

# U1000 Industrial MATRIX Drive

## Low Harmonic Regenerative Drive for Industrial Applications

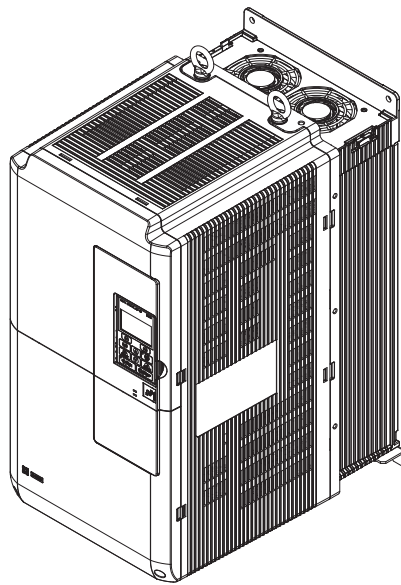
### Quick Start Guide

Type: CIMR-UU

Models: 200 V Class: 7.5 to 75 kW (10 to 100 HP ND)

400 V Class: 5.5 to 260 kW (7.5 to 350 HP ND)

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



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# **U1000 MATRIX Quick Start Guide**

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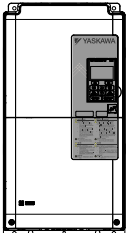
## i.1 Preface

Yaskawa manufactures products used as components in a wide variety of industrial systems and equipment. The selection and application of Yaskawa products remain the responsibility of the equipment manufacturer or end user. Yaskawa accepts no responsibility for the way its products are incorporated into the final system design. Under no circumstances should any Yaskawa product be incorporated into any product or design as the exclusive or sole safety control. Without exception, all controls should be designed to detect faults dynamically and fail safely under all circumstances. All systems or equipment designed to incorporate a product manufactured by Yaskawa must be supplied to the end user with appropriate warnings and instructions as to the safe use and operation of that part. Any warnings provided by Yaskawa must be promptly provided to the end user. Yaskawa offers an express warranty only as to the quality of its products in conforming to standards and specifications published in the Yaskawa manual. **NO OTHER WARRANTY, EXPRESS OR IMPLIED, IS OFFERED.** Yaskawa assumes no liability for any personal injury, property damage, losses, or claims arising from misapplication of its products.

This manual is designed to ensure correct and suitable application of U1000-Series Drives. Read this manual before attempting to install, operate, maintain, or inspect a drive and keep it in a safe, convenient location for future reference. Be sure you understand all precautions and safety information before attempting application.

### ◆ Applicable Documentation

The following manuals are available for U1000-series drives:

	<p>U1000 Industrial MATRIX Drive Quick Start Guide</p> <p>Read this guide first. This guide is packaged together with the product and contains basic information required to install and wire the drive. It also gives an overview of fault diagnostics, maintenance safety, and parameter settings. The most recent version of this manual is available for download on our documentation website, <a href="http://www.yaskawa.com">www.yaskawa.com</a>.</p>
	<p>U1000 Industrial MATRIX Drive Technical Manual</p> <p>The most recent version of this manual is available for download on our documentation website, <a href="http://www.yaskawa.com">www.yaskawa.com</a>. This manual provides detailed information on parameter settings, drive functions, and MEMOBUS/Modbus specifications. Use this manual to expand drive functionality and to take advantage of higher performance features.</p>

### ◆ Supplemental Safety Information

General Precautions
<ul style="list-style-type: none"> <li>• The diagrams in this manual may be indicated without covers or safety shields to show details. Replace the covers or shields before operating the drive and run the drive according to the instructions described in this manual.</li> <li>• 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.</li> <li>• 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.</li> <li>• 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.</li> <li>• If nameplate becomes worn or damaged, order a replacement from your Yaskawa representative or the nearest Yaskawa sales office.</li> </ul>

### ⚠ WARNING

Read and understand this manual before installing, operating or servicing this drive. The drive 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 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!** may 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.**

**CAUTION!** may 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:** may 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.

**Electrical Shock Hazard**

**Before servicing, disconnect all power to the equipment.**

The capacitor for the control power supply remains charged even after the power supply is turned off. The charge indicator LED will extinguish when the control power supply voltage is below 50 Vdc. To prevent electric shock, wait for at least the time specified on the warning label, once all indicators are OFF, measure for unsafe voltages to confirm the drive is safe prior to servicing.

Failure to comply will result in death or serious injury.

**⚠ WARNING****Sudden Movement Hazard**

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

Clear all personnel from the drive, motor and machine area before applying power. Secure covers, couplings, shaft keys and machine loads before applying power to the drive.

**Electrical Shock Hazard**

**Do not attempt to modify or alter the drive in any way not explained in this manual.**

Failure to comply could result in death or serious injury.

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

**Do not allow unqualified personnel to use equipment.**

Failure to comply could result in death or serious injury.

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

**⚠ WARNING**

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

Failure to comply could result in death or serious injury.

**Make sure the protective earthing conductor complies with technical standards and local safety regulations.**

Because the leakage current exceeds 3.5 mA in models 4□0302 and larger, IEC/EN 61800-5-1 states that either the power supply must be automatically disconnected in case of discontinuity of the protective earthing conductor or a protective earthing conductor with a cross-section of at least 10 mm<sup>2</sup> (Cu) or 16 mm<sup>2</sup> (Al) must be used. Failure to comply may result in death or serious injury.

**Always use appropriate equipment for Ground Fault Circuit Interrupters (GFCIs).**

The drive can cause a residual current with a DC component in the protective earthing conductor. Where a residual current operated protective or monitoring device is used for protection in case of direct or indirect contact, always use a type B GFCI according to IEC/EN 60755.

**Fire Hazard**

**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 drive matches the voltage of the incoming power supply before applying power.

**Install adequate branch circuit protection according to applicable local codes and this Installation Manual. Failure to comply could result in fire and damage to the drive or injury to personnel.**

The device is suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical amperes, 240 Vac maximum (200 V class), 480 Vac maximum (400 V class: 4E□□□□ and 4W□□□□), and 500 Vac maximum (400 V class: 4A□□□□ and 4P□□□□) when protected by branch circuit protection devices specified in this document.

**Crush Hazard**

**Do not use this drive in lifting applications without installing external safety circuitry to prevent accidental dropping of the load.**

**The drive does not possess built-in load drop protection for lifting applications.**

Failure to comply could result in death or serious injury from falling loads.

Install electrical and/or mechanical safety circuit mechanisms independent of drive circuitry.

**⚠ CAUTION**

**Crush Hazard**

**Do not carry the drive by the front cover.**

Failure to comply may result in minor or moderate injury from the main body of the drive falling.

**NOTICE**

**Observe proper electrostatic discharge procedures (ESD) when handling the drive and circuit boards.**

Failure to comply may result in ESD damage to the drive circuitry.

**Do not perform a withstand voltage test on any part of the drive.**

Failure to comply could result in damage to the sensitive devices within the drive.

**Do not operate damaged equipment.**

Failure to comply could result in further damage to the equipment.

Do not connect or operate any equipment with visible damage or missing parts.

## NOTICE

**If a fuse is blown or a Ground Fault Circuit Interrupter (GFCI) is tripped, check the wiring and the selection of the peripheral devices.**

Contact your supplier if the cause cannot be identified after checking the above.

**Do not restart the drive immediately operate the peripheral devices if a fuse is blown or a GFCI is tripped.**

Check the wiring and the selection of peripheral devices to identify the cause. Contact your supplier before restarting the drive or the peripheral devices if the cause cannot be identified.

**Do not expose the drive to halogen group disinfectants.**

Failure to comply may cause damage to the electrical components in the drive.

Do not pack the drive in wooden materials that have been fumigated or sterilized.

Do not sterilize the entire package after the product is packed.

## ■ General Application Precautions

### Selection

#### Drive Rated Output Current

Make sure that the motor rated current is less than the rated output current for the drive.

#### When 2 Seconds is Required for Momentary Power Loss Ride-Thru Time

Use the units listed below when continuing drive operation after the power is restored even after a momentary loss of power of 2 seconds occurs:

- 200 V class Momentary Power Loss Ride-Thru unit: Model no. P0010
- 400 V class Momentary Power Loss Ride-Thru unit: Model no. P0020

#### Drive Start-Up Time

The drive requires 1.5 seconds to prepare for operation after the power is turned on. Be mindful of this delay when using an external reference input.

**Note:** 1.5 seconds is the required time when no optional devices are used with the drive. When using an optional communication device, the time required for the drive to be ready for operation will vary in accordance with the start up time of the communication card.

#### Selection of Power Supply Capacity

Use a power supply greater than the rated input capacity (kVA) of the drive. If the power supply is lower than the rated capacity of the drive, the device will be unable to run the application properly and will trigger a fault.

The rated input capacity of the drive,  $S_{CONV}$  (kVA), can be calculated by the following formula:

$$S_{CONV} = \sqrt{3} \times I_{in} \times V_{in} / 1000$$

( $I_{in}$ : Rated input current [A],  $V_{in}$ : Applicable power supply voltage [V])

#### Connection to Power Supply

The total impedance of the power supply and wiring for the rated current of the drive is %Z = 10% or more. Power voltage distortion may occur when the impedance of the power supply is too large. When wiring over long distances, be sure to take preventative measures such as using thick cables or series wiring to lower the impedance of wiring. Contact Yaskawa or your Yaskawa agent for details.

#### Grounding the Power Supply

Yaskawa recommends using a dedicated ground for the power supply, as the drive is designed to run with a 1:1 ratio relative to the power supply. Ground other devices should as directed in the specifications for those devices. Take particular care when connecting sensitive electronic equipment such as OA devices. Separate ground lines and install a noise filter to prevent problems from noise.

#### When Using a Generator as a Power Supply

Select the generator capacity approximately twice as large as the drive input power supply capacity. Set the deceleration time or load so that the regenerative power from the motor will be 10% or less of the generator capacity. For further information, contact a Yaskawa representative.

#### When a Phase Advance Capacitor or Thyristor Controller is Provided for the Power Supply

The drive does not require a phase advance capacitor. Installing a phase advance capacitor to the drive will weaken the power factor.

## i.1 Preface

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Attach a phase-advance capacitor with a series reactor to prevent oscillation with the drive after installing the phase advance capacitor on the same power supply system as the drive.

Contact Yaskawa or your Yaskawa agent when a device generating voltage surge or voltage distortion such as DC motor drive thyristor controller or magnetic agitator is installed on the same power supply system.

### Prevention Against EMC or Harmonic Leakage Current

Use units with built-in EMC filters that have the CE marking.

Use a zero-phase reactor as a noise filter when a device that will be affected by noise is near the drive.

### Effects of Power Supply Distortion

Distortion of the power supply voltage increases the harmonics contents due to power supply harmonics entering the drive.

### Starting Torque

The startup and acceleration characteristics of the motor are restricted to the drive overload current rating (HD: 150% 60 s, ND: 120% 60 s).

The overload rating for the drive determines the starting and accelerating characteristics of the motor. Expect lower torque than when running from line power. To achieve a higher starting torque, use a larger drive or a drive and motor with larger capacity.

### Emergency Stop

During a drive fault condition, the output shuts off but the motor does not stop immediately. A mechanical brake may be required when it is necessary to stop the motor faster than the ability of the Fast Stop function of the drive.

### Repetitive Starting/Stopping

Laundry machines, punching presses, and other applications with frequent starts and stops often approach 150% of their rated output current values. Heat stress generated from repetitive high current will shorten the life span of the IGBTs. The expected life span of the IGBTs is about 8 million start and stop cycles with a 4 kHz carrier frequency and a 150% peak current.

Run only one motor from each drive when using vector control. It is not possible to run more than one motor from one drive with vector control.

## ■ Carrier Frequency Derating

Reduce the rated output current of the drive when increasing the carrier frequency above the factory default setting. Refer to the Technical Manual for details.

### Installation

#### Enclosure Panels

Keep the drive in a clean environment by installing the drive in an enclosure panel or selecting an installation area free of airborne dust, lint, and oil mist. Be sure to leave the required space between drives to provide for cooling, and take proper measures so the ambient temperature remains within allowable limits and keep flammable materials away from the drive. Yaskawa offers protective designs for drives that must be used in areas subjected to oil mist and excessive vibration. Contact Yaskawa or your Yaskawa agent for details.

#### Installation Direction

**NOTICE:** *Install the drive upright as specified in the manual. [Refer to Mechanical Installation on page 16](#) for more information on installation. Failure to comply may damage the drive due to improper cooling.*

### Settings

#### Motor Code

When using a permanent magnet motor, set the proper motor code to parameter E5-01 before performing a trial run.

#### Upper Limits

**NOTICE:** *The drive is capable of running the motor up to 400 Hz. Be sure to set the upper limit for the frequency of the drive to prevent the possible danger of accidentally operating equipment at higher than rated speed. The default setting for the maximum output frequency is 60 Hz.*

#### DC Injection Braking

**NOTICE:** *Excessive current during DC Injection Braking and excessive duration of DC Injection Braking can cause motor overheat.*

#### Acceleration/Deceleration Times

Acceleration and deceleration times are affected by the amount of torque generated by the motor, the load torque, and the moment of inertia. Set a longer accel/decel time when Stall Prevention is enabled. The accel/decel times are lengthened for as long as the Stall Prevention function is in operation. Use a larger drive and motor for faster acceleration and deceleration.



## General Handling

### Wiring Check

**NOTICE:** Be sure to perform a final check of all sequence wiring and other connections before turning on the power and also check for short circuits on the control terminals, which may damage the drive.

### Selecting a Circuit Breaker or Circuit Interrupter

Yaskawa recommends installing a Ground Fault Circuit Interrupter (GFCI) to the power supply side. The GFCI should be designed for use with AC drives (e.g., Type B according to IEC/EN 60755).

Select a Molded Case Circuit Breaker (MCCB) or GFCI with a rated current 1.5 to 2 times higher than the drive rated current to avoid nuisance trips caused by harmonics in the drive input current.

### Magnetic Contactor Installation

**WARNING!** Fire Hazard. Shut off the drive with a magnetic contactor (MC) when a fault occurs in any external equipment such as braking resistors. Failure to comply may cause resistor overheating, fire, and injury to personnel.

**NOTICE:** To get the full performance life out of the capacitor for the control power supply and circuit relays, refrain from switching the drive power supply off and on more than once every 30 minutes. Frequent use can damage the drive. Use the drive to stop and start the motor.

### Inspection and Maintenance

**WARNING!** Electrical Shock Hazard. Capacitors for the control power supply do not immediately discharge after shutting off the power. Wait for at least the amount of time specified on the drive before touching any components after shutting off the power. Failure to comply may cause injury to personnel from electrical shock.

**WARNING!** Electrical Shock Hazard. When a drive is running a PM motor, voltage continues to be generated at the motor terminals after the drive is shut off while the motor coasts to stop. Take the precautions described below to prevent shock and injury:

- In applications where the machine can still rotate after the drive has fully stopped a load, install a switch to the drive output side to disconnect the motor and the drive.
- Do not allow an external force to rotate the motor beyond the maximum allowable speed or to rotate the motor when the drive has been shut off.
- Wait for at least the time specified on the warning label after opening the load switch on the output side before inspecting the drive or performing any maintenance.
- Do not open and close the load switch while the motor is running.
- If the motor is coasting, make sure the power to the drive is turned on and the drive output has completely stopped before closing the load switch.

**WARNING!** Burn Hazard. Because the heatsink can get very hot during operation, take proper precautions to prevent burns. When replacing the cooling fan, shut off the power and wait at least 15 minutes to be sure that the heatsink has cooled down. Failure to comply may cause burn injury to personnel.

### Wiring

All wire ends should use ring terminals for UL/cUL compliance. Use only the tools recommended by the terminal manufacturer for crimping.

### Transporting the Drive

**NOTICE:** Never steam clean the drive. During transport, keep the drive from coming into contact with salts, fluorine, bromine, phthalate ester, and other such harmful chemicals.

## ■ Motor Application Precautions

### Standard Induction Motors

#### Low-Speed Range

The cooling fan of a standard motor should sufficiently cool the motor at the rated speed. As the self-cooling capability of such a motor decreases with the speed, applying full torque at low speed will possibly damage the motor. Reduce the load torque as the motor slows to prevent motor damage from overheat. [Figure i.1](#) shows the allowable load characteristics for a Yaskawa standard motor. Use a motor designed specifically for operation with a drive when 100% continuous torque is needed at low speeds.

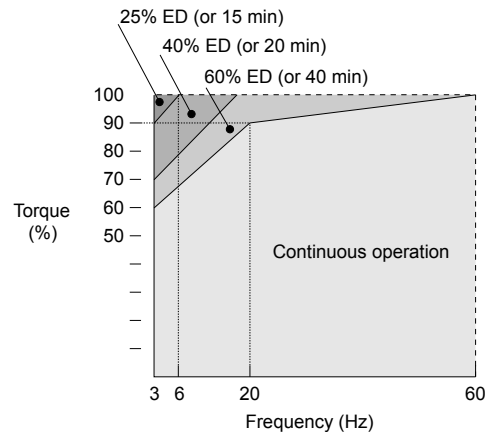


Figure i.1 Allowable Load Characteristics for a Yaskawa Motor

### Insulation Tolerance

**NOTICE:** Consider motor voltage tolerance levels and motor insulation in applications with an input voltage of over 440 V or particularly long wiring distances.

### High-Speed Operation

**NOTICE:** Problems may occur with the motor bearings and dynamic balance of the machine when operating a motor beyond its rated speed. Contact the motor or machine manufacturer.

### Torque Characteristics

Torque characteristics differ compared to operating the motor directly from line power. The user should have a full understanding of the load torque characteristics for the application.

### Vibration and Shock

The drive allows selection of high carrier PWM control. Selecting Closed Loop Vector control can help reduce motor oscillation.

- Take particular caution when adding a variable speed drive to an application running a motor from line power at a constant speed. If resonance occurs, install shock-absorbing rubber around the base of the motor and enable the Jump frequency selection to prevent continuous operation in the resonant frequency range.
- Mechanical resonance can occur with long motor shafts and in applications such as turbines, blowers, and fans with high inertia loads.

### Audible Noise

The audible noise of the motor varies based on the carrier frequency setting. However, drive current derating may be required. When using a high carrier frequency, audible noise from the motor is comparable to the motor noise generated when running from line power.

### Synchronous Motors

- Contact Yaskawa or a Yaskawa agent when planning to use a synchronous motor not endorsed by Yaskawa.
- Use a standard induction motor when running multiple synchronous motors simultaneously. A single drive does not have this capability.
- A synchronous motor may rotate slightly in the opposite direction of the Run command at start depending on parameter settings and rotor position.
- The amount of generated starting torque differs depending on the control mode and motor type. Set up the motor with the drive after verifying the starting torque, allowable load characteristics, impact load tolerance, and speed control range.

Contact Yaskawa or a Yaskawa agent when planning to use a motor that does not fall within these specifications:

- In Open Loop Vector Control for PM motors, the allowable load inertia is approximately 50 times higher than the motor inertia.

Contact Yaskawa or a Yaskawa agent for questions concerning applications with larger inertia.

- When using a holding brake in Open Loop Vector Control for PM motors, release the brake prior to starting the motor. Failure to set the proper timing can cause speed loss.
- Use the Speed Search function to restart a coasting motor rotating over 200 Hz while in V/f Control.

## Specialized Motors

### Multi-Pole Motor

The rated current of a multi-pole motor differs from that of a standard motor, so be sure to check the maximum current when selecting a drive. Always stop the motor before switching between the number of motor poles. The motor will coast to stop if a regen overvoltage (ov) fault occurs or if overcurrent (oC) protection is triggered.

### Submersible Motor

The rated current of a submersible motor is greater than that of a standard motor, so select the drive accordingly. Use a motor cable large enough to avoid decreasing the maximum torque level from voltage drop caused by a long motor cable.

### Explosion-Proof Motor

The motor and the drive must be tested together to be certified as explosion-proof. The drive is not designed for explosion-proof areas.

When attaching an encoder to an explosion-proof motor, make sure the encoder is also explosion-proof. Use an insulating signal converter to connect the encoder signal lines to the speed feedback option card.

### Geared Motor

Make sure that the gear and the lubricant are rated for the desired speed range to avoid gear damage when operating at low speeds or very high speeds. Consult with the manufacturer for applications that require operation outside the rated speed range of the motor or gear box.

### Single-Phase Motor

Variable speed drives are not designed to operate with single phase motors. Using capacitors to start the motor causes excessive current to flow and can damage drive components. A split-phase start or a repulsion start can burn out the starter coils because the internal centrifugal switch is not activated. The drive is for use with three-phase motors only.

### Motor with Brake

Take caution when using the drive to operate a motor with a built-in holding brake. If the brake is connected to the output side of the drive, it may not release at start due to low voltage levels, so be sure to install a separate power supply for the motor brake. Note that motors with built-in brakes tend to generate a fair amount of noise when running at low speeds.

### Notes on Power Transmission Machinery

Installing an AC drive in machinery that was previously connected directly to the power supply will allow the machine to operate at variable speeds. Continuous operation outside of the rated speeds can wear out lubrication material in gear boxes and other power transmission parts. Make sure that lubrication is sufficient within the entire speed range to avoid machine damage. Note that operation above the rated speed can increase the noise generated by the machine.

### ◆ Drive Label Warning Example

Always heed the warning information listed in *Figure i.2*.

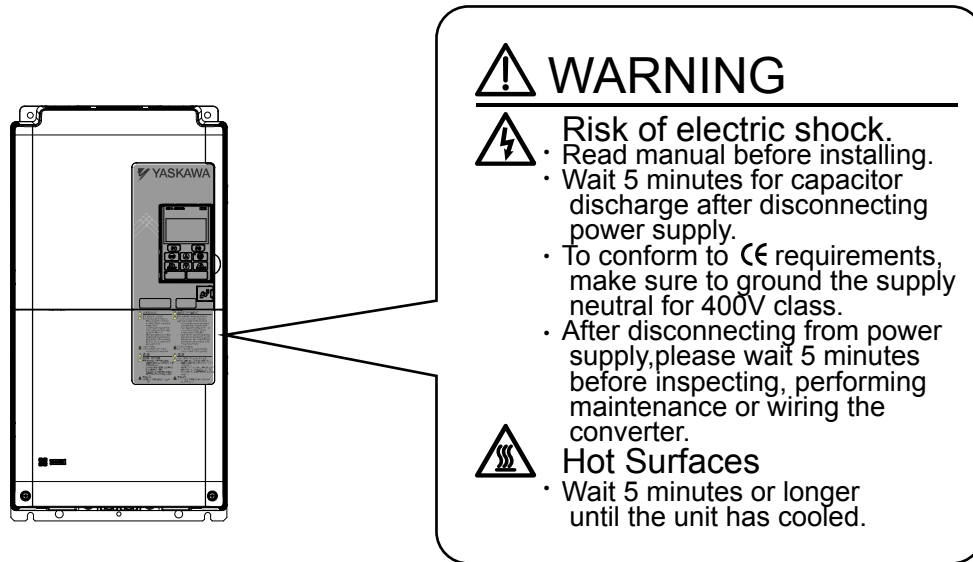


Figure i.2 Warning Information Example and Position

### ◆ Warranty Information

#### ■ Restrictions

The drive is 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 power, electric power, or in underwater applications must first contact their Yaskawa representatives or the nearest Yaskawa sales office.

**WARNING!** *Injury to Personnel. 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.*

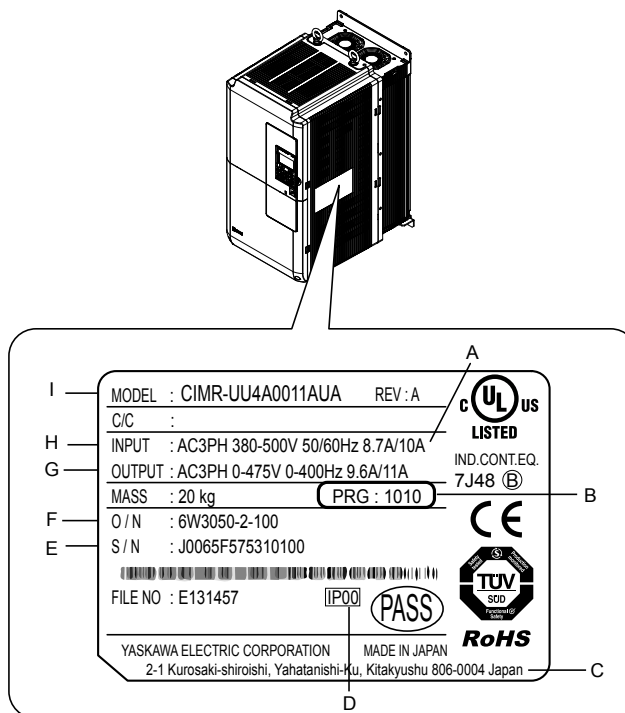
## i.2 Receiving

### ◆ Model Number and Nameplate Check

Please perform the following tasks after receiving the drive:

- Inspect the drive for damage.  
If the drive appears damaged upon receipt, contact the shipper immediately.
- Verify receipt of the correct model by checking the information on the nameplate.
- If you have received the wrong model or the drive does not function properly, contact your supplier.

### ◆ Nameplate



**A** – Normal Duty amps / Heavy Duty  
amps  
**B** – Software version  
**C** – Address <1>  
**D** – Enclosure type  
**E** – Serial number

**F** – Lot number  
**G** – Output specifications  
**H** – Input specifications  
**I** – AC drive model  
Refer to [Figure i.4](#) for details.

**Figure i.3 Nameplate Information Example**

<1> The address of the head office of Yaskawa Electric Corporation (responsible for product liability) is shown on the nameplate.

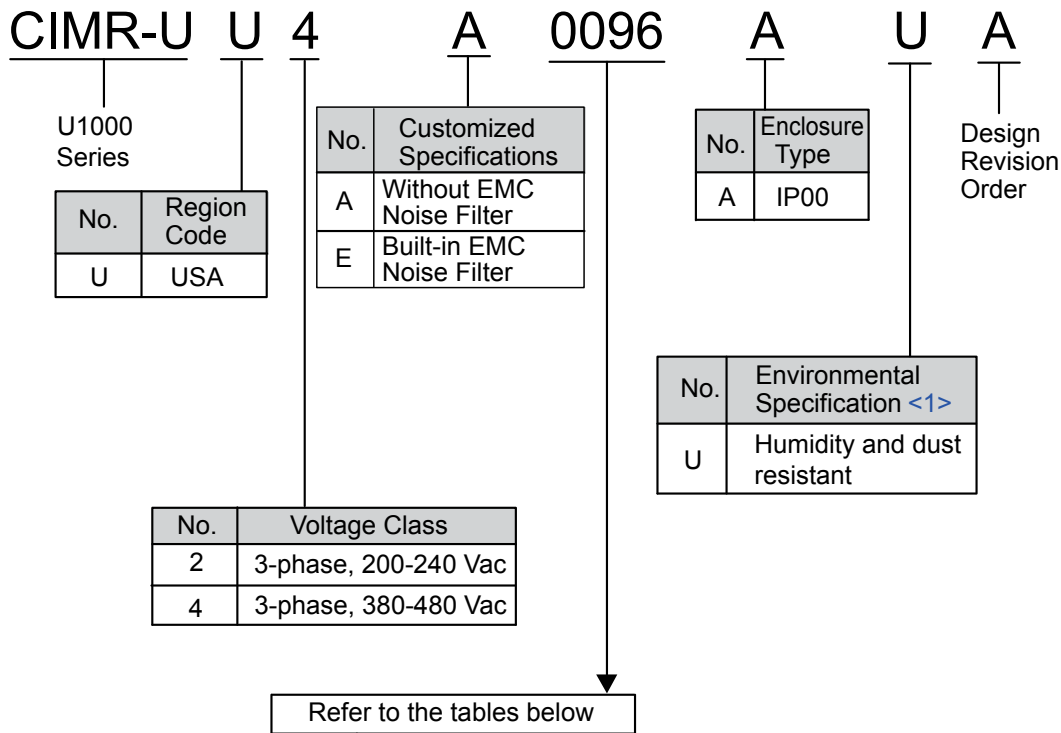


Figure i.4 Drive Model Number Definition

<1> Drives with these specifications do not guarantee complete protection for the environmental conditions indicated.

■ Three-Phase 200 V Class

Table i.1 Model Number and Specifications (200 V Class)

Normal Duty (ND) C6-01 = 1		
Drive Model	Reference Motor Capacity kW (HP)	Rated Output Current A
2□0028	7.5 (10)	28
2□0042	11 (15)	42
2□0054	15 (20)	54
2□0068	18.5 (25)	68
2□0081	22 (30)	81
2□0104	30 (40)	104
2□0130	37 (50)	130
2□0154	45 (60)	154
2□0192	55 (75)	192
2□0248	75 (100)	248

Heavy Duty (HD) C6-01 = 0		
Drive Model	Reference Motor Capacity kW (HP)	Rated Output Current A
2□0028	5.5 (7.5)	22
2□0042	7.5 (10)	28
2□0054	11 (15)	42
2□0068	15 (20)	54
2□0081	18.5 (25)	68
2□0104	22 (30)	81
2□0130	30 (40)	104
2□0154	37 (50)	130
2□0192	45 (60)	154
2□0248	55 (75)	192

## ■ Three-Phase 400 V Class

Table i.2 Model Number and Specifications (400 V Class)

Normal Duty (ND) C6-01 = 1		
Drive Model	Reference Motor Capacity kW (HP)	Rated Output Current A
4□0011	5.5 (7.5)	11
4□0014	7.5 (10)	14
4□0021	11 (15)	21
4□0027	15 (20)	27
4□0034	18.5 (25)	34
4□0040	22 (30)	40
4□0052	30 (40)	52
4□0065	37 (50)	65
4□0077	45 (60)	77
4□0096	55 (75)	96
4□0124	75 (100)	124
4□0156	90 (125)	156
4□0180	110 (150)	180
4□0216	132 (175)	216
4□0240	150 (200)	240
4□0302	185 (250)	302
4□0361	220 (300)	361
4□0414	260 (350)	414

Heavy Duty (HD) C6-01 = 0		
Drive Model	Reference Motor Capacity kW (HP)	Rated Output Current A
4□0011	3.7 (5)	9.6
4□0014	5.5 (7.5)	11
4□0021	7.5 (10)	14
4□0027	11 (15)	21
4□0034	15 (20)	27
4□0040	18.5 (25)	34
4□0052	22 (30)	40
4□0065	30 (40)	52
4□0077	37 (50)	65
4□0096	45 (60)	77
4□0124	55 (75)	96
4□0156	75 (100)	124
4□0180	90 (125)	156
4□0216	110 (150)	180
4□0240	132 (175)	216
4□0302	150 (200)	240
4□0361	185 (250)	302
4□0414	220 (300)	361

## i.3 Mechanical Installation

This section outlines specifications, procedures, and the environment for proper mechanical installation of the drive.

### ◆ Installation Environment

Install the drive in an environment matching the specifications in [Table i.3](#) to help prolong the optimum performance life of the drive.

**Table i.3 Installation Environment**

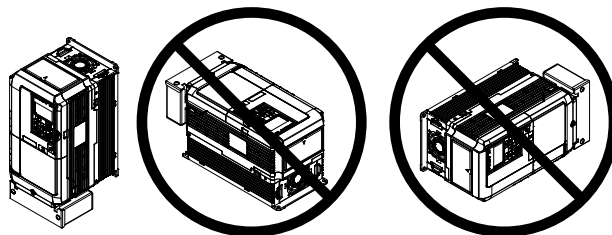
Environment	Conditions
Installation Area	Indoors
Ambient Temperature	IP00/Open Type enclosure: -10 °C to +50 °C (14 °F to 122 °F) IP20/NEMA Type 1 enclosure: -10 °C to +40 °C (14 °F to 104 °F) Drive reliability improves in environments without wide temperature fluctuations. When using the drive in an enclosure panel, install a cooling fan or air conditioner in the area to ensure that the air temperature inside the enclosure does not exceed the specified levels. Do not allow ice to develop on the drive.
Humidity	95% RH or less and free of condensation
Storage Temperature	-20 °C to +60 °C (-4 °F to +104 °F)
Surrounding Area	Install the drive in an area free from: <ul style="list-style-type: none"> <li>• oil mist and dust</li> <li>• metal shavings, oil, water, or other foreign materials</li> <li>• radioactive materials</li> <li>• combustible materials (e.g., wood)</li> <li>• harmful gases and liquids</li> <li>• excessive vibration</li> <li>• chlorides</li> <li>• direct sunlight.</li> </ul>
Altitude	1000 m (3281 ft.) or lower, up to 3000 m (9843 ft.) with derating
Vibration	10 to 20 Hz at 9.8 m/s <sup>2</sup> (32.15 ft/s <sup>2</sup> ) 20 to 55 Hz at 5.9 m/s <sup>2</sup> (19.36 ft/s <sup>2</sup> ) (Models 2□0028 to 2□0081 and 4□0011 to 4□0077) 2.0 m/s <sup>2</sup> (6.56 ft/s <sup>2</sup> ) (Models 2□0104 to 2□0248 and 4□0096 to 4□0414)
Orientation	Install the drive vertically to maintain maximum cooling effects.

**NOTICE:** Avoid placing drive peripheral devices, transformers, or other electronics near the drive as the noise created can lead to erroneous operation. If such devices must be used in close proximity to the drive, take proper steps to shield the drive from noise.

**NOTICE:** Prevent foreign matter such as metal shavings and wire clippings from falling into the drive during installation. Failure to comply could result in damage to the drive. Place a temporary cover over the top of the drive during installation. Remove the temporary cover before drive start-up, as the cover will reduce ventilation and cause the drive to overheat.

### ◆ Installation Orientation and Spacing

**NOTICE:** Install the drive upright as illustrated in [Figure i.5](#). Failure to comply may damage the drive due to improper cooling.



**Figure i.5 Correct Installation Orientation**

**NOTICE:** Install the drive upright as specified in the manual. Failure to comply may damage the drive due to improper cooling.

### ■ Single Drive Installation

[Figure i.6](#) shows the installation distance required to maintain sufficient space for airflow and wiring.



