

Do not allow unqualified personnel to perform work on the Matrix converter.

Failure to comply could result in death or serious injury.

Installation, maintenance, inspection, and servicing must be performed only by authorized personnel familiar with installation, adjustment, and maintenance of Medium Voltage AC drives.

Fire Hazard

Tighten all terminal screws to the specified tightening torque.

Loose electrical connections could result in death or serious injury by fire due to overheating of electrical connections.

Do not use improper combustible materials.

Failure to comply could result in death or serious injury by fire.

Attach the Matrix converter to metal or other noncombustible material.

Do not use an improper voltage source.

Failure to comply could result in death or serious injury by fire.

Verify that the rated voltage of the Matrix converter matches the voltage of the incoming power supply before applying power.

NOTICE

Observe proper electrostatic discharge procedures (ESD) when handling the Matrix converter and circuit boards.

Failure to comply may result in ESD damage to the Matrix converter circuitry.

Never connect or disconnect the motor from the Matrix converter while the Matrix converter is outputting voltage.

Improper equipment sequencing could result in damage to the Matrix converter.

Do not use unshielded cable for control wiring.

Failure to comply may cause electrical interference resulting in poor system performance. Use shielded twisted-pair wires and ground the shield to the ground terminal of the Matrix converter.

Do not allow unqualified personnel to use the product.

Failure to comply could result in damage to the Matrix converter.

Do not modify the Matrix converter circuitry.

Failure to comply could result in damage to the Matrix converter and will void warranty.

Yaskawa is not responsible for any modification of the product made by the user. This product must not be modified.

Check all the wiring to ensure that all connections are correct after installing the Matrix converter and connecting any other devices.

Failure to comply could result in damage to the Matrix converter.

4.2 Trial Operation Flowchart

Carry out a trial operation according to the flowchart below.

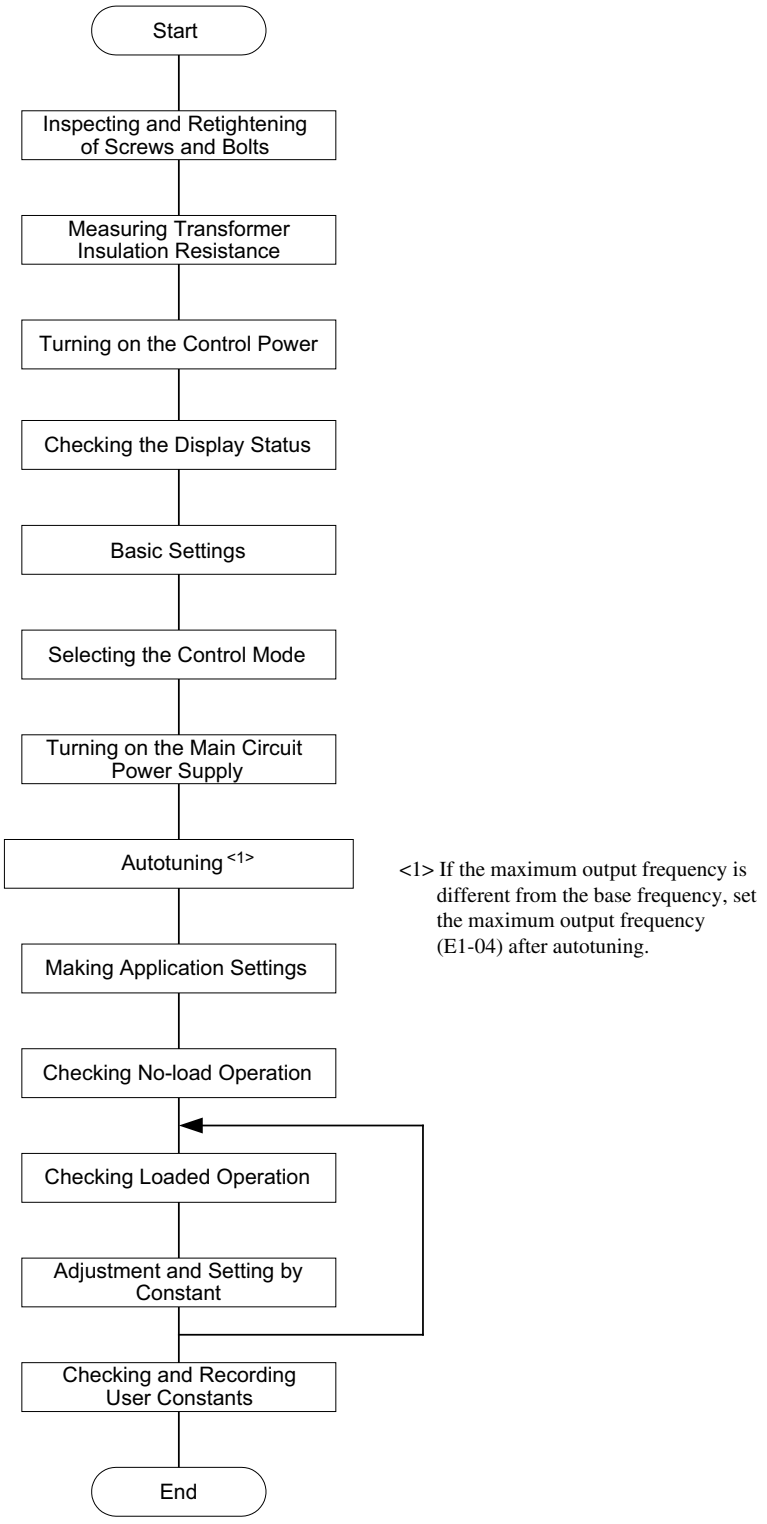


Figure 4.1 Trial Operation Flowchart

4.3 Trial Operation Procedures

The procedures for trial operation are described in this section.

DANGER! *Disconnect all main power before servicing. To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc. Failure to comply may result serious injury of death from electric shock.*

DANGER! *The MX1S Matrix converter has two (2) sources of power, the 4160V main supply and a 480V control power supply. Make sure that both sources are off before inspecting and retightening or measuring transformer insulation. Failure to observe this precaution may result in serious personal injury or death.*

◆ Inspecting and Retightening Screws and Bolts

After installing and wiring the Matrix converter, visually check the components on and in the panels and confirm that nothing is damaged or missing.

Also check for loose screws or bolts, and retighten if necessary.

◆ Measuring Transformer Insulation Resistance

CAUTION! *The primary circuit is grounded at high-resistance for input voltage detection. Isolate both the grounding wire and the detection signal wires that are connected to the control board before measuring insulation resistance. Failure to observe this precaution may result in minor injury.*

Disconnect the incoming primary line from the Matrix converter, and then measure the insulation resistance at the transformer input terminal using a 1000 V Megohmmeter insulation resistance tester. Confirm that the measured value is 30 Mohms or more.

◆ Turning on the Control Power

Items to be checked before turning on the control power supply:

- Confirm that the control power supply is the correct voltage.
- Confirm that the control circuit terminals and controller are correctly connected.
- When using a PG, be certain the PG is correctly wired.

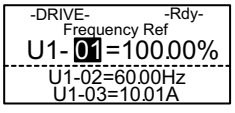
Items to be checked after turning on the control power supply:

- Measure the voltage input from the control power supply.
  If the input voltage is different from the value indicated on the connection diagram, switch the transformer tap setting for control, and measure the transformer secondary side voltage.
- Manually operate the cooling fan and check the following:
  Rotation direction, vibration, and air leakage.

◆ Checking the Display Status

When the power is turned on, the Digital Operator display in the normal status reads as follows.

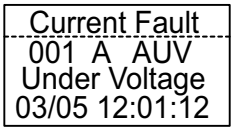
[Display in the normal status]



Monitor displays the speed (frequency) reference on the data display screen

When the Matrix converter detects an alarm, the details of the alarm are displayed on the Digital Operator. Take appropriate measures by referring to ***Troubleshooting on page 199***. A sample display with an alarm detected is shown below. When an alarm is detected, the ALARM lamp at the upper right of the Digital Operator lights or flashes.

[Display at alarm detection]



The display varies depending on the details of the alarm. The figure to the left shows an example when main circuit power supply voltage reduction (AUV) was detected.

◆ Basic Settings

Switch to the quick programming mode (QUICK will be displayed on the LCD screen), and then set the following user constants.

Refer to ***Digital Operator and Modes on page 55*** for Digital Operator operating procedures and to ***Description of User Constant Tables on page 84*** and ***Constant Settings by Function on page 135*** for details on user constants.

Table 4.1 Required and Optional Constant Settings

R: Required constant settings, O: Optional constant settings

Category	Constant Number	Name	Description	Setting Range	Factory Setting
R	A1-02	Control method selection	Select the MX1S control mode. 2: Open-loop vector control 3: Flux vector control	2 or 3	3
R	b1-01	Reference selection	Select the frequency reference input method. 0: Digital Operator 1: Control circuit terminal (analog input) 2: MEMOBUS communications 3: PLC	0 to 3	3
R	b1-02	Starting method selection	Select the Run Command input method. 0: Digital Operator 1: Control circuit terminal (sequence input) 2: MEMOBUS communications 3: PLC	0 to 3	3
O	b1-03	Stopping method selection	Select the stopping method used when a Stop Command is input. 0: Deceleration to stop 1: Coast to stop	0 or 1	1
R	C1-01	Acceleration time 1	Set the acceleration time to accelerate from 0 to the maximum output frequency, in 1-second units.	0.0 to 6000.0	60.0 s
R	C1-02	Deceleration time 1	Set the deceleration time to decelerate from the maximum output frequency to 0, in 1-second units.	0.0 to 6000.0	60.0 s
O	d1-01	Frequency reference 1	Set the frequency reference.	0.00 to 110.00	0.00 %
R	E1-01	Input voltage setting	Set the voltage input to the matrix converter cell in 1-V units. This is used as the reference value for the protective functions, etc.	180 to 700	590 V
R	E1-04 to -06 and -09	Maximum output frequency Maximum voltage Base frequency Minimum output frequency	Set the voltages and frequencies required for V/f characteristics	Voltage: 0 to 8000 V Frequency: 0 to 8000 r/min	Refer to page ***101***.

R: Required constant settings, O: Optional constant settings

Category	Constant Number	Name	Description	Setting Range	Factory Setting
R	E2-01 to -04	Motor rated current Motor rated slip Motor no-load current Number of motor poles	Set the motor constants according to the specifications on the nameplate, test report, etc.	Refer to page ***102***.	Refer to page ***102***.
O	o2-04	MX1S Capacity Selection	The code indicating the MX1S capacity is set before shipment. Normally, the initial setting can be left unchanged. Confirm the setting in Advanced Programming Mode.	60 to FF	Code corresponding to Matrix converter capacity

◆ Control Method Settings

Autotuning methods depend on the control method set for the Matrix converter. Select the setting based on the control method intended to be used.

■ Control Method Selection

Either of the following two control methods can be selected.

Control Method	Constant Setting	Basic Control	Main Applications
Open-loop vector control	A1-02 = 2	Current vector control without a PG	Variable speed control that requires high performance without using a PG
Flux vector control	A1-02 = 3 (Factory setting)	Current vector control with a PG	Ultra high-performance control using a PG such as high-accuracy speed control, torque control, and torque limit

◆ Turning on the Medium-voltage Power Supply

DANGER! *Check to be sure that Matrix converter door is closed before tuning on the main circuit power supply. Do not open the Matrix converter door while power is being supplied. Electric shock may occur.*

Items to be checked before turning on the main circuit power supply:

- Confirm that the main circuit power supply is correct voltage.
- Confirm that the Matrix converter main circuit input and output terminals (input terminals R, S, and T and output terminals U, V, and W) are correctly connected.
- Confirm that the motor is not connected to a mechanical system (No-load status).

Items to be checked after turning on the main circuit power supply:

DANGER! *The following measurements must be carried out by personnel qualified for medium-voltage work. There is significant risk of electric shock that could result in injury or death.*

- Measure the input voltage of each Power Cell.
  Measure the input voltage of each power cell using a digital multimeter. (Measure the voltage between L1, L2, L3 of each power cell.) The measured input voltage must be the rated voltage (590 Vac) ±10 V. If the majority of measured values exceeds the allowable range, remove power and adjust the primary voltage tap (+5, 0, or –5 % can be selected)..

Confirm the following by using the Digital Operator.

- Confirm input power supply voltage U1-90.
- Is the Matrix converter in the normal status?

◆ Autotuning

CAUTION! *During autotuning, the motor must be disconnected from any load (machine, equipment).*
The motor may operate in an unexpected manner, possibly resulting in injury or damage to equipment. Also, motor constants cannot be correctly set with the motor attached to a load.

CAUTION! *Protect both exposed ends of any coupling detached for autotuning with tape or cloth.*
Otherwise, the coupling may be damaged or grease may splash.

CAUTION! *Do not touch the motor during autotuning.*
The motor may suddenly restart from the stopped state, leading to injury.

Use the following procedure to perform autotuning to automatically set motor constants.
If the control method is changed after autotuning, perform autotuning again.

Press the STOP Key on the Digital Operator to cancel autotuning.

■ Setting the Autotuning Mode

For an example of the keystroke sequencing, refer to ***Example of Operation on page 66***.

Rotational autotuning (T1-01 = 0)

Set T1-01 to 0, input the data described on the nameplate, and then press the RUN Key on the Digital Operator. The Matrix converter will keep the motor stopped for approximately one minute and then set all the required motor constants while operating the motor for approximately four minutes.

Stationary autotuning for line-to-line resistance only (T1-01 = 2)

This mode can be used to improve control accuracy when the motor cable is long (50 m or longer), the length of the motor cable has been changed at installation after performing autotuning, or the capacities of the motor and Matrix converter differ.

By setting T1-01 to 2 and pressing the RUN Key on the Digital Operator, the Matrix converter will energize the motor while it is stopped for approximately one minute and automatically measure the line-to-line resistance of the motor (E2-05) and cable resistance.

CAUTION! *Sudden Movement Hazard. Do not release the mechanical brake during stationary Auto-Tuning. Inadvertent brake release may cause damage to equipment or injury to personnel. Ensure that the mechanical brake release circuit is not controlled by the Matrix converter multi-function digital outputs.*

DANGER! *Electrical Shock Hazard. When executing stationary Auto-Tuning for line-to-line resistance only, the motor does not rotate, however, power is applied. Do not touch the motor until Auto-Tuning is completed. Failure to comply may result in injury from electric shock.*

■ Precautions before Performing Autotuning

If the motor nameplate voltage is higher than Matrix converter input voltage, several parameters need to be adjusted for proper motor excitation during autotuning. If this is the case, (refer to ***Figure 4.2***), decrease the motor rated voltage and base frequency parameters for proper autotuning.
Perform autotuning by following the procedure below.

1. Enter the Matrix converter input voltage (main circuit power supply voltage) into T1-03 (Motor rated voltage).
2. Input the value obtained by the calculation below for T1-05 (Motor base frequency).
   (Base frequency stated on the motor nameplate) × (T1-03 set value) / (Rated voltage stated on the motor nameplate)
3. Execute autotuning.

Input the base frequency stated on the nameplate of the motor for E1-04 (Maximum output frequency) after completion of autotuning.

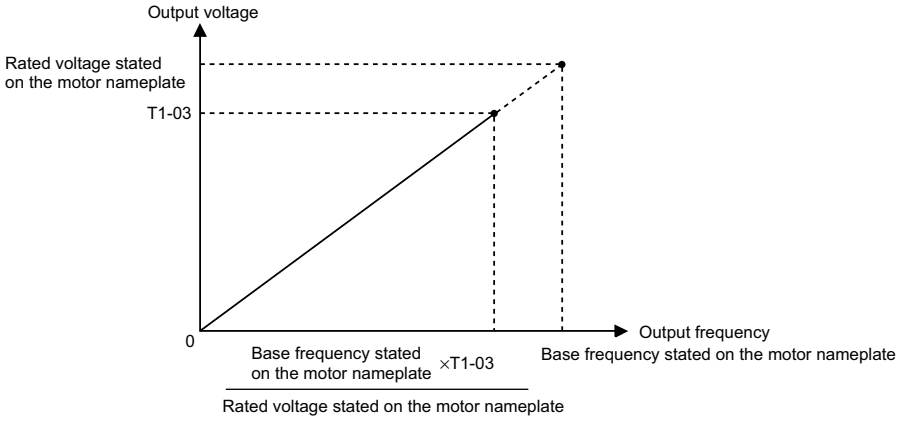


Figure 4.2 Motor Base Frequency and Matrix converter Main Circuit Voltage Settings

Note: **1.** When speed accuracy is required in the high-speed range (90 % or more of the rated speed), set "input power supply voltage 0.9" for T1-03 (Motor rated voltage).
2. In the high-speed range (90 % or more of the rated speed), the output current will increase in relation to the decrease of the main circuit power supply voltage. Confirm the current margin of the Matrix converter.

■ Precautions after Performing Autotuning

If the desired maximum output frequency is different from the base frequency, set the maximum output frequency (E1-04) after completion of autotuning.

■ Constant Settings for Autotuning

The following constants must be set before autotuning.

Table 4.2 Constants to be Set Before Autotuning

Constant No.	Name / Display	Description	Setting Range	Factory Setting	Data Displays during Autotuning	
					Open-loop Vector	Flux Vector
T1-01	Autotuning mode selection / Tuning Mode Sel	Set the autotuning mode. 0: Rotational autotuning 2: Stationary autotuning for line-to-line resistance only	0 or 2	0	Yes	Yes
T1-03	Motor rated voltage / Rated Voltage	Set the voltage equivalent to the rated speed of no-load operation. (Typically the nameplate voltage. See ***Precautions before Performing Autotuning on page 77***)	0 to 8000	Voltages set in E1-13	Yes	Yes

Constant No.	Name / Display	Description	Setting Range	Factory Setting	Data Displays during Autotuning	
					Open-loop Vector	Flux Vector
T1-04	Motor rated current / Rated Current	Set the motor rated current in units of amps. <1> <4> (Set the rated current indicated on the nameplate.)	0.1 to 1500.0 <1>	Amperes set in E2-01	Yes	Yes
T1-05	Motor base frequency / Rated frequency	Set the motor base frequency in hertz. <2> <3> (Set the rated frequency indicated on the nameplate.)	0.00 to 400.00	Hertz set in E1-06	Yes	Yes
T1-06	Number of motor poles / Number of Poles	Set the number of motor poles. (Set the number of motor poles indicated on the nameplate.)	2 to 48	Number of poles set in E2-04	Yes	Yes
T1-07	Motor base speed / Rated speed	Set the motor base speed in r/min <2> (Set the speed indicated on the nameplate)	0 to 12000	Calculated value r/min	Yes	Yes
T1-08	Number of PG pulses when tuning / PG Pulses/Rev	Set the number of pulses per revolution for the PG (pulse generator or encoder) being used without any multiplication factor.	0 to 8192	Number of pulses set in H7-01	-	Yes
T1-10	Motor insulation class / Insulating Class	Set the insulation class described on the motor nameplate. 0: Insulation class A (100°C) 1: Insulation class B (120°C) 2: Insulation class C (130°C) 3: Insulation class D (155°C) 4: Insulation class E (180°C)	0 to 4	1	Yes	Yes

<1> Setting range is between 10 and 200 % of the Matrix converter rated output current.
<2> For fixed output motors, set the base speed value.
<3> For inverter motors or for specialized vector motors, the voltage or frequency may be lower than for general-purpose motors. Always confirm the information on the nameplate or in test reports. If the no-load values are known, input the no-load voltage in T1-03 and the no-load frequency in T1-05 to ensure accuracy.
<4> The settings that ensure stable vector control are between 50 and 100 % of the Matrix converter rating.

Refer to ***Autotuning Mode on page 65*** for Digital Operator displays during autotuning.

■ Precautions When Setting Constants Using Precise Data

When performing autotuning by setting the constants to the values noted on the motor test report or design data, the contents of data to be set for autotuning differ as shown in the table below.

Digital Operator Display (Constant No.)	Normal Setting	Setting with Precise Data
T1-03	Motor rated voltage	No-load voltage at motor rated speed
T1-05	Motor base frequency	No-load frequency at motor rated speed

◆ Making Application Settings

Set the constants as required in advanced programming mode (ADV will be displayed on the LCD screen). All constants that can be set in quick programming mode can also be displayed and set in advanced programming mode.

Two setting examples for specific requirements are given below.

- To operate the machine in reverse, set b1-04 to 0 to enable reverse operation.
- To increase the speed of a 60 Hz motor by 10 %, set E1-04 to 66.0 Hz.

◆ Checking No-load Operation

Disconnect the motor from the machine, and then press the LOCAL/REMOTE Key on the Digital Operator to select LOCAL mode (the LED indicator lamps SEQ and REF on the Digital Operator will turn off).

After confirming safety conditions around the motor and the machine, operate the Matrix converter from the Digital Operator. Confirm that the motor rotates correctly and that no fault is displayed on the Digital Operator.

The motor will continue running at the JOG speed reference (d1-17, factory setting 10.00 %) as long as the JOG Key on the Digital Operator is being pressed. If the external sequence prevents operation from the Digital Operator, confirm that the emergency stop circuits and machine safety mechanisms function correctly, and then start operation in REMOTE mode (i.e., with signals from the control circuit terminals). Safety precautions must always be taken whether the motor is connected to a machine or not.

Note: Both a Run command (forward/reverse) and frequency reference (or multi-step speed reference) must be input to start Matrix converter operation.
Input the command and reference whether the operation method is Local or Remote.

◆ Checking Loaded Operation

Connect the machine to the motor, and start operation from the Digital Operator or using signals from the control circuit terminals in the same way as described in No-load Operation.

■ Connecting the Load

- After confirming that the motor is completely stopped, connect the machine to the motor.
- Be sure to tighten all screws when securing the motor shaft to the machine.

■ Operation Using the Digital Operator

- Use the Digital Operator to start operation in LOCAL mode in the same way as for no-load operation.
- Make sure that the STOP Key on the Digital Operator can be easily accessed in case of fault occurrence.
- Set the frequency reference to a low-speed value, approximately one tenth of the actual operation speed.

■ Checking Operation Status

- Confirm that the operating direction is correct and that the machine operates smoothly at a low-speed, and then increase the frequency reference.
- Change the frequency reference (and rotation direction if the application can operate in reverse) to confirm that there is no vibration or abnormal noise from the machine. Check the monitor display to ensure that U1-03 (Output Current) is not too high.
- If there are problems such as hunting and vibration caused by control performance, refer to ***Making Adjustments on page 80*** and adjust the settings.

◆ Checking and Recording User Constants

Check the constants for which the settings were changed during trial operation, and record them in the constants table.

4.4 Making Adjustments

If problems such as hunting and vibration caused by control performance occur during trial operation, change the settings of the constants listed below according to the selected control method. The table below lists only the most commonly used constants.

Table 4.3 Constants to be Adjusted

Control Method	Name (Constant No.)	Functions	Factory Setting	Recommended Setting	Adjustment Method
Open-loop vector control (A1-02 = 2)	Speed feedback detection control (AFR) gain (n2-01)	• Improves torque and speed response. • Reduces hunting and vibration at middle-speed (10 to 40 Hz)	2.00	0.50 to 2.00	• If torque or speed response is slow, reduce the setting. • If hunting or vibration occurs, increase the setting.
	Torque Compensation primary delay time constant (C4-02)	• Improves torque and speed response. • Reduces hunting and vibration	100 ms	0 to 10000 ms	• If torque or speed response is slow, reduce the setting. • If hunting or vibration occurs, increase the setting.
	Slip compensation primary delay time constant (C3-02)	• Improves speed response. • Increases speed stability	3000 ms	100 to 5000 ms	• If speed response is slow, reduce the setting. • If speed is unstable, increase the setting.
	Slip compensation gain (C3-01)	• Improves speed accuracy.	1.0	0.5 to 1.5	• If speed is too low, increase the setting. • If speed is too high, decrease the setting.
Flux vector control (A1-02=3)	Speed control (ASR) proportional gain 1 (C5-01) Speed control (ASR) proportional gain 2 (C5-03)	• Improves torque and speed response. • Reduces hunting and vibration	5.00	2.00 to 15.00	• If torque or speed response is slow, increase the setting. • If hunting or vibration occurs, decrease the setting.
	Speed control (ASR) integral time 1 (High-speed) (C5-02) Speed control (ASR) integral time 2 (Low-speed) (C5-04)	• Improves torque and speed response • Reduces hunting and vibration	5.000 s	1.000 to 10.000 s	• If torque or speed response is slow, decrease the setting. • If hunting or vibration occurs, increase the setting.
	Speed control (ASR) gain switching frequency (C5-07)	Switches the ASR proportional gain and integral time according to the output frequency.	0.0 %	0.0 to 100.0 %	Set the output frequency so that the ASR proportional gain and integral time can be secured at both low and high speeds.

The constant settings that indirectly change control performance are listed below.

Table 4.4 Constants that Indirectly Change Control Performance and their Functions

Name (Constant No.)	Functions
Acceleration/deceleration time (C1-01 to -11)	Affects the torque during acceleration and deceleration.
S-curve characteristics (C2-01 to -04)	Used to prevent shock at completion of acceleration/deceleration.
Jump frequency (d3-01 to -04)	Used to avoid machine resonance points during operation.
Analog input filter time constant (H3-16)	Used to prevent fluctuation of analog input signals caused by noise.
Stall prevention (L3-01 to -03)	Used to prevent motor stall or overvoltage (OV) for heavy-load operation or rapid acceleration. Factory setting: Disabled
Torque limit (L7-01 to -04)	Sets the maximum torque for vector control. When increasing the setting, use a Matrix converter with higher capacity than the motor. Excessively decreasing the setting under heavy load will cause motor stall.

5

User Constants

This chapter describes all user constants that can be set in the MX1S Matrix converter.

5.1 User Constant Descriptions

This section describes the contents of the user constant tables.

◆ Description of User Constant Tables

User constant tables are structured as shown below. Here, A1-00 (Digital Operator Language Selection) is used as an example.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
A1-00	Language selection for Digital Operator display / Select Language	Selects the language displayed on the LCD Digital Operator. 0: English 1: Japanese	0 or 1	1	Yes	A	A	100H

- Constant Number: The number of the user constant.
- Name: The name of the user constant.
- Description: Details of the function or settings of the user constant.
- Setting Range: The setting range for the user constant.
- Factory Setting: For some constants, the factory setting may change depending on Control Method selected. For an MX1S made to a customer's specification, the factory settings of some constants may have been changed.
- Change during Operation: Indicates whether or not the constant can be changed while the Matrix converter is in operation.
  - Yes: Change possible during operation.
  - No: Change not possible during operation.
- Control Methods: Indicates the control methods in which the user constant can be monitored or set. Refer to page ***60*** for details of Matrix converter modes.
  - Q: Items which can be monitored and set in either quick programming mode or advanced programming mode.
  - A: Items which can be monitored and set only in advanced programming mode.
  - No: Items which cannot be monitored or set for the control method.
- MEMOBUS Register: The register number used for MEMOBUS communications.

5.2 User Constant Tables

This section describes the contents of the user constant tables.
Refer to the parameter setting table included in the performance test record for the set values at the time of shipment and the completion of a test run.

Group Number	Group Name	Functional Number	Functional Name
A	Setup Settings	A1	Initialize Mode
		A3	Hi Speed Trace
		A4	Lo Speed Trace
B	Application Constants	b1	Operation Mode Selections
		b2	DC Injection Braking
		b3	Speed Search
		b7	Droop Control
C	Tuning Constants	C1	Acceleration/Deceleration
		C2	S-curve Acceleration/Deceleration Time
		C3	Motor Slip Compensation
		C4	Torque Compensation
		C5	Speed Control - Automatic Speed Regulator (ASR)
D	Reference Constants	d1	Frequency Reference
		d2	Frequency Reference Limits
		d3	Jump Frequencies
		d6	Field Forcing Control
E	Motor Constants	E1	V/f Pattern
		E2	Motor Setup
F	PLC Constants	F8	PLC
H	Terminal Function Constants <*1*>	H1	Multi-function Contact Inputs
		H2	Multi-function Contact Outputs
		H3	Multi-function Analog Inputs
		H4	Multi-function Analog Outputs
		H7	PG Setup
L	Protection Function Constants	L1	Motor Protection
		L2	Momentary Power Loss Ridethrough
		L3	Stall Prevention
		L4	Frequency Detection
		L5	Fault Restart
		L6	Overtorque/Undertorque Detection
		L7	Torque Limits
		L8	Hardware Protection 1
		L9	Hardware Protection 2
N	Special Adjustments	n2	Speed Feedback Detection Control Functions (AFR)
		n9	Factory Adjustment
O	Digital Operator Constants	o1	Monitor Select
		o2	Multi-function Selections
Y	Factory Settings	Y1	Factory Settings 2
T	Motor Autotuning	T1	Autotuning
U	Monitor Constants	U1	Monitors
		U2	Fault Trace
		U4	Calendar

<1>The “H” parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the terminals they control are not normally part of user setup.

◆ A: Setup Settings

The following settings are made using the environment constants (A constants): Language displayed on the Digital Operator, access level, control method, initialization of constants.

■ A1: Initialize Mode

User constants for the environment modes are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
A1-00	Language selection for Digital Operator display / Select Language	Selects the language displayed on the LCD Digital Operator. 0:English 1:Japanese	0 or 1	1	Yes	A	A	100H
A1-01	Constant access level / Access Level	Selects the constant access level (read only or set and read.) 0: Monitoring only (Monitoring drive mode and initialize mode.) 2:Advanced (A) (Constants can be read and set in both quick programming (Q) mode and advanced programming (A) mode.)	0 or 2	2	No	A	A	101H
A1-02	Control method selection / Control Method	2: Open-loop vector control 3: Flux vector control This constant is not set by the initialize operation.	2, 3	3	No	Q	Q	102H
A1-03	Initialize / Init Parameters	Sets the constants using the specified method. 0: No initializing 2220: Initializes to the factory settings.	0 to 9999	0000	No	A	A	103H
A1-04	Password / Enter Password	(Manufacturer's password number)	0 to 9999	0000	No	A	A	104H
A1-06	Simulation Mode / Test Mode Sel	0: Disabled 1: Enabled Always set to 0: Disabled during operation.	0 or 1	0	No	A	A	106H
A1-11	Year setting / Year	Sets the year of calendar. (The lower two places)	0 to 99	–	No	A	A	10BH
A1-12	Month and Date setting / Month/Date	Sets the month and the day of calendar.	1.01 to 12.31	–	No	A	A	10CH
A1-13	Hour and Minute setting / Hour/Minute	Sets the hours and the minutes.	0.00 to 23.59	–	No	A	A	10DH

■ A3: Hi Speed Trace

User constants for Hi speed trace are shown in the following table.

Note: Constant groups A3 and A4 select parameters to be output at time of Matrix converter fault. These parameters can be viewed with the DriveTool PC software. Normally they do not need to be changed.

Constant Number	Name Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods Open-loop Vector	Control Methods Flux Vector	MEMOBUS Register
A3-01	Trace data 01 selection Trace Data01 Sel	Sets the trace data of Hi speed trace. Sets the MEMOBUS address of U1 constants.	00H to A2H	40H (U1-01)	No	A	A	130H
A3-02	Trace data 02 selection Trace Data02 Sel		00H to A2H	41H (U1-02)	No	A	A	131H
A3-03	Trace Data03 Sel Trace data 03 selection		00H to A2H	42H (U1-03)	No	A	A	132H
A3-04	Trace data 04 selection Trace Data04 Sel		00H to A2H	44H (U1-05)	No	A	A	133H
A3-05	Trace data 05 selection Trace Data05 Sel		00H to A2H	45H (U1-06)	No	A	A	134H
A3-06	Trace data 06 selection Trace Data06 Sel		00H to A2H	48H (U1-09)	No	A	A	135H
A3-07	Trace data 07 selection Trace Data07 Sel		00H to A2H	49H (U1-10)	No	A	A	136H
A3-08	Trace data 08 selection Trace Data08 Sel		00H to A2H	4AH (U1-11)	No	A	A	137H
A3-09	Trace data 09 selection Trace Data09 Sel		00H to A2H	4BH (U1-12)	No	A	A	138H
A3-10	Trace data 10 selection Trace Data10 Sel		00H to A2H	51H (U1-18)	No	A	A	139H
A3-11	Trace data 11 selection Trace Data11 Sel		00H to A2H	52H (U1-19)	No	A	A	13AH
A3-12	Trace data 12 selection Trace Data12 Sel		00H to A2H	59H (U1-26)	No	A	A	13BH
A3-13	Trace data 13 selection Trace Data13 Sel		00H to A2H	5AH (U1-27)	No	A	A	13CH
A3-14	Trace data 14 selection Trace Data14 Sel		00H to A2H	70H (U1-49)	No	A	A	13DH
A3-15	Trace data 15 selection Trace Data15 Sel		00H to A2H	8DH (U1-78)	No	A	A	13EH
A3-16	Trace data 16 selection Trace Data16 Sel		00H to A2H	99H (U1-90)	No	A	A	13FH
A3-33	Hi speed trace interval setting HiTrace Interval	Sets the Hi speed trace interval.	1 to 30000	4	No	A	A	150H

■ A4: Lo Speed Trace

User constants for Lo speed trace are shown in the following table.

Note: Constant groups A3 and A4 select parameters to be output at time of Matrix converter fault. These parameters can be viewed with the DriveTool PC software. Normally they do not need to be changed.

Constant Number	Name	Description	Setting Range	Factory Setting	Change during Operation	Control Methods		MEMOBUS Register
	Display					Open-loop Vector	Flux Vector	
A4-01	Trace data 01 selection Trace Data01 Sel	Sets the trace data of Lo speed trace. Sets the MEMOBUS address of U1 constants.	00H to A2H	40H (U1-01)	No	A	A	160H
A4-02	Trace data 02 selection Trace Data02 Sel		00H to A2H	41H (U1-02)	No	A	A	161H
A4-03	Trace data 03 selection Trace Data03 Sel		00H to A2H	42H (U1-03)	No	A	A	162H
A4-04	Trace data 04 selection Trace Data04 Sel		00H to A2H	44H (U1-05)	No	A	A	163H
A4-05	Trace data 05 selection Trace Data05 Sel		00H to A2H	45H (U1-06)	No	A	A	164H
A4-06	Trace data 06 selection Trace Data06 Sel		00H to A2H	48H (U1-09)	No	A	A	165H
A4-07	Trace data 07 selection Trace Data07 Sel		00H to A2H	49H (U1-10)	No	A	A	166H
A4-08	Trace data 08 selection Trace Data08 Sel		00H to A2H	4AH (U1-11)	No	A	A	167H
A4-09	Trace data 09 selection Trace Data09 Sel		00H to A2H	4BH (U1-12)	No	A	A	168H
A4-10	Trace data 10 selection Trace Data10 Sel		00H to A2H	51H (U1-18)	No	A	A	169H
A4-11	Trace data 11 selection Trace Data11 Sel		00H to A2H	52H (U1-19)	No	A	A	16AH
A4-12	Trace data 12 selection Trace Data12 Sel		00H to A2H	59H (U1-26)	No	A	A	16BH
A4-13	Trace data 13 selection Trace Data13 Sel		00H to A2H	5AH (U1-27)	No	A	A	16CH
A4-14	Trace data 14 selection Trace Data14 Sel		00H to A2H	70H (U1-49)	No	A	A	16DH
A4-15	Trace data 15 selection Trace Data15 Sel		00H to A2H	8DH (U1-78)	No	A	A	16EH
A4-16	Trace data 16 selection Trace Data16 Sel		00H to A2H	99H (U1-90)	No	A	A	16FH
A4-17	Trace data 17 selection Trace Data17 Sel		00H to A2H	00H	No	A	A	170H
A4-18	Trace data 18 selection Trace Data18 Sel		00H to A2H	00H	No	A	A	171H
A4-19	Trace data 19 selection Trace Data19 Sel		00H to A2H	00H	No	A	A	172H

Constant Number	Name	Description	Setting Range	Factory Setting	Change during Operation	Control Methods		MEMOBUS Register
	Display					Open-loop Vector	Flux Vector	
A4-20	Trace data 20 selection	Sets the trace data of Lo speed trace. Sets the MEMOBUS address of U1 constants.	00H to A2H	00H	No	A	A	173H
	Trace Data20 Sel							
A4-21	Trace data 21 selection		00H to A2H	00H	No	A	A	174H
	Trace Data21Sel							
A4-22	Trace data 22 selection		00H to A2H	00H	No	A	A	175H
	Trace Data22 Sel							
A4-23	Trace data 23 selection		00H to A2H	00H	No	A	A	176H
	Trace Data23 Sel							
A4-24	Trace data 24 selection		00H to A2H	00H	No	A	A	177H
	Trace Data24 Sel							
A4-25	Trace data 25 selection		00H to A2H	00H	No	A	A	178H
	Trace Data25 Sel							
A4-26	Trace data 26 selection		00H to A2H	00H	No	A	A	179H
	Trace Data26 Sel							
A4-27	Trace data 27 selection		00H to A2H	00H	No	A	A	17AH
	Trace Data27 Sel							
A4-28	Trace data 28 selection		00H to A2H	00H	No	A	A	17BH
	Trace Data28 Sel							
A4-29	Trace data 29 selection		00H to A2H	00H	No	A	A	17CH
	Trace Data29 Sel							
A4-30	Trace data 30 selection		00H to A2H	00H	No	A	A	17DH
	Trace Data30 Sel							
A4-31	Trace data 31 selection		00H to A2H	00H	No	A	A	17EH
	Trace Data31 Sel							
A4-32	Trace data 32 selection		00H to A2H	00H	No	A	A	17FH
	Trace Data32 Sel							
A4-33	Lo speed trace interval setting	Sets the Lo speed trace interval.	1 to 30000	20	No	A	A	180H
	LoTrace interval							

◆ b: Application Constants

The following settings are made with the application constants (b constants): Operation method selection, DC injection braking, and speed search.

■ b1: Operation Mode Selections

User constants for operation mode selection are shown in the following table.

Constant Number	Name	Description	Setting Range	Factory Setting	Change during Operation	Control Methods		MEMOBUS Register
	Display					Open-loop Vector	Flux Vector	
b1-01	Reference selection	Sets the frequency reference input method. 0: Digital Operator 1: Control circuit terminal (analog input) 2: MEMOBUS communications 3: Built-in PLC	0 to 3	3	No	Q	Q	1A0H
	Reference Source							

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b1-02	Starting command selection / Run Source	Sets the Run Command input method. 0: Digital Operator 1: Control circuit terminal (sequence input) 2: MEMOBUS communications 3: Built-in PLC	0 to 3	3	No	Q	Q	1A1H
b1-03	Stopping method selection / Stopping Method	Sets the stopping method used when a Stop Command is input. 0: Deceleration to stop 1: Coast to stop	0 or 1	1	No	Q	Q	1A2H
b1-04	Reverse operation selection / Reverse Oper	Permits or disables reverse operation. 0: Reverse enabled 1: Reverse disabled	0 or 1	1	No	A	A	1A3H
b1-05	Operation selection when at or below the minimum output frequency setting (E1-09) / Zero-Speed Oper	Sets the method of operation when the frequency reference input is less than the minimum output frequency setting (E1-09). 0: Run at frequency reference (E1-09 not effective). 1: STOP (coast to stop.) 2: Run at minimum frequency. (E1-09) 3: Run at zero-speed (Stay in RUN mode at zero speed)	0 to 3	1 <1>	No	No	A	1A4H
b1-06	Read sequence input twice / Cntl Input Scans	Sets the responsiveness of the control inputs (forward/reverse and multi-function inputs.) 0: Two scans every 1 ms 1: Two scans every 5 ms	0 or 1	1	No	A	A	1A5H
b1-07	Operation selection after switching to remote mode / LOC/REM RUN Sel	Defines the action taken when switching to the Remote mode using the Local/Remote Key. 0: MX1S will stop if it was running, or remain stopped if a RUN command is present from the Remote source. Remote Run signal must be cycled ‘off ‘to ‘on’ to start the MX1S. 1: Run signals become effective immediately after switching to the Remote mode.	0 or 1	0 <2>	No	A	A	1A6H

<1> The factory setting will change when the control method is changed.
<2> WARNING! Sudden Movement Hazard. If b1-07 is set to 1, switching from LOC to REM will energize the Matrix converter if the Remote run command is present. Ensure that machine safety circuitry is functional before setting b1-07 to 1. Ensure that the machine control logic is suitable for this configuration.