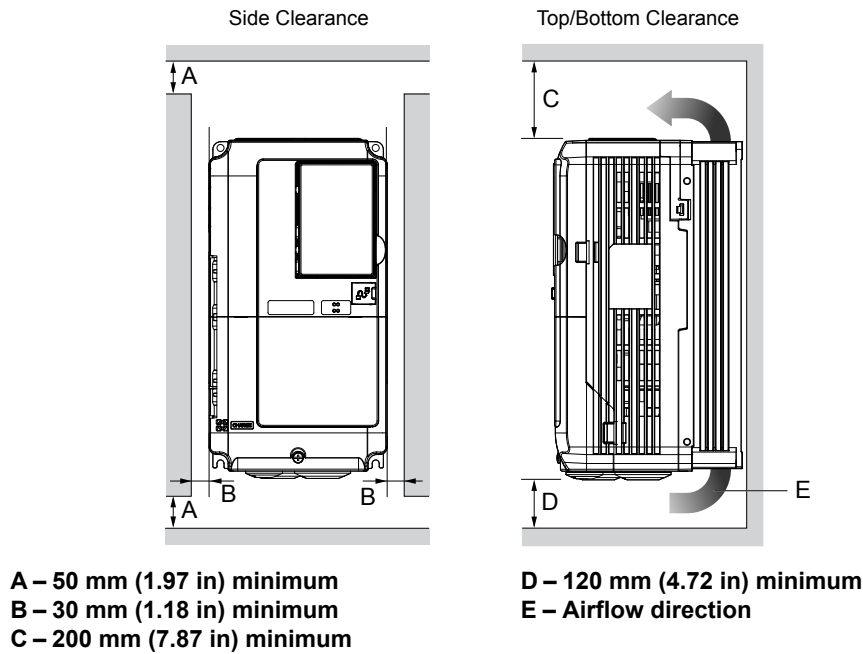


Figure i.6 Correct Installation Spacing

**Note:** IP20/NEMA Type 1 enclosure and IP00/Open Type enclosure models require the same amount of space above and below the drive for installation.

### ◆ Instructions on Installation Using the Eye Bolts and Hanging Brackets

Eye bolts and hanging brackets are used to install the drive or to temporarily lift the drive during drive replacement. Using the eye bolts and hanging brackets, the drive can be installed in an enclosure panel or on a wall. Do not leave the drive suspended by the wires in a horizontal or vertical position for long periods of time. Do not transport the drive over long distances. Read the following precautions and instructions before installing the drive.

**WARNING! Crush Hazard.** Observe the following instructions and precautions. Failure to comply could result in serious injury or death from falling equipment.

Only use vertical suspension to temporarily lift the drive during installation to an enclosure panel. Do not use vertical suspension to transport the drive.

Confirm that the spring washer is completely closed prior to lifting to prevent damage to the drive.

Use screws to securely affix the drive front cover, terminal blocks, and other drive components prior to vertical suspension.

Do not subject the drive to vibration or impact greater than 1.96 m/s<sup>2</sup> (0.2 G) while it is suspended by the wires.

Do not leave the drive unattended while it is suspended by the wires.

Do not attempt to flip the drive over while it is suspended by the wires.

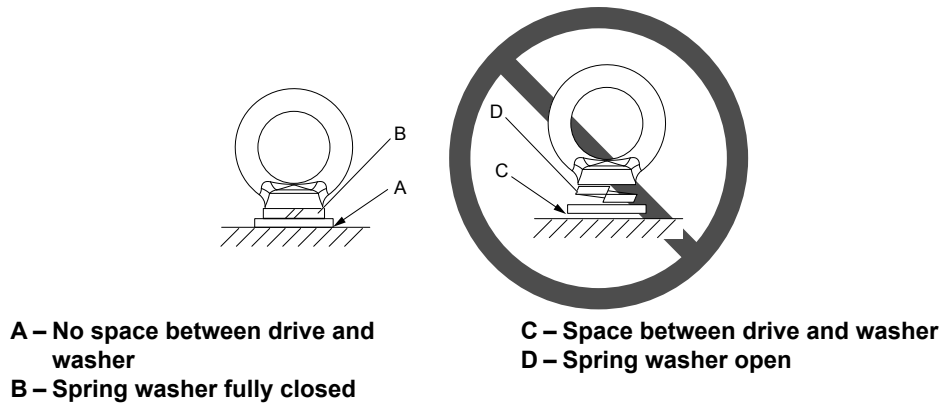


Figure i.7 Spring Washer

### ■ Horizontal Suspension of Drive Models 2□0154 to 2□0248 and 4□0156 to 4□0414

To make a wire hanger or frame for use when lifting the drive with a crane, lay the drive in a horizontal position and pass a wire through the hanging brackets.

### i.3 Mechanical Installation

**NOTICE:** Use the hanging brackets on the top and hanging holes of the bottom cover when lifting models 2□0154F, 2□0192F, 4□0156F, and 4□0180F.

2□0154A, 2□0192A, 2□0248,  
4□0156A, 4□0180A, and 4□0216 to 4□0414

2□0154F, 2□0192F, 4□0156F, and 4□0180F

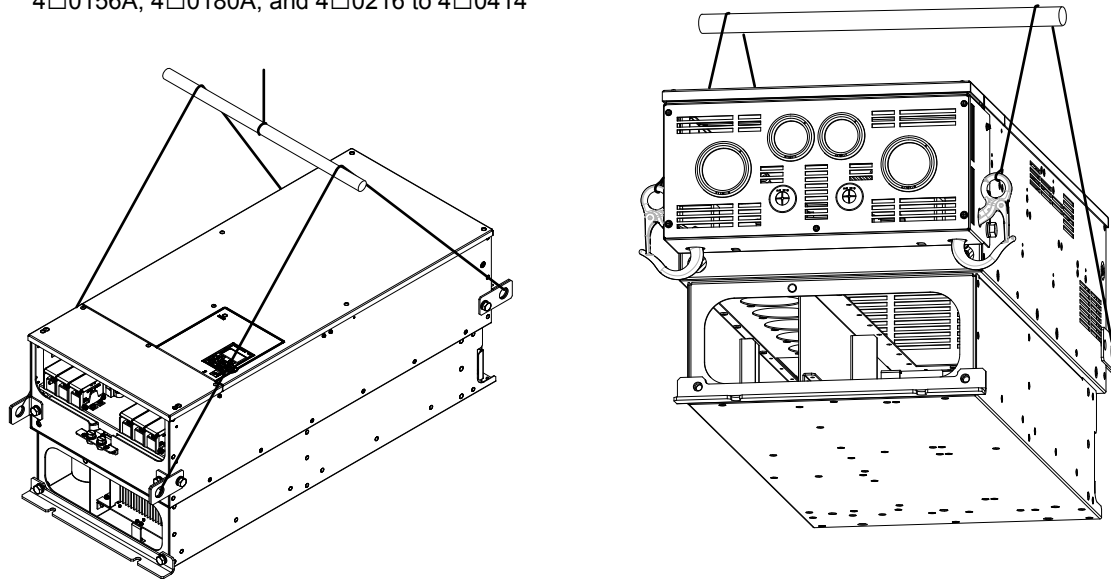


Figure i.8 Horizontal Suspension (Models 2□0154 to 2□0248 and 4□0156 to 4□0414)

#### ■ Vertical Suspension of the Drive

Follow the procedure described below when suspending the drive with eye bolts or hanging brackets.

*Models 2□0028 to 2□0130 and 4□0011 to 4□0124*

**WARNING!** *Crush Hazard.* Use an adequate length of wire to ensure a 50° or wider suspension angle as illustrated in [Figure i.9](#). The maximum allowable load of the eye bolts cannot be guaranteed when the drive is suspended with the wires at angles less than 50°. Failure to comply may result in serious injury or death from falling equipment.

1. Pass wire through the holes of the two eye bolts.

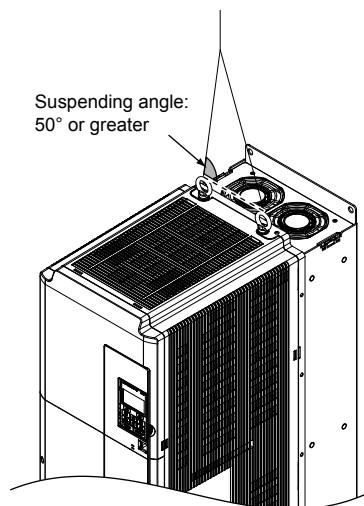


Figure i.9 Drive Suspension Using Wires and Eye Bolts  
(Models 2□0028 to 2□0130 and 4□0011 to 4□0124)

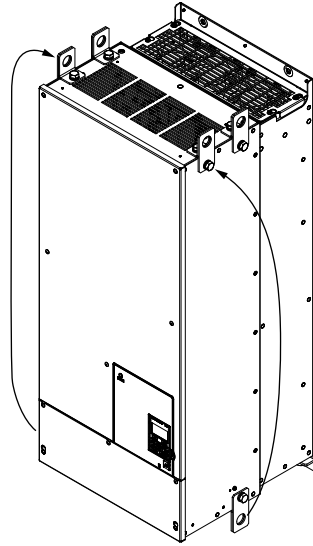
2. Gradually take up the slack in the wires and hoist the drive after the wires are stretched tight.
3. Lower the drive when ready to install in the enclosure panel. Stop lowering the drive when it is near the floor, then slowly begin lowering the drive again until the drive is placed correctly.

*Models 2□0154 to 2□0248 and 4□0156 to 4□0414*

**WARNING! Crush Hazard.** Use an adequate length of wire to ensure a 50° or wider suspension angle as illustrated in **Figure i.10**. The maximum allowable load of the eye bolts cannot be guaranteed when the drive is suspended with the wires at angles less than 50°. Failure to comply may result in serious injury or death from falling equipment.

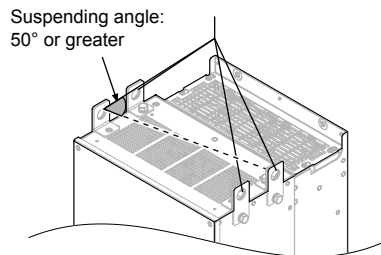
1. Remove the two hanging brackets from the drive lower side panels and bolt them on the top panel.

- Note:**
1. Tighten the hanging brackets with the specified tightening torque: M10: 18 to 23 N·m (159 to 204 in-lb), M12: 32 to 40 N·m (283 to 354 in-lb).
  2. Four hanging brackets are attached to the top of NEMA Type 1 drives 2□0154F, 2□0192F, 4□0156F, and 4□0180F.



**Figure i.10 Location of Hanging Brackets (Models 2□0154 to 2□0248 and 4□0156 to 4□0414)**

2. Pass wire through the holes of all four hanging brackets.



**Figure i.11 Drive Suspension Using Wires and Hanging Brackets (Models 2□0154 to 2□0248 and 4□0156 to 4□0414)**

3. Gradually take up the slack in the wires and hoist the drive after the wires are stretched tight.
4. Lower the drive when ready to install in the enclosure panel. Stop lowering the drive when it is near the floor, then slowly begin lowering the drive again until the drive is placed correctly.

## ◆ Drive Dimensions

### NOTICE

Refer to the U1000 Industrial MATRIX Drive Technical Manual SIEP C710636 04 for IP20/NEMA Type 1 and IP00/Open Chassis dimensions.

The U1000 Industrial MATRIX Drive Technical Manual is posted on the Yaskawa website, [www.yaskawa.com](http://www.yaskawa.com).

# i.4 Electrical Installation

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## ◆ Standard Connection Diagram

Connect the drive and peripheral devices as shown in [Figure i.12](#). It is possible to set and run the drive via the digital operator without connecting digital I/O wiring.

**NOTICE:** *Inadequate wiring could result in damage to the drive. Install adequate branch circuit protection per applicable codes. The drive is suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical amperes, 240 Vac maximum (200 V class), 480 Vac maximum (400 V class: 4E□□□□ and 4W□□□□), and 500 Vac maximum (400 V class: 4A□□□□ and 4P□□□□) when protected by branch circuit protection devices specified in this document.*

**NOTICE:** *Do not connect AC control circuit ground to drive enclosure. Improper drive grounding can cause control circuit malfunction.*

**NOTICE:** *Route motor leads U/T1, V/T2, and W/T3 separate from all other leads to reduce possible interference related issues. Failure to comply may result in abnormal operation of drive and nearby equipment.*

**NOTICE:** *Correctly set Sink/Source jumper S3 for internal power supply. Failure to comply may result in damage to the drive.*

**Note:** The minimum load for the relay outputs M1-M2, M3-M4, M5-M6, and MA-MB-MC is 10 mA.

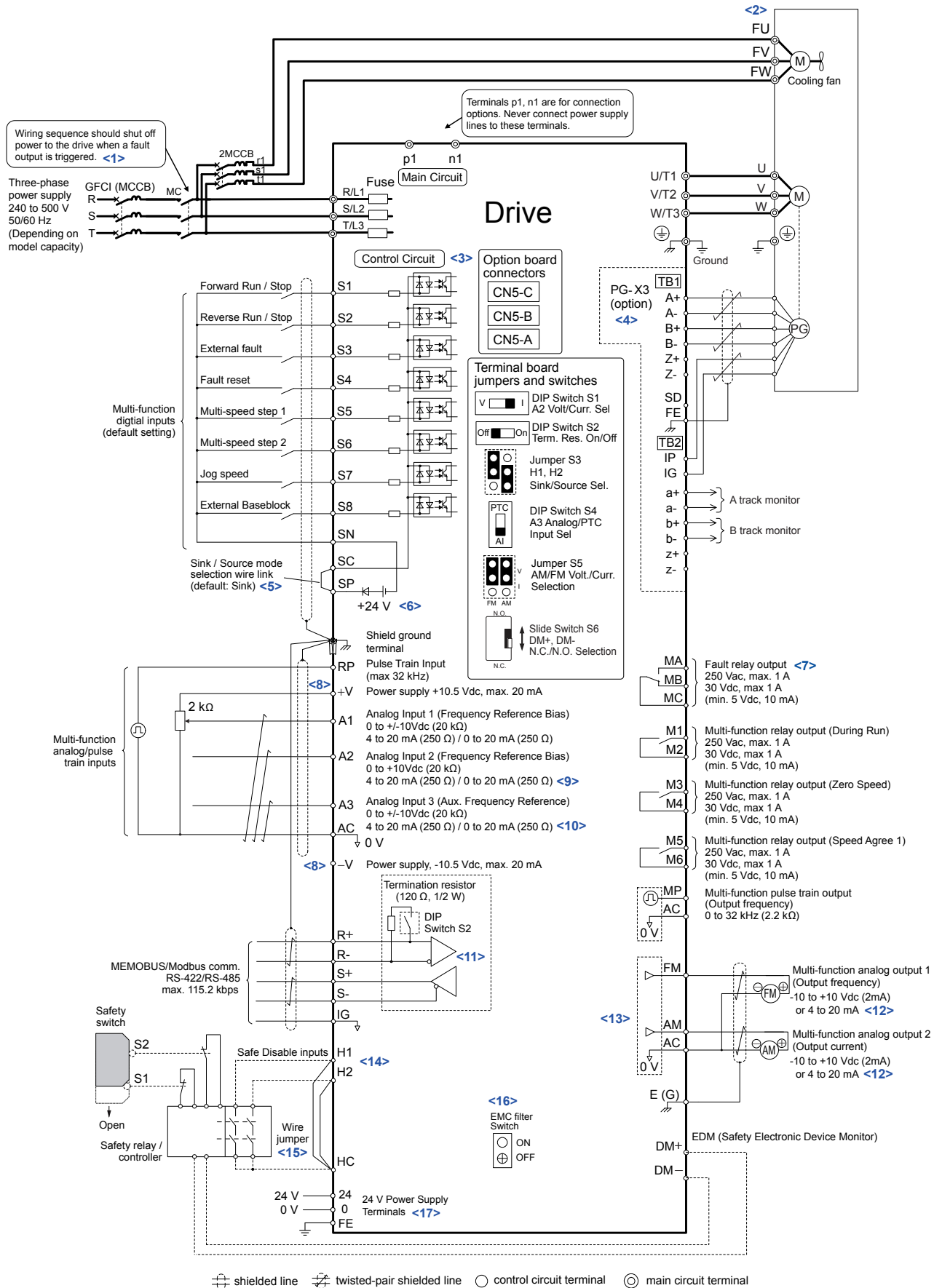


Figure i.12 Drive Standard Connection Diagram (example: model 2□0028)

## i.4 Electrical Installation

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- <1> When setting L5-02 to 1 to trigger a fault output whenever the fault restart function is activated, a sequence to interrupt power when a fault occurs will turn off power to the drive as the drive attempts to restart. The default setting for L5-02 is 0 (Fault output not active during restart attempt).
- <2> Self-cooling motors do not require wiring that is necessary for motors using a cooling fan.
- <3> Supplying power to the control circuit separately from the main circuit requires 24 V power supply (option).
- <4> PG option card wiring is not necessary for control modes that do not use a motor speed feedback signal.
- <5> This figure illustrates an example of a sequence input to S1 through S8 using a non-powered relay or an NPN transistor. Install the wire link between terminals SC-SP for Sink mode, between SC-SN for Source mode, or leave the link out for external power supply. Never short terminals SP and SN, as it will damage the drive.
- <6> This voltage source supplies a maximum current of 150 mA when not using a digital input card DI-A3.
- <7> Wire the fault relay output separately from the main circuit power supply and other power lines.
- <8> The maximum output current capacity for the +V and -V terminals on the control circuit is 20 mA. Never short terminals +V, -V, and AC, as it can cause erroneous operation or damage the drive.
- <9> Set DIP switch S1 to select between a voltage or current input signal to terminal A2. The default setting is for current input.
- <10> Set DIP switch S4 to select between analog or PTC input for terminal A3.
- <11> Set DIP switch S2 to the ON position to enable the termination resistor in the last drive in a MEMOBUS/Modbus network.
- <12> Monitor outputs work with devices such as analog frequency meters, ammeters, voltmeters, and wattmeters. They are not intended for use as a feedback-type signal.
- <13> Use jumper S5 to select between voltage or current output signals at terminals AM and FM. Set parameters H4-07 and H4-08 accordingly.
- <14> Use jumper S3 to select between Sink mode, Source mode, and external power supply for the Safe Disable inputs.
- <15> Disconnect the wire jumper between H1 - HC and H2 - HC when utilizing the Safe Disable input.
- <16> Models UU□A□□□□ and UU□P□□□□ do not have a built-in EMC filter switch.
- <17> Models UU□P□□□□ and UU□W□□□□ have terminals 24, 0, and FE.

**WARNING!** Sudden Movement Hazard. Do not close the wiring for the control circuit unless the multifunction input terminal parameters are properly set. Improper sequencing of run/stop circuitry could result in death or serious injury from moving equipment.

**WARNING!** Sudden Movement Hazard. Ensure start/stop and safety circuits are wired properly and in the correct state before energizing the drive. Failure to comply could result in death or serious injury from moving equipment. When programmed for 3-Wire control, a momentary closure on terminal S1 may cause the drive to start.

**WARNING!** Sudden Movement Hazard. When using a 3-Wire sequence, set the drive to 3-Wire sequence prior to wiring the control terminals and set parameter b1-17 to 0 so the drive will not accept a Run command at power up (default). If the drive is wired for a 3-Wire sequence but set up for a 2-Wire sequence (default), and parameter b1-17 is set to 1 so the drive accepts a Run command at power up, the motor will rotate in reverse direction at drive power up and may cause injury.

**WARNING!** Sudden Movement Hazard. Confirm the drive I/O signals and external sequence before executing the application preset function. Executing the application preset function or setting A1-06 ≠ 0 will change the drive I/O terminal functions and may cause unexpected equipment operation. Failure to comply may cause death or serious injury.

**NOTICE:** When using the automatic fault restart function with wiring designed to shut off the power supply upon drive fault, make sure the drive does not trigger a fault output during fault restart (L5-02 = 0, default). Failure to comply will prevent the automatic fault restart function from working properly.

## ◆ Main Circuit Connection Diagram

Refer to [Figure i.13](#) when wiring the main circuit of the drive. Connections may vary based on drive capacity. The DC power supply for the main circuit also provides power to the control circuit.

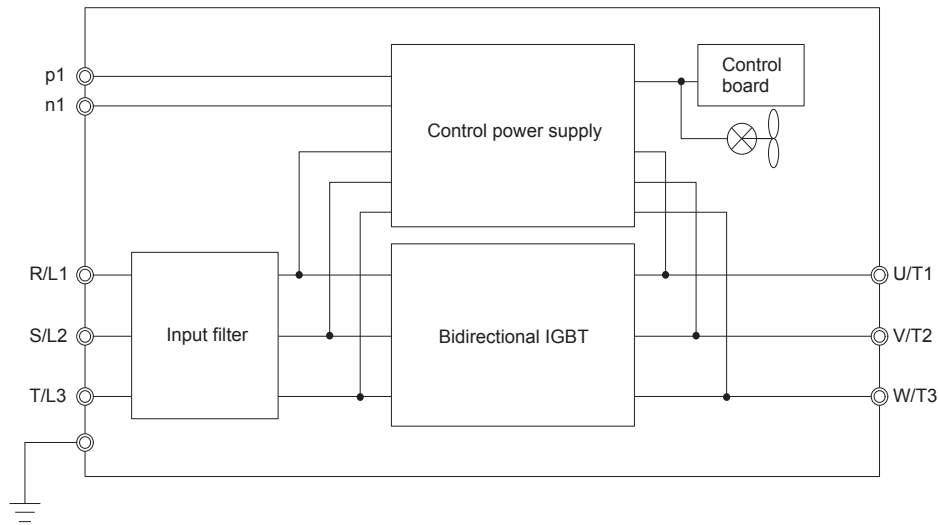


Figure i.13 Connecting Main Circuit Terminals

## ◆ Main Circuit Wiring

This section describes the functions, specifications, and procedures required to safely and properly wire the main circuit in the drive.

**NOTICE:** Do not solder the ends of wire connections to the drive. Soldered wiring connections can loosen over time. Improper wiring practices could result in drive malfunction due to loose terminal connections.

**NOTICE:** Do not switch the drive input to start or stop the motor. Frequently switching the drive on and off shortens the lifetime of the DC bus charge circuit and the DC bus capacitors, and can cause premature drive failures. For the full performance life, refrain from switching the drive on and off more than once every 30 minutes.

## ◆ Main Circuit Terminal Functions

Table i.4 Main Circuit Terminal Functions

Drive Model	2□0028 to 2□0248	4□0011 to 4□0414	Function	Page
Terminal	Type			
R/L1	Main circuit power supply input		Connects line power to the drive	21
S/L2				
T/L3				
U/T1	Drive output		Connects to the motor	21
V/T2				
W/T3				
p1, n1	Momentary power loss recovery unit input		Available for connecting a momentary power loss recovery unit option	–
⊕	100 Ω or less	10 Ω or less	Grounding terminal	29

## ◆ Protecting Main Circuit Terminals

### ■ Insulation Caps or Sleeves

Use insulation caps or sleeves when wiring the drive with crimp terminals. Take particular care to ensure that the wiring does not touch nearby terminals or the surrounding case.

### ■ Main Circuit Protective Cover

Close the protective cover after wiring the main circuit terminals on 2□0028 to 2□0081 and 4□0011 to 4□0077.

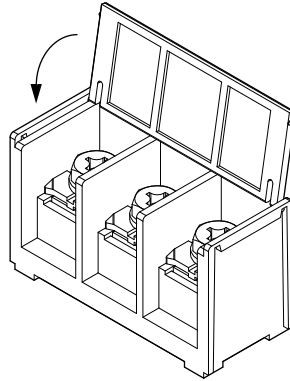


Figure i.14 Main Circuit Protective Cover (Models 2□0028 to 2□0081 and 4□0011 to 4□0077)

Attach the protective covers after wiring the main circuit terminals and p1, and n1 terminals on models 2□0104 to 2□0248 and 4□0096 to 4□0414.

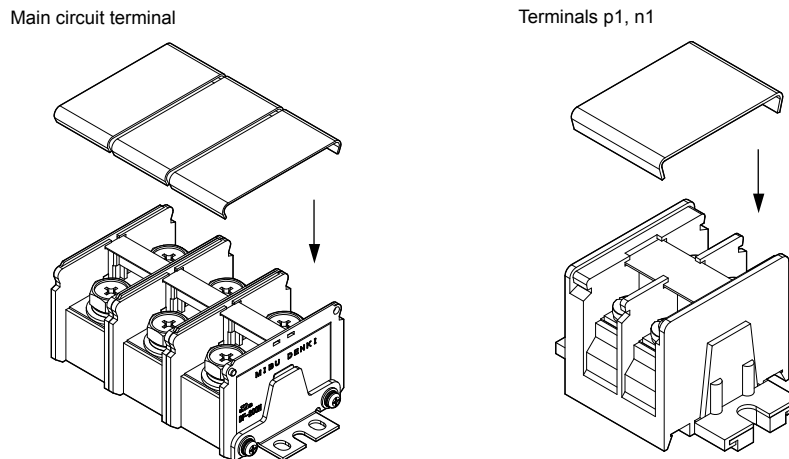


Figure i.15 Protective Cover (Models 2□0104 to 2□0248 and 4□0096 to 4□0414)

### ◆ Main Circuit Wire Gauges and Tightening Torque

Use the tables in this section to select the appropriate wires and crimp terminals.

Gauges listed in the tables are for use in the United States.

**Note:** Wire gauge recommendations based on drive continuous current ratings (ND) using 75 °C 600 Vac vinyl-sheathed wire assuming ambient temperature within 40 °C and wiring distance less than 100 m.

Consider the amount of voltage drop when selecting wire gauges. Increase the wire gauge when the voltage drop is greater than 2% of motor rated voltage. Ensure the wire gauge is suitable for the terminal block. Use the following formula to calculate the amount of voltage drop:

$$\text{Line drop voltage (V)} = \sqrt{3} \times \text{wire resistance } (\Omega/\text{km}) \times \text{wire length (m)} \times \text{current (A)} \times 10^{-3}$$

*Refer to [UL Standards Compliance on page 82](#) for information on UL compliance.*

The wire gauges listed in the following tables are Yaskawa recommendations. Refer to local codes for proper wire gauge selections.



### ■ Three-Phase 200 V Class

Table i.5 Wire Gauge and Torque Specifications (Three-Phase 200 V Class)

Drive Model	Terminal	For USA and Canada		For South America		Screw Size	Tightening Torque N·m (lb.in.)
		Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)	Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)		
2□0028	R/L1, S/L2, T/L3	10 (8)	6 to 10 (10 to 8)	4 (12)	2.5 to 10 (14 to 8)	M5	2.3 to 2.7 (20.4 to 23.9)
	U/T1, V/T2, W/T3	10 (8)	6 to 10 (10 to 8)	4 (12)	2.5 to 10 (14 to 8)	M5	
	⊖	10 (8)	6 to 16 (10 to 6)	6 (10)	6 to 16 (10 to 5)	M6	3.9 to 4.9 (34.7 to 43.4)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
2□0042	R/L1, S/L2, T/L3	16 (6)	10 to 25 (8 to 3)	10 (8)	6 to 25 (10 to 3)	M6	4 to 6 (35.4 to 53.1)
	U/T1, V/T2, W/T3	16 (6)	10 to 25 (8 to 3)	10 (8)	6 to 25 (10 to 3)	M6	
	⊖	10 (8)	6 to 25 (10 to 3)	10 (8)	6 to 25 (10 to 3)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
2□0054	R/L1, S/L2, T/L3	25 (4)	16 to 25 (6 to 3)	16 (5)	10 to 25 (8 to 3)	M6	4 to 6 (35.4 to 53.1)
	U/T1, V/T2, W/T3	25 (4)	16 to 25 (6 to 3)	16 (5)	10 to 25 (8 to 3)	M6	
	⊖	16 (6)	10 to 25 (8 to 3)	10 (8)	10 to 25 (8 to 3)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
2□0068	R/L1, S/L2, T/L3	25 (4)	25 (4 to 3)	16 (5)	16 to 25 (5 to 3)	M6	4 to 6 (35.4 to 53.1)
	U/T1, V/T2, W/T3	25 (4)	25 (4 to 3)	16 (5)	16 to 25 (5 to 3)	M6	
	⊖	16 (6)	16 to 25 (6 to 3)	16 (5)	16 to 25 (5 to 3)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
2□0081	R/L1, S/L2, T/L3	16 × 2 (6 × 2P)	16 to 25 × 2 (6 to 3 × 2P)	25 (3)	16 to 25 (5 to 3 × 2P)	M6	4 to 6 (35.4 to 53.1)
	U/T1, V/T2, W/T3	16 × 2 (6 × 2P)	16 to 25 × 2 (6 to 3 × 2P)	25 (3)	16 to 25 (5 to 3 × 2P)	M6	
	⊖	16 (6)	16 to 25 (6 to 3)	16 (5)	16 to 25 (5 to 3)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
2□0104	R/L1, S/L2, T/L3	35 (1)	16 to 50 × 2 (6 to 1/0 × 2P)	35 (1)	10 to 50 × 2P (8 to 1/0 × 2P)	M8	8 to 10 (70.8 to 88.5)
	U/T1, V/T2, W/T3	35 (1)	16 to 50 × 2 (6 to 1/0 × 2P)	35 (1)	10 to 50 × 2P (8 to 1/0 × 2P)	M8	
	⊖	25 (4)	25 to 35 (4 to 1)	25 (3)	10 to 35 (8 to 1)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)

## i.4 Electrical Installation

Drive Model	Terminal	For USA and Canada		For South America		Screw Size	Tightening Torque N·m (lb.in.)
		Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)	Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)		
2□0130	R/L1, S/L2, T/L3	25 × 2 (4 × 2P)	16 to 50 × 2 (6 to 1/0 × 2P)	16 × 2P (5 × 2P)	10 to 50 × 2P (8 to 1/0 × 2P)	M8	8 to 10 (70.8 to 88.5)
	U/T1, V/T2, W/T3	25 × 2 (4 × 2P)	16 to 50 × 2 (6 to 1/0 × 2P)	16 × 2P (5 × 2P)	10 to 50 × 2P (8 to 1/0 × 2P)	M8	
	⊕	25 (4)	25 to 35 (4 to 1)	16 (5)	16 to 35 (5 to 1)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
2□0154	R/L1, S/L2, T/L3	25 × 2 (3 × 2P)	25 to 95 × 2 (4 to 4/0 × 2P)	25 × 2P (3 × 2P)	16 to 95 × 2P (5 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	25 × 2 (3 × 2P)	25 to 95 × 2 (4 to 4/0 × 2P)	25 × 2P (3 × 2P)	16 to 95 × 2P (5 to 4/0 × 2P)	M10	
	⊕	25 (4)	25 to 70 (4 to 2/0)	25 (3)	25 to 70 (3 to 2/0)	M10	17.7 to 22.6 (156 to 200)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
2□0192	R/L1, S/L2, T/L3	35 × 2 (1 × 2P)	25 to 95 × 2 (3 to 4/0 × 2P)	35 × 2P (1 × 2P)	25 to 95 × 2P (3 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	35 × 2 (1 × 2P)	25 to 95 × 2 (3 to 4/0 × 2P)	35 × 2P (1 × 2P)	25 to 95 × 2P (3 to 4/0 × 2P)	M10	
	⊕	25 (3)	25 to 70 (4 to 2/0)	25 (3)	25 to 70 (3 to 2/0)	M10	17.7 to 22.6 (156 to 200)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
2□0248	R/L1, S/L2, T/L3	70 × 2 (2/0 × 2P)	35 to 95 × 2 (1 to 4/0 × 2P)	50 × 2P (1/0 × 2P)	35 to 95 × 2P (1 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	70 × 2 (2/0 × 2P)	35 to 95 × 2 (1 to 4/0 × 2P)	50 × 2P (1/0 × 2P)	35 to 95 × 2P (1 to 4/0 × 2P)	M10	
	⊕	25 (3)	25 to 95 (4 to 4/0)	35 (1)	25 to 95 (3 to 4/0)	M12	31.4 to 39.2 (278 to 347)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)

### ■ Three-Phase 400 V Class

Table i.6 Wire Gauge and Torque Specifications (Three-Phase 400 V Class)

Drive Model	Terminal	For USA and Canada		For South America		Screw Size	Tightening Torque N·m (lb.in.)
		Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)	Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)		
4□0011	R/L1, S/L2, T/L3	2.5 (14)	2.5 to 10 (14 to 8)	2.5 (14)	2.5 to 10 (14 to 8)	M5	2.3 to 2.7 (20.4 to 23.9)
	U/T1, V/T2, W/T3	2.5 (14)	2.5 to 10 (14 to 8)	2.5 (14)	2.5 to 10 (14 to 8)	M5	
	⊕	6 (10)	4 to 16 (12 to 6)	2.5 (14)	2.5 to 16 (14 to 5)	M6	3.9 to 4.9 (34.7 to 43.4)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
4□0014	R/L1, S/L2, T/L3	4 (12)	2.5 to 10 (14 to 8)	2.5 (14)	2.5 to 10 (14 to 8)	M5	2.3 to 2.7 (20.4 to 23.9)
	U/T1, V/T2, W/T3	4 (12)	2.5 to 10 (14 to 8)	2.5 (14)	2.5 to 10 (14 to 8)	M5	
	⊕	6 (10)	4 to 16 (12 to 6)	2.5 (14)	2.5 to 16 (14 to 5)	M6	3.9 to 4.9 (34.7 to 43.4)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)

Drive Model	Terminal	For USA and Canada		For South America		Screw Size	Tightening Torque N·m (lb.in.)
		Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)	Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)		
4□0021	R/L1, S/L2, T/L3	6 (10)	4 to 10 (12 to 8)	2.5 (14)	2.5 to 10 (14 to 8)	M5	2.3 to 2.7 (20.4 to 23.9)
	U/T1, V/T2, W/T3	6 (10)	4 to 10 (12 to 8)	2.5 (14)	2.5 to 10 (14 to 8)	M5	
	⊕	6 (10)	4 to 16 (12 to 6)	2.5 (14)	2.5 to 16 (14 to 5)	M6	3.9 to 4.9 (34.7 to 43.4)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
4□0027	R/L1, S/L2, T/L3	10 (8)	6 to 10 (10 to 8)	4 (12)	2.5 to 10 (14 to 8)	M5	2.3 to 2.7 (20.4 to 23.9)
	U/T1, V/T2, W/T3	10 (8)	6 to 10 (10 to 8)	4 (12)	2.5 to 10 (14 to 8)	M5	
	⊕	10 (8)	4 to 16 (12 to 6)	4 (12)	4 to 16 (12 to 5)	M6	3.9 to 4.9 (34.7 to 43.4)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
4□0034	R/L1, S/L2, T/L3	10 (8)	10 (8)	6 (10)	4 to 10 (12 to 8)	M5	2.3 to 2.7 (20.4 to 23.9)
	U/T1, V/T2, W/T3	10 (8)	10 (8)	6 (10)	4 to 10 (12 to 8)	M5	
	⊕	10 (8)	6 to 16 (10 to 6)	6 (10)	6 to 16 (10 to 5)	M6	3.9 to 4.9 (34.7 to 43.4)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
4□0040	R/L1, S/L2, T/L3	10 (8)	10 to 25 (8 to 3)	10 (8)	6 to 25 (10 to 3)	M6	4 to 6 (35.4 to 53.1)
	U/T1, V/T2, W/T3	10 (8)	10 to 25 (8 to 3)	10 (8)	6 to 25 (10 to 3)	M6	
	⊕	10 (8)	10 to 25 (10 to 3)	10 (8)	6 to 25 (10 to 3)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
4□0052	R/L1, S/L2, T/L3	16 (6)	10 to 25 (8 to 3)	10 (8)	10 to 25 (8 to 3)	M6	4 to 6 (35.4 to 53.1)
	U/T1, V/T2, W/T3	16 (6)	10 to 25 (8 to 3)	10 (8)	10 to 25 (8 to 3)	M6	
	⊕	16 (6)	10 to 25 (8 to 3)	10 (8)	10 to 25 (8 to 3)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
4□0065	R/L1, S/L2, T/L3	25 (4)	16 to 25 (6 to 3)	16 (5)	10 to 25 (8 to 3)	M6	4 to 6 (35.4 to 53.1)
	U/T1, V/T2, W/T3	25 (4)	16 to 25 (6 to 3)	16 (5)	10 to 25 (8 to 3)	M6	
	⊕	16 (6)	16 to 25 (6 to 3)	16 (5)	16 to 25 (5 to 3)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)
4□0077	R/L1, S/L2, T/L3	25 (3)	25 (4 to 3)	25 (3)	16 to 25 (5 to 3)	M6	4 to 6 (35.4 to 53.1)
	U/T1, V/T2, W/T3	25 (3)	25 (4 to 3)	25 (3)	16 to 25 (5 to 3)	M6	
	⊕	16 (6)	16 to 25 (6 to 3)	16 (5)	16 to 25 (5 to 3)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1 to 1.4 (8.9 to 12.4)

## i.4 Electrical Installation

Drive Model	Terminal	For USA and Canada		For South America		Screw Size	Tightening Torque N·m (lb.in.)
		Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)	Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)		
4□0096	R/L1, S/L2, T/L3	35 (1)	10 to 50 (8 to 1/0 × 2P)	35 (1)	10 to 50 × 2P (8 to 1/0 × 2P)	M8	8 to 10 (70.8 to 88.5)
	U/T1, V/T2, W/T3	35 (1)	10 to 50 (8 to 1/0 × 2P)	35 (1)	10 to 50 × 2P (8 to 1/0 × 2P)	M8	
	⊕	25 (4)	25 to 35 (4 to 1)	25 (3)	10 to 35 (8 to 1)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
4□0124	R/L1, S/L2, T/L3	25 × 2 (4 × 2P)	16 to 50 × 2 (6 to 1/0 × 2P)	16 × 2P (5 × 2P)	10 to 50 × 2P (8 to 1/0 × 2P)	M8	8 to 10 (70.8 to 88.5)
	U/T1, V/T2, W/T3	25 × 2 (4 × 2P)	16 to 50 × 2 (6 to 1/0 × 2P)	16 × 2P (5 × 2P)	10 to 50 × 2P (8 to 1/0 × 2P)	M8	
	⊕	25 (4)	25 to 35 (4 to 1)	16 (5)	16 to 35 (5 to 1)	M8	8.8 to 10.8 (78.1 to 95.5)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
4□0156	R/L1, S/L2, T/L3	25 × 2 (3 × 2P)	25 to 95 × 2 (4 to 4/0 × 2P)	25 × 2P (3 × 2P)	16 to 95 × 2P (5 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	25 × 2 (3 × 2P)	25 to 95 × 2 (4 to 4/0 × 2P)	25 × 2P (3 × 2P)	16 to 95 × 2P (5 to 4/0 × 2P)	M10	
	⊕	25 (4)	25 to 70 (4 to 2/0)	25 (3)	25 to 70 (3 to 2/0)	M10	17.7 to 22.6 (156 to 200)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
4□0180	R/L1, S/L2, T/L3	35 × 2 (2 × 2P)	25 to 95 × 2 (3 to 4/0 × 2P)	25 × 2P (3 × 2P)	25 to 95 × 2P (3 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	35 × 2 (2 × 2P)	25 to 95 × 2 (3 to 4/0 × 2P)	25 × 2P (3 × 2P)	25 to 95 × 2P (3 to 4/0 × 2P)	M10	
	⊕	25 (3)	25 to 70 (4 to 2/0)	25 (3)	25 to 70 (3 to 2/0)	M10	17.7 to 22.6 (156 to 200)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
4□0216	R/L1, S/L2, T/L3	50 × 2 (1/0 × 2P)	35 to 95 × 2 (2 to 4/0 × 2P)	35 × 2P (1 × 2P)	25 to 95 × 2P (3 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	50 × 2 (1/0 × 2P)	35 to 95 × 2 (2 to 4/0 × 2P)	35 × 2P (1 × 2P)	25 to 95 × 2P (3 to 4/0 × 2P)	M10	
	⊕	25 (3)	25 to 95 (4 to 4/0)	35 (1)	25 to 95 (3 to 4/0)	M12	31.4 to 39.2 (278 to 347)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
4□0240	R/L1, S/L2, T/L3	50 × 2 (1/0 × 2P)	50 to 95 × 2 (1/0 to 4/0 × 2P)	50 × 2P (1/0 × 2P)	35 to 95 × 2P (1 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	50 × 2 (1/0 × 2P)	50 to 95 × 2 (1/0 to 4/0 × 2P)	50 × 2P (1/0 × 2P)	35 to 95 × 2P (1 to 4/0 × 2P)	M10	
	⊕	35 (2)	35 to 95 (2 to 4/0)	50 (1/0)	35 to 95 (1 to 4/0)	M12	31.4 to 39.2 (278 to 347)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
4□0302 </>	R/L1, S/L2, T/L3	70 × 2 (3/0 × 2P)	50 to 95 × 2 (1/0 to 4/0 × 2P)	70 × 2P (3/0 × 2P)	50 to 95 × 2P (1/0 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	70 × 2 (3/0 × 2P)	50 to 95 × 2 (1/0 to 4/0 × 2P)	70 × 2P (3/0 × 2P)	50 to 95 × 2P (1/0 to 4/0 × 2P)	M10	
	⊕	35 (1)	35 to 150 (1 to 300)	70 (3/0)	35 to 150 (1 to 300)	M12	31.4 to 39.2 (278 to 347)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)

Drive Model	Terminal	For USA and Canada		For South America		Screw Size	Tightening Torque N·m (lb.in.)
		Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)	Recomm. Gauge mm <sup>2</sup> (AWG, kcmil)	Wire Range mm <sup>2</sup> (AWG, kcmil)		
4□0361 </>	R/L1, S/L2, T/L3	95 × 2 (4/0 × 2P)	70 to 95 × 2 (3/0 to 4/0 × 2P)	95 × 2P (4/0 × 2P)	70 to 95 × 2P (3/0 to 4/0 × 2P)	M10	15 to 20 (133 to 177)
	U/T1, V/T2, W/T3	95 × 2 (4/0 × 2P)	70 to 95 × 2 (3/0 to 4/0 × 2P)	95 × 2P (4/0 × 2P)	70 to 95 × 2P (3/0 to 4/0 × 2P)	M10	
	⊕	50 (1/0)	50 to 150 (1/0 to 300)	95 (4/0)	70 to 150 (3/0 to 300)	M12	31.4 to 39.2 (278 to 347)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)
4□0414 </>	R/L1, S/L2, T/L3	150 × 2 (300 × 2P)	95 to 150 × 2 (4/0 to 300 × 2P)	95 × 2P (4/0 × 2P)	95 to 150 × 2P (4/0 to 300 × 2P)	M12	25 to 35 (221 to 310)
	U/T1, V/T2, W/T3	150 × 2 (300 × 2P)	95 to 150 × 2 (4/0 to 300 × 2P)	95 × 2P (4/0 × 2P)	95 to 150 × 2P (4/0 to 300 × 2P)	M12	
	⊕	50 (1/0)	50 to 240 (1/0 to 400)	95 (4/0)	70 to 240 (3/0 to 400)	M12	31.4 to 39.2 (278 to 347)
	p1, n1	2.5 (14)	2.5 to 4 (14 to 12)	2.5 (14)	2.5 to 4 (14 to 12)	M4	1.2 to 2.0 (10.6 to 17.7)

<1> Take additional measures in accordance with IEC/EN 61800-5-1 when wiring an EMC filter is installed. Refer to the Technical Manual for details.

### ◆ Main Circuit Terminal and Motor Wiring

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

**NOTICE:** When connecting the motor to the drive output terminals U/T1, V/T2, and W/T3, the phase order for the drive and motor should match. Failure to comply with proper wiring practices may cause the motor to run in reverse if the phase order is backward.

**NOTICE:** Route motor leads U/T1, V/T2, and W/T3 separate from all other leads to reduce possible interference related issues. Failure to comply may result in abnormal operation of drive and nearby equipment.

### ■ Ground Wiring

Follow the precautions below when wiring the ground for one drive or a series of drives.

**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.

**WARNING! Electrical Shock Hazard.** Be sure to ground the drive ground terminal (200 V class: ground to 100 Ω or less; 400 V class: ground to 10 Ω or less). Improper equipment grounding could result in death or serious injury by contacting ungrounded electrical equipment.

**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 drive or equipment malfunction due to electrical interference.

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

Refer to [Figure i.16](#) when using multiple drives. Do not loop the ground wire.

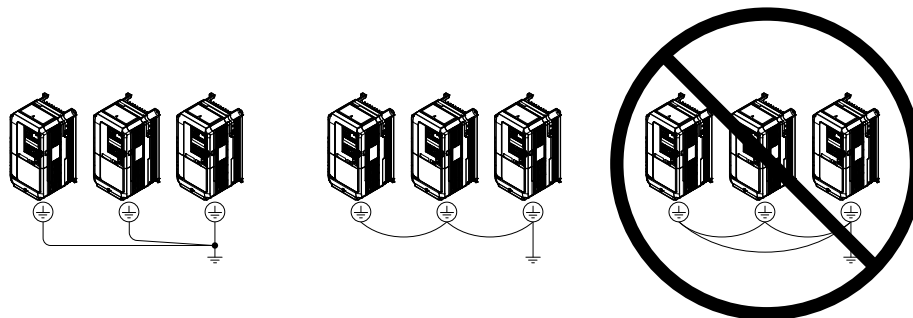


Figure i.16 Multiple Drive Wiring

**◆ Control Circuit Terminal Block Functions**

Drive parameters determine which functions apply to the multi-function digital inputs (S1 to S8), multi-function digital outputs (M1 to M6), multi-function analog inputs (A1 to A3), and multi-function analog monitor outputs (FM, AM). The default setting is listed next to each terminal in [Figure i.12](#) on page 21.

**WARNING!** *Sudden Movement Hazard. Always check the operation and wiring of control circuits after being wired. Operating a drive with untested control circuits could result in death or serious injury.*

**WARNING!** *Sudden Movement Hazard. Confirm the drive I/O signals and external sequence before starting test run. Setting parameter A1-06 may change the I/O terminal function automatically from the factory setting. Failure to comply may result in death or serious injury.*

**■ Input Terminals**

[Table i.7](#) lists the input terminals on the drive. Text in parenthesis indicates the default setting for each multi-function input.

**Table i.7 Control Circuit Input Terminals**

Type	No.	Terminal Name (Function)	Function (Signal Level) Default Setting	
Multi-Function Digital Inputs	S1	Multi-function input 1 (Closed: Forward run, Open: Stop)	<ul style="list-style-type: none"> <li>• Photocoupler</li> <li>• 24 Vdc, 8 mA</li> <li>• <a href="#">Refer to Sinking/Sourcing Mode for Digital Inputs on page 34.</a></li> </ul>	
	S2	Multi-function input 2 (Closed: Reverse run, Open: Stop)		
	S3	Multi-function input 3 (External fault, N.O.)		
	S4	Multi-function input 4 (Fault reset)		
	S5	Multi-function input 5 (Multi-step speed reference 1)		
	S6	Multi-function input 6 (Multi-step speed reference 2)		
	S7	Multi-function input 7 (Jog reference)		
	S8	Multi-function input 8 (Baseblock command (N.O.))		
	SC	Multi-function input common		Multi-function input common
	SP	Digital input power supply +24 Vdc		24 Vdc power supply for digital inputs, 150 mA max (only when not using digital input option DI-A3)
	SN	Digital input power supply 0 V	<b>NOTICE:</b> <i>Do not jumper or short terminals SP and SN. Failure to comply will damage the drive.</i>	
Safe Disable Inputs	H1	Safe Disable input 1	<ul style="list-style-type: none"> <li>• 24 Vdc, 8 mA</li> <li>• One or both open: Output disabled</li> <li>• Both closed: Normal operation</li> <li>• Internal impedance: 3.3 kΩ</li> <li>• Off time of at least 1 ms</li> <li>• Disconnect the wire jumpers shorting terminals H1, H2, and HC to use the Safe Disable inputs. Set the S3 jumper to select between sinking, sourcing mode, and the power supply as explained on page 34.</li> </ul>	
	H2	Safe Disable input 2		
	HC	Safe Disable function common		Safe disable function common

Type	No.	Terminal Name (Function)	Function (Signal Level) Default Setting
Analog Inputs / Pulse Train Input	RP	Multi-function pulse train input (Frequency reference)	<ul style="list-style-type: none"> <li>Input frequency range: 0 to 32 kHz</li> <li>Signal Duty Cycle: 30 to 70%</li> <li>High level: 3.5 to 13.2 Vdc, low level: 0.0 to 0.8 Vdc</li> <li>Input impedance: 3 kΩ</li> </ul>
	+V	Power supply for analog inputs	10.5 Vdc (max allowable current 20 mA)
	-V	Power supply for analog inputs	-10.5 Vdc (max allowable current 20 mA)
	A1	Multi-function analog input 1 (Frequency reference bias)	-10 to 10 Vdc, 0 to 10 Vdc (input impedance: 20 kΩ)
	A2	Multi-function analog input 2 (Frequency reference bias)	<ul style="list-style-type: none"> <li>-10 to 10 Vdc, 0 to 10 Vdc (input impedance: 20 kΩ)</li> <li>4 to 20 mA, 0 to 20 mA (input impedance: 250 Ω)</li> <li>Voltage or current input must be selected by DIP switch S1 and H3-09.</li> </ul>
	A3	Multi-function analog input 3 (Auxiliary frequency reference)/PTC Input	<ul style="list-style-type: none"> <li>-10 to 10 Vdc, 0 to 10 Vdc (input impedance: 20 kΩ)</li> <li>Use DIP switch S4 on the terminal board to select between analog and PTC input.</li> </ul>
	AC	Frequency reference common	0 V
	E (G)	Ground for shielded lines and option cards	—

■ Output Terminals

Table i.8 lists the output terminals on the drive. Text in parenthesis indicates the default setting for each multi-function output.

Table i.8 Control Circuit Output Terminals

Type	No.	Terminal Name (Function)	Function (Signal Level) Default Setting
Fault Relay Output	MA	N.O. output (Fault)	30 Vdc, 10 mA to 1 A; 250 Vac, 10 mA to 1 A Minimum load: 5 Vdc, 10 mA
	MB	N.C. output (Fault)	
	MC	Fault output common	
Multi-Function Digital Output <I>	M1	Multi-function digital output (During run)	30 Vdc, 10 mA to 1 A; 250 Vac, 10 mA to 1 A Minimum load: 5 Vdc, 10 mA
	M2		
	M3	Multi-function digital output (Zero speed)	
	M4		
	M5	Multi-function digital output (Speed Agree 1)	
	M6		
Monitor Output	MP	Pulse train output (Output frequency)	32 kHz (max)
	FM	Analog monitor output 1 (Output frequency)	-10 to +10 Vdc, 0 to +10 Vdc, or 4 to 20 mA
	AM	Analog monitor output 2 (Output current)	
	AC	Monitor common	0 V
Safety Monitor Output	DM+	Safety monitor output	Outputs status of Safe Disable function. Closed when both Safe Disable channels are closed. Up to +48 Vdc 50 mA
	DM-	Safety monitor output	
External Power Supply	24V	External power supply	24 V (Max. 150 mA)

<I> Refrain from assigning functions to digital relay outputs that involve frequent switching, as doing so may shorten relay performance life. Switching life is estimated at 200,000 times (assumes 1 A, resistive load).

■ Serial Communication Terminals

Table i.9 Control Circuit Terminals: Serial Communications

Type	No.	Signal Name	Function (Signal Level)
MEMOBUS/Modbus Communication <I>	R+	Communications input (+)	MEMOBUS/Modbus communication: Use an RS-422 or RS-485 cable to connect the drive. RS-422/RS-485 communication protocol 115.2 kbps (max.)
	R-	Communications input (-)	
	S+	Communications output (+)	
	S-	Communications output (-)	
	IG	Shield ground	0 V

<I> Enable the termination resistor in the last drive in a MEMOBUS/Modbus network by setting DIP switch S2 to the ON position. Refer to the manual section on **Control I/O Connections** for more information.

◆ Terminal Configuration

The control circuit terminals are arranged as shown in *Figure i.17*.

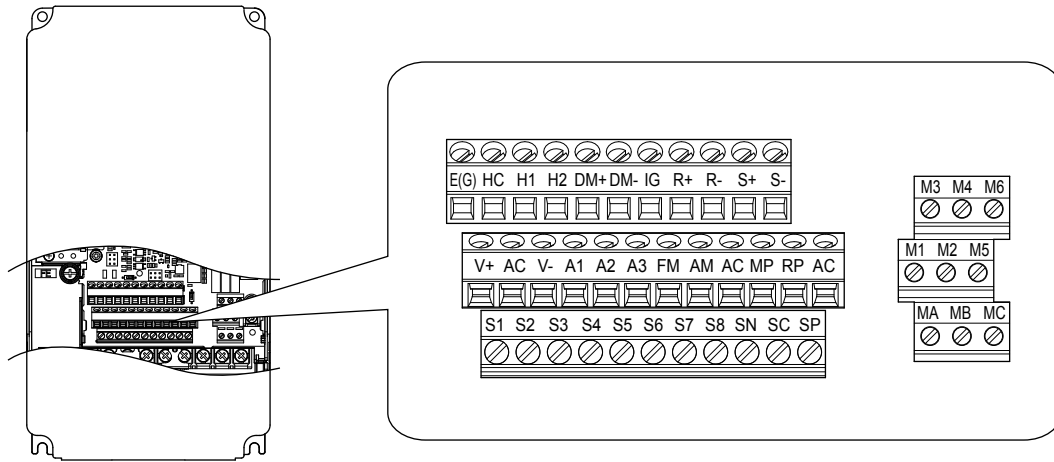


Figure i.17 Control Circuit Terminal Arrangement

■ Wire Size and Torque Specifications

Select appropriate wire type and gauges from *Table i.10*. For simpler and more reliable wiring, use crimp ferrules on the wire ends.

Table i.10 Wire Gauges

Terminal	Screw Size	Tightening Torque N•m (lb. in)	Bare Wire Terminal		Ferrule-Type Terminal		Wire Type
			Recomm. wire size mm <sup>2</sup> (AWG)	Applicable wire size mm <sup>2</sup> (AWG)	Recomm. wire size mm <sup>2</sup> (AWG)	Applicable wire size mm <sup>2</sup> (AWG)	
S1-S8, SC, SN, SP	M3	0.5 to 0.6 (4.4 to 5.3)	0.75 (18)	Stranded wire: 0.2 to 1.0 (24 to 16) Solid wire: 0.2 to 1.5 (24 to 16)	0.5 (20)	0.25 to 0.5 (24 to 20)	Shielded wire, etc.
H1, H2, HC							
RP, V+, V-, A1, A2, A3, AC, 24 V							
MA, MB, MC							
M1-M6							
MP, FM, AM, AC							
DM+, DM-							
R+, R-, S+, S-, IG							

◆ Wiring the Control Circuit Terminal

This section describes the proper procedures and preparations for wiring the control terminals.

**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 circuit wiring from main circuit wiring (terminals R/L1, S/L2, T/L3, U/T1, V/T2, W/T3, p1, n1) and other high-power lines. Improper wiring practices could result in drive malfunction due to electrical interference.*

**NOTICE:** *Separate wiring for digital output terminals MA, MB, MC, and M1 to M6 from wiring to other` control circuit lines. Improper wiring practices could result in drive or equipment malfunction or nuisance trips.*

**NOTICE:** *Use a class 2 power supply when connecting to the control terminals. Improper application of peripheral devices could result in drive performance degradation due to improper power supply. Refer to NEC Article 725 Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power Limited Circuits for requirements concerning class 2 power supplies.*

**NOTICE:** *Insulate shields with tape or shrink tubing to prevent contact with other signal lines and equipment. Improper wiring practices could result in drive 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 drive or equipment malfunction or nuisance trips.*

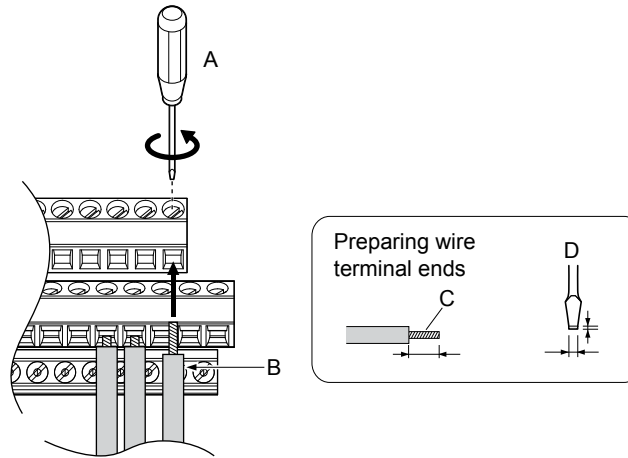


**NOTICE:** Do not tighten screws beyond the specified tightening torque. Failure to comply may result in erroneous operation, damage to the terminal block, or cause a fire.

**NOTICE:** Use shielded twisted-pair cables as indicated to prevent operating faults. Improper wiring practices could result in drive or equipment malfunction due to electrical interference.

Wire the control circuit only after terminals have been properly grounded and main circuit wiring is complete. Refer to [Terminal Board Wiring Guide on page 33](#) for details. Prepare the ends of the control circuit wiring as shown in [Figure i.20](#). Refer to [Wire Gauges on page 32](#).

Connect control wires as shown in [Figure i.18](#) and [Figure i.19](#).



A – Loosen screw to insert wire.  
B – Single wire or stranded wire

C – Avoid fraying wire strands when stripping insulation from wire. Strip length 5.5 mm.  
D – Blade depth of 0.4 mm or less  
Blade width of 2.5 mm or less

Figure i.18 Terminal Board Wiring Guide

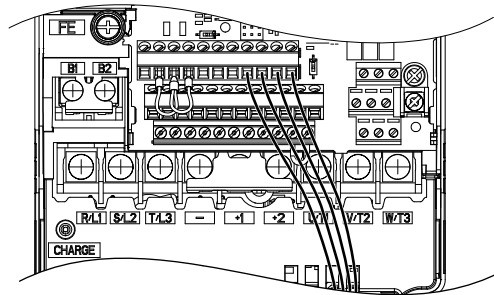
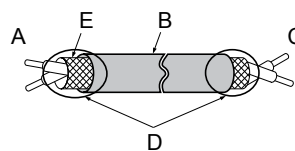


Figure i.19 Terminal Board Location Inside the Drive

When setting the frequency by analog reference from an external potentiometer, use shielded twisted-pair wires (preparing wire ends as shown in [Figure i.20](#)) and connect the shield to the ground terminal of the drive.



A – Drive side  
B – Insulation  
C – Control device side

D – Shield sheath (insulate with tape)  
E – Shield

Figure i.20 Preparing the Ends of Shielded Cables

## i.4 Electrical Installation

**NOTICE:** The analog signal wiring between the drive and the operator station or peripheral equipment should not exceed 50 meters when using an analog signal from a remote source to supply the frequency reference. Failure to comply could result in poor system performance.

### ◆ Sinking/Sourcing Mode for Digital Inputs

Use the wire jumper between terminals SC and SP or SC and SN to select between Sink mode, Source mode or external power supply for the digital inputs S1 to S8 as shown in [Table i.11](#) (Default: Sink mode, internal power supply).

**NOTICE:** Do not short terminals SP and SN. Failure to comply will damage the drive.

**Table i.11 Digital Input Sink/Source/External Power Supply Selection**

Mode	Drive Internal Power Supply (Terminals SN and SP)	External 24 Vdc Power Supply
Sinking Mode (NPN)		
Sourcing Mode (PNP)		

### ◆ Sinking/Sourcing Mode Selection for Safe Disable Inputs

Use jumper S3 on the terminal board to select between Sink mode, Source mode or external power supply for the Safe Disable inputs H1 and H2 as shown in [Table i.12](#) (Default: Source mode, internal power supply).

Table i.12 Safe Disable Input Sink/Source/External Power Supply Selection

Mode	Drive Internal Power Supply	External 24 Vdc Power Supply
Sinking Mode		
Sourcing Mode		

### ◆ Using the Pulse Train Output

The pulse train output terminal MP can supply power or be used with an external power supply.

**NOTICE:** Connect peripheral devices in accordance with the specifications. Failure to comply may cause unexpected drive operation, and can damage the drive or connected circuits.

### ■ Using Power from the Pulse Output Terminal (Source Mode)

The high voltage level of the pulse output terminal depends on the load impedance.

Load Impedance $R_L$ (k $\Omega$ )	Output Voltage $V_{MP}$ (V) (insulated)
1.5 k $\Omega$	5 V
4 k $\Omega$	8 V
10 k $\Omega$	10 V

**Note:** The load resistance needed in order to get a certain high level voltage  $V_{MP}$  can be calculated by:  $R_L = V_{MP} \cdot 2 / (12 - V_{MP})$

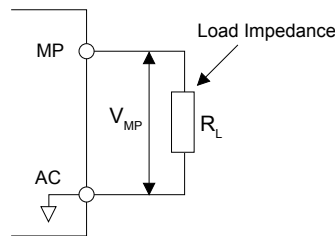


Figure i.21 Pulse Output Connection Using Internal Voltage Supply

### ■ Using External Power Supply (Sink Mode)

The high voltage level of the pulse output signal depends on the external voltage applied. The voltage must be between 12 and 15 Vdc. The load resistance must be adjusted so that the current is lower than 16 mA.

External Power Supply (V)	Load Impedance (k $\Omega$ )
12 to 15 Vdc $\pm 10\%$	1.0 k $\Omega$ or higher

## i.4 Electrical Installation

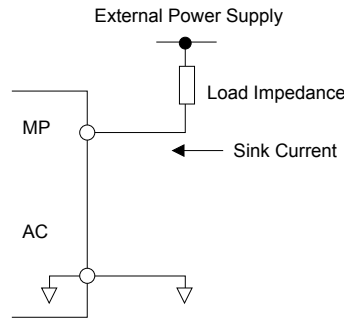


Figure i.22 Pulse Output Connection Using External Voltage Supply

### ◆ Terminal A2 Input Signal Selection

Terminal A2 can be used to input either a voltage or a current signal. Select the signal type using switch S1 as explained in [Table i.13](#). Set parameter H3-09 accordingly as shown in [Table i.14](#).

**Note:** If terminals A1 and A2 are both set for frequency bias (H3-02 = 0 and H3-10 = 0), both input values will be combined to create the frequency reference.

Table i.13 DIP Switch S1 Settings

Setting	Description
V (left position)	Voltage input (-10 to +10 V or 0 to 10 V)
I (right position)	Current input (4 to 20 mA or 0 to 20 mA); default setting

Table i.14 Parameter H3-09 Details

No.	Parameter Name	Description	Setting Range	Default Setting
H3-09	Terminal A2 signal level selection	Selects the signal level for terminal A2. 0: 0 to 10 Vdc 1: -10 to 10 Vdc 2: 4 to 20 mA 3: 0 to 20 mA	0 to 3	2

### ◆ Terminal A3 Analog/PTC Input Selection

Terminal A3 can be configured either as multi-function analog input or as PTC input for motor thermal overload protection. Use switch S4 to select the input function as described in [Table i.15](#).

Table i.15 DIP Switch S4 Settings

Setting	Description
AI (lower position) (default)	Analog input for the function selected in parameter H3-06
PTC (upper position)	PTC input. Parameter H3-06 must be set to E (PTC input)

### ◆ Terminal AM/FM Signal Selection

The signal type for terminals AM and FM can be set to either voltage or current output using jumper S5 on the terminal board as explained in [Table i.16](#). When changing the setting of jumper S5, parameters H4-07 and H4-08 must be set accordingly. The default selection is voltage output for both terminals.

Table i.16 Jumper S5 Settings

Terminal	Voltage Output	Current Output
Terminal AM		
Terminal FM		

Table i.17 Parameter H4-07 and H4-08 Details

No.	Parameter Name	Description	Setting Range	Default Setting
H4-07	Terminal AM signal level selection	0: 0 to 10 Vdc 1: -10 to 10 Vdc 2: 4 to 20 mA	0 to 2	0
H4-08	Terminal FM signal level selection			

### ◆ MEMOBUS/Modbus Termination

This drive is equipped with a built-in termination resistor for the RS-422/RS-485 communication port. DIP switch S2 enables or disabled the termination resistor as shown in [Table i.18](#). The OFF position is the default. The termination resistor should be placed to the ON position when the drive is the last in a series of slave drives.

Table i.18 MEMOBUS/Modbus Switch Settings

S2 Position	Description
ON	Internal termination resistor ON
OFF	Internal termination resistor OFF (default setting)

### ◆ Terminal DM+ and DM- Output Signal Selection

Slide switch S6 selects N.C. or N.O. as the state of the DM+ and DM- terminals for EDM output.

Table i.19 EDM Switch Settings

S2 Position	Description
N.O.	Normally open
N.C.	Normally closed (default setting)

**Note:** Refer to [Safe Disable Input Function on page 88](#) for details on EDM.

### ◆ Enable the Internal EMC Filter

**DANGER!** *Electrical Shock Hazard. Do not touch SW screw while power is applied to the drive. Failure to comply will result in death or serious injury.*

**WARNING!** *Electrical Shock Hazard. Connect the ground cable correctly. Failure to comply may result in death or serious injury.*

**NOTICE:** *When disabling the internal EMC filter, move the screws from ON to OFF and then tighten to the specified torque. Completely removing the screws or tightening the screws to an incorrect torque may cause drive failure.*

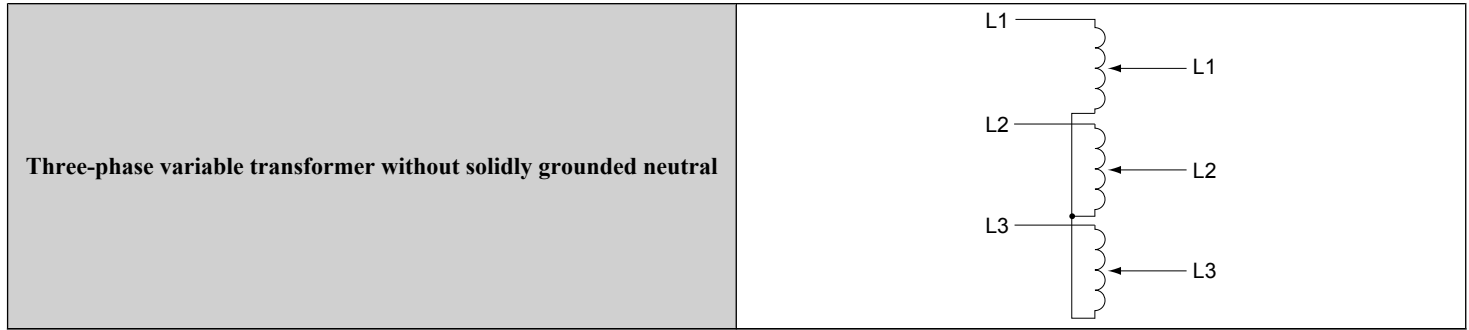
**Note:** For floating, impedance grounded, or asymmetrically grounded networks, disconnect the internal EMC filter by moving the SW screw to the OFF position.

[Table i.20](#) shows asymmetrical grounded networks. Asymmetrical networks require first moving the SW screw to disconnect the internal ground connection. (Drives are shipped with the SW screw installed at the OFF position.)

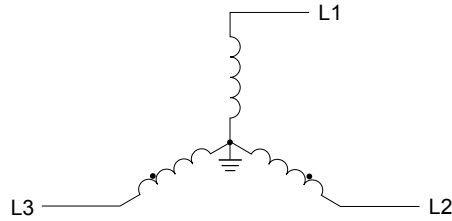
Table i.20 Asymmetrical Grounded Network

Grounded at the corner of the delta	
Grounded at the middle of the side	
Single-phase, grounded at the end point	

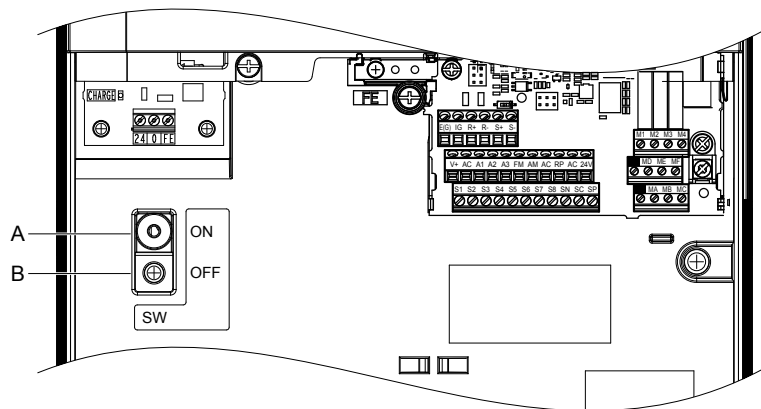
## i.4 Electrical Installation



If EMC is a concern and the network is grounded symmetrically, install the SW screw to the ON position. Installing the SW screw enables the internal EMC filter (Drives are shipped with the SW screw installed at the OFF position).