■ b2: DC Injection Braking

User constants for injection braking are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b2-01	Zero-speed level (DC injection braking starting frequency) DCInj Start Freq	Defines the frequency where DC injection braking begins when deceleration to stop is selected, in 1 % units. When b2-01 is less than E1-09, E1-09 becomes the DC injection braking starting frequency. (In flux vector control, zero speed control will start when the frequency is the value of b2-01)	0.00 to 10.00	0.50 % <1>	No	A	A	1B0H
b2-02	DC injection braking current DCInj Current	Sets the DC injection braking current as a percentage of the Matrix converter rated current. (In flux vector control, the DC exciting current will be the setting of E2-03).	0 to 100	50 %	No	A	No	1B1H
b2-03	DC injection braking time at start DCInj Time@Start	Sets the time to perform DC injection braking at start in units of 1 second. Used to stop a coasting motor and restart it. When the set value is 0, DC injection braking at start is not performed.	0.00 to 10.00	0.00 s	No	A	A	1B2H
b2-04	DC injection braking time at stop DCInj Time@Stop	Sets the time to perform DC injection braking at stop in units of 1 second. Used to prevent coasting after a Stop Command. When the set value is 0.00, DC injection braking at stop is not performed.	0.00 to 10.00	0.50 s	No	A	A	1B3H

<1> The factory setting will change when the control method is changed.

■ b3: Speed Search

User constants for the speed search are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b3-01	Speed search selection (on or off). SpdSrch at Start	Enables/disables the Speed Search function at start. 0: Disabled - Speed Search is not automatically performed at start. 1: Enabled - Speed Search is automatically performed at start.	0 or 1	0 <1>	No	A	A	1C0H
b3-02	Speed search deactivation current SpdSrch Current	Sets the current level at which the speed is assumed to be detected and Speed Search is ended. Set as a percentage of the Matrix converter rated current. Not normally necessary to set. If restarting is not possible with the factory settings, reduce the value.	0 to 200	30 % <1>	No	A	No	1C1H
b3-03	Speed search deceleration time SpdSrch Dec Time	Sets the ramp used to reduce the output frequency during Speed Search. This is the time to ramp from the maximum output frequency to the minimum output frequency.	0.1 to 10.0	4.0 s	No	A	No	1C2H
b3-05	Speed search wait time SpdSrch Delay	Delays the Speed Search operation after a momentary power loss to allow time for an external output contactor to close.	0.0 to 20.0	0.2 s	No	A	A	1C4H
b3-06	Output current 1 during speed search Srch Im Lvl1	Sets the current provided to the motor during the first half of Speed Search. Set as a factor of the motor rated current (E2-01). Increase the set value if the search speed is extremely slow.	0.0 to 1.0	0.5	No	A	A	1C5H
b3-07	Output current 2 during speed search Srch Im Lvl2	Sets the current provided to the motor during the second half of speed search. Set as a factor of the motor no-load current (E2-03). The product of motor no-load current and set coefficient is limited to the motor rated current (E2-01) Increase the set value if the search speed becomes extremely slow as speed match is approached.	0.0 to 3.0	1.5	No	A	A	1C6H
b3-10	Speed search detection compensation gain Srch Detect Comp	This factor is used when the Matrix converter has “found” the motor speed and is ready to transfer to Operating mode. Increase this setting if an OV fault occurs when performing Speed Search.	1.00 to 1.50	1.00	No	A	No	1C9H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b3-11	Speed search switching level / Srch Mthd Sw Lvl	The search is automatically switched to Operating mode as a function of the motor residual voltage. Set the switching level.	0.5 to 100.0	2.0 %	No	A	A	1CAH
b3-12	Current detection dead-zone width during speed search / Srch I Deadband	The motor speed is calculated from the detected current value. The dead-zone of the current detection must be set. Decrease the set value if the search speed becomes extremely slow.	0.5 to 10.0	4.0	No	A	A	1CBH
b3-13	Torque compensation time constant during speed search / TComp T at SpdSr	Sets primary lag of the torque compensation function during speed search in units of milliseconds.	0 to 10000	10 ms	No	A	A	1CCH
b3-14	Current control start level during voltage restoration / Srch Lvl Red I	Sets the current level during the transition from Search to Operation. Set the level based on no-load current = 1.0.	0.0 to 5.0	2.0	No	A	A	1CDH
b3-15	Time constant for current control during voltage restoration / Srch T Red I	Sets the time constant in units of 1ms for the current loop during the transition from Search to Operation.	0 to 100	5 ms	No	A	A	1CEH
b3-16	Wait time after completion of speed search / SpdSrch Ret Time	Sets the wait time in units of 1s for switching to normal control after completion of speed search. The frequency reference will be held during the set wait time.	0.00 to 5.00	0.01 s	No	A	No	1CFH
b3-17	Software CLA current limit 1 during speed search / SpdSrch CLA Lvl1	Sets the software current limit value during speed search as a percentage to the motor rated current.	0.0 to 300.0	100.0 %	No	A	A	1D0H
b3-18	Software CLA current limit 2 during speed search / SpdSrch CLA Lvl2	Sets the software current limit value at 0 Hz during speed search as a percentage of the motor rated current.	0.0 to 300.0	100.0 %	No	A	A	1D1H

<1> The factory setting will change when the control method is changed.

■ b7: Droop Control

User constants for the droop control are shown in the following table.

Constant Number	Name Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods Open-loop Vector	Control Methods Flux Vector	MEMOBUS Register
b7-01	Droop control gain	Sets the slip amount at rated torque and maximum output frequency. Setting to 0.0 will disable the droop control.	0.0 to 100.0	0.0 %	Yes	No	A	1CFH
b7-02	Droop control delay time	Used to adjust the responsiveness of droop control. Increases the value when vibration or hunting occurs.	0.03 to 2.00	0.05 s	Yes	No	A	1CFH

◆ C: Tuning Constants

The following settings are made with the tuning constants (C constants): Acceleration/deceleration times, s-curve characteristics, slip compensation, torque compensation, and speed control.

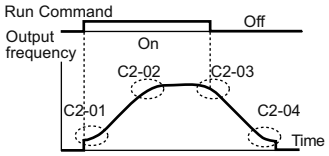
■ C1: Acceleration/Deceleration

User constants for acceleration and deceleration times are shown in the following table.

Constant Number	Name	Description	Setting Range	Factory Setting	Change during Operation	Control Methods		MEMOBUS Register
	Display					Open-loop Vector	Flux Vector	
C1-01	Acceleration time 1 Accel Time 1	Sets the acceleration time to accelerate from 0 to the maximum output frequency, in units of 1s.	0.0 to 6000.0	60.0 s	Yes	Q	Q	240H
C1-02	Deceleration time 1 Decel Time 1	Sets the deceleration time to decelerate from the maximum output frequency to 0, in units of 1s.		60.0 s	Yes	Q	Q	241H
C1-03	Acceleration time 2 Accel Time 2	Sets the acceleration time when the multi-function input “Accel/ Decel Time 1” is on, in units of 1s.		60.0 s	Yes	A	A	242H
C1-04	Deceleration time 2 Decel Time 2	Sets the deceleration time when the multi-function input “Accel/ Decel Time 1” is on, in units of 1s.		60.0 s	Yes	A	A	243H
C1-05	Acceleration time 3 Accel Time 3	Sets the acceleration time when the multi-function input “Accel/ Decel Time 2” is on, in units of 1s.		60.0 s	No	A	A	244H
C1-06	Deceleration time 3 Decel Time 3	Sets the deceleration time when the multi-function input “Accel/ Decel Time 2” is on, in units of 1s.		60.0 s	No	A	A	245H
C1-07	Acceleration time 4 Accel Time 4	Sets the acceleration time when the multi-function inputs “Accel/ Decel Time 1” and “Accel/Decel Time 2” are on, in units of 1s.		60.0 s	No	A	A	246H
C1-08	Deceleration time 4 Decel Time 4	Sets the deceleration time when the multi-function inputs “Accel/ Decel Time 1” and “Accel/Decel Time 2” are on, in units of 1s.		60.0 s	No	A	A	247H
C1-09	Emergency stop time Fast Stop Time	Sets the deceleration time when the multi-function input “Emergency stop at external fault” is selected, in units of 1s.		10.0 s	No	A	A	248H
C1-11	Accel/decel time switching frequency Acc/Dec SW Freq	Sets the output frequency where acceleration/deceleration ramps will be switched. Below the set frequency: Accel/ decel time 4 Above the set frequency: Accel/ decel time 1 The multi-function input “accel/ decel time 1” or “accel/decel time 2” take priority.	0.0 to 100.00	0.00 %	No	A	A	24AH

■ C2: S-curve Acceleration/Deceleration

User constants for S-curve characteristics are shown in the following table.

Constant Number	Name: Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
C2-01	S-curve characteristic time at acceleration start SCrv Acc @ Start	All sections of the S-curve characteristic time are set in units of 1s. S-curve is used to soften the starting and stopping ramps. The longer the S-curve time, the softer the starting and stopping ramp. 	0.00 to 2.50	0.00 s	No	A	A	250H
C2-02	S-curve characteristic time at acceleration end SCrv Acc @ End		0.00 to 2.50	0.00 s	No	A	A	251H
C2-03	S-curve characteristic time at deceleration start SCrv Dec @ Start		0.00 to 2.50	0.00 s	No	A	A	252H
C2-04	S-curve characteristic time at deceleration end SCrv Dec @ End		0.00 to 2.50	0.00 s	No	A	A	253H

■ C3: Motor Slip Compensation

User constants for slip compensation are shown in the following table.

Constant Number	Name: Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
C3-01	Slip compensation gain Slip Comp Gain	Improves speed accuracy when operating with a load. Normally setting is not necessary. Adjust this constant in the following cases: When actual speed is low compared to set speed, increase the set value. When actual speed is high compared to set speed, decrease the set value. Used as a control gain when in flux vector control.	0.0 to 2.5	1.0	Yes	A	A	260H
C3-02	Slip compensation primary delay time Slip Comp Time	Sets the slip compensation primary delay time in units of ms. Normally setting is not necessary. Adjust this constant in the following cases: Reduce the setting when slip compensation response is slow. Increase the setting if speed does not stabilize with load change.	0 to 10000	3000 ms	No	A	A	261H
C3-03	Slip compensation limit Slip Comp Limit	Sets the slip compensation limit as a percentage of motor rated slip.	0 to 250	200 %	No	A	No	262H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
C3-04	Slip compensation selection during regeneration Slip Comp Regen	0: Disabled during regeneration 1: Enabled during regeneration	0 or 1	0	No	A	No	263H
C3-05	Output voltage limit operation selection Output V limit	0: Disabled. 1: Enabled. (The motor flux will be lowered automatically when the output voltage become saturated.)	0 or 1	1	No	A	A	264H

■ C4: Torque Compensation

User constants for torque compensation are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
C4-01	Torque compensation gain Torq Comp Gain	Sets the torque compensation gain. Normally setting is not necessary. Adjust in the following circumstances: When cable length is long; increase the set value. When the motor capacity is smaller than the Matrix converter capacity (Maximum applicable motor capacity), increase the set value. If the motor is oscillating, decrease the set value. Adjust the gain to a range where the output current at low-speed does not exceed the MX1S rated output current.	0.00 to 2.50	1.00	Yes	A	No	270H
C4-02	Torque compensation primary delay time constant Torq Comp Time	The torque compensation delay time is set in units of ms. Normally adjusting is not necessary. Adjust in the following circumstances: If the motor is oscillating, increase the set value. If the responsiveness of the motor is slow, decrease the set value.	0 to 10000	100 ms	No	A	No	271H

■ C5: Speed Control (ASR)

User constants for Automatic Speed Regulator (ASR) speed control are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
C5-01	ASR proportional (P) gain 1 ASR P Gain 1	Set the proportional gain of the speed loop (ASR.) at maximum output frequency.	0.00 to 300.00	20.00	Yes	No	A	280H
C5-02	ASR integral (I) time 1 ASR I Time 1	Set the integral time of the speed loop (ASR) in 1-second units at maximum output frequency	0.000 to 10.000	0.500 s	Yes	No	A	281H
C5-03	ASR proportional (P) gain 2 ASR P Gain 2	Set the proportional speed gain and integral time at minimum output frequency. Normally setting is not necessary	0.00 to 300.00	20.00	Yes	No	A	282H
C5-04	ASR integral (I) time 2 ASR I Time 2		0.000 to 10.000	0.500 s	Yes	No	A	283H
C5-06	ASR primary delay time ASR Delay Time	Sets the filter time constant for outputting torque references from the speed control loop (ASR). It is set in 1-second units. Normally setting is not necessary.	0.000 to 0.500	0.012 s	Yes	No	A	285H
C5-07	ASR switching speed ASR Gain SW Freq	Sets the speed for switching between Proportional Gain 1 and 2 and Integral Time in %. The multi-function input Speed Control (ASR) Proportional Gain Switching is given priority.	0.00 to 100.00	0.00 %	No	No	A	286H
C5-08	ASR integral (I) limit ASR I Limit	Sets the upper limit of speed loop (ASR) integration as a percentage of the value at the rated load.	0 to 400	200 %	No	No	A	287H

◆ d: Reference Constants

The following settings are made with the reference constants (d constants): Frequency references.

■ d1: Frequency Reference

User constants for frequency references are shown in the following table.

Note: Constant d1-01 is the speed reference. The remaining constants in the d1 group are used by the MX1S internal PLC.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d1-01	Frequency reference 1 Reference 1	Sets the frequency reference as a percentage of the maximum output frequency.	0.00 to 100.00	0.00 %	Yes	Q	Q	2C0H
d1-02	Frequency reference 2 Reference 2	Sets the frequency reference when the multi-function input “Multi-step speed reference 1” is on, as a percentage of the maximum output frequency.	0.00 to 110.00	0.00 %	Yes	Q	Q	2C1H

Constant Number	Name Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods Open-loop Vector	Control Methods Flux Vector	MEMOBUS Register
d1-03	Frequency reference 3 Reference 3	Sets the frequency reference when the multi-function input “Multi-step speed reference 2” is on, as a percentage of the maximum output frequency.	0.00 to 110.00	0.00 %	Yes	Q	Q	2C2H
d1-04	Frequency reference 4 Reference 4	Sets the frequency reference when the multi-function inputs “Multi-step speed reference 1” and “Multi-step speed reference 2” are on, as a percentage of the maximum output frequency.	0.00 to 110.00	0.00 %	Yes	Q	Q	2C3H
d1-05	Frequency reference 5 Reference 5	Sets the frequency reference when the multi-function input “Multi-step speed reference 3” is on, as a percentage of the maximum output frequency.	0.00 to 110.00	0.00 %	Yes	Q	Q	2C4H
d1-06	Frequency reference 6 Reference 6	Sets the frequency reference when the multi-function inputs “Multi-step speed reference 1” and “Multi-step speed reference 3” are on, as a percentage of the maximum output frequency.	0.00 to 110.00	0.00 %	Yes	Q	Q	2C5H
d1-07	Frequency reference 7 Reference 7	Sets the frequency reference when the multi-function inputs “Multi-step speed reference 2” and “Multi-step speed reference 3” are on, as a percentage of the maximum output frequency.	0.00 to 110.00	0.00 %	Yes	Q	Q	2C6H
d1-08	Frequency reference 8 Reference 8	Sets the frequency reference when the multi-function inputs “Multi-step speed reference 1”, “Multi-step speed reference 2” and “Multi-step speed reference 3” are on, as a percentage of the maximum output frequency.	0.00 to 110.00	0.00 %	Yes	Q	Q	2C7H
d1-17	Jog frequency reference Jog Reference	Sets the frequency reference when the multi-function inputs “JOG frequency selection”, “FJOG command” and “RJOG command” are on, as a percentage of the maximum output frequency.	0.00 to 100.00	10.00 %	Yes	Q	Q	2D0H

■ d2: Frequency Reference Limits

User constants for frequency reference limits are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d2-01	Frequency reference upper limit / Ref Upper Limit	Sets the output frequency upper limit as a percent of the maximum output frequency.	0.0 to 110.0	100.0 %	No	A	A	2E0H
d2-02	Frequency reference lower limit / Ref Lower Limit	Sets the output frequency lower limit as a percentage of the maximum output frequency.	0.0 to 109.0	0.0 %	No	A	A	2E1H

■ d3: Jump Frequencies

User constants for jump frequencies are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d3-01	Jump frequency 1 / Jump Freq 1	Sets the center values of the jump frequencies in % of maximum speed. This function is disabled by setting the jump frequency to 0 Hz. Always ensure that the following applies: d3-01 ≥ d3-02 ≥ d3-03 Operation in the jump frequency range is prohibited, but during acceleration and deceleration the speed will change smoothly through the jump frequency width.	0.0 to 100.0	0.0 %	No	A	A	2F0H
d3-02	Jump frequency 2 / Jump Freq 2		0.0 to 100.0	0.0 %	No	A	A	2F1H
d3-03	Jump frequency 3 / Jump Freq 3		0.0 to 100.0	0.0 %	No	A	A	2F2H
d3-04	Jump frequency width / Jump Bandwidth	Sets the jump frequency bandwidth in %. The jump frequency range will be the jump frequency ± d3-04.	0.0 to 100.0	1.0 %	No	A	A	2F3H

■ d6: Field Forcing Control

User constants for field forcing control are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d6-08	Field forcing gain / Field Force Gain 1	Sets the field forcing gain. **Note:** Normally there is no need to change this setting. Increase the value in the event an OV fault occurs during sharp acceleration/deceleration in the constant HP zone.	0.0 to 20.0	0.0	No	No	A	327H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d6-09	Field forcing time constant correction gain / Field Force Gain 2	Sets the field forcing time constant in multiples of the motor secondary circuit time constant: Field force time constant = Secondary circuit time constant × d6-09	0.01 to 20.0	1.0	No	No	A	328H

◆ E: Motor Constants

The following settings are made with the motor constants (E constants): V/f characteristics and motor constants.

■ E1: V/f Pattern

User constants for V/f characteristics are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
E1-01	Input voltage setting / Input Voltage	Sets the Power Cell input voltage in 1 volt units.	180 to 700	590 V	No	Q	Q	340H
E1-02	Motor type selection / Motor Selection	0: General-purpose motor 1: Matrix converter motor 2: Vector motor	0 to 2	2	No	Q	Q	341H
E1-04	Maximum output frequency / Max Frequency	Setting units Frequency (speed): r/min Voltage: Volt (V) To obtain a straight-line V/f characteristic pattern, set the same values for E1-07 and E1-09. In this case, the setting for E1-08 will be disregarded. Always ensure that the four frequencies are set in the following manner: E1-04 (FMAX) ≥ E1-06 (FA) > E1-07 (FB) ≥ E1-09 (FMIN)	0 to 8000	1200 r/min	No	Q	Q	344H
E1-05	Maximum voltage / Max Voltage		0 to 8000	3300 V	No	Q	Q	347H
E1-06	Base frequency / Base Frequency		0 to 8000	1200 r/min	No	Q	Q	349H
E1-07	Middle output frequency / Mid Frequency A		0 to 8000	0 r/min	No	A	No	34CH
E1-08	Midddle Voltage / Mid Voltage A		0 to 8000	0 V	No	A	No	34EH
E1-09	Minimum output frequency / Min Frequency		0 to 8000	0 r/min	No	Q	A	350H
E1-10	Minimum voltage / Min Voltage		0 to 8000	0 V	No	A	No	353H
E1-11	Middle output frequency 2 / Mid Frequency B	Set only to fine-adjust V/f for the rated output (constant HP) range. Normally, this setting is not required. Setting units Frequency (speed): r/min Voltage: Volt (V)	0 to 8000	0 r/min <1>	No	A	A	355H
E1-12	Middle voltage 2 / Mid Voltage B		0 to 8000	0 V	No	A	A	357H
E1-13	Base voltage / Base Voltage		0 to 8000	3300 V	No	Q	Q	358H

<1> The factory settings depend on the Matrix converter capacity.

■ E2: Motor Setup

User constants for motor are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
E2-01	Motor rated current / Motor Rated FLA	Sets the motor rated current in 1 A units. The set value will become the reference value for motor protection, torque limits and torque control.	0.1 to 1500.0	86.6 A	No	Q	Q	360H
E2-02	Motor rated slip / Motor Rated Slip	Sets the motor rated slip in Hz units. The set value will become the reference value for slip compensation.	0.00 to 20.00	0.75 Hz	Yes	Q	Q	361H
E2-03	Motor no-load current / No-Load Current	Sets the motor no-load current in 1 A units.	0.00 to 1500.0	32.2 A	Yes	Q	Q	362H
E2-04	Number of motor poles / Number of Poles	Sets the number of motor poles.	2 to 48 <1>	6 poles	No	Q	Q	363H
E2-05	Motor line-to-line resistance / Term Resistance	Sets the motor phase-to-phase resistance in ohms.	0.000 to 65.000	0.307	Yes	A	A	364H
E2-06	Motor leak inductance / Leak Inductance	Sets the voltage drop due to motor leakage inductance as a percentage of the motor rated voltage.	0.0 to 40.0	27.2 %	Yes	A	A	365H
E2-07	Motor iron saturation coefficient 1 / Saturation Comp1	Sets the motor iron saturation coefficient at 50 % of magnetic flux.	0.00 to 1.00	0.50	Yes	A	A	366H
E2-08	Motor iron saturation coefficient 2 / Saturation Comp2	Sets the motor iron saturation coefficient at 75 % of magnetic flux.	0.00 to 1.00	0.75	Yes	A	A	367H
E2-09	Motor mechanical loss / Mechanical Loss	Sets the motor mechanical loss as a percentage of motor rated output. Normally setting is not necessary. Adjust in the following circumstances: When there is high friction in the motor or drive train bearings. When the friction loss in the pump or fan is large. This setting will compensate for fixed torque consumption.	0.0 to 10.0	0.0 %	Yes	No	A	368H
E2-11	Motor rated output / Mtr Rated Power	Sets the rated output of the motor in units of kW.	0 to 10000	630 kW	No	Q	Q	36AH
E2-12	Motor wiring resistance / Wiring Resistor	Compensates for cable voltage drop to motor. Set as % of base voltage.	0.00 to 1.00	0.00 %	Yes	A	A	36BH
E2-13	Motor temperature OH level / Motor Temp OHLVL	Sets the motor OH (Over Heat or Over Temperature) level in units of °C.	50 to 200	120°C	No	A	A	36CH
E2-14	Motor Thermistor selection / Motor Thermistor	0: Motor Thermistor disabled. 1: Motor Thermistor enabled.	0 or 1	0	No	A	A	36DH

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
E2-15	Motor iron loss compensation current / Iron Loss Current	Set the motor iron loss current in %.	0.0 to 10.0	0.0 %	No	A	A	36EH
E2-16	Motor iron-core saturation coefficient	Sets the core saturation coefficient at the magnetic flux density 25 %	0.00 to 1.00	0.25	Yes	A	A	36FH

<1> Can only be set in multiples of 2.

◆ F: PLC Constants

The following settings for the built-in PLC are made with the PLC constants (F constants).

■ F8: PLC

User constants for PLC are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
F8-06	Control response 1 selection / ControlResponse1	Sets the number of the monitor item to be control response 1. (U1-□□)	1 to 99	9	No	A	A	405H
F8-07	Control response 2 selection / ControlResponse2	Sets the number of the monitor item to be control response 2. (U1-□□)	1 to 99	90	No	A	A	406H
F8-08	Control response 3 selection / ControlResponse3	Sets the number of the monitor item to be control response 3 (U1-□□)	1 to 99	43	No	A	A	407H
F8-09	Control response 4 selection / ControlResponse4	Sets the number of the monitor item to be control response 4. (U1-□□)	1 to 99	54	No	A	A	408H
F8-11	External-magnetic-flux reference selection / Ext-Mag-flux Sel	0: Disabled. 1: Enabled.	0 or 1	0	No	No	A	40AH
F8-12	ASR proportional gain selection / ASR P Gain Sel	0: Disabled. 1: Enabled.	0 or 1	1	No	No	A	40BH
F8-13	Torque limit selection (FWD) / Torque limit Sel	0: Disabled. 1: Enabled.	0 or 1	1	No	A	A	40CH
F8-14	Torque limit selection (REV) / Torque limit Sel	0: Disabled. 1: Enabled.	0 or 1	1	No	A	A	40DH
F8-16	Droop gain selection / DROOP Gain Sel	0: Disabled. 1: Enabled.	0 or 1	1	No	No	A	40FH

◆ H: Terminal Function Constants

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the terminals they control are not normally part of user setup.

The following settings are made with the terminal function constants (H constants): Settings for external terminal functions.

Confirm the actual external terminal numbers by checking the elementary wiring diagram. In some cases, the external terminal numbers are customized for each Matrix converter.

The names of the input and output terminals in these tables relate to the Control Circuit Terminals as follows:

	Constant Tables	Control Circuit Terminal
Digital Input	S1 to S20	DI_0 to DI_19
Digital Output	DO1 to DO8	DO_0 to DO_7
Analog Input	AI1 to AI4	AI_0 to AI_3
Analog Output	AO1 to AO4	AO_0 to AO_3

■ H1: Multi-function Contact Inputs

User constants for multi-function contact inputs are shown in the following tables.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H1-03	Terminal S3 function selection / Terminal S3 Sel	Multi-function contact input (S3)	00 to 7FH	0FH	No	A	A	422H
H1-04	Terminal S4 function selection / Terminal S4 Sel	Multi-function contact input (S4)	00 to 7FH	0FH	No	A	A	423H
H1-05	Terminal S5 function selection / Terminal S5 Sel	Multi-function contact input (S5)	00 to 7FH	0FH	No	A	A	424H
H1-06	Terminal S6 function selection / Terminal S6 Sel	Multi-function contact input (S6)	00 to 7FH	0FH	No	A	A	425H
H1-07	Terminal S7 function selection / Terminal S7 Sel	Multi-function contact input (S7)	00 to 7FH	0FH	No	A	A	426H
H1-08	Terminal S8 function selection / Terminal S8 Sel	Multi-function contact input (S8)	00 to 7FH	0FH	No	A	A	427H
H1-09	Terminal S9 function selection / Terminal S9 Sel	Multi-function contact input (S9)	00 to 7FH	0FH	No	A	A	428H
H1-10	Terminal S10 function selection / Terminal S10 Sel	Multi-function contact input (S10)	00 to 7FH	0FH	No	A	A	429H
H1-11	Terminal S11 function selection / Terminal S11 Sel	Multi-function contact input (S11)	00 to 7FH	0FH	No	A	A	42AH
H1-12	Terminal S12 function selection / Terminal S12 Sel	Multi-function contact input (S12)	00 to 7FH	0FH	No	A	A	42BH

Constant Number	Name Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods Open-loop Vector	Control Methods Flux Vector	MEMOBUS Register
H1-13	Terminal S13 function selection Terminal S13 Sel	Multi-function contact input (S13)	00 to 7FH	0FH	No	A	A	42CH
H1-14	Terminal S14 function selection Terminal S14 Sel	Multi-function contact input (S14)	00 to 7FH	0FH	No	A	A	42DH
H1-15	Terminal S15 function selection Terminal S15 Sel	Multi-function contact input (S15)	00 to 7FH	0FH	No	A	A	42EH
H1-16	Terminal S16 function selection Terminal S16 Sel	Multi-function contact input (S16)	00 to 7FH	0FH	No	A	A	42FH

Multi-function Contact Input Functions

Setting Value	Function	Control Methods Open-loop Vector	Control Methods Flux Vector
00	3-wire sequence (Forward/Reverse Run Command)	Yes	Yes
01	Local/Remote selection (on: Operator, off: Constant setting)	Yes	Yes
02	Option/Matrix converter selection (on: Option board)	Yes	Yes
03	Multi-step speed reference 1 When H3-09 (Multi-function analog input function selection) is set to 0 [Auxiliary frequency (speed) reference], this function is combined with the master/auxiliary speed switch.	Yes	Yes
04	Multi-step reference 2	Yes	Yes
05	Multi-step reference 3	Yes	Yes
06	Jog frequency command (higher priority than multi-step speed reference)	Yes	Yes
07	Accel/decel time 1	Yes	Yes
08	External baseblock NO (NO contact: Baseblock at on)	Yes	Yes
09	External baseblock NC (NC contact: Baseblock at off)	Yes	Yes
0A	Acceleration/deceleration ramp hold (on: Acceleration/deceleration stopped, frequency on hold)	Yes	Yes
0B	OH2 alarm signal input (on: OH2 will be displayed)	Yes	Yes
0C	Multi-function analog input selection (on: Enable)	Yes	Yes
0E	Speed control integral reset (on: Integral control disabled)	No	Yes
0F	Not used (Set when the terminal is used for the built-in PLC or not used.)	Yes	Yes
10	Up command (Always set with the down command.)	Yes	Yes
11	Down command (Always set with the up command.)	Yes	Yes
12	FJOG command (on: Forward run at jog frequency (d1-17))	Yes	Yes
13	RJOG command (on: Reverse run at jog frequency (d1-17))	Yes	Yes
14	Fault reset (Reset when turned on.)	Yes	Yes
15	Emergency stop (NO contact: Decelerates to a stop within the time specified by C1-09 when on)	Yes	Yes
17	Emergency stop (NC contact: Decelerates to a stop within the time specified by C1-09 when off)	Yes	Yes
1A	Accel/decel time 2	Yes	Yes
1B	Constants write enable (on: All constants can be written. off: All constants other than speed monitor are write prohibited.)	Yes	Yes
1E	Analog frequency reference sample/hold	Yes	Yes
1F	Frequency reference terminal AI1/AI2 selection (on: AI2)	Yes	Yes
20 to 2F	External fault (Desired settings possible) Input mode: NO contact/NC contact, Detection mode: Normal/ during operation, Stopping method: Deceleration to a stop/coast to a stop/ emergency stop/ continues running	Yes	Yes

Setting Value	Function	Control Methods	
		Open-loop Vector	Flux Vector
60	DC injection braking command (on: Performs DC injection braking)	Yes	Yes
61	External speed search command 1 (on: Speed search enabled)	Yes	No
62	External speed search command 2 (on: Speed search enabled)	Yes	No
6F	Emergency stop (NO contact: Coast to a stop when on)	Yes	Yes
70	Emergency stop (NC contact: Coast to a stop when off)	Yes	Yes
77	Speed control (ASR) proportional gain switch (on: C5-03, off: Gain determined by C5-01 and C5-03)	No	Yes

Note: Set the Terminal function constant to 0F when a contact input is used for the built-in PLC or if the terminal is not used as a multi-function contact input. The factory settings of all multi-function contact inputs are 0F. Input the signals shown in ***Figure 2.1*** to each contact input. The input signals are processed by the built-in PLC.

■ H2: Multi-function Contact Outputs

User constants for multi-function outputs are shown in the following tables.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods		MEMOBUS Register
						Open-loop Vector	Flux Vector	
H2-01	Terminal DO1 function selection (contact) / DO1 Sel	Multi-function contact output 1 (DO1)	00 to FFH	0FH	No	A	A	440H
H2-02	Terminal DO2 function selection (contact) / DO2 Sel	Multi-function contact output 2 (DO2)	00 to FFH	0FH	No	A	A	441H
H2-03	Terminal DO3 function selection (contact) / DO3 Sel	Multi-function contact output 3 (DO3)	00 to FFH	0FH	No	A	A	442H
H2-04	Terminal DO4 function selection (contact) / DO4 Sel	Multi-function contact output 4 (DO4)	00 to FFH	0FH	No	A	A	443H
H2-05	Terminal DO5 function selection (contact) / DO5 Sel	Multi-function contact output 5 (DO5)	00 to FFH	0FH	No	A	A	444H
H2-06	Terminal DO6 function selection (contact) / DO6 Select	Multi-function contact output 6 (DO6)	00 to FFH	0FH	No	A	A	445H
H2-07	Terminal DO7function selection (contact) / DO7 Select	Multi-function contact output 7 (DO7)	00 to FFH	0FH	No	A	A	446H
H2-08	Terminal DO8 function selection (contact) / DO8 Select	Multi-function contact output 8 (DO8)	00 to FFH	0FH	No	A	A	447H

Multi-function Contact Output Functions

Setting Value	Function	Control Methods	
		Open Loop Vector	Flux Vector
00	During run (on: Run command is on or voltage is being output)	Yes	Yes
01	Zero-speed	Yes	Yes
02	Frequency (speed) agree 1 [L4-02 (detection width) is used]	Yes	Yes
03	Desired frequency (speed) agree 1 [on: Output frequency = ±L4-01, L4-02 (detection width) is used and during frequency agree]	Yes	Yes
04	Frequency (FOUT) detection 1 [on: +L4-01 ≥ Output frequency ≥ -L4-01, L4-02 (detection width) is used]	Yes	Yes
05	Frequency (FOUT) detection 2 [on: Output frequency (speed) ≥ +L4-01 or output frequency ≤ -L4-01, L4-02 (detection width) is used]	Yes	Yes
06	Matrix converter operation ready (operation ready: Normal status without error after initialization)	Yes	Yes
07	During main circuit undervoltage (AUV) detection	Yes	Yes
08	During baseblock (on: during baseblock)	Yes	Yes
09	Frequency reference selection (on: Frequency reference from operator)	Yes	Yes
0A	Run command selection status (on: Run command from operator)	Yes	Yes
0B	Overtorque/undertorque detection 1 NO (NO contact: Overtorque/undertorque detection when on)	Yes	Yes
0C	Loss of frequency reference [Effective when L4-05 (operation selection when frequency reference is lost) is set to 1]	Yes	Yes
0E	Fault (on: Error other than CPF00 and CPF01 has occurred)	Yes	Yes
0F	Not used (Set when the terminal is used for the built-in PLC or not used.)	Yes	Yes
10	Minor fault (on: Alarm displayed)	Yes	Yes
11	Fault reset command active	Yes	Yes
13	Frequency (speed) agree 2 [L4-04 (detection width) is used]	Yes	Yes
14	Desired frequency (speed) agree 2 [on: Output frequency = L4-03, L4-04 (detection width) is used, and frequency agree]	Yes	Yes
15	Frequency (FOUT) detection 3 [on: Output frequency ≤ L4-03, L4-04 (detection width) is used]	Yes	Yes
16	Frequency (FOUT) detection 4 [on: Output frequency ≥ L4-03, L4-04 (detection width) is used]	Yes	Yes
17	Overtorque/undertorque detection 1 NC (NC contact: Overtorque/undertorque detection when off)	Yes	Yes
18	Overtorque/undertorque detection 2 NO (NO contact: Overtorque/undertorque detection when on)	Yes	Yes
19	Overtorque/undertorque detection 2 NC (NC contact: Overtorque/undertorque detection when off)	Yes	Yes
1A	During reverse run (on: During reverse run)	Yes	Yes
1B	During baseblock 2 (off: During baseblock)	Yes	Yes
1D	During regeneration (on: During regeneration)	No	Yes
31	During speed limit (on: During speed limit)	No	Yes
37	During run 2 (on: Frequency output, off: Base block, DC injection braking, initial excitation, operation stop)	Yes	Yes

Note: Set the Terminal function constant to 0F when a contact output is used for the built-in PLC or if the terminal is not used as a multi-function contact output. The factory settings of all multi-function contact outputs are 0F and the signals shown in ***Figure 2.1*** are output from the built-in PLC.

■ H3: Analog Inputs

User constants for analog inputs are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H3-01	Signal level selection (terminal AI1) / Term AI1 Signal	0: 0 to 10 V 1: -10 V to 10 V	0 or 1	0	No	A	A	450H
H3-02	Gain (terminal AI1) / Term AI1 Gain	Sets the frequency when 10 V is input, as a percentage of the maximum output frequency.	0.0 to 1000.0	100.0 %	Yes	A	A	451H
H3-03	Bias (terminal AI1) / Term AI1 Bias	Sets the frequency when 0 V is input, as a percentage of the maximum output frequency.	-100.0 to 100.0	0.0 %	Yes	A	A	452H
H3-04	Signal level selection (terminal AI2) / Term AI2 Signal	0: 0 to 10 V 1: -10 V to 10 V	0 or 1	0	No	A	A	453H
H3-05	Multi-function analog input (terminal AI2) / Term AI2 Sel	Selects multi-function analog input function for terminal AI2.	00 to 1FH	1FH	No	A	A	454H
H3-06	Gain (terminal AI2) / Term AI2 Gain	Sets the input level when terminal AI2 is 10 V. Set according to the 100 % value selected in H3-05.	0.0 to 1000.0	100.0 %	Yes	A	A	455H
H3-07	Bias (terminal AI2) / Term AI2 Bias	Sets the input level when terminal AI2 is 0 V. Set according to the 100 % value selected in H3-05.	-100.0 to 100.0	0.0 %	Yes	A	A	456H
H3-08	Signal level selection (terminal AI3) / Term AI3 Signal	0: 0 to 10 V 1 :-10 V to 10 V	0, 1	0	No	A	A	457H
H3-09	Multi-function analog input (terminal AI3) / Term AI3 Sel	Selects multi-function analog input function for terminal AI3.	00 to 1FH	0FH	No	A	A	458H
H3-10	Gain (terminal AI3) / Term AI3 Gain	Sets the input level when terminal AI3 is 10 V. Set according to the 100 % value selected in H3-09.	0.0 to 1000.0	100.0 %	Yes	A	A	459H
H3-11	Bias (terminal AI3) / Term AI3 Bias	Sets the input level when terminal AI3 is 0 V. Set according to the 100 % value selected in H3-09.	-100.0 to 100.0	0.0 %	Yes	A	A	45AH
H3-12	Signal level selection (terminal AI4) / Term AI4 Signal	0: 0 to 10 V 1: -10 V to 10 V	0 or 1	0	No	A	A	45BH
H3-13	Multi-function analog input (terminal AI4) / Term AI4 Sel	Selects multi-function analog input function for terminal AI4.	00 to 1FH	0FH	No	A	A	45CH

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H3-14	Gain (terminal AI4) / Term AI4 Gain	Sets the input level when terminal AI4 is 10 V. Set according to the 100 % value selected in H3-13.	0.0 to 1000.0	100.0 %	Yes	A	A	45DH
H3-15	Bias (terminal AI4) / Term AI4 Bias	Sets the input level when terminal AI4 is 0 V. Set according to the 100 % value selected in H3-13.	-100.0 to 100.0	0.0 %	Yes	A	A	45EH
H3-16	Analog input filter time constant / Filter Avg Time	Sets primary delay filter time constant in seconds for the four analog input terminals (AI1,AI2,AI3,AI4). Effective for noise control, etc.	0.00 to 2.00	0.00 s	No	A	A	45FH

Multi-function Analog Input Functions

Setting Value	Function	Contents (100 %)	Control Methods: Open-loop Vector	Control Methods: Flux Vector
00	Auxiliary frequency reference (Can be set only for H3-09)	Maximum r/min	Yes	Yes
01	Frequency gain	Frequency reference command value	Yes	Yes
02	Frequency bias	Maximum r/min	Yes	Yes
05	Accel/decel time changes (reduction coefficient)	Set acceleration and deceleration times	Yes	Yes
06	DC injection braking current	Matrix converter rated current	Yes	No
07	Overtorque detection level	Motor rated torque	Yes	Yes
09	Frequency reference lower limit level	Maximum r/min	Yes	Yes
0A	Jump frequency	Maximum r/min	Yes	Yes
0E	Motor temperature	450°C (0 % at -50°C)	Yes	Yes
0F	Not used (Set when the terminal is used for the built-in PLC or not used)	–	Yes	Yes
10	Positive torque limit	Motor rated torque	Yes	Yes
11	Negative torque limit	Motor rated torque	Yes	Yes
12	Regenerative torque limit	Motor rated torque	Yes	Yes
14	Torque compensation	Motor rated torque	No	Yes
15	Positive/negative torque limit	Motor rated torque	Yes	Yes
1F	(For H3-09 and H3-13) Analog input not used	–	Yes	Yes
	(For H3-05) Frequency reference	Maximum r/min		

Note: Set the constant to 0F when the analog input is used for the built-in PLC or if the terminal is not used as multi-function analog input.

■ H4: Multi-function Analog Outputs

User constants for multi-function analog outputs are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H4-01	Monitor selection (terminal AO1) / Term AO1 Signal	Sets AO1 for multi-function analog output.	0 to 99	2	Yes	A	A	470H
H4-02	Gain (terminal AO1) / Term AO1 Gain	Sets the multi-function analog output 1 voltage level gain. The output (10 V as 100 %) of the monitored item will be increased by the set gain factor. However, the voltage output from the terminal will be limited to 10 V.	0 to 30.00	1.00	Yes	A	A	471H
H4-03	Bias (terminal AO1) / Term AO1 Bias	Sets the bias added to the AO1 voltage level. The bias is 0 % to ±10 % when 10 V is 100 %. However, the voltage output from the terminal will be limited to 10 V.	-100.0 to 100.0	0.0 %	Yes	A	A	472H
H4-04	Monitor selection (terminal AO2) / Term AO2 Signal	Sets AO2 for multi-function analog output.	0 to 99	3	Yes	A	A	473H
H4-05	Gain (terminal AO2) / Term AO2 Gain	Sets the multi-function analog output 2 voltage level gain. The output (10 V as 100 %) of the monitored item will be increased by the set gain factor. However, the voltage output from the terminal will be limited to 10 V.	0 to 30.00	1.00	Yes	A	A	474H
H4-06	Bias (terminal AO2) / Term AO2 Bias	Sets the bias added to the AO2 voltage level. The bias is 0 % to ±10 % when 10 V is 100 %. However, the voltage output from the terminal will be limited to 10 V.	-100.0 to 100.0	0.0 %	Yes	A	A	475H
H4-07	Monitor selection (terminal AO3) / Term AO3 Signal	Sets AO3 for multi-function analog output.	0 or 99	5	Yes	A	A	476H
H4-08	Gain (terminal AO3) / Term AO3 Gain	Sets the multi-function analog output 3 voltage level gain. The output (10 V as 100 %) of the monitored item will be increased by the set gain factor. However, the voltage output from the terminal will be limited to 10 V.	0 to 30.00	1.00	Yes	A	A	477H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H4-09	Bias (terminal AO3) Term AO3 Bias	Sets the bias added to the AO3 voltage level. The bias is 0 % to ±10 % when 10 V is 100 %. However, the voltage output from the terminal will be limited to 10 V.	-100.0 to 100.0	0.0 %	Yes	A	A	478H
H4-10	Monitor selection (terminal AO4) Term AO4 Signal	Sets AO4 for multi-function analog output.	0 to 99	9	Yes	A	A	479H
H4-11	Gain (terminal AO4) Term AO4 Gain	Sets the multi-function analog output 4 voltage level gain. The output (10 V as 100 %) of the monitored item will be increased by the set gain factor. However, the voltage output from the terminal will be limited to 10 V.	0 to 30.00	1.00	Yes	A	A	47AH
H4-12	Bias (terminal AO4) Term AO4 Bias	Sets the bias added to the AO4 voltage level. The bias is 0 % to ±10 % when 10 V is 100 %. However, the voltage output from the terminal will be limited to 10 V.	-100.0 to 100.0	0.0 %	Yes	A	A	47BH
H4-13	Analog output signal level selection Signal Select	0: 0 to +10 V 1: -10 to +10 V	0 or 1	1	No	A	A	47CH

■ H7: PG Setup

User constants for PG setup are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H7-01	PG constant PG Pulses/Rev	Sets the number of PG (pulse generator or encoder) pulses. Sets the number of pulses per motor revolution without multiplication.	0 to 8192	600 <1>	No	No	Q	4A0H
H7-04	Operation selection at deviation PG Deviation Sel	Sets the stopping method when a speed deviation (DEV) fault occurs. 0: Decelerate to stop 1: Coast to stop 2: Emergency stop 3: Continue operation	0 to 3	3	No	No	A	4A3H
H7-05	PG rotation PG Rotation Sel	0: Phase A leads with forward run command. 1: Phase A leads with reverse run command.	0 or 1	1	No	No	A	4A4H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H7-08	Overspeed detection level / PG Overspd Level	Sets the overspeed detection method. Overspeed is detected when a frequency above the level specified by H7-08 (a percentage of the maximum output frequency) has continued for more than the time specified by H7-09 (detection time in units of seconds).	0 to 120	115 %	No	No	A	4A7H
H7-09	Overspeed detection delay time / PG Overspd Time		0.0 to 2.0	0.0 s	No	No	A	4A8H
H7-10	Excessive speed deviation detection level / PG Deviate Level	Sets the excessive speed deviation (DEV) detection method. An excessive speed deviation is detected when a speed deviation above the level specified by H7-10 (a percentage of the maximum output frequency) has continued for more than the time specified by H7-11 (detection time in units of seconds). Speed deviation: The difference between the actual motor speed and the commanded speed (reference)	0 to 50	10 %	No	No	A	4A9H
H7-11	Excessive speed deviation detection delay time / PG Deviate Time		0 to 10.0	0.5 s	No	No	A	4AAH
H7-14	PG open-circuit detection time / PGO Detect Time	Sets the time for the software to detect a PG disconnection in units of second.	0.0 to 10.0	3.0 s	No	No	A	4ADH
H7-24	PG counter multiplication selection / Pulse CNT Mode	0: ×1 1: ×4	0 or 1	1	No	No	A	4B7H

<1> When the control method is changed, the factory setting will change. The flux vector factory setting is given.

◆ L: Protection Function Constants

The following settings are made with the protection function constants (L constants): Motor protection selection, power loss ride-through function, stall prevention function, speed detection, overtorque/undertorque detection, torque limits, and hardware protection.

■ L1: Motor Overload

User constants for motor overloads are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L1-01	Motor protection selection / MOL Fault Select	Selects whether the Matrix converter's internal motor overload function is enabled or disabled. 0: Disabled 1: Enabled	0 or 1	1	No	A	A	4E0H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L1-02	Motor protection time constant / MOL Time Const	Sets the time when the motor must be in overload (> L1-07) before the internal overload function is triggered, in units of seconds. The factory setting is 60.0 seconds. Set the protection time according to the motor overload capability.	1.0 to 600.0	60.0 s	No	A	A	4E1H
L1-04	Operation selection at motor overload / MOL Select	Selects the operation when the motor is overloaded. 0: Decelerate to stop 1: Coast to stop 2: Emergency stop using the deceleration time in C1-09 ***95***. 3: Continue operation	0 to 3	1	No	A	A	4E3H
L1-06	Motor overload detection start level / OL1 Start Level	Sets the minimum level (bias) for motor overload detection as a percentage of the motor rated torque. The set value must be smaller than L1-07. When E2-14 ***102*** is set to 1 (enabled), this setting is invalid.	20 to 300	110 %	No	A	A	4E5H
L1-07	Motor overload detection level / OL1 Level	Sets the motor overload detection level as a percentage of the motor rated torque. The set value must be larger than L1-06. When E2-14 ***102*** is set to 1 (enabled), this setting is invalid.	30 to 300	150 %	No	A	A	4E6H

■ L2: Power Loss Ridethrough

User constants for power loss ridethrough are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L2-01	Momentary power loss detection / PwrL Selection	0: Disabled (Major fault occurs immediately after a momentary power loss.) 1: Enabled (Continued operation within the allowable ride-through time after a momentary power loss.) A backup power source for the control power supply is required to successfully ride through a momentary power loss.	0 or 1	0	No	A	A	4F0H
L2-02	Momentary power loss ridethrough time / PwrL Ridethru t	Ridethrough time, when Momentary Power Loss Selection (L2-01) is set to 1, in units of seconds.	0.0 to 10.0	2.0 s	No	A	A	4F1H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L2-03	Minimum baseblock time / PwrL Baseblock t	"Baseblock" prohibits any output from the Matrix converter. L2-03 sets the minimum time to baseblock the motor, in units of seconds. Select the time required for the motor residual voltage to be discharged. If an overcurrent (OC) occurs during the start of speed search or DC injection braking, increase the set value.	0.1 to 5.0	2.0 s	No	A	A	4F2H
L2-04	Voltage recovery time / PwrL V/F Ramp t	Select the time to restore the normal output voltage of the Matrix converter after the completion of speed search, in units of seconds. Sets the time required to recover the output voltage from 0 V to the maximum.	0.0 to 10.0	3.0 s	No	A	A	4F3H
L2-21	AUV detection level / Power UV Level	Sets the input power supply undervoltage (AUV) detection level in units of volts (V).	2080 to 4160	2704 V	No	A	A	504H

■ L3: Stall Prevention

User constants for the stall prevention function are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L3-01	Stall prevention selection during accel / StallP Accel Sel	0: Disabled (Acceleration as set. With a heavy load, the Matrix converter may reach current limit or trip (OC) or the motor may stall.) 1: Enabled (Acceleration stops when L3-02 level is exceeded. Acceleration starts again when the current reduces.) 2:Intelligent acceleration mode (Acceleration continues at the L3-02 current level. Set acceleration time is disregarded.)	0 to 2	0	No	A	No	520H
L3-02	Stall prevention level during accel / StallP Accel Lvl	Effective when L3-01 is set to 1 or 2. Set as a percentage of Matrix converter rated current. Normally setting is not necessary. Reduce the value if the motor stalls with the factory settings.	0 to 200	120 %	No	A	No	521H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L3-03	Stall prevention limit during accel / StallP CHP Lvl	Sets a stall prevention current level during acceleration for speeds between base speed and maximum speed as a percentage of the Matrix converter rated current. This is the frequency range above E1-06 ***101***. Normally setting is not necessary.	0 to 100	100 % <1>	No	A	No	522H

<1> The factory setting will change when the control method is changed.

■ L4: Frequency Detection

User constants for the reference detection function are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L4-01	Speed agree detection level / Spd Agree Level	Effective when “Desired frequency (ref/setting) agree 1,” “Frequency detection 1,” or “Frequency detection 2" is set for a multi-function output. Sets the output frequencies or motor speeds to be detected as percentages.	0.0 to 100.0	0.0 %	No	A	A	530H
L4-02	Speed agree detection width / Spd Agree Width	Effective when “Frequency (speed) agree 1,” “Desired frequency (speed) agree 1,” or “Frequency (FOUT) detection 1,” Frequency (FOUT) detection 2 is set for a multi-function output. Sets the acceptable range for the output as a percentage.	0.0 to 100.0	2.0 %	No	A	A	531H
L4-03	Speed agree detection level (+/-) / Spd Agree Lvl+-	Effective when “Desired frequency (speed) agree 2,” “Frequency (FOUT) detection 3,” or “Frequency (FOUT) detection 4” is set for a multi-function output. Output frequency or motor speed detection range is set as a percentage.	-100.0 to 100.0	0.0 %	No	A	A	532H
L4-04	Speed agree detection width (+/-) / Spd Agree Width+-	Effective when “Frequency (speed) agree 2,” “Desired frequency (speed) agree 2,” Frequency (FOUT) detection 3 or “Frequency detection 4" is set for a multi-function output. Sets the acceptable range for the output as a percentage.	0.0 to 100.0	2.0 %	No	A	A	533H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L4-05	Operation when frequency reference is missing / Ref Loss Sel	0: Stop (Operation follows the frequency reference.) 1: Operation at 80 % speed continues. (At 80 % of speed before the frequency reference was lost) "Frequency reference is lost" is defined as: Frequency reference dropped over 90 % in 400 ms.	0 or 1	0	No	A	A	534H

■ L5: Fault Restart

User constants for the auto restart function are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L5-01	Number of auto restart attempts / Num of Restarts	Sets the number of auto restart attempts. Automatically restarts after a fault and conducts a speed search from the run frequency.	0 to 5	0	No	A	A	540H
L5-02	Auto restart operation selection / Restart Sel	Sets whether a fault contact output is activated during fault restart. 0: Not output (Fault contact is not activated.) 1: Output (Fault contact is activated.)	0 or 1	0	No	A	A	541H
L5-03	Maximum restart time / Max Restart Time	The Matrix converter will continue to execute fault restarts until the time in L5-03 passes. If a successful fault restart has not occurred, this parameter will cause a fault and the restart process will cease.	0.01 to 18.00	0.05	No	A	A	542H

■ L6: Overtorque/Undertorque Detection

User constants for the torque detection function are shown in the following table.

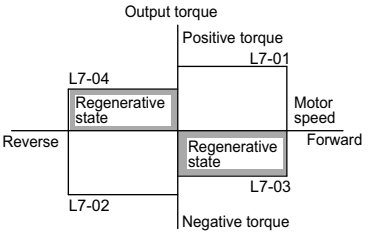
Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L6-01	Overtorque/ Undertorque detection selection 1 Torq Det 1 Sel	0: Overtorque/undertorque detection disabled. 1: Overtorque detection only with speed agreement <1>; operation continues after overtorque (warning). 2: Overtorque detected continuously during operation; operation continues after overtorque (warning). 3: Overtorque detection only with speed agreement; output stopped upon detection (protected operation). 4: Overtorque detected continuously during operation; output stopped upon detection (protected operation). 5: Undertorque detection only with speed agreement <1>; operation continues after overtorque (warning). 6: Undertorque detected continuously during operation; operation continues after overtorque (warning). 7: Undertorque detection only with speed agreement <1>; output stopped upon detection (protected operation). 8: Undertorque detected continuously during operation; output stopped upon detection (protected operation).	0 to 8	0	No	A	A	550H
L6-02	Overtorque/ Undertorque detection level 1 Torq Det 1 Lvl	Sets the detection level 1 as a percentage of the motor rated torque.	0 to 300	150 %	No	A	A	551H
L6-03	Overtorque/ Undertorque detection time 1 Torq Det 1 Time	Sets the overtorque/undertorque detection time in 1-second units.	0.0 to 10.0	0.1 s	No	A	A	552H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L6-04	Overtorque/Undertorque detection selection 2 / Torq Det 2 Sel	Multi-function output for overtorque detection 1 is output to multi-function contact output when overtorque detection 1 NO or overtorque detection 1 NC is selected. Multi-function output for overtorque detection 2 is output to multi-function contact output when overtorque detection 2 NO or overtorque detection 2 NC is selected.	0 to 8	0	No	A	A	553H
L6-05	Overtorque/Undertorque detection level 2 / Torq Det 2 Lvl		0 to 300	150 %	No	A	A	554H
L6-06	Overtorque/Undertorque detection time 2 / Torq Det 2 Time		0.0 to 10.0	0.1 s	No	A	A	555H

<1> “Speed agreement” means “at set speed”, i.e., not accelerating or decelerating.

■ L7: Torque Limits

User constants for torque limits are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L7-01	Forward drive torque limit / Torq Limit Fwd	Sets the torque limit value as a percentage of the motor rated torque. Four individual regions can be set. 	0 to 300	150 %	No	A	A	560H
L7-02	Reverse drive torque limit / Torq Limit Rev		0 to 300	150 %	No	A	A	561H
L7-03	Forward regenerative torque limit / Torq Lmt Fwd Rgn		0 to 300	150 %	No	A	A	562H
L7-04	Reverse regenerative torque limit / Torq Lmt Rev Rgn		0 to 300	150 %	No	A	A	563H

■ L8: Hardware Protection 1

User constants for hardware protection functions are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L8-07	Output open-phase protection selection / Ph Loss Out Sel	0: Disabled 1: Enabled (Detects open phase of one phase only) 2: Enabled (Detects open phase of two or more phases) When applied motor capacity is small for Matrix converter capacity, output open-phase may be detected inadvertently or open-phase may not be detected. In this case, set to 0.	0 to 2	2	No	A	A	576H
L8-08	Output open-phase detection level / Ph Loss Out Lvl	• In the case of L8-07=1 When output current > 5 % and output frequency ≥1.0 Hz, if the output current of one of U, V, and W is less than L8-08, and when it continues 500 ms or more, it is detected as output open-phase. • In the case of L8-07=2 When the output frequency ≥1.0 Hz, and all the output current of U, V and W is less than L8-08, and when it continues 500 ms or more, it is detected as output open-phase. • The count at 500 ms is an UP/DOWN counter.	0.0 to 20.0	3.0 %	No	A	A	577H
L8-19	Soft CLA selection / Soft CLA Sel	0: Disable (Gain is set to 0) 1: Enable	0 or 1	1	No	A	A	582H

■ L9: Hardware Protection 2

User constants for hardware protection 2 functions are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L9-01	Main power supply input voltage / Main Input Volt	Sets the Matrix converter main input voltage in 1 volt. (Transformer primary side) This setting is used as a reference value in protection functions.	3500 to 4800	4160 V	No	A	A	5A0H
L9-02	Input overvoltage detection selection / IOV Select	Selects the operation when overvoltage is detected. 0: Detection disabled 1: Coast to a stop (fault) 2: Continue operation (alarm)	0 to 2	1	No	A	A	5A1H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L9-03	Input overvoltage detection time / IOV Time	Sets the input overvoltage detection time in 0.01 s units. Any input voltage above 120 % of the L9-01 set level that continues for the time set in L9-03 is detected.	0.00 to 2.00	0.05 s	No	A	A	5A2H
L9-06	Output overvoltage detection level / OUTPUT OV Lvl	Sets the output overvoltage detection level in 0.1 % units. [100 %: Maximum motor voltage (E1-05)]	110.0 to 200.0	120 %	No	A	A	5A5H
L9-07	Output overvoltage detection time / OV Time	Sets the output overvoltage detection time in 0.01-seconds units. Any output voltage above the L9-06 set level that continues for the time set in L9-07 is detected.	0.00 to 10.00	1.00 s	No	A	A	5A6H
L9-14	Control power supply fault detection selection / Term20 Det Sel	Selects the control power supply fault detection. 0: Detection disabled 1: Detection enabled	0 or 1	0	No	A	A	5ADH
L9-20	Selection of operation when ground fault is detected on output side / OGF Select	Selects the operation when software detects output ground fault. 0: Detection disabled 1: Coast to a stop (fault) 2: Continue operation (alarm)	0 to 2	1	No	A	A	5B3H
L9-21	Output ground fault detection level / Output OGF Lvl	Sets the software output ground fault detection level in units of 0.1 %. (100 %: Voltage class) (3 kV class: 3300 V, 4kV class: 4160V, 6 kV class: 6600 V)	0.0 to 100.0	5.0 %	No	A	A	5B4H
L9-22	Output ground fault detection time / OGF Time	Sets the time for software output ground fault detection in units of 0.001 second. The output ground fault (OGF) is detected when the total of output voltage of three phases exceeds the level set in L9-21 for the time set in L9-22 or longer.	0.001 to 2.000	0.200 s	No	A	A	5B5H

◆ n: Special Adjustments

The following settings are made with the special adjustments constants (N constants): Speed feedback detection control.

■ n2: Speed Feedback Detection Control Functions

User constants for speed feedback detection control functions are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
n2-01	Speed feedback detection control Automatic Flux Regulator (AFR) gain / AFR Gain	Sets the internal speed feedback detection control gain using a multiplication function. Normally, there is no need to adjust this setting. Adjust this constant as follows: If hunting occurs, increase the set value. If response is slow, decrease the set value. Adjust the setting by 0.05 at a time, while checking the response.	0.00 to 10.00	2.00	No	A	No	5D0H
n2-02	Speed feedback detection control (AFR) time constant / AFR Time	Sets the time constant to define the rate of change in the speed feedback detection control. Setting unit: ms	0 to 2000	250 ms	No	A	No	5D1H
n2-03	Speed feedback detection control (AFR) time constant 2 / AFR Time 2	Increase the setting if overvoltage (OV) failures occur at the completion of acceleration, or when the load changes rapidly. Setting unit: ms	0 to 2000	750 ms	No	A	No	5D2H
n2-05	Starting gain for AFR gain change / AFR G of Start	Sets the gain to the AFR gain at 0 Hz. Controls hunting by AFR at low speed (0 to12 Hz).	0.00 to 2.00	0.20	No	A	No	5D4H

■ n9: Factory Adjustment 1

User constants for factory adjustment are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
n9-03	ACR q gain during normal operations / ACR q Gain	Sets the ACR q gain for the normal control range.	0.00 to 2.00	0.40 <1>	No	A	A	692H
n9-04	ACR q integral time during normal operations / ACR q I Time	Sets the ACR q integral time for the normal control range.	0.0 to 100.0	6.0 ms <1>	No	A	A	693H
n9-05	ACR q limit during normal operations / ACR q Limit	Sets the ACR q limit for the normal control range.	0 to 150	100 % <1>	No	A	A	694H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
n9-06	ACR d gain during normal operations / ACR d Gain	Sets the ACR d gain for the normal control range.	0.00 to 2.00	0.40 <1>	No	A	A	695H
n9-07	ACR d integral time during normal operations / ACR d I Time	Sets the ACR d integral time for the normal control range.	0.0 to 100.0	6.0 ms <1>	No	A	A	696H
n9-08	ACR d limit during normal operations / ACR d Limit	Sets the ACR d limit for the normal control range.	0 to 150	100 % <1>	No	A	A	697H

<1> The factory setting will change when the control method is changed.

◆ o: Digital Operator Constants

The following settings are made with the Digital Operator constants (o constants): Monitor select and multi-function selections.

■ o1: Monitor Select

User constants for Digital Operator Displays are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
o1-05	LCD brightness adjustment / LCD Contrast	Sets a smaller value to lighten the LCD and a larger value to darken the LCD (standard: 10).	0 to 20	10	No	A	A	6E4H

■ o2: Multi-function Selections

User constants for Digital Operator key functions are shown in the following table.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
o2-01	LOCAL/REMOTE key enable/disable / Local/Remote Key	Sets the Digital Operator Local/ Remote Key 0: Disabled 1: Enabled (Switches between the Digital Operator and the constant settings.)	0 or 1	1	No	A	A	6F0H
o2-02	STOP key during control circuit terminal operation / Oper STOP Key	Sets the Stop Key in the run mode. 0: Disabled (When the Run Command is issued from and external terminal, the Stop Key is disabled.) 1: Enabled (Effective even during run.)	0 or 1	0	No	A	A	6F1H

Constant Number	Name Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods Open-loop Vector	Control Methods Flux Vector	MEMOBUS Register
o2-04	kVA selection	Not initialized in A1-03 (Initialize). Code: rated voltage, kVA, HP, rated current 90: 4 kV class, 505 kVA, 550 HP, 70 A 91: 4 kV class, 650 kVA, 700 HP, 90 A 92: 4 kV class, 735 kVA, 800 HP, 102 A 93: 4 kV class, 830 kVA, 900 HP, 115 A 94: 4 kV class, 890 kVA, 1000 HP, 123 A 95: 4 kV class, 1110 kVA, 1250 HP, 154 A 96: 4 kV class, 1330 kVA, 1500 HP, 185 A 97: 4 kV class, 1550 kVA, 1750 HP, 215 A 98: 4 kV class, 1765 kVA, 2000 HP, 245 A 99: 4 kV class, 2025 kVA, 2250 HP, 281 A 9A: 4 kV class, 2240 kVA, 2500 HP, 311 A 9B: 4 kV class, 2420 kVA, 2750 HP, 336 A 9C: 4 kV class, 2680 kVA, 3000 HP, 372 A 9D: 4 kV class, 3140 kVA, 3500 HP, 436 A 9E: 4 kV class, 3750 kVA, 4000 HP, 520 A Normally setting is not necessary.	60 to FFH	Code corresponding to Matrix converter capacity	No	A	A	6F3H
o2-05	Frequency reference setting method selection Operator M.O.P.	When the frequency reference is set on the Digital Operator frequency reference monitor, sets whether the Enter Key is necessary. 0: Enter Key needed 1: Enter Key not needed A setting of 1 creates a digital M.O.P. function.	0 or 1	0	No	A	A	6F4H
o2-06	Operation selection when digital operator is disconnected Oper Detection	Sets the operation when the Digital Operator is disconnected. 0: Disabled (Operation continues even if the Digital Operator is disconnected.) 1: Enabled (OPR is detected at Digital Operator disconnection. Matrix converter output is cut off, and fault contact is operated.)	0 or 1	0	No	A	A	6F5H
o2-07	Cumulative operation time setting Elapsed Time Set	Sets the cumulative operating time in hours. Operation time is calculated from the set value.	0 to 65535	0 hr	No	A	A	6F6H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
o2-08	Cumulative operation time selection / Elapsed Time Run	0: Cumulative time when the primary power supply comes on (The time from the moment the primary power supply comes on until it turns off is totalled.) 1:Cumulative operation time (The time while the matrix converter is outputting voltage after baseblock is cancelled is totalled.)	0 or 1	0	No	A	A	6F7H

◆ Y: Factory Settings

Note: The "Y" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "Y" parameters are not normally part of user setup.

Use the factory constants (Y constants) to set the hardware adjustment settings.

■ Y1: Factory Setting 2

The following table shows the user constants for factory setting 2 display.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
Y1-22	Gain equivalent to input voltage / Input V Gain	Gain for adjustment of input voltage detection value (Operated in inverse proportion)	0 to 10.000	5.389	No	A	A	785H
Y1-23	Gain equivalent to input current / Input I Gain	Gain for adjustment of input current detection value (Operated in inverse proportion)	0 to 15.000	3.300 <1>	No	A	A	786H
Y1-24	Gain equivalent to output voltage / Output V Gain	Gain for adjustment of output voltage detection value (Operated in inverse proportion)	0 to 10.000	5.389	No	A	A	787H
Y1-25	Gain equivalent to output current / Output I Gain	Gain for adjustment of output current detection value (Operated in inverse proportion)	0 to 10.000	5.940 <1>	No	A	A	788H
Y1-26	Transformer primary input voltage / Input V of Trans	Set the transformer primary rated voltage.	12100 to 3700 <1>	4.160 V <1>	No	A	A	789H

<1> The factory settings depend on the Matrix converter capacity.

◆ T: Motor Autotuning

The following settings are made with the motor autotuning constants (T constants): Settings for autotuning.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
T1-01	Autotuning mode Tuning Mode Sel	Sets the autotuning mode. 0: Rotational autotuning 1: Stationary autotuning for line-to-line resistance only	0 or 2	0	No	Yes	Yes	720H
T1-03	Motor rated voltage Rated Voltage	Sets the voltage equivalent to the rated speed of no-load operation.	0 to 8000	E1-13 V	No	Yes	Yes	722H
T1-04	Motor rated current Rated Current	Sets the rated current on the nameplate in units of A.	0.1 to 1500.0	E2-01 A	No	Yes	Yes	723H
T1-05	Motor rated frequency Rated Frequency	Sets the motor base frequency on the nameplate in units of Hz.	0.00 to 400.00	E1-06 Hz	No	Yes	Yes	724H
T1-06	Number of motor poles Number of Poles	Sets the number of poles on the nameplate.	2 to 48	E2-04	No	Yes	Yes	725H
T1-07	Motor base speed Rated Speed	Sets the base speed on the nameplate. (Rated speed with rated load)	0 to 12000	Calculated value r/min	No	Yes	Yes	726H
T1-08	Number of PG pulses when rotating PG Pulses/Rev	Sets the number of pulses per revolution for the PG (pulse generator or encoder) being used without any multiplication factor.	0 to 8192	H7-01	No	–	Yes	727H
T1-10	Motor insulation class Insulation class	Sets the motor insulation class on the nameplate. 0: Insulation class A (100°C) 1: Insulation class E (120°C) 2: Insulation class B (130°C) 3: Insulation class F (155°C) 4: Insulation class H (180°C)	0 to 4	1	No	Yes	Yes	729H

◆ U: Monitor Constants

The following settings are made with the monitor constants (U constants): Setting constants for monitoring in drive mode.

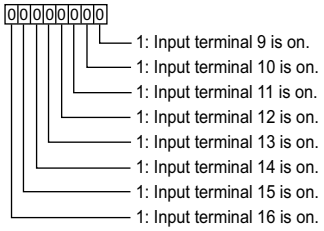
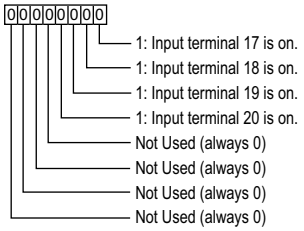
■ U1: Status Monitor Constants

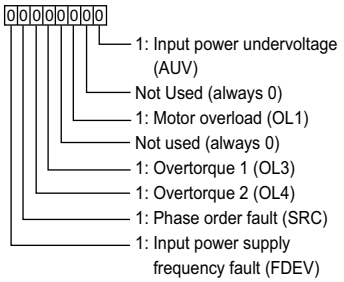
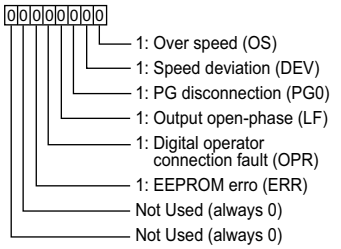
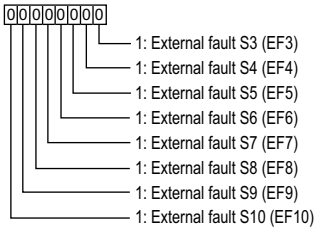
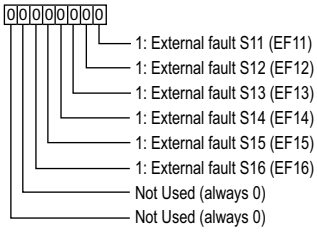
The constants used for monitoring status are listed in the following table.

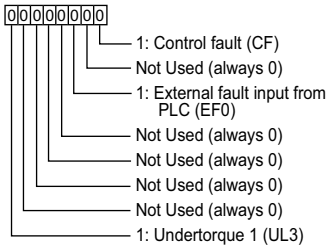
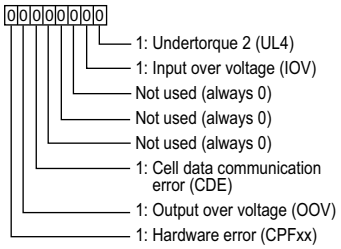
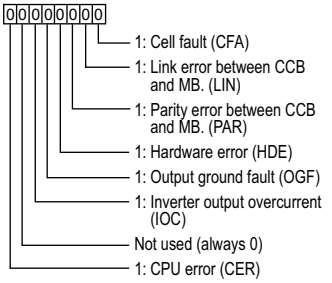
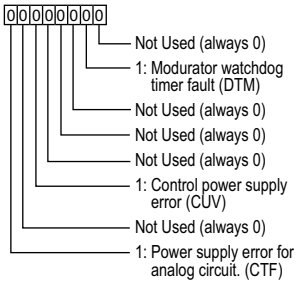
Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U1-01	Speed reference Frequency Ref	Monitors/sets the speed reference value.	Maximum speed	0.01 %	A	A	40H
U1-02	Output frequency Output Freq	Monitors the output frequency.	Maximum frequency	0.01 Hz	A	A	41H
U1-03	Output current Output Current	Monitors the output current.	Matrix converter rated output current	0.1 A	A	A	42H
U1-04	Control method Control Method	Checks the current control method.	(Cannot be output.)	[No.]	A	A	43H

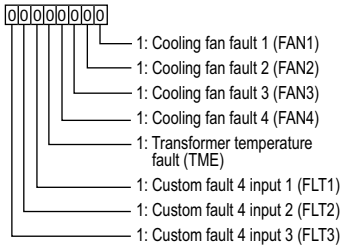
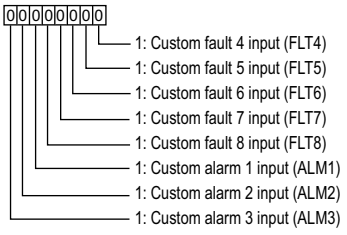
Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U1-05	Motor speed Motor Speed	Monitors the detected motor speed.	Maximum speed	0.01 %	A	A	44H
U1-06	Output voltage Output Voltage	Monitors the output voltage reference value in the Matrix converter.	Voltage class (4160 Vac)	1 V	A	A	45H
U1-08	Output power Output kWatts	Monitors the output power.	Matrix converter capacity (maximum applicable motor capacity)	1 kW	A	A	47H
U1-09	Torque reference Torque Reference	Monitors the internal torque reference value.	Motor rated torque	0.1 %	A	A	48H
U1-10	Shows input on/ off status. (1-8) Input Sts (1-8)	0 0 0 0 0 0 0 0 1: Input terminal 1 is on. 1: Input terminal 2 is on. 1: Input terminal 3 is on. 1: Input terminal 4 is on. 1: Input terminal 5 is on. 1: Input terminal 6 is on. 1: Input terminal 7 is on. 1: Input terminal 8 is on.	–	[Bit]	A	A	49H
U1-11	Shows output on/ off status. (1-8) Output Term Sts	0 0 0 0 0 0 0 0 1: Output terminal 1 is on. 1: Output terminal 2 is on. 1: Output terminal 3 is on. 1: Output terminal 4 is on. 1: Output terminal 5 is on. 1: Output terminal 6 is on. 1: Output terminal 7 is on. 1: Output terminal 8 is on.	–	[Bit]	A	A	4AH
U1-12	Matrix converter operating status Int Ctl Sts	Matrix converter operating status. Low/High register is changed by the digital operator [DATA/ENTER] key. Lower register (L) status 0 0 0 0 0 0 0 0 1: Run 1: Zero speed 1: Reverse 1: Reset signal input 1: Speed agree 1: Inverter ready 1: Minor fault 1: Major fault High register (H) status 0 0 0 0 0 0 0 0 1: Operation fault 1: Restarted after power loss 1: Remote operation 1: During regenarative operation Not Used (always 0) 1: During speed limit. Not Used (always 0) Not Used (always 0)	–	[Bit]	A	A	4BH
U1-13	Cumulative operation time Elapsed Time	Monitors the total operating time of the Matrix converter.	–	1H	A	A	4CH

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U1-14	Software No. (CPU) / CPU Rev.	(Manufacturer's ID number)	–	[No.]	A	A	4DH
U1-15	Terminal AI1 input voltage / AI1 Input	Monitors the input voltage of the multi-function analog input 1.	10 V	0.01 %	A	A	4EH
U1-16	Terminal AI2 input voltage / AI2 Input	Monitors the input voltage of the multi-function analog input 2.	10 V	0.01 %	A	A	4FH
U1-17	Terminal AI3 input voltage / AI3 Input	Monitors the input voltage of the multi-function analog input 3.	10 V	0.01 %	A	A	50H
U1-18	Motor secondary current (Iq) / Mot SEC Current	Monitors the calculated value of the motor secondary current.	Motor rated secondary current	0.1 %	A	A	51H
U1-19	Motor exciting current (Id) / Mot EXC Current	Monitors the calculated value of the motor excitation current.	Motor rated secondary current	0.1 %	A	A	52H
U1-20	Output frequency after soft-start / SFS Output	Monitors the output frequency after a soft start.The frequency given does not include compensations, such as slip compensation.	Maximum frequency	0.01 %	A	A	53H
U1-21	ASR input / ASR Input	Monitors the input to the speed control loop.	Maximum frequency	0.01 %	No	A	54H
U1-22	ASR output / ASR Output	Monitors the output from the speed control loop.	Motor rated secondary current	0.01 %	No	A	55H
U1-23	ASR integral value / ASR Integral	Monitors the integral value from the speed control loop.	Motor rated secondary current	0.01 %	No	A	56H
U1-25	Terminal AI4 input voltage / AI4 Input	Monitors the input voltage of the multi-function analog input 4.	10 V	0.1 %	A	A	58H
U1-26	Output voltage reference (Vq) / Voltage Ref (Vq)	Monitors the Matrix converter internal voltage reference for motor secondary current control.	Voltage class (4160 Vac)	1 V	A	A	59H
U1-27	Output voltage reference (Vd) / Voltage Ref (Vd)	Monitors the Matrix converter internal voltage reference for motor excitation current control.	Voltage class (4160 Vac)	1 V	A	A	5AH
U1-28	Software No.(FPGA) / FPGA Rev.	(Manufacturer's FPGA software No.)	–	[No.]	A	A	5BH
U1-32	ACR output of q axis / ACR(q) Output	Monitors the current control output value for the motor secondary current.	Voltage class (4160 Vac)	0.1 %	A	A	5FH
U1-33	ACR output of d axis / ACR(d) Output	Monitors the current control output value for the motor excitation current.	Voltage class (4160 Vac)	0.1 %	A	A	60H
U1-34	OPE fault constant / OPE Detected	Shows the first constant number where an OPE fault was detected.	–	Constant Number	A	A	61H

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U1-41	Actual fin temperature / Actual Fin Temp	Monitors the temperature of fin in A1 cell. (temperature is displayed above about 80°C)	–	1°C	A	A	68H
U1-42	Shows input on/off status. (9-16) / Input Sts(9-16)		–	[Bit]	A	A	69H
U1-43	Shows input on/off status. (17-20) / Input Sts(17-20)		–	[Bit]	A	A	6AH
U1-46	Superior command 1 / Superior Cmd 1	The operation command lower byte from the built-in PLC	–	[Bit]	A	A	6DH
U1-47	Superior command 2 / Superior Cmd 2	The operation command high byte from the built-in PLC	–	[Bit]	A	A	6EH
U1-49	Output zero-voltage / Output Zero V	Monitors the output zero-phase voltage value in the Matrix converter.	–	1 V	A	A	70H
U1-51	Input torque compensation / Input T-Cmp	Monitors the Input torque compensation.	Motor rated torque	0.01 %	No	A	72H
U1-52	Slip frequency reference / Slip Reference	Monitors the slip frequency reference.	Motor rated slip	0.01 %	A	A	73H
U1-53	Magnetic flux reference / Mag-flux Ref.	Monitors the magnetic flux reference.	Motor no-load current	0.01 %	A	A	74H
U1-54	Power supply descent value / Power Descent	Not used.	–	0.01 %	A	A	75H
U1-55	Motor temperature / Motor Temp.	Monitors the motor temperature. (Enabled only when E2-14 is set to 1 (enabled).)	–	1°C	A	A	76H
U1-64	Current reference of q axis / Iq Reference	Monitors the current reference of q axis.	Motor rated current	0.1 %	A	A	7FH
U1-65	Current reference of d axis / Id Reference	Monitors the current reference of d axis.	Motor rated current	0.1 %	A	A	80H
U1-71	PG counter value / PG Counter Value	Monitors the pulse counter from PG (pulse generator or encoder).	65536	Pulse	–	A	86H

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U1-77	Output current average / Output I Average	Monitors the average output current integrated value. (Average current over 40 minutes.)	Matrix converter rated output current	0.1 A	A	A	8CH
U1-78	Output voltage / Output Voltage	Monitors the output voltage.	Voltage class (4160 Vac)	1 V	A	A	8DH
U1-80	Error status 1 / Error Sts 1	Matrix converter error status 1. Low/High register is changed by the digital operator [DATA/ENTER] key. Lower register (L) status  High register (H) status  	–	[Bit]	A	A	8FH
U1-81	Error status 2 / Error Sts 2	Matrix converter error status 2. Low/High register is changed by the digital operator [DATA/ENTER] key. Lower register (L) status  High register (H) status  	–	[Bit]	A	A	90H

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U1-82	Error status 3 Error Sts 3	Matrix converter error status 3. Low/High register is changed by the digital operator [DATA/ENTER] key. Lower register (L) status  High register (H) status  	–	[Bit]	A	A	91H
U1-83	Error status 4 Error Sts 4	Matrix converter error status 4. Low/High register is changed by the digital operator [DATA/ENTER] key. Lower register (L) status  High register (H) status  	–	[Bit]	A	A	92H

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U1-84	Error status 5 Error Sts 5	Matrix converter error status 5. Low/High register is changed by the digital operator [DATA/ENTER] key. Lower register (L) status  High register (H) status  	–	[Bit]	A	A	93H
U1-86	AO1 output value AO1 output value	Monitors the AO1 output value. -10 to +10[V]: -32768 to 32767	32767	–	A	A	95H
U1-87	AO2 output value AO2 Output	Monitors the AO2 output value. -10 to +10[V]: -32768 to 32767	32767	–	A	A	96H
U1-88	AO3 output value AO3 Output	Monitors the AO3 output value. -10 to +10[V]: -32768 to 32767	32767	–	A	A	97H
U1-89	AO4 output value AO4 Output	Monitors the AO4 output value. -10 to +10[V]: -32768 to 32767	32767	–	A	A	98H
U1-90	Power supply voltage Power Voltage	Monitors the main power supply input voltage.	Main circuit input voltage (L9-01)	1 V	A	A	99H
U1-94	Power supply current Power Current	Not used.	–	0.1 A	A	A	9DH
U1-95	Primary current reference Primary Cur Ref.	Monitors the primary current reference.	0.1 %	0.1 %	A	A	9EH

■ U2: Fault Trace

User constants for error tracing are shown in the following table.