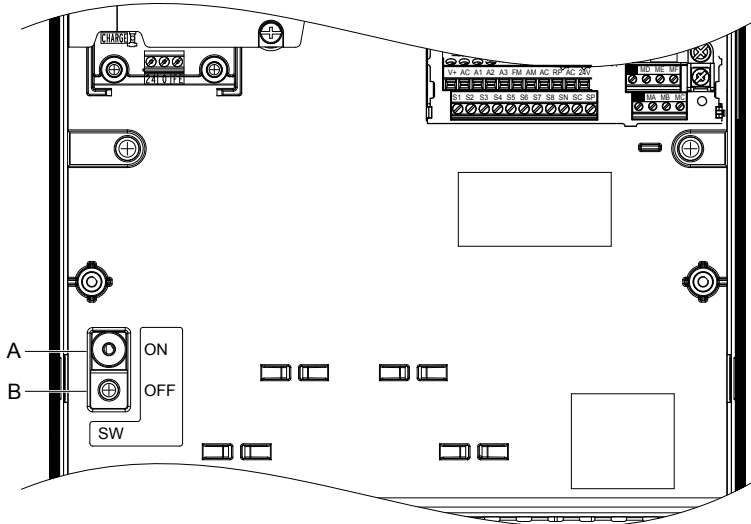
**Figure i.23 Symmetrical Grounded Network**



**A – SW (ON)**

**B – Screw (OFF)**

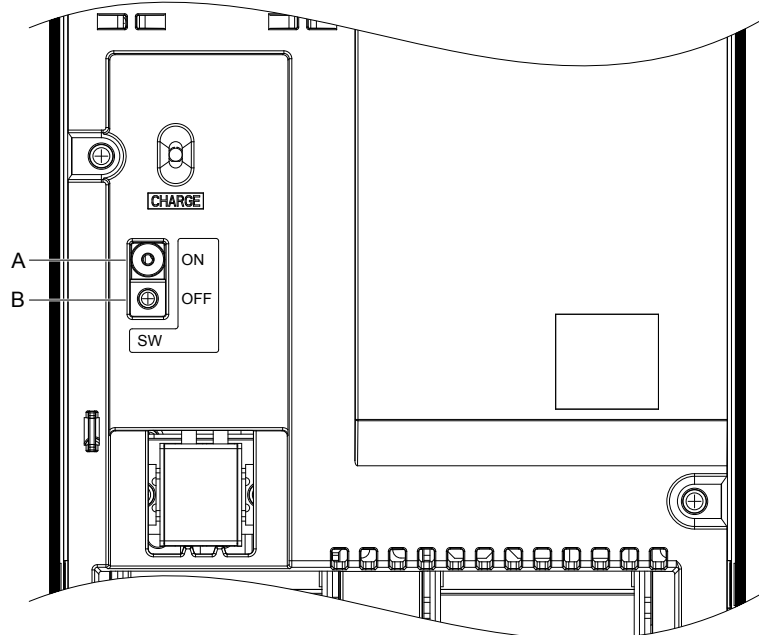
**Figure i.24 EMC Filter Switch Location**  
(Models 2E0028, 2W0028, 4E0011 to 4E0034, and 4W0011 to 4W0034)



A – SW (ON)

B – Screw (OFF)

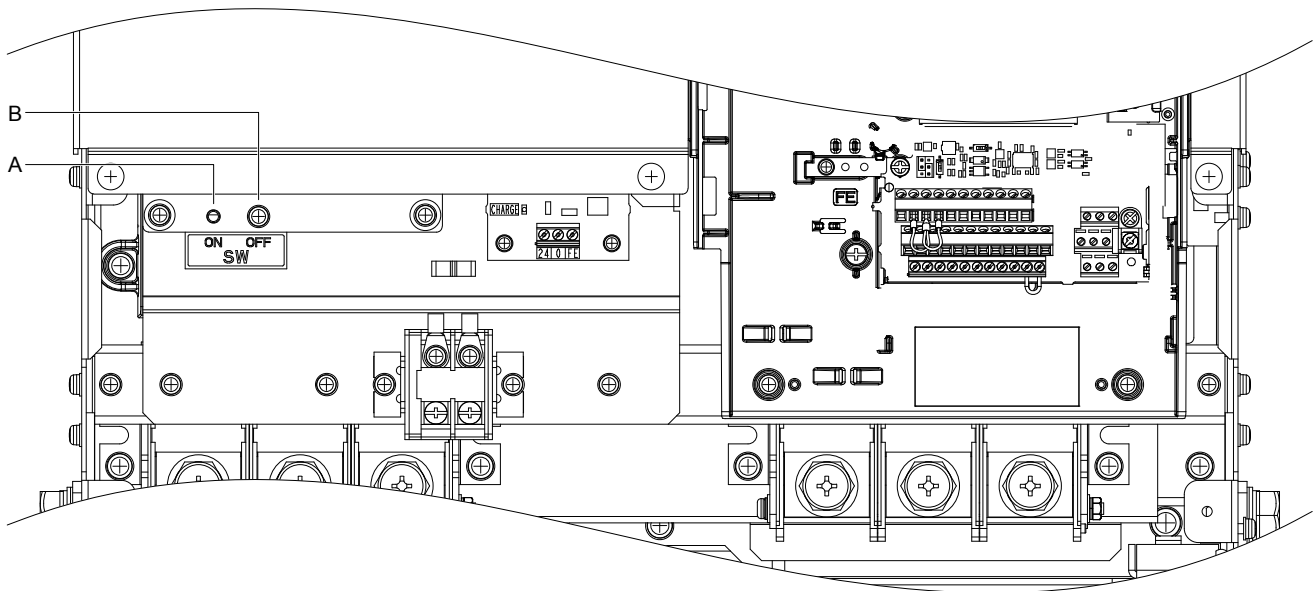
Figure i.25 EMC Filter Switch Location  
(Models 2E0042, 2W0042, 2E0054, 2W0054, 4E0040 to 4E0077, and 4W0040 to 4W0077)



A – SW (ON)

B – Screw (OFF)

Figure i.26 EMC Filter Switch Location  
(Models 2E0104, 2W0104, 2E0130, 2W0130, 4E0096, 4W0096, 4E0124, and 4W0124)

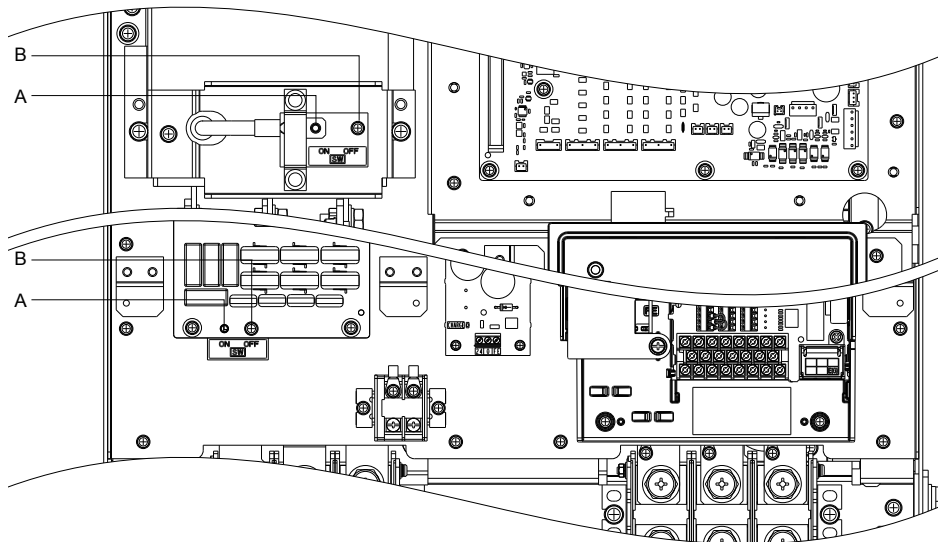


**A – SW (ON)**

**B – Screw (OFF)**

**Figure i.27 EMC Filter Switch Location**

**(Models 2E0154, 2W0154, 2E0192, 2W0192, 4E0156, 4W0156, 4E0180, and 4W0180)**



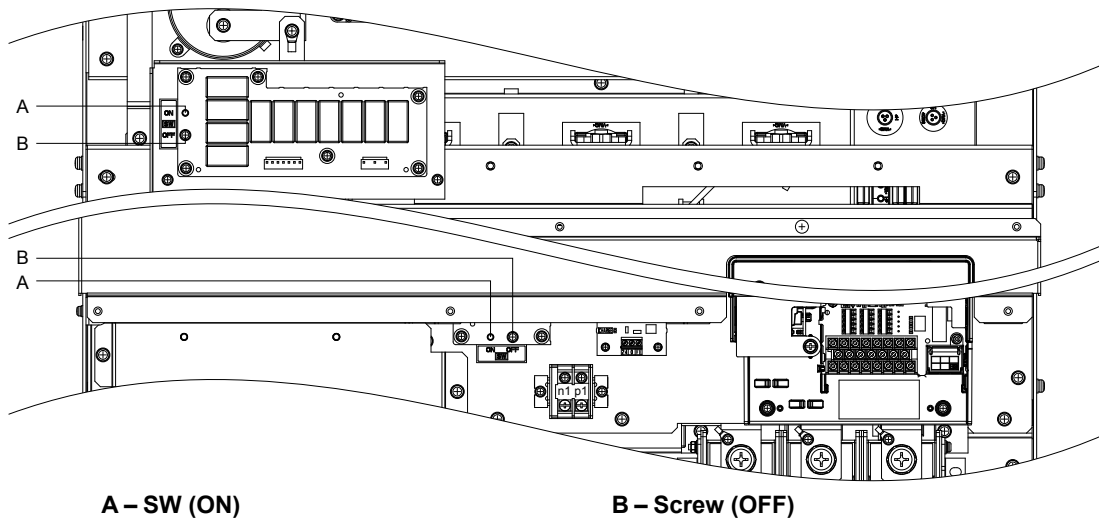
**A – SW (ON)**

**B – Screw (OFF)**

**Figure i.28 EMC Filter Switch Location**

**(Models 2E0248, 2W0248, 4EU0216, 4W0216, 4E0240, and 4W0240)**





**Figure i.29 EMC Filter Switch Location**  
(Models 4E0302 to 4E0414 and 4W0302 to 4W0414)

## ◆ Wiring Checklist

<input checked="" type="checkbox"/>	No.	Item	Page(s)
<b>Drive, Peripherals, Option Cards</b>			
<input type="checkbox"/>	1	Check drive model number to ensure receipt of correct model.	–
<input type="checkbox"/>	2	Make sure you have the correct peripheral devices.	–
<input type="checkbox"/>	3	Check the option card model number.	–
<b>Installation Area and Physical Setup</b>			
<input type="checkbox"/>	4	Ensure that the area surrounding the drive complies with specifications.	16
<b>Power Supply Voltage, Output Voltage</b>			
<input type="checkbox"/>	5	The voltage from the power supply should be within the input voltage specification range of the drive.	–
<input type="checkbox"/>	6	The voltage rating for the motor should match the drive output specifications.	13
<input type="checkbox"/>	7	Verify that the drive is properly sized to run the motor.	
<b>Main Circuit Wiring</b>			
<input type="checkbox"/>	8	Confirm proper branch circuit protection as specified by national and local codes.	–
<input type="checkbox"/>	9	Properly wire the power supply to drive terminals R/L1, S/L2, and T/L3.	23
<input type="checkbox"/>	10	Properly wire the drive and motor together. The motor lines and drive output terminals U/T1, V/T2, and W/T3 should match in order to produce the desired phase order. If the phase order is incorrect, the drive will rotate in the opposite direction.	29
<input type="checkbox"/>	11	Use 600 Vac vinyl-sheathed wire for the power supply and motor lines.	24
<input type="checkbox"/>	12	Use the correct wire gauges for the main circuit. <i>Refer to Main Circuit Wire Gauges and Tightening Torque on page 24.</i> <ul style="list-style-type: none"> <li>• Consider the amount of voltage drop when selecting wire gauges. Increase the wire gauge when the voltage drop is greater than 2% of motor rated voltage. Ensure the wire gauge is suitable for the terminal block. Use the following formula to calculate the amount of voltage drop: Line drop voltage (V) = <math>\sqrt{3} \times \text{wire resistance } (\Omega/\text{km}) \times \text{wire length (m)} \times \text{current (A)} \times 10^{-3}</math></li> <li>• If the cable between the drive and motor exceeds 50 m, adjust the carrier frequency set to C6-02 accordingly.</li> </ul>	24
<input type="checkbox"/>	13	Properly ground the drive.	29
<input type="checkbox"/>	14	Tighten control circuit and grounding terminal screws.	24

## i.4 Electrical Installation

<input checked="" type="checkbox"/>	No.	Item	Page(s)
<input type="checkbox"/>	15	Set up overload protection circuits when running multiple motors from a single drive. <div style="text-align: center; margin: 10px 0;"> </div> <p><b>Note:</b> Close MC1 – MCn before operating the drive. MC1 – MCn cannot be switched off during run.</p>	–
<input type="checkbox"/>	16	Verify that ground wiring for models UU□E□□□□ and UU□W□□□□ is correct before turning on the EMC filter switch.	–
<input type="checkbox"/>	17	Verify phase advancing capacitors, input noise filters, or GFCIs are NOT installed on the output side of the drive.	–
<b>Control Circuit Wiring</b>			
<input type="checkbox"/>	18	Use twisted-pair line for all drive control circuit wiring.	32
<input type="checkbox"/>	19	Ground the shields of shielded wiring to the GND ⊕ terminal.	32
<input type="checkbox"/>	20	For 3-Wire sequence, set parameters for multi-function contact input terminals S1 – S8, and wire control circuits.	–
<input type="checkbox"/>	21	Properly wire any option cards.	32
<input type="checkbox"/>	22	Check for any other wiring mistakes. Only use a multimeter to check wiring.	–
<input type="checkbox"/>	23	Properly fasten drive control circuit terminal screws.	24
<input type="checkbox"/>	24	Pick up all wire clippings.	–
<input type="checkbox"/>	25	Ensure that no frayed wires on the terminal block are touching other terminals or connections.	–
<input type="checkbox"/>	26	Properly separate control circuit wiring and main circuit wiring.	–
<input type="checkbox"/>	27	Analog signal line wiring should not exceed 50 m.	–
<input type="checkbox"/>	28	Safe Disable input wiring should not exceed 30 m.	88
<input type="checkbox"/>	29	Verify the logic of Safety Monitor Output Signal (DM+, DM-).	–
<input type="checkbox"/>	30	Disconnect the internal EMC filter by moving the SW screw to the OFF position for floating, impedance grounded, or asymmetrically grounded networks.	37

## i.5 Start-Up Programming and Operation

### ◆ Digital Operator Keys and Displays

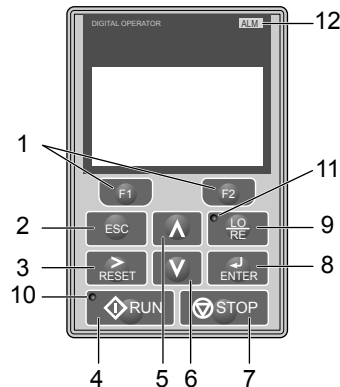


Figure i.30 Keys and Displays on the Digital Operator

No.	Display	Name	Function
1		Function Key (F1, F2)	The functions assigned to F1 and F2 vary depending on the currently displayed menu. The name of each function appears in the lower half of the display window.
2		ESC Key	<ul style="list-style-type: none"> <li>Returns to the previous display.</li> <li>Moves the cursor one space to the left.</li> <li>Pressing and holding this button will return to the Frequency Reference display.</li> </ul>
3		RESET Key	<ul style="list-style-type: none"> <li>Moves the cursor to the right.</li> <li>Resets the drive to clear a fault situation.</li> </ul>
4		RUN Key	Starts the drive in LOCAL mode.
5		Up Arrow Key	Scrolls up to display the next item, selects parameter numbers, and increments setting values.
6		Down Arrow Key	Scrolls down to display the previous item, selects parameter numbers, and decrements setting values.
7		STOP Key <1>	Stops drive operation.
8		ENTER Key	<ul style="list-style-type: none"> <li>Enters parameter values and settings.</li> <li>Selects a menu item to move between displays</li> </ul>
9		LO/RE Selection Key <2>	Switches drive control between the operator (LOCAL) and an external source (REMOTE) for the Run command and frequency reference.
10		RUN Light	Lit while the drive is operating the motor.
11		LO/RE Light	Lit while the operator is selected to run the drive (LOCAL mode).
12		ALM LED Light	Lit when the drive detects an alarm or error.

<1> The STOP key has highest priority. Pressing the STOP key will always cause the drive to stop the motor, even if a Run command is active at any external Run command source. To disable the STOP key priority, set parameter o2-02 to 0.

<2> The LO/RE key can only switch between LOCAL and REMOTE when the drive is stopped. To disable the LO/RE key to prohibit switching between LOCAL and REMOTE, set parameter o2-01 to 0.

◆ LCD Display

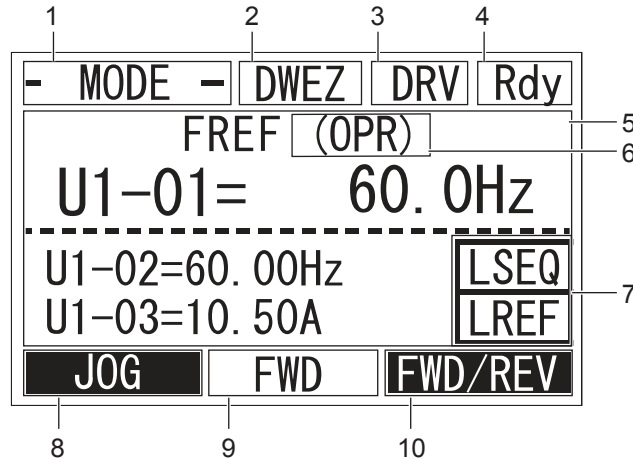






Figure i.31 LCD Display

Table i.21 Display and Contents

No.	Name	Display	Content
1	Operation Mode Menus	MODE	Displayed when in Mode Selection.
		MONITR	Displayed when in Monitor Mode.
		VERIFY	Indicates the Verify Menu.
		PRMSET	Displayed when in Parameter Setting Mode.
		A.TUNE	Displayed during Auto-Tuning.
		SETUP	Displayed when in Setup Mode.
2	DriveWorksEZ Function Selection	DWEZ	Displayed when DriveWorksEZ is being used.
3	Mode Display Area	DRV	Displayed when in Drive Mode.
		PRG	Displayed when in Programming Mode.
4	Ready	Rdy	Indicates the drive is ready to run.
5	Data Display	—	Displays specific data and operation data.
6	Frequency Reference Assignment </>	OPR	Displayed when the frequency reference is assigned to the LCD Operator.
		AI	Displayed when the frequency reference is assigned to the Analog Input of the drive.
		COM	Displayed when the frequency reference is assigned to the MEMOBUS/Modbus Communication Inputs of the drive.
		OP	Displayed when the frequency reference is assigned to an Option Unit of the drive.
		RP	Displayed when the frequency reference is assigned to the Pulse Train Input of the drive.
7	LO/RE Display </>	RSEQ	Displayed when the run command is supplied from a remote source.
		LSEQ	Displayed when the run command is supplied from the operator keypad.
		RREF	Displayed when the frequency reference is supplied from a remote source.
		LREF	Displayed when the frequency reference is supplied from the operator keypad.
8	Function Key 1 (F1)	JOG	Pressing  runs the motor at the Jog frequency.
		HELP	Pressing  displays the Help menu.
		←	Pressing  scrolls the cursor to the left.
		HOME	Pressing  returns to the top menu (Frequency Reference).
		ESC	Pressing  returns to the previous display.
9	FWD/REV	FWD	Indicates forward motor operation.
		REV	Indicates reverse motor operation.

No.	Name	Display	Content
10	Function Key 2 (F2)	FWD/REV	Pressing  switches between forward and reverse.
		DATA	Pressing  scrolls to the next display.
		→	Pressing  scrolls the cursor to the right.
		RESET	Pressing  resets the existing drive fault error.

<1> Displayed when in Frequency Reference Mode.

<2> Displayed when in Frequency Reference Mode and Monitor Mode.

◆ Menu Structure for Digital Operator

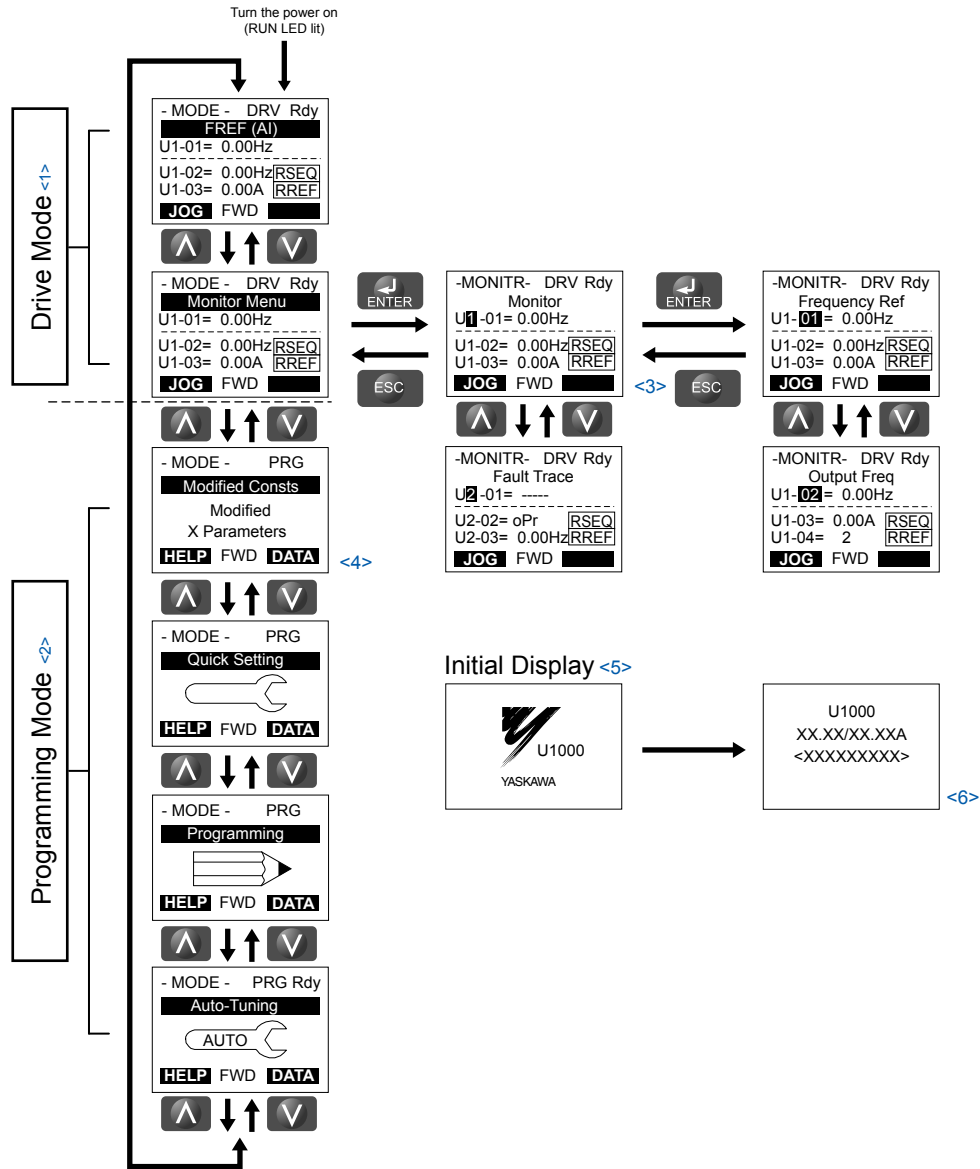


Figure i.32 Digital Operator Menu and Screen Structure

- <1> Pressing will start the motor.
- <2> Drive cannot operate motor.
- <3> Flashing characters are shown as **1**.
- <4> “X” characters are used as examples in this manual. The LCD Operator will display the actual setting values.
- <5> The Frequency Reference appears after the initial display that shows the product name.
- <6> The information that appears on the display will vary depending on the drive.

## ◆ Basic Start-Up and Motor Tuning Flowchart

The flowchart shown in *Figure i.33* describes a basic start-up sequence that varies slightly depending on the application. Use the drive default parameter settings in simple applications that do not require high precision.

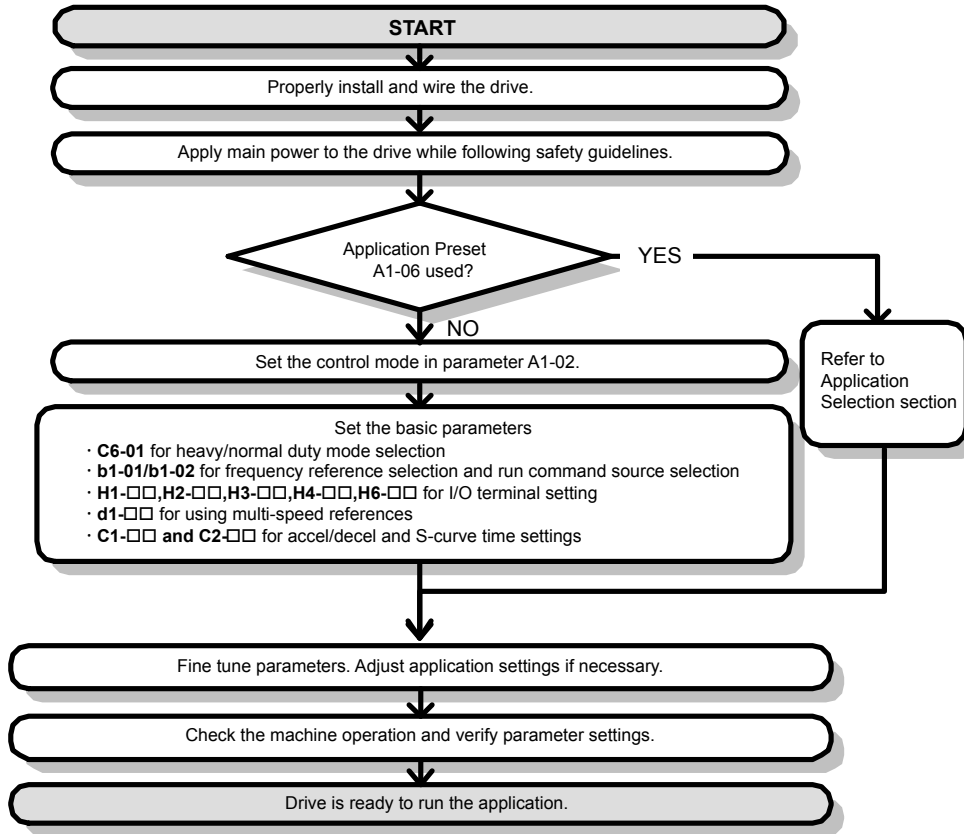


Figure i.33 Basic Start-Up

## ■ Powering Up the Drive

Review the following checklist before turning the power on.

Item to Check	Description
Power supply voltage	200 V class: Three-phase 200 to 240 Vac 50/60 Hz 400 V class: Models 4A□□□□ and 4P□□□□: Three-phase 380 to 500 Vac 50/60 Hz 400 V class: Models 4E□□□□ and 4W□□□□: Three-phase 380 to 480 Vac 50/60 Hz
	Properly wire the power supply input terminals (R/L1, S/L2, T/L3).
	Check for proper grounding of drive and motor. Use a power supply with a capacity that is equal to or greater than drive capacity.
Drive output terminals and motor terminals	Properly wire drive output terminals U/T1, V/T2, and W/T3 with motor terminals U, V, and W.
Control circuit terminals	Check control circuit terminal connections.
Drive control terminal status	Open all control circuit terminals (off).
Status of the load and connected machinery	Decouple the motor from the load.

## ◆ Basic Drive Setup Adjustments

### ■ A1-02: Control Method Selection

Selects the Control Method (also referred to as the control mode) that the drive uses to operate the motor. Parameter A1-02 determines the control mode for motor 1 when the drive is set up to run two motors.

**Note:** When changing control modes, all parameter settings depending upon the setting of A1-02 will be reset to the default.

## i.5 Start-Up Programming and Operation

No.	Parameter Name	Setting Range	Default
A1-02	Control Method Selection	0, 1, 2, 3, 5, 6, 7	0

### *Control Modes for Induction Motors (IM)*

#### **Setting 0: V/f Control for Induction Motors**

Use this mode for simple speed control and for multiple motor applications with low demands to dynamic response or speed accuracy. This control mode is also used when the motor parameters are unknown and Auto-Tuning cannot be performed. The speed control range is 1:40.

#### **Setting 1: V/f Control with PG Speed Feedback**

Use this mode for general-purpose applications that require high speed accuracy but do not require high dynamic response. This control mode is also used when the motor parameters are unknown and Auto-Tuning cannot be performed. The speed control range is 1:40.

#### **Setting 2: Open Loop Vector Control**

Use this mode for general, variable-speed applications with a speed control range of 1:200 that require precise speed control, quick torque response, and high torque at low speed without using a speed feedback signal from the motor.

#### **Setting 3: Closed Loop Vector Control**

Use this mode for general, variable-speed applications that require precise speed control down to zero speed, quick torque response or precise torque control, and a speed feedback signal from the motor. The speed control range is up to 1:1500.

### *Control Modes for Permanent Magnet Motors (SPM or IPM)*

#### **Setting 5: Open Loop Vector Control for PM**

Use this mode for general, variable-speed applications with low demands on dynamic response or speed accuracy. The drive can control an SPM or IPM motor with a speed range of 1:20 in this control mode.

#### **Setting 6: Advanced Open Loop Vector Control for PM**

Use this mode for general, variable speed applications that require precise speed control and torque limit. Set High Frequency Injection parameter n8-57 to 1 to achieve a speed control range as high as 1:100.

#### **Setting 7: Closed Loop Vector Control for PM**

Use this mode for high-precision control of a PM motor in constant torque or variable torque applications. The speed control range reaches 1:1500. A speed feedback signal is required.

### ■ A1-03: Initialize Parameters

Resets parameters to default values. After initialization, the setting for A1-03 automatically returns to 0.

No.	Parameter Name	Setting Range	Default
A1-03	Initialize Parameters	0, 1110, 2220, 3330, 5550	0

#### **Setting 1110: User Initialize**

Resets parameters to the values selected by the user as User Settings. User Settings are stored when parameter o2-03 is set to "1: Set defaults".

**Note:** User Initialization resets all parameters to a user-defined set of default values previously saved to the drive. Set parameter o2-03 to 2 to clear the user-defined default values.

#### **Setting 2220: 2-Wire Initialization**

Resets parameters to default settings with digital inputs S1 and S2 configured as Forward run and Reverse run, respectively.

#### **Setting 3330: 3-Wire Initialization**

Resets parameters to default settings with digital inputs S1, S2, and S5 configured as Run, Stop, and Forward/Reverse respectively.

#### **Setting 5550: oPE04 Reset**

An oPE04 error appears on the digital operator when a terminal block with settings saved to its built-in memory is installed in a drive that has edited parameters. Set A1-03 to 5550 to use the parameter settings saved to the terminal block memory.



## ■ b1-01: Frequency Reference Selection 1

Selects the frequency reference source 1 for the REMOTE mode.

- Note:**
1. If a Run command is input to the drive but the frequency reference entered is 0 or below the minimum frequency, the RUN indicator LED on the digital operator will light and the STOP indicator will flash. However, the RUN indicator LED will light in zero speed control when A1-02 is set to 3, 4, or 6.
  2. Press the LO/RE key to set the drive to LOCAL and use the operator keypad to enter the frequency reference.

No.	Parameter Name	Setting Range	Default
b1-01	Frequency Reference Selection 1	0 to 4	1

### Setting 0: Operator keypad

Using this setting, the frequency reference can be input by:

- switching between the multi-speed references in the d1-□□ parameters.
- entering the frequency reference on the operator keypad.

### Setting 1: Terminals (analog input terminals)

Using this setting, an analog frequency reference can be entered as a voltage or current signal from terminals A1, A2, or A3.

### Switching between Main/Auxiliary Frequency References

The frequency reference input can be switched between the analog terminals A1, A2, and A3 using multi-speed inputs. [Refer to Multi-Step Speed Selection on page 55](#) for details on using this function.

### Setting 2: MEMOBUS/Modbus Communications

This setting requires entering the frequency reference via the RS-485/RS-422 serial communications port (control terminals R+, R-, S+, S-).

### Setting 3: Option card

This setting requires entering the frequency reference via an option board plugged into connector CN5-A on the drive control board. Consult the option board manual for instructions on integrating the drive with the communication system.

- Note:** If the frequency reference source is set for Option PCB (b1-01 = 3), but an option board is not installed, an oPE05 operation error will be displayed on the digital operator and the drive will not run.

### Setting 4: Pulse Train Input

This setting requires a pulse train signal to terminal RP to provide the frequency reference. Follow the directions below to verify that the pulse signal is working properly.

### Verifying the Pulse Train is Working Properly

- Set b1-01 to 4 and set H6-01 to 0.
- Set the H6-02 to the pulse train frequency value that equals 100% of the frequency reference.
- Enter a pulse train signal to terminal RP and check for the correct frequency reference on the display.

## ■ b1-02: Run Command Selection 1

Determines the Run command source 1 in the REMOTE mode.

No.	Parameter Name	Setting Range	Default
b1-02	Run Command Selection 1	0 to 3	1

### Setting 0: Operator

This setting requires entering the Run command via the digital operator RUN key and also illuminates the LO/RE indicator on the digital operator.

### Setting 1: Control Circuit Terminal

This setting requires entering the Run command via the digital input terminals using one of following sequences:

- 2-Wire sequence 1:  
Setting A1-03 to 2220 initializes the drive and presets terminals S1 and S2 to FWD/Stop and REV/Stop. These are the default settings of the drive.
- 2-Wire sequence 2:  
Two inputs (Start/Stop-FWD/REV).
- 3-Wire sequence:

## i.5 Start-Up Programming and Operation

Setting A1-03 to 3330 initializes the drive and presets terminals S1, S2, and S5 to Start, Stop, and FWD/REV.

### Setting 2: MEMOBUS/Modbus Communications

This setting requires entering the Run command via serial communications by connecting the RS-485/RS-422 serial communication cable to control terminals R+, R-, S+, and S- on the removable terminal block.

### Setting 3: Option Card

This setting requires entering the Run command via the communication option board by plugging a communication option board into the CN5-A port on the control PCB. Refer to the option board manual for instructions on integrating the drive into the communication system.

**Note:** If b1-02 is set to 3, but an option board is not installed in CN5-A, an oPE05 operation error will be displayed on the digital operator and the drive will not run.

## ■ b1-03: Stopping Method Selection

Selects how the drive stops the motor when the Run command is removed or when a Stop command is entered.

No.	Parameter Name	Setting Range	Default
b1-03	Stopping Method Selection	0 to 3 <f>	0

<f> The setting range is 0, 1, or 3 in CLV, OLV/PM, AOLV/PM, and CLV/PM.

### Setting 0: Ramp to Stop

When the Run command is removed, the drive will decelerate the motor to stop. The deceleration rate is determined by the active deceleration time. The default deceleration time is set to parameter C1-02.

When the output frequency falls below the level set in parameter b2-01, the drive will start DC injection or Zero Speed Control depending on the selected control mode. .

#### V/f, V/f w/PG and OLV (A1-02 = 0, 1, 2)

For these control modes, parameter b2-01 sets the starting frequency for DC Injection Braking at Stop. When the output frequency falls below the setting of b2-01, DC Injection Braking is enabled for the time set in parameter b2-04.