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U2-01	Current fault / Current Fault	Cleared by fault reset.	–	Error Code	A	A	–
U2-02	Previous fault / Last Fault	Cleared by initialize.	–	Error Code	A	A	–
U2-03	Speed reference at fault (U1-01) / Frequency Ref	Cleared by initialize.	Maximum speed	0.01 %	A	A	–
U2-04	Output frequency at fault (U1-02) / Output Freq	Cleared by initialize.	Maximum frequency	0.01Hz	A	A	–
U2-05	Output current at fault (U1-03) / Output Current	Cleared by initialize.	Matrix converter rated output current	0.1 A	A	A	–
U2-06	Motor speed at fault (U1-05) / Motor Speed	Cleared by initialize.	Maximum speed	0.01 %	A	A	–
U2-07	Output voltage at fault (U1-06) / Output Voltage	Cleared by initialize.	Voltage class 3300 Vac (6600 Vac)	0.1 V	A	A	–
U2-09	Output power at fault (U1-08) / Output kWatts	Cleared by initialize.	Matrix converter capacity (maximum applicable motor capacity)	0.1 kW	A	A	–
U2-10	Torque reference at fault (U1-09) / Torque Reference	Cleared by initialize.	Motor rated torque	0.1 %	A	A	–
U2-11	Input terminal status at fault (U1-10) / Input Term Sts	Cleared by initialize. The format is the same as for U1-10.	–	[Bit]	A	A	–
U2-12	Output terminal status at fault (U1-11) / Output Term Sts	Cleared by initialize. The format is the same as for U1-11.	–	[Bit]	A	A	–
U2-13	Operation status 1 at fault (U1-12_L) / MxC Status	Cleared by initialize. The format is the same as for U1-12(L).	–	[Bit]	A	A	–
U2-14	Operation status 2 at fault (U1-12_H) / MxC Status 2	Cleared by initialize. The format is the same as for U1-12(H).	–	[Bit]	A	A	–
U2-15	Cumulative operation time at fault (U1-13) / Elapsed time	Cleared by initialize.	–	1H	A	A	–

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U2-18	ASR output at fault (U1-22) / ASR Output	Cleared by initialize.	Motor rated secondary current	0.01 %	No	A	–
U2-20	Input torque compensation at fault (U1-51) / Input T-Cmp	Cleared by initialize.	Motor rated torque	0.01 %	No	A	–
U2-21	Magnetic flux reference at fault (U1-53) / Mag-flux Ref	Cleared by initialize.	Motor no-load current	0.01 %	A	A	–

■ U4: Calendar

The constants used for monitoring calendar are listed in the following table.

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U4-01	Monitor Year / Year	Monitors the year of calendar. (Last two places)	–	–	A	A	–
U4-02	Monitor Month and Date / Month/Date	Monitors the month and the day of calendar.	–	–	A	A	–
U4-03	Monitor Hour and Minute / Hour/Minute	Monitors the hours and the minutes of calendar.	–	–	A	A	–
U4-04	Monitor Minute and Second / Minute/Second	Monitors the minutes and the seconds of calendar.	–	–	A	A	–

■ U5: Cell Monitor

The constant used for monitoring power cell temperature is in the following table.

Constant Number	Name / Display	Description	100 % Value	Unit	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
U5-01 nn*	Cell temperature (IGBT) / Cell Temp (IGBT)	Monitors cell temperature (IGBT). * nn means cell number.	–	1°C	A	A	–

Note: **1.** Monitoring range of cell temperature (IGBT) in U5-01: 25°C to 130°C ± 5°C
2. A temperature below 25°C will not be accurately displayed.

6

Constant Settings by Function

6.1 Frequency Reference

This section explains how to input the frequency reference.

◆ Selecting the Frequency Reference Source

Set constant b1-01 to select the frequency reference source.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b1-01	Reference selection / Reference Source	Sets the frequency reference input method. 0: Digital Operator 1: Control circuit terminal (analog input) 2: MEMOBUS communications 3: Built-in PLC	0 to 3	3	No	Q	Q	1A0H

■ Input the Reference Frequency from the Digital Operator

When b1-01 is set to 0, the frequency reference can be set from the Digital Operator.

For details on setting the reference frequency, refer to ***Digital Operator on page 58***.

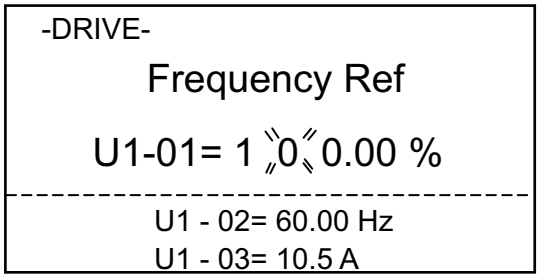


Figure 6.1 Frequency Setting Display

■ Inputting the Frequency Reference Using Control Circuit Terminal (Analog Setting)

When b1-01 is set to 1, the frequency reference can be set from control circuit terminal AI1.

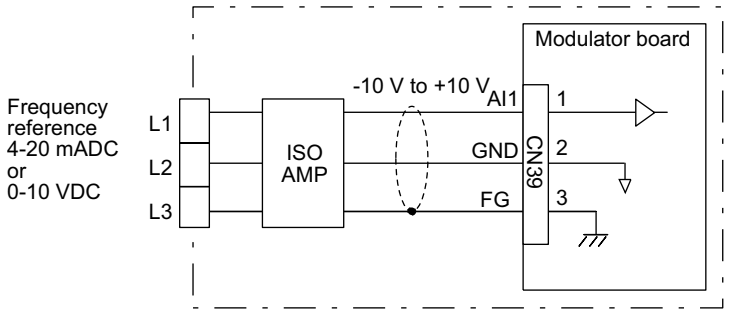


Figure 6.2 Voltage Input for Master Speed Frequency Reference

Note: "ISO AMP" has two types of input, voltage and current. The standard Matrix converter is equipped with an "ISO AMP" which is proportional to 4-20 mADC. When changing the external reference, change the "ISO AMP" as well.

Note: The Factory Setting for b1-01 is 3, since the Matrix converter is normally operated through the built-in PLC. Review the elementary drawing accompanying the specific Matrix converter.

6.2 Run Command

This section explains input methods for the Run Command.

◆ Selecting the Run Command Source

Set constant b1-02 to select the source for the Run Command.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b1-02	Starting command selection / Run Source	Sets the Run Command input method. 0: Digital Operator 1: Control circuit terminal (sequence input) 2: MEMOBUS communications 3: Built-in PLC	0 to 3	3	No	Q	Q	1A1H

■ Performing Operations Using the Digital Operator

When b1-02 is set to 0, the Matrix converter can be operated from the Digital Operator keys (RUN, STOP, JOG, and FWD/REV). For details on the Digital Operator, refer to ***Digital Operator on page 58***.

■ Performing Operations Using Control Circuit Terminals

When b1-02 is set to 1, the Matrix converter can be operated from the control circuit terminals.

Note: The Factory Setting for b1-02 is 3, since the Matrix converter is normally operated through the built-in PLC. Review the elementary drawing accompanying the specific Matrix converter.

6.3 Stopping Methods

This section explains methods of stopping the Matrix converter.

◆ Selecting the Stopping Method at time of Stop Command

There are two methods of stopping the Matrix converter when Stop is commanded:

- Deceleration to stop
- Coast to stop

Set constant b1-03 to select the Matrix converter stopping method.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b1-03	Stopping method selection / Stopping Method	Sets the stopping method used when a Stop Command is input. 0: Deceleration to stop 1: Coast to stop	0 or 1	1	No	Q	Q	1A2H
b1-05	Operation selection when at or below the minimum output frequency setting (E1-09) / Zero-Speed Oper	Sets the method of operation when the frequency reference input is less than the minimum output frequency (E1-09). 0: Run at frequency reference (E1-09 not effective). 1: STOP (coast to stop.) 2: Run at minimum frequency. (E1-09) 3: Run at zero-speed (Stay in RUN mode at zero speed)	0 to 3	1 <1>	No	No	A	1A4H
b2-01	Zero-speed level (DC injection braking starting frequency) / DCInj Start Freq	Defines the frequency where DC injection braking begins when deceleration to stop is selected, in 1 % units. When b2-01 is less than E1-09, E1-09 becomes the DC injection braking starting frequency. (In flux vector control, zero speed control will start when the frequency is the value of b2-01)	0.00 to 10.00	0.50 % <1>	No	A	A	1B0H
b2-02	DC injection braking current / DCInj Current	Sets the DC injection braking current as a percentage of the Matrix converter rated current. In flux vector control, the DC injection braking current depends on the setting of E2-03 ***102***.	0 to 100	50 %	No	A	No	1B1H
b2-03	DC injection braking time at start / DCInj Time@Start	Sets the time to perform DC injection braking at start in units of 1 second. Used to stop a coasting motor and restart it. When the set value is 0, DC injection braking at start is not performed.	0.00 to 10.00	0.00 s	No	A	A	1B2H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b2-04	DC injection braking time at stop / DCInj Time@Stop	Sets the time to perform DC injection braking at stop in units of 1 second. Used to prevent coasting after the Stop Command. When the set value is 0.00, DC injection braking at stop is not performed.	0.00 to 10.00	0.50 s	No	A	A	1B3H

<1> The factory setting will change when the control method is changed.

■ Deceleration to Stop

At the time of a Stop Command (i.e., the Run Command is turned off) when b1-03 is set to 0, the motor decelerates to a stop according to the deceleration time that has been set. (Factory setting: C1-02 (Deceleration Time 1))

When the output frequency while decelerating to stop falls below b2-01, DC injection braking will be applied using the DC current set in b2-02, for the time set in b2-04.

For deceleration time settings, refer to ***Setting Acceleration and Deceleration Times on page 143***.

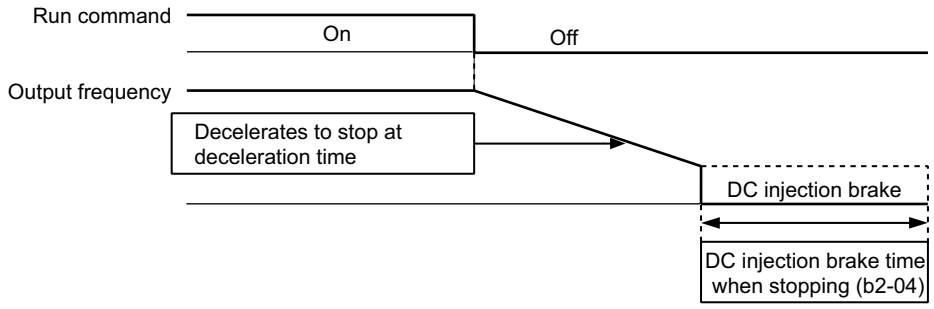


Figure 6.3 Deceleration to Stop

When flux vector control is selected (A1-02 = 3), the Matrix converter will start Zero Speed Control instead of DC Injection Braking.

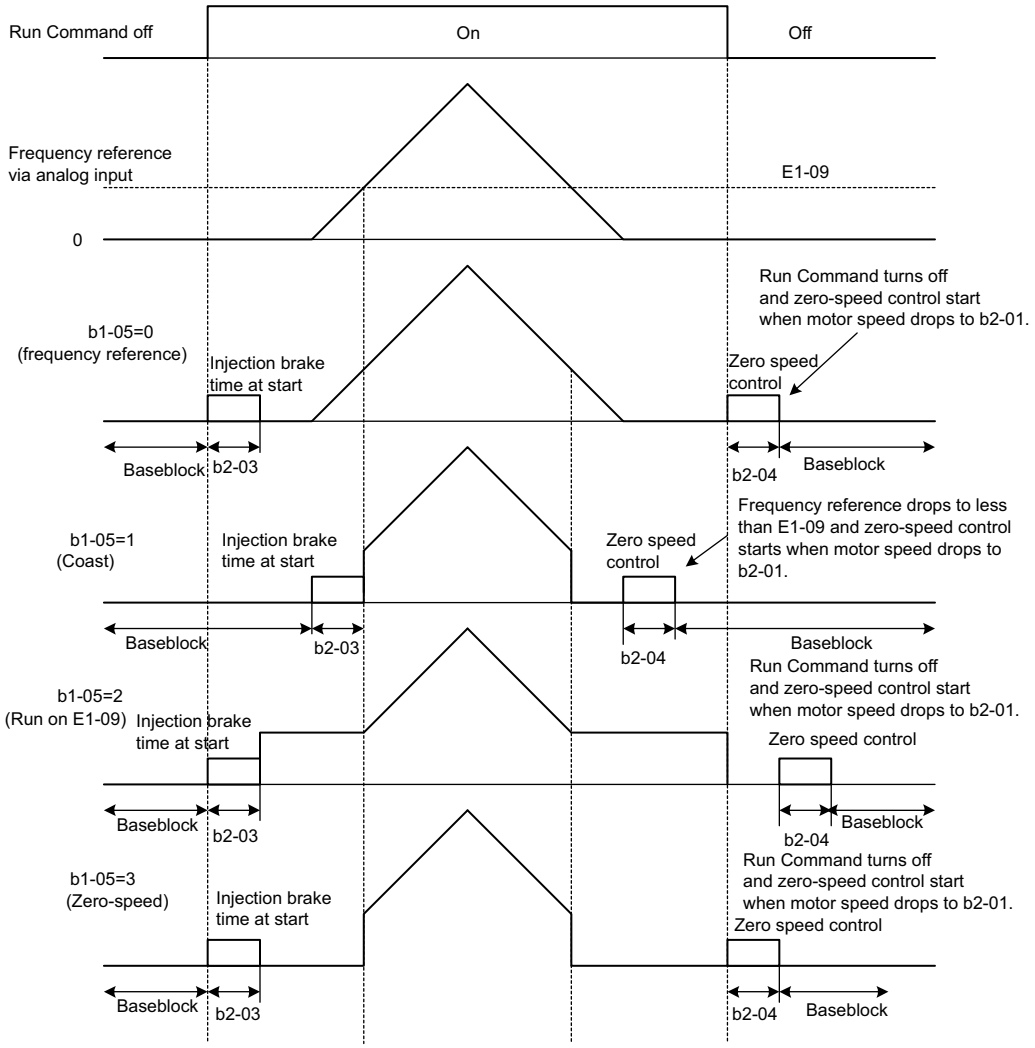


Figure 6.4 Deceleration to Stop (for Flux Vector Control)

Setting Precautions

- When using flux vector control, zero-speed control starts when the motor speed drops to b2-01 during deceleration. Also, setting b2-01 < E1-09 is possible.
- When using flux vector control, the current level during injection brake time at start is the value of E2-03 (motor no-load current). b2-02 is invalid in flux vector control.

■ Coast to Stop

At the time of a Stop Command (i.e., the Run Command is turned off) when b1-03 is set to 1, the Matrix converter output voltage is interrupted. The motor coasts to a stop at the rate defined by friction and the load inertia.

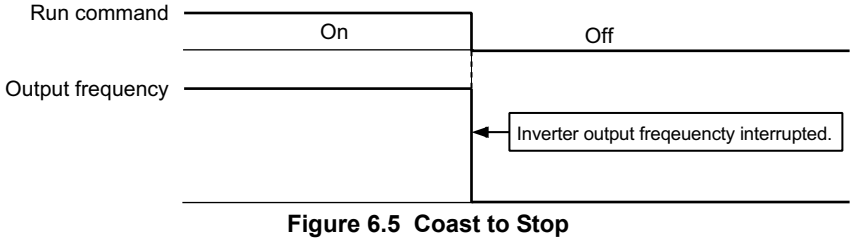


Figure 6.5 Coast to Stop

Note: After a Stop Command, Run Commands are ignored until the Minimum Baseblock Time (L2-03) has elapsed.

◆ Using the DC Injection Brake

At Start: If it is necessary to start a coasting motor, set constant b2-03 to apply DC injection braking current to the motor to stop the motor and then restart it.

Set b2-03 to 0 to disable the DC injection brake at start.

Set the DC injection brake current using b2-02. (b2-02 is only used in open loop vector control. If DC injection braking at start is used for flux vector control, it will use the current set in E2-03 (Motor no-load current)).

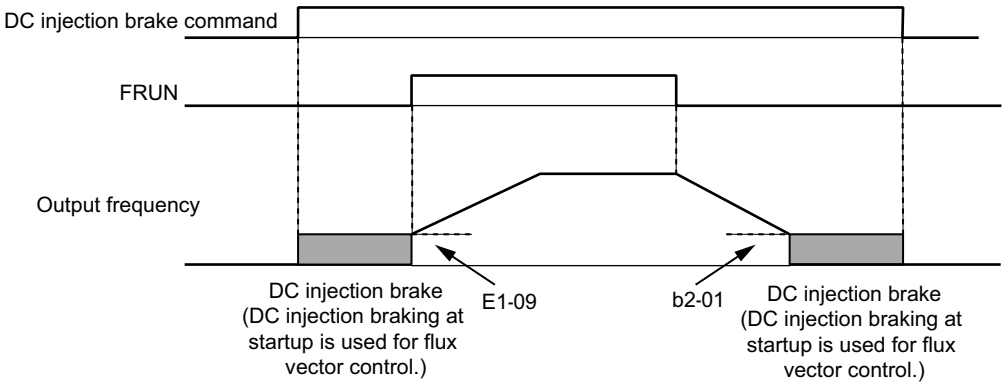
■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b2-02	DC injection braking current / DCInj Current	Sets the DC injection braking current as a percentage of the Matrix converter rated current. In flux vector control, the DC injection braking current will be the setting of E2-03.	0 to 100	50 %	No	A	No	1B1H
b2-03	DC injection braking time at start / DCInj Time@Start	Sets the time to perform DC injection braking at start in units of 1 second. Used to stop a coasting motor and restart it. When the set value is 0, DC injection braking at start is not performed.	0.00 to 10.00	0.00 s	No	A	A	1B2H

■ Inputting the DC Injection Brake Command from Control Circuit Terminals

If a multi-function contact input terminal (H1-□□) is set to 60 (DC injection brake command), the DC injection brake will be applied by activating that terminal. A Start command will override the DC injection brake command. DC injection braking is used at startup for flux vector control.

The time chart for the DC injection brake is shown below.



If the DC injection brake is commanded from an external terminal, and a Run or Jog Command is input, the DC injection brake will be disabled, and operation will resume.

Figure 6.6 DC Injection Brake Time Chart

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the terminals they control are not normally part of user setup.

■ Changing the DC Injection Brake Current Using an Analog Input

If H3-05 (Analog Input Terminal AI2 Function Selection), H3-09 (Analog Input Terminal AI3 Function Selection), or H3-13 (Analog Input Terminal AI4 Function Selection) is set to 6 (DC injection brake current), the DC injection brake current level can be changed using an analog input.

At 10 V input (voltage) or 20 mA input (current), 100 % of the Matrix converter rated current will be applied.

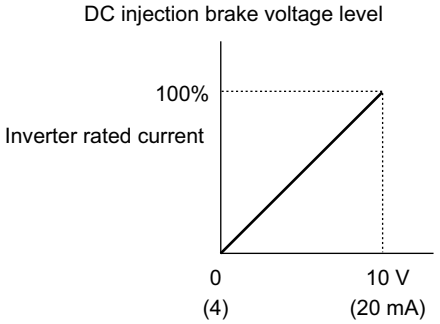


Figure 6.7 DC Injection Brake Current Using an Analog Input

Note: The “H” parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the terminals they control are not normally part of user setup.

◆ Using an Emergency Stop

Set a multi-function input terminal (H1-□□) to 6F or 70 (emergency stop) to coast to a stop. If inputting the emergency stop with an NO contact, set the multi-function input terminal (H1-□□) to 6F, and if inputting the emergency stop with an NC contact, set the multi-function input terminal (H1-□□) to 70.

CAUTION! *The “H” parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the terminals they control are not normally part of user setup. Incorrect wiring of the Emergency Stop function may result in injury. Review the elementary drawing accompanying the specific Matrix converter.*

6.4 Acceleration and Deceleration Characteristics

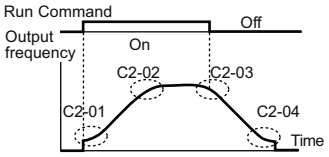
This section explains the acceleration and deceleration characteristics of the Matrix converter.

◆ Setting Acceleration and Deceleration Times

Acceleration time indicates the time taken for the output frequency to climb from 0 % to 100 %. Deceleration time indicates the time taken for the output frequency to reduce from 100 % to 0 %. The factory setting of the acceleration time is C1-01, and the factory setting of the deceleration time is C1-02.

■ Related Parameters

Constant Number	Name	Description	Setting Range	Factory Setting	Change during Operation	Control Methods		MEMOBUS Register
	Display					Open-loop Vector	Flux Vector	
C1-01	Acceleration time 1 Accel Time 1	Sets the acceleration time to accelerate from 0 to the maximum output frequency, in units of 1s.	0.0 to 6000.0	60.0 s	Yes	Q	Q	240H
C1-02	Deceleration time 1 Decel Time 1	Sets the deceleration time to decelerate from the maximum output frequency to 0, in units of 1s.		60.0 s	Yes	Q	Q	241H
C1-03	Acceleration time 2 Accel Time 2	Sets the acceleration time when the multi-function input “Accel/Decel Time 1” is on, in units of 1s.		60.0 s	Yes	A	A	242H
C1-04	Deceleration time 2 Decel Time 2	Sets the deceleration time when the multi-function input “Accel/Decel Time 1” is on, in units of 1s.		60.0 s	Yes	A	A	243H
C1-05	Acceleration time 3 Accel Time 3	Sets the acceleration time when the multi-function input “Accel/Decel Time 2” is on, in units of 1s.		60.0 s	No	A	A	244H
C1-06	Deceleration time 3 Decel Time 3	Sets the deceleration time when the multi-function input “Accel/Decel Time 2” is on, in units of 1s.		60.0 s	No	A	A	245H
C1-07	Acceleration time 4 Accel Time 4	Sets the acceleration time when the multi-function inputs “Accel/Decel Time 1” and “Accel/Decel Time 2” are on, in units of 1s.		60.0 s	No	A	A	246H
C1-08	Deceleration time 4 Decel Time 4	Sets the deceleration time when the multi-function inputs “Accel/Decel Time 1” and “Accel/Decel Time 2” are on, in units of 1s.		60.0 s	No	A	A	247H
C1-11	Accel/decel time switching frequency Acc/Dec SW Freq	Sets the output frequency where acceleration/deceleration ramps will be switched. Below the set frequency: Accel/decel time 4 Above the set frequency: Accel/decel time 1 The multi-function input “accel/decel time 1” or “accel/decel time 2” take priority.	0.0 to 100.00	0.00 %	No	A	A	24AH

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
C2-01	S-curve characteristic time at acceleration start / SCrv Acc @ Start	All sections of the S-curve characteristic time are set in units of 1s. S-curve is used to soften the starting and stopping ramps. The longer the S-curve time, the softer the starting and stopping ramp. 	0.00 to 2.50	0.00 s	No	A	A	250H
C2-02	S-curve characteristic time at acceleration end / SCrv Acc @ End		0.00 to 2.50	0.00 s	No	A	A	251H
C2-03	S-curve characteristic time at deceleration start / SCrv Dec @ Start		0.00 to 2.50	0.00 s	No	A	A	252H
C2-04	S-curve characteristic time at deceleration end / SCrv Dec @ End		0.00 to 2.50	0.00 s	No	A	A	253H

■ Switching Acceleration and Deceleration Time Using Multi-Function Input Terminal Commands

Four acceleration times and four deceleration times can be set in the Matrix converter. When the multi-function input terminals (H1-□□) are set to 7 (acceleration/deceleration time selection 1) and 1A (acceleration/deceleration time selection 2), the acceleration/deceleration times can be switched (even during operation) by combining the on/off status of the terminals.

The following table shows the acceleration/deceleration time switching combinations.

Acceleration/Deceleration Time Selection 1 Terminal	Acceleration/Deceleration Time Selection 2 Terminal	Acceleration Time	Deceleration Time
off	off	C1-01	C1-02
on	off	C1-03	C1-04
off	on	C1-05	C1-06
on	on	C1-07	C1-08

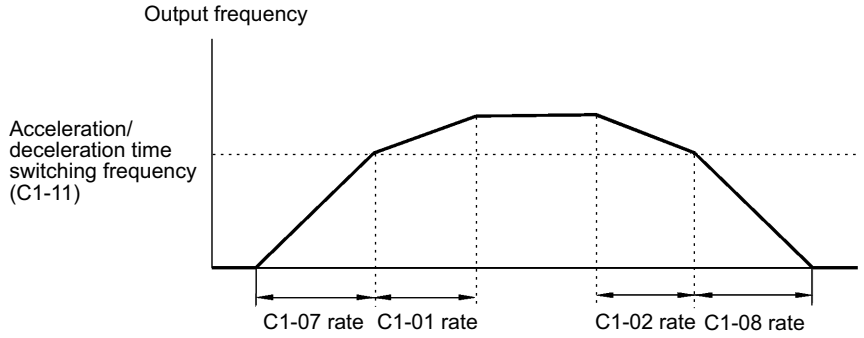
Note: The “H” parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the terminals they control are not normally part of user setup.

■ Switching Acceleration and Deceleration Time Automatically

Use this setting to switch acceleration/deceleration time automatically at a set frequency.

When the output frequency reaches the value set in C1-11, the Matrix converter switches the acceleration/deceleration time automatically as shown in the following diagram.

Set C1-11 to a value other than 0.0 Hz. If C1-11 is set to 0.0 Hz, the function will be disabled.



When output frequency ≥ C1-11, acceleration and deceleration are performed using Acceleration/deceleration Time 1 (C1-01, C1-02).
When output frequency < C1-11, acceleration and deceleration are performed using Acceleration/deceleration Time 4 (C1-07, C1-08).

Figure 6.8 Acceleration/deceleration Time Switching Frequency

■ Entering S-curve Characteristics in the Acceleration and Deceleration Time

By performing acceleration and deceleration using an S-curve pattern, shock can be reduced when starting and stopping the machine.

S-curve characteristic times can be set for each of the following: Acceleration start time, deceleration start time, acceleration end time, and deceleration end time.

Note: Set the S-curve characteristic time to lengthen acceleration/deceleration time as follows:
Acceleration time =Selected acceleration time + (Acceleration start time S-curve characteristic time + Acceleration end time S-curve characteristic time) / 2
Deceleration time =Selected deceleration time + (Deceleration start time S-curve characteristic time + Deceleration end time S-curve characteristic time) / 2

Setting Example

The S-curve characteristic when switching operation (forward/reverse) is shown in the following diagram.

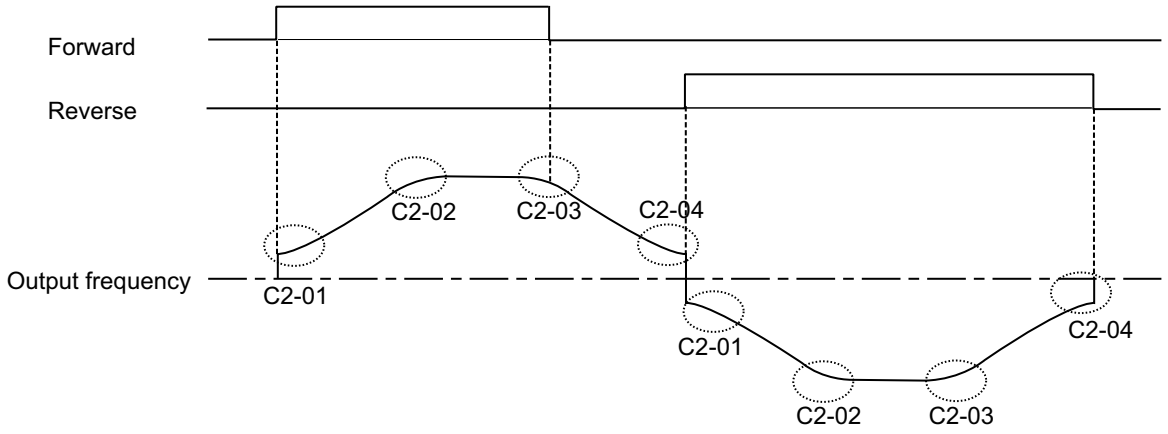


Figure 6.9 S-curve Characteristic during Operation

◆ Preventing the Motor from Stalling During Acceleration (Stall Prevention During Acceleration Function)

An induction motor will stall if the load exceeds its breakdown torque rating. The Stall Prevention During Acceleration function prevents the motor from stalling if a heavy load is placed on the motor, or sudden rapid acceleration is performed.

If L3-01 is set to 1 (enabled) and the Matrix converter output current reaches 85 % of the level set in L3-02, the acceleration rate will begin to slow down. When L3-02 is exceeded, acceleration will stop.

If L3-01 is set to 2 (intelligent acceleration mode), the motor will accelerate at the current level set in L3-02. With this setting, the acceleration time setting is ignored.

■ Related Parameters

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L3-01	Stall prevention selection during accel / StallP Accel Sel	0: Disabled (Acceleration as set. With a heavy load, the Matrix converter may reach current limit or trip (OC) or the motor may stall.) 1: Enabled (Acceleration stops when L3-02 level is exceeded. Acceleration starts again when the current reduces.) 2: Intelligent acceleration mode (Acceleration continues at the L3-02 current level. Set acceleration time is ignored.)	0 to 2	0	No	A	No	520H
L3-02	Stall prevention level during accel / StallP Accel Lvl	Effective when L3-01 is set to 1 or 2. Set as a percentage of Matrix converter rated current. Normally setting is not necessary. Reduce the value if the motor stalls with the factory settings.	0 to 200	120 %	No	A	No	521H
L3-03	Stall prevention limit during accel in Constant HP range (CHP) / StallP CHP Lvl	Sets a stall prevention current level during acceleration for speeds between base speed and maximum speed as a percentage of the Matrix converter rated current. This is the frequency range above E1-06. Normally setting is not necessary.	0 to 100	100 % <1>	No	A	No	522H

<1> The factory setting will change when the control method is changed.

■ Time Chart

The following figure shows the frequency characteristics when L3-01 is set to 1.

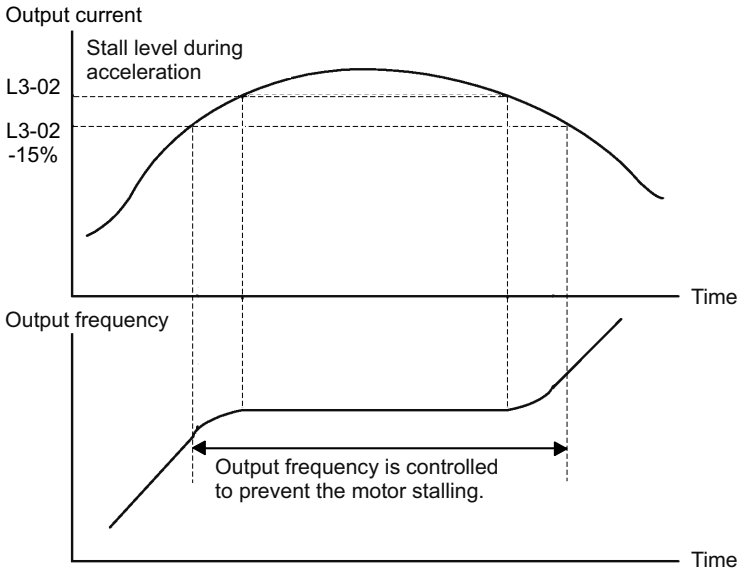


Figure 6.10 Time Chart for Stall Prevention During Acceleration

■ Setting Precautions

- If the motor rating is small compared to the Matrix converter capacity, or if the motor is operated using the factory settings and the motor stalls, lower the set value of L3-02.
- If the motor is operating in the constant HP range (above base frequency), L3-02 will be automatically lowered to prevent stalling. L3-03 sets a minimum level for the current reduction.
- Set the constants as a percent taking the Matrix converter rated current as 100 %.

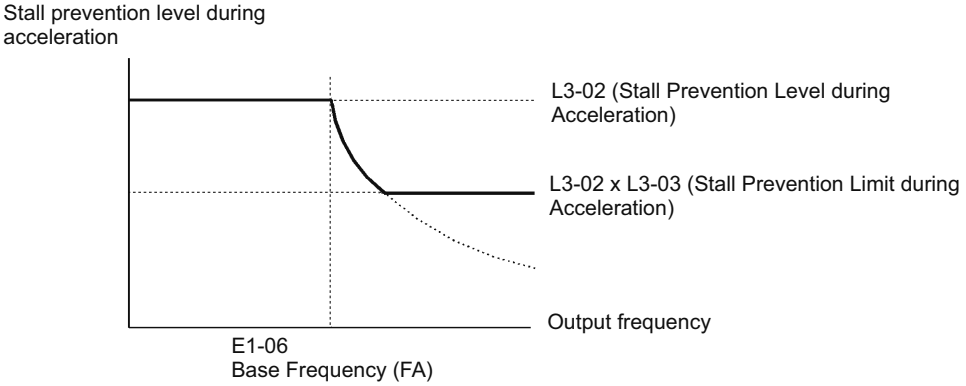


Figure 6.11 Stall Prevention Level and Limit During Acceleration

6.5 Adjusting Frequency References

This section explains methods of adjusting frequency references.

◆ Adjusting Analog Frequency References

Gain and bias are among the constants used to adjust analog inputs.

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the terminals they control are not normally part of user setup.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H3-01	Signal level selection (terminal AI1) / Term AI1 Signal	0: 0 to 10 V 1: -10 V to 10 V	0 or 1	0	No	A	A	450H
H3-02	Gain (terminal AI1) / Term AI1 Gain	Sets the frequency when 10 V is input, as a percentage of the maximum output frequency.	0.0 to 1000.0	100.0 %	Yes	A	A	451H
H3-03	Bias (terminal AI1) / Term AI1 Bias	Sets the frequency when 0 V is input, as a percentage of the maximum frequency.	-100.0 to 100.0	0.0 %	Yes	A	A	452H
H3-04	Signal level selection (terminal AI2) / Term AI2 Signal	0: 0 to 10 V 1: -10 V to 10 V	0 or 1	0	No	A	A	453H
H3-05	Multi-function analog input (terminal AI2) / Term AI2 Sel	Selects multi-function analog input function for terminal AI2.	0 to 1FH	1FH	No	A	A	454H
H3-06	Gain (terminal AI2) / Term AI2 Gain	Sets the input gain (level) when terminal AI2 is 10 V. Set according to the 100 % value selected in H3-05.	0.0 to 1000.0	100.0 %	Yes	A	A	455H
H3-07	Bias (terminal AI2) / Term AI2 Bias	Sets the input gain (level) when terminal AI2 is 0 V. Set according to the 100 % value selected in H3-05.	-100.0 to 100.0	0.0 %	Yes	A	A	456H
H3-08	Signal level selection (terminal AI3) / Term AI3 Signal	0: 0 to 10 V 1: -10 V to 10 V	0, 1	0	No	A	A	457H
H3-09	Multi-function analog input (terminal AI3) / Term AI3 Sel	Selects multi-function analog input function for terminal AI3.	00 to 1FH	0FH	No	A	A	458H
H3-10	Gain (terminal AI3) / Term AI3 Gain	Sets the input gain (level) when terminal AI3 is 10 V. Set according to the 100 % value selected in H3-09.	0.0 to 1000.0	100.0 %	Yes	A	A	459H
H3-11	Bias (terminal AI3) / Term AI3 Bias	Sets the input gain (level) when terminal AI3 is 0 V. Set according to the 100 % value selected in H3-09.	-100.0 to 100.0	0.0 %	Yes	A	A	45AH

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H3-12	Signal level selection (terminal AI4) Term AI4 Signal	0: 0 to 10 V 1: -10 V to 10 V	0 or 1	0	No	A	A	45BH
H3-13	Multi-function analog input (terminal AI4) Term AI4 Sel	Selects multi-function analog input function for terminal AI4.	00 to 1FH	0FH	No	A	A	45CH
H3-14	Gain (terminal AI4) Term AI4 Gain	Sets the input gain (level) when terminal AI4 is 10 V. Set according to the 100 % value selected in H3-13.	0.0 to 1000.0	100.0 %	Yes	A	A	45DH
H3-15	Bias (terminal AI4) Term AI4 Bias	Sets the input gain (level) when terminal AI3 is 0 V. Set according to the 100 % value selected in H3-13.	-100.0 to 100.0	0.0 %	Yes	A	A	45EH
H3-16	Analog input filter time constant Filter Avg Time	Sets primary delay filter time constant in seconds for the four analog input terminals (AI1,AI2,AI3,AI4). Effective for noise control, etc.	0.00 to 2.00	0.00 s	No	A	A	45FH

◆ Operation Avoiding Resonance (Jump Frequency Function)

The jump frequency function operates the motor while avoiding resonance caused by mechanical characteristic frequencies in the machine.

This function is effective in creating a frequency reference dead band.

During constant-speed operation, operation within the jump frequency range is prohibited. During acceleration and deceleration the speed will change smoothly through the jump frequency width.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d3-01	Jump frequency 1 Jump Freq 1	Sets the center values of the jump frequencies in % of maximum speed. This function is disabled by setting the jump frequency to 0 Hz. Always ensure that the following applies: d3-01 ≥ d3-02 ≥ d3-03 Operation in the jump frequency range is prohibited, but during acceleration and deceleration the speed will change smoothly through the jump frequency width.	0.0 to 100.0	0.0 %	No	A	A	2F0H
d3-02	Jump frequency 2 Jump Freq 2		0.0 to 100.0	0.0 %	No	A	A	2F1H
d3-03	Jump frequency 3 Jump Freq 3		0.0 to 100.0	0.0 %	No	A	A	2F2H
d3-04	Jump frequency width Jump Bandwidth	Sets the jump frequency bandwidth in %. The jump frequency range will be the jump frequency ± d3-04.	0.0 to 100.0	1.0 %	No	A	A	2F3H

The relationship between the output frequency and the jump frequency reference is as follows:

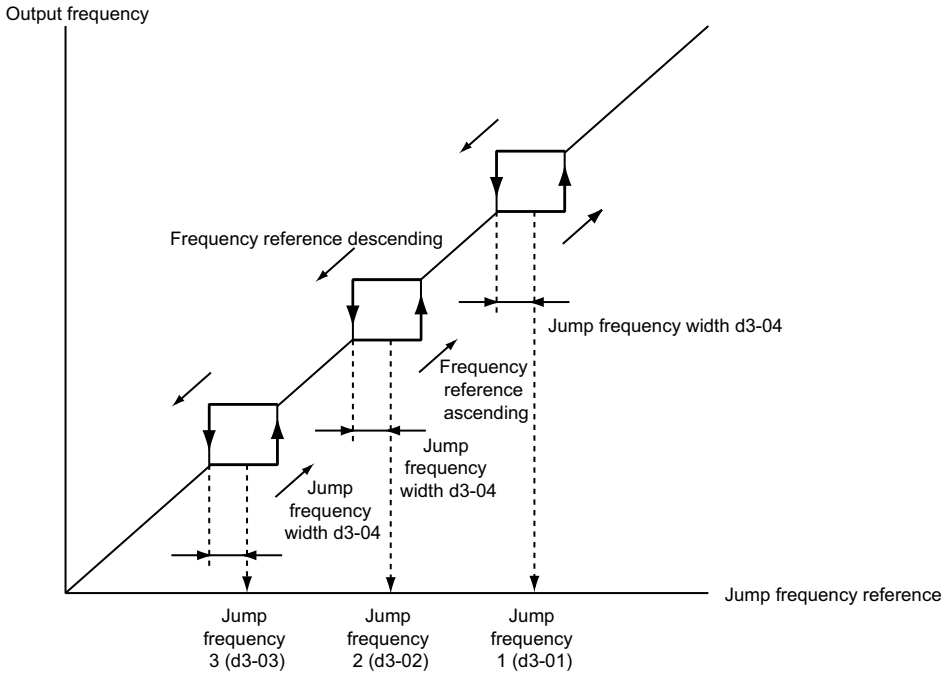


Figure 6.12 Jump Frequency

■ Setting Precautions

- Set the jump frequency according to the following formula: d3-01 ≥ d3-02 ≥ d3-03.
- When constants d3-01 through d3-03 are set to 0 %, the jump frequency function is disabled.

6.6 Speed Limit (Frequency Reference Limit Function)

This section explains how to limit the motor speed.

◆ Limiting Maximum Output Frequency

Use constant d2-01 to clamp the maximum output frequency of the Matrix converter.

Set the upper limit value of the Matrix converter output frequency as a percent, taking E1-04 (Maximum Output Frequency) to be 100 %.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d2-01	Frequency reference upper limit / Ref Upper Limit	Sets the output frequency upper limit as a percent of the maximum output frequency.	0.0 to 110.0	100.0 %	No	A	A	2E0H

◆ Limiting Minimum Frequency

Use constant d2-02 to clamp the minimum output frequency of the Matrix converter.

Set the lower limit value of the Matrix converter output frequency as a percent, taking E1-04 (Maximum Output Frequency) to be 100 %.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d2-02	Frequency reference lower limit / Ref Lower Limit	Sets the output frequency lower limit as a percentage of the maximum output frequency.	0.0 to 109.0	0.0 %	No	A	A	2E1H

6.7 Improved Operating Efficiency

This section explains functions for improving motor operating efficiency.

◆ Reducing Motor Speed Fluctuation (Slip Compensation Function)

When the load is large, the amount of motor slip grows and the motor speed decreases. The slip compensation function controls the motor at a constant speed, regardless of changes in load. When the motor is operating at the rated load, constant E2-02 (Motor Rated Slip) × the frequency in constant C3-01 is added to the output frequency.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
C3-01	Slip compensation gain / Slip Comp Gain	Improves speed accuracy when operating with a load. Normally setting is not necessary. Adjust this constant in the following cases: When actual speed is low compared to set speed, increase the set value. When actual speed is high compared to set speed, decrease the set value. Used as a control gain when in flux vector control.	0.0 to 2.5	1.0	Yes	A	A	260H
C3-02	Slip compensation primary delay time / Slip Comp Time	Sets the slip compensation primary delay time in units of ms. Normally setting is not necessary. Adjust this constant in the following cases: Reduce the setting when slip compensation response is slow. Increase the setting if speed does not stabilize with load change.	0 to 10000	3000 ms	No	A	A	261H
C3-03	Slip compensation limit / Slip Comp Limit	Sets the slip compensation limit as a percentage of motor rated slip.	0 to 250	200 %	No	A	No	262H
C3-04	Slip compensation selection during regeneration / Slip Comp Regen	0: Disabled during regeneration 1: Enabled during regeneration	0 or 1	0	No	A	No	263H
C3-05	Output voltage limit operation selection / Output V limit	0: Disabled. 1: Enabled. (The motor flux will be lowered automatically when the output voltage become saturated.)	0 or 1	1	No	A	A	264H

■ Adjusting Slip Compensation Gain

A setting of 1.0 for C3-01 is nominally correct based on the motor nameplate parameters.

Adjust the slip compensation gain using the following procedure.

1. Set E2-02 (Motor Rated Slip) and E2-03 (Motor No-load Current) correctly.
   The motor rated slip (in Hz) can be calculated from the data on the motor nameplate using the following formula:

   Motor rated slip (Hz) = Motor rated frequency (Hz) - motor rated speed (r/min) × No. of motor poles / 120.

   Set the values for rated voltage, rated frequency, and no-load current. The motor rated slip is set automatically in vector control using autotuning.
2. Apply a load, and measure the speed to adjust the slip compensation gain. Adjust the slip compensation gain by 0.1 at a time. If the speed is less than the target value, increase the slip compensation gain, and if the speed is greater than the target value, reduce the slip compensation gain.

For flux vector control, the slip compensation gain is used as the motor temperature compensation gain. When the motor temperature increases, the slip required to produce a given torque increases. If C3-01 is set, the amount of slip is adjusted as the temperature rises. Set C3-01 if the amount of torque varies with the temperature when using torque control or a torque limit. The larger the value of C3-01, the larger the compensation.

■ Adjusting Slip Compensation Primary Delay Time Constant

Set the slip compensation primary delay time constant in ms.

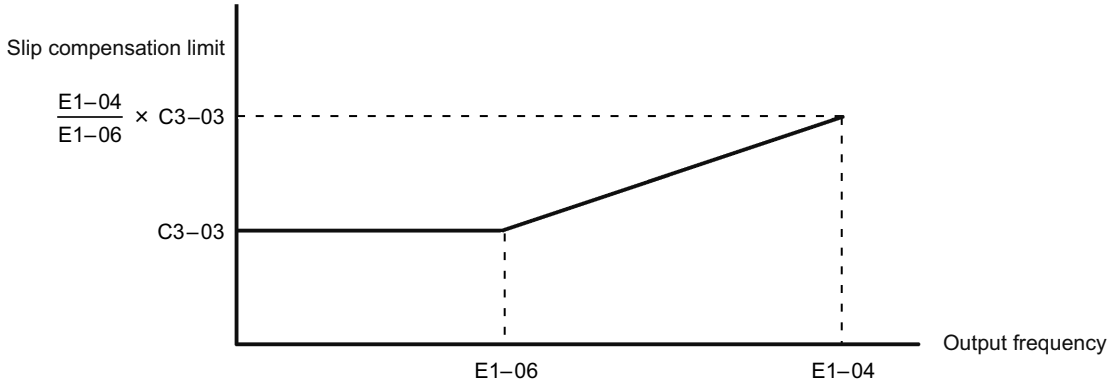
Normally, there is no need to make these settings. When the slip compensation response is slow, lower the set value. If the speed is unstable, increase the set value.

■ Adjusting Slip Compensation Limit

Set the upper limit for the slip compensation amount as a percent, taking the motor rated slip amount as 100 %.

If the speed is lower than the target value but does not change even when the slip compensation gain is adjusted, the motor may have reached the slip compensation limit. Increase the limit, and check the speed again. Ensure that the value of the slip compensation limit plus reference frequency does not exceed the maximum acceptable speed of the machine.

The following diagram shows the slip compensation limit for the constant torque range and constant HP range.



E1-06: Base frequency
E1-04: Maximum output frequency

Figure 6.13 Slip Compensation Limit

■ Selecting Output Voltage Limit Operation

If output voltage saturation occurs while the output voltage limit operation is disabled, the output current will not change, but torque control accuracy will be lost. If torque control accuracy is required, enable the output voltage limit operation.

If the output voltage limit operation is enabled, motor flux is controlled automatically, and torque control accuracy is maintained. The motor will be fully excited up to the voltage limit, and effectively operate in the constant HP range (constant voltage) beyond that. Consequently, the output current could increase by as much as 10 % at rated load and speed. Ensure that the Matrix converter current rating is adequate for this condition.

Setting Precautions

- If using the motor at medium to low speed only, or if the power supply voltage is 10 % or more higher than the motor rated voltage, or if the torque control accuracy at high speeds is unimportant, it is not necessary to change the output voltage limit operation.
- If the power supply voltage is too low compared with the motor rated voltage, torque control accuracy may be lost even if the output voltage limit operation is enabled.

◆ Compensating for Insufficient Torque at Startup and Low-speed Operation (Torque Compensation)

The torque compensation function detects that the motor load has increased, and increases the output torque.

Vector control separates the motor excitation current and the torque producing current by calculating the motor primary current, and controlling each of the two separately.

The torque producing current is calculated as follows: Calculated torque reference × C4-01

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
C4-01	Torque compensation gain / Torq Comp Gain	Sets the torque compensation gain. Normally setting is not necessary. Adjust in the following circumstances: When cable length is long; increase the set value. When the motor capacity is smaller than the Matrix converter capacity, increase the set value. If the motor is oscillating, decrease the set value. Adjust the gain to a range where the output current at low-speed does not exceed the MX1S rated output current.	0.00 to 2.50	1.00	Yes	A	No	270H
C4-02	Torque compensation primary delay time constant / Torq Comp Time	The torque compensation delay time is set in units of ms. Normally adjustment is not necessary. Adjust in the following circumstances: If the motor is oscillating, increase the set value. If the responsiveness of the motor is slow, decrease the set value.	0 to 10000	100 ms	No	A	No	271H

■ Adjusting Torque Compensation Gain

Normally, there is no need to make this adjustment.

Adjust this constant so that the output current during low-speed operation does not exceed the Matrix converter rated output current.

■ Adjusting the Torque Compensation Primary Delay Time Constant

Set the torque compensation function primary delay in ms.

Normally, there is no need to make this setting. Adjust the constant as shown below.

- If the motor is vibrating, increase the set value.
- If the motor response is slow, decrease the set value.

◆ Stabilizing Speed (Speed Feedback Detection Function)

The speed feedback detection control Automatic Flux Regulator (AFR) function stabilizes the speed when a load is suddenly applied, by calculating the fluctuation of the torque current feedback, and adjusting the output frequency to compensate.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
n2-01	Speed feedback detection control (AFR) gain / AFR Gain	Sets the internal speed feedback detection control gain using a multiplication function. Normally, there is no need to adjust this setting. Adjust this constant as follows: If hunting occurs, increase the set value. If response is low, decrease the set value. Adjust the setting by 0.05 at a time, while checking the response.	0.00 to 10.00	2.00	No	A	No	5D0H
n2-02	Speed feedback detection control (AFR) time constant / AFR Time	Sets the time constant to define the rate of change in the speed feedback detection control. Setting unit: ms	0 to 2000	250 ms	No	A	No	5D1H
n2-03	Speed feedback detection control (AFR) time constant 2 / AFR Time 2	Increase the setting if overvoltage (OV) failures occur at the completion of acceleration or when the load changes radically. Setting unit: ms	0 to 2000	750 ms	No	A	No	5D2H
n2-05	Starting gain for AFR gain change / AFR G of Start	Sets the gain to the AFR gain at 0 Hz. Controls hunting by AFR at low speed (0 to12 Hz).	0.00 to 2.00	0.20	No	A	No	5D4H

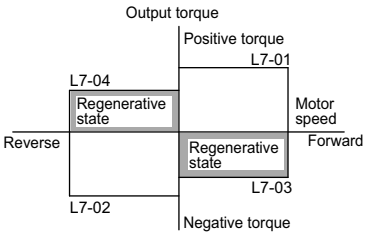
6.8 Machine Protection

This section explains functions for protecting the machine.

◆ Limiting Motor Torque (Torque Limit Function)

The user-set value is applied as a limit to the torque output calculated in the Matrix converter. Enable this function to limit motoring torque or regenerative torque to specific levels.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L7-01	Forward drive torque limit / Torq Limit Fwd	Sets the torque limit value as a percentage of the motor rated torque. Four individual regions can be set. 	0 to 300	150 %	No	A	A	560H
L7-02	Reverse drive torque limit / Torq Limit Rev		0 to 300	150 %	No	A	A	561H
L7-03	Forward regenerative torque limit / Torq Lmt Fwd Rgn		0 to 300	150 %	No	A	A	562H
L7-04	Reverse regenerative torque limit / Torq Lmt Rev Rgn		0 to 300	150 %	No	A	A	563H

Note: The forward torque limit is the limit value when the analog input signal commands forward torque. This torque limit setting is enabled when the analog input signal commands forward torque even if the motor is regenerating.

■ Setting the Torque Limit Constants

Using L7-01 to L7-04, four individual torque limits can be set: Forward drive, reverse drive, forward regeneration, and reverse regeneration.

■ Setting Precautions

- When the torque limit function is operating, control and compensation of the motor speed is disabled because torque control is given priority. Therefore, acceleration and deceleration times may increase or the motor speed may decrease.
- The torque limit accuracy is ±5 % at an output frequency of 10 Hz or above. When output frequency is less than 10 Hz, accuracy is lowered.

◆ Using Frequency Detection: L4-01 to L4-04

Set these constants when outputting one of the frequency agree or frequency detection signals from a multi-function output. When using flux vector control, the motor speed (rather than frequency) is detected.

Note: The “H” parameter group and the “L” output functions are typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the “L” terminals they control are not normally part of user setup.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L4-01	Speed agree detection level / Spd Agree Level	Effective when “Desired frequency (ref/setting) agree 1 ***115***,” “Frequency detection 1,” or “Frequency detection 2" is set for a multi-function output. Sets the output frequencies or motor speeds to be detected as percentages.	0.0 to 100.0	0.0 %	No	A	A	530H
L4-02	Speed agree detection width / Spd Agree Width	Effective when “Frequency (speed) agree 1,” “Desired frequency (speed) agree 1,” or “Frequency (FOUT) detection 1,” Frequency (FOUT) detection 2 is set for a multi-function output. Sets the output frequency or motor speed detection width as a percentage.	0.0 to 100.0	2.0 %	No	A	A	531H
L4-03	Speed agree detection level (+/–) / Spd Agree Lvl+ –	Effective when “Desired frequency (speed) agree 2,” “Frequency (FOUT) detection 3,” or “Frequency (FOUT) detection 4” is set for a multi-function output. Output frequency or motor speed detection width is set as a percentage.	–100.0 to 100.0	0.0 %	No	A	A	532H
L4-04	Speed agree detection width (+/–) / Spd Agree Width+ –	Effective when “Frequency (speed) agree 2,” “Desired frequency (speed) agree 2,” Frequency (FOUT) detection 3 or “Frequency detection 4" is set for a multi-function output. Output frequency or motor speed detection width is set as a percentage.	0.0 to 100.0	2.0 %	No	A	A	533H

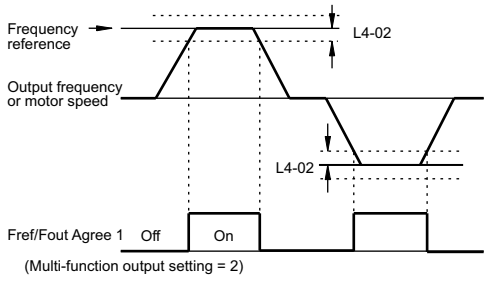
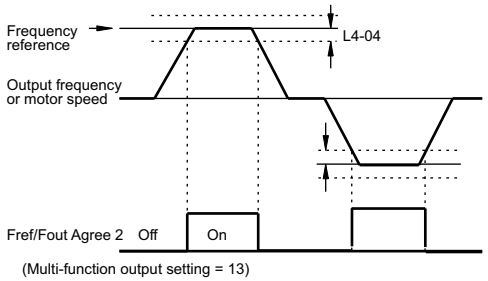
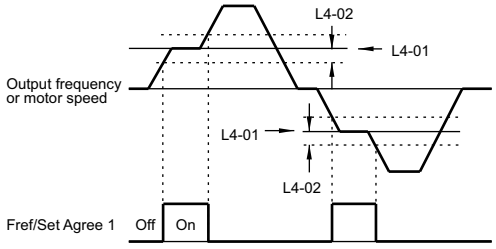
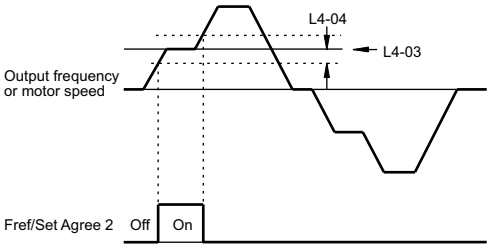
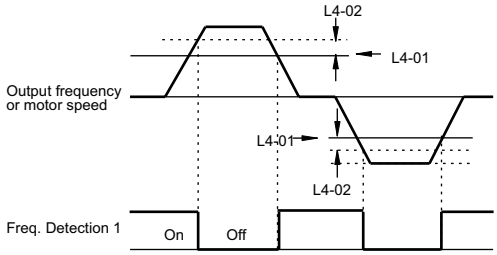
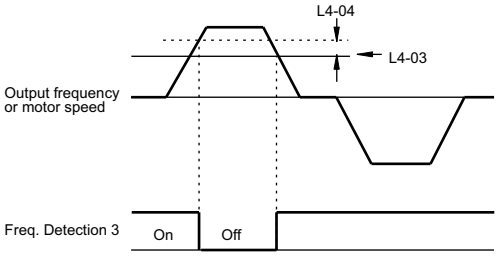
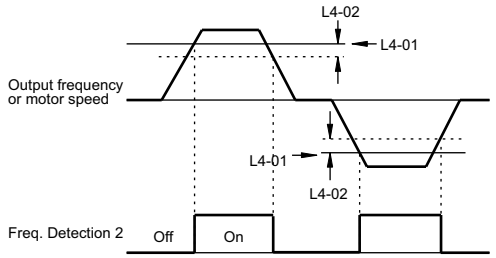
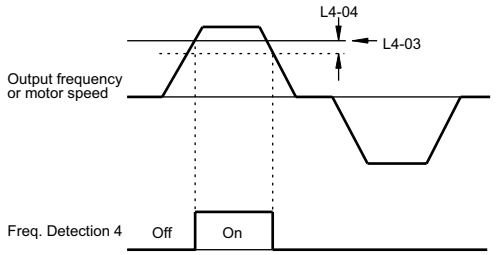
■ Constants and Output Signals

User Constant Number	Name	Function
L4-01	Speed agree detection level	Fref/Set Agree 1 Frequency Detection 1 Frequency Detection 2
L4-02	Speed agree detection width	Fref/Fout Agree 1 Fref/Set Agree 1 Frequency Detection 1 Frequency Detection 2
L4-03	Speed agree detection level (+/–)	Fref/Set Agree 2 Frequency Detection 3 Frequency Detection 4
L4-04	Speed agree detection width (+/–)	Fref/Fout Agree 2 Fref/Set Agree 2 Frequency Detection 3 Frequency Detection 4

Set the corresponding setting in the multi-function output (H2-01 to H2-08) to output the desired Fref/Fout Agree signal, Fref/Set Agree signal, or Frequency Detection signal.

Function	Setting
Fref/Fout Agree 1	2
Fref/Set Agree 1	3
Frequency Detection 1	4
Frequency Detection 2	5
Fref/Fout Agree 2	13
Fref/Set Agree 2	14
Frequency Detection 3	15
Frequency Detection 4	16

Timing Chart for Frequency Detection Operation

Related constant	L4-01: Speed Agree Level L4-02: Speed Agree Width	L4-03: Speed Agree Level +/- L4-04: Speed Agree Width +/-
Fref/Fout Agree	Fref/Fout Agree 1	Fref/Fout Agree 2
	 (Multi-function output setting = 2)	 (Multi-function output setting = 13)
Fref/Set Agree	Fref/Set Agree 1 (on at the following conditions during frequency agree)	Fref/Set Agree 2 +/– (on at the following conditions during frequency agree)
	 (Multi-function output setting = 3)	 (Multi-function output setting = 14)
Frequency Detection	Frequency (FOUT) Detection 1 (L4-01 > | Output frequency |)	Frequency (FOUT) Detection 3 (L4-03 > Output frequency)
	 (Multi-function output setting = 4)	 (Multi-function output setting = 15)
	Frequency (FOUT) Detection 2 (L4-01 < | Output frequency |)	Frequency (FOUT) Detection 4 (L4-03 < Output frequency)
	 (Multi-function output setting = 5)	 (Multi-function output setting = 16)

◆ Detecting Motor Torque

If an excessive load is placed on the machinery (overtorque) or the load is suddenly lightened (undertorque), an alarm signal can be output to the multi-function output terminals DO1 to DO8. Two independent torque detection levels can be set.

To use the overtorque/undertorque detection function, set B, 17, 18, 19 (overtorque/undertorque detection NO/NC) in one of the following constants: H2-01 to H2-08 (output terminals DO1 to DO8 function selection).

The overtorque/undertorque detection level is the motor torque (motor rated torque 100 %) in vector control.

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the DO terminals they control are not normally part of user setup.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L6-01	Overtorque/ Undertorque detection selection 1 Torq Det 1 Sel	0: Overtorque/undertorque detection disabled. 1: Overtorque detection only with speed agreement <1>; operation continues after overtorque (warning). 2: Overtorque detected continuously during operation; operation continues after overtorque (warning). 3: Overtorque detection only with speed agreement <1>; output stopped upon detection (protected operation). 4: Overtorque detected continuously during operation; output stopped upon detection (protected operation). 5: Undertorque detection only with speed agreement <1>; operation continues after overtorque (warning). 6: Undertorque detected continuously during operation; operation continues after overtorque (warning). 7: Undertorque detection only with speed agreement <1>; output stopped upon detection (protected operation). 8: Undertorque detected continuously during operation; output stopped upon detection (protected operation).	0 to 8	0	No	A	A	550H
L6-02	Overtorque/ Undertorque detection level 1 Torq Det 1 Lvl	Sets detection level 1 as a percentage of the motor rated torque.	0 to 300	150 %	No	A	A	551H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L6-03	Overtorque/ Undertorque detection time 1 Torq Det 1 Time	Sets the overtorque/undertorque detection time in 1-second units.	0.0 to 10.0	0.1 s	No	A	A	552H
L6-04	Overtorque/Undertorque detection selection 2 Torq Det 2 Sel	Same description as L6-01, except applies to Torque Detection #2.	0 to 8	0	No	A	A	553H
L6-05	Overtorque/Undertorque detection level 2 Torq Det 2 Lvl	Same description as L6-02, except applies to Torque Detection #2.	0 to 300	150 %	No	A	A	554H
L6-06	Overtorque/Undertorque detection time 2 Torq Det 2 Time	Same description as L6-03, except applies to Torque Detection #2.	0.0 to 10.0	0.1 s	No	A	A	555H

<1> “Speed agreement” means “at set speed”, i.e., not accelerating or decelerating.

Multi-function Output (H2-01 to H2-08)

Setting Value	Function	Control Methods: Open-loop Vector	Control Methods: Flux Vector
B	Overtorque/undertorque detection 1 NO (NO contact: Overtorque/undertorque detection at on)	Yes	Yes
17	Overtorque/undertorque detection 1 NC (NC Contact: Overtorque/undertorque detection at off)	Yes	Yes
18	Overtorque/undertorque detection 2 NO (NO Contact: Overtorque/undertorque detection at on)	Yes	Yes
19	Overtorque/undertorque detection 2 NC (NC Contact: Overtorque/undertorque detection at off)	Yes	Yes

■ L6-01 and L6-04 Set Values and LCD Indications

The relationship between alarms displayed by the Digital Operator when overtorque or undertorque is detected, and the set values in L6-01 and L6-04, is shown in the following table.

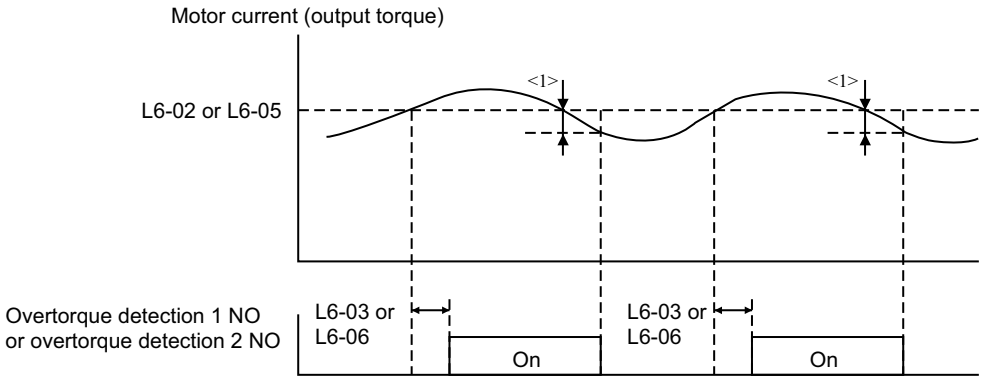
Set Value	Function	LCD Indications: Overtorque/ Undertorque Detection 1	LCD Indications: Overtorque/ Undertorque Detection 2
0	Overtorque/undertorque detection disabled.	–	–
1	Overtorque detection only with speed agreement <1>; operation continues after overtorque (warning).	OL3 flashes	OL4 flashes
2	Overtorque detected continuously during operation; operation continues after overtorque (warning).	OL3 flashes	OL4 flashes
3	Overtorque detection only with speed agreement <1>; output stopped upon detection (protected operation).	OL3 lit	OL4 lit
4	Overtorque detected continuously during operation; output stopped upon detection (protected operation).	OL3 lit	OL4 lit
5	Undertorque detection only with speed agreement <1>, operation continues after overtorque (warning).	UL3 flashes	UL4 flashes
6	Undertorque detected continuously during operation; operation continues after overtorque (warning).	UL3 flashes	UL4 flashes
7	Undertorque detection only with speed agreement <1>; output stopped upon detection (protected operation).	UL3 lit	UL4 lit
8	Undertorque detected continuously during operation; output stopped upon detection (protected operation).	UL3 lit	UL4 lit

<1> “Speed agreement” means “at set speed”, i.e., not accelerating or decelerating.

■ Setting Example

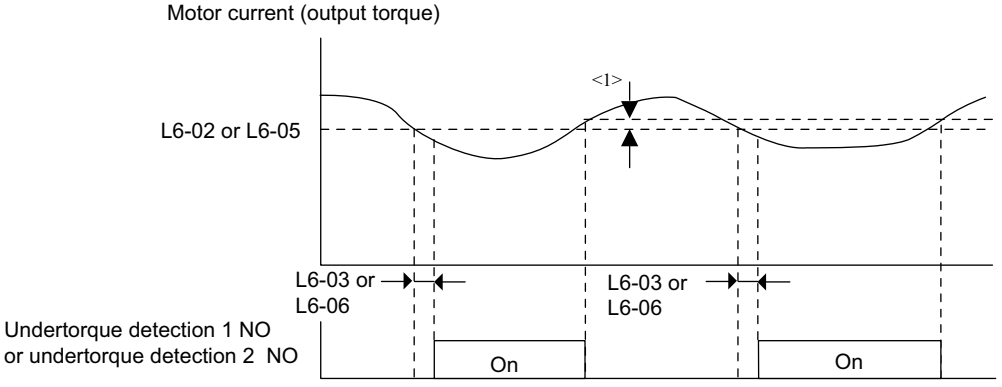
The following diagram shows the time chart for overtorque and undertorque detection.

• Overtorque Detection



<1> Overtorque detection disabled band is approximately 10% of the Inverter rated output current (or motor rated torque).

• Undertorque Detection



<1> Undertorque detection disabled band is approximately 10% of the Inverter rated output current (or motor rated torque).

◆ Motor Overload Protection

The motor can be protected from thermal overload using the Matrix converter's built-in electronic thermal overload relay.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
E2-01	Motor rated current Motor Rated FLA	Sets the motor rated current in 1 A units. The set value will become the reference value for motor protection, torque limits and torque control.	0.1 to 1500.0	86.6 A	No	Q	Q	360H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L1-01	Motor protection selection / MOL Fault Select	Sets whether the motor overload function is enabled or disabled using the electronic thermal overload relay. 0: Disabled 1: Enabled	0 or 1	1	No	A	A	4E0H
L1-02	Motor protection time constant / MOL Time Const	Sets the motor overload time at current L1-07 before output L1-06 is activated, in units of seconds ***Figure 6.14***. The factory setting is 60.0 seconds. Set the protection time according to the motor overload capacity.	1.0 to 300.0	60.0 s	No	A	A	4E1H
L1-04	Operation selection at motor overload / MOL Select	Selects the operation when the motor is overloaded. 0: Decelerate to stop 1: Coast to stop 2: Emergency stop using the deceleration time in C1-09. 3: Continue operation	0 to 3	1	No	A	A	4E3H
L1-06	Motor overload detection start level / OL1 Start Level	Sets the motor overload detection start level as a percentage of the motor rated current***Figure 6.14***. The set value must be smaller than L1-07. When E2-14 ***102*** is set to 1 (enabled), this setting is invalid.	20 to 300	110 %	No	A	A	4E5H
L1-07	Motor overload detection level / OL1 Level	Sets the motor overload detection level as a percentage of the motor rated toque. The set value must be larger than L1-06. When E2-14 ***102*** is set to 1 (enabled), this setting is invalid.	30 to 300	150 %	No	A	A	4E6H

Multi-Function Outputs (H2-01 to H2-08)

Note: The “H” parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the DO terminals they control are not normally part of user setup.

Setting Value	Function	Control Methods: Open-loop Vector	Control Methods: Flux Vector
1F	Motor overload (OL1)	Yes	Yes

■ Setting Motor Rated Current

Set the rated current value on the motor nameplate in constants E2-01. This set value is the electronic thermal base current.

◆ Setting Motor Protection Operation Time

Set the motor overload detection start level in L1-06, the motor overload detection level in L1-07, and the motor protection operation time for the motor overload detection level in L1-02. In these cases, the motor rated current is set to 100 %.

The factory setting is equivalent to 150 % for 60 seconds.

If the output current exceeds the motor overload detection start level, the electronic thermal protection will activate.

The following diagram shows an example of the characteristics of the electronic thermal protection operation time (L1-02=60 seconds, L1-06=110 %, L1-07=150 %).

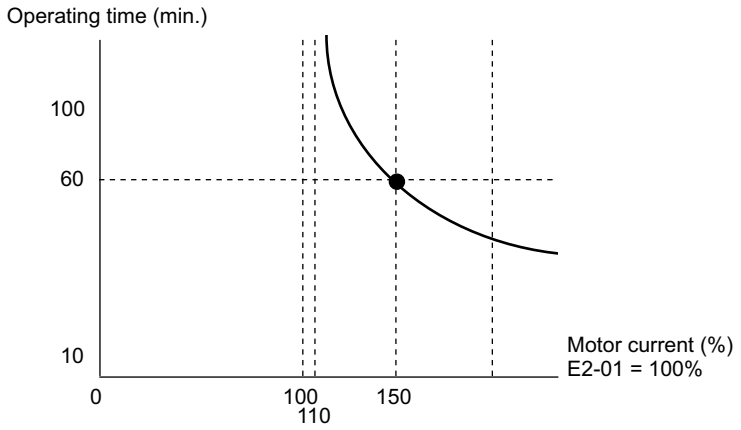


Figure 6.14 Motor Protection Operation Time

■ Setting Precautions

- To detect overloads promptly, keep the set value in L1-02 or L1-07 at a low setting.
- If L1-06 (motor overload detection start level) is set to be equal or higher than L1-07 (motor overload detection level), an OPE11 (constant setting error) operation error may occur. Set L1-06 lower than L1-07.

◆ Limiting Motor Rotation Direction

If motor reverse rotation is prohibited, a Reverse Run Command will not be accepted even if it is input. Use this setting for applications where reverse motor rotation is problematic (e.g., fans, pumps, etc.)

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b1-04	Prohibition of reverse operation / Reverse Oper	0: Reverse enabled 1: Reverse disabled	0 or 1	1	No	A	A	1A3H

6.9 Continuing Operation

This section explains functions for continuing or automatically restarting Matrix converter operation using speed search in the event of a momentary power loss.

◆ Restarting Automatically After Power Is Restored

If a momentary power loss occurs, the Matrix converter can be restarted automatically after power is restored to continue motor operation. To restart the Matrix converter after power has been restored, set L2-01 to 1.

If L2-01 is set to 1, when power is restored within the time set in L2-02, the Matrix converter will restart. If the time set in L2-02 is exceeded, alarm FDEV (input power supply frequency fault) will be set.

■ Related Constants

Constant Number	Name Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods Open-loop Vector	Control Methods Flux Vector	MEMOBUS Register
L2-01	Momentary power loss detection PwrL Selection	0: Disabled (Major fault occurs immediately after a momentary power loss.) 1: Enabled (Continued operation within the allowable ride-through time after a momentary power loss.) A backup power source for the control power supply is required to successfully ride through a momentary power loss.	0 or 1	0	No	A	A	4F0H
L2-02	Momentary power loss ridethrough time PwrL Ridethru t	Ridethrough time, when Momentary Power Loss Selection (L2-01) is set to 1, in units of seconds.	0.0 to 10.0	2.0 s	No	A	A	4F1H
L2-03	Min. baseblock time PwrL Baseblock t	Sets the time to continuously baseblock the motor without accepting commands such as run command after the motor is baseblocked, in units of seconds. Sets the time required for the motor residual voltage to be discharged. When an overcurrent (OC) occurs during the start of speed search or DC injection braking, increase the set value.	0.1 to 5.0	2.0 s	No	A	A	4F2H
L2-04	Voltage recovery time PwrL V/F Ramp t	Sets the time to restore the normal output voltage of the matrix converter in units of seconds after the completion of speed search. Sets the time required to recover the output voltage from 0 V to the maximum.	0.0 to 10.0	3.0 s	No	A	A	4F3H

■ Setting Precautions

- Error output signals are not output during momentary power loss recovery.
- To continue Matrix converter operation after power has been restored, make certain that Run Commands from the control main circuit terminal are maintained even while power is off.
- To enable momentary power loss detection the control power supply must be maintained (UPS).

◆ Speed Search

The speed search function finds the actual speed of a motor that is coasting, then starts smoothly from that speed. When restoring power after a momentary power loss, the speed search function begins after power is restored and restarts the coasting motor.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b3-01	Speed search selection on or off. / SpdSrch at Start	Enables/disables the speed search function at Run Command. 0: Disabled 1: Enabled Speed Calculation: When the search is started, the motor speed is calculated and acceleration/deceleration is performed from the calculated speed to the specified frequency (motor direction is also searched).	0 or 1	0	No	A	A	1C0H
b3-02	Speed search operating current / SpdSrch Current	Defines the current where the motor speed is assumed to be found as a % of the Matrix converter rated current. Not usually necessary to set. When restarting is not possible with the factory settings, reduce the value.	0 to 200	30 %	No	A	No	1C1H
b3-03	Speed search deceleration time / SpdSrch Dec Time	Sets the output frequency deceleration time during speed search in 1-second units. Set the time for deceleration from the maximum output frequency to the minimum output frequency.	0.1 to 10.0	4.0 s	No	A	No	1C2H
b3-05	Speed search wait time / Search Delay	Sets the contactor operating delay time when there is a high-voltage contactor on the output side of the Matrix converter. When a speed search is performed after recovering from a momentary power loss, the search operation is delayed by the time set here.	0.0 to 20.0	0.2 s	No	A	A	1C4H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b3-06	Output current 1 during speed search / Srch Im Lvl1	Sets the output current during the first half of speed search as a coefficient to the motor rated current (E2-01). Increase the set value if the speed search becomes extremely slow after the motor has been base-blocked for a long time or during speed search at startup.	0.0 to 1.0	0.5	No	A	A	1C5H
b3-07	Output current 2 during speed search / Srch Im Lvl2	Sets the output current during the last half of speed search as a coefficient to the motor no-load current (E2-03). The multiplication of motor no-load current and set coefficient is limited to the motor rated current (E2-01) of the Matrix converter. Increase the set value if the speed search becomes extremely slow after the motor has been base-blocked for a long time or during speed search at startup.	0.0 to 3.0	1.5	No	A	A	1C6H
b3-10	Speed search detection compensation gain / Srch Detect Comp	Operation will restart at the speed obtained by multiplying the calculated speed by the compensation gain.	1.00 to 1.50	1.00	No	A	No	1C9H
b3-11	Speed search method switching level / Srch Mthd Sw Lvl	The search method is automatically switched from back EMF detection to current injection according to the motor residual voltage. Set the switching level as a percentage of the motor rated voltage.	0.5 to 100.0	2.0 %	No	A	A	1CAH
b3-12	Current detection dead-zone width during speed search / Srch I Deadband	The motor speed is calculated from the detected current value. For current detection, a deadband must be set. Set the deadband width using the current detection resolution as reference amount. Decrease the set value if the speed search becomes extremely slow after the motor has been base-blocked for a long time or during speed search at startup.	0.5 to 10.0	4.0	No	A	A	1CBH
b3-13	Torque compensation time constant during speed search / TComp T at SpdSr	Sets primary lag of the torque compensation function during speed search in units of milliseconds.	0 to 10000	10 ms	No	A	A	1CCH
b3-14	Current control start level during voltage restoration / Srch Lvl Red I	Sets the current level used to limit the voltage restoration rate, to control current during speed search. Set the level as no-load current = 1.0.	0.0 to 5.0	2.0	No	A	A	1CDH

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b3-15	Time constant for current control during voltage restoration / Srch T Red I	Sets the time constant in units of 1ms for the voltage restoration rate, to control current during speed search.	0 to 100	5 ms	No	A	A	1CFH
b3-16	Wait time after completion of speed search / SpdSrch Ret Time	Sets the wait time in units of 1s for switching to normal control after completion of speed search. The frequency reference will be held during the wait time.	0.00 to 5.00	0.01 s	No	A	No	1CEH
b3-17	Software CLA current limit 1 during speed search / SpdSrch CLA Lvl1	Sets the software current limit value during speed search in percentage of the motor rated current.	0.0 to 300.0	100.0 %	No	A	A	1D0H
b3-18	Software CLA current limit 2 during speed search / SpdSrch CLA Lvl2	Sets the software current limit value at 0 Hz during speed search as a percentage of the motor rated current.	0.0 to 300.0	100.0 %	No	A	A	1D1H
L2-03	Min. baseblock time / PwrL Baseblock t	Sets the time to continuously baseblock the motor without accepting commands such as run command after the motor is baseblocked, in units of seconds. Sets the time required for the motor residual voltage to be discharged. When an overcurrent (OC) occurs during the start of speed search or DC injection braking, increase the set value.	0.1 to 5.0	2.0 s	No	A	A	4F2H
L2-04	Voltage recovery time / PwrL V/F Ramp t	Sets the time to restore the normal output voltage of the matrix converter in units of seconds after the completion of speed search. Sets the time required to recover the output voltage from 0 V to the maximum.	0.0 to 10.0	3.0 s	No	A	A	4F3H

Multi-function Contact Inputs (H1-03 to H1-16)

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the DI terminals they control are not normally part of user setup.

Setting Value	Function	Control Methods: Open-loop Vector	Control Methods: Flux Vector
61	External search command 1 (on: Speed search from maximum output frequency) OFF: Speed search disabled (Restart from the minimum output frequency.) ON: Speed search enabled	Yes	No
62	External search command 2 (on: Speed search from set frequency) OFF: Speed search disabled (Restart from the minimum output frequency.) ON: Speed search enabled	Yes	No

■ Setting Precautions

- When both external search commands 1 and 2 are set for the multi-function contact terminals, an OPE03 (invalid multi-function input selection) operation error may occur. Set either external search command 1 or external search command 2, but not both.

- If performing speed search using external search commands, control the switching sequence so that the Run Command and external search command are both on for a time longer than the Minimum Baseblock Time (L2-03).
- If the Matrix converter output is equipped with a high-voltage contactor, set the contactor operation delay time in the Speed Search Wait Time (b3-05). The factory setting is 0.2 s. When not using a contactor, the search time can be reduced by setting b3-05 to 0.0 s. After waiting for the speed search wait time, the Matrix converter starts the speed search.
- Constant b3-02 is a current agreement level (current detection level for search completion). When the current falls below the detection level, the speed search is viewed as complete, and the motor accelerates or decelerates to the set frequency. If the motor cannot restart, lower the set value.
- If an overcurrent (IOC) is detected when using speed search following a power loss, lengthen the Minimum Baseblock Time (L2-03).