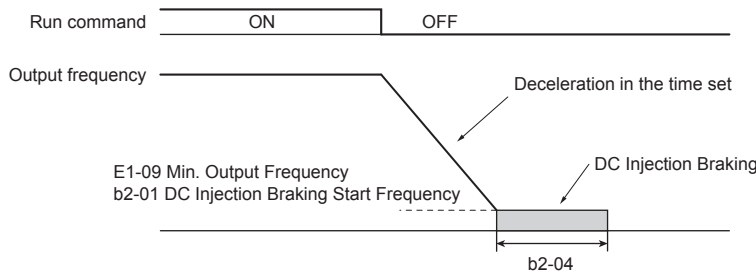


Figure i.34 DC Injection Braking at Stop for V/f, V/f w/PG, and OLV

**Note:** If b2-01 is set to a smaller value than E1-09 (Minimum Output Frequency), then DC Injection Braking will begin when the frequency falls to the E1-09 value.

#### OLV/PM and AOLV/PM (A1-02 = 5, 6)

When the output frequency falls below the setting of b2-01, drive output is shut down, and DC Injection Braking is performed for the time set in b2-04.

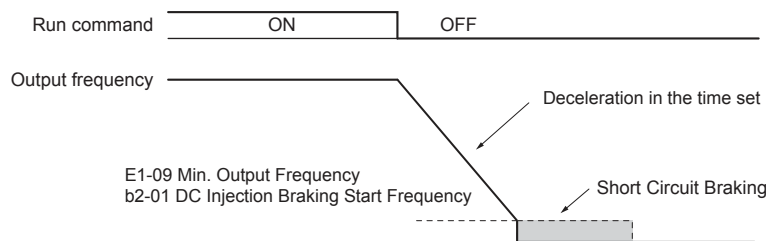


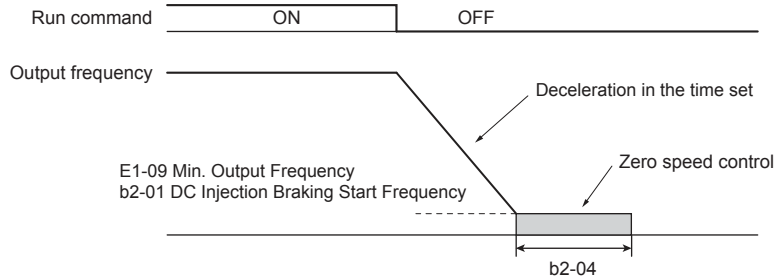
Figure i.35 Coast to Stop (OLV/PM and AOLV/PM)

**Note:** If b2-01 is set to a smaller value than E1-09 (Minimum Output Frequency), then DC Injection Braking will begin when the frequency falls to the E1-09 value.

The drive will not perform short-circuit braking when  $b2-01 = E1-09 = 0$  Hz.

**CLV and CLV/PM (A1-02 = 3, 7)**

For these control modes, parameter b2-01 sets the starting frequency for Zero Speed Control (not position lock) at Stop. When the output frequency falls below the setting of b2-01, Zero Speed Control is enabled for the time set in parameter b2-04.

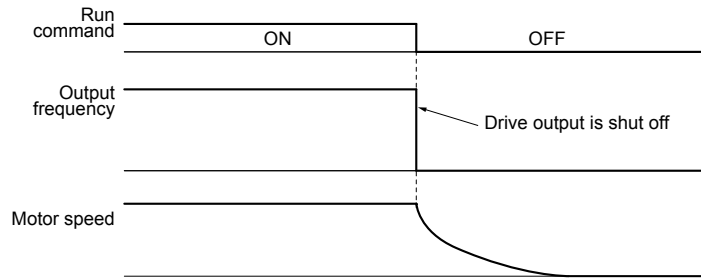


**Figure i.36 Zero Speed Control at Stop in CLV and CLV/PM**

**Note:** If b2-01 is set to lower than E1-09 (Minimum Output Frequency), then Zero Speed Control begins at the frequency set to E1-09.

**Setting 1: Coast to Stop**

When the Run command is removed, the drive will shut off its output and the motor will coast (uncontrolled deceleration) to stop. The stopping time is determined by the inertia and the friction in the driven system.



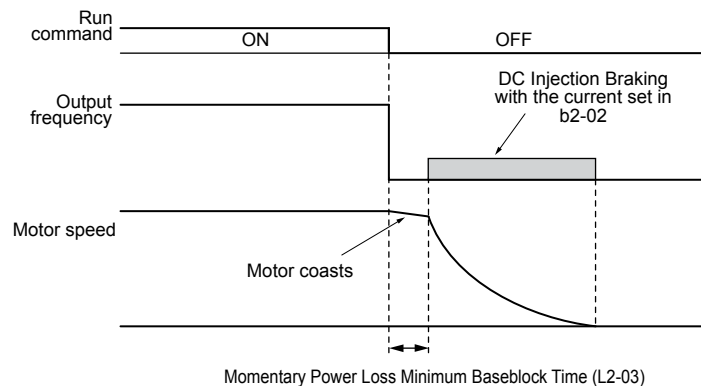
**Figure i.37 Coast to Stop**

**Note:** After a stop is initiated, any subsequent Run command entered will be ignored until the momentary power loss minimum baseblock time (L2-03) has expired. Do not enter Run command until it has come to a complete stop. Use DC Injection at Start or Speed Search to restart the motor before it has completely stopped.

**Setting 2: DC Injection Braking to Stop**

When the Run command is removed, the drive will enter baseblock (turn off its output) for the momentary power loss minimum baseblock time (L2-03). When the minimum baseblock time has expired, the drive will inject the amount DC Injection Braking is set in parameter b2-02 into the motor windings to brake the motor. The stopping time in DC Injection Braking to Stop is significantly faster compared to Coast to Stop.

**Note:** This function is not available in CLV (A1-02 = 3) or in control modes for PM motors (A1-02 = 5, 6, 7).

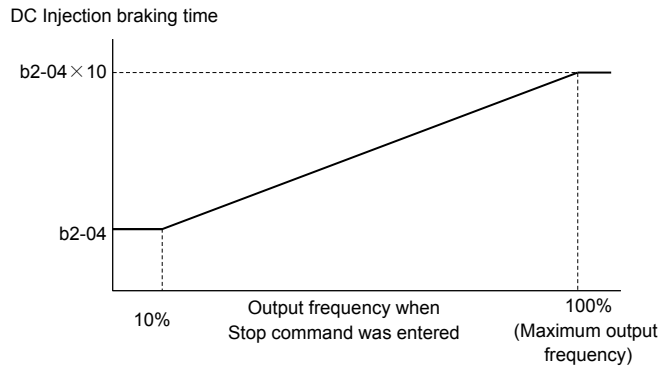


**Figure i.38 DC Injection Braking to Stop**

## i.5 Start-Up Programming and Operation

DC Injection Braking time is determined by the value set to b2-04 and the output frequency at the time the Run command is removed. It can be calculated by:

$$\text{DC Injection brake time} = \frac{(b2-04) \times 10 \times \text{Output frequency}}{\text{Max. output frequency (E1-04)}}$$

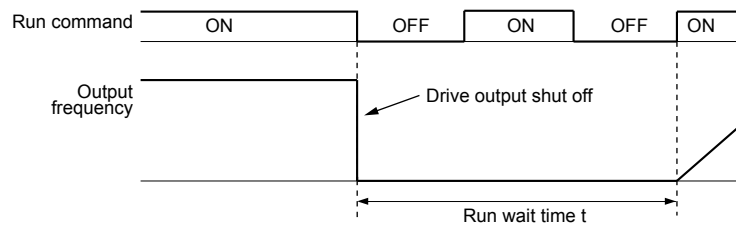


**Figure i.39 DC Injection Braking Time Depending on Output Frequency**

**Note:** If an overcurrent (oC) fault occurs during DC Injection Braking to Stop, lengthen the momentary power loss minimum baseblock time (L2-03) until the fault no longer occurs.

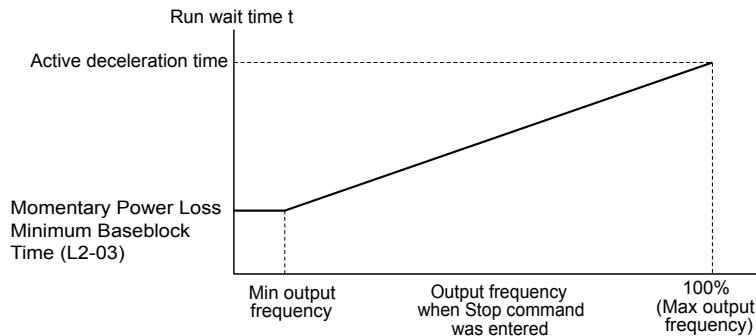
### Setting 3: Coast to Stop with Timer

When the Run command is removed, the drive will turn off its output and the motor will coast to stop. The drive will not start if a Run command is input before the time  $t$  (C1-02) has expired. Cycle the Run command that was activated during time  $t$  after  $t$  has expired to start the drive.



**Figure i.40 Coast to Stop with Timer**

The wait time  $t$  is determined by the output frequency when the Run command is removed and by the active deceleration time.



**Figure i.41 Run Wait Time Depending on Output Frequency**

### ■ b1-04: Reverse Operation Selection

Enables and disables Reverse operation. For some applications, reverse motor rotation is not appropriate and may cause problems (e.g., air handling units, pumps, etc.).

No.	Parameter Name	Setting Range	Default
b1-04	Reverse Operation Selection	0, 1	0

**Setting 0: Reverse operation enabled**

Possible to operate the motor in both forward and reverse directions.

**Setting 1: Reverse operation disabled**

Drive disregards a Reverse run command or a negative frequency reference.

■ **C1-01 to C1-08: Accel, Decel Times 1 to 4**

Four different sets of acceleration and deceleration times can be set in the drive by digital inputs, motor selection, or switched automatically.

Acceleration time parameters always set the time to accelerate from 0 Hz to the maximum output frequency (E1-04). Deceleration time parameters always set the time to decelerate from maximum output frequency to 0 Hz. C1-01 and C1-02 are the default active accel/decel settings.

No.	Parameter Name	Setting Range	Default
C1-01	Acceleration Time 1	0.0 to 6000.0 s <I>	10.0 s
C1-02	Deceleration Time 1		
C1-03	Acceleration Time 2		
C1-04	Deceleration Time 2		
C1-05	Acceleration Time 3 (Motor 2 Accel Time 1)		
C1-06	Deceleration Time 3 (Motor 2 Decel Time 1)		
C1-07	Acceleration Time 4 (Motor 2 Accel Time 2)		
C1-08	Deceleration Time 4 (Motor 2 Decel Time 2)		

<I> The setting range for the acceleration and deceleration times is determined by the accel/decel time setting units in C1-10. For example, if the time is set in units of 0.01 s (C1-10 = 0), the setting range becomes 0.00 to 600.00 s.

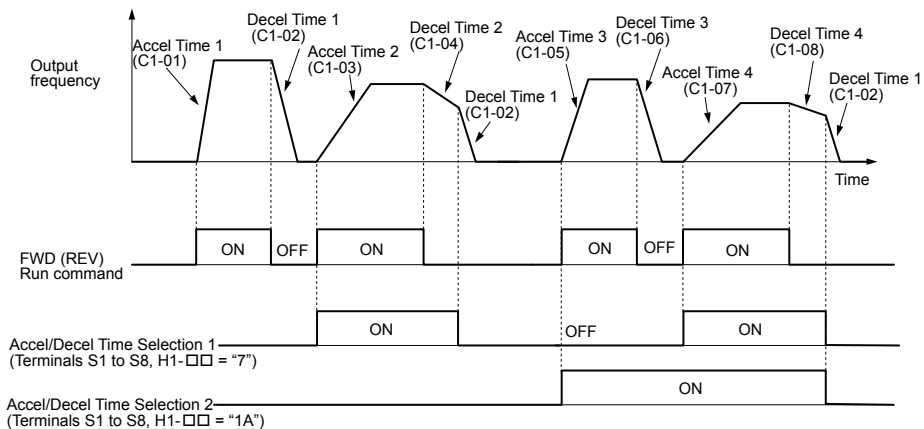
**Switching Acceleration Times by Digital Input**

Accel/decel times 1 are active by default if no input is set. Activate accel/decel times 2, 3, and 4 by digital inputs (H1-□□ = 7 and 1A) as explained in [Table i.22](#).

**Table i.22 Accel/Decel Time Selection by Digital Input**

Accel/Decel Time Sel. 1 H1-□□ = 7	Accel/Decel Time Sel. 2 H1-□□ = 1A	Active Times	
		Acceleration	Deceleration
0	0	C1-01	C1-02
1	0	C1-03	C1-04
0	1	C1-05	C1-06
1	1	C1-07	C1-08

[Figure i.42](#) shows an operation example for changing accel/decel. times. The example below requires that the stopping method be set for “Ramp to stop” (b1-03 = 0).



**Figure i.42 Timing Diagram of Accel/Decel Time Change**

## i.5 Start-Up Programming and Operation

### Switching Acceleration and Deceleration Times by Motor Selection

When switching between motor 1 and 2 using a digital input (H1-□□ = 16), parameters C1-01 to C1-04 become accel/decel times 1 and 2 for motor 1, while C1-05 to C1-08 become accel/decel times 1 and 2 for motor 2. Accel/decel times 1 and 2 can be switched for each motor using a digital inputs set to H1-□□ = 7 like shown in [Table i.23](#).

- Note:**
1. The motor 2 selection function cannot be used with PM motors.
  2. Attempting to use the digital input setting “Accel/Decel time 2 selection” (H1-□□ = 1A) together with motor 1/2 switching triggers an oPE03 error, indicating contradictory multifunction input settings.

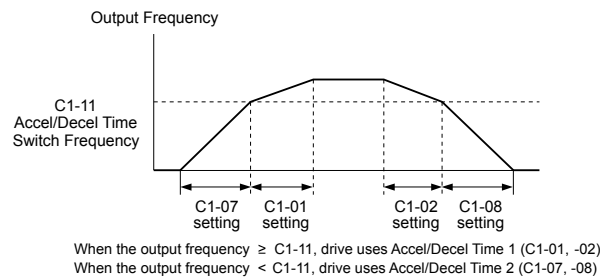
**Table i.23 Motor Switching and Accel/Decel Time Combinations**

Accel/Decel Time 1 (H1-□□ = 7)	Motor 1 Selected (Terminal set to H1-□□ = 16 OFF)		Motor 2 Selected (Terminal set to H1-□□ = 16 ON)	
	Accel	Decel	Accel	Decel
Open	C1-01	C1-02	C1-05	C1-06
Closed	C1-03	C1-04	C1-07	C1-08

### Switching Accel/Decel Times by a Frequency Level

The drive can switch between different acceleration and deceleration times automatically. The drive will switch from accel/decel time 4 in C1-07 and C1-08 to the default accel/decel time in C1-01 and C1-02 (C1-05 and C1-06 for motor 2) when the output frequency exceeds the frequency level set to parameter C1-11. When the frequency falls below this level, the accel/decel times are switched back. [Figure i.43](#) shows an operation example.

- Note:** Acceleration and deceleration times selected by digital inputs have priority over the automatic switching by the frequency level set to C1-11. For example, if accel/decel time 2 is selected, the drive will use only accel/decel time 2; it will not switch from accel/decel time 4 to the selected one.



**Figure i.43 Accel/Decel Time Switching Frequency**

## ■ C6-01: Drive Duty Mode Selection

The drive has two different duty modes from which to select based on the load characteristics. The drive rated current, overload capacity, and maximum output frequency will change depending upon the duty mode selection. Use parameter C6-01 to select Heavy Duty (HD) or Normal Duty (ND) for the application. Refer to the U1000 Technical Manual for details.

No.	Parameter Name	Setting Range	Default
C6-01	Duty Mode Selection	0, 1	1 (ND)

**Table i.24 Differences between Heavy Duty and Normal Duty**

Characteristics	Heavy Duty Rating (HD)	Normal Duty Rating (ND)
C6-01	0	1
Performance		
Application	Use Heavy Duty Rating for applications requiring a high overload tolerance with constant load torque, such as extruders and conveyors.	Use Normal Duty Rating for applications in which the torque requirements drop along with the speed, such as fans and pumps where a high overload tolerance is not required.
Overload capability (oL2)	150% of drive rated Heavy Duty current for 60 s	120% of drive rated Normal Duty current for 60 s

Characteristics	Heavy Duty Rating (HD)	Normal Duty Rating (ND)
Stall Prevention during Acceleration (L3-02)	150%	120%
Stall Prevention during Run (L3-06)	150%	120%
Default Carrier Frequency	4 kHz	4 kHz

**Note:** Changing the Duty Mode selection automatically changes the maximum size motor that the drive can run, sets the E2-□□ parameters to appropriate values (E4-□□ for motor 2), and recalculates parameter settings determined by motor capacity (e.g., b8-04, L2-03, n5-02, C5-17, and C5-37).

### ■ C7-60: Output Voltage Limit Mode Selection

Sets the mode to limit the output voltage.

Set this parameter to 0 (Harmonic suppression priority mode) to give priority to harmonic suppression. The maximum output voltage is automatically limited to suppress harmonics.

Set this parameter to 1 (High output voltage mode) to give priority to the output voltage over harmonic suppression. The effectiveness of harmonic suppression will be reduced because the maximum output voltage will be used.

No.	Parameter Name	Setting Range	Default
C7-60	Output Voltage Limit Mode Selection	0, 1	1

**Setting 0: Harmonic Suppression Priority Mode**

**Setting 1: High Output Voltage Mode**

### ■ d1-01 to d1-17: Frequency Reference 1 to 16 and Jog Frequency Reference

The drive lets the user switch between up to 17 preset frequency references during run (including the Jog reference) through the digital input terminals. The drive uses the acceleration and deceleration times that have been selected when switching between each frequency reference.

The Jog frequency overrides all other frequency references and must be selected by a separate digital input.

The multi-speed references 1, 2, and 3 can be provided by analog inputs.

No.	Parameter Name	Setting Range	Default
d1-01 to d1-16	Frequency Reference 1 to 16	0.00 to 400.00 Hz <1> <2>	0.00 Hz <2>
d1-17	Jog Frequency Reference	0.00 to 400.00 Hz <1> <2>	6.00 Hz <2>

<1> The upper limit is determined by the maximum output frequency (E1-04) and upper limit for the frequency reference (d2-01).

<2> Setting units are determined by parameter o1-03. The default is “Hz” (o1-03 = 0) in V/f, V/f w/PG, OL V, CLV, and OL V/PM control modes. The default for AOLV/PM and CLV/PM control modes expresses the frequency reference as a percentage (o1-03 = 1).

### Multi-Step Speed Selection

To use several speed references for a multi-step speed sequence, set the H1-□□ parameters to 3, 4, 5, and 32. To assign the Jog reference to a digital input, set H1-□□ to 6.

Notes on using analog inputs as Multi-Speed 1, 2, and 3:

#### • Multi-Step Speed 1

Set b1-01 to 1 to set terminal A1 analog input to Multi-Step Speed 1.

Set b1-01 to 0 when setting d1-01, Frequency Reference 1, to Multi-Step Speed 1.

#### • Multi-Step Speed 2

Set H3-06, Terminal A3 Function Selection, to 2 (Auxiliary Frequency Reference 1) when setting terminal A3 analog input to Multi-Step Speed 2.

Set H3-06 to F (Through mode) when setting d1-02, Frequency Reference 2, to Multi-Step Speed 2.

#### • Multi-Step Speed 3

Set H3-10, Terminal A2 Function Selection, to 3 (Auxiliary Frequency Reference 2) when setting terminal A2 analog input to Multi-Step Speed 3.

Set H3-10 to F (Through mode) when setting d1-03, Frequency Reference 3, to Multi-Step Speed 3.

Set H3-09 to 0 and set DIP switch S1 on the control circuit terminal board to V (voltage) when inputting 0 to 10 V to terminal A2 analog input.

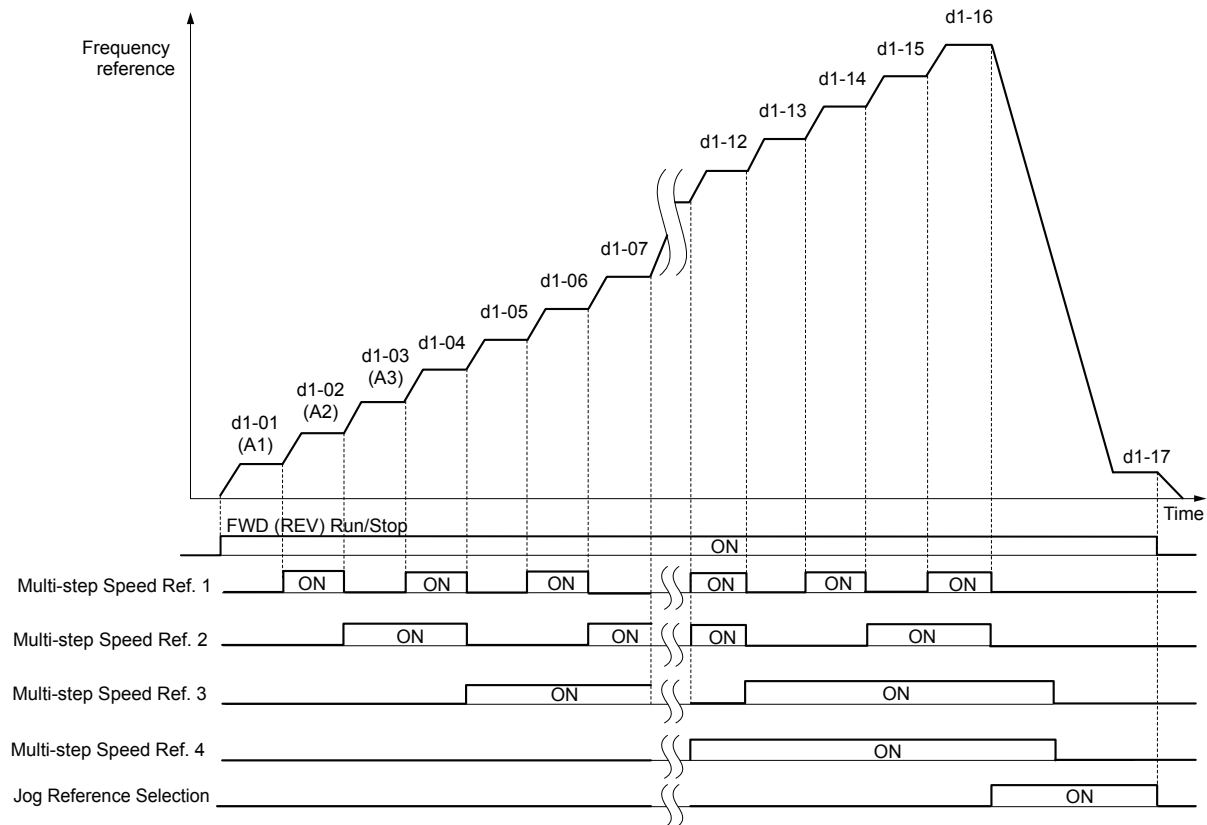
Select the different speed references as shown in [Table i.25](#). [Figure i.44](#) illustrates the multi-step speed selection.

## i.5 Start-Up Programming and Operation

**Table i.25 Multi-Step Speed Reference and Terminal Switch Combinations**

Reference	Multi-Step Speed Reference H1-□□ = 3	Multi-Step Speed Reference 2 H1-□□ = 4	Multi-Step Speed Reference 3 H1-□□ = 5	Multi-Step Speed Reference 4 H1-□□ = 32	Jog Reference Selection H1-□□ = 6
Frequency Reference 1 (set in b1-01)	OFF	OFF	OFF	OFF	OFF
Frequency Reference 2 (d1-02 or input terminal A1, A2, A3)	ON	OFF	OFF	OFF	OFF
Frequency Reference 3 (d1-03 or input terminal A1, A2, A3)	OFF	ON	OFF	OFF	OFF
Frequency Reference 4 (d1-04)	ON	ON	OFF	OFF	OFF
Frequency Reference 5 (d1-05)	OFF	OFF	ON	OFF	OFF
Frequency Reference 6 (d1-06)	ON	OFF	ON	OFF	OFF
Frequency Reference 7 (d1-07)	OFF	ON	ON	OFF	OFF
Frequency Reference 8 (d1-08)	ON	ON	ON	OFF	OFF
Frequency Reference 9 (d1-09)	OFF	OFF	OFF	ON	OFF
Frequency Reference 10 (d1-10)	ON	OFF	OFF	ON	OFF
Frequency Reference 11 (d1-11)	OFF	ON	OFF	ON	OFF
Frequency Reference 12 (d1-12)	ON	ON	OFF	ON	OFF
Frequency Reference 13 (d1-13)	OFF	OFF	ON	ON	OFF
Frequency Reference 14 (d1-14)	ON	OFF	ON	ON	OFF
Frequency Reference 15 (d1-15)	OFF	ON	ON	ON	OFF
Frequency Reference 16 (d1-16)	ON	ON	ON	ON	OFF
Jog Frequency Reference (d1-17) <1>	-	-	-	-	ON

<1> The Jog frequency overrides all other frequency references.



**Figure i.44 Preset Reference Timing Diagram**



### ■ d2-01: Frequency Reference Upper Limit

Sets the maximum frequency reference as a percentage of the maximum output frequency. This limit applies to all frequency references.

Even if the frequency reference is set to a higher value, the drive internal frequency reference will not exceed this value.

No.	Parameter Name	Setting Range	Default
d2-01	Frequency Reference Upper Limit	0.0 to 110.0%	100.0%

### ■ d2-02: Frequency Reference Lower Limit

Sets the minimum frequency reference as a percentage of the maximum output frequency. This limit applies to all frequency references.

If a lower reference than this value is entered, the drive will run at the limit set to d2-02. If the drive is started with a lower reference than d2-02, it will accelerate up to d2-02.

No.	Parameter Name	Setting Range	Default
d2-02	Frequency Reference Lower Limit	0.0 to 110.0%	0.0%

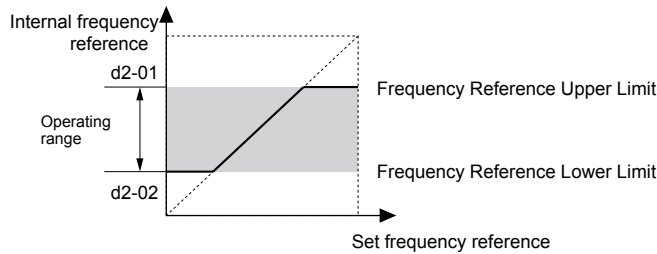


Figure i.45 Frequency Reference: Upper and Lower Limits

### ■ E2-01: Motor Rated Current

Provides motor control, protects the motor, and calculates torque limits. Set E2-01 to the full load amps (FLA) stamped on the motor nameplate. If Auto-Tuning completes successfully, the value entered to T1-04 will automatically be saved to E2-01.

No.	Parameter Name	Setting Range	Default
E2-01	Motor Rated Current	10% to 150% of the drive rated current </>	Determined by C6-01 and o2-04

- <1> Display is in the following units:  
 2□0028, 2□0042, and 4□0011 to 4□0027: 0.01 A units.  
 2□0054 to 2□0248 and 4□0034 to 4□0414: 0.1 A units.

**Note:** An oPE02 error will occur if the motor rated current in E2-01 is set lower than the motor no-load current in E2-03. Set E2-03 correctly to prevent this error.

### ■ H1-01 to H1-08: Functions for Terminals S1 to S8

No.	Parameter Name	Setting Range	Default
H1-01	Multi-Function Digital Input Terminal S1 Function Selection	1 to 9F	40 (F) </> : Forward Run Command (2-Wire sequence)
H1-02	Multi-Function Digital Input Terminal S2 Function Selection	1 to 9F	41 (F) </> : Reverse Run Command (2-Wire sequence)
H1-03	Multi-Function Digital Input Terminal S3 Function Selection	0 to 9F	24: External Fault (N.O., always detected, coast to stop)
H1-04	Multi-Function Digital Input Terminal S4 Function Selection	0 to 9F	14: Fault Reset
H1-05	Multi-Function Digital Input Terminal S5 Function Selection	0 to 9F	3 (0) </> : Multi-Step Speed Reference 1
H1-06	Multi-Function Digital Input Terminal S6 Function Selection	0 to 9F	4 (3) </> : Multi-Step Speed Reference 2
H1-07	Multi-Function Digital Input Terminal S7 Function Selection	0 to 9F	6 (4) </> : Jog Reference Selection
H1-08	Multi-Function Digital Input Terminal S8 Function Selection	0 to 9F	8: External Baseblock Command

- <1> Number appearing in parenthesis is the default value after performing a 3-Wire initialization (A1-03 = 3330).

## i.5 Start-Up Programming and Operation

### ■ H2-01 to H2-03: Terminal M1-M2, M3-M4, and M5-M6 Function Selection

No.	Parameter Name	Setting Range	Default
H2-01	Terminal M1-M2 Function Selection (relay)	0 to 192	0: During run
H2-02	Terminal M3-M4 Function Selection (relay)	0 to 192	1: Zero Speed
H2-03	Terminal M5-M6 Function Selection (relay)	0 to 192	2: Speed agree 1

### ■ L1-01: Motor Overload Protection Selection

The drive has an electronic overload protection function that estimates the motor overload level based on output current, output frequency, thermal motor characteristics, and time. When the drive detects a motor overload an oL1 fault is triggered and the drive output shuts off.

L1-01 sets the overload protection function characteristics according to the motor being used.

No.	Name	Setting Range	Default
L1-01	Motor Overload Protection Selection	0 to 6	Determined by A1-02

- Note:**
- When the motor protection function is enabled (L1-01 ≠ 0), an oL1 alarm can be output through one of the multi-function outputs by setting H2-01 to 1F. The output closes when the motor overload level reaches 90% of the oL1 detection level.
  - Set L1-01 to a value between 1 and 6 when running a single motor from the drive to select a method to protect the motor from overheat. An external thermal relay is not necessary.

#### Setting 0: Disabled (Motor Overload Protection Is Not Provided)

Use this setting if no motor overheat protection is desired or if multiple motors are connected to a single drive. If multiple motors are connected to a single drive, install a thermal relay for each motor as shown in [Figure i.46](#).

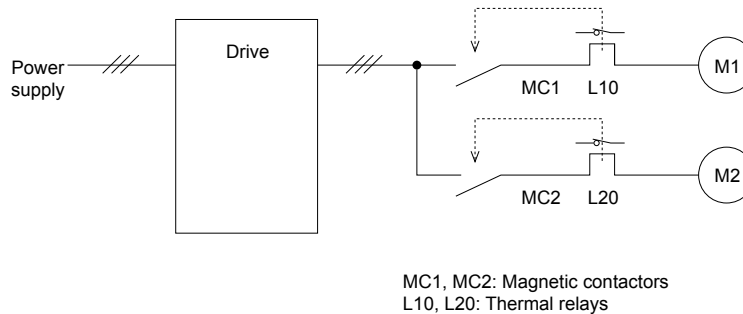


Figure i.46 Example of Protection Circuit Design for Multiple Motors

**NOTICE:** Thermal protection cannot be provided when running multi-motors simultaneously with the same drive, or when using motors with a relatively high current rating compared to other standard motors (such as a submersible motor). Failure to comply could result in motor damage. Disable the electronic overload protection of the drive (L1-01 = "0: Disabled") and protect each motor with individual motor thermal overloads.

**Note:** Close MC1 and MC2 before operating the drive. MC1 and MC2 cannot be switched off during run.

#### Setting 1: General-purpose Motor (Standard Self-cooled)

Because the motor is self-cooled, the overload tolerance drops when the motor speed is lowered. The drive appropriately adjusts the electrothermal trigger point according to the motor overload characteristics, protecting the motor from overheat throughout the entire speed range.

Overload Tolerance	Cooling Ability	Overload Characteristics
<p>Torque (%)</p> <p>Speed (%)</p> <p>60 s</p> <p>Rated Speed=100% Speed</p> <p>A: Max. speed for 200LJ and above B: Max. speed for 160MJ to 180 LJ C: Max. speed for 132MJ and below</p> <p>Continuous</p> <p>05 33 100 120 167 200</p>	<p>Motor designed to operate from line power. Motor cooling is most effective when running at rated base frequency (check the motor nameplate or specifications).</p>	<p>Continuous operation at less than line power frequency with 100% load can trigger a motor overload fault (oL1). A fault is output and the motor will coast to stop.</p>

**Setting 2: Drive Dedicated Motor (Speed Range for Constant Torque: 1:10)**

Use this setting when operating a drive duty motor that allows constant torque in a speed range of 1:10. The drive will allow the motor to run with 100% load from 10% up to 100% speed. Running at slower speeds with full load can trigger an overload fault.

Overload Tolerance	Cooling Ability	Overload Characteristics
<p>Rated Speed=100% Speed                      A: Max. speed for 200LJ and above                      B: Max. speed for 160MJ to 180 LJ                      C: Max. speed for 132MJ and below</p>	<p>Motor is designed to effectively cool itself even at low speeds.</p>	<p>Continuous operation with 100% load from 6 Hz to E1-06, Motor Base Frequency.</p>

**Setting 3: Vector Motor (Speed Range for Constant Torque: 1:100)**

Use this setting when operating a drive-dedicated motor that allows constant torque in a speed range of 1:100. This motor type is allowed to run with 100% load from 1% up to 100% speed. Running slower speeds with full load can trigger an overload fault.

Overload Tolerance	Cooling Ability	Overload Characteristics
<p>Rated Speed=100% Speed                      A: Max. speed for 200LJ and above                      B: Max. speed for 160MJ to 180 LJ                      C: Max. speed for 132MJ and below</p>	<p>Motor is designed to effectively cool itself at speeds near 0.6 Hz.</p>	<p>Continuous operation with 100% load from 0.6 Hz to E1-06, Motor Base Frequency.                      Continuous operation below 0.6 Hz may cause an oL1 or oL2 fault.</p>

**Setting 4: PM Derated Torque Motor**

Use this setting when operating a PM motor. PM motors for derated torque have a self-cooling design and the overload tolerance drops as the motor slows. Electronic thermal overload is triggered in accordance with the motor overload characteristics, providing overheat protection across the entire speed range.

Overload Tolerance	Cooling Ability	Overload Characteristics
	<p>Motor is designed to produce 100% torque at base speed. Built with effective cooling capabilities.</p>	<p>Reaching 100% when operating at below the base frequency causes a motor overload fault (oL1). The drive fault output closes and the motor coasts to stop.</p>

**Setting 5: Constant Torque PM Motors (Constant Torque Range of 1:500)**

Sets necessary protection characteristics when driving a PM with constant torque. These motors allow for a speed control from 0.2% to 100% when operating with 100% load. Slower speeds with 100% load will trigger overload.

## i.5 Start-Up Programming and Operation

Overload Tolerance	Cooling Ability	Overload Characteristics
	<p>Motor is designed to effectively cool itself at speeds near 0.2% of base speed.</p>	<p>Continuous operation with 100% load from 0.2% to 100% of base speed.</p>

### Setting 6: General-purpose Motor

**Note:** General-purpose motors are designed with a base speed that operates at line frequency (50/60 Hz depending on geographic region).

Because the motor is self-cooled, the overload tolerance drops when the motor speed is lowered. The drive appropriately adjusts the electrothermal trigger point according to the motor overload characteristics and protects the motor from overheat throughout the entire speed range.

Overload Tolerance	Cooling Ability	Overload Characteristics
	<p>Motor designed to operate from line power. Motor cooling is most effective when running at rated base frequency (check the motor nameplate or specifications)</p>	<p>Continuous operation at less than line power frequency with 100% load can trigger a motor overload fault (oL1). A fault is output and the motor will coast to stop.</p>

### ■ L1-02: Motor Overload Protection Time

Sets the time for the drive to shut down on motor overload (oL1) when the motor is running with excessive current. Enter the time the motor can withstand operating at 150% current after previously running at 100% current (hot motor overload condition). There is normally no need to change this parameter from the default value.

No.	Name	Setting Range	Default
L1-02	Motor Overload Protection Time	0.1 to 5.0 minutes	1.0 minutes

Defaulted to operate with an allowance of 150% overload operation for one minute in a hot start after continuous operation at 100%.

**Figure i.47** illustrates an example of the electrothermal protection operation time using a general-purpose motor operating at the value of E1-06, Motor Base Speed, with L1-02 set to one minute.

Motor overload protection operates in the area between a cold start and a hot start.

- Cold start: Characteristics of motor protection operation time in response to an overload situation that was suddenly reached when starting a stationary motor.
- Hot start: Characteristics of motor protection operation time in response to an overload situation that occurred while the motor was operating continuously at or below its rated current.

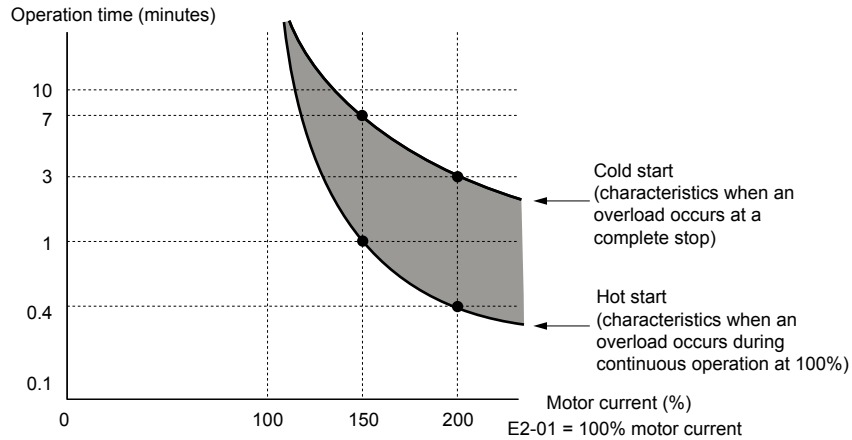


Figure i.47 Protection Operation Time for General Purpose Motors at the Rated Output Frequency

### Motor Protection Using a Positive Temperature Coefficient (PTC) Thermistor

Connect a motor PTC can to an analog input of the drive for motor overhear protection.

The motor overhear alarm level triggers an oH3 alarm and the drive continues the operation selected in L1-03. The overhear fault level triggers an oH4 fault, outputs a fault signal, and the drive stops the motor using the stop method selected in L1-04.

Connect the PTC between terminals AC and A3 and set jumper S4 on the terminal board to “PTC” as shown in [Figure i.48](#). Set H3-05 to 0 and H3-06 to E.

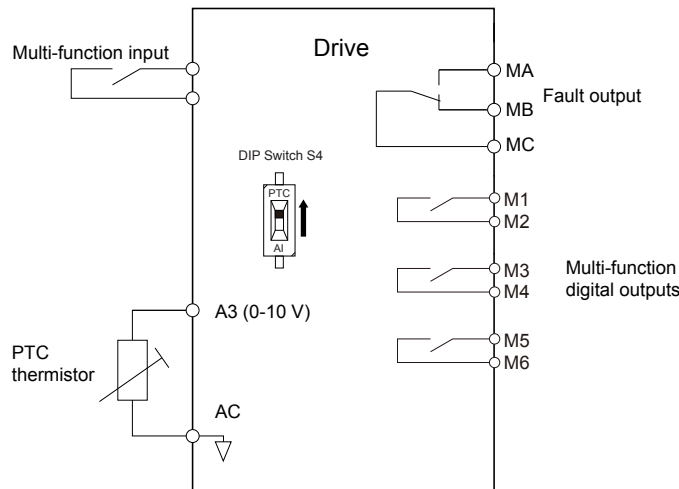
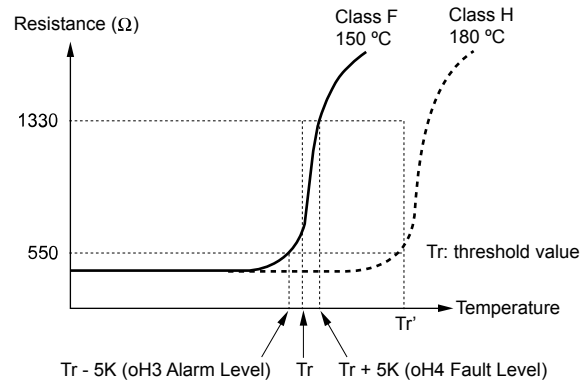


Figure i.48 Connection of a Motor PTC

The PTC must exhibit the characteristics shown in [Figure i.49](#) in one motor phase. The motor overload protection of the drive expects 3 of these PTCs to be connected in a series.

## i.5 Start-Up Programming and Operation



**Figure i.49 Motor PTC Characteristics**

Set up overheat detection using a PTC using parameters L1-03, L1-04, and L1-05 as explained in the following sections.

### ◆ Auto-Tuning

The drive offers different types of Auto-Tuning for induction motors and permanent magnet motors. The type of Auto-Tuning used differs further based on the control mode and other operating conditions. Refer to the tables below to select the type of Auto-Tuning that best suits the application.

**Note:** The drive will only show Auto-Tuning parameters that are valid for the control mode that has been set in A1-02. If the control mode is for an induction motor, the Auto-Tuning parameters for PM motors will not be available. If the control mode is for a PM motor, the Auto-Tuning parameters for induction motors will not be available. Inertia Tuning and ASR Gain Tuning parameters and setting options will be visible only when the drive is set for operation with CLV or CLV/PM.

**Table i.26 Types of Auto-Tuning for Induction Motors**

Type	Setting	Application Conditions and Benefits	Control Mode			
			V/f	V/f w/PG	OLV	CLV
<b>Rotational Auto-Tuning</b>	T1-01 = 0	<ul style="list-style-type: none"> <li>Motor can be decoupled from the load and rotate freely while Auto-Tuning is performed.</li> <li>Motor and load cannot be decoupled but the motor load is below 30%.</li> <li>Rotational Auto-Tuning gives the most accurate results, and is recommended if possible.</li> </ul>	–	–	YES	YES
<b>Stationary Auto-Tuning 2</b>	T1-01 = 4	<ul style="list-style-type: none"> <li>Motor and load cannot be decoupled and the load is higher than 30%.</li> <li>A motor test report is available. After entering the no-load current and the rated slip, the drive calculates and sets all other motor-related parameters.</li> </ul>	–	–	YES	YES
<b>Stationary Auto-Tuning for Line-to-Line Resistance</b>	T1-01 = 2	<ul style="list-style-type: none"> <li>The drive is used in V/f Control and other Auto-Tuning selections are not possible.</li> <li>Drive and motor capacities differ.</li> <li>Tunes the drive after the cable between the drive and motor has been replaced with a cable over 50 m long. Assumes Auto-Tuning has already been performed.</li> <li>Should not be used for any vector control modes unless the motor cable has changed.</li> </ul>	YES	YES	YES	YES
<b>Rotational Auto-Tuning for V/f Control</b>	T1-01 = 3	<ul style="list-style-type: none"> <li>Recommended for applications using Speed Estimation Speed Search or using the Energy Saving function in V/f Control.</li> <li>Assumes motor can rotate while Auto-Tuning is executed. Increases accuracy for certain functions like torque compensation, slip compensation, Energy Saving, and Speed Search.</li> </ul>	YES	YES	–	–
<b>Stationary Auto-Tuning 3</b>	T1-01 = 5	<ul style="list-style-type: none"> <li>A motor test report listing motor data is not available.</li> <li>Motor can be driven with a normal duty mode after Auto-Tuning. A trial run is performed after Auto-Tuning to automatically calculate motor parameters needed for vector control.</li> </ul>	–	–	YES	YES

## ■ T1-01: Auto-Tuning Mode Selection

Sets the type of Auto-Tuning to be used.

No.	Name	Setting Range	Default
T1-01	Auto-Tuning Mode Selection	V/f: 2, 3 V/f w/P.G: 2, 3 OLV: 0, 2, 4, 5 CLV: 0, 2, 4, 5, 8, 9	V/f, V/f w/P.G: 2 OLV, CLV: 0

**Setting 0: Rotational Auto-Tuning**

**Setting 2: Stationary Auto-Tuning for Line-to-Line Resistance**

**Setting 3: Rotational Auto-Tuning for V/f Control**

**Setting 4: Stationary Auto-Tuning 2**

**Setting 5: Stationary Auto-Tuning 3**

**Setting 8: Inertia Tuning**

**Setting 9: ASR Gain Auto-Tuning**

**Note:** Inertia Tuning and ASR Gain Auto-Tuning may not be available when gears are between the machine and the motor shaft.

## ◆ No-Load Operation Test Run

This section explains how to operate the drive with the motor decoupled from the load during a test run.

### ■ Before Starting the Motor

Check the following items before operation:

- Ensure the area around the motor is safe.
- Ensure external emergency stop circuitry is working properly and other safety precautions have been taken.

### ■ During Operation

Check the following items during operation:

- The motor should rotate smoothly (i.e., no abnormal noise or oscillation).
- The motor should accelerate and decelerate smoothly.

## ◆ Test Run with the Load Connected

After performing a no-load test run, connect the motor and proceed to run the motor and load together.

### ■ Checklist Before Operation

- The motor should rotate in the proper direction.
- The motor should accelerate and decelerate smoothly.

### ■ Operating the Motor under Loaded Conditions

Test run the application similarly to the no-load test procedure when connecting the machinery to the motor.

- Monitor U1-03 for overcurrent during operation.
- If the application permits running the load in the reverse direction, change the motor direction and the frequency reference while watching for abnormal motor oscillation or vibration.
- Correct any problems that occur with hunting, oscillation, and other control-related issues.

## ◆ Test Run Checklist

Review the checklist before performing a test run. Check each item that applies.

<input checked="" type="checkbox"/>	No.	Checklist	Page
<input type="checkbox"/>	1	Thoroughly read the manual before performing a test run.	–
<input type="checkbox"/>	2	Turn the power on.	–

Check the items that correspond to the control mode being used.

## i.5 Start-Up Programming and Operation

**WARNING! Sudden Movement Hazard.** Ensure start/stop and safety circuits are wired properly and in the correct state before energizing the drive. Failure to comply could result in death or serious injury from moving equipment. When programmed for 3-Wire control, a momentary closure on terminal S1 may cause the drive to start.

<input checked="" type="checkbox"/>	No.	Checklist	Page
V/f Control (A1-02 = 0) and V/f Control with PG (A1-02 = 1)			
<input type="checkbox"/>	3	Select the best V/f pattern according to the application and motor characteristics.	–
<input type="checkbox"/>	4	Perform Rotational Auto-Tuning for V/f Control if using Energy Saving functions.	–
V/f Control with PG (A1-02 = 1)			
<input type="checkbox"/>	5	Set up the PG feedback parameters correctly and make sure the encoder pulse counting direction is correct.	–
<input type="checkbox"/>	6	Set the proportional gain for ASR speed control to C5-01 and the integral time to C5-02.	–
Open Loop Vector Control (A1-02 = 2) or Closed Loop Vector Control (A1-02 = 3)			
<input type="checkbox"/>	7	Decouple motor shafts and machines when performing Rotational Auto-Tuning.	–
<input type="checkbox"/>	8	Set the Auto-Tuning mode to T1-01 (0 for Rotational Auto-Tuning).	–
<input type="checkbox"/>	9	Enter the following data according to the information listed on the motor nameplate: <ul style="list-style-type: none"> <li>• Motor rated power to T1-02 (kW)</li> <li>• Motor rated voltage to T1-03 (V)</li> <li>• Motor rated current to T1-04 (A)</li> <li>• Motor base frequency to T1-05 (Hz)</li> <li>• Number of motor poles to T1-06</li> <li>• Motor base speed to T1-07 (r/min)</li> </ul>	–
Closed Loop Vector Control (A1-02 = 3)			
<input type="checkbox"/>	10	Set F1-01 and F1-05.	–
<input type="checkbox"/>	11	Set ASR proportional gain to C5-01 and ASR integral time to C5-02. Perform ASR Tuning if possible.	–
Open Loop Vector Control for PM (A1-02 = 5)			
<input type="checkbox"/>	12	Perform Auto-Tuning as described.	–
Advanced Open Loop Vector Control for PM (A1-02 = 6)			
<input type="checkbox"/>	13	Perform Auto-Tuning as described.	–
<input type="checkbox"/>	14	Set the proportional gain for ASR speed control to C5-01 and the integral time to C5-02.	–
Closed Loop Vector Control for PM (A1-02 = 7)			
<input type="checkbox"/>	15	Set PM motor data using E5-□□ parameters.	–
<input type="checkbox"/>	16	Set ASR proportional gain to C5-01 and ASR integral time to C5-02. Perform ASR Tuning if possible.	–
<input type="checkbox"/>	17	Set F1-01 and F1-05.	–
<input type="checkbox"/>	18	Set the offset between the rotor magnetic axis and the Z-pulse of the connected encoder to E5-11.	–
<input type="checkbox"/>	19	The <b>DRV</b> should be displayed on the LCD operator after giving a Run command.	–
<input type="checkbox"/>	20	To give Run command and frequency reference from the digital operator, press “LO/RE” key to set to LOCAL.	–
<input type="checkbox"/>	21	If the motor rotates in the opposite direction during test run, switch two of U/T1, V/T2, W/T3, or change b1-14.	–
<input type="checkbox"/>	22	In accordance with load condition, set Heavy Duty or Normal Duty mode using parameter C6-01. Normal Duty is the default setting.	–
<input type="checkbox"/>	23	Set motor rated current (E2-01, E4-01, E5-03) and motor protection (L1-01) values for motor thermal protection.	–
<input type="checkbox"/>	24	Set the drive for REMOTE when control circuit terminals provide the Run command and frequency reference.	–
<input type="checkbox"/>	25	If the control circuit terminals should supply the frequency reference, select the correct voltage input signal level (0 to 10 V or -10 to +10 V) or the correct current input signal level (4 to 20 mA or 0 to 20 mA).	49
<input type="checkbox"/>	26	Apply the proper signal level to terminals A1 and A3 (0 to 10 V or -10 to +10 V).	–
<input type="checkbox"/>	27	Apply the proper signal level (-10 to +10 V, 4 to 20 mA or 0 to 20 mA) to terminal A2.	–
<input type="checkbox"/>	28	When current input is used, switch the built-in DIP switch S1 from the V-side to I-side. Set the level for current signal used to H3-09 (set “2” for 4 to 20 mA, or “3” for 0 to 20 mA).	–
<input type="checkbox"/>	29	Set DIP Switch S1 on the drive to “I” when using terminal A2 as current input. Set DIP Switch S1 on the drive to “V” when using terminal A2 as voltage input.	–



<input checked="" type="checkbox"/>	No.	Checklist	Page
<input type="checkbox"/>	30	<p>If an analog input supplies the frequency reference, make sure it produces the desired frequency reference. Make the following adjustments if the drive does not operate as expected:</p> <p>Gain adjustment: Set the maximum voltage/current signal and adjust the analog input gain (H3-03 for A1, H3-11 for A2, H3-07 for A3) until the frequency reference value reaches the desired value.</p> <p>Bias adjustment: Set the minimum voltage/current signal and adjust the analog input bias (H3-04 for A1, H3-12 for A2, H3-08 for A3) until the frequency reference value reaches the desired minimum value.</p>	-

## i.6 Troubleshooting

### NOTICE

Refer to the U1000 Industrial MATRIX Drive Technical Manual SIEP C710636 04 for information on **Troubleshooting** and complete product instructions necessary for proper installation, set-up, troubleshooting and maintenance.

The U1000 Industrial MATRIX Drive Technical Manual is posted on the Yaskawa website, [www.yaskawa.com](http://www.yaskawa.com).

## ◆ Fault Detection

### ■ Fault Displays

Digital Operator Display		Fault Name
R <sub>OV</sub>	Aov	Power Supply Overvoltage
		The input power supply voltage became equal to or higher than the Input Power Supply Overvoltage Detection Level. 200 V Class: Approximately 277 Vrms 400 V Class: Approximately 630 Vrms
R <sub>UV</sub>	AUv	Power Supply Undervoltage
		The input power supply voltage became equal to or lower than the Input Power Supply Undervoltage Detection Level (L2-21). 200 V Class: Approximately 150 Vrms 400 V Class: Approximately 300 Vrms
b <sub>US</sub>	bUS	Option Communication Error
		<ul style="list-style-type: none"> <li>The connection was lost after establishing initial communication.</li> <li>Only detected when the run command frequency reference is assigned to an option card.</li> </ul>
[CE]	CE	MEMOBUS/Modbus Communication Error
		Control data was not received for the CE detection time set to H5-09.
[CF]	CF	Control Fault
		The torque limit was reached continuously for three seconds after the Stop command was input and deceleration was not possible in OLV Control.
[CoF]	CoF	Current Offset Fault
		Drive starts operation while the current-detection circuit failure, or the induced voltage remains in the motor (coasting and after rapid deceleration).
[CPF00 to CPF03, CPF07, CPF08, CPF11 to CPF14, CPF16 to CPF24, CPF26 to CPF35, CPF40 to CPF45 <1> <2> <3>	CPF00 to CPF03, CPF07, CPF08, CPF11 to CPF14, CPF16 to CPF24, CPF26 to CPF35, CPF40 to CPF45	Control Circuit Error
[CPF06]	CPF06	Control Circuit Error
		There is an error in the data saved to EEPROM.
[CPF25]	CPF25	Terminal Board Not Connected
dE <sub>v</sub>	dEv	Speed Deviation (for Control Mode with PG)
		The deviation between the speed detection value for the pulse input and the speed reference after speed agreement was reached exceeded the setting value of F1-10 for the time set in F1-11 or longer when the Operation Selection at Deviation was set to continue operation (F1-04 = 3).
do <sub>H</sub>	doH	Damping Resistor Overheat
		The temperature of the built-in damping resistor exceeded the set value.
dv <sub>1</sub>	dv1	Z Pulse Fault (CLV/PM control mode only)
		The motor turned one full rotation without the Z Pulse being detected.
dv <sub>2</sub>	dv2	Z Pulse Noise Fault Detection (CLV/PM control mode only)
		The Z Pulse is out of phase by more than 5 degrees for 10 consecutive revolutions.
dv <sub>3</sub>	dv3	Inversion Detection (CLV/PM control mode only)
		The torque reference and acceleration are in opposite directions and the speed reference and actual motor speed differ by more than 30% for the number of times set to F1-18.

Digital Operator Display		Fault Name
dv4	dv4	Inversion Prevention Detection (CLV/PM control mode only)
		<p>Pulses indicate that the motor is rotating in the opposite direction of the speed reference. Set the number of pulses to trigger inverse detection to F1-19.</p> <p><b>Note:</b> Set F1-19 to 0 to disable inverse detection in applications where the motor may rotate in the opposite direction of the speed reference.</p>
dv7	dv7	Initial Polarity Estimation Timeout
dWAL	dWAL	DriveWorksEZ Fault
dWFL	dWFL	
dWF1	dWF1	EEPROM Memory DriveWorksEZ Data Error
		There is an error in the DriveWorksEZ program saved to EEPROM.
E5	E5	MECHATROLINK Watchdog Timer Error
		The watchdog timed out.
EF0	EF0	Option Card External Fault
		An external fault condition is present.
EF1	EF1	External Fault (input terminal S1)
		External fault at multi-function input terminal S1.
EF2	EF2	External Fault (input terminal S2)
		External fault at multi-function input terminal S2.
EF3	EF3	External Fault (input terminal S3)
		External fault at multi-function input terminal S3.
EF4	EF4	External Fault (input terminal S4)
		External fault at multi-function input terminal S4.
EF5	EF5	External Fault (input terminal S5)
		External fault at multi-function input terminal S5.
EF6	EF6	External Fault (input terminal S6)
		External fault at multi-function input terminal S6.
EF7	EF7	External Fault (input terminal S7)
		External fault at multi-function input terminal S7.
EF8	EF8	External Fault (input terminal S8)
		External fault at multi-function input terminal S8.
Err	Err	EEPROM Write Error
		Data cannot be written to the EEPROM
FAn	FAn	Fan fault
		Fan failure
FbH	FbH	Excessive PID Feedback
		PID feedback input is greater than the level set to b5-36 for longer than the time set to b5-37. Set b5-12 to 2 or 5 to enable fault detection.
FbL	FbL	PID Feedback Loss
		PID feedback loss detection is programmed to trigger a fault (b5-12 = 2 or 5) and the PID feedback level is below the detection level set to b5-13 for longer than the time set to b5-14.
Fdv	Fdv	Power Supply Frequency Fault
		The input power supply frequency exceeded the allowable frequency fluctuation.
GF	GF	Ground Fault
		<ul style="list-style-type: none"> <li>A current short to ground exceeded 50% of rated current on the output side of the drive.</li> <li>Setting L8-09 to 1 enables ground fault detection.</li> </ul>
LF	LF	Output Phase Loss
		<ul style="list-style-type: none"> <li>Phase loss on the output side of the drive.</li> <li>Setting L8-07 to 1 or 2 enables Phase Loss Detection.</li> </ul>

## i.6 Troubleshooting

Digital Operator Display		Fault Name
LF2	LF2	Output Current Imbalance One or more of the phases in the output current are lost.
LSo ↔	LSo	LSo Fault Pull-out has been detected at low speed.
nSE	nSE	Node Setup Error A terminal assigned to the node setup function closed during run.
oC	oC	Overcurrent Drive sensors detected an output current greater than the specified overcurrent level.
oFA00	oFA00	Option Card Connection Error at Option Port CN5-A Option compatibility error
oFA01	oFA01	Option Card Fault at Option Port CN5-A Option not properly connected
oFA02 to oFA06	oFA02 to oFA06	Option Card Error Occurred at Option Port CN5-A
oFA10, oFA11	oFA10, oFA11	
oFA12 to oFA17	oFA12 to oFA17	Option Card Connection Error (CN5-A)
oFA30 to oFA43	oFA30 to oFA43	Communication Option Card Connection Error (CN5-A)
oFb00	oFb00	Option Card Fault at Option Port CN5-B Option compatibility error
oFb01	oFb01	Option Card Fault at Option Port CN5-B Option not properly connected
oFb02	oFb02	Option Card Fault at Option Port CN5-B Same type of option card is currently connected
oFb03 to oFb11	oFb03 to oFb11	Option card error occurred at Option Port CN5-B
oFb12 to oFb17	oFb12 to oFb17	
oFC00	oFC00	Option Card Connection Error at Option Port CN5-C Option compatibility error
oFC01	oFC01	Option Card Fault at Option Port CN5-C Option not properly connected
oFC02	oFC02	Option Card Fault at Option Port CN5-C Same type of option card is currently connected
oFC03 to oFC11	oFC03 to oFC11	Option Card Error Occurred at Option Port CN5-C
oFC12 to oFC17	oFC12 to oFC17	
oFC50 to oFC55	oFC50 to oFC55	Option Card Error Occurred at Option Port CN5-C
oH	oH	Heatsink Overheat The heatsink temperature exceeded the overheat pre-alarm level set to L8-02. The default value for L8-02 is determined by drive model selection (o2-04).
oH1	oH1	Overheat 1 (Heatsink Overheat) The heatsink temperature exceeded the drive overheat level. Overheat level is determined by drive capacity (o2-04).
oH3	oH3	Motor Overheat Alarm (PTC Input) <ul style="list-style-type: none"> <li>The motor overheat signal to analog input terminal A1, A2, or A3 exceeded the alarm detection level.</li> <li>Detection requires setting multi-function analog inputs H3-02, H3-10, or H3-06 to E.</li> </ul>
oH4	oH4	Motor Overheat Fault (PTC Input) <ul style="list-style-type: none"> <li>The motor overheat signal to analog input terminal A1, A2, or A3 exceeded the fault detection level.</li> <li>Detection requires setting multi-function analog inputs H3-02, H3-10, or H3-06 to E.</li> </ul>
oL1	oL1	Motor Overload The electronic motor overload protection tripped
oL2	oL2	Drive Overload The thermal sensor of the drive triggered overload protection.

Digital Operator Display		Fault Name
oL3	oL3	Overtorque Detection 1
		The current has exceeded the value set for Torque Detection Level 1 (L6-02) for longer than the allowable time (L6-03).
oL4	oL4	Overtorque Detection 2
		The current has exceeded the value set for Torque Detection Level 2 (L6-05) for longer than the allowable time (L6-06).
oL5	oL5	Mechanical Weakening Detection 1
		Overtorque occurred, matching the conditions specified in L6-08.
oPr	oPr	External Digital Operator Connection Fault
		The external operator has been disconnected from the drive. <b>Note:</b> An oPr fault will occur when all of the following conditions are true: • Output is interrupted when the operator is disconnected (o2-06 = 1). • The Run command is assigned to the operator (b1-02 = 0 and LOCAL has been selected).
oS	oS	Overspeed
		The motor speed feedback exceeded the F1-08 setting.
oV	oV	Control Circuit Overvoltage
		Voltage in the control circuit has exceeded the overvoltage level. • For 200 V class drives: approximately 450 V • For 400 V class drives: approximately 900 V
PGo	PGo	PG Disconnect (for any control modes using a PG option card)
		No PG pulses are received for longer than the time set to F1-14.
PGoH	PGoH	PG Hardware Fault (detected when using a PG-X3 option card)
		PG cable is not connected properly.
SCF	SCF	Safety Circuit Fault
		Safety Circuit Fault is detected.
SEr	SEr	Too Many Speed Search Restarts
		The number of Speed Search restarts exceeded the value set to b3-19.
SoH	SoH	Snubber Discharge Resistor Overheat
SrC	SrC	Phase Order Detection Fault
		The phase rotation direction for the input power supply changed.
Srr	Srr	Internal Resistance Fault
		An operation failure occurred in the snubber discharge resistor circuit.
STo	STo	Pull-Out Detection
		Motor pull out or step out has occurred. Motor has exceeded its pull-out torque.
SvE	SvE	Zero Servo Fault
		Position deviation during zero servo.
UL3	UL3	Undertorque Detection 1
		The current has fallen below the minimum value set for Torque Detection Level 1 (L6-02) for longer than the allowable time (L6-03).
UL4	UL4	Undertorque Detection 2
		The current has fallen below the minimum value set for Torque Detection Level 2 (L6-05) for longer than the allowable time (L6-06).
UL5	UL5	Mechanical Weakening Detection 2
		The operation conditions matched the conditions set to L6-08.
Uv1	Uv1	Control Circuit Undervoltage Fault
		Voltage in the control circuit fell below the detection level: • For 200 V class drives: approximately 175 V • For 400 V class drives: approximately 350 V
Uv2	Uv2	Control Power Supply Voltage Fault
		Voltage is too low for the control drive input power.
Uv3	Uv3	Undervoltage 3 (Soft-Charge Bypass Relay Fault)
		The soft-charge bypass relay failed.

## i.6 Troubleshooting

- <1> Displayed as CPF00 when occurring at drive power up. When one of the faults occurs after successfully starting the drive, the display will show CPF01.
- <2> Displayed as CPF20 when occurring at drive power up. When one of the faults occurs after successfully starting the drive, the display will show CPF21.
- <3> Fault histories are not kept when CPF00, CPF01, CPF06, CPF24, Fdv, oFA00, oFb00, oFC00, Uv1, Uv2, or Uv3 occur.
- <4> This function prevents continuous operation in reverse when using high frequency injection (n8-57 = 1) in AOLV/PM (A1-02 = 6) with a motor for which no motor code has been entered (it does not only prevent reverse operation). Set L8-93, L8-94, and L8-95 to low values within range of erroneous detection to quickly detect undesirable reverse operation.

### ◆ Alarm Detection

#### ■ Alarm Codes

An alarm is indicated by a code on the data display and the flashing ALM LED. The drive output is not necessarily switched off.

To remove an alarm, trace and remove the cause, and reset the drive by pushing the Reset key on the operator or cycle the power supply.

Refer to the Technical Manual for a complete list of causes and possible solutions.

Digital Operator Display		Alarm Name
<i>AEr</i>	AEr	Station Address Setting Error (CC-Link, CANopen, MECHATROLINK)
		Option card node address is outside of the acceptable setting range.
<i>AUv</i>	AUv	Power Supply Undervoltage
		The input power supply voltage became equal to or lower than the Input Power Supply Undervoltage Detection Level (L2-21). 200 V Class: Approximately 150 Vrms 400 V Class: Approximately 300 Vrms
<i>bb</i>	bb	Baseblock
		Drive output interrupted as indicated by an external baseblock signal.
<i>bUS</i>	bUS	Option Communication Error
		<ul style="list-style-type: none"> <li>• The connection was lost after establishing initial communication.</li> <li>• Only detected when the run command frequency reference is assigned to an option card.</li> </ul>
<i>CALL</i>	CALL	Serial Communication Transmission Error
		Communication has not yet been established.
<i>CE</i>	CE	MEMOBUS/Modbus Communication Error
		Control data was not received for the CE detection time set to H5-09.
<i>CrST</i>	CrST	Cannot Reset
<i>CyC</i>	CyC	MECHATROLINK Comm. Cycle Setting Error
		Comm. Cycle Setting Error was detected.
<i>dEv</i>	dEv	Speed Deviation (for Control Mode with PG)
		The deviation between the speed detection value for the pulse input and the speed reference after speed agreement was reached exceeded the setting value of F1-10 for the time set in F1-11 or longer when the Operation Selection at Deviation was set to continue operation (F1-04 = 3).
<i>dnE</i>	dnE	Drive Disabled
<i>doH</i>	doH	Damping Resistor Overheat
		The temperature of the built-in damping resistor exceeded the set value.
<i>EF</i>	EF	Forward/Reverse Run Command Input Error
		Both forward run and reverse run closed simultaneously for longer than 0.5 s.
<i>EF0</i>	EF0	Option Card External Fault
		An external fault condition is present.
<i>EF1</i>	EF1	External Fault (input terminal S1)
		External fault at multi-function input terminal S1.
<i>EF2</i>	EF2	External Fault (input terminal S2)
		External fault at multi-function input terminal S2.

Digital Operator Display		Alarm Name
EF3	EF3	External Fault (input terminal S3)
		External fault at multi-function input terminal S3.
EF4	EF4	External Fault (input terminal S4)
		External fault at multi-function input terminal S4.
EF5	EF5	External Fault (input terminal S5)
		External fault at multi-function input terminal S5.
EF6	EF6	External Fault (input terminal S6)
		External fault at multi-function input terminal S6.
EF7	EF7	External Fault (input terminal S7)
		External fault at multi-function input terminal S7.
EF8	EF8	External Fault (input terminal S8)
		External fault at multi-function input terminal S8.
FbH	FbH	Excessive PID Feedback
		PID feedback input is greater than the level set to b5-36 for longer than the time set to b5-37. Set b5-12 to 2 or 5 to enable fault detection.
FbL	FbL	PID Feedback Loss
		PID feedback loss detection is programmed to trigger a fault (b5-12 = 2 or 5) and the PID feedback level is below the detection level set to b5-13 for longer than the time set to b5-14.
Fdv	Fdv	Power Supply Frequency Fault
		The input power supply frequency exceeded the allowable frequency fluctuation.
Hbb	Hbb	Safe Disable Signal Input
		Both Safe Disable Input channels are open.
HbbF	HbbF	Safe Disable Signal Input
		One Safe Disable channel is open while the other channel is closed.
HCA	HCA	Current Alarm
		Drive current exceeded overcurrent warning level (150% of the rated current).
LT-1	LT-1	Cooling Fan Maintenance Time
		The cooling fan has reached its expected maintenance period and may need to be replaced. <b>Note:</b> An alarm output (H2-□□ = 10) will only be triggered if both (H2-□□ = 2F and H2-□□ = 10) are set.
LT-2	LT-2	Capacitor Maintenance Time
		The main circuit and control circuit capacitors are nearing the end of their expected performance life. <b>Note:</b> An alarm output (H2-□□ = 10) will only be triggered if H2-□□ = 2F.
LT-3	LT-3	Soft Charge Bypass Relay Maintenance Time
		The DC bus soft charge relay is nearing the end of its expected performance life. <b>Note:</b> An alarm output (H2-□□ = 10) will only be triggered if H2-□□ = 2F.
oH	oH	Heatsink Overheat
		The heatsink temperature exceeded the overheat pre-alarm level set to L8-02. The default value for L8-02 is determined by drive model selection (o2-04).
oH2	oH2	Heatsink Overheat Warning
		“Heatsink Overheat Warning” was input to a multi-function input terminal, S1 through S8 (H1-□□ = B).
oH3	oH3	Motor Overheat Alarm (PTC Input)
		<ul style="list-style-type: none"> <li>The motor overheat signal to analog input terminal A1, A2, or A3 exceeded the alarm detection level.</li> <li>Detection requires setting multi-function analog inputs H3-02, H3-10, or H3-06 to E.</li> </ul>
oL3	oL3	Overtorque Detection 1
		The current has exceeded the value set for Torque Detection Level 1 (L6-02) for longer than the allowable time (L6-03).
oL4	oL4	Overtorque Detection 2
		The current has exceeded the value set for Torque Detection Level 2 (L6-05) for longer than the allowable time (L6-06).