■ Application Precautions for Speed Searches Using Estimated Speed

- When using vector control, always perform autotuning before using speed search.
- If the cable length between the motor and Matrix converter is changed after autotuning has been performed, perform autotuning for line-to-line resistance again. See ***Stationary autotuning for line-to-line resistance only (T1-01 = 2) on page 76***.

■ Speed Search Selection

Set whether to enable or disable speed search at startup using b3-01. To perform speed search when inputting the Run Command, set b3-01 to 1 or 3.

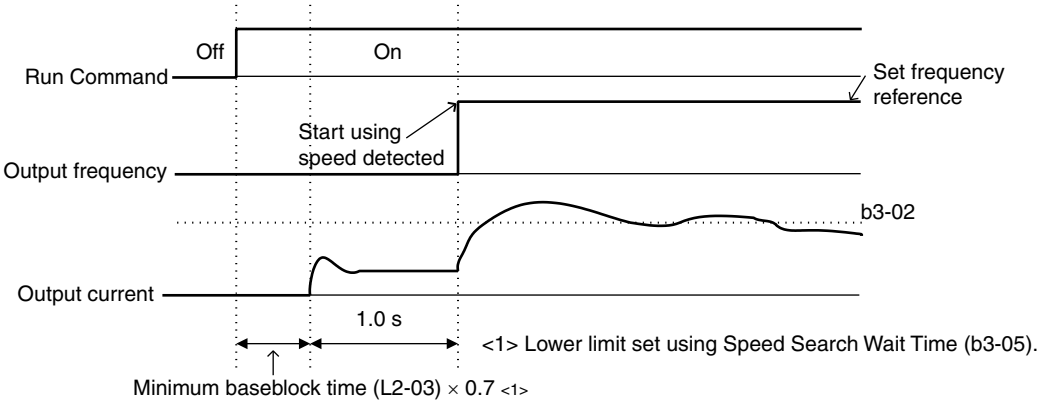
Search Name	Calculated Speed (b3-01 = 0 or 1)
Search Method	Calculates the motor speed when the search starts, and accelerates or decelerates from the calculated speed to the set frequency. Search can also include direction of motor rotation.
External Speed Search Command	External search command 1 and external search command 2 become the same operation, calculating the motor speed and starting the search from the calculated speed.
Application Precautions	Cannot be used on motors two or more ratings smaller than the Matrix converter capacity.

■ Calculated Speed Search

The time chart for calculated speed searches is shown below.

Search at Startup

The time chart when speed search at startup (or external speed search command by multi-function input) has been selected is shown below.



Note: If the stopping method is set to coast to stop, and the Run Command turns ON in a short time, the operation may be the same as the search in case 2.

Figure 6.15 Speed Search at Startup (Calculated Speed)

Speed Search after Short Baseblock (during Power Loss Recovery, etc.)

The time chart when the Matrix converter operation is restarted after power has been restored is shown below.

• Loss Time Shorter Than the Minimum Baseblock Time (L2-03)

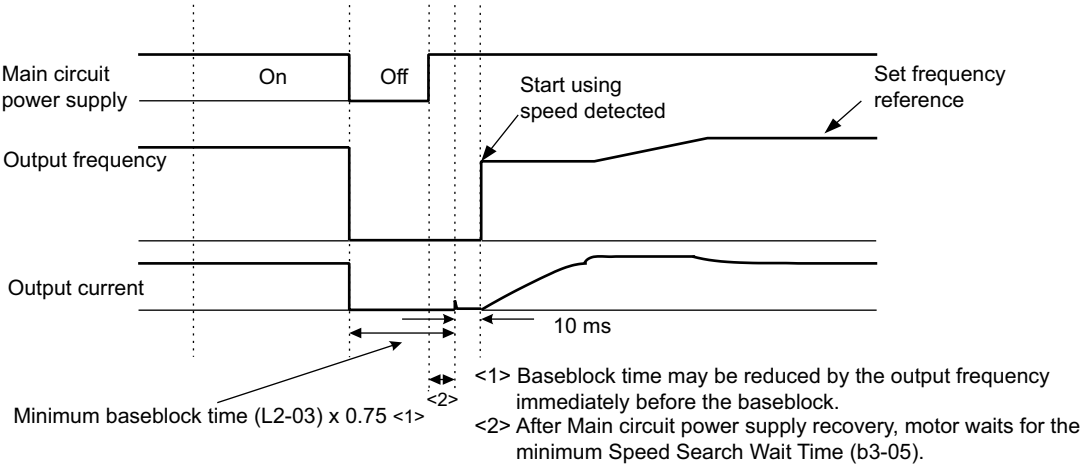


Figure 6.16 Speed Search after Baseblock (When Calculated Speed: Loss Time Is Set in L2-03)

• Loss Time Longer Than the Minimum Baseblock Time (L2-03)

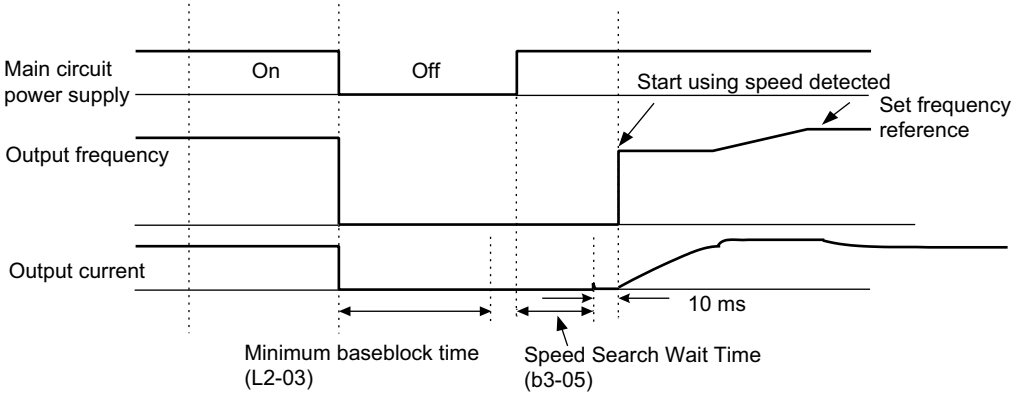


Figure 6.17 Speed Search After Baseblock (Calculated Speed: Loss Time > L2-03)

◆ Restarting Operation after Transient Fault (Auto Restart Function)

If an MX1S fault occurs during run, the MX1S will perform a self-diagnosis. If no fault is detected, the MX1S will automatically restart. This is called the auto restart function.

Set the number of auto restarts in parameter L5-01. A fault reset is carried out every 5 ms after the minimum baseblock time has passed. The counter counts the number of times that the operation is restarted after the fault is reset. If the fault is not reset after executing the number of auto restarts set in L5-01, the protection function will be activated.

The auto restart function can be applied to the following faults. If any other fault occurs, the protection function will operate and the auto restart function will not.

- IOC (overcurrent)
- OGF (output ground fault)
- OL2 (inverter overtorque)

■ Related Constants

To output auto restart signals externally, set H2-□□ (Terminals D01 to D08 Function Selection) to 1E (auto restart).

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the DO terminals they control are not normally part of user setup.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
L5-01	Number of auto restart attempts / Num of Restarts	Sets the number of auto restart attempts. Automatically restarts after a fault and conducts a speed search from the run frequency.	0 to 5	0	No	A	A	540H
L5-02	Auto restart operation selection / Restart Sel	Sets whether a fault contact output is activated during fault restart. 0: Not output (Fault contact is not activated.) 1: Output (Fault contact is activated.)	0 or 1	0	No	A	A	541H
L5-03	Maximum restart time / Max Restart Time	If the Matrix converter does not restart successfully by the time set in L5-03, the Matrix converter will shut down.	0.01 to 18.00	0.05	No	A	A	542H

■ Application Precautions

- The 'number of auto restarts' count is reset under the following conditions:
  - After auto restart, normal operation has continued for 10 minutes.
  - After the protection operation has been performed, the fault has been verified, and a fault reset has been input.
  - After the power supply is turned off, and then on again.
- WARNING: Do not use the auto restart function on elevator applications.

6.10 Input Terminal Functions

This section explains input terminal functions, which set operating methods by switching functions for the multi-function contact input terminals (S3 to S16).

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the DI terminals they control (S3 to S16) are not normally part of user setup. This section is provided for information only. Refer to the Matrix converter elementary drawing.

◆ Temporarily Switching Operation between Digital Operator and Control Circuit Terminals

The Matrix converter Run Command and frequency reference inputs can be switched between local (i.e., Digital Operator) and remote using parameters b1-01 and b1-02.

Switching between local and remote can be selected by an input contact (S3 to S16) ***H1: Multi-function Contact Inputs on page 104***. These contact functions are set by constants H1-03 to H1-16. Set the H1 constant for the desired terminal to 01. Close the contact for local (Digital Operator), open the contact for remote.

Set b1-01 and b1-02 to 1 to enable control from the control circuit terminals.

With the Matrix converter, the control circuit terminals are normally used via PLC. b1-01 and b1-02 will normally be set to 3(PLC) and not changed.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
b1-01	Reference selection / Reference Source	Sets the frequency reference input method. 0: Digital Operator 1: Control circuit terminal (analog input) 2: MEMOBUS communications 3: Built-in PLC	0 to 3	3	No	Q	Q	1A0H
b1-02	Operation method selection / Run Source	Sets the Run Command input method. 0: Digital Operator 1: Control circuit terminal (sequence input) 2: MEMOBUS communications 3: Built-in PLC	0 to 3	3	No	Q	Q	1A1H

Note: Local/remote switching can also be performed using the LOCAL/REMOTE Key on the Digital Operator. When the local/remote function has been set for the external terminals, the LOCAL/REMOTE Key function on the Digital Operator will be disabled.

◆ Blocking Matrix converter Outputs (Baseblock Commands)

Set 8 or 9 (Baseblock command NO/NC) in one of the constants H1-03 to H1-16 ***H1: Multi-function Contact Inputs on page 104*** (input terminal S3 to S16 function selection) to perform baseblock commands using the input terminal. Baseblock prohibits Matrix converter output. At this time, the motor will be coasting and "BB" will blink on the Digital Operator.

Clear the baseblock command to restart the operation. Speed search will begin at the operating frequency prior to the baseblock command.

■ Multi-function Contact Inputs (H1-01 to H1-10)

Setting Value	Function	Control Methods	
		Open-loop Vector	Flux Vector
08	External baseblock NO (NO contact: Baseblock at on)	Yes	Yes
09	External baseblock NC (NC contact: Baseblock at off)	Yes	Yes

■ Time Chart

The time chart when using baseblock commands is shown below.

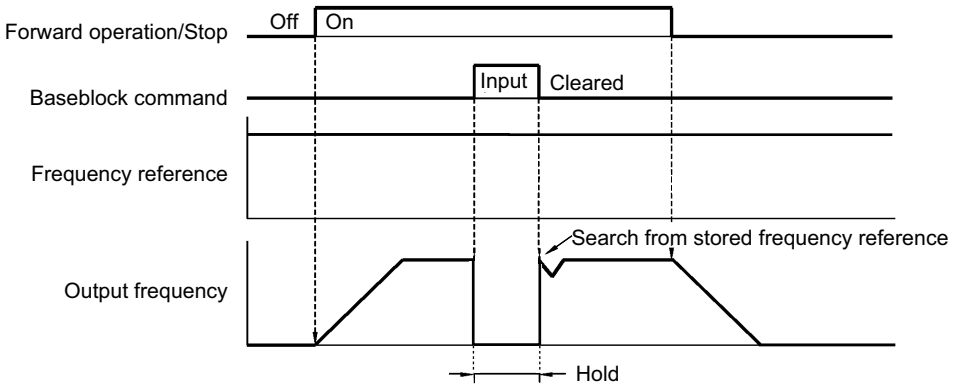


Figure 6.18 Baseblock Commands

◆ Raising and Lowering Frequency References Using Contact Signals (UP/DOWN)

The UP and DOWN commands raise and lower Matrix converter frequency references by turning on and off a multi-function contact input terminal S3 to S16.

To use this function, set one of the constants H1-03 to H1-16 ***H1: Multi-function Contact Inputs on page 104*** (input terminal S3 to S16 function selection) to 10 (UP command) and set another terminal to 11 (DOWN command). Be sure to allocate two terminals so that the UP and DOWN commands can be used as a pair.

The rate of change of the output frequency depends on the acceleration and deceleration time. Be sure to set b1-02 (Run Command selection) to 1 (Control circuit terminal).

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d2-01	Frequency reference upper limit / Ref Upper Limit	Sets the output frequency upper limit as a percent of the maximum output frequency.	0.0 to 110.0	100.0 %	No	A	A	2E0H
d2-02	Frequency reference lower limit / Ref Lower Limit	Sets the output frequency lower limit as a percentage of the maximum output frequency.	0.0 to 109.0	0.0 %	No	A	A	2E1H

■ Precautions

When setting and using UP and DOWN commands, observe the following precautions:

Setting Precautions

If multi-function input terminals S3 to S16 are set as follows, operation error OPE03 (Invalid multi-function input selection) will occur:

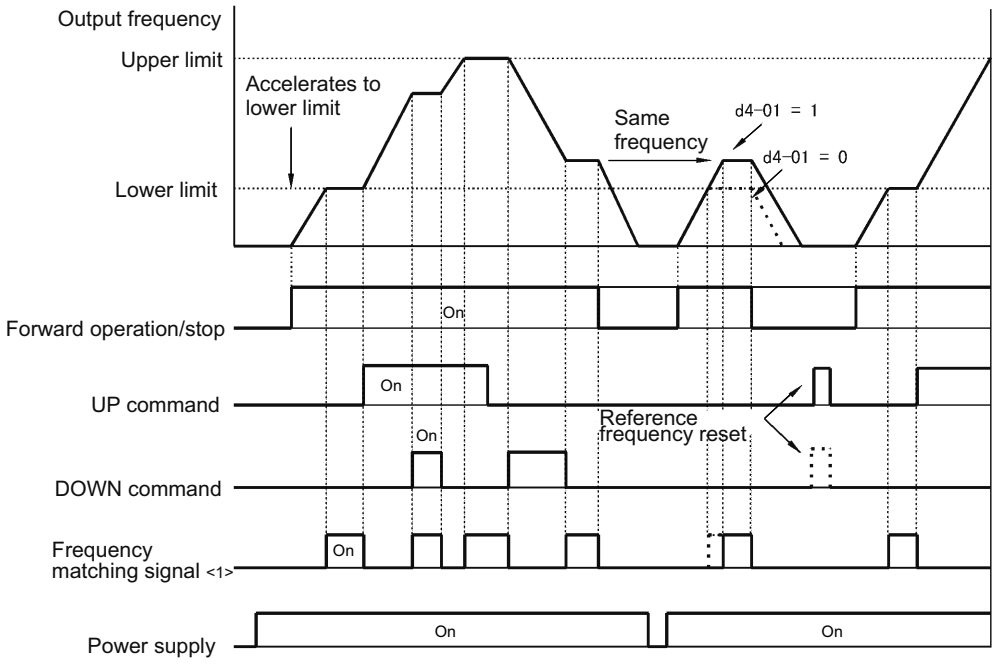
- Only the UP command function (10) or DOWN command function (11) has been selected for input terminals. Both must be selected for valid operation.
- UP/DOWN commands and Acceleration/Deceleration Ramp Hold have been activated at the same time.

Application Precautions

- Frequency outputs using UP/DOWN commands are limited by the frequency reference upper and lower limits set in constants d2-01 and d2-02. However, using UP/DOWN control, a frequency reference at terminal AI1 can become the frequency reference lower limit. If using a combination of the frequency reference from terminal AI1 and the frequency reference lower limit set in constant d2-02, the larger limit will prevail.
- At time of Run Command, when using the UP/DOWN function, the output frequency accelerates to the frequency reference lower limit.
- When using UP/DOWN commands, multi-step operations are disabled.

■ Time Chart

The time chart when using the UP/DOWN command is shown below.



<1> The frequency matching signal turns on when the motor is not accelerating/decelerating while the Run Command is on.

Figure 6.19 UP/DOWN Commands Time Chart

◆ Jog Frequency Operation without Forward and Reverse Commands (FJOG/RJOG)

The FJOG/RJOG command functions operate the Matrix converter at jog frequencies, using contact closures at S3 to S16 terminals. When using the FJOG/RJOG commands, there is no need to input the Run Command.

To use this function, set one of the constants H1-03 to H1-16 ***H1: Multi-function Contact Inputs on page 104*** (input terminal S3 to S16 function selection) to 12 (FJOG command) or 13 (RJOG command).

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
d1-17	Jog frequency reference / Jog Reference	Sets the frequency reference when the multi-function inputs "JOG frequency selection", "FJOG command" and "RJOG command" are on, as a percentage of the maximum output frequency.	0.00 to 100.00	10.00 %	Yes	Q	Q	2D0H

Multi-Function Contact Inputs (H1-03 to H1-16)

Setting Value	Function	Control Methods: Open-loop Vector	Control Methods: Flux Vector
12	FJOG command (on: Forward run at jog frequency d1-17)	Yes	Yes
13	RJOG command (on: Reverse run at jog frequency d1-17)	Yes	Yes

■ Application Precautions

- Jog frequencies using FJOG and RJOG commands are given priority over other frequency references.
- When both FJOG command and RJOG commands are on for 500 ms or longer at the same time, the Matrix converter will stop according to the setting in b1-03 (stopping method selection).

◆ Stopping the Matrix converter because of Peripheral Device Errors (External Fault Function)

The external fault function provides an error contact output, and stops the Matrix converter operation in response to an input signal. This is intended to shut down the Matrix converter in the event of a problem on the machine external to the Matrix converter. The digital operator will display EF□ (External fault [input terminal S□]). The □ in EF□ shows the number of the terminal that provided the external fault signal. For example, if an external fault signal is input to terminal S3, EF3 will be displayed.

To use the external fault function, set one of the values 20 to 2F in one of the constants H1-03 to H1-16 ***H1: Multi-function Contact Inputs on page 104*** (input terminal S3 to S16 function selection).

Select the value to be set in H1-03 to H1-16 from a combination of any of the following three conditions.

- Signal level input from peripheral device (NO or NC)
- External fault detection method (any time power is on, or only during Run or Jog).
- Operation during external fault detection (action to be taken at time of external fault

The following table shows the relationship between the combinations of conditions and the set value in H1-□□.

Set Value	Input Level (See Note 1.)		Error Detection Method (See Note 2.)		Operation During Error Detection			
	NO Contact	NC Contact	Constant Detection	Detection During Operation	Decelerate to Stop (Error)	Coast to Stop (Error)	Emergency Stop (Error)	Continue Operation (Warning)
20	Yes		Yes		Yes			
21		Yes	Yes		Yes			
22	Yes			Yes	Yes			
23		Yes		Yes	Yes			
24	Yes		Yes			Yes		
25		Yes	Yes			Yes		
26	Yes			Yes		Yes		
27		Yes		Yes		Yes		
28	Yes		Yes				Yes	
29		Yes	Yes				Yes	
2A	Yes			Yes			Yes	
2B		Yes		Yes			Yes	
2C	Yes		Yes					Yes
2D		Yes	Yes					Yes
2E	Yes			Yes				Yes
2F		Yes		Yes				Yes

Note: **1.** Set the input level to detect errors using either signal on or signal off. (NO contact: External fault when on; NC contact: External fault when off).

2. Set the detection method to detect errors using either constant detection or detection during operation.
Constant detection: Detects while power is applied to the Matrix converter.
Detection during operation: Detects only during Matrix converter operation.

3. Again, as a reminder: he “H” parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the DI terminals they control are not normally part of user setup.

6.11 Output Terminal Functions

The output terminal function, which sets the output methods by switching the functions of the multi-function output terminals (DO1 to DO8), is described here.

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the DO terminals they control are not normally part of user setup. This section is provided for information only.

◆ During Run (Setting: 0)

Off	The Run Command is off and there is not output voltage.
On	The Run Command is on or a voltage is being output.

◆ During Run 2 (Setting: 37)

Off	The Matrix converter is not outputting a frequency. (Baseblock, DC injection braking, initial excitation, or stopped)
On	The Matrix converter is outputting a frequency.

Note: These outputs can be used to indicate the Matrix converter's operating status.

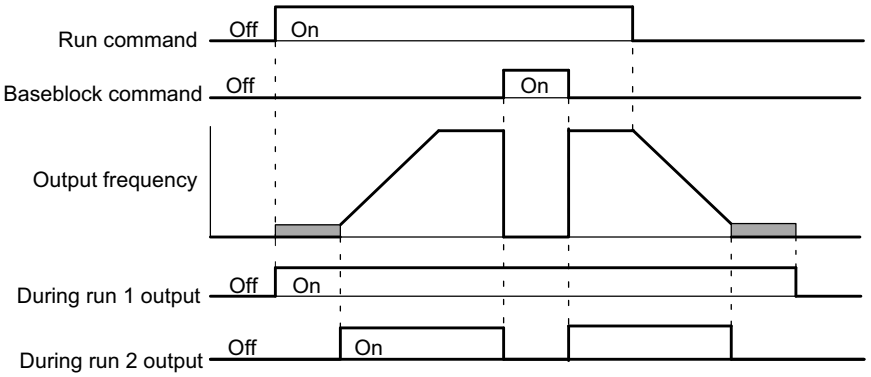


Figure 6.20 Timing Chart for "During RUN" Output

◆ Zero-speed (Setting: 1)

Off	The output frequency is greater than the minimum output frequency (E1-09). (With flux vector control, is greater than the zero-speed level (b2-01).)
On	The output frequency is less than the minimum output frequency (E1-09). (With flux vector control, is less than the zero-speed level (b2-01).)

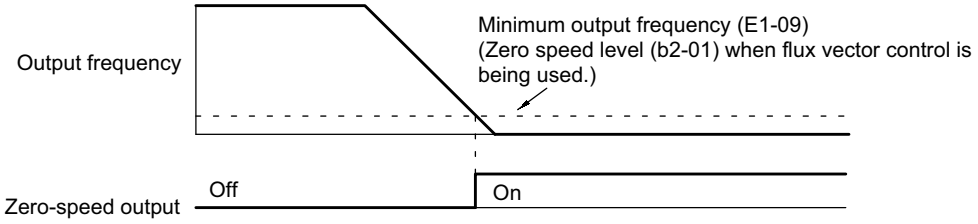


Figure 6.21 Timing Chart for Zero-speed

◆ Speed reference limit (Setting: 31)

Off	Other than on condition
On	Enables the speed reference limit in the following conditions (During flux vector control method): 1. Frequency reference ≥ Frequency reference upper limit (d2-01), Frequency reference ≤ Frequency reference lower limit (d2-02), or Frequency reference ≤ Output frequency lower limit of the multi-function analog input (Setting: 9) 2. The frequency reference is less than the Minimum output frequency (E1-09), and b1-05 is set to 1, 2, or 3.

6.12 Monitor Constants

This section explains the analog monitor constants.

◆ Using the Analog Monitor Constants

Up to 4 analog signals can be selected for remote monitoring. The factory setting for signal AO1 is output frequency. The factory setting for signal AO2 is output current.

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the AI/AO terminals they control are not normally part of user setup. This section is provided for information only.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H4-01	Monitor selection (terminal AO1) / Term AO1 Signal	Sets AO1 for multi-function analog output.	0 to 99	2	Yes	A	A	470H
H4-02	Gain (terminal AO1) / Term AO1 Gain	Sets the multi-function analog output 1 voltage level gain. The output (10 V as 100 %) of the monitored item will be increased by the set gain factor. However, the voltage output at the terminal will be limited to 10 V.	0 to 30.00	1.00	Yes	A	A	471H
H4-03	Bias (terminal AO1) / Term AO1 Bias	Sets the bias added to the AO1 voltage level. The bias is 0 % to ±10 % when 10 V is 100 %. However, the voltage output at the terminal will be limited to 10 V.	-100.0 to 100.0	0.0 %	Yes	A	A	472H
H4-04	Monitor selection (terminal AO2) / Term AO2 Signal	Sets AO2 for multi-function analog output.	0 to 99	3	Yes	A	A	473H
H4-05	Gain (terminal AO2) / Term AO2 Gain	Sets the multi-function analog output 2 voltage level gain. The output (10 V as 100 %) of the monitored item will be increased by the set gain factor. However, the voltage output at the terminal will be limited to 10 V.	0 to 30.00	1.00	Yes	A	A	474H
H4-06	Bias (terminal AO2) / Term AO2 Bias	Sets the bias added to the AO2 voltage level. The bias is 0 % to ±10 % when 10 V is 100 %. However, the voltage output at the terminal will be limited to 10 V.	-100.0 to 100.0	0.0 %	Yes	A	A	475H
H4-07	Monitor selection (terminal AO3) / Term AO3 Signal	Sets AO3 for multi-function analog output.	0 to 99	5	Yes	A	A	476H

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H4-08	Gain (terminal AO3) / Term AO3 Gain	Sets the multi-function analog output 3 voltage level gain. The output (10 V as 100 %) of the monitored item will be increased by the set gain factor. However, the voltage output at the terminal will be limited to 10 V.	0 to 30.00	1.00	Yes	A	A	477H
H4-09	Bias (terminal AO3) / Term AO3 Bias	Sets the bias added to the AO3 voltage level. The bias is 0 % to ±10 % when 10 V is 100 %. However, the voltage output at the terminal will be limited to 10 V.	-100.0 to 100.0	0.0 %	Yes	A	A	478H
H4-10	Monitor selection (terminal AO4) / Term AO4 Signal	Sets AO4 for multi-function analog output.	0 to 99	9	Yes	A	A	479H
H4-11	Gain (terminal AO4) / Term AO4 Gain	Sets the multi-function analog output 4 voltage level gain. The output (10 V as 100 %) of the monitored item will be increased by the set gain factor. However, the voltage output at the terminal will be limited to 10 V.	0 to 30.00	1.00	Yes	A	A	47AH
H4-12	Bias (terminal AO4) / Term AO4 Bias	Sets the bias added to the AO4 voltage level. The bias is 0 % to ±10 % when 10 V is 100 %. However, the voltage output at the terminal will be limited to 10 V.	–100.0 to 100.0	0.0 %	Yes	A	A	47BH
H4-13	Analog output signal level selection / Signal Select	0: 0 to +10 V 1: –10 to +10 V	0 or 1	1	No	A	A	47CH

■ Selecting Analog Monitor Items

The digital operator monitor items (U1-□□ [status monitor]) that represent analog signals can be provided to the multi-function analog output terminals AO1 to AO4. Refer to ***H4: Multi-function Analog Outputs on page 110***, and set the values for the □□ part of U1-□□ (status monitor).

■ Adjusting the Analog Monitor Items

Adjust the output voltage for multi-function analog output terminals AO1 to AO4 using the gain and bias in H4-02, H4-03, H4-05, H4-06, H4-08, H4-09, H4-11, and H4-12.

Adjusting the Meter

The output voltage for terminals AO1 to AO4 can be adjusted while the Matrix converter is stopped. For example, pressing the Enter Key and displaying the data setting display for H4-02 or H4-03 will cause the following voltage to be output to the AO1 terminals.

10 V/100 % monitor output × output gain (H4-02) + output bias (H4-03)

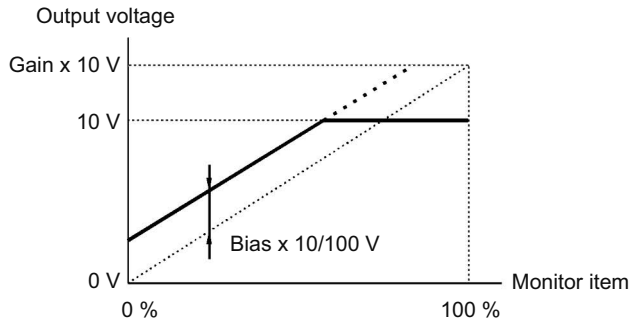


Figure 6.22 Monitor Output Adjustment

■ Switching Analog Monitor Signal Levels

Monitor items corresponding to –10 to 10 V provide 0 to 10 V signals when the monitor value is positive (+), and 0 to –10 V signals when the monitor value is negative (–). For monitor items corresponding to –10 to 10 V, refer to ***H4: Multi-function Analog Outputs on page 110***.

6.13 Digital Operator Functions

This section explains the Digital Operator functions.

◆ Setting Digital Operator Functions

The function of several of the Digital Operator keys can be modified by constant setting.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
o2-01	LOCAL/REMOTE key enable/disable Local/Remote Key	Sets the Digital Operator Local/ Remote Key 0: Disabled 1: Enabled (Switches between the Digital Operator and the external settings.)	0 or 1	1	No	A	A	6F0H
o2-02	STOP key function during REMOTE operation. Oper STOP Key	Enables or disables the Stop key. 0: Disabled (When in REMOTE operation the Stop Key is disabled.) 1: Enabled (Stop key is enabled during REMOTE operation.)	0 or 1	0	No	A	A	6F1H
o2-05	Frequency reference setting method selection Operator M.O.P.	Enables a Digital M.O.P. function. 0: Enter Key needed. Set speed with UP or DOWN key, press Enter to complete the speed command. 1: Enter Key not needed. Speed will increase or decrease as commanded by the UP or DOWN keys. (M.O.P. functionality).	0 or 1	0	No	A	A	6F4H
o2-07	Cumulative operation time setting Elapsed Time Set	Sets the cumulative operating time in hour units. Operating time is calculated from the set values.	0 to 65535	0 hr	No	A	A	6F6H

■ Disabling the LOCAL/REMOTE Key

Set o2-01 to 0 to disable the LOCAL/REMOTE Key on the Digital Operator. When disabled, b1-01 (Reference Selection), or b1-02 (Operation Method Selection) are not functional.

■ Disabling the STOP Key

If b1-02 (Start Command Selection) is set to 1, 2, or 3, the Stop Command from the STOP Key on the Digital Operator is an emergency Stop Command.

Set o2-02 to 0 to disable the STOP Key on the Digital Operator.

■ Setting the Frequency Reference using the UP and DOWN Keys without Using the Enter Key

Use this parameter for a digital M.O.P. function on the Digital Operator. When o2-05 is set to 1, the frequency reference can be adjusted by increasing or decreasing increments using the UP and DOWN Keys without using the Enter Key.

For example, enter the Run Command using a 0 % reference, and then continuously press the UP Key to increment the frequency reference. Press and hold the UP Key for 3 s minimum to reach the maximum output frequency 10 s after that. The frequency increments by 0.01 % for the first 0.5 s, and then by 0.01 % every 80 ms for 3 s thereafter. The frequency reference that has been set will be stored in memory 5 s after the UP or DOWN Keys are released.

■ Clearing Cumulative Operation Time

Set the cumulative operation time initial value in time units in constant o2-07. Set o2-07 to 0 to clear U1-13 (Matrix converter Operating Time).

◆ Prohibiting Writing Constants from the Digital Operator

If A1-01 is set to 0, only the A1-01 ***86*** and A1-04 ***86*** constants can be set. The Digital Operator can still be used for monitoring.

If one of the constants H1-03 to H1-16 ***H1: Multi-function Contact Inputs on page 104*** (input terminal S3 to S16 function selection) is set to 1B (write constants permitted), constants can be written from the digital operator when this terminal is on. When the set terminal is off, writing constants other than the frequency reference is prohibited. Constants can still be read when the terminal is off.

Note: The “H” parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the terminals they control are not normally part of user setup. This section is provided for information only.

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
A1-01	Constant access level / Access Level	Selects the constant access level (read only or set and read.) 0: Monitoring only (Monitoring drive mode and initialize mode.) 2: Advanced (A) (Constants can be read and set in both quick programming (Q) mode and advanced programming (A) mode.)	0 to 2	2	No	A	A	101H

6.14 Individual Functions

This section explains individual functions that can be used in special applications.

◆ Performing Closed Loop Speed Control with Pulse Generator (PG)

This section explains functions with Flux vector control.

■ Related Constants

Constant Number	Name / Display	Description	Setting Range	Factory Setting	Change during Operation	Control Methods: Open-loop Vector	Control Methods: Flux Vector	MEMOBUS Register
H7-01	PG constant / PG Pulses/Rev	Sets the PG (pulse generator or encoder) pulses per revolution (ppr). Sets the number of pulses per motor revolution (ppr) without multiplication.	0 to 8192	600 <1>	No	No	Q	4A0H
H7-04	Operation selection at deviation / PG Deviation Sel	Sets the stopping method when a speed deviation (DEV) fault occurs. 0: Decelerate to stop 1: Coast to stop 2: Emergency stop 3: Continue operation	0 to 3	3	No	No	A	4A3H
H7-05	PG rotation direction setting / PG Rotation Sel	0: Phase A leads with forward run command. 1: Phase A leads with reverse run command.	0 or 1	1	No	No	A	4A4H
H7-08	Overspeed detection level / PG Overspd Level	Sets the overspeed detection method. Overspeed is detected when a frequency above the level specified by H7-08 (a percentage of the maximum output frequency) has continued for more than the time specified by H7-09 (detection time in units of seconds).	0 to 120	115 %	No	No	A	4A7H
H7-09	Overspeed detection delay time / PG Overspd Time		0.0 to 2.0	0.0 s	No	No	A	4A8H
H7-10	Excessive speed deviation detection level / PG Deviate Level	Sets the excessive speed deviation (DEV) detection method. An excessive speed deviation is detected when a speed deviation above the level specified by H7-10 (a percentage of the maximum output frequency) has continued for more than the time specified by H7-11 (detection time in units of seconds). Speed deviation: The difference between the actual motor speed and the commanded speed (reference)	0 to 50	10 %	No	No	A	4A9H
H7-11	Excessive speed deviation detection delay time / PG Deviate Time		0 to 10.0	0.5 s	No	No	A	4AAH
H7-14	PG open-circuit detection time / PGO Detect Time	Sets the time for the software to detect a PG disconnection in units of seconds.	0.0 to 10.0	3.0 s	No	No	A	4ADH

<1> When the control method is changed, the factory setting will change. The flux vector factory setting is given.

■ Setting the Number of PG Pulses

Set the number of PG (Pulse Generator/Encoder) pulses in pulses/revolution. Set the number of A-phase or B-phase pulses per 1 motor rotation in H7-01.

■ Matching PG Rotation Direction and Motor Rotation Direction

Constant H7-05 matches the PG rotation direction and the motor rotation direction. When the motor is rotating forward, set whether it is A-phase driven or B-phase driven (A-phase leading or B-phase leading).

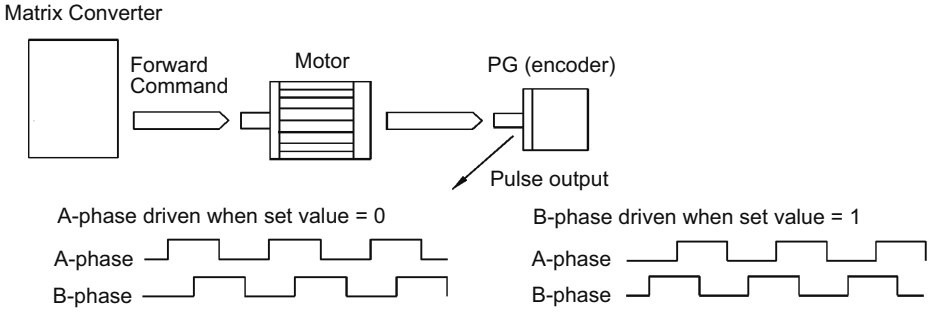
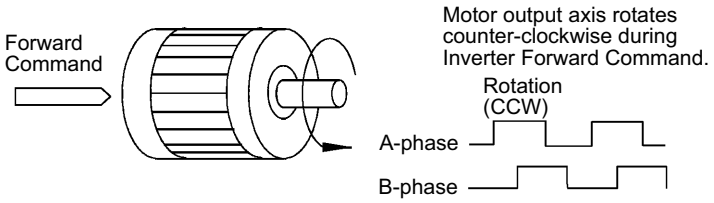


Figure 6.23 PG Rotation Direction Setting

Example: Forward rotation of standard Yaskawa motor (PG used: Samtack (KK))



Yaskawa standard PG used is A-phase driven (CCW) when motor rotation is forward.

Figure 6.24 Motor Rotation Direction Setting

Generally, a PG is A-phase driven when rotation is counterclockwise (CCW) viewed from its shaft end. Also, motor rotation is counter-clockwise (CCW) viewed from the shaft end when a Forward Command is output. Consequently, when motor rotation is forward, the PG is normally A-phase driven.

■ Detecting PG Open Circuit

When a PG cable disconnection (PGO) is detected, the motor will coast to stop.

CAUTION! *Continuing to operate the Matrix converter after loss of feedback signal (PG cable disconnection) may result in damage to machinery and may result in injury. To protect the motor or machinery, do not operate the Matrix converter until the PGO fault is corrected.*

■ Detecting Motor Overspeed

An error is detected when the motor speed (r/min) exceeds the specified limit. An overspeed (OS) is detected when a frequency that exceeds the set value in H7-08 continues for longer than the time set in H7-09. After detecting an overspeed (OS), the Matrix converter stops according to the setting in H7-04.

■ Detecting Speed Difference between the Motor and Speed Reference

An error is detected when the speed deviation (i.e., the difference between the commanded speed and the actual motor speed) is too great. Speed deviation (DEV) is detected after speed agreement <1> , and after the speed reference and actual speed are within the setting of L4-02 ***115***. DEV is activated if a speed deviation great than the set value in H7-10 continues for longer than the time set in H7-11. After a speed deviation is detected, the Matrix converter stops according to the setting in H7-04.

<1> Speed agreement means “at set speed”, i.e. not accelerating or decelerating.

7

Troubleshooting

This chapter describes the fault displays and countermeasure for the MX1S Matrix converter and motor problems and countermeasures.

7.1 Section Safety

⚠ DANGER

Electrical Shock Hazard

Disconnect all main power before servicing.

Failure to comply may result in serious injury or death from electric shock.

To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc.

⚠ WARNING

Electrical Shock Hazard

Do not operate equipment with covers removed.

Failure to comply could result in death or serious injury.

The diagrams in this section may show Matrix converters without covers or safety shields to show details. Be sure to reinstall covers or shields before operating the Matrix converters and run the Matrix converters according to the instructions described in this manual.

Always ground the motor-side grounding terminal.

Improper equipment grounding could result in death or serious injury by contacting the motor case.

Do not perform work on the Matrix converter while wearing loose clothing, jewelry or without eye protection.

Failure to comply could result in death or serious injury.

Remove all metal objects such as watches and rings, secure loose clothing, and wear eye protection before beginning work on the Matrix converter.

Do not remove covers or touch circuit boards while the power is on.

Failure to comply could result in death or serious injury.

Do not allow unqualified personnel to perform work on the Matrix converter.

Failure to comply could result in death or serious injury.

Installation, maintenance, inspection, and servicing must be performed only by authorized personnel familiar with installation, adjustment, and maintenance of Medium Voltage AC drives.

Fire Hazard

Tighten all terminal screws to the specified tightening torque.

Loose electrical connections could result in death or serious injury by fire due to overheating of electrical connections.

Do not use improper combustible materials.

Failure to comply could result in death or serious injury by fire.

Attach the Matrix converter to metal or other noncombustible material.

Do not use an improper voltage source.

Failure to comply could result in death or serious injury by fire.

Verify that the rated voltage of the Matrix converter matches the voltage of the incoming power supply before applying power.

NOTICE

Observe proper electrostatic discharge procedures (ESD) when handling the Matrix converter and circuit boards.

Failure to comply may result in ESD damage to the Matrix converter circuitry.

Never connect or disconnect the motor from the Matrix converter while the Matrix converter is outputting voltage.

Improper equipment sequencing could result in damage to the Matrix converter.

Do not use unshielded cable for control wiring.