## i.6 Troubleshooting

Digital Operator Display		Alarm Name
oS	oS	Overspeed
		The motor speed feedback exceeded the F1-08 setting.
ov	ov	Control Circuit Overvoltage
		Voltage in the control circuit exceeded the trip point. <ul style="list-style-type: none"> <li>For 200 V class drives: approximately 450 V</li> <li>For 400 V class drives: approximately 900 V</li> </ul>
PASS	PASS	MEMOBUS/Modbus Comm. Test Mode Complete
PGo	PGo	PG Disconnect (for any control modes using a PG option card)
		No PG pulses are received for longer than the time set to F1-14.
PGoH	PGoH	PG Hardware Fault (detected when using a PG-X3 option card)
		PG cable is not connected properly.
rUn	rUn	Motor Switch during Run
		A command to switch motors was entered during run.
SE	SE	MEMOBUS/Modbus Communication Test Mode Error <b>Note:</b> This alarm will not trigger a multi-function output terminal that is set for alarm output (H2-□□ = 10).
SrC	SrC	Phase Order Detection Fault
		The phase rotation direction for the input power supply changed.
UL3	UL3	Undertorque Detection 1
		The current has fallen below the minimum value set for Torque Detection Level 1 (L6-02) for longer than the allowable time (L6-03).
UL4	UL4	Undertorque Detection 2
		The current has fallen below the minimum value set for Torque Detection Level 2 (L6-05) for longer than the allowable time (L6-06).
Uv	Uv	Control Circuit Undervoltage
		One of the following conditions occurred: <ul style="list-style-type: none"> <li>Contactors to suppress inrush current in the drive was opened.</li> <li>Low voltage in the control drive input power. This alarm outputs only if L2-01 is not 0 and DC bus voltage is under L2-05.</li> </ul>

### ◆ Operator Programming Errors

#### ■ oPE Codes

An Operator Programming Error (oPE) occurs when a contradictory parameter is set or an individual parameter is set to an inappropriate value.

The drive will not operate until the parameter or parameters causing the problem are set correctly. An oPE, however, does not trigger an alarm or fault output. When an oPE appears on the operator display, press the ENTER button to view U1-18 and see which parameter is causing the oPE.

Digital Operator Display		Error Name
oPE01	oPE01	Unit Capacity Setting Fault
		Unit capacity and the value set to o2-04 do not match.
oPE02	oPE02	Parameter Range Setting Error
		Use U1-18 to find parameters set outside the range.
oPE03	oPE03	Multi-Function Input Selection Error
		A contradictory setting is assigned to multi-function contact inputs H1-01 to H1-08.
oPE04	oPE04	Initialization Required
oPE05	oPE05	Run Command/Frequency Reference Source Selection Error
oPE06	oPE06	Control Method Selection Error
		Correct the setting for the control method.
oPE07	oPE07	Multi-Function Analog Input Selection Error
		A contradictory setting is assigned to multi-function analog inputs H3-02, H3-10, or H3-06 and PID functions conflict.



Digital Operator Display		Error Name
<i>oPE08</i>	oPE08	Parameter Selection Error
		A function has been set that cannot be used in the motor control method selected.
<i>oPE09</i>	oPE09	PID Control Selection Fault
		PID control function selection is incorrect. Requires that PID control is enabled (b5-01 = 1 to 4).
<i>oPE10</i>	oPE10	V/f Data Setting Error
		One or more of the parameters listed below are not set according to the formula: <ul style="list-style-type: none"> <li>• <math>E1-09 \leq E1-07 &lt; E1-06 \leq E1-11 \leq E1-04</math></li> <li>• <math>E3-09 \leq E3-07 &lt; E3-06 \leq E3-11 \leq E3-04</math></li> </ul>
<i>oPE11</i>	oPE11	Carrier Frequency Setting Error
		Correct the setting for the carrier frequency.
<i>oPE13</i>	oPE13	Pulse Monitor Selection Error
		Incorrect setting of monitor selection for pulse train (H6-06).
<i>oPE15</i>	oPE15	Torque Control Setting Error
		Parameter settings that are not allowed in combination with Torque Control have been set.
<i>oPE16</i>	oPE16	Energy Savings Constants Error
<i>oPE18</i>	oPE18	Online Tuning Parameter Setting Error
		Parameters controlling online tuning are not set correctly.
<i>oPE20</i>	oPE20	PG-F3 Setting Error
		The encoder signal frequency is too high.
<i>oPE30</i>	oPE30	Incorrect Input Voltage Adjustment
		The input voltage offset adjustment has not been performed.

## ◆ Auto-Tuning Errors

### ■ Auto-Tuning Codes

Auto-Tuning faults in this section are displayed on the digital operator and will cause the motor to coast to a stop. Auto-Tuning faults do not trigger a multi-function digital output set for fault or alarm output.

An End□ error on the digital operator display indicates Auto-Tuning has successfully completed with discrepancies in the calculations. Restart Auto-Tuning after fixing the cause of the End□ error.

The drive may be used in the application if no cause can be identified despite the existence of an End□ error.

An Er□ error indicates that Auto-Tuning has not completed successfully. Check for the cause of the error using the tables in this section, and perform Auto-Tuning again after fixing the cause.





Digital Operator Display		Error Name
<i>End1</i>	End1	Excessive V/f Setting (detected only during Rotational Auto-Tuning and displayed after Auto-Tuning is complete)
<i>End2</i>	End2	Motor Iron-Core Saturation Coefficient (detected only during Rotational Auto-Tuning and displayed after Auto-Tuning is complete)
<i>End3</i>	End3	Rated Current Setting Alarm (displayed after Auto-Tuning is complete)
<i>End4</i>	End4	Adjusted Slip Calculation Error
<i>End5</i>	End5	Resistance Tuning Error
<i>End6</i>	End6	Leakage Inductance Alarm
<i>End7</i>	End7	No-Load Current Alarm
<i>Er-01</i>	Er-01	Motor Data Error
<i>Er-02</i>	Er-02	Minor Fault
<i>Er-03</i>	Er-03	STOP Button Input
<i>Er-04</i>	Er-04	Line-to-Line Resistance Error
<i>Er-05</i>	Er-05	No-Load Current Error
<i>Er-08</i>	Er-08	Rated Slip Error
<i>Er-09</i>	Er-09	Acceleration Error
<i>Er-10</i>	Er-10	Motor Direction Error

## i.6 Troubleshooting

Digital Operator Display		Error Name
<i>Er-11</i>	Er-11	Motor Speed Error
<i>Er-12</i>	Er-12	Current Detection Error
<i>Er-13</i>	Er-13	Leakage Inductance Error
<i>Er-14</i>	Er-14	Motor Speed Error 2
<i>Er-15</i>	Er-15	Torque Saturation Error
<i>Er-16</i>	Er-16	Inertia ID Error
<i>Er-17</i>	Er-17	Reverse Prohibited Error
<i>Er-18</i>	Er-18	Induction Voltage Error
<i>Er-19</i>	Er-19	PM Inductance Error
<i>Er-20</i>	Er-20	Stator Resistance Error
<i>Er-21</i>	Er-21	Z Pulse Correction Error
<i>Er-25</i>	Er-25	High Frequency Injection Parameter Tuning Error

### ◆ Fault Reset Methods

When a fault occurs, the cause of the fault must be removed and the drive must be restarted. The table below lists the different ways to restart the drive.

After the Fault Occurs	Procedure	
Fix the cause of the fault, restart the drive, and reset the fault	Press  on the digital operator when the error code is displayed.	
Resetting via Fault Reset Digital Input S4	Close then open the fault signal digital input via terminal S4. S4 is set for "Fault Reset" as default (H1-04 = 14).	
Turn off the main power supply if the above methods do not reset the fault. Reapply power after the digital operator display has turned off.		

**Note:** If the Run command is present, the drive will disregard any attempts to reset the fault. Remove the Run command before attempting to clear a fault situation.

## i.7 Drive Specifications

- Note:**
1. Perform rotational Auto-Tuning to obtain the performance specifications given below.
  2. For optimum performance life of the drive, install the drive in an environment that meets the required specifications.

	Item	Specification
<b>Control Characteristics</b>	<b>Control Method</b>	The following control methods can be set using drive parameters: <ul style="list-style-type: none"> <li>• V/f Control (V/f)</li> <li>• V/f Control with PG (V/f w/PG)</li> <li>• Open Loop Vector Control (OLV)</li> <li>• Closed Loop Vector Control (CLV)</li> <li>• Open Loop Vector Control for PM (OLV/PM)</li> <li>• Advanced Open Loop Vector Control for PM (AOLV/PM)</li> <li>• Closed Loop Vector Control for PM (CLV/PM)</li> </ul>
	<b>Frequency Control Range</b>	0.01 to 400 Hz
	<b>Frequency Accuracy (Temperature Fluctuation)</b>	Digital input: within $\pm 0.01\%$ of the max output frequency ( $-10$ to $+40$ °C) Analog input: within $\pm 0.1\%$ of the max output frequency ( $25$ °C $\pm 10$ °C)
	<b>Frequency Setting Resolution</b>	Digital inputs: 0.01 Hz Analog inputs: 1/2048 of the maximum output frequency setting (11 bit plus sign)
	<b>Output Frequency Resolution</b>	0.001 Hz
	<b>Frequency Setting Signal</b>	Main speed frequency reference: DC $-10$ to $+10$ V (20 k $\Omega$ ), DC $0$ to $+10$ V (20 k $\Omega$ ), 4 to 20 mA (250 $\Omega$ ), 0 to 20 mA (250 $\Omega$ ) Main speed reference: Pulse train input (max. 32 kHz)
	<b>Starting Torque</b>	V/f, V/f w/PG: 150% at 3 Hz OLV: 200% at 0.3 Hz $\langle \! / \! \rangle$ CLV, AOLV/PM, CLV/PM: 200% at 0.0 r/min $\langle \! / \! \rangle$ OLV/PM: 100% at 3 Hz
	<b>Speed Control Range</b>	V/f, V/f w/PG: 1:40 OLV: 1:200 CLV, CLV/PM: 1:1500 OLV/PM: 1:20 AOLV/PM: 1:100
	<b>Speed Control Accuracy</b>	OLV: $\pm 0.2\%$ ( $25$ °C $\pm 10$ °C) $\langle \! / \! \rangle$ CLV: $\pm 0.02\%$ ( $25$ °C $\pm 10$ °C) $\langle \! / \! \rangle$
	<b>Speed Response</b>	OLV: 10 Hz ( $25$ °C $\pm 10$ °C ( $77$ °F $\pm 50$ °F)) CLV: 250 Hz ( $25$ °C $\pm 10$ °C ( $77$ °F $\pm 50$ °F))
	<b>Torque Limit</b>	Parameters setting allow separate limits in four quadrants (available in OLV, CLV, AOLV/PM, CLV/PM)
	<b>Accel/Decel Time</b>	0.0 to 6000.0 s (4 selectable combinations of independent acceleration and deceleration settings)
	<b>Braking Torque</b>	Same value as overload tolerance in motoring or regeneration.
	<b>V/f Characteristics</b>	User-selected programs and V/f preset patterns possible
<b>Main Control Functions</b>	Torque Control, Droop Control, Speed/torque Control Switching, Feed Forward Control, Zero Servo Function, Momentary Power Loss Ride-Thru, Speed Search, Synchronous Transfer with Commercial Power Supply, Overtorque/Undertorque Detection, Torque Limit, 17 Step Speed (max), Accel/decel Switch, S-curve Accel/decel, 3-wire Sequence, Auto-tuning (rotational, stationary tuning), Dwell, Cooling Fan on/off Switch, Slip Compensation, Torque Compensation, Frequency Jump, Upper/lower Limits for Frequency Reference, DC Injection Braking at Start and Stop, PID Control (with sleep function), Energy Saving Control, MEMOBUS/Modbus Comm. (RS-422/RS-485 max, 115.2 kbps), Fault Restart, Application Presets, DriveWorksEZ (customized function), Removable Terminal Block with Parameter Backup Function, Online Tuning, Overexcitation Deceleration, Inertia (ASR) Tuning, High Frequency Injection.	

## i.7 Drive Specifications

Item		Specification
<b>Protection Functions</b>	<b>Power Supply Regeneration</b>	Available
	<b>Motor Protection</b>	Electronic thermal overload relay
	<b>Momentary Overcurrent Protection</b>	Drive stops when output current reaches about 200% of the rated current.
	<b>Overload Protection</b>	Drive stops after 60 s at 150% of rated Heavy Duty output current <3>
	<b>Overvoltage Protection</b>	200 V class: Stops when input voltage exceeds approx. 315 V 400 V class: Stops when input voltage exceeds approx. 630 V
	<b>Undervoltage Protection</b>	200 V class: Stops when input voltage falls below approx. 150 V 400 V class: Stops when input voltage falls below approx. 300 V
	<b>Momentary Power Loss Ride-Thru</b>	Immediately stop after 2 ms or longer power loss <4> Continuous operation during power loss shorter than 2 s (standard) <5>
	<b>Heatsink Overheat Protection</b>	Thermistor
	<b>Stall Prevention</b>	Stall Prevention is available during acceleration, deceleration, and during run.
	<b>Ground Protection</b>	Electronic circuit protection <6>
<b>Charge LED of Capacitor for Control Power Supply</b>	Remains lit until control power supply voltage falls below 50 V	
<b>Environment</b>	<b>Area of Use</b>	Indoors
	<b>Ambient Temperature</b>	IP20/NEMA Type 1 enclosure: -10 °C to +40 °C (14 °F to 104 °F) IP00 enclosure: -10 °C to +50 °C (14 °F to 122 °F)
	<b>Humidity</b>	95 RH% or less (no condensation)
	<b>Storage Temperature</b>	-20 °C to +60 °C (short-term temperature during transportation)
	<b>Altitude</b>	Up to 1000 meters without derating, up to 3000 m with output current and voltage derating.
	<b>Vibration/Shock</b>	10 to 20 Hz: 9.8 m/s <sup>2</sup> 20 to 55 Hz: 5.9 m/s <sup>2</sup> (2□0028 to 2□0081 and 4□0011 to 4□0077) 2.0 m/s <sup>2</sup> (2□0104 to 2□0248 and 4□0096 to 4□0414)
	<b>Standard</b>	<ul style="list-style-type: none"> <li>• UL508C</li> <li>• IEC/EN 61800-3, IEC/EN 61800-5-1</li> <li>• ISO/EN 13849-1 Cat.3 PLe, IEC/EN 61508 SIL3</li> </ul>
	<b>Protection Design</b>	IP00/Open Type enclosure <7>, IP20/NEMA Type 1 enclosure

<1> Current derating is required. Select control modes in accordance with drive capacity.

<2> The accuracy of these values depends on motor characteristics, ambient conditions, and drive settings. Specifications may vary with different motors and with changing motor temperature. Contact Yaskawa for consultation.

<3> Overload protection may be triggered when operating with 150% of the rated output current if the output frequency is less than 6 Hz.

<4> Actual specifications may vary depending on motor characteristics.

<5> A separate Momentary Power Loss Ride-Thru Unit is required if the application needs to continue running for up to 2 seconds during a momentary power loss.

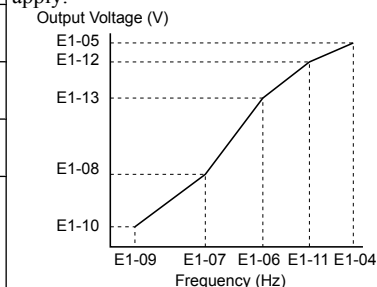
<6> Ground protection cannot be provided when the impedance of the ground fault path is too low, or when the drive is powered up while a ground fault is present at the output.

<7> Attaching the top protective cover and bottom cover on an IP00 enclosure drive will convert the drive to a NEMA Type 1 drive.

## i.8 Parameter Table

This parameter table shows the most important parameters. Default settings are in **bold type**. Refer to the Technical Manual for a complete list of parameters.

No.	Name	Description	No.	Name	Description
A1-02	Control Method Selection	<b>0: V/f Control</b> 1: V/f Control with PG 2: Open Loop Vector Control 3: Closed Loop Vector Control 5: Open Loop Vector Control for PM 6: Advanced Open Loop Vector Control for PM 7: Closed Loop Vector Control for PM	C6-02	Carrier Frequency Selection	1: 4.0 kHz 2: 6.0 kHz 3: 8.0 kHz 4: 10.0 kHz F: User-defined (determined by C6-03 to C6-05) Default setting value is determined by A1-02, Control Method Selection, C6-01, Drive Duty Selection, and o2-04, Drive Model Selection.
A1-03	Initialize Parameters	<b>0: No initialization</b> 1110: User Initialize (parameter values must be stored using parameter o2-03) 2220: 2-Wire initialization 3330: 3-Wire initialization 5550: oPE04 error reset	C7-60	Output Voltage Limit Mode Selection	<b>0: Harmonic suppression priority mode</b> <b>1: High output voltage mode</b>
A1-06	Application Preset	<b>0: General-purpose</b> 1: Water supply pump 2: Conveyor 3: Exhaust fan 4: HVAC fan 5: Air compressor	d1-01 to d1-16	Frequency Reference 1 to 16	Sets the frequency reference for the drive. Setting units are determined by parameter o1-03.
b1-01	Frequency Reference Selection 1	0: Digital operator <b>1: Analog input terminals</b> 2: MEMOBUS/Modbus communications 3: Option PCB 4: Pulse train input (terminal RP)	d1-17	Jog Frequency Reference	Sets the Jog frequency reference. Setting units are determined by parameter o1-03.
b1-02	Run Command Selection 1	0: Digital operator <b>1: Digital input terminals</b> 2: MEMOBUS/Modbus communications 3: Option PCB	d2-01	Frequency Reference Upper Limit	Sets the frequency reference upper limit as a percentage of the maximum output frequency.
b1-03	Stopping Method Selection	<b>0: Ramp to stop</b> 1: Coast to stop 2: DC Injection Braking to stop 3: Coast with timer	d2-02	Frequency Reference Lower Limit	Sets the frequency reference lower limit as a percentage of the maximum output frequency.
b1-04	Reverse Operation Selection	<b>0: Reverse enabled.</b> 1: Reverse disabled.	E1-03	V/f Pattern Selection	0: 50 Hz, Constant torque 1 1: 60 Hz, Constant torque 2 2: 60 Hz, Constant torque 3 (50 Hz base) 3: 72 Hz, Constant torque 4 (60 Hz base) 4: 50 Hz, Variable torque 1 5: 50 Hz, Variable torque 2 6: 60 Hz, Variable torque 1 7: 60 Hz, Variable torque 2 8: 50 Hz, High starting torque 1 9: 50 Hz, High starting torque 2 A: 60 Hz, High starting torque 3 B: 60 Hz, High starting torque 4 C: 90 Hz (60 Hz base) D: 120 Hz (60 Hz base) E: 180 Hz (60 Hz base) <b>F: Custom V/f, E1-04 through E1-13 settings define the V/f pattern</b>
C1-01	Acceleration Time 1	Sets the time to accelerate from 0 to maximum frequency.	E1-04	Maximum Output Frequency	Parameters E1-04 and E1-06 to E1-13 can only be changed when E1-03 is set to F. To set linear V/f characteristics, set the same values for E1-07 and E1-09. In this case, the setting for E1-08 will be disregarded. Ensure that the five frequencies are set according to the following rules to prevent triggering an oPE10 fault: $E1-09 \leq E1-07 < E1-06 \leq E1-11 \leq E1-04$ Setting E1-11 to 0 disables both E1-11 and E1-12 and the above conditions do not apply.
C1-02	Deceleration Time 1	Sets the time to decelerate from maximum frequency to 0.	E1-05	Maximum Voltage	
C2-01	S-Curve Characteristic at Accel Start	S-curve at acceleration start.	E1-06	Base Frequency	
C2-02	S-Curve Characteristic at Accel End	S-curve at acceleration end.	E1-07	Middle Output Frequency	
C2-03	S-Curve Characteristic at Decel Start	S-curve at deceleration start.	E1-08	Middle Output Frequency Voltage	
C2-04	S-Curve Characteristic at Decel End	S-curve at deceleration end.	E1-09	Minimum Output Frequency	
C6-01	Drive Duty Selection	0: Heavy Duty (HD) Overload capability: 150% of drive rated Heavy Duty current for 60 s Default Carrier Frequency: 2 kHz <b>1: Normal Duty (ND)</b> Overload capability: 120% of drive rated Normal Duty current for 60 s Default Carrier Frequency: 2 kHz Swing PWM	E1-10	Minimum Output Frequency Voltage	
			E1-11	Middle Output Frequency 2	
			E1-12	Middle Output Frequency Voltage 2	
			E1-13	Base Voltage	



## i.8 Parameter Table

No.	Name	Description
E2-01	Motor Rated Current	Sets the motor nameplate full load current in amps. Automatically set during Auto-Tuning.
H1-01 to H1-08	Multi-Function Digital Input Terminal S1 to S8 Function Selection	Selects the function of terminals S1 to S8.
H2-01	Multi-Function Contact Output (terminal M1-M2)	Sets the function for the relay output M1-M2.
H2-02	Multi-Function Contact Output 2 (terminal M3-M4)	Sets the function for the relay output M3-M4.
H2-03	Terminal M5-M6 function selection (relay)	Sets the function for the relay output M5-M6
H2-06	Power Consumption Output Unit Selection	0: 0.1 kWh units <b>1: 1 kWh units</b> 2: 10 kWh units 3: 100 kWh units 4: 1000 kWh units
H2-07	MEMOBUS Register 1 Address Select	Sets the addresses of the MEMOBUS/Modbus registers from which data will be sent to contact outputs 62 and 162.
H2-08	MEMOBUS Register 1 Bit Select	Sets the bits for the MEMOBUS/Modbus registers from which data will be sent to contact outputs 62 and 162.
H2-09	MEMOBUS Register 2 Address Select	Sets the addresses of the MEMOBUS/Modbus registers from which data will be sent to contact outputs 63 and 163.
H2-10	MEMOBUS Register 2 Bit Select	Sets the bits for the MEMOBUS/Modbus registers from which data will be sent to contact outputs 63 and 163.
H3-01	Terminal A1 Signal Level Selection	<b>0: 0 to 10 V</b> 1: -10 to 10 V
H3-02	Terminal A1 Function Selection	Sets the function of terminal A1.
H3-03	Terminal A1 Gain Setting	Sets the level of the input value selected in H3-02 when 10 V is input at terminal A1.
H3-04	Terminal A1 Bias Setting	Sets the level of the input value selected in H3-02 when 0 V is input at terminal A1.
H3-05	Terminal A3 Signal Level Selection	<b>0: 0 to 10 V</b> 1: -10 to 10 V
H3-06	Terminal A3 Function Selection	Sets the function of terminal A3.
H3-07	Terminal A3 Gain Setting	Sets the level of the input value selected in H3-06 when 10 V is input at terminal A3.
H3-08	Terminal A3 Bias Setting	Sets the level of the input value selected in H3-06 when 0 V is input at terminal A3.
H3-09	Terminal A2 Signal Level Selection	0: 0 to 10 V 1: -10 to 10 V <b>2: 4 to 20 mA</b> 3: 0 to 20 mA  <b>Note:</b> Use DIP switch S1 to set input terminal A2 for a current or a voltage input signal.
H3-10	Terminal A2 Function Selection	Sets the function of terminal A2.
H3-11	Terminal A2 Gain Setting	Sets the level of the input value selected in H3-10 when 10 V (20 mA) is input at terminal A2.
H3-12	Terminal A2 Bias Setting	Sets the level of the input value selected in H3-10 when 0 V (0 or 4 mA) is input at terminal A2.

No.	Name	Description
H3-13	Analog Input Filter Time Constant	Sets a primary delay filter time constant for terminals A1, A2, and A3. Used for noise filtering.
H3-14	Analog Input Terminal Enable Selection	1: Terminal A1 only 2: Terminal A2 only 3: Terminals A1 and A2 only 4: Terminal A3 only 5: Terminals A1 and A3 6: Terminals A2 and A3 <b>7: All terminals enabled</b>
H3-16	Terminal A1 Offset	Adds an offset when the analog signal to terminal A1 is at 0 V.
H3-17	Terminal A2 Offset	Adds an offset when the analog signal to terminal A2 is at 0 V.
H3-18	Terminal A3 Offset	Adds an offset when the analog signal to terminal A3 is at 0 V.
H4-01	Multi-Function Analog Output Terminal FM Monitor Selection	Selects the data to be output through multi-function analog output terminal FM. Set the desired monitor parameter to the digits available in U□-□□. For example, enter "103" for U1-03.
H4-02	Multi-Function Analog Output Terminal FM Gain	Sets the signal level at terminal FM that is equal to 100% of the selected monitor value.
H4-03	Multi-Function Analog Output Terminal FM Bias	Sets the signal level at terminal FM that is equal to 0% of the selected monitor value.
H4-04	Multi-Function Analog Output Terminal AM Monitor Selection	Selects the data to be output through multi-function analog output terminal AM. Set the desired monitor parameter to the digits available in U□-□□. For example, enter "103" for U1-03.
H4-05	Multi-Function Analog Output Terminal AM Gain	Sets the signal level at terminal AM that is equal to 100% of the selected monitor value.
H4-06	Multi-Function Analog Output Terminal AM Bias	Sets the signal level at terminal AM that is equal to 0% of the selected monitor value.
H4-07	Multi-Function Analog Output Terminal FM Signal Level Selection	<b>0: 0 to 10 V</b> 1: -10 to 10 V 2: 4 to 20mA
H4-08	Multi-Function Analog Output Terminal AM Signal Level Selection	<b>0: 0 to 10 V</b> 1: -10 to 10 V 2: 4 to 20 mA
H5-01	Drive Node Address	Selects drive station node number (address) for MEMOBUS/Modbus terminals R+, R-, S+, S-. Cycle power for the setting to take effect.
H5-02	Communication Speed Selection	0: 1200 bps 1: 2400 bps 2: 4800 bps <b>3: 9600 bps</b> 4: 19200 bps 5: 38400 bps 6: 57600 bps 7: 76800 bps 8: 115200 bps Cycle power for the setting to take effect.
H5-03	Communication Parity Selection	<b>0: No parity</b> 1: Even parity 2: Odd parity Cycle power for the setting to take effect.
H5-04	Stopping Method After Communication Error (CE)	0: Ramp to stop 1: Coast to stop 2: Fast Stop <b>3: Alarm only</b>
H5-05	Communication Fault Detection Selection	0: Disabled <b>1: Enabled. If communication is lost for more than two seconds, a CE fault will occur.</b>

No.	Name	Description	No.	Name	Description
H5-06	Drive Transmit Wait Time	Set the wait time between receiving and sending data.	L3-04	Stall Prevention Selection during Deceleration	0: Disabled. Deceleration at the active deceleration rate. An ov fault may occur. <b>1: General purpose. Deceleration is paused when the DC bus voltage exceeds the Stall Prevention level.</b> 4: Overexcitation Deceleration. Decelerates while increasing the motor flux. 6: Enable (Current Limit). The deceleration rate is automatically adjusted while limiting the regeneration current at the setting value of the stall prevention level (L3-14).
H5-07	RTS Control Selection	0: Disabled. RTS is always on. <b>1: Enabled. RTS turns on only when sending.</b>			
H5-09	Communication Fault Detection Time	Sets the time required to detect a communications error.			
H5-10	Unit Selection for MEMOBUS/Modbus Register 0025H	<b>0: 0.1 V units</b> 1: 1 V units			
H5-11	Communications ENTER Function Selection	<b>0: Drive requires an Enter command before accepting any changes to parameter settings.</b> 1: Parameter changes are activated immediately without the Enter command.	L5-01	Number of Auto Restart Attempts	Sets the number of times the drive may attempt to restart after the following faults occur: GF, LF, oC, oH1, oL1, oL3, oL4, ov, Sto, Uv1.
H5-12	Run Command Method Selection	<b>0: FWD/Stop, REV/Stop</b> 1: Run/Stop, FWD/REV	L6-01	Torque Detection Selection 1	<b>0: Disabled</b> 1: oL3 detection only active during speed agree, operation continues after detection 2: oL3 detection always active during run, operation continues after detection 3: oL3 detection only active during speed agree, output shuts down on an oL3 fault 4: oL3 detection always active during run, output shuts down on an oL3 fault 5: UL3 detection only active during speed agree, operation continues after detection 6: UL3 detection always active during run, operation continues after detection 7: UL3 detection only active during speed agree, output shuts down on a UL3 fault 8: UL3 detection always active during run, output shuts down on a UL3 fault
H6-01	Pulse Train Input Terminal RP Function Selection	<b>0: Frequency reference</b> 1: PID feedback value 2: PID setpoint value 3: V/f Control with Simple PG feedback (possible only when using motor 1 in V/f Control)			
H6-02	Pulse Train Input Scaling	Sets the terminal RP input signal frequency that is equal to 100% of the value selected in H6-01.			
H6-03	Pulse Train Input Gain	Sets the level of the value selected in H6-01 when a frequency with the value set in H6-02 is input.			
H6-04	Pulse Train Input Bias	Sets the level of the value selected in H6-01 when 0 Hz is input.			
H6-05	Pulse Train Input Filter Time	Sets the pulse train input filter time constant.			
H6-06	Pulse Train Monitor Selection	Select the pulse train monitor output function (value of the □-□□ part of U□-□□). For example, enter “501” for U5-01.			
H6-07	Pulse Train Monitor Scaling	Sets the terminal MP output signal frequency when the monitor value is 100%. For example, to have the pulse train monitor output equal the output frequency, set H6-06 to 102 and H6-07 to 0.			
H6-08	Pulse Train Input Minimum Frequency	Sets the minimum frequency for the pulse train input to be detected. Enabled when H6-01 = 0, 1, or 2.	L6-02	Torque Detection Level 1	Sets the overtorque and undertorque detection level.
L1-01	Motor Overload Protection Selection	0: Disabled 1: General purpose motor (standard fan cooled) 2: Drive dedicated motor with a speed range of 1:10 3: Vector motor with a speed range of 1:100 4: PM motor with variable torque 5: PM motor with constant torque control 6: General purpose motor (50 Hz) Default setting is determined by parameter A1-02, Control Method Selection.	L6-03	Torque Detection Time 1	Sets the time an overtorque or undertorque condition must exist to trigger torque detection 1.
			o1-03	Digital Operator Display Selection	0: 0.01 Hz 1: 0.01% (100% = E1-04) 2: r/min (calculated using the number of motor poles setting in E2-04, E4-04, or E5-04) 3: User-selected units (set by o1-10 and o1-11) Default setting is determined by parameter A1-02, Control Method Selection.
			T1-01	Auto-Tuning Mode Selection	<b>0: Rotational Auto-Tuning</b> 2: Stationary Auto-Tuning for Line-to-Line Resistance 3: Rotational Auto-Tuning for V/f Control (necessary for Energy Savings and Speed Estimation Speed Search) 4: Stationary Auto-Tuning 2 5: Stationary Auto-Tuning 3 8: Inertia Tuning (perform Rotational Auto-Tuning prior to Inertia Tuning) 9: ASR Gain Tuning (perform Rotational Auto-Tuning prior to ASR Gain Auto-Tuning)
L1-02	Motor Overload Protection Time	Sets the motor thermal overload protection (oL1) time.			
L2-01	Momentary Power Loss Operation Selection	<b>0: Disabled. Drive trips on Uv1 fault when power is lost.</b> 1: Recover within the time set in L2-02. Uv1 will be detected if power loss is longer than L2-02. 2: Recover as long as CPU has power. Uv1 is not detected.			

<1> Available in drive software versions PRG: 1015 and later.

## i.9 Standards Compliance

### ◆ European Standards



Figure i.50 CE Mark

The CE mark indicates that a product is in compliance with applicable European Directives for safety and environmental regulations. It is required for engaging in business and commerce in Europe.

The applicable European Directives for this product are as follows. We declared the CE marking based on the harmonized standards in [Table i.27](#).

Table i.27 European Directives

Applicable European Directive	Applicable Harmonized Standards
Low Voltage Directive (2006/95/EC)	IEC/EN618995-1: 2007
EMC Guidelines (2004/108/EC)	IEC/EN 61800-3: 2004
Machinery Directive (2006/42/EC)	ISO/EN ISO 13849-1/AC: 2009 IEC/EN 62061: 2005 (SILCL3) IEC/EN 61800-5-2: 2007 (SIL3)

The user(s) is solely responsible for ensuring that the end products used with this drive comply with all applicable European directives and with other national regulations (if required).

### ◆ CE Low Voltage Directive Compliance

This drive has been tested according to European standard IEC/EN 61800-5-1, and it fully complies with the Low Voltage Directive.

To comply with the Low Voltage Directive, be sure to meet the following conditions when combining this drive with other devices:

#### ■ Area of Use

Do not use drives in areas with pollution higher than severity 2 and overvoltage category 3 in accordance with IEC/EN 664.

#### ■ Grounding

The drive is designed to be used in T-N (grounded neutral point) networks. If installing the drive in other types of grounded systems, contact your Yaskawa representative for instructions. [Refer to Enable the Internal EMC Filter on page 37](#) for details.

#### ■ Guarding Against Harmful Materials

When installing IP00/Open Type enclosure drives, use an enclosure that prevents foreign material from entering the drive from above or below.

### ◆ EMC Guidelines Compliance

Models U□□E□□□□ and U□□W□□□□ have built-in EMC filters, are tested according to European standards IEC/EN 61800-3: 2004, and comply with EMC guidelines. Use drives with built-in EMC filters to comply with EMC guidelines.

#### ■ EMC Filter Installation

##### Installation Method

Verify the following installation conditions to ensure that other devices and machinery used in combination with drive models U□□E□□□□ and U□□W□□□□ also comply with EMC guidelines.

1. Place the drive in the enclosure.
2. Use braided shield cable for the drive and motor wiring, or run the wiring through a metal conduit.
3. Keep wiring as short as possible. Ground the shield on both the drive side and the motor side.



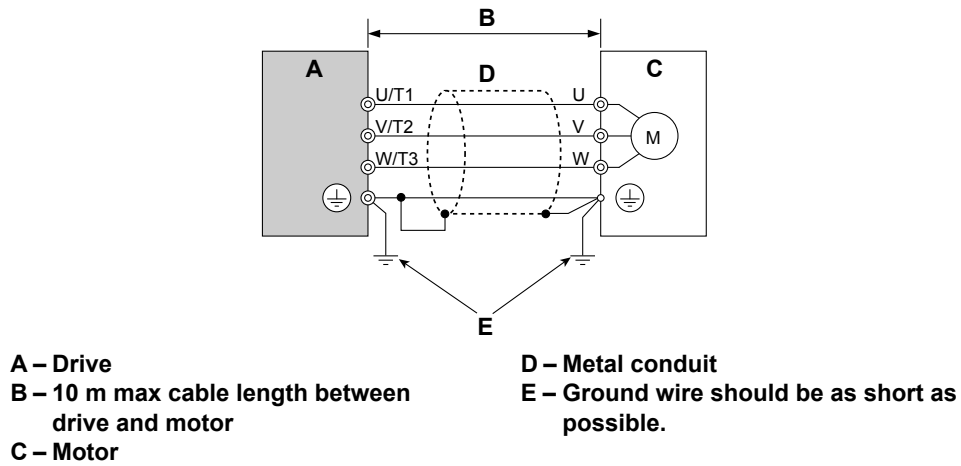


Figure i.51 Installation Method

4. Make sure the protective earthing conductor complies with technical standards and local safety regulations.

**WARNING!** *Electrical Shock Hazard. Because the leakage current exceeds 3.5 mA in models 4□0302 and larger, IEC/EN 61800-5-1 states that either the power supply must be automatically disconnected in case of discontinuity of the protective earthing conductor, or a protective earthing conductor with a cross-section of at least 10 mm<sup>2</sup> (Cu) or 16 mm<sup>2</sup> (Al) must be used. Failure to comply may result in death or serious injury.*

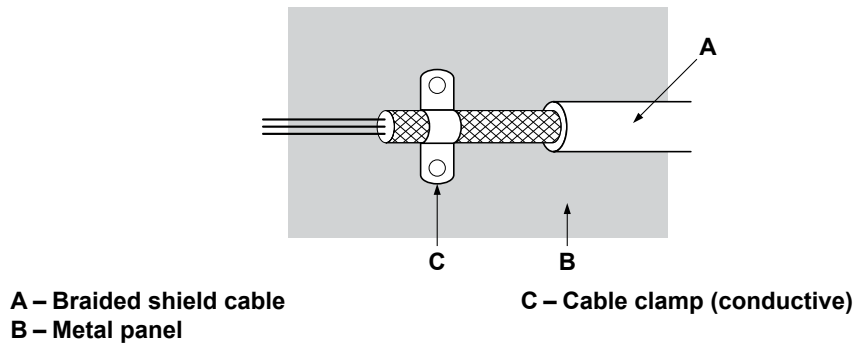


Figure i.52 Ground Area

## i.9 Standards Compliance

### Three-Phase 200 V / 400 V Class

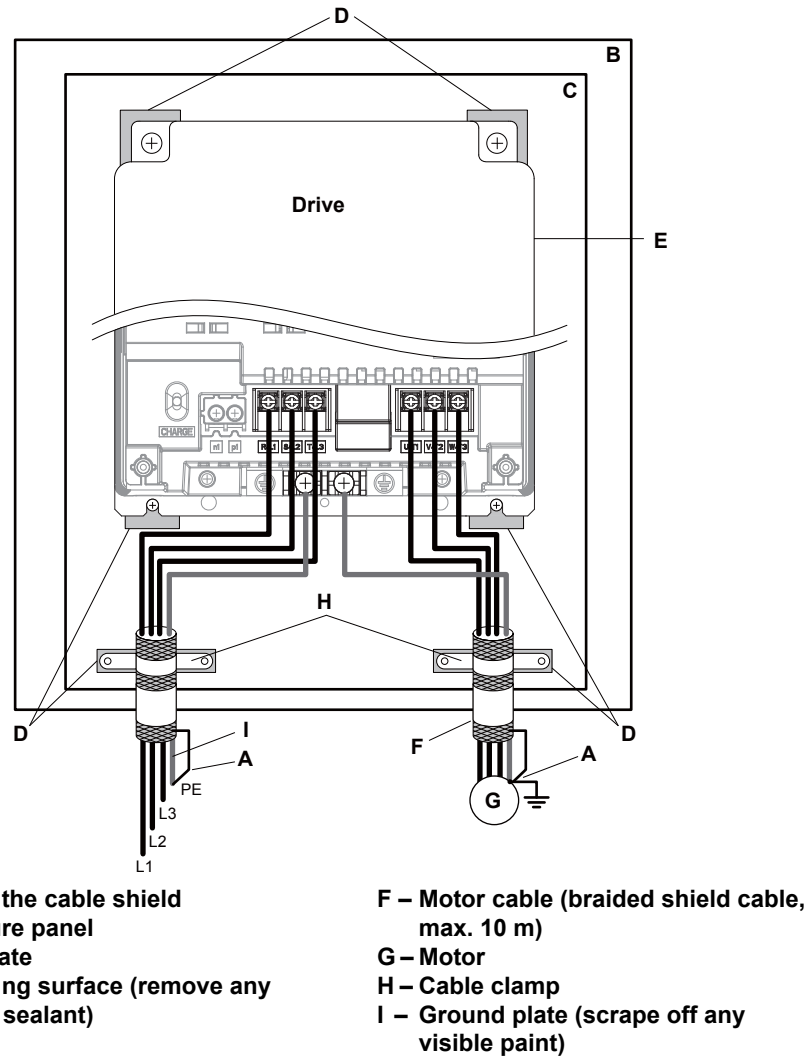


Figure i.53 EMC Filter and Drive Installation for CE Compliance (Three-Phase 200 V / 400 V Class)

## ◆ UL Standards Compliance

The UL/cUL mark applies to products in the United States and Canada. It indicates that UL has performed product testing and evaluation, and determined that their stringent standards for product safety have been met. For a product to receive UL certification, all components inside that product must also receive UL certification.



Figure i.54 UL/cUL Mark

This drive is tested in accordance with UL standard UL508C and complies with UL requirements. The conditions described below must be met to maintain compliance when using this drive in combination with other equipment:

### ■ Installation Area

Do not install the drive to an area greater than pollution degree 2 (UL standard).

■ **Ambient Temperature**

IP20/NEMA Type 1 Enclosure: -10 to +40 °C

IP00 Open Type Enclosure: -10 to +50 °C

■ **Main Circuit Terminal Wiring**

Yaskawa recommends using closed-loop crimp terminals on all drive models. Use only the tools recommended by the terminal manufacturer for crimping. *Refer to Closed-Loop Crimp Terminal Recommendations on page 83* for closed-loop crimp terminal recommendations.

**Wire Gauges and Tightening Torques**

*Refer to Main Circuit Wire Gauges and Tightening Torque on page 24.*

**Closed-Loop Crimp Terminal Recommendations**

To maintain UL/cUL approval, UL Listed closed-loop crimp terminals are specifically required when wiring the drive main circuit terminals on models 2□0068 to 2□0248 and 4□0052 to 4□0414. Use only the tools recommended by the terminal manufacturer for crimping. Yaskawa recommends UL Listed crimp terminals made by JST and Tokyo DIP (or equivalent) for the insulation cap. *Table i.28* matches the wire gauges and terminal screw sizes with Yaskawa-recommended crimp terminals, tools, and insulation caps. Refer to the appropriate Wire Gauge and Torque Specifications table for the wire gauge and screw size for your drive model. Place orders with a Yaskawa representative or the Yaskawa sales department.

Wire gauge values shown in ***bold italic*** are the recommended values. Refer to local codes for proper selections.

**Table i.28 Closed-Loop Crimp Terminal Size**

Drive Model	Wire Gauge (AWG, kcmil)	Screw Size	Crimp Terminal Model Number	Tool		Insulation Cap Model No.	Code <†>
	R/L1, S/L2, T/L3 U/T1, V/T2, W/T3			Machine No.	Die Jaw		
<b>200 V Class</b>							
2□0028	10	M5	R5.5-5	YA-4	AD-900	TP-005	100-054-030
	<b>8</b>		R8-5		AD-901	TP-008	100-054-032
2□0042	8	M6	R8-6	YA-4	AD-901	TP-008	100-065-184
	<b>6</b>		R14-6		AD-902	TP-014	100-051-261
	4		R22-6	YA-5	AD-953	TP-022	100-051-262
	<b>3</b>		R22-6				
2□0054	6	M6	R14-6	YA-5	AD-952	TP-014	100-051-261
	<b>4</b>		R22-6		AD-953	TP-022	100-051-262
	3						
2□0068	<b>4</b>	M6	R22-6	YA-5	AD-953	TP-022	100-051-262
	3						
2□0081	<b>6</b>	M6	R14-6	YA-5	AD-952	TP-014	100-051-261
	4		R22-6		AD-953	TP-022	100-051-262
	3						
2□0104	6	M8	R14-8	YA-4	AD-902	TP-014	100-054-035
	4		R22-8	YA-5	AD-953	TP-022	100-051-263
	3						
	2		R38-8		AD-954	TP-038	100-051-264
	<b>1</b>		R60-8		AD-955	TP-060	100-051-265
	1/0						
2□0130	6	M8	R14-8	YA-5	AD-952	TP-014	100-054-035
	<b>4</b>		R22-8		AD-953	TP-022	100-051-263
	3						
	2		R38-8		AD-954	TP-038	100-051-264
	1		R60-8		AD-955	TP-060	100-051-265
	1/0						

## i.9 Standards Compliance

Drive Model	Wire Gauge (AWG, kcmil)	Screw Size	Crimp Terminal Model Number	Tool		Insulation Cap Model No.	Code <?>	
	R/L1, S/L2, T/L3 U/T1, V/T2, W/T3			Machine No.	Die Jaw			
2□0154	4	M10	R22-10	YA-5	AD-953	TP-022	100-061-113	
	3		R38-10		AD-954	TP-038	100-061-114	
	2				AD-955	TP-060	100-051-266	
	1		70-10	YF-1 YET-300-1	TD-322 TD-311	TP-080	100-064-251	
	1/0				TD-323 TD-312		100-051-267	
	2/0			R100-10	YF-1	TD-324	TP-100	100-051-269
	3/0							
	4/0							
2□0192	3	M10	R22-10	YA-5	AD-953	TP-022	100-061-113	
	2		R38-10		AD-954	TP-038	100-061-114	
	1				AD-955	TP-060	100-051-266	
	1/0		70-10	YF-1 YET-300-1	TD-322 TD-311	TP-080	100-064-251	
	2/0				TD-323 TD-312		100-051-267	
	3/0			R100-10	YF-1	TD-324	TP-100	100-051-269
	4/0							
	2□0248		1	M10	R38-10	YA-5	AD-954	TP-038
1/0		70-10	YF-1 YET-300-1		TD-321 TD-311	TP-060	100-051-266	
2/0					TD-322 TD-311	TP-080	100-064-251	
3/0					TD-323 TD-312		100-051-267	
4/0					R100-10	TD-324 TD-312	TP-100	100-051-269
<b>400 V Class</b>								
4□0011	14	M5	R2-5	YA-4	AD-900	TP-003	100-123-030	
	12		R5.5-5			TP-005	100-054-030	
	10				R8-5	AD-901	TP-008	100-054-032
	8							
4□0014	14	M5	R2-5	YA-4	AD-900	TP-003	100-123-030	
	12		R5.5-5			TP-005	100-054-030	
	10				R8-5	AD-901	TP-008	100-054-032
	8							
4□0021	12	M5	R5.5-5	YA-4	AD-900	TP-005	100-054-030	
	10				R8-5	AD-901	TP-008	100-054-032
	8							
4□0027	10	M5	R5.5-5	YA-4	AD-900	TP-005	100-054-030	
	8		R8-5		AD-901	TP-008	100-054-032	
4□0034	8	M5	R8-5	YA-4	AD-901	TP-008	100-054-032	
4□0040	8	M6	R8-6	YA-4	AD-901	TP-008	100-065-184	
	6		R14-6		AD-902	TP-014	100-051-261	
	4		R22-6	YA-5	AD-953	TP-022	100-051-262	
	3							
4□0052	8	M6	R8-6	YA-4	AD-901	TP-008	100-065-184	
	6		R14-6		AD-902	TP-014	100-051-261	
	4		R22-6	YA-5	AD-953	TP-022	100-051-262	
	3							

Drive Model	Wire Gauge (AWG, kcmil)	Screw Size	Crimp Terminal Model Number	Tool		Insulation Cap Model No.	Code <f>
	R/L1, S/L2, T/L3 U/T1, V/T2, W/T3			Machine No.	Die Jaw		
4□0065	6	M6	R14-6	YA-5	AD-952	TP-014	100-051-261
	4		R22-6		AD-953	TP-022	100-051-262
	3						
4□0077	4	M6	R22-6	YA-5	AD-953	TP-022	100-051-262
	3						
4□0096	8	M8	R8-8	YA-4	AD-901	TP-008	100-601-111
	6		R14-8		AD-902	TP-014	100-054-035
	4		YA-5	R22-8	AD-953	TP-022	100-051-263
	3			R38-8	AD-954	TP-038	100-051-264
	2			R60-8	AD-955	TP-060	100-051-265
	1						
	1/0						
4□0124	6	M8	R14-8	YA-5	AD-952	TP-014	100-054-035
4	R22-8		AD-953		TP-022	100-051-263	
3	R38-8		AD-954		TP-038	100-051-264	
2	R60-8		AD-955		TP-060	100-051-265	
1							
1/0							
4□0156	4	M10	R22-10	YA-5	AD-953	TP-022	100-061-113
	3		R38-10		AD-954	TP-038	100-061-114
	2		R60-10		AD-955	TP-060	100-051-266
	1						
	1/0		70-10	YF-1 YET-300-1	TD-322 TD-311	TP-080	100-064-251
	2/0		80-10		TD-323 TD-312		100-051-267
	3/0		R100-10		TD-324 TD-312	TP-100	100-051-269
4/0							
4□0180	3	M10	R22-10	YA-5	AD-953	TP-022	100-061-113
	2		R38-10		AD-954	TP-038	100-061-114
	1		R60-10		AD-955	TP-060	100-051-266
	1/0						
	2/0		70-10	YF-1 YET-300-1	TD-322 TD-311	TP-080	100-064-251
	3/0		80-10		TD-323 TD-312		100-051-267
	4/0		R100-10		TD-324 TD-312	TP-100	100-051-269
4□0216	2	M10	R38-10	YA-5	AD-954	TP-038	100-061-114
	1		R60-10	YF-1 YET-300-1	TD-321 TD-311	TP-060	100-051-266
	1/0		70-10		TD-322 TD-311	TP-080	100-064-251
	2/0		80-10		TD-323 TD-312		100-051-267
	3/0		R100-10		TD-324 TD-312	TP-100	100-051-269
	4/0						

## i.9 Standards Compliance

Drive Model	Wire Gauge (AWG, kcmil)	Screw Size	Crimp Terminal Model Number	Tool		Insulation Cap Model No.	Code <1>
	R/L1, S/L2, T/L3 U/T1, V/T2, W/T3			Machine No.	Die Jaw		
4□0240	1/0	M10	R60-10	YF-1 YET-300-1	TD-321 TD-311	TP-060	100-051-266
	2/0		70-10		TD-322 TD-311	TP-080	100-064-251
	3/0		80-10		TD-323 TD-312		100-051-267
	4/0		R100-10		TD-324 TD-312	TP-100	100-051-269
4□0302	1/0	M10	R60-10	YF-1 YET-300-1	TD-321 TD-311	TP-060	100-051-266
	2/0		70-10		TD-322 TD-311	TP-080	100-064-251
	3/0		80-10		TD-323 TD-312		100-051-267
	4/0		R100-10		TD-324 TD-312	TP-100	100-051-269
4□0361	3/0	M10	80-10	YF-1 YET-300-1	TD-323 TD-312	TP-080	100-051-267
	4/0		R100-10		TD-324 TD-312	TP-100	100-051-269
4□0414	4/0	M12	R100-12	YF-1 YET-300-1	TD-324 TD-312	TP-100	100-051-270
	250		R150-12		TD-325 TD-313	TP-150	100-051-273
	300						

<1> Codes refer to a set of three crimp terminals and three insulation caps. Prepare input and output wiring using two sets for each connection.

**Note:** Use crimp insulated terminals or insulated shrink tubing for wiring connections. Wires should have a continuous maximum allowable temperature of 75 °C 600 Vac UL-approved vinyl-sheathed insulation.

### ■ Low Voltage Wiring for Control Circuit Terminals

Wire low voltage wires with NEC Class 1 circuit conductors. Refer to national state or local codes for wiring. The external power supply shall be a UL Listed Class 2 power supply source or equivalent only.

**Table i.29 Control Circuit Terminal Power Supply**

Input / Output	Terminal Signal	Power Supply Specifications
Open Collector Outputs	DM+, DM-	Requires class 2 power supply
Digital inputs	S1 to S8, SN, SC, SP, HC, H1, H2	Use the internal LVLC power supply of the drive. Use class 2 for external power supply.
Analog inputs / outputs	+V, -V, A1, A2, A3, AC, AM, FM	Use the internal LVLC power supply of the drive. Use class 2 for external power supply.

### ■ Drive Short Circuit Rating

The drive is suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical Amperes, 240 Vac maximum (200 V Class) and 480 Vac maximum (400 V class: 4E□□□□ and 4W□□□□), and 500 Vac maximum (400 V class: 4A□□□□ and 4P□□□□) with built-in fuses manufactured by Hinode Electric Co., Ltd. and Mersen (or equivalent).

### ◆ Drive Motor Overload Protection

Set parameter E2-01 (motor rated current) to the appropriate value to enable motor overload protection. The internal motor overload protection is UL Listed and in accordance with the NEC and CEC.

#### ■ E2-01: Motor Rated Current

Setting Range: 10% to 180% of the drive rated current

Default Setting: Model-dependent

Parameter E2-01 protects the motor when parameter L1-01 is not set to 0. The default for L1-01 is 1, which enables protection for standard induction motors.

If Auto-Tuning has been performed successfully, the motor data entered to T1-04 and T2-06 are automatically written to parameter E2-01. If Auto-Tuning has not been performed, manually enter the correct motor rated current to parameter E2-01.

**■ L1-01: Motor Overload Protection Selection**

The drive has an electronic overload protection function (oL1) based on time, output current, and output frequency that protects the motor from overheating. The electronic thermal overload function is UL-recognized, so it does not require an external thermal relay for single motor operation.

This parameter selects the motor overload curve used according to the type of motor applied.

**Table i.30 Overload Protection Settings**

Setting	Description	
0	Disabled	Disabled the internal motor overload protection of the drive.
1	Standard fan-cooled motor (default)	Selects protection characteristics for a standard self-cooled motor with limited cooling capabilities when running below the rated speed. The motor overload detection level (oL1) is automatically reduced when running below the motor rated speed.
2	Drive duty motor with a speed range of 1:10	Selects protection characteristics for a motor with self-cooling capability within a speed range of 10:1. The motor overload detection level (oL1) is automatically reduced when running below 1/10 of the motor rated speed.
3	Vector motor with a speed range of 1:100	Selects protection characteristics for a motor capable of cooling itself at any speed including zero speed (externally cooled motor). The motor overload detection level (oL1) is constant over the entire speed range.
4	Permanent Magnet motor with variable torque	Selects protection characteristics for a variable torque PM motor. The motor overload detection level (oL1) is automatically reduced when running below the motor rated speed.
5	Permanent Magnet motor with constant torque	Selects protection characteristics for a constant torque PM motor. The motor overload detection level (oL1) is constant over the whole speed range.
6	Standard fan-cooled motor (50 Hz)	Selects protection characteristics for a standard self-cooled motor with limited cooling capabilities when running below the rated speed. The motor overload detection level (oL1) is automatically reduced when running below the motor rated speed.

When connecting the drive to more than one motor for simultaneous operation, disable the electronic overload protection (L1-01 = 0) and wire each motor with its own motor thermal overload relay.

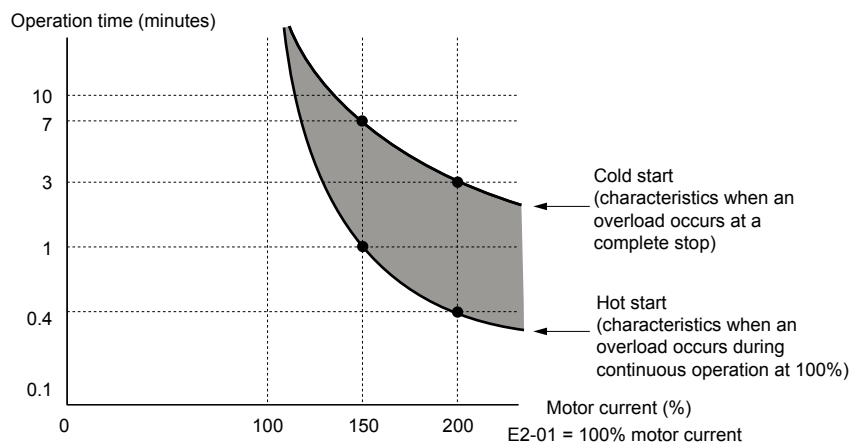
Enable motor overload protection (L1-01 = 1 to 6) when connecting the drive to a single motor, unless another motor overload preventing device is installed. The drive electronic thermal overload function causes an oL1 fault, which shuts off the output of the drive and prevents additional overheating of the motor. The motor temperature is continually calculated while the drive is powered up.

**■ L1-02: Motor Overload Protection Time**

Setting Range: 0.1 to 5.0 min

Factory Default: 1.0 min

Parameter L1-02 determines how long the motor is allowed to operate before the oL1 fault occurs when the drive is running a hot motor at 60 Hz and at 150% of the full load amp rating (E2-01) of the motor. Adjusting the value of L1-02 can shift the set of oL1 curves up the y axis of the diagram below, but will not change the shape of the curves.



**Figure i.55 Motor Overload Protection Time**

## i.9 Standards Compliance

### ■ L1-03: Motor Overheat Alarm Operation Selection (PTC input)

Sets the drive operation when the PTC input signal reaches the motor overheat alarm level (oH3).

No.	Name	Setting Range	Default
L1-03	Motor Overheat Alarm Operation Selection (PTC input)	0 to 3	3

#### Setting 0: Ramp to Stop

The drive stops the motor using the deceleration time 1 set in parameter C1-02.

#### Setting 1: Coast to Stop

The drive output is switched off and the motor coasts to stop.

#### Setting 2: Fast Stop

The drive stops the motor using the Fast Stop time set in parameter C1-09.

#### Setting 3: Alarm Only

The operation is continued and an oH3 alarm is displayed on the digital operator.

### ■ L1-04: Motor Overheat Fault Operation Selection (PTC input)

Sets the drive operation when the PTC input signal reaches the motor overheat fault level (oH4).

No.	Name	Setting Range	Default
L1-04	Motor Overheat Fault Operation Selection (PTC input)	0 to 2	1

#### Setting 0: Ramp to Stop

The drive stops the motor using the deceleration time 1 set in parameter C1-02.

#### Setting 1: Coast to Stop

The drive output is switched off and the motor coasts to stop.

#### Setting 2: Fast Stop

The drive stops the motor using the Fast Stop time set in parameter C1-09.

## ◆ Safe Disable Input Function

This section explains the Safe Disable function. Contact Yaskawa if more information is required.

### ■ Safety Standards

The TUV mark indicates compliance with safety standards.



Figure i.56 TUV Mark

Table i.31 Safety Standards and Applicable Harmonized Standards

Safety Standards	Applicable Harmonized Standards
Functional Safety	IEC/EN 61508 series: 2010 (SIL3)
	IEC/EN 62061: 2005 (SILCL3)
	IEC/EN 61800-5-2: 2007 (SIL3)
Safety of Machinery	ISO/EN ISO 13849-1/AC: 2009 (PL e (Cat.3))
EMC	IEC/EN 61326-3-1: 2008 (EMC-related)

The Safe Disable function is in compliance with these standards.



## ■ Specifications

The Safe Disable inputs provide a stop function in compliance with “Safe Torque Off” as defined in the IEC/EN 61800-5-2. Safe Disable inputs have been designed to meet the requirements of the ISO/EN 13849-1 and IEC/EN 61508.

A Safe Disable Status Monitor for error detection in the safety circuit is also provided.

**Table i.32 Specifications for Safe Disable Function**

<b>Inputs/Outputs</b>		<ul style="list-style-type: none"> <li>• Input signal specifications Signal ON level: 18 to 28 Vdc Signal OFF level: -4 to 4 Vdc</li> <li>• Inputs: 2 Safe Disable inputs H1, H2</li> <li>• Outputs: 1 Safe Disable Monitor output EDM (DM+, DM-)</li> </ul>
<b>Response Time from Input Open to Drive Output Stop</b>		Shorter than 3 ms
<b>Response Time from Input Open of H1 and H2 Terminals to EDM</b>		Shorter than 4 ms
<b>Failure Probability</b>	<b>Demand Rate Low</b>	PFD = 8.14E <sup>-6</sup>
	<b>Demand Rate High/Continuous</b>	PFH = 1.96E <sup>-9</sup>
<b>Performance Level</b>		The Safe Disable inputs satisfy the following requirements (DC from EDM considered) Performance Level (PL) e according to ISO/EN 13849-1
<b>HFT (Hardware Fault Tolerance)</b>		N = 1
<b>Classification of Subsystem</b>		Type B

## ◆ Precautions

**DANGER!** *Sudden Movement Hazard. Improper use of the Safe Disable function can result in serious injury or even death. Make sure the whole system or machinery in which the Safe Disable function is used complies with safety requirements. When implementing the Safe Disable function into the safety system of a machine, perform a thorough risk assessment for the entire system to assure compliance with relevant safety norms.*

**DANGER!** *Sudden Movement Hazard. When using a PM motor, even if the drive output is shut off by the Safe Disable function, a breakdown of two output transistors can cause current to flow through the motor winding, resulting in a rotor movement for a maximum angle of 180 degrees (electrically). Make sure such a situation would have no effect on the safety of the application when using the Safe Disable function.*

**DANGER!** *Electrical Shock Hazard. The Safe Disable function can switch off the drive output, but does not cut the drive power supply and cannot electrically isolate the drive output from the input. Always shut off the drive power supply when performing maintenance or installations on the drive input side as well as the drive output side.*

**DANGER!** *Sudden Movement Hazard. The motor will move when an external gravitational force in the vertical axis is applied even if the Safe Disable function is in operation. Failure to comply may result in serious injury or death.*

**DANGER!** *Sudden Movement Hazard. Connect the Safe Disable inputs to the devices in compliance with safety requirements. Failure to comply will result in death or serious injury.*

**WARNING!** *Sudden Movement Hazard. When using the Safe Disable inputs, make sure to remove the wire links between terminals H1, H2, and HC that were installed prior to shipment. Failing to do so will keep the Safe Disable circuit from operating properly and can cause injury or even death.*

**NOTICE:** *All safety features (including Safe Disable) should be inspected daily and periodically. If the system is not operating normally, there is a risk of serious personal injury.*

**NOTICE:** *Only a qualified technician with a thorough understanding of the drive, the instruction manual, and safety standards should be permitted to wire, inspect, and maintain the Safe Disable input.*

**NOTICE:** *From the moment terminal inputs H1 and H2 have opened, it takes up to 2 ms for drive output to shut off completely. The sequence set up to trigger terminals H1 and H2 should make sure that both terminals remain open for at least 2 ms in order to properly interrupt drive output.*

**NOTICE:** *The Safe Disable Monitor (output terminals DM+ and DM-) should not be used for any other purpose than to monitor the Safe Disable status or to discover a malfunction in the Safe Disable inputs. The monitor output is not considered a safe output.*

**NOTICE:** *When utilizing the Safe Disable function, an EMC filter must be used.*

## ◆ Using the Safe Disable Function

The Safe Disable inputs provide a stop function in compliance with “Safe Torque Off” as defined in the IEC/EN 61800-5-2. Safe Disable inputs have been designed to meet the requirements of the ISO/EN 13849-1, Category 3 PLe, and IEC/EN 61508, SIL3.

A Safe Disable Status Monitor for error detection in the safety circuit is also provided.

### ■ Safe Disable Circuit

The Safe Disable circuit consists of two independent input channels that can block the output transistors (terminals H1 and H2). The input can use either the drive internal power supply or an external power supply. Use jumper S3 on the terminal board to select between Sink or Source mode with either internal or external power supply.

A photocoupler output is available to monitor the status of Safe Disable terminals DM+ and DM-. *Refer to Output Terminals on page 31* for signal specifications when using this output.

Additionally, a Safe Disable monitor function can be assigned to a digital output (H2-□□ = 58).

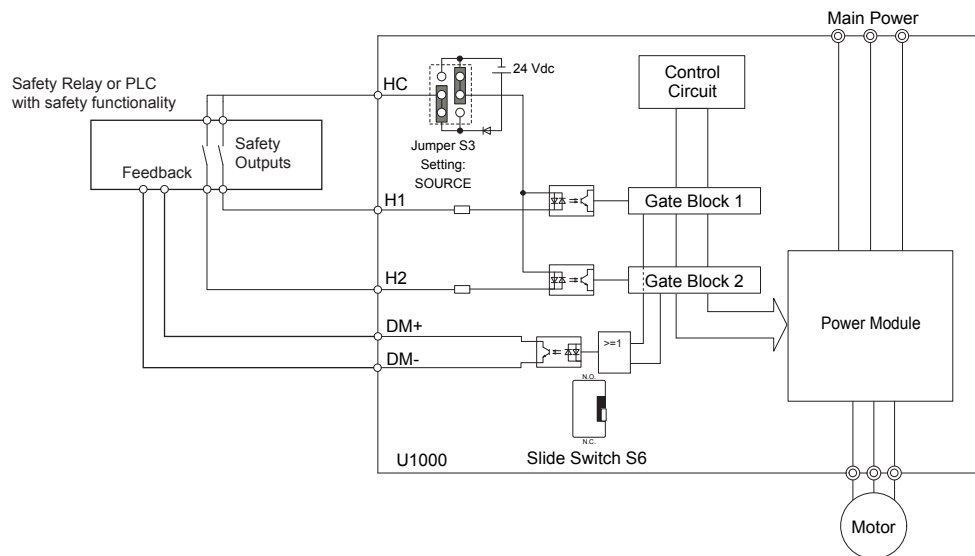


Figure i.57 Safe Disable Function Wiring Example (Source Mode)

### ■ Disabling and Enabling the Drive Output (“Safe Torque Off”)

Figure i.58 illustrates the Safe Disable input operation.

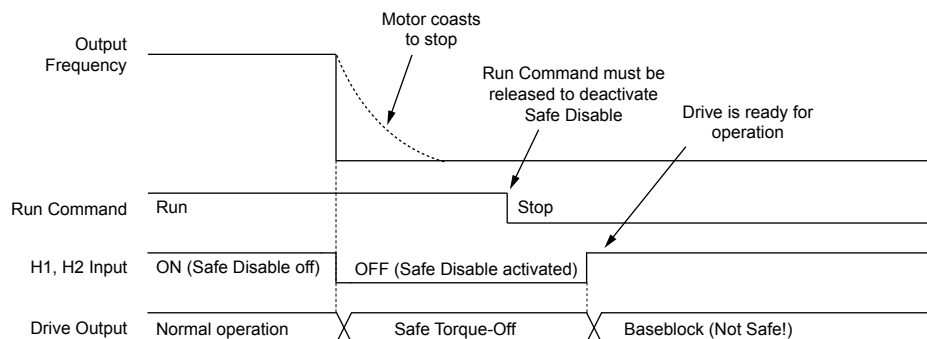


Figure i.58 Safe Disable Operation

#### Entering the “Safe Torque Off” State

When one or both Safe Disable inputs are open, the motor torque is shut off by switching off the drive output. If the motor was running before the Safe Disable inputs opened, then the motor will coast to stop regardless of the stopping method set in parameter b1-03.

The “Safe Torque Off” state can only be achieved using the Safe Disable function. Removing the Run command stops the drive and shuts the output off (baseblock), but does not create a “Safe Torque Off” status.

**Note:** To avoid an uncontrolled stop during normal operation, make sure that the Safe Disable inputs are opened first when the motor has completely stopped.

**Returning to Normal Operation after Safe Disable**

The Safe Disable function can only be deactivated when a Run command is not active.

If Safe Disable was activated during stop, turn on both Safe Disable inputs by deactivating “Safe Torque Off” to resume normal operation.

If Safe Disable was activated during run, remove the Run command then turn on the Safe Disable inputs before restarting the drive.

**■ Safe Disable Monitor Output Function and Digital Operator Display**

*Table i.33* explains the drive output and Safe Disable monitor state depending on the Safe Disable inputs.

**Table i.33 Safety Input and EDM Terminal Status**

Safe Disable Input Status		Safe Disable Status Monitor, (DM+, DM-)		Drive Output Status	Digital Operator Display
Input 1, H1-HC	Input 2, H2-HC	S6 Switch = “N.O.”	S6 Switch = “N.C.”		
OFF	OFF	OFF	ON	Safely disabled, “Safe Torque Off”	Hbb (flashes)
ON	OFF	ON	OFF	Safely disabled, “Safe Torque Off”	HbbF (flashes)
OFF	ON	ON	OFF	Safely disabled, “Safe Torque Off”	HbbF (flashes)
ON	ON	ON	OFF	Baseblock, ready for operation	Normal display

**Safe Disable Status Monitor**

Slide Switch S6 controls the polarity of this signal. Refer to *Table i.33* for functionality.

With the Safe Disable monitor output (terminals DM+ and DM-), the drive provides a safety status feedback signal. This signal should be read by the device that controls the Safe Disable inputs (PLC or a safety relay) in order to prohibit leaving the “Safe Torque Off” status in case the safety circuit malfunctions. Refer to the instruction manual of the safety device for details on this function.

**Digital Operator Display**

When both Safe Disable inputs are open, “Hbb” will flash in the digital operator display.

If one Safe Disable channel is on while the other is off, “HbbF” will flash in the display to indicate that there is a problem in the safety circuit or in the drive. This display should not appear under normal conditions if the Safe Disable circuit is utilized properly.

If a fault in the safety circuit of the drive is detected, “SCF” will be displayed in the LCD operator. This indicates damage to the drive.

**■ Validating Safe Disable Function**

Always perform the following validation test on the safe disable inputs after completing the wiring after start-up, when replacing parts, or when conducting maintenance. Maintain check results as a record of tests performed.

- When the H1 and H2 signals turn OFF, confirm that “Hbb” is displayed on the LCD operator, and that the motor is not in operation.
- Monitor the ON/OFF status of the H1 and H2 signals and confirm the EDM signal according to *Table i.33*.

If the ON/OFF status of the signals do not match the display, it is possible that there is an error in the external device, the external wiring is disconnected, there is a short circuit in the external wiring, or a failure in the drive. Find the cause and correct the problem.

- In normal operation, confirm the EDM signal according to *Table i.33*.

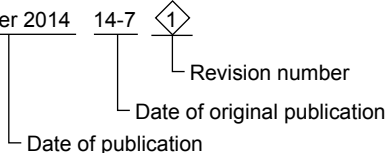
## i.10 Revision History

The revision dates and the numbers of the revised manuals appear on the bottom of the back cover.

Example:

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Published in Japan October 2014 14-7 



Date of Publication	Revision Number	Section	Revised Content
January 2015	2	Front Cover	Revision: Models
		Receiving	Revision: Reference Motor Capacity kW (HP) values Revision: Figure i.4
		Back Cover	Revision: Address
October 2014	1	All	Upgraded the software version to PRG: 1015
		Front Cover Back Cover	Revision: Title
		Preface	Revision: Applicable Documentation
		Electrical Installation	Revision: EMC filter switch for models 2E0248, 2W0248, 4EU0216, 4W0216, 4E0240, and 4W0240
		Parameter Table	Addition: H2-06 = 0 (0.1 kWh units)
July 2014	–	–	First Edition. This manual supports drive software version PRG: 1014.



# U1000 Industrial MATRIX Drive

## Low Harmonic Regenerative Drive for Industrial Applications

### Quick Start Guide

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