Failure to comply may cause electrical interference resulting in poor system performance. Use shielded twisted-pair wires and ground the shield to the ground terminal of the Matrix converter.

Do not allow unqualified personnel to use the product.

Failure to comply could result in damage to the Matrix converter.

Do not modify the Matrix converter circuitry.

Failure to comply could result in damage to the Matrix converter and will void warranty.

Yaskawa is not responsible for any modification of the product made by the user. This product must not be modified.

Check all the wiring to ensure that all connections are correct after installing the Matrix converter and connecting any other devices.

Failure to comply could result in damage to the Matrix converter.

7.2 Protective and Diagnostic Functions

This section describes the alarm functions of the Matrix converter. The alarm functions include fault detection, alarm detection, operation error detection, and autotuning error detection.

When an alarm is detected in the Matrix converter, the LED "ALARM" indicator on the Digital Operator illuminates (fault detection) or flashes (alarm detection), and the fault detail is displayed on the monitor. After the fault is reset, the former fault log can be verified by calling up the menu. Maintenance, inspection and parts replacement must be performed by a technician who has been trained and certified on the structure and circuits of the Matrix converter.

DANGER! *Disconnect all main power before servicing. To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc. Failure to comply may result serious injury of death from electric shock.*

WARNING! *The MX1S Matrix converter has two (2) sources of power, the 4160V main supply and a 480V control power supply. Make sure that both sources are off before starting maintenance or inspection. Failure to observe this precaution may result in serious personal injury or death.*

NOTICE: *Damage to Equipment. Observe proper electrostatic discharge procedures (ESD) when handling the Matrix converter and circuit boards. Failure to comply may result in ESD damage to the Matrix converter circuitry.*

◆ Fault Detection and Alarm Detection

When the Matrix converter detects a fault, the fault contact output operates, and the Matrix converter output is shut off causing the motor to coast to a stop. (The stopping method can be selected for some faults, and the selected stopping method will be used with these faults.) A fault code is displayed on the Digital Operator.

When a fault has occurred, refer to the following table to identify and correct the cause of the fault.

Use one of the following methods to reset the fault before restarting the Matrix converter:

- Set a multi-function contact input (H1-03 to H1-16) to 14 (Fault Reset) and turn on the fault reset signal.
  Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the terminals they control are not normally part of user setup. This item is provided for information only.
- Press the RESET Key on the Digital Operator.
- Turn the main circuit and control circuit power supplies off and then on again.

Alarms are a type of protection function that do not operate the fault contact output. The system will automatically return to its original status once the cause of the alarm has been removed.

The Digital Operator display blinks and an alarm is sent from the multi-function outputs.

Fault detection (F) and alarm detection (A) are classified into "Drive Faults" and "Cell Faults".

◆ Drive Faults

Drive faults are detected by the main control units. If any of these faults occurs, it is displayed on the Digital Operator, and its detail is recorded in memory.

Table 7.1 List of Drive Faults

Fault Display	Rank <1>	Fault Details	Corrective Actions
IOV Overvoltage	F	Input power overvoltage Voltage exceeded 120 % of rated power supply voltage (L9-01).	• Check the main power supply voltage. • Confirm that the detected value of the power supply voltage (U1-90) and the setting value of the rated main power supply input voltage (L9-01) are appropriate. • If detection is faulty, replace the isolation board, which detects input voltage, or the modulator board. • Take measures to adjust the power supply voltage (changing taps of transformer etc.).
AUV	F(A)	Input power undervoltage The main circuit input voltage has dropped to below the value set for L2-21 for the detection time or longer. The alarm is activated while the motor is stopped.	
FDEV	F	Input power frequency fault The difference from the power supply rated frequency has exceeded the detection level for the detection time or longer.	
SRC	F	After the power supply was turned on, the phase order was not established within the detection time. The phase order has been changed since the last time the power supply was turned on.	
CUV CTL PS UnderVolt	F	Control power supply fault Control power supply voltage was lowered (or removed). Exclusive contact signal input from the 5-V power supply board.	• Check the control power supply. • Replace the 5-V power supply board.
IOC Over Current	F	Drive overcurrent The Matrix converter output current exceeded the overcurrent detection level (132 % of rated current).	• Measure the insulation resistance of the motor and cable. • Check the output cable connection. • Check the acceleration/deceleration time settings. • Check the PG installation and signals. • Check the load.
OOV Output OV Fault	F	Output overvoltage The Matrix converter output voltage (L9-06) exceeded the overvoltage detection level (L9-07).	• Check the motor constants. ***Refer to E: Motor Constants on page 101*** Constants: E1-□□, E2-□□Confirm that the settings of L9-06 and L9-07 are appropriate. • Check the output cable connection.
TME Tr Overtemp	F	Transformer temperature fault (input terminal DI_1) A fault detected from a contact input terminal on the control board. **Note:** Check the actual external terminal number on the elementary wiring diagram.	• Check to see if the transformer is overheated. • Check the contact input terminal status. • Inspect the cooling fan on the Control Panel. • Check the amount of cooling air. • Clean the air-inlet filter. • Check the mechanical system and correct the cause of the fault.
FAN1 Fan Fault 1	F	Cooling fan fault 1(input terminal DI_2) A fault detected from a contact input terminal on the control board. **Note:** Check the actual external terminal number on the elementary wiring diagram. When using more than one cooling fan, faults may be found in multiple contact input terminals (FAN2 to 4).	• Check the cooling fan operation and the contact input terminal status. • Replace the cooling fan. (Normally, input terminals need to be activated within 10 seconds after fan operating commands [both on and off] are sent).

Fault Display	Rank <1>	Fault Details	Corrective Actions
OL1 Motor Overloaded	F/A	Motor Overload (Operation selection – L1-04) ***Refer to L: Protection Function Constants on page 112***. The motor overload protection function has operated based on the internal electronic thermal value.	• Check the Motor Rated Current (E2-02). • Confirm that the settings of detection (L1-02, L1-06, and L1-07) are appropriate. • Check the size of the load and the length of the acceleration, deceleration, and cycle times.
OL3 Overtorque Det 1	F/A	Overtorque Detected 1 (Operation selection – L6-01) The torque has exceeded the overtorque detection level 1 (L6-02) for the detection time (L6-03) or longer.	• Make sure that the settings in L6-02 and L6-03 are appropriate. • Check the mechanical system and correct the cause of the overtorque.
OL4 Overtorque Det 2	F/A	Overtorque Detected 2 (Operation selection – L6-04) The torque has exceeded the overtorque detection level 2 (L6-05) for the detection time (L6-06) or longer.	• Make sure that the current setting in L6-05 and time setting in L6-06 are appropriate. • Check the mechanical system and correct the cause of the overtorque.
UL3 Undertorque Det 1	F/A	Undertorque Detected 1 (Operation selection – L6-01) The torque has dropped below the undertorque detection level (L6-02) for the detection time (L6-03) or longer.	• Make sure that the settings in L6-02 and L6-03 are appropriate. • Check the mechanical system and correct the cause of the undertorque.
UL4 Undertorque Det 2	F/A	Undertorque Detected 2 (Operation selection – L6-04) The torque has dropped below the undertorque detection level (L6-05) for the detection time (L6-06) or longer.	• Make sure that the current setting in L6-05 and time setting in L6-06 are appropriate. • Check the mechanical system and correct the cause of the undertorque.
PGO PG Open	F/A	PG Disconnection Detected***Refer to Performing Closed Loop Speed Control with Pulse Generator (PG) on page 184*** PG pulses were absent when the Matrix converter was outputting a frequency.	• Fix the wiring. • Supply power to the PG properly. • Check the PG itself (output).
DEV Speed Deviation	F/A	Excessive Speed Deviation (Operation selection – H7-04) The speed deviation has been greater than the setting in H7-10 for longer than the setting in H7-11.	• Reduce the load. • Lengthen the acceleration time and deceleration time. (Constant: C1-□□. Check the settings in H7-10 and H7-11.
OS Overspeed Det	F	Overspeed The speed has been greater than the setting in H7-08 for longer than the setting in H7-09.	• Check the settings in H7-08 and H7-09. • Make sure that the motor constants are appropriate. (Constant: E-□□, E2-□□) • Check the mechanical system and correct the cause of the overspeed.
OGF Ground Fault	F	Output Ground Fault The ground fault current at the Matrix converter output exceeded approximately 25 % of the Matrix converter rated output current. Or, the zero-phase voltage at the Matrix converter output exceeded the ground fault detection level (L9-21) for the detection time (L9-22).	• Measure motor and cable insulation resistances. • Check the motor cable.
LF Output Pha Loss	F	Output Open-phase An open-phase occurred at the Matrix converter output. This fault is detected when L8-07 is set to "Enabled."	• Check the motor cable.
EF External Fault	A	Forward/Reverse run Simultaneous Input The forward-run and the reverse–run input continued 0.5 seconds or more simultaneously.	• Check the input sequence.**Note:** When this alarm occurs, the motor decelerates to stop.
CF Out of Control	F	Control Fault The torque limit was reached continuously for 3 seconds or longer during a deceleration stop during open-loop vector control.	• Check the motor constants. Constant: E1-□□, E2-□□ Lengthen the deceleration time. Constant: C1-□□

Fault Display	Rank <1>	Fault Details	Corrective Actions
OPR Opr Disconnect	F	Digital Operator Connection Fault The connection to the Digital Operator was interrupted. (Only active in Local mode). Detected when 02-06 is set to1.	• Check the connection to the Digital Operator.
CPF00 COM-ERR (OP &MxC)	F	Digital Operator Communications Error 1. Communications with the Digital Operator were not established within 5 seconds after the power was turned on.	• Disconnect the Digital Operator and reconnect it. • Cycle the control power supply off and on. • Replace the Digital Operator or the CPU board.
CPF01 COM-ERR (OP &MxC)	F	Digital Operator Communications Error 2. After communications were established, there was a communications error with the Digital Operator for 2 seconds or longer.	• Disconnect the Digital Operator and reconnect it. • Replace the Digital Operator or the CPU board.
CPF03 EEPROM Error	F	EEPROM error The control circuit is damaged.	• Cycle the control power supply off and on. • Replace the modulator board.
CPF05 External A/D Err	F	A/D converter error The control circuit is damaged.	• Cycle the control power supply off and on. • Replace the modulator board.
HDE HARD Fault	F	Modulator board Hardware Fault The modulator board is damaged.	• Cycle the control power supply off and on. • Replace the modulator board.
DTM MB Watchdog Flt	F	Modulator Watchdog Fault A communication error between with the modulator board and the CPU board occurred.	• Cycle the control power supply off and on. • Replace the CPU board or the modulator board.
CTF Analog Pwr Fault	F	Analog Power supply Fault The analog power supply (±15 V) was lowered or lost.	• Replace the analog power supply (±15 V).
CER CTL CPU Fault	F	CPU Watchdog Fault The watchdog time was exceeded in the CPU board.	• Cycle the control power supply off and on. • Replace the CPU board.
BAT Weak Battery	A	Low Battery The battery for memory backup on the CPU board is uncharged.	• Replace the battery on the CPU board.
LIN (MB)	F	A cell communications error (link error) was detected on the modulator board.	• Inspect the fiber optic cable, and replace it if damaged. • Replace the CCB. • Replace the modulator board.
PAR (MB)	F	A cell communications error (parity check error) was detected on the modular board.	• Inspect the fiber optic cable and replace it if damaged. • Replace the CCB. • Replace the modulator board.
EF□ Ext Fault S□	F/A	External Fault (Input terminal S□) □ = 3 to 16 An “external fault” was input from a multi-function input terminal. Check elementary diagram for terminal number.	• Reset external fault inputs to the multi-function inputs. • Remove the cause of the external fault.

<1> F:Fault,
A: Alarm,
F/A: Fault or alarm depending on the constant setting

◆ Cell Faults

Cell faults are detected by the control circuit of each Power Cell, and transmitted to the main control section. If any of these faults occur, it is displayed on the Digital Operator, and the details are recorded in memory.

Table 7.2 List of Cell Faults

Fault Display <1>	Rank	Fault Details	Corrective Actions
LIN [Detail] nn: LINK FLT	F	Communications Error (link error) A Cell Control Board (CCB) communications error was detected.	• Inspect the fiber optic cable, and replace it if damaged. • Replace the CCB. • Replace the modulator board.
CFA	F	Cell Fault	
[Detail] nn: OVR VOLT	F	Snubber DC Circuit Overvoltage The voltage of snubber DC circuit rose to 1300 V±5 % or higher.	• Check the cell input voltage. • Check the cell power fuse. • Replace the CCB.
[Detail] nn: CTR PWR UV	F	Snubber DC Circuit Undervoltage The voltage of snubber DC circuit dropped to 677 V±5 % or lower.	• Check the cell input voltage • Check the cell power fuse. • Replace the CCB.
[Detail] nn: OC FLT	F	Overcurrent The cell output current exceeded the detection level.	• Check the output circuit wiring. • Check the motor insulation. • Check the acceleration/deceleration time setting. • Check the PG installation and signals. • Check the load. • Replace the CCB.
[Detail] nn: SROH FLT	F	Snubber Resistor Overheated The temperature of snubber discharging resistor increased.	• Check the input ac supply voltage waveform for excessive distortion.
[Detail] nn: OVER TEMP	F	Cell Overheated The thermistor installed on the fin detected a temperature of 90°C or higher. Cell for 35 A to 260 A: 95°C Cell for 400 A or 520 A: 105°C	• Inspect the cooling fan on the Control Panel. • Check the amount of cooling air. • Clean the air inlet filter. • Inspect and clean the cell unit. • Replace the CCB. • Replace the thermistor or cell unit.
[Detail] nn: CAP FLT	F	DC Capacitor Overvoltage The voltage of the electrolytic capacitor of snubber DC circuit increased to 520 V±5 % or higher.	• Check the electrolytic capacitor for deterioration, and replace if necessary. • Check the balance resistor. • Replace the CCB
[Detail] nn: CELL INIERR	F	Initial Setting Error The cell initial setting data is incorrect.	• Check the setting of CCB SW1. • Replace the CCB.
[Detail] nn: INVOLT ERR	F	Input Voltage Error The cell input power fuse is open. An input open phase occurred.	• Check the cell input power fuse. • Check the IGBT. • Check the cell input voltage. • Replace the CCB.
[Detail] nn: WDT OVR	F	Hardware Fault A watchdog timer error occurred. (Faulty CCB)	• Replace the CCB.

<1> [Detail] shows the detail display on the Digital Operator, and “nn” shows the cell number.

◆ LED Indicators on the Controller and CCB (Cell Control Board) (For Reference)

The following describes the LED indicators on the controller in the Control Panel and the CCB in the Power Cell Panel, which display operation status and faults for reference.

WARNING! *Electrical Shock Hazard. The MX1S is a medium voltage device, do not open panel doors to check LEDs when main circuit or control circuit power is ON. Ensure all power to the MX1S of OFF and wait 15 minutes before opening panel doors. Failure to observe this precaution may result in an electric shock.*

■ LED indicators on the controller

The controller has two types of LED indicators: An LED indicator that displays the controller status, and an LED indicator that displays the cell status detected by the controller.

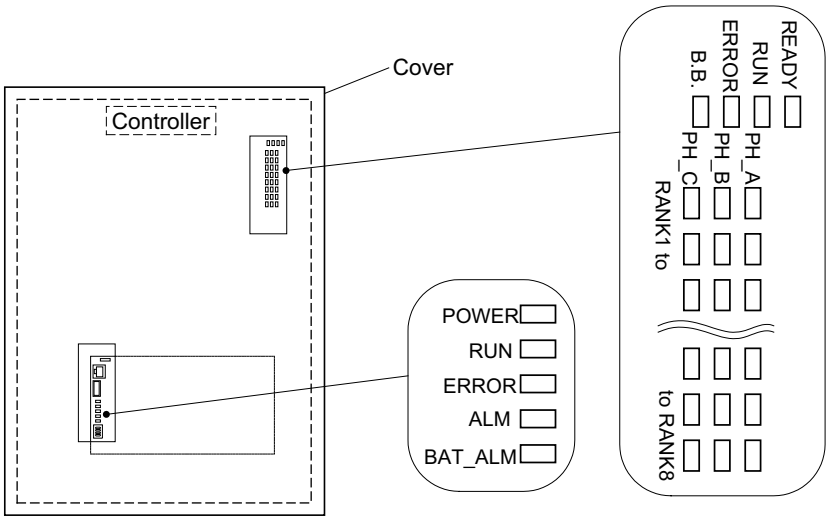


Figure 7.1 LED on Controller

Table 7.3 Controller Status LED

LED	Status
POWER (Green)	Lit when control power is on.
RUN (Green)	Lit when controller is operating.
ERROR (Red)	Lit when a controller fault occurs.
ALM (Red)	Lit when an alarm occurs in controller.
BAT ALM (Red)	Lit when battery voltage has dropped.

Table 7.4 Cell Status LED

LED	Status
READY (Green)	Lit when interface circuit of the cell is operating.
RUN (Green)	Lit when interface circuit of the cell is normal.
ERROR (Red)	Lit when a fault in the interface circuit of the cell occurs.
B.B. (Red)	Lit during baseblock.
PH_A RANK0 to 8 (Red)	Lit when an A-phase rank 1 to 8 cell fault occurs.
PH_A RANK0 to 8 (Red)	Lit when a B-phase rank 1 to 8 cell fault occurs.
PH_A RANK0 to 8 (Red)	Lit when a C-phase rank 1 to 8 cell fault occurs.

■ LED Indicators on CCB (Cell Control Board)

The LED indicator lamps on the CCB indicate the CCB power supply status, IGBT operating status, and fault occurrence as shown below.

Table 7.5 CCB Power Supply Status LED

LED	Status
CHARGE	Lit when the snubber DC voltage is charged (Illuminates when the voltage reaches approximately 50 V.)
FLT	Lit when a cell fault occurs.
LINK-ON	Lit during normal transmission with the controller
RUN	Lit while the cell is operating.
POWER	Lit while the controller is operating.

Never touch the Power Cell while any LED indicator lamp is lit.

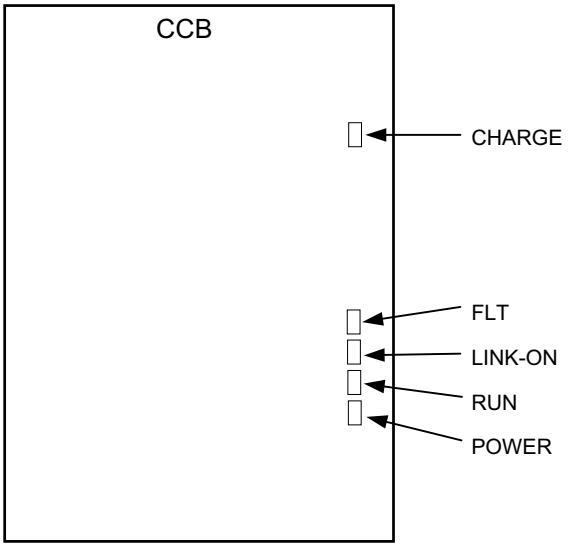


Figure 7.2 LED Indicator Lamps on CCB

Table 7.6 LED Indicator Lamp Status

LED	Ready	Running	Fault
CHARGE (Red)	1	1	1
FLT (Red)	○	○	1
LINK-ON (Green)	1	1	1
RUN (Green)	○	1	○
POWER (Green)	1	1	1

○: Unlit
l: Lit

◆ Operation Errors

An operation error will occur if there is an invalid setting or a contradiction between two constant settings. It is impossible to start the Matrix converter until the constants have been set correctly. (The alarm output and fault contact outputs will not operate either.)

When an operation error has occurred, refer to ***Table 7.7*** to identify and correct the cause of the errors.

Table 7.7 Operation Error Displays and Incorrect Settings

Display	Meaning	Incorrect settings
OPE02Limit	Constant Setting Range Error	The constant setting is outside of the valid setting range. Press the ENTER Key on the Digital Operator to display OPE fault constant (U1-34).
OPE03Terminal	Multi-function Input Selection Error	One of the following errors has been made in the multi-function input (H1-01 to H1-10) settings: The same setting has been selected for two or more multi-function inputs. An up or down command was selected independently. UP and DOWN commands cannot be used at the same time. (Down must be off to allow the use of UP, and vice-versa.) Speed Search 1 (61, maximum output frequency) and Speed Search 2 (62. set frequency) were selected at the same time. The emergency Stop Command NO and NC have been set at the same time. **Note:** The "H" parameter group, and the multi-function I/O, is typically preprogrammed, specific to an individual Matrix converter and its particular application. Refer to the elementary drawing.
OPE07Analog Selection	Multi-function Analog Input Selection Error	The same setting has been selected for two or more multi-function analog inputs.
OPE08 Ctrl Func Error	Constant Selection Error	Functions that cannot be used in the selected control mode are set. For example, a function that can be used only in flux vector control mode is set for open-loop control mode. The error code will be displayed together with the constant number whose setting is incorrect.
OPE10 V/f Ptrn Setting	V/f Data Setting Error	Constants E1-04, E1-06, E1-07, and E1-09 do not satisfy the following conditions: E1-04 (FMAX) ≥ E1-06 (FA) > E1-07 (FB) ≥ E1-09 (FMIN)
OPE11 Carr Freq/On-Delay	Constant Setting Error	The motor overload detection start level (L1-06) has been set to a value above the motor overload detection level (L1-07).
ERR EEPROM R/W Err	EEPROM Write Error	A verification error occurred when writing EEPROM. Cycle the control power supply off and on. Reset the constants.

◆ Errors During Autotuning

The errors that can occur during autotuning are given in the following table. If an error is detected, the motor will coast to a stop and an error code will be displayed on the Digital Operator. The error contact output and alarm output will not function.

Table 7.8 Errors During Autotuning

Display	Meaning	Probable causes	Corrective Actions
ER-01 Data Invalid	Motor data error	There is an error in the relationship between the rated frequency, the rated motor r/min, and the number of motor poles.	Correct the data as follows: motor r/min < 120 × rated frequency/ number of motor pole.
ER-02 Accelerate	Acceleration error The motor did not accelerate in the specified time.	• Torque limit function is operating. • Acceleration time is too long. • The load is connected to the motor.	• Check and correct the setting values of L7-01 to 04 (torque limits). • Increase the setting value of C1-01 (Acceleration Time). • Disconnect the load from the motor.
ER-03 PG Direction	Motor Direction Error The sign of the speed reference differs from that of speed feedback.	There is a faulty (or inconsistent sequence) connection between the Matrix converter, PG (A-phase and B-phase), and motor (U-phase, V-phase, and W-phase).	• Check the PG wiring. • Check the motor wiring. • Check the PG rotation direction and setting value of H7-05 (PG rotation direction).
ER-04 Motor Speed	Motor speed error Torque reference value has exceeded 100 % for 3 seconds during autotuning.	• The motor power cable is disconnected. • The load is connected to the motor.	• Check the wiring. • Disconnect the load from the motor.
ER-05 Resistance	Line-to-line resistance error	• Autotuning was not completed in the specified time. • The result of autotuning is out of the constant setting range. • The setting value of the motor rated current is wrong. • The motor power cable is disconnected.	• Check and correct the input data. • Check the wiring.
ER-06 No-Load Current	No-load current error		
ER-07 Motor core saturation 1	Motor core saturation error 1		
ER-08 Motor core saturation 2	Motor core saturation error 2		
ER-09 Rated FLA Alm	Rated current setting alarm	• Autotuning was not completed in the specified time. • The result of autotuning is out of the constant setting range. • The load is connected to the motor.	Disconnect the load from the motor.
ER-10 STOP key	STOP key input	The STOP Key was pressed to cancel autotuning.	–
ER-11 I-det. Circuit	Current detection error The current flow exceeded the motor rated current. The detected current sign was the opposite of what it should be.	• The setting value of the motor rated current is wrong. • There is an error in the current detector.	• Check and correct the input data. • Check the current detection circuit, motor wiring, current detector, and installation methods.
ER-12 Base Block	Base block stop	The base block command was input from the PLC to cancel autotuning.	Clear the base block command from the PLC.

7.3 Troubleshooting

Due to constant setting errors, faulty wiring, etc., the Matrix converter and motor may not operate as expected when the system is started up. If that should occur, use this section as a reference and apply the appropriate measures.

If the contents of the fault are displayed, refer to ***Protective and Diagnostic Functions on page 190***.

◆ If Constants Cannot Be Set

Use the following information if a Matrix converter constant cannot be set.

■ The display does not change when the Increment and Decrement Keys are pressed.

The following causes are possible.

The Matrix converter is operating (drive mode).

There are some constants that cannot be set during operation. Turn the Matrix converter off and then make the settings.

Constant write enable is input.

This occurs when "constant write enable" (set value: 1B) is set for a multi-function input terminal (H1-03 to H1-16). If the constant write enable input is off, the constants cannot be changed. Turn it on and then set the constants.

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the terminals they control are not normally part of user setup. This item is provided for information only.

■ OPE02 through OPE11 is displayed.

The set value for the constant is wrong. Refer to ***Table 7.7*** and correct the setting.

■ CPF00 or CPF01 is displayed.

This is a Digital Operator communications error. The connection between the Digital Operator and the Matrix converter may be faulty. Disconnect the Digital Operator and reconnect it.

◆ If the Motor Does Not Operate

Use the following information if the motor does not operate.

■ The motor does not operate when the RUN Key on the Digital Operator is pressed.

The following causes are possible.

Note: If the Matrix converter is not in drive mode (i.e., it is in a programming mode), the DRIVE indicator on the Digital Operator (JVOP-160) will not be lit, and the Matrix converter will remain in ready status and will not start. Press the Menu Key to display the drive mode, and enter the drive mode by pressing the DATA/ENTER Key. "-Rdy-" will be displayed when drive mode is entered.

The operation method setting is wrong.

If constant b1-02 (Operation Method Selection) is set to any number but 0, the motor will not operate when the Run Key is pressed. Either press the LOCAL/REMOTE Key to switch to Digital Operator operation or set b1-02 to 0 (Digital Operator).

Note: The LOCAL/REMOTE Key is enabled by setting o2-01 to 1 and disabled by setting o2-01 to 0. It is enabled when the drive mode is entered.

The frequency reference is too low.

If the frequency reference is set below the frequency set in E1-09 (Minimum Output Frequency), the Matrix converter will not operate.

Raise the frequency reference to at least the minimum output frequency.

There is a multi-function analog input setting error.

If multi-function analog input H3-05, H3-09 or H3-13 is set to 1 (frequency gain), and if no voltage (current) is input, then the frequency reference will be zero. Check to be sure that the set value and analog input value are correct.

■ The motor does not operate when an external operation signal is input.

The following causes are possible.

The Matrix converter is not in drive mode.

If the Matrix converter is not in drive mode and the DRIVE indicator does not illuminate, the Matrix converter will remain in ready status and will not start. Press the MENU Key to make the DRIVE indicator flash, and enter the drive mode by pressing the DATA/ENTER Key. “-Rdy-” will be displayed when drive mode is entered.

The operation method selection is wrong.

If constant b1-02 (reference selection) is set to 0 (Digital Operator), the motor will not operate when an external operation signal is input. Set b1-02 to 3 (PLC) and try again.

Similarly, the motor will also not operate if the LOCAL/REMOTE Key has been pressed to switch to Digital Operator operation. In that case press the LOCAL/REMOTE Key again to return to the original setting.

Note: The LOCAL/REMOTE Key is enabled by setting o2-01 to 1 and disabled by setting o2-01 to 0. It is enabled when the drive mode is entered.

The frequency reference is too low.

If the frequency reference is set below the frequency set in E1-09 (Minimum Output Frequency), the Matrix converter will not operate. Raise the frequency reference to at least the minimum output frequency.

There is a multi-function analog input setting error.

If multi-function analog inputs H3-05, H3-09, and H3-13 are set to 1 (frequency gain), and if no voltage (current) is input, then the frequency reference will be zero. Check to be sure that the set value and analog input value are correct.

Note: The “H” parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. “H” parameters and the terminals they control are not normally part of user setup. This item is provided for information only.

■ The motor stops during acceleration or when a load is connected.

The load may be too heavy. The Matrix converter has a stall prevention function, but the motor response may be exceeded if acceleration is too rapid or if the load is too heavy. Lengthen the acceleration time or reduce the load. Confirm that the motor is sized adequately to drive the load.

■ The motor does not accelerate.

If the torque limit settings (L7-01 to L7-04)***Refer to L7: Torque Limits on page 118*** are too small, the motor may not be able to accelerate. Check the settings and input values.

■ The motor only rotates in one direction.

“Reverse run prohibited” is selected. If b1-04 (Prohibition of Reverse Operation) is set to 1 (reverse run prohibited), the Matrix converter will not receive Reverse Run Commands. To use both forward and reverse operation, set b1-04 to 0.

◆ If the Direction of the Motor Rotation is Reversed

If the motor operates in the wrong direction, the motor output wiring is incorrect. When the Matrix converter's U, V, and W are properly connected to the motor's U, V, and W, the motor operates in a forward direction when a Forward Run Command is executed. The forward direction depends on the manufacturer and the motor type, so be sure to check the specifications.

The direction of rotation can be reversed by switching two wires among U, V, and W.

WARNING! *Electric Shock Hazard. Do not connect or disconnect wiring while the power is on. Failure to comply will result in serious personal injury or death.*

◆ If the Motor Does Not Produce Torque or If Acceleration is Slow

Use the following information if the motor does not output torque or if acceleration is too slow.

■ The torque limit has been reached.

When a torque limit has been set in constants L7-01 to L7-04, ***Refer to L7: Torque Limits on page 118*** no torque will be output beyond those limits. This can cause the torque to be insufficient, or the acceleration time to be too long. Check to be sure that the value set for the torque limit is suitable.

If torque limits have been set for the multi-function analog input (H3-05, H3-09, or H3-13 = 10 to 12 or 15), check to be sure that the analog input value is suitable.

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the terminals they control are not normally part of user setup. This item is provided for information only.

■ The stall prevention level during acceleration is too low.

If the value set for L3-02 (Stall Prevention Level during Acceleration) is too low, the acceleration time will be long. Check to be sure that the set value is suitable.

■ Autotuning has not been performed for vector control

Vector control will not perform well if autotuning has not been performed. Perform autotuning separately for the motor, or set the motor constants through calculations.

◆ If the Motor Operates at a Speed Higher Than the Reference

Use the following information if the motor operates higher than the reference.

■ The analog frequency reference bias setting is wrong (the gain setting is wrong).

The frequency reference bias set in constant H3-03 (Frequency Reference Terminal AI1 Function Selection) is added to the frequency reference. Check to be sure that the set value is suitable.

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the terminals they control are not normally part of user setup. This item is provided for information only.

■ A signal is being input to the frequency reference (current) terminal AI1.

When constant H3-09 (Multi-function Analog Input Terminal AI3 Function Selection) is set to 0, a frequency corresponding to the terminal AI3 input voltage (current) is added to the frequency reference. Check to be sure that the set value and analog input value are suitable.

Note: The "H" parameter group is typically preprogrammed, specific to an individual Matrix converter and its particular application. "H" parameters and the terminals they control are not normally part of user setup. This item is provided for information only.

◆ If the Slip Compensation Function Has Low Speed Precision

If speed control accuracy is low when using the slip compensation function, the slip compensation limit has been reached. Compensation cannot be carried out beyond the slip compensation limit set in constant C3-03. Check that the set value is suitable.

◆ If Speed Control Accuracy is low when operating at High speed in Open-loop Vector Control

The motor's rated voltage is high compared with the input power voltage.

The Matrix converter's maximum output voltage is determined by its input voltage. (For example, if 4160 Vac is input, then the maximum output voltage will be 4160 Vac.) If, the output voltage required by the vector control algorithm exceeds the Matrix converter output voltage maximum value, the speed control accuracy will decrease. Use a motor with a lower rated voltage (i.e., a special motor for use with vector control), or change to flux vector control. Alternatively, increase the input voltage level to the Matrix converter, within the specification limit of 4160V ±10 %.

◆ If the Motor Overheats

Take the following steps if the motor overheats.

■ The load is too large.

If the motor load is too heavy and the required torque exceeds the motor's rated torque, the motor will overheat. Some motor ratings are given for short period performance and are not continuous ratings. Reduce the load amount by either lightening the load or lengthening the acceleration/deceleration time. Also consider increasing the motor capacity.

■ The ambient temperature is too high.

The motor rating is determined within a particular ambient operating temperature range. The motor will burn out if it is run continuously at rated torque in an environment where the maximum ambient operating temperature is exceeded. Lower the motor's ambient temperature to within the acceptable ambient operating temperature range.

■ Autotuning has not been performed

Vector control will not work effectively if autotuning has not been performed. Perform autotuning before using vector control.

◆ If There is Mechanical Oscillation

Use the following information when there is mechanical oscillation.

■ The machinery is making unusual sounds.

The following cause is possible.

There may be resonance between a machine's characteristic frequency and the output frequency of the Matrix converter.

To prevent this from occurring, either use the jump frequency functions in constants d3-01 to d3-04 or install rubber mounts on the motor base to reduce oscillation.

■ Oscillation and hunting are occurring with open-loop vector control.

The gain adjustment may be incorrect. Reset the gain to a more effective level by adjusting constants C4-02 (torque compensation primary delay time constant), n2-01 (Speed feedback detection control (AFR) gain), and C3-02 (Slip Compensation Primary Delay Time) in that order. Lower the gain setting and raise the primary delay time setting.

Vector control will not work effectively if autotuning has not been performed. Perform autotuning before using vector control.

■ Oscillation and hunting are occurring with flux vector control.

The gain adjustment is incorrect. Adjust the various gains for speed control (ASR). If the oscillation points overlap with those of the machine and cannot be eliminated, increase the primary delay time constant for speed control (ASR) in C5-06 and then readjust the gains.

If autotuning is not performed, optimum performance cannot be achieved for flux vector control. Perform autotuning or set the motor constants according to calculations.

■ Autotuning has not been performed.

Vector control will not work effectively if autotuning has not been performed. Perform autotuning before using vector control.

◆ If the Torque Generated for the Motor is Insufficient (Insufficient Power)

If autotuning has not been performed, or the control method has been changed since last performing autotuning, perform autotuning.

◆ If the Motor Rotates Even When Matrix converter Output is Stopped

If the motor continues to coast at a low speed after a deceleration to stop command has been executed, the DC injection braking current (applied when the frequency dropped to the value of b2-01, DC Injection Braking Start Frequency) was insufficient. Adjust the DC injection braking by changing the following constant settings.

- Increase the constant b2-02 (DC Injection Braking Current) setting.
- Increase the constant b2-04 (DC Injection Braking Time at Stop) setting.

◆ If Output Frequency Does Not Rise to Frequency Reference

Use the following information if the output frequency is low compared to the frequency reference.

■ The frequency reference is within the jump frequency range.

When the jump frequency function is used, the output frequency does not change within the jump frequency range. Check to be sure that the Jump Frequency 1 to 3 (constants d3-01 to d3-03) and Jump Frequency Width (constant d3-04) settings are suitable.

■ The frequency reference upper limit has been reached.

The output frequency upper limit is determined by the following formula:
Maximum Output Frequency (E1-04) × Frequency Reference Upper Limit (d2-01) / 100
Check to be sure that the constant E1-04 and d2-01 settings are suitable.

8

Maintenance and Inspection

This chapter describes basic maintenance and inspection for the MX1S Matrix converter.

8.1 Section Safety

⚠ DANGER

Electrical Shock Hazard

Disconnect all main power before servicing.

Failure to comply may result in serious injury or death from electric shock.
To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc.

⚠ WARNING

Electrical Shock Hazard

Do not operate equipment with covers removed.

Failure to comply could result in death or serious injury.

The diagrams in this section may show Matrix converters without covers or safety shields to show details. Be sure to reinstall covers or shields before operating the Matrix converters and run the Matrix converters according to the instructions described in this manual.

Always ground the motor-side grounding terminal.

Improper equipment grounding could result in death or serious injury by contacting the motor case.

Do not perform work on the Matrix converter while wearing loose clothing, jewelry or without eye protection.

Failure to comply could result in death or serious injury.

Remove all metal objects such as watches and rings, secure loose clothing, and wear eye protection before beginning work on the Matrix converter.

Do not remove covers or touch circuit boards while the power is on.

Failure to comply could result in death or serious injury.

Do not allow unqualified personnel to perform work on the Matrix converter.

Failure to comply could result in death or serious injury.

Installation, maintenance, inspection, and servicing must be performed only by authorized personnel familiar with installation, adjustment, and maintenance of Medium Voltage AC drives.

Fire Hazard

Tighten all terminal screws to the specified tightening torque.

Loose electrical connections could result in death or serious injury by fire due to overheating of electrical connections.

Do not use improper combustible materials.

Failure to comply could result in death or serious injury by fire.

Attach the Matrix converter to metal or other noncombustible material.

Do not use an improper voltage source.

Failure to comply could result in death or serious injury by fire.

Verify that the rated voltage of the Matrix converter matches the voltage of the incoming power supply before applying power.

⚠ CAUTION

Crush Hazard

Follow detailed instructions when removing power cells.

Failure to comply may result in minor or moderate injury from the power cell falling.

NOTICE

Observe proper electrostatic discharge procedures (ESD) when handling the Matrix converter and circuit boards.

Failure to comply may result in ESD damage to the Matrix converter circuitry.

Never connect or disconnect the motor from the Matrix converter while the Matrix converter is outputting voltage.

Improper equipment sequencing could result in damage to the Matrix converter.

Do not use unshielded cable for control wiring.

Failure to comply may cause electrical interference resulting in poor system performance. Use shielded twisted-pair wires and ground the shield to the ground terminal of the Matrix converter.

Do not allow unqualified personnel to use the product.

Failure to comply could result in damage to the Matrix converter.

Do not modify the Matrix converter circuitry.

Failure to comply could result in damage to the Matrix converter and will void warranty.

Yaskawa is not responsible for any modification of the product made by the user. This product must not be modified.

Check all the wiring to ensure that all connections are correct after installing the Matrix converter and connecting any other devices.

Failure to comply could result in damage to the Matrix converter.

8.2 Maintenance and Inspection

Power electronics have limited life and may exhibit changed characteristics or performance deterioration after years of use under normal conditions. To help avoid such problems, it is important to perform preventive maintenance and periodic inspection on the Matrix converter.

Matrix converters contain a variety of power electronics such as power transistors, semiconductors, capacitors, resistors, fans, and relays. The electronics in the Matrix converter serve a critical role in maintaining proper motor control.

Follow the inspection lists provided in this chapter as a part of a regular maintenance program.

Note: The Matrix converter will require more frequent inspection if it is placed in harsh environments, such as:

- High ambient temperatures
- Frequent starting and stopping
- Fluctuations in the AC supply or load
- Excessive vibration or shock loading
- Dust, metal dust, salt, sulfuric acid, chlorine atmospheres
- Poor storage conditions.

Perform the first equipment inspection 3 months after installation.

This chapter describes the maintenance and inspection required to maintain the high reliability of the MX1S Matrix converter over a long period of time.

DANGER! *Disconnect all main power before servicing. To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc. Failure to comply may result serious injury of death from electric shock.*

WARNING! *The MX1S Matrix converter has two (2) sources of power, the 4160 V main supply and a 480 V control power supply. Make sure that both sources are off before starting maintenance or inspection. Failure to observe this precaution may result in serious personal injury or death.*

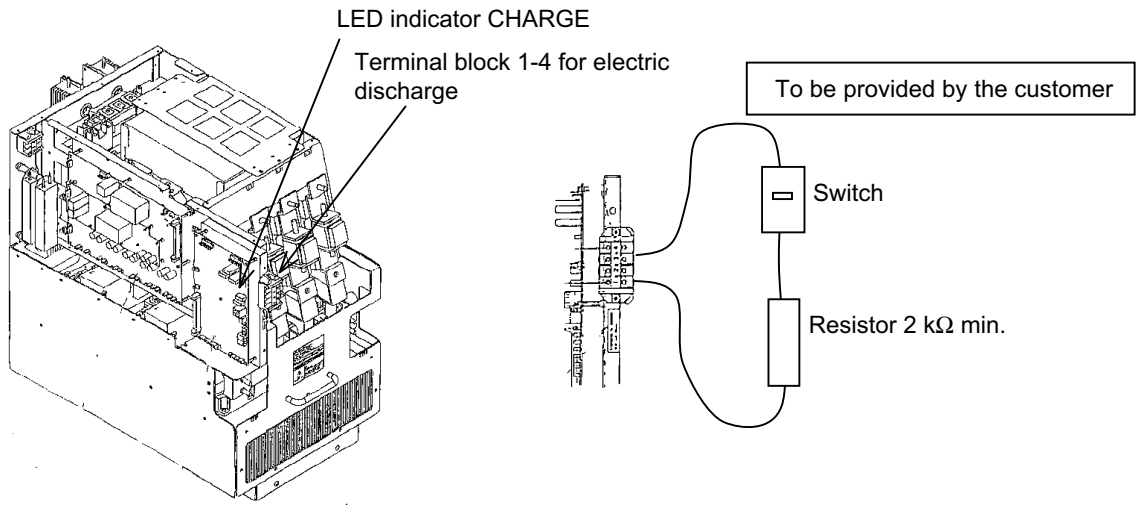
WARNING! *Maintenance, inspection, and parts replacement must be performed by a technician who has been trained and certified on the structure and circuits of the Matrix converter.*

WARNING! *Be certain that tools, etc. are not left in the panels after maintenance, inspection, or parts replacement.*

NOTICE: *Use an insulated measuring instrument, such as insulated oscilloscope probe, instead of simply grounding the instrument. Otherwise, the Matrix converter or the measuring instrument may be damaged.*

NOTICE: *Damage to Equipment. Observe proper electrostatic discharge procedures (ESD) when handling the Matrix converter and circuit boards. Failure to comply may result in ESD damage to the Matrix converter circuitry.*

Note: When the Power Cell requires urgent replacement, carry out the following operation before replacing the Cell. Start the operation at least one minute after shutting off the medium-voltage primary power supply and control power supply.
The terminal block 1-4 for electric discharge is mounted on the front of the Power Cell. Connect a resistor with a minimum resistance of 2 kohms and a minimum thermal capacity of 80 W to the terminal block to discharge the dc snubber capacitors.
Make sure that the LED indicator for CHARGE on the front of the Power Cell is unlit and that the control power supply is off before starting the replacement.



◆ Daily Inspection

Check the following items while the system is operating.

Table 8.1 Daily Inspections

Location	Item	Inspection
Entire system	Ambient conditions	Check the ambient temperature and humidity and check for dust, harmful gas, and oil mist.
	Entire MX1S	Check for abnormal vibration and noise.
	Power supply voltage	Check the main circuit voltage and control circuit voltage. (Check the voltage of the power supply unit using an appropriate measuring device.)
Main circuit	Transformer	Check for abnormal smells and humming.
Cooling system	Cooling fan	Check for abnormal vibration or noise.
		Clean the air filter.
Indicators	Indicator lamps	Check for burnt-out lamps.
	Meters	Confirm the correct measurement and indication.

◆ Periodic Inspection

Check the following items during periodic inspections.

DANGER! *Disconnect all main power before servicing. To prevent electric shock, wait at least 15 minutes before opening panel doors. Check to ensure all indicators are off and use test equipment to verify no hazardous voltages are present. The snubber circuit remains charged even after the power supply is turned off. The CHARGE indicator LED on the front of each power cell will extinguish when the capacitor voltage is below 50 Vdc. Failure to comply may result serious injury of death from electric shock.*

WARNING! *The MX1S Matrix converter has two (2) sources of power, the 4160 V main supply and a 480 V control power supply. Make sure that both sources are off before starting maintenance or inspection. Failure to observe this precaution may result in serious personal injury or death.*

Table 8.2 Periodic Inspections (Once per Year)

Location	Item	Inspection
Transformer Panel, Power Cell Panel	Entire Transformer and Power Cell Panels	Megger check between the main circuit terminals and ground terminal
		Check for loose screws, bolts, or connectors.
		Check for trace of overheat on each part.
		Clean inside the panels.
	Wires	Check for damage or deterioration of cable insulation.
	Transformer	Confirm that primary/secondary voltages are normal.
	Power cells	Check for fluid leakage from the capacitors in the snubber circuit filter.
		Confirm that the safety valve of the capacitors in the snubber circuit filter are not protruding.
		Confirm that the capacitors in the snubber circuit filter have not expanded.
		Measure the capacitance of the capacitor in the snubber circuit filter. (The measured capacitance must be at least 80 % of the rating.)
		Check for loose screws or bolts.
		Confirm that the main circuit and control circuit fuses are normal.
		Check for accumulated dust and dirt on the heat sink.
Control Panel	Operation	Confirm that there are no abnormalities in protective and indication circuits
	Relays	Confirm smooth operation
		Confirm timer operation.
		Check for damaged contacts.
	Board	Check for abnormal smells and discoloration.
		Confirm the power supply voltage.
Cooling system	Cooling fan	Check for abnormal vibration and noise.
		Confirm the bearing operation.
	Air filter	Check for soil or clogging in the air filter.

■ Location of Parts

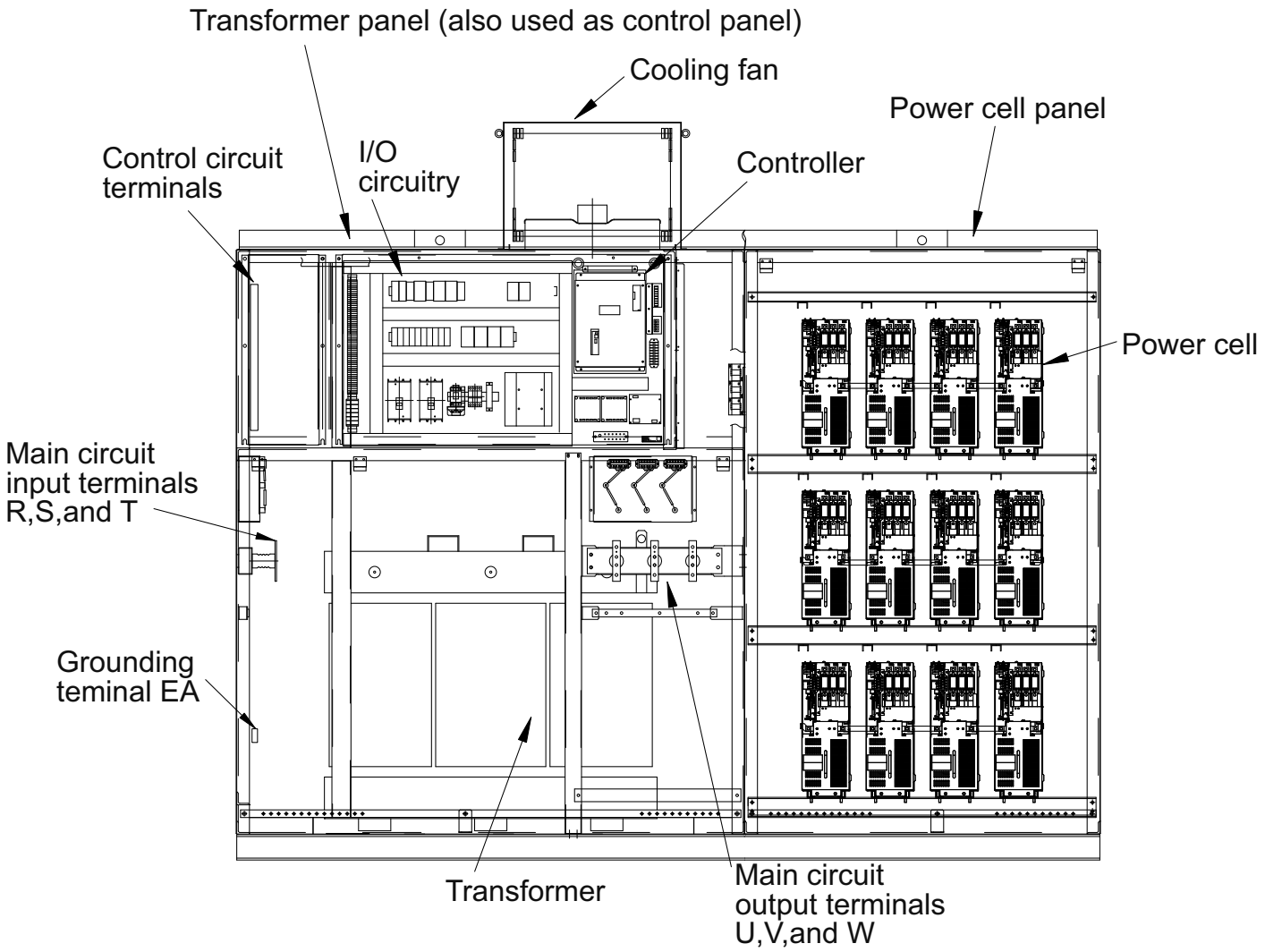


Figure 8.1 Internal Configuration Examples (800 HP Class)

■ Details of Periodic Inspections

Megger Check (Measurement of Insulation Resistance)

1. Measure insulation resistance of the Matrix converter primary circuit.

CAUTION! *The primary circuit is grounded at high-resistance for input voltage detection. Isolate both the grounding wire and the detection signal wires that are connected to the control board before measuring insulation resistance.*

Use a 1000 V Megger insulation resistance tester. The measured insulation resistance must be 30 Mohms or more.

2. Measure insulation resistance of the Matrix converter secondary circuit (motor side)

CAUTION! *The secondary circuit is grounded at high-resistance for output voltage detection and ground-fault detection. Isolate the high-resistance resistor and Power Cell output cables connected to the output terminals before measuring insulation resistance*

Use a 1000 V Megger insulation tester. The measured insulation resistance must be 2 Mohms or more.

(If an output contactor is provided, it may be convenient to open the contactor and measure the insulation resistance at the contactor output terminals.)

Screws, Bolts, and Connectors

Loose I/O terminal bolts and/or loose board connectors can cause failure or malfunction of the Matrix converter. During periodic inspection, be sure to retighten the screws and bolts and re-insert the connectors securely.

Inspect the following terminals and connectors.

- Medium-voltage I/O terminals
- Input and output voltage detection circuits (high-resistance section)
- Transformer I/O terminals and primary voltage tap terminals
- Transformer output terminal block
- Power cell I/O terminals and fiber optic cable connector
- Power cell screws, bolts, and connectors
- Control power supply input terminals
- Control transformer I/O terminals
- Cooling fan contactor I/O terminals
- Screws, bolts, and connectors of each control board
- External I/O terminals

Tighten M10 bolts for medium voltage I/O terminals with a tightening torque of 1800 to 2300 N·cm (159 to 204 lb-in).

Tighten M12 bolts for medium voltage I/O terminals with a tightening torque of 3150 to 3950 N·cm (279 to 350 lb-in).

Tighten the bolts on the cell to the following torque.

- Mounting bolts: 900 to 1080 N·cm (80 to 96 lb-in)
- Input terminals: 1800 to 2300 N·cm (159 to 204 lb-in) for 520 A cell, and 900 to 1080 N·cm (80 to 96lb-in) for cells other than 520 A
- Output terminals: 1800 to 2300 N·cm for 520 A cell (159 to 204 lb-in), and 900 to 1080 N·cm (80 to 96 lb-in) for cells other than 520A
- Power fuse: 900 to 1080 N·cm (80 to 96 lb-in)

Transformer

Inspect the transformer as described below.

1. Check the external appearance
2. Retighten the bolts of transformer I/O terminals and primary voltage tap terminals

WARNING! *The inspection in step 3 must be carried out by personnel qualified for high-voltage work. There is significant risk of electric shock that could result in injury or death.*

3. Measure the transformer secondary voltage.
   Turn on the control power supply and medium-voltage power supply, and measure the input voltages to the power cells as shown in ***Figure 8.2***.
   Measure the input voltage of each power cell using a digital multimeter. (Measure the voltage between L1, L2, L3 of each power cell.) The measured input voltage must be the rated voltage (590 Vac) ±10 V. If the majority of measured values exceeds the allowable range, remove power and adjust the primary voltage tap (+5, 0, or –5 % can be selected).

Power Cells

Inspect the power cells as described below.

1. Check the external appearance.
   Check for discolorations such as burn marks on the Power Cell, signs of leakage, protruding safety valve, or expansion of the snubber circuit filter capacitor.
2. Retighten the bolts of input terminals L1, L2, and L3.
3. Retighten the bolts of output terminals T1 and T2.
4. Re-insert the fiber optic cable connector.
5. Retighten the screws and bolts inside the Power Cell Panel.
   Check the main circuit fuse.
   Check for discoloration and looseness.

6. Clean the heat sink.

If dirt and dust have accumulated on the heat sink, use dry air of 39.2 × 104 to 58.8×104 Pa (4 to 6 kg·cm2) (55 to 85 psi) to clean it.

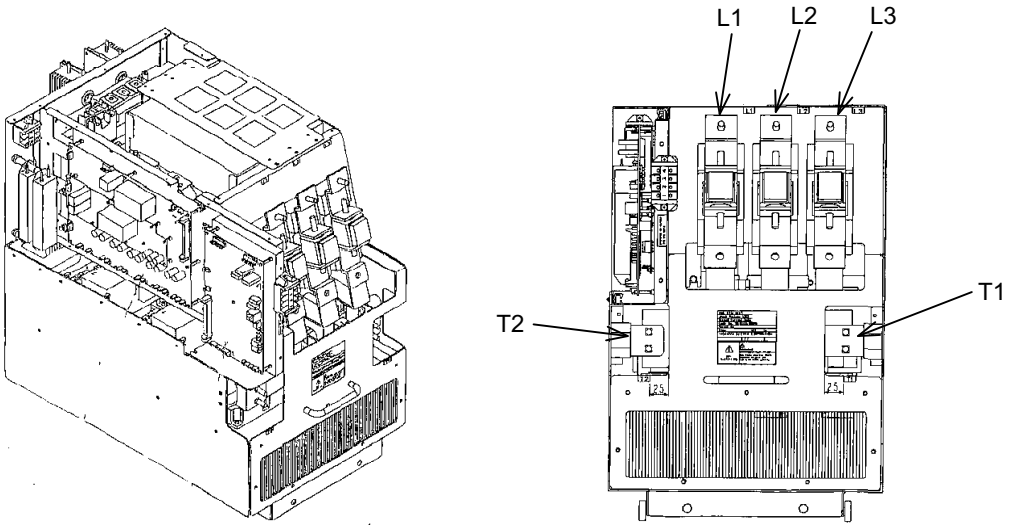


Figure 8.2 Power Cell Input Voltage Measurement

Air Filter

If the air filter is clogged with dirt and dust, the cooling capacity of the Matrix converter will be degraded, resulting in abnormal temperature rise. Check the air filter for dirt and dust at each daily inspection, and periodically remove it and clean it with neutral detergent. Dry thoroughly before replacement.

Control Board

Visually check the control board for the following items.

1. Abnormal smell or discoloration of the board
2. Loose screws or connectors

Cooling Fan

Inspect the cooling fan as described below.

1. Check for abnormal vibration or noise.
2. Retighten the mounting bolts.
3. Measure the motor insulation resistance.
   Use a 500 V megger tester. The measured resistance must be 10 Mohm minimum.
4. Fan motor bearing
   The service life of the bearings are approximately 15,000 hours.

◆ Periodic Maintenance of Parts

In order to keep the MX1S Matrix converter operating normally over a long period of time, it is recommended that parts are replaced in accordance with their service life.

The Matrix converter is configured with many parts, and these parts must be operating properly in order to make full use of the Matrix converter functions. Among the electronic components, there are some that require maintenance depending on their usage conditions.

Periodic inspection standards vary, depending on the Matrix converter installation environment and usage conditions. Matrix converter maintenance periods are noted below for reference.

Refer to Page *217* for the replacement procedure for the cooling fan.

For replacement of other parts, contact your Yaskawa representative. These replacements require trained professionals.

Table 8.3 Part Replacement Guidelines

Part Name	Standard Replacement Period <1>	Replacement Method and Remarks
Cooling fan	1 to 2 years (15,000 service hours)	Replace the bearings. (Bearings on motor and fan)
Fuses	10 years	Replace with new fuses.
Lithium battery	5 years	Replace with a new battery. Type: 000025, Specifications: 3 V/2000 mAh Product name: CR6L-CN014S manufactured by FDK Corporation
Filter capacitor for Power Cell snubber circuit	–	Replace (Inspect the capacitor and replace it if necessary.)
Aluminum capacitor on the printed circuit board	–	Replace (Inspect the capacitor and replace it if necessary.)
Breaker and power fuses	–	Determine replacement need after inspection.

<1> The standard replacement period is based on the following usage conditions.
Ambient temperature: Yearly average of 30°C.
Load factor: 80 % maximum.
Operating rate: 12 hours maximum per day.

◆ Spare Parts

Considering the importance of the system in which the MX1S Matrix converter is used, it is recommended that spare parts be kept on hand for maintenance management. ***Table 8.4*** lists the recommended spare parts. Confirm the following items and contact your Yaskawa representative when ordering the spare parts.

MX1S: Model, capacity, serial number, and Yaskawa order number

Spare parts: Part name, model and quantity

1) Related to Boards

Table 8.4 List of Recommended Spare Parts

Part Name		Model	Remarks
Cell control board (CCB)		–	Refer to ***Table 8.6***.
Controller	CPU board	JEBC-61301-HMXC	Control board to be mounted on the modulator board
	Modulator board	JEBC-61302-HMXC	Medium voltage Matrix converter control module
	Current detection resistance board	JEBC-61902-x	x depends on the Matrix converter capacity. Refer to ***Table 8.5***.
	fiber optic interface board	JEBC-61601	Used only for 6 kV class Matrix converter
Isolation board		JEBC-61701	Input/Output voltage detection analog isolation board.
RS232/RS485 converter board		JEBC-61602	RS485/RS232 converter board mounted on the digital operator panel
5 V power supply board		JEBC-61901	Quantity 3 ea. 5 Vdc outputs
±15 V power supply		–	MMB50A-6-CN (COSEL)
24 V power supply		–	R25A-24-CN (COSEL)

2) Related to Main Circuit

Part Name	Model	Remarks
Power cell	–	Refer to ***Table 8.6***.

Note: If a Power Cell fails, replacing the Cell with a spare (kept on site) can immediately restore operation. Return the failed Power Cell to Yaskawa for repair.

3) Control Circuit

Part Name	Model	Remarks
Molded-case circuit breaker	–	FAZ series or NZMB1 series manufactured by Klockner Moeller
Contactor	–	SC series manufactured by Fuji Electric Holding Co., Ltd.
Thermal relay	–	SC series manufactured by Fuji Electric Holding Co., Ltd.

4) Others

Part Name	Model	Remarks
Digital operator	JVOP-160	
Fiber optic cable	WRMZ-1295	
Cooling fan for panel	–	M4D110-GF (manufactured by EBM-PAPST)
EWS cable (3 m)	JZCP-751904	

5) Current Detection Resistor Board Models

Table 8.5 Current Detection Resistor Board Models

Model	Resistance	Applicable MX1S Capacity
JEBC-61902-2	30 Ohms	4.16 kV: 550 HP
JEBC-61902-4	22 Ohms	4.16 kV: 700 HP, 800 HP, 2000 HP, 2250 HP
JEBC-61902-5	15 Ohms	4.16 kV: 900 HP, 1000 HP, 1250 HP, 2500 HP, 2750 HP, 3000 HP
JEBC-61902-8	10 Ohms	4.16 kV: 1500 HP, 1750 HP, 3500 HP, 4000 HP

6) Power Cell

Table 8.6 Power Cell Models

Power Cell Rating	Power Cell Model	Cell Control Board (CCB) Model	GDB Model <1>	TRB <2> Model	Applicable MX1S Capacity
					4.16 kV Class
70A	7910240-1023 X	JEBC-61401-3	JEBC-61504	JEBC-61504	550 HP
90A	7910240-1024 X	JEBC-61401-1	JEBC-61504	JEBC-61504	700 HP
102A	7910240-1024 X	JEBC-61401-1	JEBC-61504	JEBC-61504	800 HP
115A	7910240-1024 X	JEBC-61401-1	JEBC-61504	JEBC-61504	900 HP
123A	7910240-1025 X	JEBC-61401-1	JEBC-61504	JEBC-61504	1000 HP
154A	7910240-1025 X	JEBC-61401-1	JEBC-61504	JEBC-61504	1250 HP
185A	7910240-1026 X	JEBC-61401-1	JEBC-61502	JEBC-61504	1500 HP
215A	7910240-1026 X	JEBC-61401-1	JEBC-61502	JEBC-61504	1750 HP
245A	7910240-1027 X	JEBC-61401-1	JEBC-61502	JEBC-61504	2000 HP
281A	7910240-1027 X	JEBC-61401-1	JEBC-61502	JEBC-61504	2250 HP
311A	7910240-1028 X	JEBC-61401-2	JEBC-61502	JEBC-61504	2500 HP
336A	7910240-1028 X	JEBC-61401-2	JEBC-61502	JEBC-61504	2750 HP
372A	7910240-1028 X	JEBC-61401-2	JEBC-61502	JEBC-61504	3000 HP
436A	7910240-1029 X	JEBC-61401-2	JEBC-61502	JEBC-61504	3500 HP
520A	7910240-1029 X	JEBC-61401-2	JEBC-61502	JEBC-61504	4000 HP

<1> Gate Drive Board
<2> Power Supply Board

◆ Models and Number of Cooling Fans Mounted in an MX1S Matrix converter

Table 8.6 shows the cooling fan models, specifications, and number of cooling fans mounted in an MX1S Matrix converter.

When replacing the cooling fans, use the models specified in ***Table 8.7***. These cooling fans are manufactured by Mitsubishi Electric Corporation.

If cooling fans other than those specified in ***Table 8.7*** are used, Matrix converter performance cannot be guaranteed.

Table 8.7 Models and Number of Cooling Fans Mounted in an MX1S Matrix converter

Voltage Class	Frequency [Hz]	Model CIMR-MX1S KB□□□	Cooling Fans in Transformer Panel		Cooling Fans in Power Cell Panel	
			Model/Specifications	Qty	Model/Specifications	Qty
4.16 kV	60	070	M4D110-GF	1	–	–
		090	M4D110-GF	1	–	–
		102	M4D110-GF	1	–	–
		115	M4D110-GF	2	–	–
		123	M4D110-GF	2	–	–
		154	M4D110-GF	2	–	–
		185	M4D110-GF	1	M4D110-GF	1
		215	M4D110-GF	1	M4D110-GF	1
		245	M4D110-GF	2	M4D110-GF	2
		281	M4D110-GF	2	M4D110-GF	2
		311	M4D110-GF	2	M4D110-GF	2
		336	M4D110-GF	2	M4D110-GF	2
		372	M4D110-GF	2	M4D110-GF	2
		436	M4D110-GF	3	M4D110-GF	3
		520	M4D110-GF	3	M4D110-GF	3

◆ Cooling Fan Replacement Procedure

Refer to ***Figure 8.3*** and use the following procedure to replace the cooling fan.

WARNING! *The MX1S Matrix converter has two (2) sources of power, the 4160 V main supply and a 480 V control power supply. Make sure that both sources are off before starting maintenance or inspection. Failure to observe this precaution may result in serious personal injury or death.*

■ Removing the Cooling Fan

1. Remove the ventilation cover on the top of the Matrix converter.
2. Disconnect the cooling fan cables from the panel top or from relay terminals inside the Matrix converter.
3. Remove the cooling fan mounting screws.
4. Pull the cooling fan upward to remove.

■ Mounting a New Cooling Fan

1. Mount the new cooling fan on the panel top and tighten the mounting screws.
2. Reinstall the components in the reverse order of removal. Make sure that the cables are fixed so that they will not have contact with or be caught in the cooling fan blades.

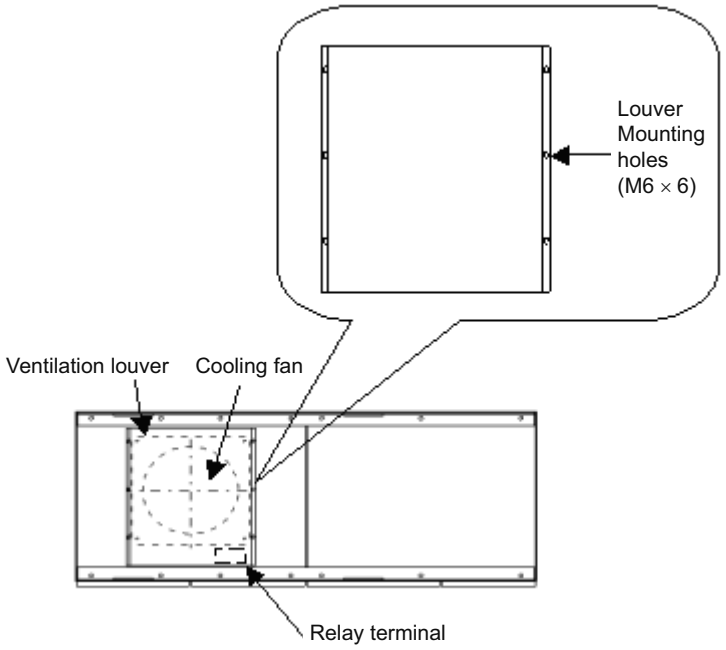


Figure 8.3 Cooling Fan Replacement

◆ Removing and Remounting a Power Cell

Use the following procedure to remove a power cell.

WARNING! *The MX1S Matrix converter has two (2) sources of power, the 4160 V main supply and a 480 V control power supply. Make sure that both sources are off before starting maintenance or inspection. Failure to observe this precaution may result in serious personal injury or death.*

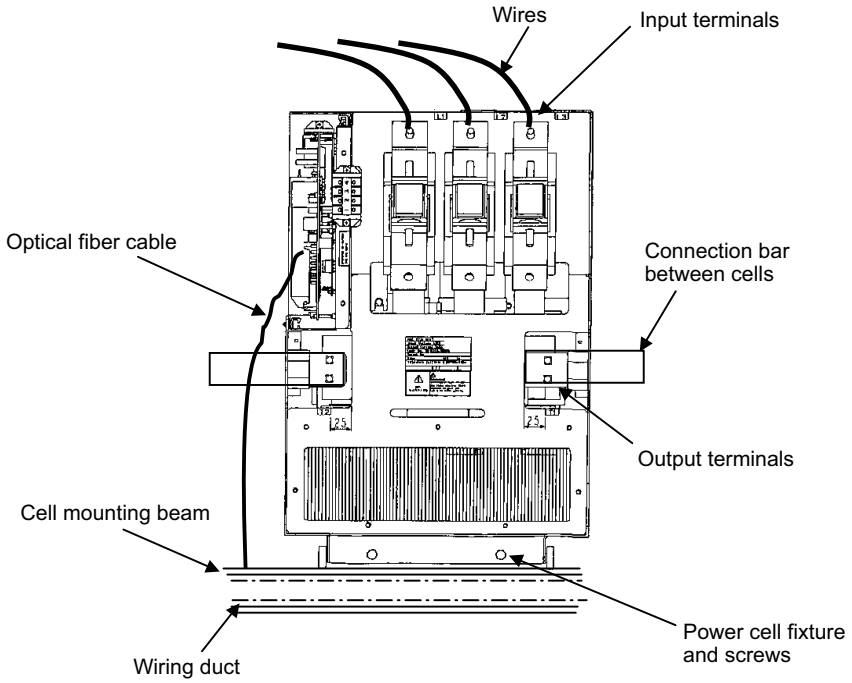
Refer to ***Figure 8.4*** and ***Figure 8.5*** for the part names.

1. Disconnect three-phase input wires (copper bar or wires) from the input terminals L1, L2, and L3.
2. Disconnect wires from the output terminals T1 and T2.
3. Disconnect the fiber optic cable from the cell control board (CCB).
   (Take special care not to damage the board when removing the power cell.)
4. Remove the cell mounting screws on the front bottom of the power cell.
5. Extend the lifter platform to place under the power cell.
6. Lift the power cell out of the panel.

CAUTION! *There are wheels mounted on the bottom of the power cell frame so that it can roll out on the mounting rails. There are holes in the mounting rails to locate the power cell in the proper position. The wheels sit in these holes when fully installed. Pull the power cell with gradually increasing force until the wheels roll up onto the rails. Then roll the power cell onto the Lifter. If the power cell is pulled out too strongly, it can fall out, and may result in injury.*

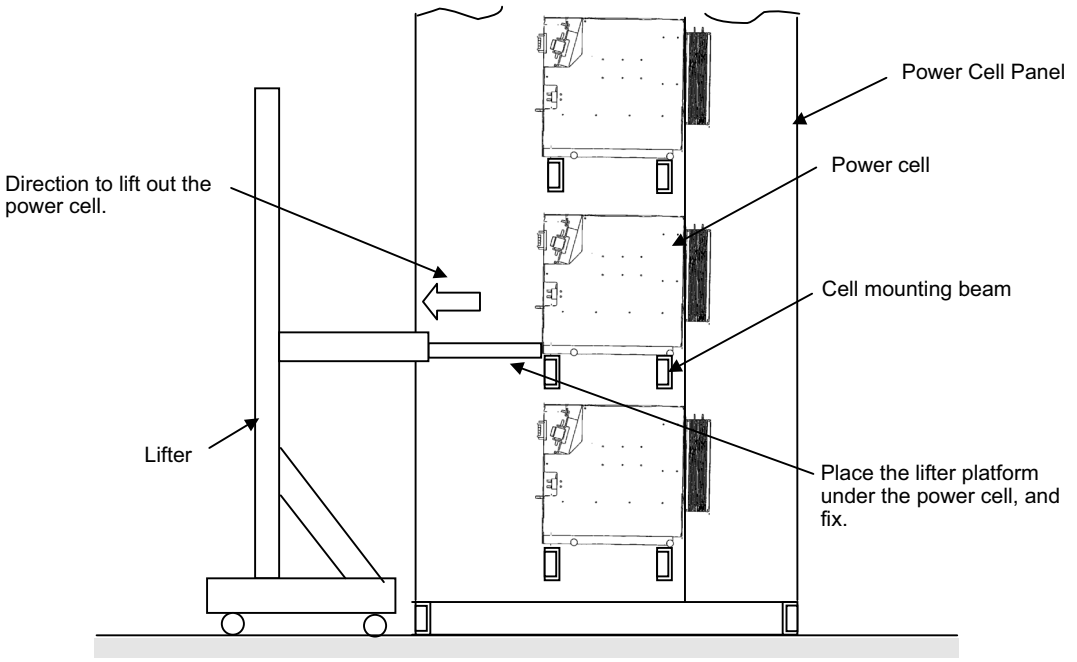
7. When the entire power cell is placed on the lifter platform, fix the power cell on the platform with a strap to prevent the power cell from falling off.
8. Return the extended platform to its original position, lower the platform together with the power cell, and transport the power cell.

Remount the power cell in the reverse order of removal after inspection and replacement.

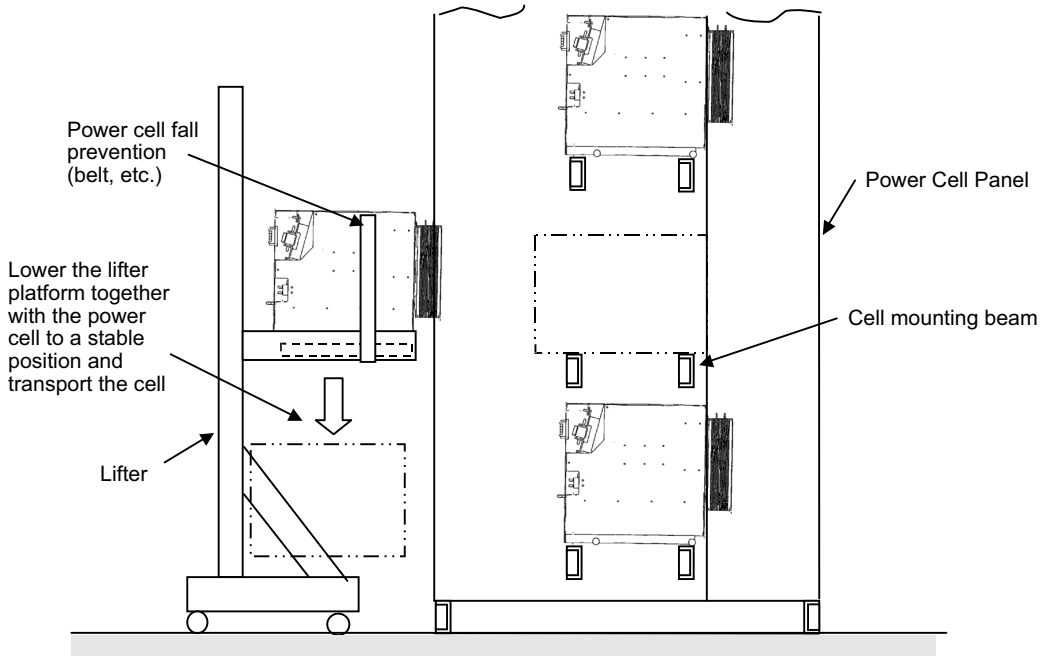


<260A Cell Example>

Figure 8.4 Power Cell Wiring and Fixing Screw Locations



<Positioning the lifter platform and lifting out the power cell>



<Fix the power cell on the lifter platform for transportation>

Figure 8.5 Lifting Out the Power Cell

◆ Memory Backup Battery Replacement Procedure

■ Replacement Period

A battery for memory backup is provided in the controller.

If the LED indicator lamp BAT ALM lights, the battery voltage is low. Replace the battery. (It is recommended that the battery be replaced every 5 years regardless of the indicator lamp status.)

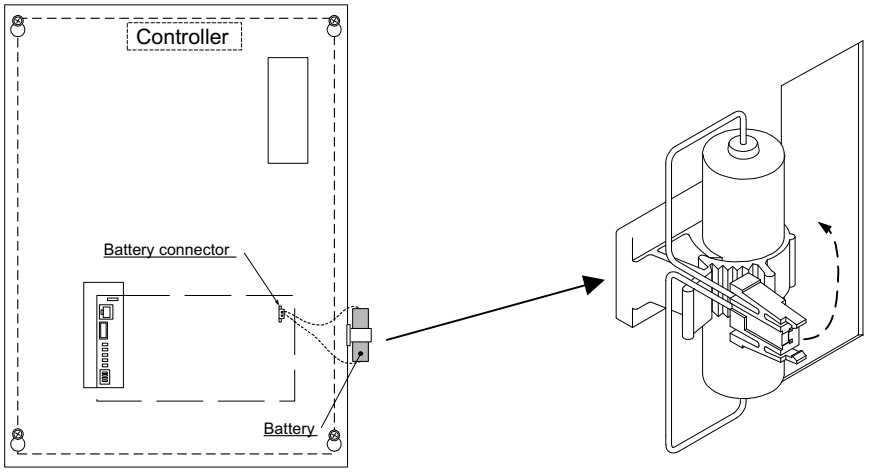
If the control power supply is turned off while the BAT ALM is lit, the data and calendar settings stored in the memory may be lost.

Use battery model CR6L-CN014S (see ***Table 8.3***).

■ Replacement Procedure

1. Turn off the control power supply.
   Always turn off the control power supply before replacing the battery.
   To retain data in the memory, the battery must be replaced within one hour after the control power supply is turned off. The time that the memory is backed up by the internal capacitor is limited to one hour.
2. Remove the battery.
   Touch the controller cover to remove static electricity before starting replacement work.
   Remove the cover from the controller. Disconnect the cable from the battery connector, and then remove the battery from the battery holder.
3. Clean the battery connector.
   Clean the battery connector with alcohol or equivalent if there is dust or oil on the connector.
4. Mount a new battery.
   Mount a new battery in the battery holder. Confirm the polarities and connect the cable to the battery connector.

NOTICE: *Be careful not to short-circuit the battery connector when removing or mounting the battery or cleaning the connector. If the connector is short-circuit, the backup data may be lost. Check the backup data to confirm it has not been lost before restarting operation.*



9

Specifications

This chapter describes the MX1S Matrix converter standard specifications.

9.1 MX1S Standard Specifications

◆ Specifications by Model

Table 9.1 MX1S Standard Specifications

TYPE	CIMR-MX1SKB□□□		070	090	102	115	123	154	185	215	245	281	311	336	372	436	520
Nominal Capacity		[kVA]	505	650	735	830	890	1110	1330	1550	1765	2025	2240	2420	2680	3140	3750
Rated Output Current		[A]	70	90	102	115	123	154	185	215	245	281	311	336	372	436	520
Maximum Applicable Capacity		[HP]	550	700	800	900	1000	1250	1500	1750	2000	2250	2500	2750	3000	3500	4000
Rated Output Voltage		[V]	3-phase, 4160 V														
Main Circuit Power Supply			3-phase, 4160 V ± 10 %, 60 Hz ± 5 %														

Efficiency / Power Factor		Efficiency: Approximately 98 % Power Factor: 95 % or more
Overload Capacity		100 % continuous
Cooling Method		Forced air-cooling by fan (with failure detection)
Control Power Supply		Controller: 3-phase, 460/480 V ± 10 %, 60Hz ± 5 %, 3 kVA or more
Control Specifications	Control Method	Open-loop vector control, flux vector control
	Frequency Control Range	0.01 to 120 Hz
	Frequency Control Accuracy	±0.5 %
	Analog Input Resolution	0.03 Hz
	Acceleration/Deceleration Time	0.1 to 6,000 seconds
	Main Control Functions	Restart after momentary power loss, <1> torque limit, acceleration stall prevention speed search, jump frequencies, S-curve acceleration/deceleration, multi-step speed operation, full regenerative control, etc.
Protective Functions		Overcurrent, overvoltage, undervoltage, output ground fault, output open-phase, overload, cooling fan fault, motor overheat, etc.
Communications Functions (optional)		Modbus, Ethernet, Profibus.
Maintainability	Digital Operator	Status display, fault display, run command, parameter setting, parameter reference
	Display Tools on PC	Trend display, data analysis
	Main Circuit	Modular configuration
Input Transformer		Class H dry type, ± 5 % taps, secondary multi phase winding
Number of I/O Terminals		Digital inputs: 10, digital outputs: 8, analog inputs: 2, analog outputs: 2
Temperature Protection		Power cells: protected by thermistor, transformer: protected by thermostat

<1> Auto restart after momentary power loss requires an uninterrupted power supply for control power, by others.

Applicable Standards		UL347A
Environmental Specifications	Atmosphere	General environmental conditions (free from dust, saline and corrosive gases)
	Ambient Temperature	–5 to +40°C
	Relative Humidity	95 % RH or less (without condensation)
	Storage Temperature	–10 to +50°C
	Altitude	2000 m or less
Cabinet Specifications	Form	Frame and panel construction, vertical-standalone, with protective inner front panel
	Painting	RAL 7032 semi-gloss both for inner and outer surfaces
Enclosure		NEMA1, IP40

Revision History

The revision dates and numbers of the revised manuals are given on the bottom of the back cover.

MANUAL NO. EZZ010917
Published in Japan September 2011 11-9
Place of publication
Date of publication
Date of original publication

Date of publication	Rev. No.	Section	Revised Content
September 2011	–	–	First edition

Super Energy-saving Medium-voltage Matrix Converter

FSDrive-MX1S

Instructions

TOKYO OFFICE
New Pier Takeshiba South Tower, 1-16-1, Kaigan, Minatoku, Tokyo 105-6891 Japan
Phone 81-3-5402-4502 Fax 81-3-5402-4580
http://www.yaskawa.co.jp

YASKAWA AMERICA, INC.
2121 Norman Drive South, Waukegan, IL 60085, U.S.A.
Phone (800) YASKAWA (800-927-5292) or 1-847-887-7000 Fax 1-847-887-7310
http://www.yaskawa.com

YASKAWA ELECTRIC CORPORATION

MANUAL NO. EZZ010917
Published in U.S.A. September 2011 11-9